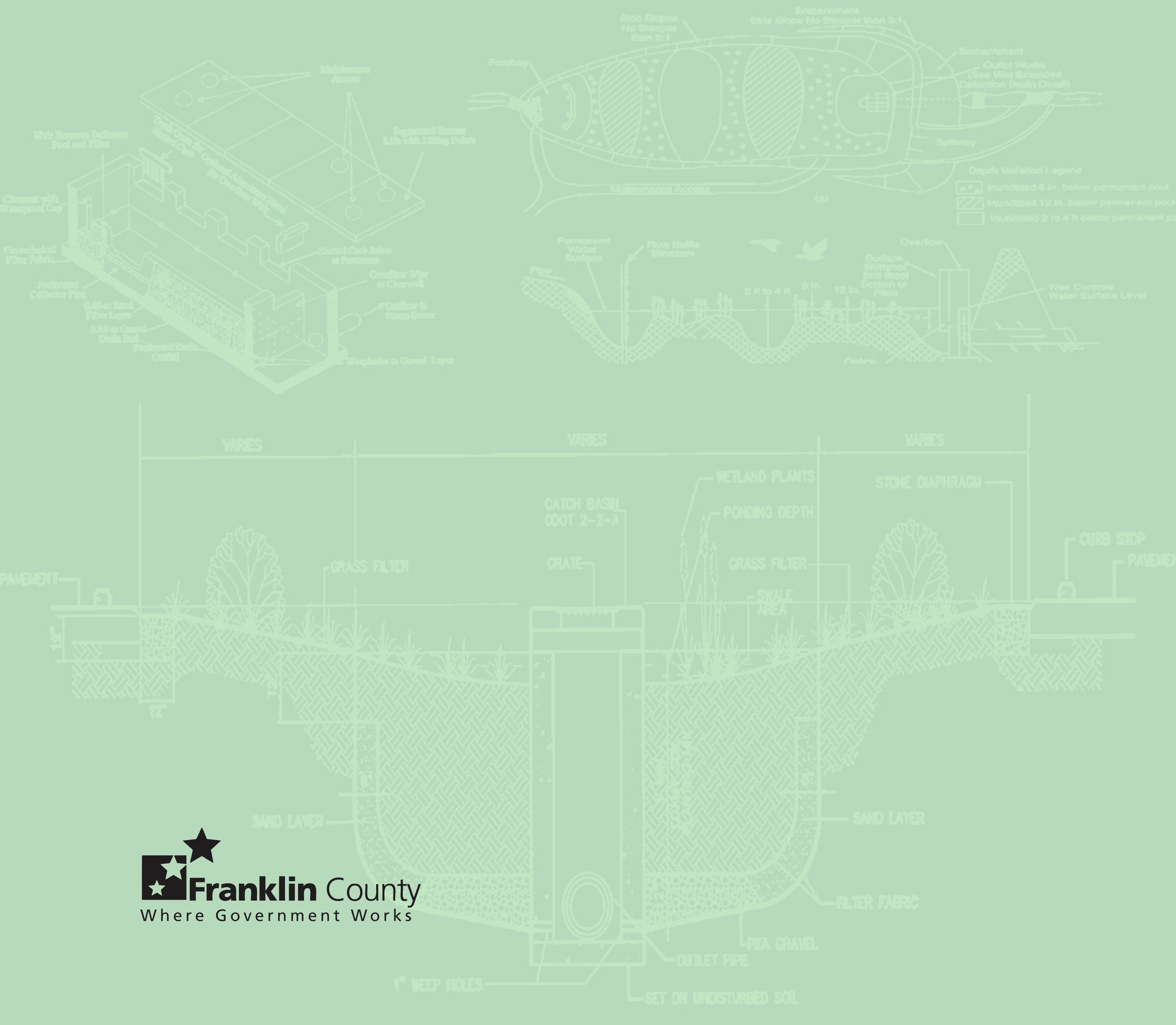
Franklin County

Stormwater Drainage Manual



Franklin County
Where Government Works

Franklin County
Stormwater Drainage Manual

For unincorporated areas of Franklin County, Ohio

Approved March 13, 2012

Franklin County
Where Government Works

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Stormwater Drainage Manual

Introduction

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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. According to 2009 estimates made available by the Mid-Ohio Regional Planning Commission, Franklin County is comprised of an estimated 1,164,725 residents. Of this population, 91.6 percent live in cities and incorporated villages of Franklin County and the remaining 8.4 percent of the population, or 98,106 people, live in unincorporated areas of the county.

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. In 2000, there was a development restriction placed on land in the Darby Watershed, and at that time, the Darby Accord was formed through participation of watershed communities. The resulting product was the Big Darby Watershed Master Plan developed in 2006 and adopted by all 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.

Due to the dispersed nature of incorporated areas in Franklin County and the fact that watersheds, streams and storm sewers connect the incorporated and unincorporated lands, the technical design specifications in this manual are concurrent with those found in the City of Columbus Stormwater Drainage Manual and will reference the City's standard construction drawings as well as Construction Materials and Specifications (CMSC). This manual is intended to serve the unincorporated area of Franklin County as a technical guidance document in support of subdivision regulations and zoning regulations.

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 County's Stormwater Drainage Manual (the Manual) provides guidance and direction for meeting these goals.

The purpose of the Manual is to protect existing natural stormwater resources, convey and control stormwater in a safe and responsible manner, and meet water quality goals. The Manual is intended to provide information to the general public on the 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 apply to protect sensitive ecological areas (i.e., Hellbranch Run and the Darby Creek watersheds) or to meet the goals of Total Maximum Daily Loads established by the Ohio EPA. Where alternative standards conflict with the requirements of the Manual, the more stringent criteria shall apply.

Applicability

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

Unless otherwise exempt, any new development or redevelopment disturbing more than one acre and/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 if less than one acre is disturbed.

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) 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) Long Term Operation and Maintenance of Stormwater Infrastructure and Best Management Practices (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 management systems shall be submitted to the County for review and approval in accordance with this section.

3) Stormwater Management Report Submittal Requirements (Section 7) provides guidance on the information required for plan approval and presents plan details (including title, plan, profile, and cross section sheets) which shall be included in the construction plans.

Construction Requirements

The current edition of the City of Columbus Construction and Materials Specifications (CMSC), and Standard Construction Drawings, shall govern the construction of stormwater facilities described in the Manual. All construction activity within the Unincorporated County must also comply with the requirements stipulated by the OEPA and Section 3.5 of this manual, whichever is more restrictive. Copies of the current City of Columbus CMSC and Standard Construction Drawings are available at the Division of Sewerage and Drainage, Sewer Permits Desk, 910 Dublin Road, or online at: http://publicservice.columbus.gov/Contractors_and_Consultants.aspx

Variances

Accepted procedures, guidelines, and requirements for stormwater management within the County are provided by the Manual and supplemented by reference materials identified herein. The County's stormwater policies and design criteria, as expressed in the Manual, may not provide solutions to all drainage problems. 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 Manual may grant variances in the following circumstance:

1) 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:
   a. that the proposed alternative will provide the same level of flood and water quality protection as those provided for in the Manual, or
   b. that the project provides for stormwater quality and quantity protection to the extent practicable, and that the project provides a substantial public benefit, such as brownfield redevelopment, urban infill development, or substantial environmental benefit.

County and Township regulatory agencies do not have the authority to grant variances to state or federal regulations.

Definitions

For the purpose of the Manual, the following terms, phrases, and definitions shall apply and are provided here for quick reference and convenience. Words used in the singular shall include the plural, and 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.

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.

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

1) Material and waste handling and storage areas, including but not limited to loading docks, fuel and other liquid storage/dispensing facilities, material bins, containers, stockpiles, and other storage containers, waste dumpsters, bins, cans, tanks, stockpiles, and other waste containers,

2) Processing, manufacturing, fabrication, cleaning, or other permanent outdoor equipment or work areas, and

3) Areas where vehicles and equipment are repaired, maintained, stored, disassembled, or disposed.

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

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

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

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 drainage facility; or clearing, scraping, grubbing, killing or otherwise removing the vegetation from a site; or adding, removing, exposing, excavating, leveling, grading, digging, burrowing, dumping, piling, dredging or otherwise significantly disturbing the soil, mud, sand or rock of a site.

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

Drainage Facility — Any component of the drainage system.

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

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

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

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

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

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

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

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

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

ODOT L&D Manual — ODOT Location &Design Manual in effect as of the effective date of the SWDM or an applicable revisions or amendments

Offsite — Taking place or located away from the site.

Onsite — Taking place or located within the site.

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

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

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

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

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

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

Private Facility — Property or facility which is not owned by the County or a municipality.

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

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

Public Facility — Property or facility which is owned by the County.

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

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

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

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

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

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

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

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

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

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

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

Stream — Streams shown on the USGS 7.5 minute Quad maps as solid or dashed blue lines or a surface watercourse with a well-defined bed and bank, either natural or artificial, which confines and conducts continuous or periodic flowing water.

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.

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 trading that changes drainage direction or volume.

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

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

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

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

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

Acronyms

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

Stormwater Drainage Manual

Part I
Introduction

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Part I – Stormwater Policy and Facility Design Criteria

Part I of the Manual supports the layout and design of stormwater management facilities. The 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.

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Stormwater Drainage Manual

Part I

Section I

Preservation and Protection

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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 Flow Impacts

The introduction of impervious surfaces increases the quantity of storm water runoff which in turn alters the flow characteristics of our streams in several ways:

Increase Runoff Volumes - more water running off the land into the streams than normally 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 - the increase in impervious surfaces and the introduction of paved gutters and storm pipes increase the 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.

1.2 Stream Geometry Impacts

The increase in stream flows due to increased impervious surfaces has 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, 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 a 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 in to 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 and velocities cause flood levels to rise. The filling of the floodplain causes these flood elevations to rise even higher.

1.3 Ecosystem Impacts

The changes in stream geometry due to increases in flow 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 provide valuable habitat for fish and other aquatic species especially during dry periods. Increased flows and sediment loads 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 effects 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 in the water needed for a stable food chain.

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 Ohio EPA water quality standards.

1.4 Water Quality Impacts

Development also increases 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 come from urban runoff containing lawn fertilizers, animal waste, and detergents. These nutrients promote algae blooms in ponds and lakes. Algae blooms 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 and 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 on 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 only survive in a narrow temperature range.

Trash and Debris - Trash and debris can cause a variety of problems. First 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. The purpose of this manual is to specify water quantity and quality standards that land disturbing activities of over one acre must meet.

See ODNR Rainwater and Land Development Manual, Chapter One, for more information on stream impacts due to urbanization.

1.5 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 Best Management Practices for the development site and the regional watershed in which the site is located. Designs should consider TMDL 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.

1.5.1 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 Soils

1.5.2. 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

1.5.3 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 sidewalks on one side of the street only.
7) Consider specifying pervious pavements for overflow parking areas, driveways, sidewalks, recreation and pedestrian facilities.

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Stormwater Drainage Manual

Part I

Section II

Stormwater Conveyance

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Section 2
Stormwater Conveyance

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

2.1 General Criteria

2.2 Hydrology Requirements

2.3 Design of Minor Stormwater Conveyance Systems

2.4 Design of Major Stormwater Routing Systems

2.1 General Criteria

The 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 facilities designed in accordance with the requirements specified in Section 3 of the Manual. No stormwater management plans will be approved until it is demonstrated that onsite runoff will not cause flooding within the development site for the designated design storm.

2.1.3 Downstream Analysis

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

1) A public storm sewer system adequately sized for the intended flows,
2) A public open channel system (generally excluding roadside ditches),
3) A stream,
4) 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

5) 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.

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

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

1) The next increase in pipe diameter in an existing downstream storm sewer system,
2) The downstream face of the next bridge or culvert crossing in an open conveyance system (generally excluding roadside ditches), or
3) A point designated by the Franklin County Engineer, Drainage Engineer or flood plain 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 be required, and/or require the Applicant to provide the necessary downstream improvements to satisfy the conditions of this section.

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

1) Previous studies that may be on file at the 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 must be used, and design criteria specified in the Manual shall be used to evaluate the offsite drainage systems of the same type.

2.1.4 Agricultural Field Tile Systems

Agricultural field tiles are for agricultural drainage purposes only and, in general, may not be used as an outlet of any development or stormwater facility except in instances where the field tile is the only available outlet of the site. Field tiles that are discovered or intercepted during construction and do not exhibit evidence of conveying septic effluent 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 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 respective County Drainage Engineer's Office and local Soil and Water Conservation District to confirm the existence and location of existing tile systems. All visible field tile outlets and locations shall be field located and shown on the stormwater management plans. Any plan information for field tile systems received from county agencies shall also be shown.

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

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

2.1.5 Stormwater System Diversions

The diversion of stormwater runoff from one watershed or receiving stormwater system to another is generally prohibited because such diversions have the potential to cause or exacerbate flooding, erosion, or water quality problems in receiving watercourses. For the purposes of the manual, stormwater diversions are defined as the relocation of stormwater discharges from original receiving streams or stormwater systems to other systems that did not receive such discharges prior to construction. While it is recognized that stormwater runoff from small, onsite, tributary areas must be conveyed between catch basin subcatchments, the County will not allow the diversion of stormwater runoff from one major storm sewer system or open watercourse to another without proper documentation that includes proof of benefit and public comment. Stormwater system diversions between 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 his/her designee.

2.2 Hydrology Requirements

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

2.2.1 Acceptable Hydrologic Methods/Models

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

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

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

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

Table 2-1

Applications of the Recommended Hydrologic Methods

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

Table 2-2
Constraints to Using Recommended Hydrologic Methods

Method	Size Limitation	Applicability
Peak Flow Methods		
▪ Rational Method	Up to 200 acres	Method can be used for estimating peak flows and the design of small conveyance systems.
▪ Regression Equations	Between 17 and 2600 acres with defined channels	Method can be used for estimating peak flows along streams. More specific size limitations are outlined in each of the USGS reports.
▪ NRCS (SCS) Curve Number Method	Peak flow for areas 200 to 640 acres[2]	Method can be used for estimating peak flows and the design of larger conveyance systems
Approved Hydrograph Methods	All drainage area sizes	Method can be used for estimating peak flows and hydrographs for all design applications
Water Quality	Limits set for each Structural Control	Method used for calculating the Water Quality Volume (WQ_v)

[1] For new culvert or culvert replacements developed under County CIP projects only.
[2] Mid-Ohio Regional Planning Commission, Stormwater Design Manual, 1977, pg.30

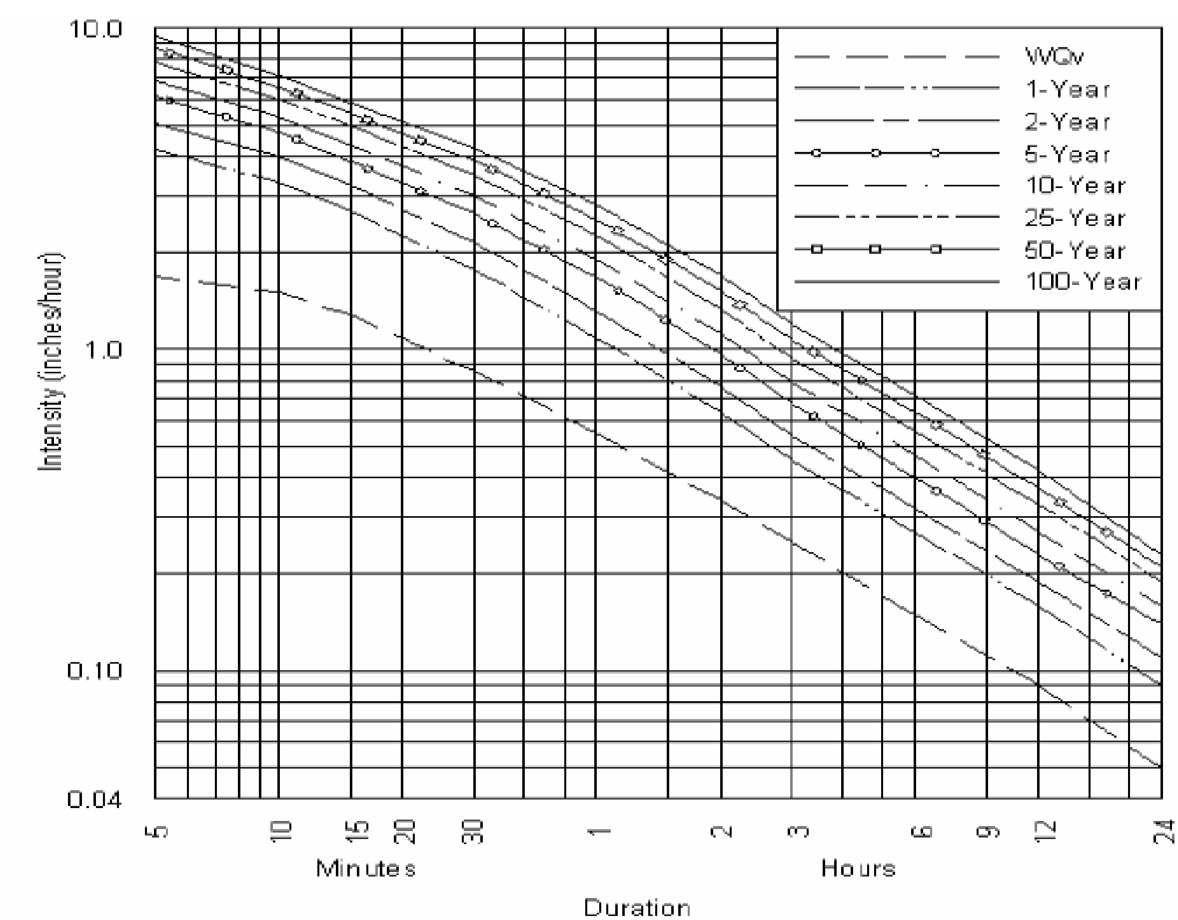
2.2.2 Hydrologic Components

2.2.2.1 Rainfall

Rainfall intensity-duration-frequency (IDF) curves for Central Ohio[3] (**Figure 2-1**) shall be used in conjunction with the appropriate hydrologic method and/or model defined in Sections 2.2.3 and 2.2.4 to determine design runoff volumes and intensities. In general, these curves shall be used directly where the rational formula is appropriate to calculate runoff, or shall be used to develop a design rainfall hyetograph for runoff calculations using hydrograph methods. Design rainfall hyetographs shall be developed using the 24-hour rainfall volume from Figure 2-1, distributed over a 24-hour period with the SCS Type II distribution (**Table 2-3**). The 24-hour Type II rainfall distribution represents design rainfall intensities over a time of concentration range typical of a small urban watershed, coupled with wet antecedent conditions at the time of peak rainfall intensity.

Figure 2-1

Intensity Duration Frequency (IDF) Curves
Ohio (39.972 N, 83.01 W, 744 Feet)



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

Table 2-3
Type II SCS Design Storm Hyetograph

	Type II		Type II 24-Hour Rainfall Distribution (In)							
Hour	Mass Curve	Delta Rain	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

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

Hour	Type II Mass Curve	Delta Rain	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
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
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.[4]

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

Overland Flow or Sheet Flow

Overland flow, or sheet flow, is defined as flow that maintains a uniform depth across a sloping surface with no discernible channel. In general, sheet flow occurs at the upstream extent of an overland flow path, rarely exceeding a length of 300 feet in mildly sloped, undeveloped areas. In developed areas, sheet flow lengths are typically no longer than 100 to 150 feet in pervious areas, and 50 to 75 feet in impervious areas. The overland flow time shall be calculated using Manning's Kinematic Equation[5]:

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

where:

t_o = Time of overland flow (hr),

n = Manning's roughness coefficient for sheet flow

L = Flow length (ft)

P_2 = 2-year, 24-hour rainfall (in)

s = Slope of hydraulic grade line (land slope, ft/ft)

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

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[4] Haestad Methods Engineering Staff, *Computer Applications in Hydraulic Engineering*, 2002, pg. 56.
[5] United States Department of Agriculture, Soil Conservation Service, *Urban Hydrology for Small Watersheds, Technical Release 55*, June 1986.

Table 2-4

Roughness Coefficients (Manning's "n") for Sheet Flow

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

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

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

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

Shallow Concentrated Flow

Beyond the maximum overland flow length defined in the previous section, sheet flow becomes concentrated flow and must be conveyed by a storm sewer, drainage ditch, or natural channel. The average velocity for shallow concentrated flow shall be determined from Figure 3-1 of SCS TR-55[6], in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in Appendix F of SCS TR-55.

Pipe or Open Channel Flow

The velocity of flow in an open channel or pipe shall be estimated using the Manning's Equation. The travel time for both shallow concentrated flow and open channel or pipe flow is calculated as follows[7]:

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

where:

t_s = Travel time for shallow concentrated flow in minutes

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

L = Flow length in feet

V = Velocity in fps

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

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

2.2.2.3 Soil Variables

The hydrologic soil group (HSG) associated with soils on the project site prior to development shall be defined by Table 16 – Soil and Water Features[8] of the latest edition of the "Soil Survey of Franklin County". A table of the HSGs for the United States soil classifications is also provided in Appendix A of SCS TR-55[9]. 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 2-5**. An average C is to be computed based on the percentage of each land use within the drainage area

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

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

A = Drainage area in acres

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

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

Table 2-5
Runoff Coefficients "C" for Typical Land Uses in Franklin County

Cover Type and Hydrologic Condition	Average Percent Impervious area (5)	Runoff Coefficient for Hydrologic Soil			
		A	B	C	D
Fully Developed Urban Areas (vegetation established) (1)					
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		0.94	0.94	0.94	0.94
Open Space (lawns, parks, golf courses cemeteries, etc.)					
Poor condition (grass cover 50%)		0.29	0.48	0.63	0.70
Fair condition (grass cover 50% to 75%)		0.07	0.30	0.48	0.58
Good Condition (grass cover > 75%)		NA	0.19	0.39	0.50
Commercial and business	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	80	0.63	0.75	0.80	0.83
1/12 to 1/6 acre lots	75	0.56	0.70	0.77	0.83
1/8 acre	65	0.44	0.60	0.72	0.77
1/4 acre	38	0.19	0.40	0.56	0.65
1/2 acre	25	0.11	0.32	0.50	0.60
1 acre	20	0.08	0.29	0.48	0.58
Undeveloped or agricultural lands (1)					
Cultivated Land:					
Without conservation treatment		0.35	0.52	0.67	0.75
With conservation treatment		0.21	0.34	0.46	0.52
Pasture, grassland, or range – continuous forage for grazing (2)					
Hydrologic Condition:					
Poor		0.29	0.48	0.63	0.70
Fair		0.07	0.30	0.48	0.58
Good		NA	0.19	0.39	0.50
Meadow – Continuous grass, protected from grazing and generally mowed for hay.		NA	0.16	0.34	0.46
Brush-brush-weed-grass mixture with brush the major element. (3)					
Poor		0.06	0.27	0.44	0.56
Fair		NA	0.13	0.32	0.44
Good		NA	0..06	0.25	0.37
Woods (4)					
Poor		0.04	0.26	0.44	0.56
Fair		NA	0.18	0.37	0.44
Good		NA	0.12	0.32	0.37
Farmsteads – buildings, lanes, driveways, and surrounding lots.		0.17	0.39	0.54	0.63

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

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

(2) Poor: <50% ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover in not heavily grazed areas.
Good: > 75% ground cover in lightly or only occasionally grazed areas.

(3) Poor: <50% ground cover.
Fair: 50 to 75% ground cover.
Good: > 75% ground cover.

(4) Poor: Forest litter, small trees, and brush are destroyed by heavy grazed or regular burning.
Fair: Woods are grazed but not burned, and some forest litters cover the soil.

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

(6) These runoff coefficients were calculated from CN's drawn from the NRCS (SCS) Peak Discharge Method from TR-55 assuming a 10 year, 24- hour storm. For larger design storms the runoff coefficients should be increased using the following C value correction factors:
1:0 for the 10-year design storm and less
1:1 for the 25-year design storm
1:2 for the 50-year design storm
1:3 for the 100-year design storm

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

2.2.3.2 Regression Equations

The regression equations presented in USGS Report 93-135[10] 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 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 drainage system are then evaluated within each third of the basin and assigned a value of 1 or 0:

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

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

2) ***Channel linings*** include any length of the main drainage channels and principal tributaries that have been lined with an impervious material such as concrete. A value of 1 is assigned if at least 50 percent of the upstream channels have been lined.

3) ***Storm drains or storm sewers*** are defined as enclosed drainage structures (usually pipes) frequently used on secondary tributaries where drainage is received directly from streets or parking lots. A value of 1 is then assigned when more than 50 percent of the upstream secondary tributaries consist of storm drains.

4) ***Curb and gutter streets*** frequently empty into storm drains. If more than 50 percent of the upstream basin is developed with streets and highways constructed with curbs and gutters, then a value of 1 will be assigned.

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

Table 2-6

Example Determination of the Basin Development Factor

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

2.2.3.3 The NRCS (SCS) Curve Number Method

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

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

where:

Q = runoff depth (in)

P = rainfall (in)

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

CN = runoff curve number, and

I_a = initial abstraction (in)
= 0.2 * S

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

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

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

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

$$= 93$$

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 2-7. Additional information regarding the use of SCS's runoff curve number method is available in Technical Release 55 – *Urban Hydrology for Small Watersheds*.

The peak rate of runoff is then calculated as:

$$q_p = q_u A_m Q F_p$$

where:

q_p = peak discharge (cfs)

q_u = unit peak discharge (csm/in) (see **Figure 2-2**)

A_m= drainage area (mi^2)

Q = runoff depth (in)

F_p= pond and swamp adjustment factor (see **Table 2-8**)

Table 2-7

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

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

Notes:

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

Figure 2-2

Unit Peak Discharge Determination

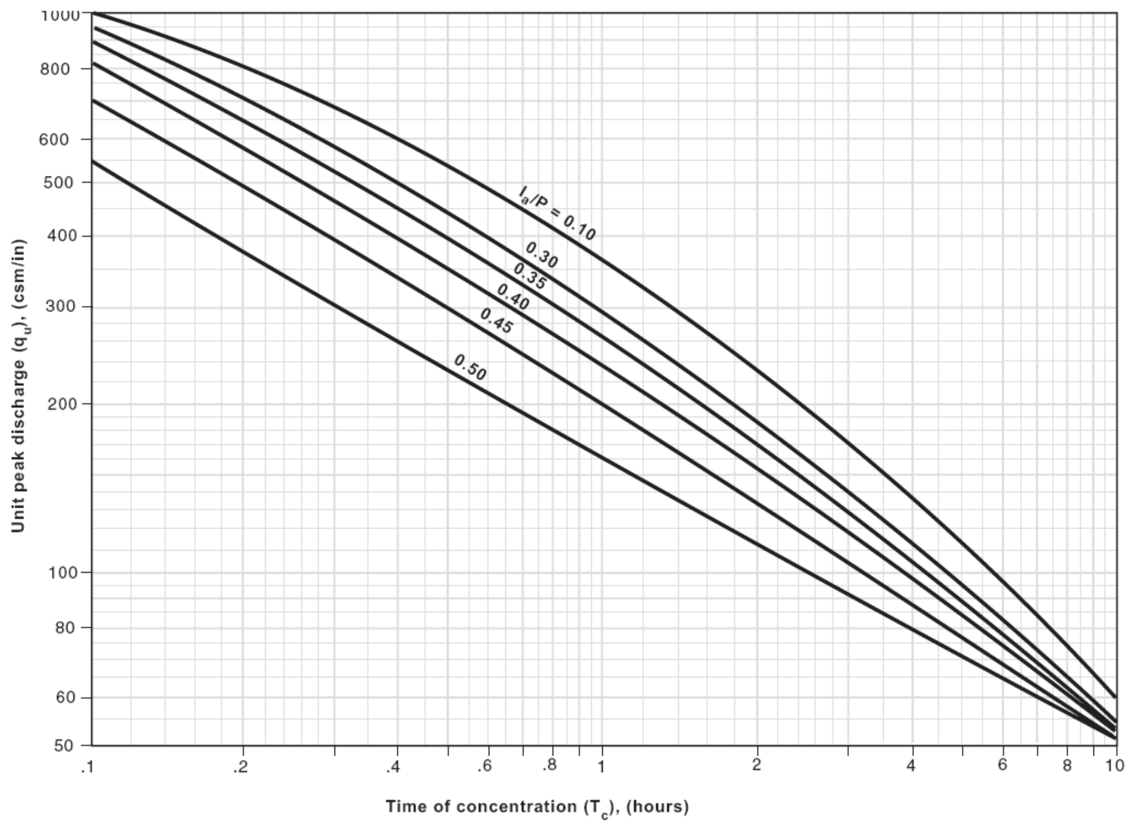


Table 2-8

Adjustment Factor (F_p) for Ponds and Swamps	
Percentage of pond and swamp areas	F_p
0	1.00
0.2	0.97
1.0	0.87
3.0	0.75
5.0	0.72

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

2.2.4 Acceptable Runoff Hydrograph Development Methods

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

Several methodologies are available for defining runoff hydrographs and routing them through the drainage system. The 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 drainage system design. Furthermore, hydrograph methods are generally provided by common engineering computer software, such as the NRCS TR-20, the US Army COE HEC-1 models and U.S. EPA SWMM, which may be allowed if the model results are presented in the format defined in the Manual.

2.2.4.1 Rainfall Hyetographs

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

2.2.4.2 Abstractions from Rainfall

For each catchment, abstractions from rainfall must be determined for each 15-minute rainfall volume within this hyetograph. Abstractions are comprised of depression storage and infiltration into the soil, and shall be based upon the soil and land cover characteristics of the catchment. The initial abstraction at the beginning of the design storm shall be based upon average soil moisture conditions. Changes in abstractions shall be tracked during the storm event as available depression storage and soil infiltration capacity is filled. The NRCS curve number methodology presented in Section 2.2.3.3 is accepted by the County for defining rainfall abstractions. Other methods, including the Green-Ampt and Horton's methods[12], for determining the change in soil infiltration during a precipitation event may be used with appropriate documentation at the discretion of the County.

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

2.2.4.3 Unit Hydrographs

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

$t_p = 0.666 * t_c$ 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

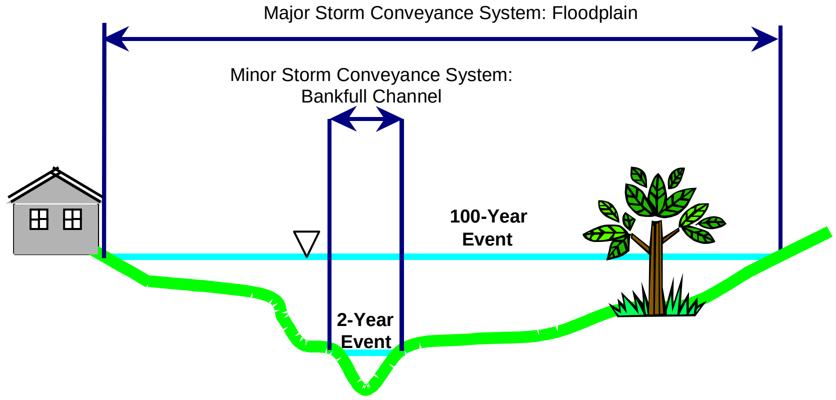
The total hydrograph responding to the SCS Type II rainfall hyetograph from the catchment is determined by adding the individual unit hydrographs determined using the previous equation. The County will accept calculations based on computer models that use the SCS unit hydrograph method to develop runoff 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.

SCS Dimensionless Unit Hydrograph

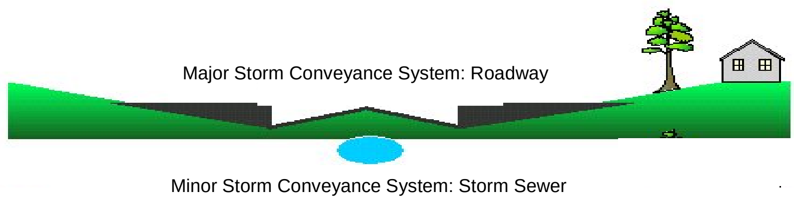
t/t_p	Q/Q_p
0.0	0.000
0.2	0.100
0.4	0.310
0.6	0.660
0.8	0.930
1.0	1.000
1.2	0.930
1.4	0.780
1.6	0.560
1.8	0.390
2.0	0.280
2.2	0.207
2.4	0.147
2.6	0.107
2.8	0.077
3.0	0.055
3.2	0.040
3.4	0.029
3.6	0.021
3.8	0.015
4.0	0.011
4.2	0.008
4.4	0.006
4.6	0.004
4.8	0.002
5.0	0.000

2.3 Design of Minor Stormwater Conveyance Systems

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



Streams



Urban Drainage

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

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

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

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

Table 2-9

Pavement Design Criteria (Stormwater Drainage Manual Section 2.3.2)

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 Intensity Duration Frequency (IDF) Curves in the current City of Colu7mbus Storm water Drainage Manual.

(6) ODOT CDSS Program is acceptable for use in City of Columbus Spread calculations submittals; however, if ODOT CDSS is BOT used, note (5) above prevails

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

Note: Franklin County reserves the option of waiving Table 2-9 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 Engineers Office.

Table 2-10

Storm Sewers, Culverts, Level Spreaders, and Open Watercourses

Design Criteria (Manual Sections 2.3.1, 2.3.3, 2.3.6 and 2.3.7)

Functional Classification	**Storm Sewers**		**Culverts**[13]	**Level Spreaders**	**Open Watercourses**
	Design Storm	Check Storm			
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*	10-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).**

2.3.1 Storm Sewers

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

Storm sewer calculations shall be summarized onto a Storm Sewer Computation Sheet and a Storm Sewer Check Sheet, presented in **Appendix C**, for each proposed sewer run. These sheets shall be submitted to the 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).

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

2.3.1.2 Storm Sewer Hydraulic Requirements

Pipe Sizing Criteria

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

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

where:

Q_f = Full flow capacity of the storm sewer (cfs)
n = Manning's roughness coefficient
R = Hydraulic radius (feet)
= A/P
A = Cross-sectional area ($feet^2$)
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 0.012 per 1104.4.5 ODOT's L&D Manual 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

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

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

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

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

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

Endwalls shall be provided at all storm sewer outlets and shall conform to the most current edition of the City 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 along side lot lines in a single family development site or where the trench limits of the storm sewer are to be within 10 feet of a building foundation. Trench limits for storm and sanitary sewers, as referenced herein, shall be defined as the minimum trench limits listed in the City 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)

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

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

where:

H_m = minor loss (feet)

K = minor loss coefficient for the specific fitting

V = velocity (feet/s)

g = gravitational acceleration = 32.2 feet/s^2

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

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

where:

S_f = frictional slope (feet)

Q_{HGL} = Design flow (cfs)

n = Manning's roughness coefficient

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

R = hydraulic radius (feet) = cross-sectional area of the pipe (A) / wetted perimeter (P)

H_m = minor loss (feet)

L = length of pipe (feet)

Flow Velocity Criteria

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

Table 2-11

Minor Loss Coefficients for Storm Sewers[14]

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

2.3.1.3 Pipe Material, Bedding, Cover, and Encasement Requirements

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

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

2.3.1.4 Storm Sewer Easement Requirements

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

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

2.3.2 Curb Inlets and Catch Basins

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

2.3.2.1 General Criteria

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

The rational method (see Section 2.2.3.1) and a minimum time of concentration of 5 minutes shall be used to determine the amount of runoff that will be collected by the proposed inlet structures. Hydraulic analyses used to size and space inlets and catch basins shall be based on the methods presented in (FHWA) Hydraulic Engineering Circular No. 12 "Drainage of Highway Pavements" and Hydraulic Engineering Circular No. 22 "Urban Drainage Design Manual." **Table 2-12** summarizes the dimensions of the inlets and catch basins that are provided in the City 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)[2]
AA-S115	Round Catch Basin	2.9	3.0	3.0	-	-
AA-S116	Round Catch Basin	2.7	3.0	3.0	-	-
AA-S123	42" Curb Inlet	-	-	-	3.5	>4
AA-S123	60" Curb Inlet	-	-	-	5.0	>4
AA-S126	Standard Curb Inlet	-	-	-	2.33	6.25
AA-S128[1]	Combination Curb and Gutter - Standard	2.7	2.8	1.4	-	-
AA-S133	Square Catch Basin	2.5	3.9	2.1	-	-
AA-S138	Round Catch Basin	0.9	1.9	1.9	-	-
AA-S139	Square Catch Basin	1.9	1.6	2.0	-	-
AA-S140	Rectangular Catch Basin	1.1	1.8	1.2	-	-
AA-S141	Square Catch Basin	1.9	1.9	2.0		

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

2.3.2.2 Underpass or Sag Requirements

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

2.3.2.3 Inlets on Continuous Grade Requirements

At a minimum, the catch basin and/or curb inlet shall be placed at the point where the flow spread is projected to reach the maximum allowable spread listed in Table 2-9. In addition, a basin/inlet shall be placed at intersections where necessary to prevent the gutter flow from crossing the pavement. The 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[15] and in FHWA's HY8 model[16]. All materials used in construction of roadway culverts shall conform to the City of Columbus's CMSC.

2.3.3.1 General Requirements

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

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[15] FHWA, Hydraulic Engineering Circular No. 5 *Hydraulic Charts for the Selection of Highway Culverts*, available from the Superintendent of Documents, U.S. Government Printing Office.
[16] FHWA,*Culvert Analysis Microcomputer Program.* FHWA-EPD-87-101.

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 [17]

Roadway Type	Design Storm Event
Interstate highways, other freeways, and expressways	50-year
Major arterial	25-year
Minor arterial and collectors	25-year
Locals, other parking and development areas	10-year

Types of Culvert Flow

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

Tailwater Conditions

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

1) Previous studies that may be on file with the County or a municipality within the County, or

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

2) Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM) and data.

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

Maximum Allowable Headwater

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

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

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

Manning's "n" Value

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

Entrance Loss Coefficients

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

Maximum Allowable Outlet Velocity

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

Table 2-14

Minor (Entrance) Loss Coefficients for Culverts under Outlet Control, Full or Partly Full Entrance Head Loss[19, 20]

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

[19] Water Environment Federation and American Society of Civil Engineers, *Design and Construction of Urban Stormwater Management Systems*, 1992, pg 156.
[20] Federal Highway Administration, *Hydraulic Design of Highway Culverts, Hydraulic Design Series No. 5*, Report No. FHWA-IP-85-15, Washington DC, 1985.

Bankfull Design Considerations

The designer shall check that 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 3%.

The bankfull discharge shall be determined using a field-obtained stream cross-section from a portion of the stream that does not exhibit bank or bed erosion.[21] 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 [22]

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.

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

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 [23]

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

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

Structural and Cover Requirements

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

2.3.3.5 Culvert Easement Requirements

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

2.3.4 End Treatments

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

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

Precast pipe culvert endwalls approved for pipe culverts 8 to 60 inches in diameter, shall be constructed per City 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.

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

2.3.5 Outlet Channel Protection

2.3.5.1 Outlet Channel Protection Required

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

1) Rock Channel Protection and Riprap Aprons, suitable for outlet velocities up to 20 feet per second.

2) Energy Dissipation Devices, suitable for outlet velocities greater than 20 feet per second.

Table 2-17

Maximum Velocities for Channel Lining Materials [24,25]

Channel Lining Material	Maximum Allowable Velocity (ft/s)*
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**
▪ Crown vetch	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 [26]	
▪ Concrete	18
▪ Concrete block mat	18

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

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

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

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

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

2.3.5.2 Rock Channel Protection and Riprap Aprons

Riprap aprons (**Figure 2-3**[27]) may be used as transitions from culverts or storm sewer outfalls to stable channel sections. Riprap aprons are constructed at a zero grade for a distance related to the outlet flow rate and tailwater depth. The use of riprap aprons is restricted to outlet Froude (Fr) numbers less than or equal to 2.5. Riprap aprons are commonly used because of their low cost and ease of installation. Acceptable design procedures for riprap aprons are found in Georgia Soil and Water Conservation Commission, *Manual for Erosion and Sediment Control in Georgia*, 5th Edition, 2000.[28]

Tailwater Depth

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

Apron Length

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

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

Apron Width

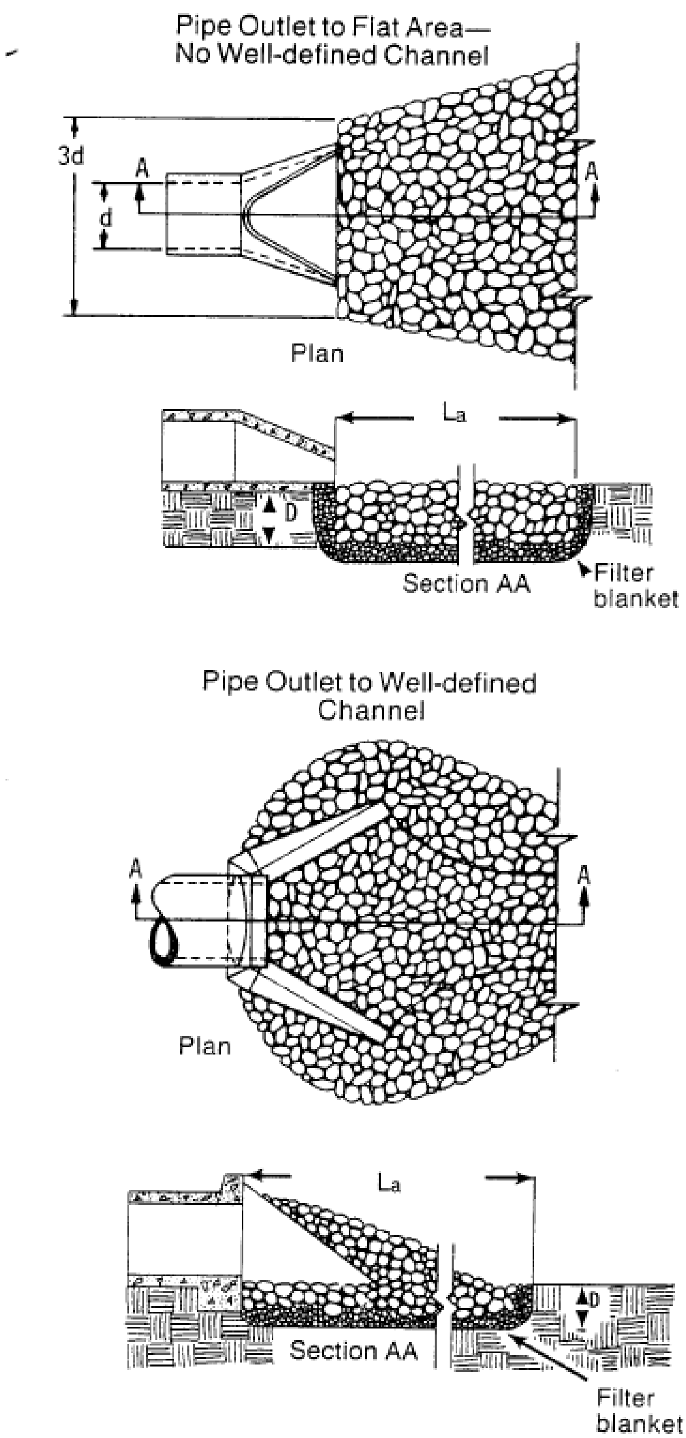
When the pipe discharges directly into a well-defined channel, the apron shall extend across the channel bottom and up the channel banks to an elevation one foot above the maximum tailwater depth or to the top of the bank, whichever is less. If the pipe discharges onto a flat area with no defined channel,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

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

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

Figure 2-3

Riprap Apron Detail



Notes

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

Figure 2-4

Design of Outlet Protection – Minimum Tailwater Condition

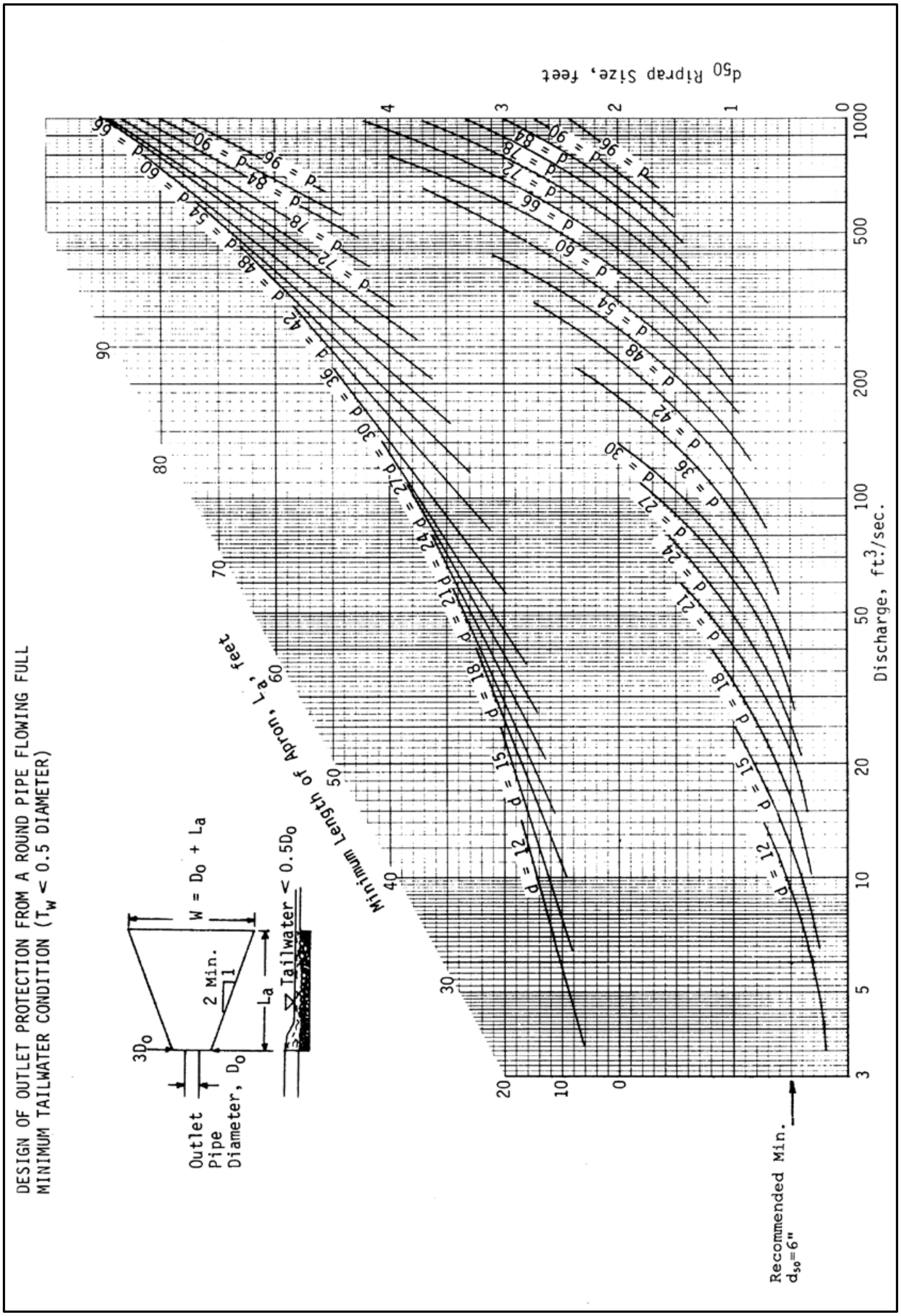
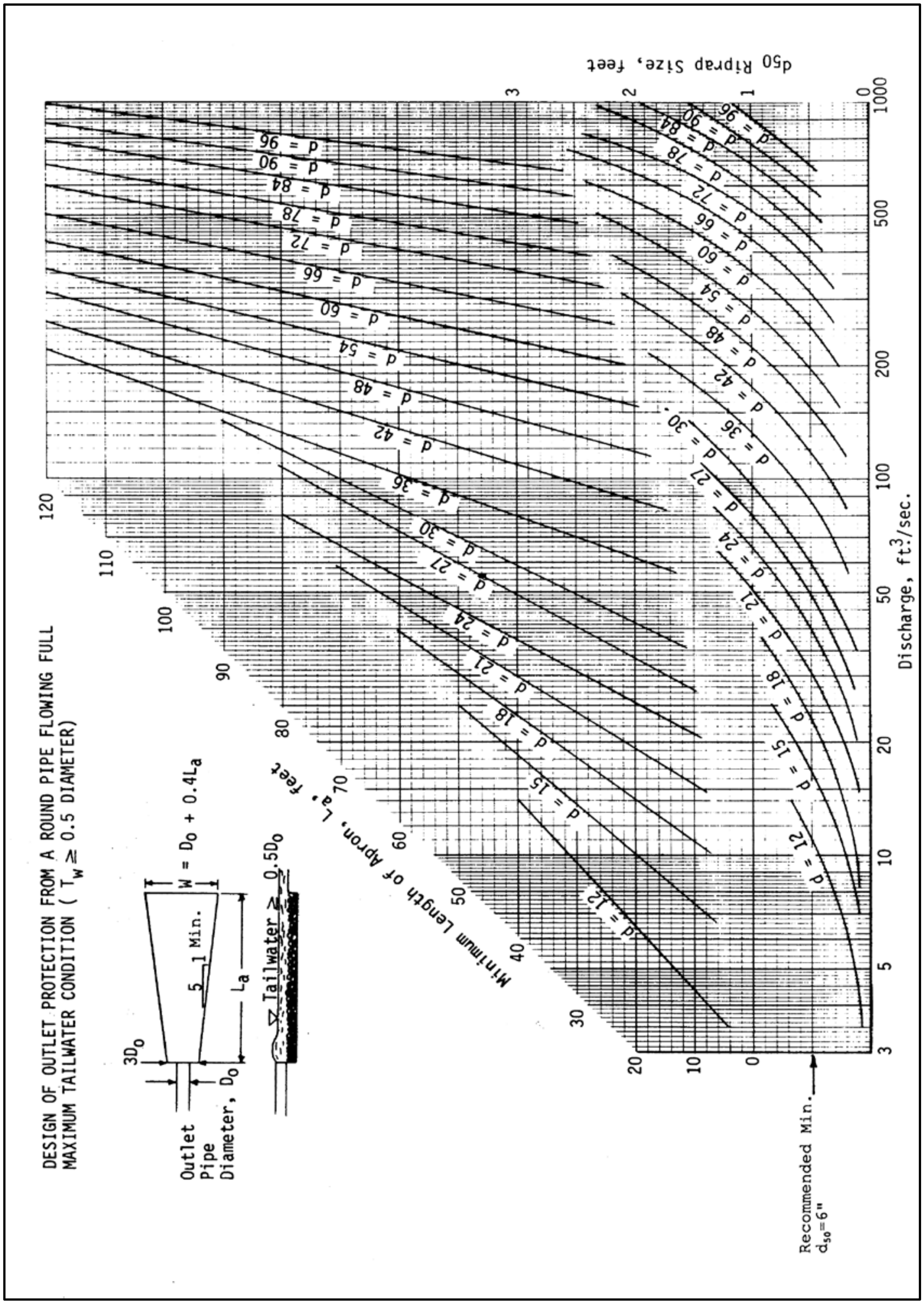


Figure 2-5

Design of Outlet Protection – Maximum Tailwater Condition



Bottom Grade

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

Side Slope

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

Alignment

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

Materials

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

2.3.5.3 Energy Dissipation Devices

Energy dissipation devices[29] are required to prevent scour at culvert and storm sewer outlets and minimize potential for downstream erosion whenever the outlet velocity exceeds 20 ft/sec or the outlet discharges under supercritical flow conditions. Since energy dissipaters function by creating a hydraulic jump, performance is dependent on tailwater conditions. If there is potential for high tailwater conditions in the downstream channel and an energy dissipation device is necessary, then the device shall be designed for low tailwater conditions while the downstream channel is sized to account for higher tailwater conditions. Outlet structures shall provide uniform redistribution or spreading of the flow without excessive separation and turbulence. The maximum velocity exiting an energy dissipation device shall not exceed the maximum velocity of the downstream channel lining in Table 2-17.

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

Riprap Outlet Basins

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

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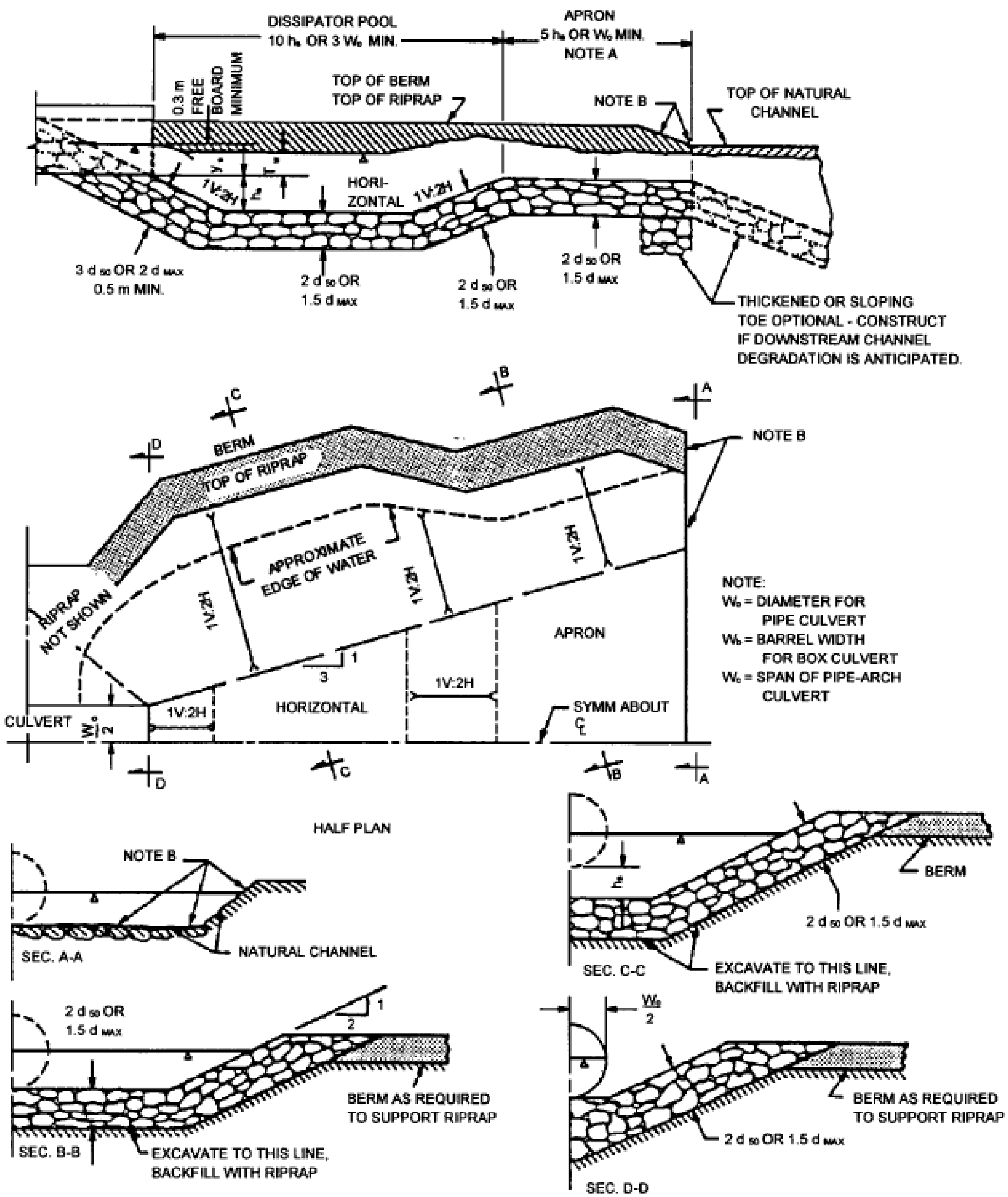
[29] Atlanta Regional Commission, *Georgia Stormwater Management Manual*, Volume 2 (Technical Handbook), 1st Edition, August 2001, Section 4.5.

Figure 2-6

Riprap Outlet Basin Detail



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

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

Baffled Outlets

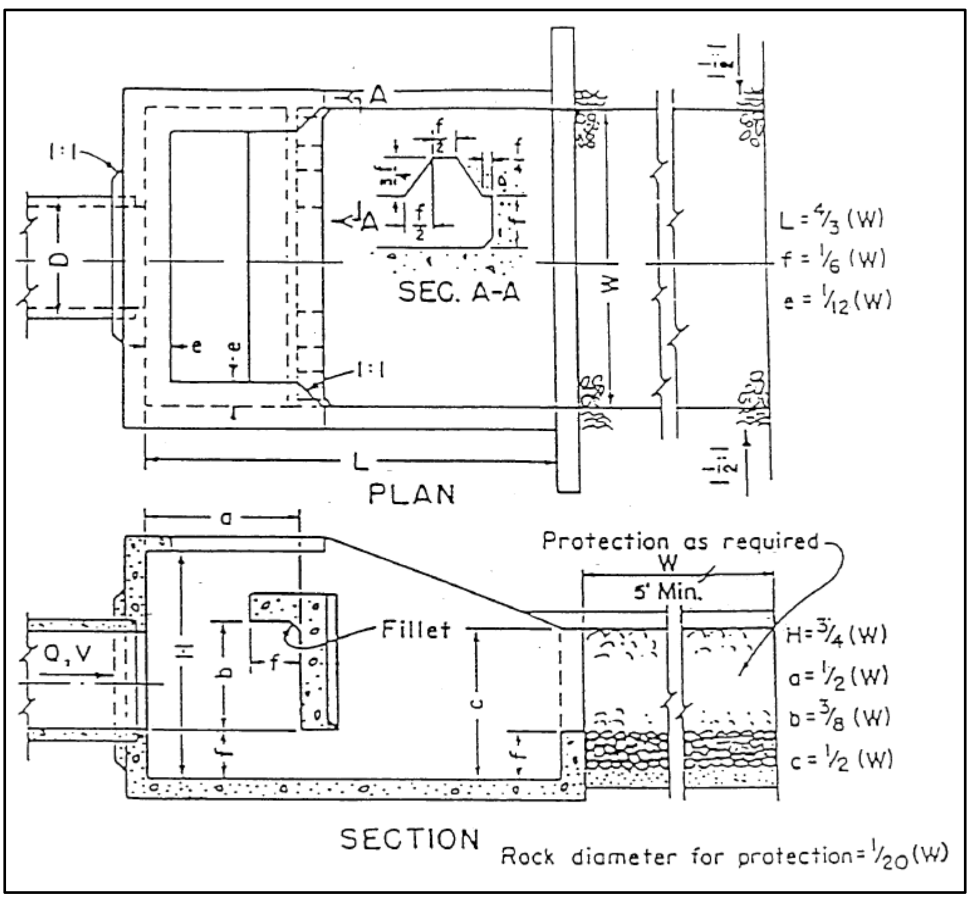
Baffled outlets (also known as Impact Basins – U.S. Bureau of Reclamation Type VI) consist of a boxlike structure with a vertical hanging baffle and an end sill (**Figure 2-7**). Energy is dissipated through the impact of water striking the baffle and the resulting turbulence. Baffled outlets may be used for outlets with a Froude number between 1 and 9 and velocities up to 50 feet/sec. 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, *Design or Small Canal Structures* or other design criteria acceptable to the County Engineer.

Figure 2-7

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 BMPs (e.g. filter strips; see section 3.3.6.2) where "treatment" of stormwater runoff is dependent on the velocity and depth of flow.

2.3.6.1 Use Restrictions

Use of level spreaders is limited by both the flow rate over the level spreader lip as well as the slope and ground cover across the downstream, sheet flow area. Research indicates that level spreader systems designed within parameters shown in **Table 2-18** are more prone to remain stable and reduce potential for flow re-concentration. Level spreaders may not be used where the criteria presented in **Table 2-18** cannot be met.

Table 2-18

Level Spreader Use Criterion

Ground Cover	Slope Limits	Level Spreader Length (ft.) Min./Max.	Distance from Level Spreader Lip to Stream Bank	Length of Level Spreader per Maximum 1 cfs of Flow
Grass or thick ground	0 to 6 percent	13/130	No limit	13 feet
Forested	0 to 6 percent	13/130	0 to 99 feet	65 feet
Forested	0 to 6 percent	13/130	100 to 150 feet	50 feet
Forested	0 to 6 percent	13/130	> 150 feet	40 feet

2.3.6.2 Level Spreader Features

The following features are recommended for incorporation into a level spreader design to ensure proper function and longevity of the level spreader system. **Figure 2-8** and **Figure 2-9** illustrate the components of a level spreader system.

Level Spreader Lip

1. A level spreader channel reinforced with rock or grass lining should be installed along the upstream face of the level spreader lip to distribute flow equally along the entire length of the level spreader.

2. An underdrain system should be installed under the level spreader channel to prevent standing water during periods of no flow. The underdrain should outlet into a stormwater conveyance system.

3. The level spreader lip should be constructed of concrete and supported by an adequately sized concrete footing to prevent settlement and overturning.

4. The width of the level spreader lip should be at least three (3) times the diameter of the inlet pipe up to a maximum width of 24 inches.

5. The lip of the level spreader should be elevated 3 to 6 inches above the ground surface on the downstream side and not less than 9 inches from the invert of the level spreader channel along the upstream side.

6. The level spreader lip should be installed at zero percent grade and parallel to contours. Level spreaders may be curved , if needed, to fit site contours and ensure a level lip.

7. The downstream side of the level spreader lip should be protected to prevent erosion.

Bypass Channel

1. A bypass channel shall be provided for level spreaders intended to convey flows that exceed capacity of the level spreader system.

2. The bypass channel must be sized and appropriately lined to convey the 10-year storm event without flooding or inducing channel erosion.

3. The use of turf reinforcement for channel lining is preferred over stone where adequate sunlight and channel velocities allow.

2.3.6.3 Maintenance

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

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

Figure 2-8

Level Spreader Plan View

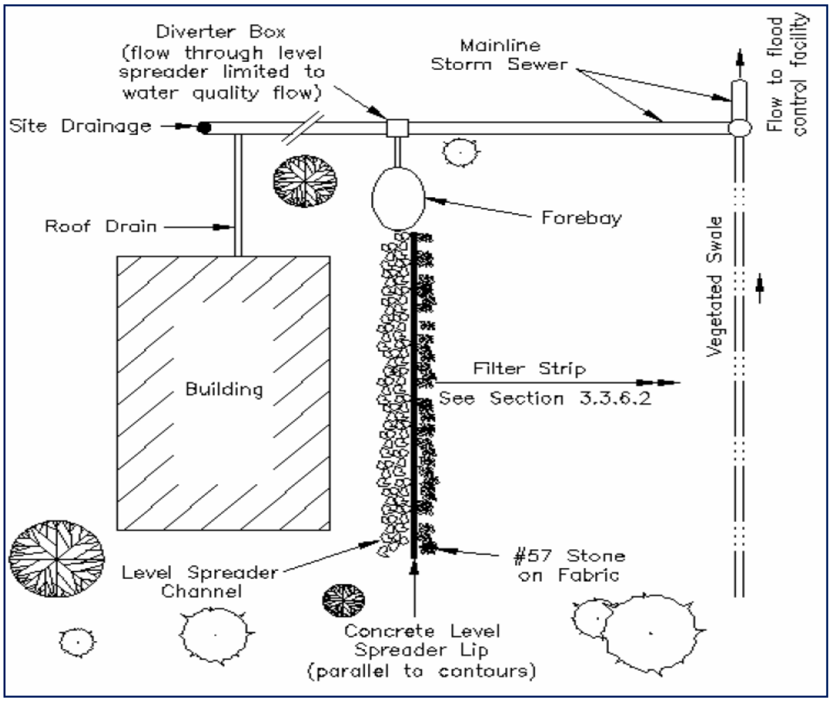
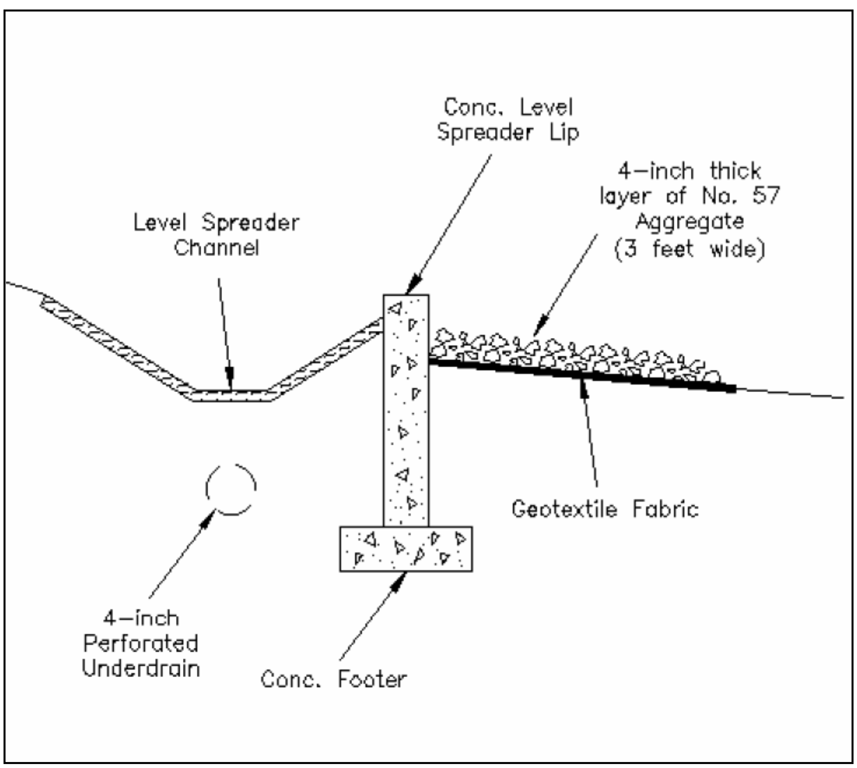


Figure 2-9

Level Spreader Cross Section View



2.3.7 Open Watercourses

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

1) NRCS Ohio Practice Standard 412, Grassed Waterways,
2) NRCS Engineering Field Handbook (EFH) Part 650, Chapter 7 – Grassed Waterways,
3) Agricultural Handbook 667, Stability Design of Grass-lined Open Channels, and
4) Federal Highway Administration, 1988, Design of Roadside Channels with Flexible Linings. Hydraulic Engineering Circular No. 15.

2.3.7.1 Channel Hydrology Requirements

The hydrologic computation methods specified in Section 2.2.1 shall be used to design open watercourses in the 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

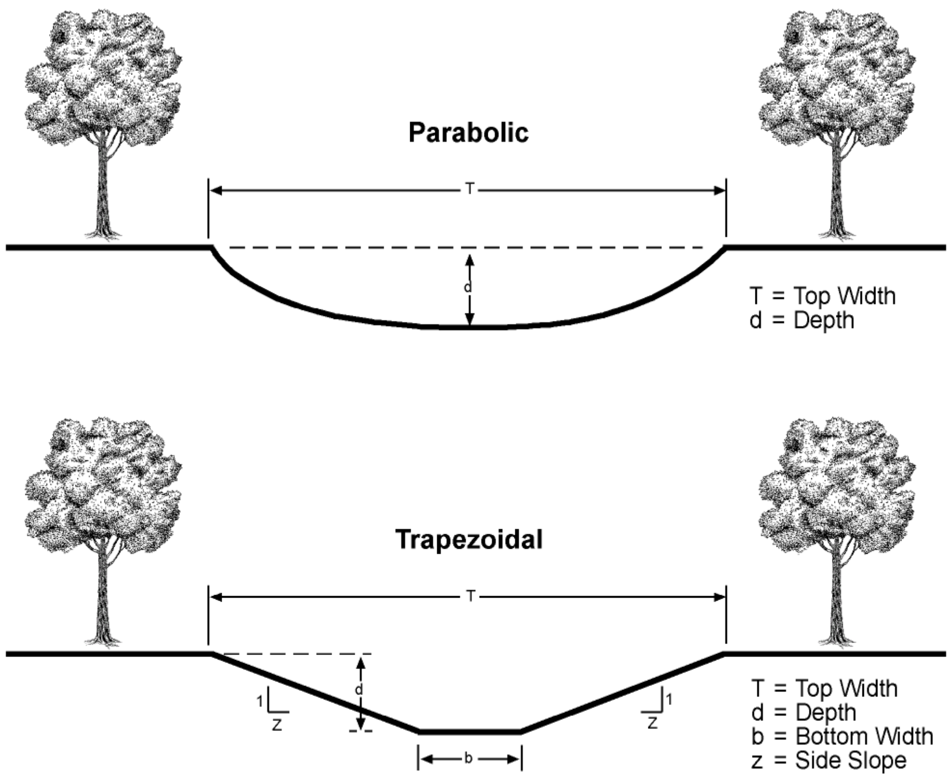
Constructed open watercourses shall be designed to convey the 10-year design storm without causing erosion, sedimentation, or overbank flooding within and along the channel. Criteria in Section 2.4 shall be used if the channel will also serve as a flood routing channel for the 100-year design storm. 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 2-10**) shall be used for open watercourses within development projects. Side slopes shall be 3(H) to 1(V) or milder, with a minimum 2-foot bottom width for trapezoidal channels, unless alternative dimensions are approved by the County due to specific project conditions. Channel cross sections shall be designed such that erosion and sediment deposition is minimized.

Figure 2-10

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 include rock channel protection and cellular soil retaining mats and are typically less expensive than a rigid lining. The use of flexible linings, however, may require the installation of a filter fabric or other means to protect the underlying soil, prevent washout, and prevent soil piping through the rock when using channel protection. Rigid linings include concrete and rigid block and are usually used where high velocities are unavoidable.

Final design of constructed open channels should be consistent with velocity limitations for the selected channel lining. Maximum velocity values for selected vegetated and non-vegetated lining categories are presented in Table 2-17.

The Manning's Equation shall be used to design an open channel that satisfies the maximum velocity criteria in the previous sections:

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

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 2-19**.

Table 2-19

Manning's Roughness Coefficients (n) for Vegetative and Artificial Channels [30]

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.

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

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[31]

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

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

where:

D = depth of flow (feet)
S = channel slope (feet/feet)
Γ_{ac} = actual shear stress (lbs/$feet^2$)

Table 2-20
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 rock channel protection shall be utilized for lining channels with steep grades (slopes 10%-25%) that carry flow from the end of a cut section down to the lowest elevation on the bottom of the channel. FHWA's HEC-15 procedures for steep gradient channels shall be used with a safety factor of 1.5. The County Engineer shall be consulted if rock channel protection is proposed in instances where the peak flow during the 10-year design storm is greater than or equal to 50 cfs.

[31] Ohio Department of Transportation, *Location and Design Manual, Volume 2, Drainage Design.*

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 ten feet on one side, or
2) A minimum width of 20 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 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[32]. 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

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

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 improvements to provide an adequate major storm routing path downstream of the development.

Stormwater Drainage Manual

Part I

Section III

Stormwater Controls

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Section 3
Stormwater Controls

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

3.1 General Criteria

3.2 Stormwater Quantity Controls

3.3 Post-Construction Stormwater Quality Controls

3.4 As-Built Surveys

3.5 Construction Stormwater Quality Controls

3.1 General Criteria

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

1) Stormwater control facilities shall not be located within designated Federal Emergency Management Agency (FEMA) floodplain boundaries.

2) Discharges from stormwater control facilities shall be directed into an approved stream, either directly as sheet flow from a level spreader, or via a storm sewer or open channel conveyance system, according to criteria in Section 2.1 of the Manual.

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 Section 3.2 and 3.3 of the Manual.

3.2 Stormwater Quantity Controls

Stormwater quantity control facilities shall be designed to control runoff from small, moderate, and large storm events before it is discharged offsite. The design criteria provided in this section are intended to minimize flooding downstream of the development site and to reduce streambank erosion. The stormwater management report for the project, prepared according to the guidelines and criteria in Section 6, shall show the location of the stormwater quantity control facilities and calculations defining how they were sized.

3.2.1 Stormwater Quantity Control Exemptions

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

1) 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) Development site is located on and discharges directly to the Scioto River, Olentangy River, Alum Creek, or Big Walnut Creek (Fourth Order Stream).

4) Construction or reconstruction on an existing impervious surface which does not add any new impervious surface.

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

3.2.2 Hydrologic Requirements

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

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

1) Determine the total volume of runoff from a 1-year, 24-hour storm, occurring over each of the site's drainage areas before and after development, using the methodology in Section 2.2.4.

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

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

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

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[2]. Additionally, the peak runoff rate during the 100-year storm event shall be released at a rate less than or equal to the peak runoff rate during the 10-year storm event under pre-developed conditions (where the critical storm is more frequent than a 100-year storm).

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 (i.e., those with a permanent pool),
3) Parking Lot Storage,
4) Underground Tank Storage, and
5) Green Roof Technologies.

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

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

3.2.4 Dry and Wet Detention Basins

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

3.2.4.1 General Requirements for All Detention Basins

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

Layout and Geometry Requirements

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

3) 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 from a 100-year, 24-hour storm event to a suitable downstream flood routing path without erosion, scouring, or soil undermining, and to meet Applicable Ohio Dam Safety requirements.

4) The basin shall be designed so that the peak water surface elevation in the basin does not overtop the basin embankment or flood structures around the basin. **Table 3-2** provides the peak water surface requirements for basins with different design intent.

5) Side slopes within and adjacent to the basin shall be 4 (H) to 1 (V) or flatter to prevent bank erosion and minimize safety risks when the basin is full. The maximum cross slope for the vehicle access way shall be 10 (H) to 1 (V)

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

Table 3-2

Peak Basin Water Surface Elevation Requirements

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

Note:

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

7) The Applicant shall submit preliminary design information to ODNR as necessary to determine the regulatory classification (Class I through Class IV) of any impoundment structures (e.g., dams, berms, embankments, levies) under Ohio dam safety regulations, and shall provide the 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.

8) All inflow pipes to the detention basin that are not entirely submerged below the permanent pool elevation shall be designed with headwalls or endwalls according to criteria in Section 2.3.4. Rock channel protection designed according to criteria in Section 2.3.5 shall be used to minimize erosion around the headwall or endwall, as well as along the side slopes of the basin under each inflow pipe or open channel.

9) If inflow to the facility is conveyed through an open watercourse, including a major storm routing path (Section 2.4), the open channel conveyance system shall be designed in accordance with Sections 2.3.5 and 2.3.7. Channel protection shall be provided along any reaches within 20 feet of the 100-year high-water mark of the basin, or to the edge of the easement (for publicly maintained basins) surrounding the basin, whichever is wider. Channel protection shall be designed according to criteria in Section 2.3.5 and shall be used where the peak flow velocity during the 10-year, 24-hour design storm exceeds the criteria for grass watercourses as presented in Section 2.3.7. Such protection shall extend to the basin's bottom or 2 feet below the normal water elevation of any permanent pool.

10) Woody vegetation may not be planted or allowed to grow on the embankment, within 15 feet of the toe of the embankment, and within 25 feet from the principal spillway structure. The establishment of woody vegetation in other areas around the basin is encouraged to provide shade and moderate surface water temperatures.

11) Permanent stormwater quantity control basins, as defined herein, may be used as temporary sedimentation basins designed to control sedimentation during construction as long as collected sediments are removed, the design grade of the facility is restored, permanent vegetation is established, the temporary outlet is removed, and permanent outlet structure is constructed as designed. In instances where vegetation is not established, additional measures shall be taken to ensure that the area stabilized, including providing additional topsoil, additional seeding and mulching, or providing sodding in the areas where sparse ground cover occurs

Debris Control Requirements

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

Outlet Facility and Outfall Protection Requirements

1) The detention basin shall be designed with an outlet control structure sized to meet the stormwater quantity control requirements presented in Section 3.2.2, the stormwater quality control requirements presented in Section 3.3, or both.

2) Seepage along any structure that extends through the embankment to the downstream slope shall be controlled using an anti-seep collar or drainage diaphragm. The collar/diaphragm shall be aligned approximately parallel to the centerline of the stormwater basin or approximately perpendicular to the direction of seepage flow, extending horizontally and vertically into the adjacent embankment and foundation to intercept potential cracks, poorly compacted soil zones or other discontinuities associated with the structure or its installation. Appropriate criteria for establishing the minimum horizontal and vertical distances from the surface of the conduit may be obtained from NRCS Technical Release 60, Amendment 1 pg. 6-7, dated January 1991, or NRCS Technical Note 709 – Dimensioning of Filter-Drainage Diaphragms for Conduits According to TR-60, dated April 1985.

3) Open channels receiving discharges from the facility shall be protected with rock channel protection designed according to criteria in Section 2.3.5 of the Manual.

4) The outlet structure shall be sized to achieve the release rates required under Section 3.2.2 and 3.3.4. This outlet shall be designed to resist plugging by meeting the following criteria. The County will not allow the use of a single orifice outlet that is less than 4 inches in diameter unless the designer presents sufficient information proving that the orifice will not clog. Alternative outlet designs (e.g., V-notch weir, perforated) of smaller orifice diameter may be permitted upon County approval if acceptable design practice is proven for site conditions. Alternative orifice designs shall also include schedules for more frequent operation and maintenance.

   The detention basin outlet structure shall be designed to retain floatables, such as debris, oil, and grease within the basin up through and including the 100-year design storm event. Acceptable floatables control devices are illustrated in Section 3.3.4, including perforated pipes, skimmers, baffles, inverted pipes (Figure 3-5) and other devices that the County determines to be suitable.

   It is recommended that detention basins be provided with an emergency drain, where practicable, so that the basin may be emptied if the primary outlet becomes clogged and/or to drain the permanent pool to facilitate maintenance. If an emergency drain is used, the emergency drain should be designed to drain by gravity where possible. Where used, gravity pipes shall be made of approved materials as specified in Item 901 of the CMSC. If site conditions prevent gravity flow, the basin may be designed to drain by pumping. Basins requiring pumping may be provided with an emergency drain made of ductile iron pipe with mechanical joints and a quick connect coupling extended to the bottom of the basin at a point near the outlet structure. It is suggested that emergency drains have an elbow within the basin to prevent sediment deposition, and a diameter capable of draining the basin within 24 hours. The emergency drain should include an operable gate, plug valve, mud valve, ball valve, or sluice gate, which should be set and locked in the closed position. Valves or gates should be located inside of the riser at a point where they will not normally be inundated and can be operated in a safe manner.

3.2.4.2 Additional Layout Requirements for Dry Detention Basins

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

1) Dry detention basins shall be designed to drain toward the outlet or micropool in order to minimize standing water and saturated soil conditions that impede maintenance and mowing of the facility.

2) Dry detention basins that will be publicly maintained shall include a paved low flow channel from each inlet pipe or open channel to the basin's outfall. Paved low flow channels are recommended for privately maintained detention facilities. The maintenance plan for dry basins that do not include a paved low flow channel shall describe how the basin will be maintained and drain efficiently. Low flow channels shall be designed per the following requirements:

   a. ***Bottom width*** – minimum width shall be 6 feet (to allow access for maintenance equipment such as a Bobcat),

   b. ***Side slopes*** – shall not be steeper than 4 (H) to 1 (V),

   c. ***Channel slope*** – minimum slope toward the basin outlet shall be 0.5 percent for channels with paved bottoms, and

   d. ***Channel depth*** – minimum depth of channel shall be 1 foot

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

3) The minimum bottom width for dry detention basins, other than the low flow channel, shall be 12 feet to allow for vehicular access for maintenance. The detention basin bottom shall be sloped to drain, and such slopes shall be sufficient to mitigate against "flat spots" developing due to construction errors and soil conditions. The minimum transverse slope for the bottoms of such facilities shall be 2.0 percent.

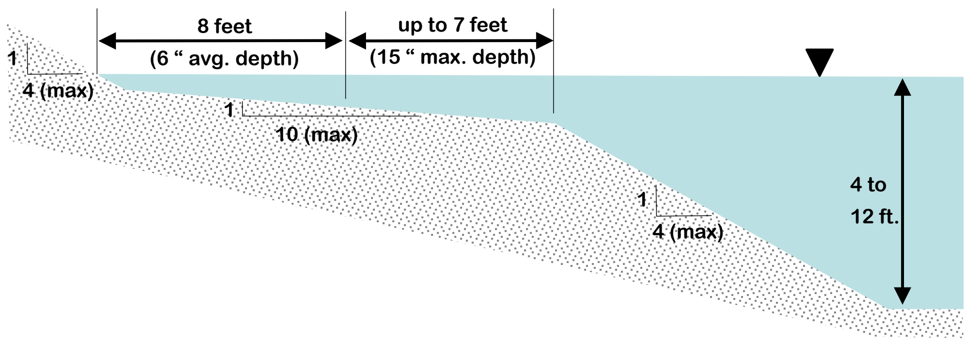
4) Dry detention basins shall be provided with topsoil, and shall be seeded and mulched to prevent erosion (per CMSC Sections 653 and 659). Grasses seeded within the basin should be able to survive 48 hours under water. Jute and Excelsior matting shall be used as required to stabilize slopes and prevent erosion.

3.2.4.3 Additional Layout Requirements for Wet Detention Basins

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

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

2) The perimeter of all permanent pool areas deeper than 4 feet shall be surrounded by an aquatic bench that extends at least 8 feet and no more than 15 feet outward from the normal water edge, as illustrated below. The portion of the aquatic bench within 8 feet of the shoreline shall have an average depth of 6 inches below the permanent pool to promote the growth of aquatic vegetation. The remainder of the aquatic bench shall be no more than 15 inches below the permanent pool to enhance public safety, and to limit growth of dense vegetation in a manner that allows waves and mosquito predators to pass through the vegetation. The maximum slope of the aquatic bench shall be 10 (H) to 1 (V).



3) The designer shall prepare a landscaping plan for the aquatic bench. Plantings along the aquatic bench shall be selected from the shallow water-emergent species in the list of Native Plant Species for Central Ohio, 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.

4) Side slopes for wet basins shall be 4 (H) to 1 (V) from the maintenance berm (see maintenance access requirements Section 4.1.1) down to the aquatic bench, and from the aquatic bench to the bottom of the basin.

5) At a minimum, wet detention basins shall be provided with topsoil, seeded and mulched (per CMSC Sections 653 and 659), in all areas that are above the basin's permanent pool. Appropriate species listed in Appendix B shall be specified in areas along the perimeter of the basin at elevations higher than the permanent pool that are periodically inundated after storms.

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

3.2.5 Parking Lot Storage

Parking lot 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) Runoff from specific graded areas within a parking lot shall be controlled by orifices. The release rate of the flow from a parking lot storage facility shall meet the allowable post-development runoff criteria presented in Section 3.2.2. The outlet device shall be at least a 4-inch diameter single orifice for water quantity control; however, alternative outlet designs (e.g., V-notch weir, perforated) of smaller diameter that are required to fully meet design criteria may be permitted upon submittal of an adequate maintenance plan and County approval.

3) A site with a parking lot storage facility shall employ a separate water quality treatment BMP that meets the water quality treatment criteria presented in Section 3.3. This BMP may be located either downstream of the parking lot or integrated into the medians, landscaping, or other pervious areas of the parking lot.

3.2.6 Underground Storage

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

1) Underground storage facilities shall not be used in instances where the County is to own, operate or maintain the facility.

2) If storage tanks are to be used for a site, a plan for long term maintenance of the facility shall be provided to the County, including a health and safety plan for confined space entry.

3) The release rate of the flow from underground storage facilities shall meet the allowable post-development runoff criteria presented in Section 3.2.2.

4) The minimum size outlet device shall be a 4-inch single orifice for water quantity control. Alternative outlet designs (e.g., V-notch weir, perforated) of smaller diameter may be permitted upon County approval.

5) Air-tight lids shall be used on all access structures, and traps shall be provided on inlet and outlet pipes to limit mosquito access to standing water.

3.2.7 Green Roof Technologies

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

1) Extensive green roofs, illustrated in **Figure 3-1**, typically use drought tolerant roof covers of succulents, grasses and mosses which require little to no maintenance. These roofs are not intended for recreation, are generally less expensive than intensive green roofs, and are typically not designed for public access.

2) Intensive green roofs are typically more elaborately designed roof landscapes, such as roof gardens, that are intended for human interaction and need to be engineered to conform to the additional load requirements for such activities.

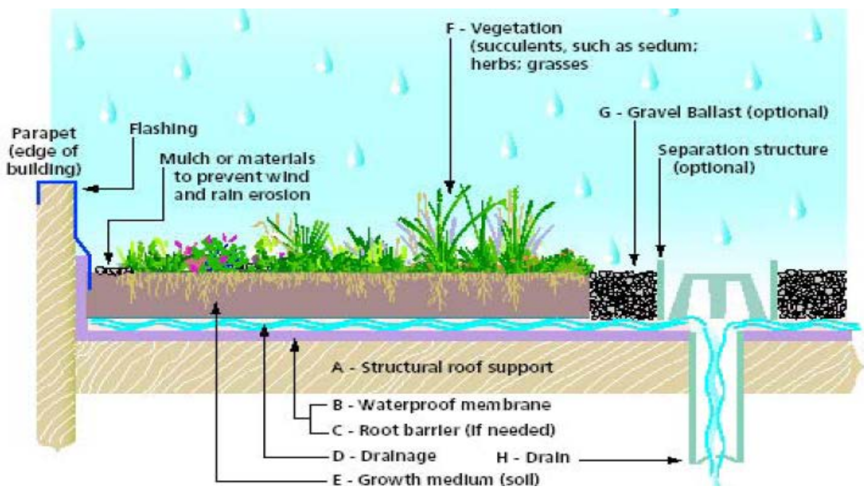


Figure 3-1
Schematic of Typical Extensive Green Roof

3.2.7.1 Design Guidelines and Performance Standards

Developers may use green roof technology on new development and redevelopment projects as a best management practice (BMP) to assist in satisfying the County's stormwater quantity and quality control requirements. The County will accept submittals with green roof components if they are designed to retain at least 50 percent of the average annual precipitation in the Franklin County area (approximately 19 inches per year) and satisfy the design criteria defined in this section. **Table 3-3**[3] presents general guidelines and design criteria that shall be used to design green roof projects in Franklin County. These criteria are based on limited and on-going studies of green roof applications in the Midwestern United States and may be revised as industry-wide design and material standards develop.

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

Table 3-3

Extensive Green Roof System Components

Major Green Roof Component	Design Requirement
Structural roof support (for both existing and new construction)	Adequate to hold an additional 10 – 25 psf (pounds per square foot) of saturated soil weight (in addition to snow load requirements)
Waterproof Membrane (Impermeable Material)	Acceptable material includes modified asphalts (bitumens), synthetic rubber (EPDM), hypolan (CPSE), and reinforced PVC
Protection Boards or Materials	Composed of soft fibrous materials; used to protect the waterproof membrane
Root Barrier (as needed)	Typically required for roofs with modified asphalt waterproof membranes while not required for EPDM and PVC membranes. (Check with waterproof membrane manufacturer to determine if required)
Drainage Layer	Range of acceptable manufactured products from plastic to gravel layers; minimum recommended thickness is 20mm
Growth Medium (Soil)	▪ Medium shall have a minimum depth of 4 inches and shall consist of a blended, lightweight, well-draining, material ▪ Medium blend shall consist of no more than 20% organic material that may include, but is not limited to compost mulch, or peat ▪ Inorganic material shall consist of expanded clay, shale or slate
Vegetation	▪ Drought and extreme-weather (heat, cold, high winds) tolerant ▪ Acceptable vegetation includes plants from the Sedums spp. with the exception of Sedum hybridum 'Immergrauch' ▪ Mature plant growth patterns which cover at least 90% of the overall surface within 2 years
Gravel Ballast (as needed)	Dependent upon operational and structural design issues
Drain	Must safely drain runoff from the roof to an appropriate stormwater conveyance system
Leak Detection	Some companies recommend the incorporation of an electronic leak detection system between or underneath the waterproof membrane to pinpoint the exact location of water leaks. [4]
Minimum Roof Slope	Chapter 15 of the Ohio Building Code provides minimum roof slope criteria for various roof materials. Minimum slopes shall also comply with recommendations provided by the green roof manufacturer.
Maximum Roof Slope	25%

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

3.2.7.2 Maintenance Requirements

While green roofs should be designed to minimize maintenance requirements, some maintenance is necessary to ensure its continued stormwater management performance. **Table 3-4**[5] presents the minimum maintenance requirements that shall be provided for green roof installations. The developer shall include specific requirements in a maintenance plan, as defined in Section 4.

Table 3-4

Green Roof Maintenance Requirements

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

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

3.3 Post Construction Stormwater Quality Controls

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

3.3.1 General Requirements

3.3.1.1 Stormwater Runoff Quality Control

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

1) Appropriate currently effective Ohio EPA's Authorization for Stormwater Discharges Associated with Construction Activity under the National Pollutant Discharge Elimination System (Construction General Permit),
2) supplemental documents prepared by Ohio EPA pertaining to the Construction General Permit Post-Construction criteria, and
3) criteria provided in this section, as well as Section 3.1.

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

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

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

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

3.3.1.2 Illicit Discharge and Illegal Dumping Control

An illicit discharge is any discharge into the storm drainage system that is not composed entirely of stormwater[6]. It is the policy of the County that no person shall:

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

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

3.3.2 Water Quality Volume (WQ_v) Determination

The following formula shall be used to determine the design water quality volume (WQ_v)[7]:

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

where:

WQ_v = water quality volume in acre-feet

C = runoff coefficient appropriate for storms less than 1 inch

P = precipitation depth = 0.75 inch, and

A = drainage area in acres

3.3.2.1 Runoff Coefficients for Water Quality

Runoff coefficients appropriate for the various land uses and single family residential development densities in Franklin County are presented in **Table 3-5**. Runoff coefficients for land uses not included in **Table 3-5** may be determined using the following equation[8]:

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

where:

i = percent of the drainage area that is impervious

Detailed criteria for using the WQ_v to design each accepted type of stormwater quality control facility is found in subsequent sections of the Manual.

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

[7] Ohio Environmental Protection Agency, Authorization for Stormwater Discharges Associated with Construction Activity Under the National Pollutant Discharge Elimination System.

[8] ASCE/WEF, "Urban Runoff Quality Management", 1997.

3.3.2.2 Minimum Drawdown Requirements

With the exception of swales and proprietary flow-through devices, stormwater quality controls proposed for new development and redevelopment projects that disturb one (1) acre or more, shall meet the minimum drawdown times specified in Sections 3.3.4 and 3.3.5. The minimum drawdown times provided in Section 3.3.6.3 are applicable where vegetated swales are proposed to provide runoff treatment for projects that disturb five (5) acres or more. For vegetated swales, filter strips, or proprietary flow-through devices intended to serve project sites that disturb less than five (5) acres, the water quality flow (WQ_f) criteria presented below may be used to size these facilities.

Table 3-5
Runoff Coefficients for Determining WQv

Land Use	Runoff Coefficient for WQv
Commercial/Business and Industrial	0.8
Multi-family	0.6
1/12 – 1/8 acre lots	0.6
1/8 acre lots	0.5
1/4 acre lots	0.4
1/2 acre lots	0.3
Undeveloped	0.2

3.3.2.3 Water Quality Flow (WQF) Determination

Vegetated swales, filter strips, and proprietary flow-through devices shall be designed to treat the entire WQ_v from the tributary area. Since treatment occurs as stormwater "flows through" these facilities, it is necessary to develop a design peak flow for the WQ_V representative of flow conditions that maximize treatment and retard flow. The following procedure shall be used to develop the design peak water quality flow:

1) Determine the time of concentration for the area draining into the swale, using the methodology in Section 2.2.2.2.
2) Define the peak intensity of the design storm producing the WQ_v using the intensity-duration-frequency curve for Central Ohio (Figure 2-1). For example, a drainage basin with a time of concentration of 10 minutes would have a peak rainfall intensity of approximately 1.5 inches/hour.
3) Use the rational method (Section 2.2.3.1) and the runoff coefficients (Section 3.3.2.1) to determine the peak flow rate through the swale.

3.3.3 Stormwater Quality Control – Acceptable Methods and Criteria

Four general categories of stormwater quality control facilities have been approved for use in the unincorporated area of Franklin County:

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

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

Table 3-6

Major Selection Criteria for Stormwater Quality Controls

Criteria	Group 1: Stormwater Basins	Group 2: Media Filters	Group 3: Vegetated Swales and Filter Strips	Group 4: Controls for Commercial Activity Areas
Drainage Area	> 10 ac	<5 ac	<5 ac	<5 ac
Land Required	2-3%	> 5%	> 5%	Varies
Cold Weather Issues	▪ Impacts of Pavement Deicers	▪ Impacts of Pavement Deicers ▪ Clogging from Icing	▪ Impacts of Pavement Deicers	▪ Clogging from Icing
Locational Conflicts	▪ Separation from buildings and sanitary sewers	▪ Separation from buildings and sanitary sewers ▪ Minimum elevation difference across filter	▪ Requires mild slopes	▪ Varies
Mosquito and Vector Control Issues	▪ Excessive aquatic vegetation ▪ Habitat for mosquito predator species	▪ Media clogging causes stagnant water	▪ Zero slopes, rutting, impermeable soils causing standing water	▪ Sediment debris buildup causes stagnant water
Pollutant Removal	▪ Meets Ohio EPA Criteria for New Development	▪ Meets Ohio EPA Criteria for New Development	▪ Meets Ohio EPA Criteria for New Development	▪ Pretreatment for Commercial Activity Areas

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

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

2) ***Hydraulics*** —Design the facility with an outlet to control release rates and prevent clogging, provide storage for intense rain events, and install an observable high-flow bypass.

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

4) ***Health & Safety*** — Design facilities containing a permanent pool with a healthy aquatic habitat for mosquito control and an aquatic bench with a maximum slope of 10 (H) to 1 (V) to increase public safety.

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

6) ***Maintainability*** — Design the facility to minimize the amount and frequency of maintenance, to ease required maintenance activities, and to eliminate emergency / extraordinary maintenance requirements. Design criteria in the Manual are intended to facilitate maintenance, are required for facilities that will be maintained by the County, and are recommended for other facilities. If a design is proposed that does not include some or all of these features, the maintenance plan shall explain how maintenance activities shall be performed.

7) ***Accessibility*** — Design the facility to eliminate physical barriers (e.g., curbs and steep slopes) to entry for maintenance or emergency access, use strong, lightweight, 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.

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

9) ***Separation from buildings and sanitary sewers*** — Keep water quality controls that allow infiltration of runoff into the ground away from buildings, sanitary sewers, and building laterals to minimize infiltration/inflow into sanitary sewers.

10) ***Cold Weather Issues*** — Stormwater quality control facilities shall be designed to operate effectively under cold weather conditions. Design considerations include use of outlets that will not clog when frozen, additional pre-treatment and/or sediment storage/disposal in areas where sand or other solids are used for pavement deicing, and salt-tolerant plants in controls that incorporate vegetation.

11) ***Mosquito and Vector Control*** — Design criteria are included in the Manual that minimize conditions causing mosquito breeding without significantly compromising the effectiveness of controls that rely upon permanent pools of water and vegetation. The following guiding principles apply:

a. Areas of facilities outside the permanent pool shall be designed to drain completely toward the outlet or permanent pool within 72 hours of a precipitation event. Small depressions in paved, rip-rap, and/or vegetated areas shall not be allowed, and shall be eliminated if they form.

b. Wet detention basins and wetlands shall be designed to maximize habitats that promote colonization of the facility by mosquito predators (i.e., dragonflies, diving beetles, and mosquito fish). These facilities shall also incorporate large areas of open water to allow waves to propagate through vegetated areas, drowning mosquito larvae.

c. Underground and enclosed vaults containing certain stormwater quality controls are particularly susceptible to mosquito breeding. Facilities not intended to include a permanent pool of water shall be designed to drain without allowing standing water to remain, and shall not permit any trapped debris or sediment to create standing water. Air-tight lids shall be used on all access structures, and traps shall be provided on inlet and outlet pipes to limit mosquito access to standing water.

d. The maintenance plan for the facility shall address mosquito monitoring and control activities, including periodic harvesting of aquatic vegetation, removal of invasive/exotic and/or emigrant vegetation, removal of trash, debris sediment accumulation, and cleaning/rejuvenation of media filters.

3.3.4 Group 1 – Stormwater Basins

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

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

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

At a minimum, all stormwater basins shall be designed according to the general criteria in Sections 3.1 and 3.2.4.1. Additional design requirements are specified in the following sections. **Table 3-7** summarizes the major design criteria for the three types of stormwater basins. Major differences in design criteria are the required facility size, the use of permanent pools, and the required drawdown time for a basin at design capacity. If a dam or spillway is part of the basin's design, the design and construction of the basin are required to follow Ohio law pertaining to dam design (Section 1521 of the Ohio Revised Code and Chapter 1501:21 of the Ohio Administrative Code) and safety requirements.

Table 3-7

Major Design Criteria for Stormwater Basins

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

[1] Facility volumes should be increased 20 percent for sediment storage.
[2] Equals 0.10(WQv).
[3] Equals twice the 30-day summertime evaporation rate or 0.75 WQv, whichever is greater.

3.3.4.1 Extended Dry Detention Basins

Extended dry detention basins are designed to capture stormwater during small to moderate rain events and slowly release the captured volume over a specified period of time. **Figure 3-2** provides a schematic drawing of an of extended dry detention basin The following criteria shall be used to design extended dry detention basins intended to serve as water quality BMPs.

General Criteria

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

1) The general criteria for stormwater controls in Section 3.1,

2) The general criteria for stormwater detention basins in Section 3.2.4.1,

3) The criteria for dry stormwater quantity control detention basins in Section 3.2.4.2, and

4) Specific criteria in this section.

Hydrology Requirements

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

Layout and Geometry Requirements

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

1) The recommended minimum drainage area of ten acres is proposed to avoid outlets with extremely small orifices prone to clogging. Alternative stormwater quality control facilities specified in the Manual are generally preferred for drainage areas smaller than ten acres.

2) Additional storage equal to at least twenty percent of the WQ_v shall be provided within the basin to account for sediment deposition. Ten percent of the storage volume shall be placed in the micropool surrounding the outlet control structure of the basin. The remaining ten percent of the storage volume shall be provided in the basin forebay.

3) The minimum length-to-width ratio for extended dry detention basins shall be 2:1. Where site conditions allow, basins should be wedge-shaped, narrowest at the inlet and widest at the outlet to achieve the required length-to-width ratio. Where site conditions do not allow this configuration, the length-to-width ratio shall be increased by relocating the basin inlet or outlet where possible, or by installing berms or baffles within the basin to the full depth of the WQ_v to avoid short-circuiting and to increase travel time to the outlet.

4) If water quantity control is provided by parking lot storage, the WQ_v shall not extend onto paved surfaces.

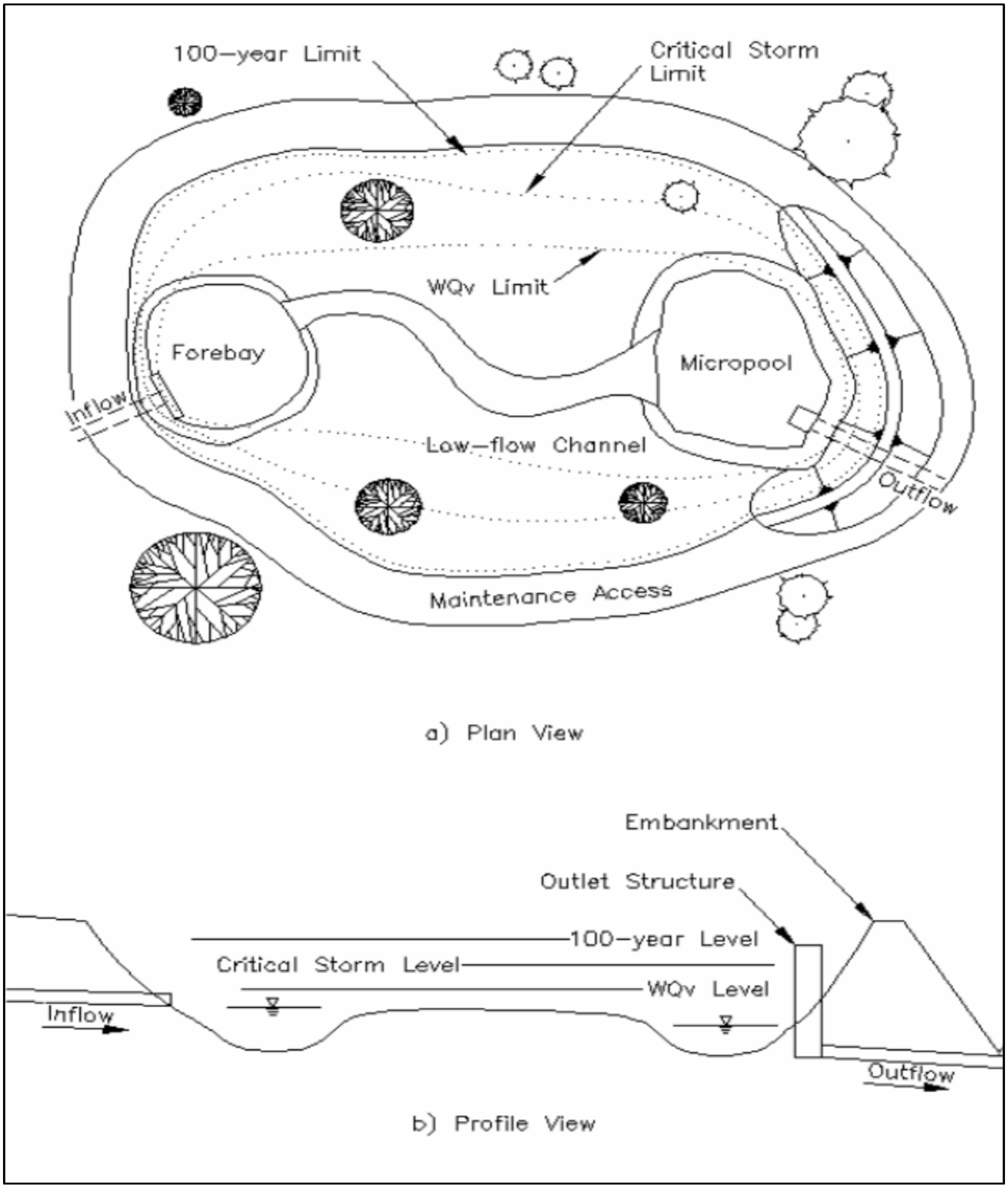


Figure 3-2

Schematic of an Extended Dry Detention Basin

Pretreatment Requirements

A forebay or other pretreatment feature shall be provided at all inlets of extended dry detention basins. Basin forebays shall be designed to meet the following minimum requirements:

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

Outlet Facility and Outfall Protection Requirements

Outlet designs shall provide the necessary drawdown time, route flood flows, resist clogging, and facilitate maintenance. The outlet designs for extended wet detention basins may be used (see Section 3.3.4.2 and **Figure 3-3** for design criteria) for extended dry detention basins with micropools. The following criteria shall be used to design outlet facilities and outfall protection:

1) The outlet shall be designed to release no more than 50 percent of the WQ_v in 16 hours, and 100 percent of the WQ_v in 48 – 60 hours.
2) A micropool shall be provided at the outlet end of the basin. Basin micropools shall be sized at no less than 10 percent of the WQv. The storage volume provided within the micropool will not count toward the total WQv requirement. 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).

3) 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

4) Single orifice outlets with diameters of at least 4 inches may be used as the water quality outlet for extended dry detention basins. To prevent clogging, the County will not allow using a single orifice4 outlet that is less than 4 inches in diameter unless the designer presents sufficient information proving that the orifice will not clog. Alternative outlet designs (e.g. V-notch weir, perforated) of smaller orifice diameter may be permitted upon County approval if acceptable design practice is proven for site conditions. Alternative orifice designs shall also include appropriately aggressive operation and maintenance plans.

5) The principal spillway for flows in excess of the WQ_v shall be designed according to criteria in Section 3.2 and equipped with a removable trash rack.

6) Extended dry detention basins that are intended to serve as a stormwater quality control only, must be designed to safely bypass all storms larger than the WQ_v, up to and including the 100-year storm event (Section 2.2) to an appropriately sized stormwater quantity control facility.

3.3.4.2 Extended Wet Detention Basins

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

General Criteria

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

1) The general criteria for stormwater controls in Section 3.1,

2) The general criteria for stormwater detention basins in Section 3.2.4.1,

3) The criteria for wet stormwater quantity control detention basins in Section 3.2.4.3, and

4) Specific criteria in this section.

Hydrology Requirements

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

1) This volume shall be split, with approximately 75 percent of the WQ_v placed in the permanent pool, and 75 percent of the WQ_v placed in the extended detention volume overlaying the permanent pool.

2) If a stormwater quality control basin is incorporated within a stormwater quantity control basin, the entire stormwater quantity design storm, as defined in Section 3.2, shall be routed through the stormwater quality portion of the basin when sizing the facility.

Layout and Geometry Requirements

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

1) The recommended minimum drainage area of 20 acres is proposed to avoid basins where the permanent pool partially or completely evaporates during dry weather conditions. Alternative facilities specified in the Manual are generally preferred for drainage areas smaller than 20 acres.

2) Extended wet detention basins shall only be allowed under the following conditions:

   a. Where existing soils are categorized as hydrologic soil group C (HSG-C) or hydrologic soil group D (HSG-D),

   b. Where gravelly sands or fractured bedrock are not present, or

   c. Where a liner is installed to sustain the permanent pool of water thereby avoiding basins where the permanent pool partially or completely infiltrates into the ground.

3) The minimum length-to-width ratio for extended wet detention basins shall be 2 (L) to 1 (W). Where site conditions allow, basins should be wedge-shaped, narrowest at the inlet and widest at the outlet to achieve the required length-to-width ratio. Where site conditions do not allow this configuration, the length-to-width ratio shall be increased by relocating the basin inlet or outlet where possible, or by installing berms or baffles within the basin to the full depth of the WQ_v to avoid short-circuiting and to increase travel time to the outlet.

4) The depths of open water areas within the basin shall be between 4-feet and 12-feet on average to prevent thermal stratification. The perimeter of all deep pool areas (four feet or greater in depth) shall be surrounded by an aquatic bench meeting the design criteria in Section 3.2.4.3.

5) Wherever possible, wetland plants shall be incorporated into the basin design. A landscaping plan for the basin shall be prepared to indicate how aquatic and terrestrial areas will be established with vegetation. A list of recommended Native Plant Species for the Central Ohio area is provided in Appendix B**.**

6) Additional storage equal to at least 20 percent of the WQ_v shall be provided within the basin to account for sediment deposition.

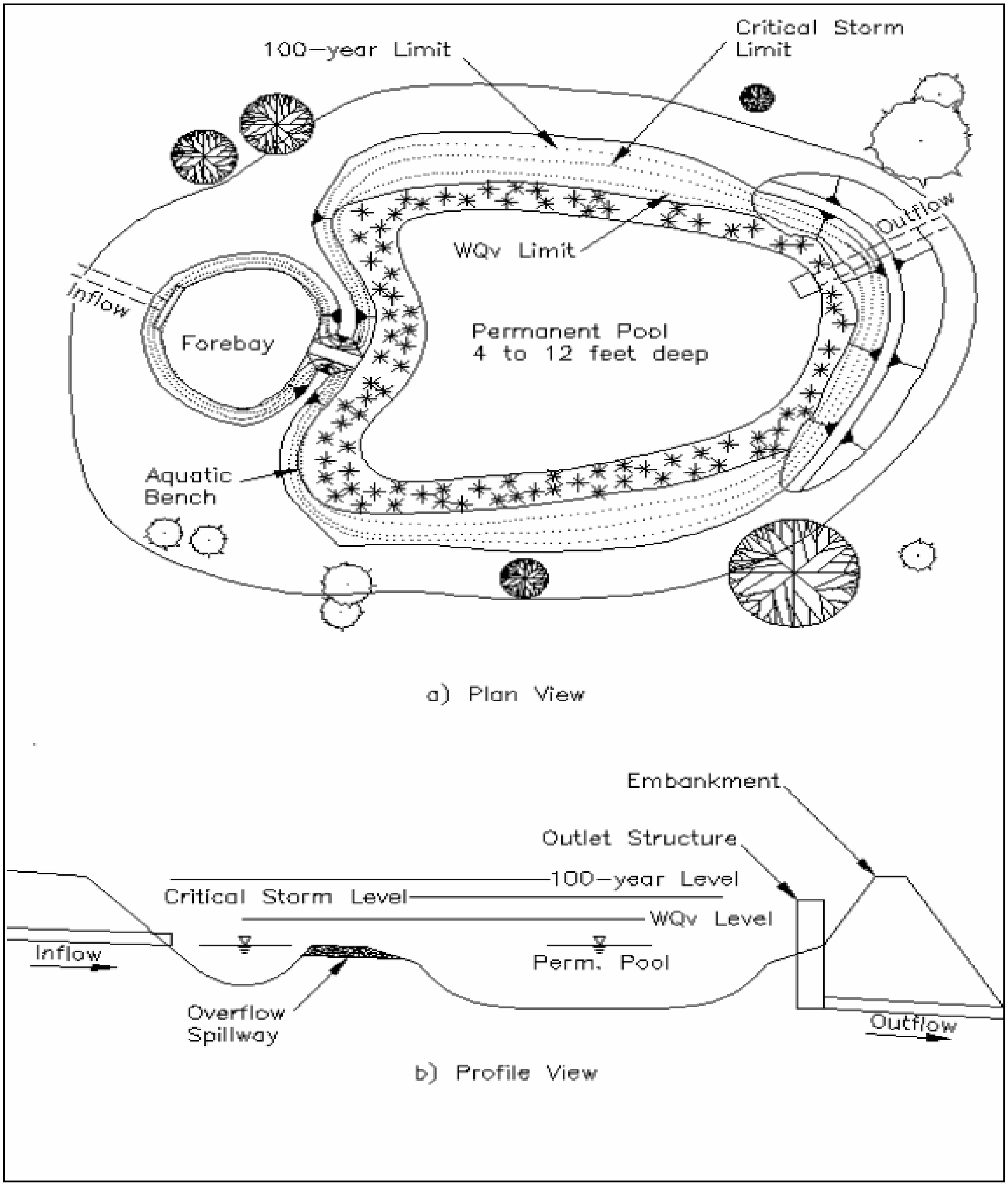


Figure 3-3

Schematic of an Extended Wet Detention Basin

Pretreatment

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

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

Outlet Facility and Outfall Protection Requirements

Outlet designs shall provide extended drawdown time, route flood flows, resist clogging, and facilitate maintenance. **Figure 3-4** illustrates accepted outlets for extended wet detention basins and extended dry detention basins with micropools. Regardless of the design drawdown time, the outlet shall be designed according to the following criteria:

1) The outlet shall be designed to release no more than 50 percent of the WQ_v in 8 hours and 100 percent of the WQ_v in approximately 24 hours.
2) The principal spillway for flows in excess of the WQ_v shall be designed according to criteria in Section 3.2 and equipped with a removable trash rack.
3) Extended detention basins that are intended to serve as a water quality BMP only, must be designed to safely bypass all storms up to and including the 100-year storm event to an appropriately sized flood control facility.

4) To prevent clogging, the County will not allow using a single orifice outlet that is less than 4 inches in diameter unless the designer presents sufficient information proving that the orifice will not clog. Alternative outlet designs (e.g., V-notch weir, perforated) of smaller orifice diameter may be permitted upon County approval if acceptable design practice is proven for site conditions. Alternative orifice designs shall also include appropriately aggressive operation and maintenance plans.

5) 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.

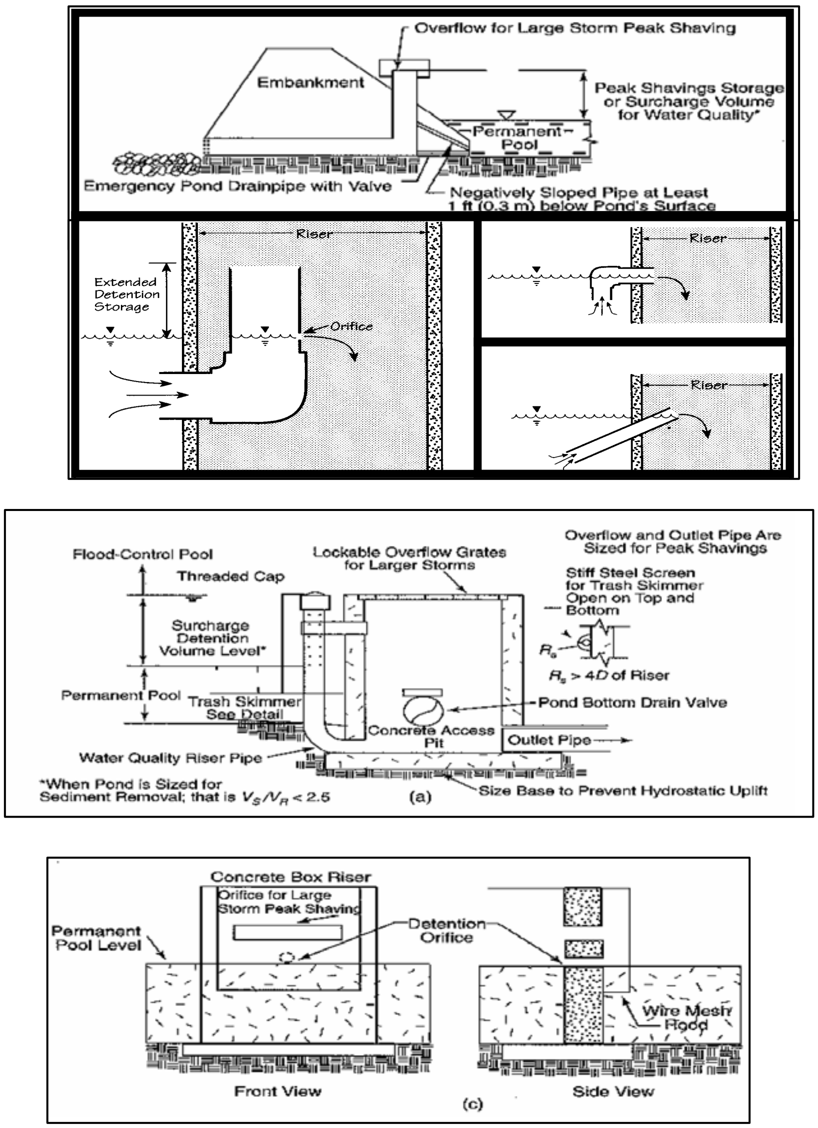


Figure 3-4

Accepted Outlet Designs for Extended Wet Detention Basins and Micropools within Extended Dry Detention Basins

3.3.4.3 Constructed Wetlands

Similar in design to wet basins, constructed wetlands treat stormwater by providing an extended detention zone (above shallow permanent pools) sized to capture and release the calculated WQ_v. Constructed wetlands, illustrated in **Figure 3-5**, are depressed, heavily planted areas that are designed to receive flow during dry periods in order to support aquatic vegetation. 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 are defined as pocket wetlands. Pocket wetlands must rely on groundwater as an alternative source to sustain a permanent pool. The following criteria shall apply to the design of constructed wetlands.

General Criteria

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

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

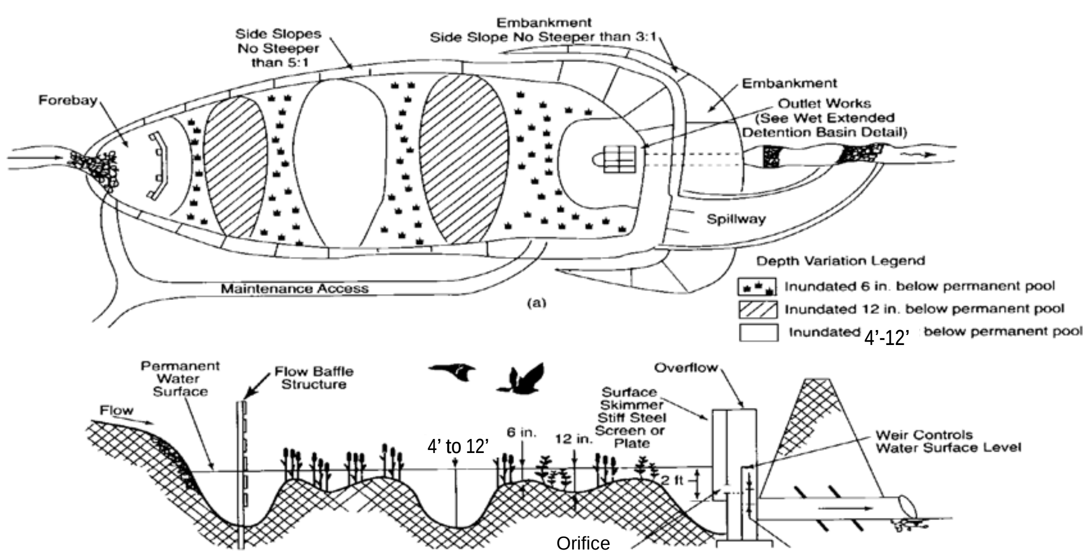


Figure 3-5
Schematic of a Typical Stormwater Wetland

Layout and Geometry Requirements

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

1) The recommended minimum drainage area of 20 acres is proposed to avoid wetlands where the permanent pool completely evaporates during dry weather conditions. Pocket wetlands may be used to treat drainage areas smaller than 20 acres; however, a constant permanent pool must be provided by placing the bottom of the pocket wetland below the groundwater table. Applicants must demonstrate that sufficient groundwater elevation exists to support a pocket wetland system.

2) Constructed wetlands shall only be allowed where soils categorized by the NRCS as HSG-C or HSG-D exist, where gravelly sands or fractured bedrock are not present, or where a liner is installed to sustain the permanent pool of water and avoid permanent pools that partially or completely infiltrate into the ground. This requirement does not apply to pocket wetlands where the permanent pool is sustained by a groundwater source.

3) The permanent pool of any constructed wetlands 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 permanent pool of pocket wetlands shall be at least two times the volume of evapotranspiration during a thirty day drought at summer evaporation rates or the WQv, whichever is greater. In cases where subsurface infiltration into and exfiltration out of the wetland are negligible, the summer evapotranspiration rates may be estimated[9] as 0.75 times the pan evaporation rate of 0.2 inches/day reported for Franklin County during June, July and August[10]. **Appendix D** provides an example water balance calculation.

4) An extended detention volume equal to the WQ_v shall be provided above the permanent pool of all constructed wetlands. The outlet structure shall be designed to release 50 percent of the WQ_v in 8 hours and 100 percent of the WQ_v in 24 hours.

5) The minimum length-to-width ratio for a constructed wetland shall be 2:1. Where site conditions allow, basins should be wedge-shaped, narrowest at the inlet and widest at the outlet, to achieve the required length-to-width ratio. Where site conditions do not allow this configuration, the length-to-width ratio shall be increased by relocating the basin inlet or outlet where possible, or by installing berms or baffles within the basin to the full depth of the WQ_v to avoid short-circuiting and to increase travel time to the outlet.

6) 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 3.2.4.1.

7) With the exception of 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

[9] Kadlec, Robert and Robert Knight, *Treatment Wetlands,* CRC Lewis Publishers, 1996, pp. 184-185.
[10] National Oceanographic and Atmospheric Administration, Mean Monthly, Seasonal, and Annual Pan Evaporation for the United States, NOAA Technical Report NWS 34, Washington DC, 1982.

the WQ_v, shall be placed in deep water zones (areas with depths between 4- and 12-feet) to sustain fish communities and provide wave action to control mosquito populations. At a minimum, deep water zones shall be placed within the forebay and around the primary outlet to minimize disruption of wetland vegetation during sediment removal operations. The remainder of the facility shall consist of shallow water zones. Dry weather depths in shallow water zones (i.e. areas less than 18 inches deep) should vary depending on the vegetation selected. Permanent pool depths shall be 6 inches or less within at least 35 percent of the shallow water zone.

For pocket wetlands requiring a permanent pool volume equivalent to the WQ_v, approximately 25 percent of the permanent pool volume, plus a sediment storage volume equal to at least 20 percent of the permanent pool volume,, shall be placed in deep water zones (areas with depths between 4 and 12 feet). As with larger wetlands, the deep water zones shall be place within 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) should vary depending on the vegetation selected. Permanent pool depths shall be 6 inches or less within at least 35 percent of the shallow water zone.

8) The bottom of the permanent pool between the deep and shallow water zones shall be sloped no steeper than 4 (H) to 1 (V).

9) The maximum depth of the extended detention zone above the permanent pool shall not exceed 2 feet to reduce stress on herbaceous wetland plants.

10) Permanent pool areas of wetlands that are deeper than 4 feet must be provided with an aquatic bench per Section 3.2.4.3.

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

Pretreatment

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

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

Landscape Requirements

1) A landscaping plan shall be provided that indicates the methods used to establish and maintain wetland coverage. Minimum elements of a plan include: delineation of landscaping zones, selection of appropriate plant species, planting plan, sequence for preparing the wetland bed (including soil amendments, if needed), and sources of plant material. The width of the vegetation zones and amount of emergent vegetation shall be limited to no more than 50 percent of the wetland area in order to control mosquitoes.
2) If a minimum vegetative coverage of 50 percent is not achieved in the planted wetland zones after the second growing season, a reinforcement planting will be required.
3) All landscaping and reinforcement plans shall be signed by a registered engineer or registered landscape architect, with direction provided by an experienced wetland scientist.

Outlet Facility and Outfall Protection Requirements

The outlet design requirements provided in Section 3.3.4.2 for extended wet detention basins shall apply to 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.

3.3.5 Group 2 – Media Filters

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

1) Bioretention Facility

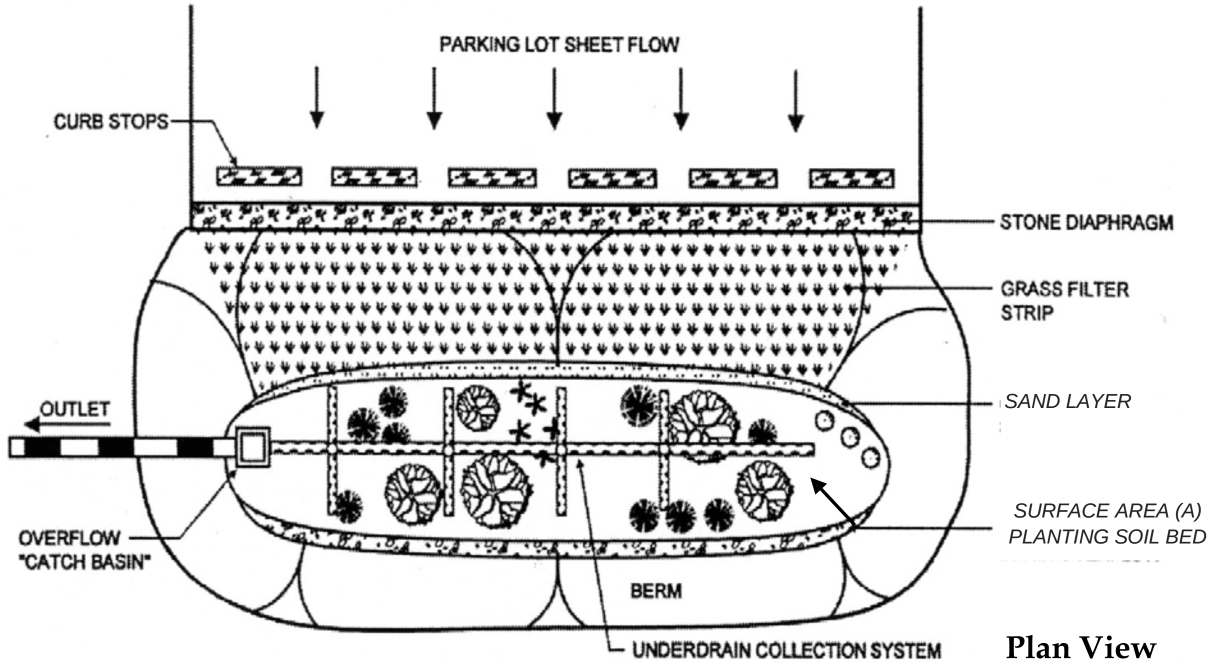
2) Sand Filter

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

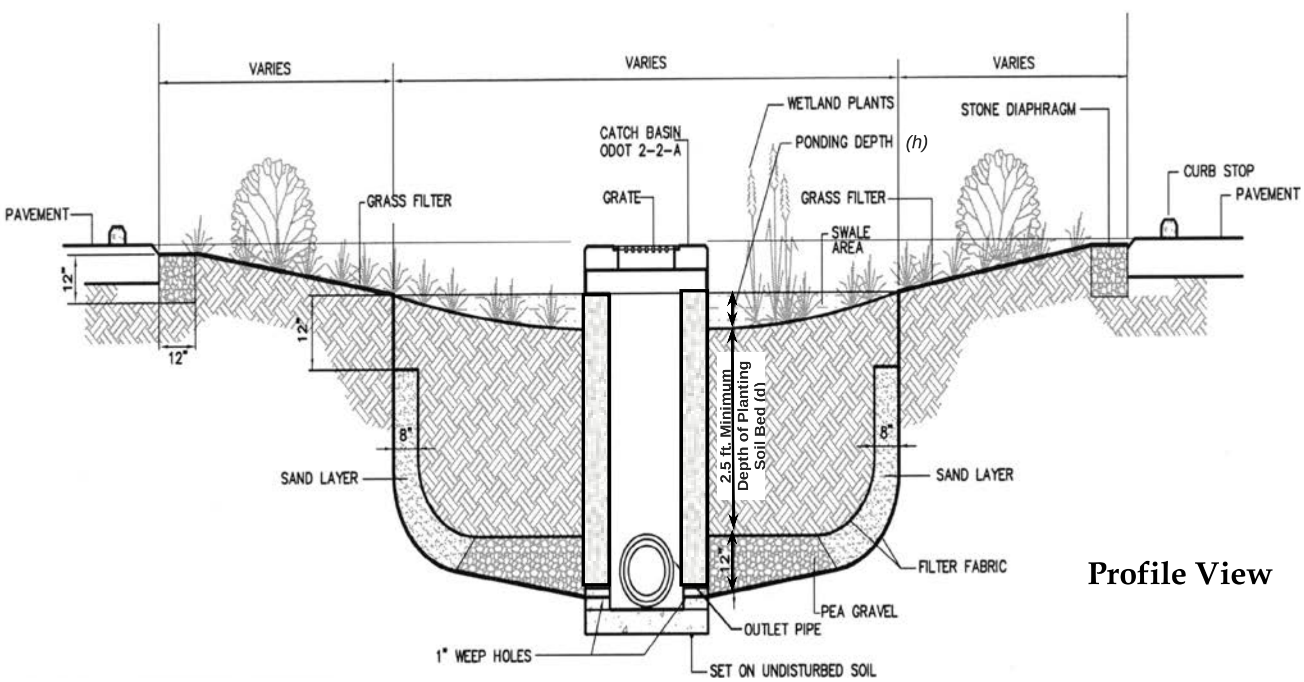
3.3.5.1 Bioretention Facilities

A bioretention system consists of a soil bed planted with native vegetation located above an underdrained gravel layer. Stormwater runoff entering the bioretention system is filtered first through the vegetation and then the soil bed before being conveyed downstream through the underdrain system, slowing the runoff velocity and treating stormwater runoff by absorption, decomposition, and filtration[11]. Bioretention facilities are often sited adjacent to and used to treat runoff from paved surfaces such as parking lots. Sites utilizing bioretention facilities for water quality control must also meet the stormwater quantity control requirements of Section 3.2. Stormwater quantity controls may either be integrated into the bioretention system or provided in a separate downstream facility. A schematic of a bioretention facility is shown in **Figure 3-6.**

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



Plan View



Profile View

Figure 3-6
Schematic of a Typical Bioretention Facility

Hydrology Requirements

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

Layout and Geometry Requirements

1) The recommended maximum total drainage area of a bioretention facility is 5 acres, with drainage areas of one acre or less preferred in order to maximize sheet flow into the facility and to minimize ponding depth.

2) Bioretention systems may be constructed on-line or off-line. On-line systems receive runoff from all storms, providing treatment of the WQ_v, with runoff from larger storms conveyed and/or stored within the bioretention system and discharged through an overflow. In off-line bioretention systems, most of the runoff from storms larger than the WQ_v bypasses the system through an upstream diversion and is directed toward a stormwater quantity control device designed according to criteria in Section 3.2.

3) Bioretention facilities shall not be allowed in areas where the water table or bedrock is above the invert of the underdrain system.

4) In order to maximize treatment effectiveness, the site must be graded in such a way that minimizes erosion as sheet flow is conveyed to the treatment area.

5) Runoff from the tributary area of the bioretention facility shall be directed into a swale or other storage area sized to contain the entire WQ_v. This swale shall partially or completely overlay the bioretention facility, as long as the maximum depth of water over the filtering media is no more than 12 inches. Water shall not cover the media longer than 72 hours after a precipitation event.

6) The surface area of the bioretention soil bed shall be determined based on the following equation:

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

Where:

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

7) The minimum dimensions of the bioretention facility shall be 15 feet wide by 40 feet long, with facility widths of 25 feet preferred. These width criteria are established to allow enough space for a dense, randomly-distributed area of trees and shrubs to become established, enabling the bioretention area to tolerate the effects of heat stress, acid rain, runoff pollutants, and insect and disease infestations.

8) The side slopes for bioretention facilities shall not exceed 4 (H) to 1 (V).

Planting Soil (Filter Media) Requirements

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

1) The planting soil for bioretention facilities shall consist of a mixture of sand, topsoil, and compost with a pH range of 5.5 and 6.5, a range where pollutants such as organic nitrogen and phosphorus can be adsorbed by the soil and microbial activity can flourish. In addition, the soil shall have infiltration rates no less than 0.5 inches per hour, achieved through the following standards[12]:

    a. 4 parts sand (per CMSC 703.06),

    b. 2 parts topsoil (per CMSC 653.02), and

    c. 2 parts compost (per ODOT CMSC 659.06). Note: Com-Til Compost from the City of Columbus's DOSD's Compost Facility is acceptable for use in bioretention facilities.

    Additional recommendations for the planting soil include a 1.5 to 3 percent organic content and a maximum 500 ppm concentration of soluble salts[13].

2) If the existing soil does not meet the above characteristics, then it shall either be adjusted to meet the criteria or removed and replaced with an acceptable planting soil. Soil tests shall be performed for every 500 cubic yards of planting soil, with the exception of pH and organic content tests, which are required only once per bioretention area.

3) To prevent root intrusion into the underdrain system, the depth of the planting soil shall be no shallower than the root zone of the vegetation planted in the bioretention cell. The minimum depth shall be 2.5 feet. In addition, the depth shall be at least 4 inches below the largest root ball.

4) Planting soil depths of greater than 4 feet may require additional construction practices such as shoring measures. Planting soil shall be placed in 18 inches or greater lifts and lightly compacted until the desired depth is reached.

5) An 8-inch thick sand layer shall be placed along the sides of the trench, starting 12 inches below the final grade level and extending to the gravel layer in the bottom of the trench. The sand shall comply with CMSC 703.06, and shall be surrounded with a filter fabric.

[12] ODOT, "Location and Design Manual, Volume 2, Drainage Design", Section 1116.7
[13] California BMP Handbook (Section 5-7, TC-32)

6) Bioretention facilities shall be planted with a mixture of grass and other hardy, vegetation that can withstand prolonged periods in a wet environment, and be tolerant to road salts if receiving runoff from areas to be treated with deicing materials. Vegetation shall be selected from the list of Native Plant Species for Central Ohio is provided in Appendix B. Vegetation may include a mix of grasses and woody species, or may include woody species only with bare ground covered with mulch. Approximately one tree or shrub per 50 ft^2 (or 1000 per acre) of bioretention area should be included. It is recommended that three species each of both trees and shrubs are planted. Trees with high branching or open habits of growth are recommended to avoid shading and loss of grass cover. Since high canopy trees may be destroyed during maintenance the bioretention area should be vegetated to resemble a terrestrial forest community ecosystem that is dominated by understory trees. The shrub-to-tree ratio shall be 2:1 to 3:1.

7) A mulching layer 2 to 3 inches thick shall be provided above the planting soil when grass is not used, and shall be composed of shredded hardwood material to avoid floating. Mulch plays an important role in the bioretention facility. It helps maintain soil moisture, prevents erosion and helps to trap finer sediments.

Underdrain and Outlet Requirements

1) A perforated pipe underdrain shall be provided beneath the planting soil. The underdrain shall have a minimum grade of 0.5 percent. The perforated pipe shall have a diameter of 4 or 6 inches and shall meet the requirements of CMSC Section 720.07 or 720.12. A granular backfill of durable No. 57 aggregate, in accordance with CMSC Section 703.01, shall be provided up to a minimum of 4 inches above the outside diameter of the pipe.

2) An overflow designed to convey all storms up to and including the 100-year event shall be provided. Use of a vertical stand pipe or catch basin is recommended. For on-line facilities, this overflow may be designed to achieve the water quantity control criteria specified in Section 3.2.

Pretreatment

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

3.3.5.2 Sand Filters

Stormwater sand filters are usually two-chambered facilities that include a pretreatment settling basin and a filter bed filled with sand or other absorptive filtering media. As stormwater flows into the first chamber, large particles settle out, and then finer particles and other pollutants are removed as stormwater flows through the filtering media in the second chamber. The two most common examples of sand filters used in the United States are the Austin Sand Filter[14] (**Figure 3-7**) and the Delaware Sand Filter[15] (**Figure 3-8**). The Austin sand filtration system is built at grade and is most commonly used for larger drainage areas that have both impervious and pervious surfaces. Delaware Sand Filter Systems are installed underground, and thus are most commonly used for highly impervious areas where land available for structural controls is limited.

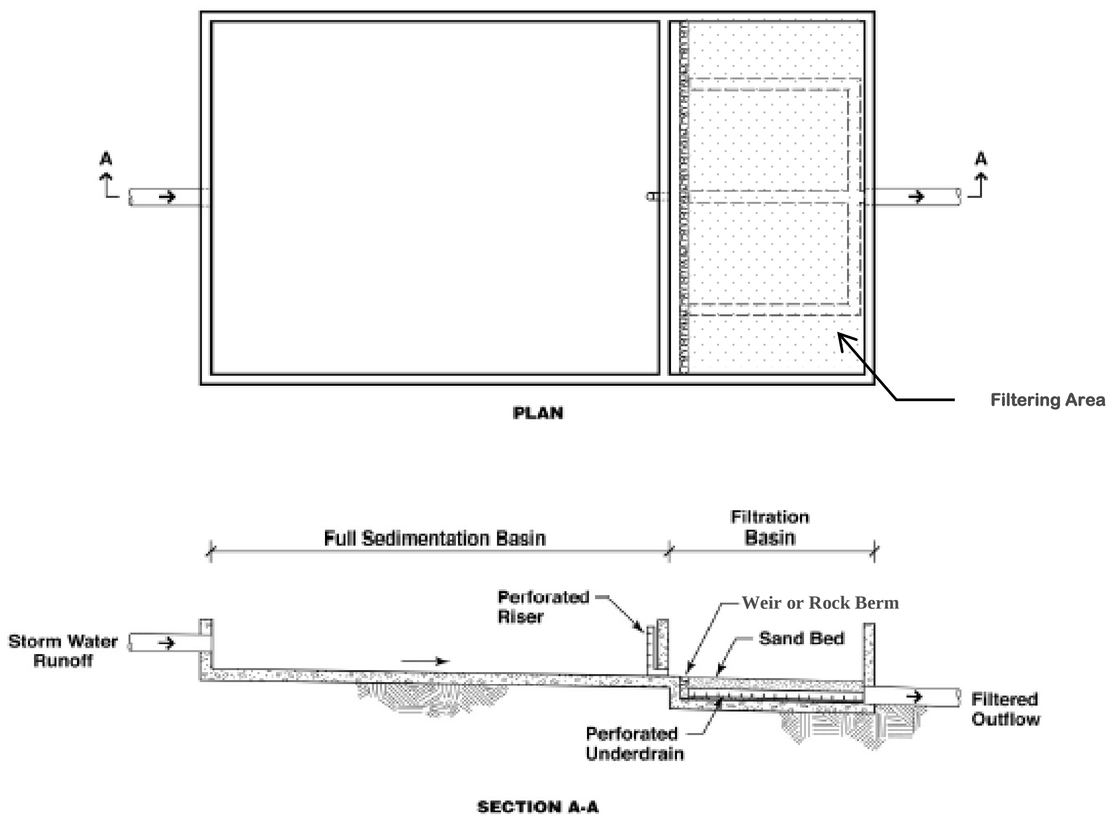


Figure 3-7

Schematic Representation of an Austin Sand Filter

[14] City of Austin, TX. "Design of Water Quality Controls". 1996.
[15] Young, G.K., et al., "Evaluation and Management of Highway Runoff Water Quality", Publication No. FHWA-PD-96-032, U.S. Department of Transportation, Federal Highway Administration, Office of Environment and Planning, 1996.

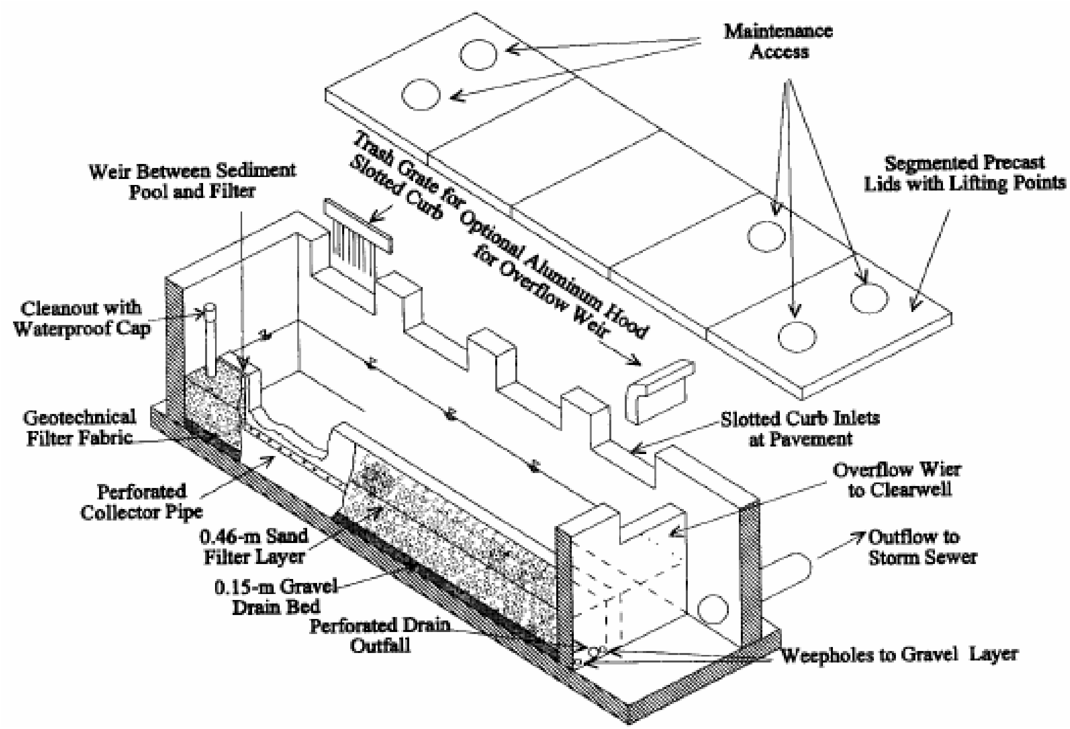


Figure 3-8

Schematic Representation of a Delaware Sand Filter

Hydrology Requirements

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

Layout and Geometry Requirements

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

Filter Media Requirements

1) The filter bed shall be sized to discharge the capture volume over a period of 40 hours using Darcy's Law, which relates the velocity of fluids to the hydraulic head and the coefficient of permeability of a medium[16]. The resulting equation, as derived by the City of Austin, Texas, (1996), is:

$$A_f = WQ_V\, d/[k\, t\, (h+d)]$$

where:

A_f = area of the filter bed (ft^2)

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

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

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

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

2) The sand filter shall be constructed with 18 inches of sand (CMSC 703.02(A)) overlying 6 inches of gravel (CMSC 703.04(A)). The sand and gravel media shall be separated by permeable geotextile fabric (CMSC 712.09, Type A), and the gravel layer shall be placed on geotextile fabric. Four-inch perforated PVC pipe (CMSC 720.07) shall be used to drain captured flows from the gravel layer. A minimum of 2 inches of gravel must cover the top surface of the PVC pipe. **Figure 3-9** presents a schematic representation of a standard sand bed profile.

3) The sand grain size distribution shall be comparable to that of "washed concrete sand," as specified for fine aggregate in CMSC 703.02(A).

Underdrain and Outlet Requirements

1) In an Austin filter, the underdrain piping shall consist of a main collector pipe and two or more lateral branch pipes, each with a minimum diameter of 4 inches. The pipes shall have a minimum slope of 1% (1/8 inch per foot) and the laterals shall be spaced at intervals of no more than 10 feet. There shall be no fewer than two lateral branch pipes.

2) All piping shall be Schedule 40 PVC per CMSC 720.07.

3) The maximum spacing between rows of perforations shall not exceed 6 inches.

4) Each individual underdrain pipe shall have a cleanout access location.

[16] City of Austin, TX. "Design of Water Quality Controls". 1996.

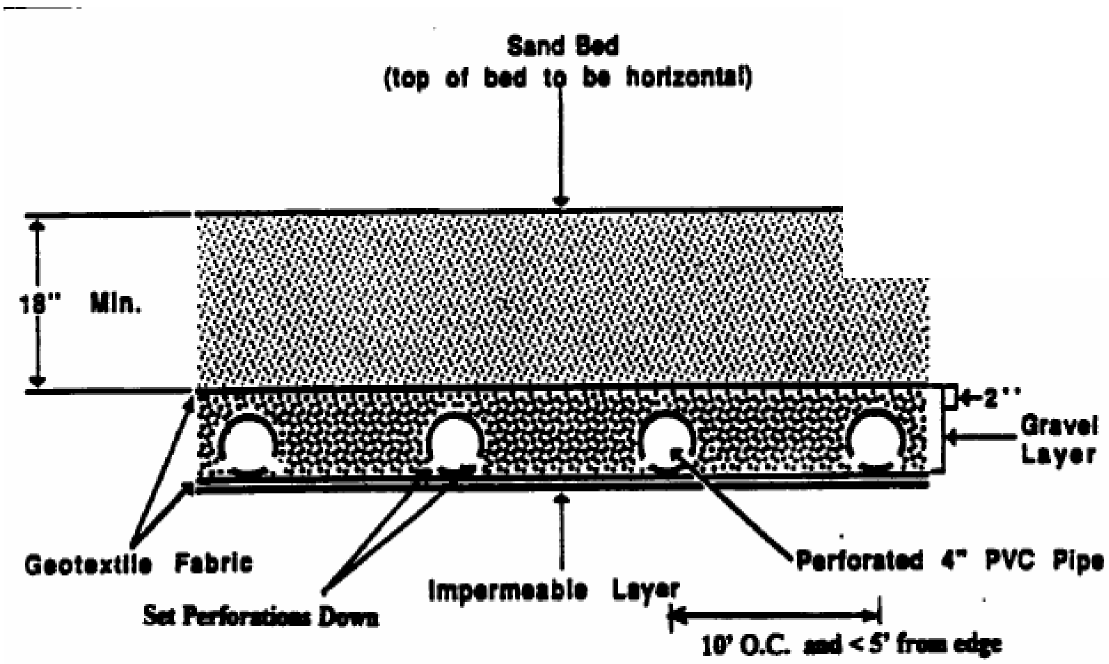


Figure 3-9

Sand Bed Profile with Gravel Filter

Pretreatment

1) A sedimentation basin shall pretreat runoff before entering the sand filter. The sedimentation basin shall be designed to capture the entire WQ_v and discharge it over 40 hours.

2) The water depth in the sedimentation basin when full should be at least 2 feet and no greater than 10 feet.

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

4) The inflow structure to the sedimentation chamber shall incorporate a flow-splitting device capable of isolating the capture volume and bypassing the peak flow of larger storms around the facility when the sedimentation/filtration basin is full.

5) Energy dissipation is required at the sedimentation basin inlet. Flows entering the basin shall be distributed uniformly and at maximum allowable velocities of 2 ft/sec in order to prevent re-suspension and encourage calm conditions necessary for deposition of solids.

6) The outflow structure from the sedimentation chamber shall be either a weir or a riser pipe through a concrete wall. Any weirs shall extend across the full width of the facility such that no short-circuiting of flows can occur.

7) The receiving end of the sand filter shall be protected (splash pad, riprap, etc.) such that erosion of the sand media does not occur and flow is spread across the entire filter bed.

8) If a riser pipe is used to connect the sedimentation and filtration basins (example[17] in **Figure 3-10**), a valve shall be included to isolate the sedimentation basin in case of a hazardous material spill in the watershed. The control for the valve must be accessible at all times, including when the basin is full. The riser pipe shall have a minimum diameter of 6 inches with four 1-inch perforations per row. The vertical spacing between rows should be 4 inches (on centers).

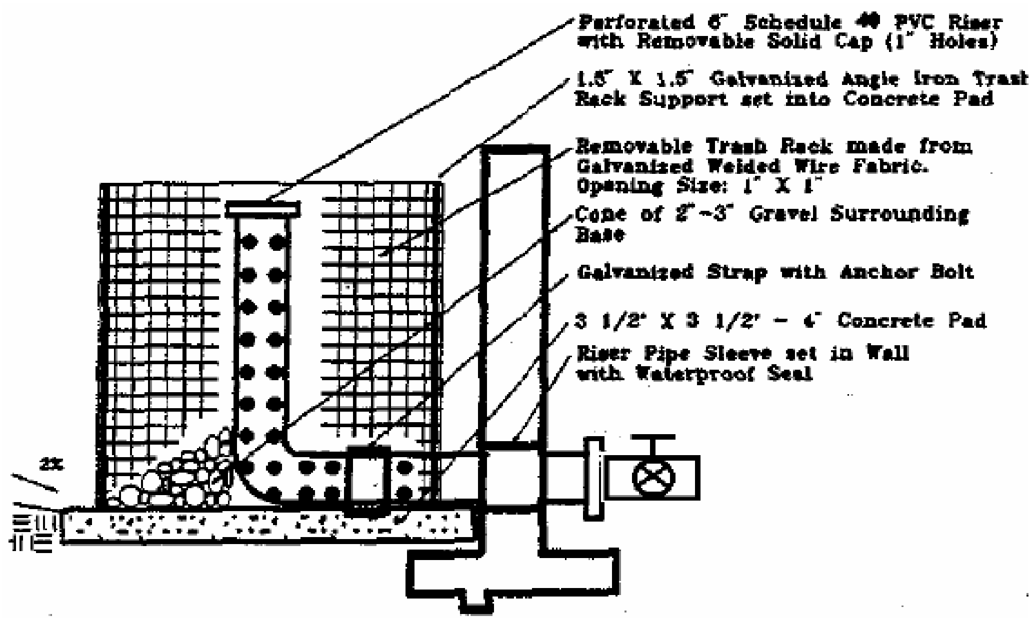


Figure 3-10
Schematic Representation of a Perforated Riser for Discharging the Sedimentation Basin into the Sand Filter

3.3.6 Group 3 – Swales and Filter Strips

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

[17] California Stormwater Quality Association, "California Stormwater BMP Handbook – New Development and Redevelopment", TC-40, 2003.

3.3.6.1 Vegetated Swales [18]

Vegetated swales are open, shallow channels with vegetation covering the side slopes and bottom that collect and slowly convey runoff flow to downstream discharge points. They are designed to treat runoff through filtering by the vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Swales can be natural or manmade. **Figure 3-11** shows a schematic diagram[19] of a typical vegetated filter strip and swale.

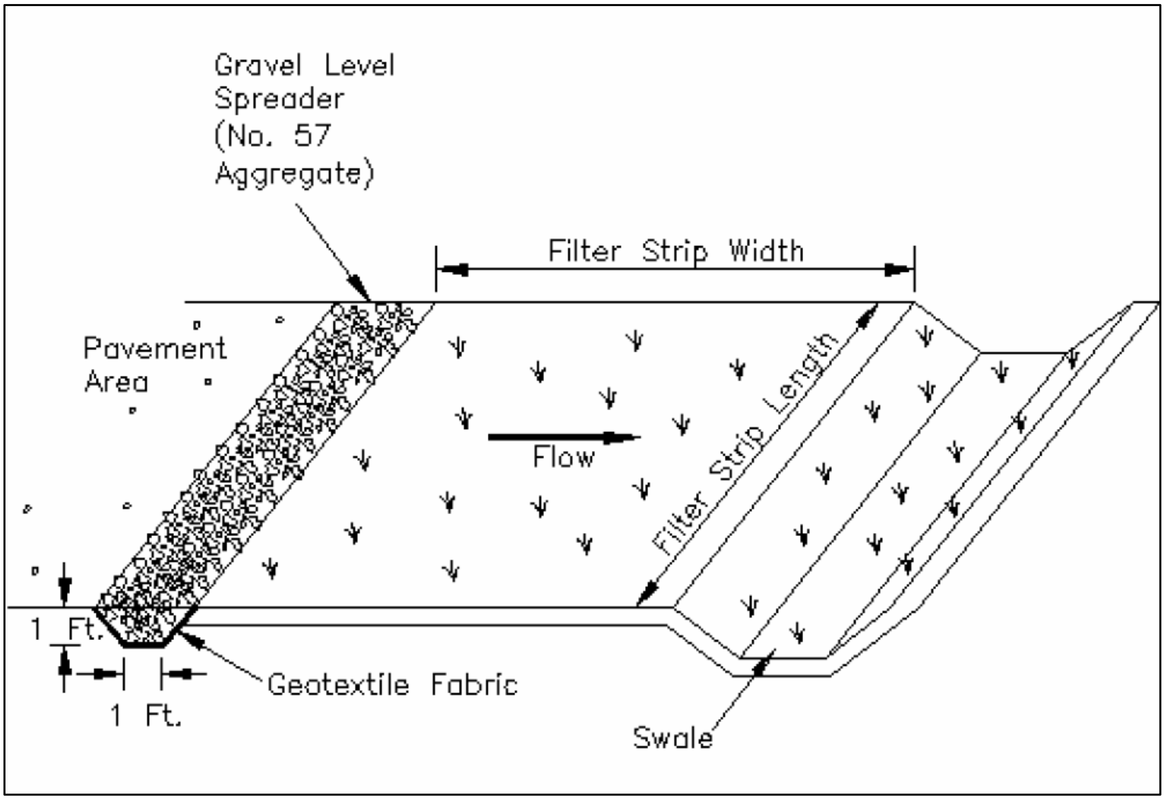


Figure 3-11

Typical Vegetated Swale and Filter Strip

Hydrology Requirements

Vegetated swales that are proposed for sites less than five acres shall be designed to treat the WQf generated by the tributary area. Procedures for determining the WQ_f are provided in Section 3.3.2.3.

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

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[18] California Stormwater Quality Association, "California Stormwater BMP Handbooks, New Development and Redevelopment Handbook", TC-30, January 2003.
[19] California Stormwater Quality Association, "California Stormwater BMP Handbook – New Development and Redevelopment", TC-30, January 2003.

Layout and Geometry Requirements

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

1) Swales are generally recommended for drainage areas less than 5 acres, with a total drainage area of 1 to 2 acres preferred.

2) Trapezoidal channels are normally recommended, but other configurations, such as parabolic, can also provide substantial water quality improvement and may be easier to mow than designs with sharp breaks in slope.

3) Use Manning's Equation to design the swale under peak WQ_v design storm conditions, using criteria within this section to establish design limits for the swale.

4) The swale shall be designed so that the water level does not exceed 3 inches at the design peak flow for the WQ_v.

5) It is recommended that longitudinal slopes along the swale shall not exceed 2.5 percent, and shall be milder if necessary to keep the peak velocity within the swale less than 0.9 feet/second. However, longitudinal slopes may range between 2 and 6 percent. Flatter slopes can be used, if sufficient to provide adequate conveyance. Steep slopes increase flow velocity, decrease detention time, and may require energy dissipating and grade check. Steep slopes also can be managed using a series of check dams to terrace the swale and reduce the slope to within acceptable limits. The use of check dams with swales also promotes infiltration.

6) The width of the swale should be determined using Manning's Equation, at the peak flow during the water quality design storm, using a Manning's "n" of 0.25. The maximum bottom width shall not exceed 10 feet unless a dividing berm is provided.

7) The swale shall have a length that provides a minimum hydraulic residence time, or the time it takes for the water to pass through the swale, of at least five minutes. Regardless of the hydraulic residence time, the length of the swale shall not be less than 100 feet.

8) Swales may be designed to safely convey storms generating more than the WQ_f according to criteria provided in Section 2.3.7. The peak velocity of the 10-year design storm through the swale shall be non-erosive for the soil and vegetative cover provided (See **Table 2-17** for maximum allowable velocities). Three inches of freeboard should be provided.

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

Vegetation Requirements

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

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

Pretreatment Requirements

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

3.3.6.2 Vegetated Filter Strips [20]

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

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

Hydrology Requirements

Vegetated filter strips must be designed to treat the entire WQ_f generated by the tributary area. Procedures for determining the WQf are provided in Section 3.3.2.3.

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

Layout and Geometry Requirements

Filter strips shall be located across gently sloping areas between 1 and 6 percent and have a robust and diffuse vegetative cover. Concentrated flow shall not be allowed to occur along filter strips, as it causes erosion that effectively eliminates water quality benefits.

1) Filter strips are generally recommended for drainage areas less than 5 acres, with a total drainage area of 1 to 2.5 acres preferred.

2) Only sheet flow shall be allowed to enter the filter strip. Both the top and toe of the slope shall be level to encourage sheet flow and prevent erosion.

   In instances where the filter strip receives sheet flow directly from adjacent pavement areas, the top of the filter strip shall be installed 2 to 5 inches below the adjacent pavement so that vegetation and sediment accumulation at the edge of the strip does not prevent runoff from entering. To prevent erosion along the upstream edge of the filter strip, a rock level spreader shall be used at the top of the slope. The rock level spreader must be placed level; have a minimum width and depth of 1 foot; and be constructed of No. 57 aggregate. See **Figure 3-12** for details.

   In instances where a filter strip is to receive flow from either a storm sewer or open conveyance channel, the concentrated flow must be converted to sheet flow using a concrete level spreader as illustrated in **Figures 2-8** and **2-9**.

3) The length (perpendicular to flow) of the filter strip shall be determined using Manning's equation based on a wide-flow assumption. Flow depth across the filter strip shall not exceed 1.5 inches and a minimum Manning's "n" value of 0.20 shall apply.

4) The required filter strip width (parallel to flow) shall be based on filter strip slope as follows:

Filter Strip Slope (%)	Minimum filter Strip Width (Ft.)[21]
1	30
2	60
3	75
4	100
5	120
6	150

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[21] Adapted from ODNR, "Rainwater and Land Development Manual, Third Edition", Pg. 65.

5) Filter strips shall be designed to drain between storms. To satisfy this requirement, perforated underdrains may be required under filter strips where the seasonal groundwater level is at least 2 feet below the filter strip, based on the Franklin County Soil Survey or a soils report prepared to support project design.

Vegetation Requirements

The vegetation requirements for filter strips shall be identical to those provided for vegetated swales in Section 3.3.6.1.

Pretreatment Requirements

Runoff shall enter filter strips as sheet flow. It is preferred that sheet flow across impervious surfaces be maintained into and through the filter strip thereby eliminating the need for a level spreader. Use of a level spreading device designed according to criteria in Section 2.3.6 will be required by the County in instances where concentrated flow must be converted to sheet flow prior to discharge across the filter strip.

3.3.6.3 Dry Extended Detention Swales

Dry extended detention swales incorporate a combination of dry cells formed by check dams or other means and filtering media to treat stormwater runoff by settling, absorption, decomposition, and filtration. The practical applications for dry extended detention swales are low density residential projects or for very small impervious areas. Sites utilizing dry extended detention swales for water quality control may incorporate additional storage and outlet structures to meet the stormwater quantity control requirements of Section 3.2. A schematic of a dry extended detention swale is shown in **Figure 3-12.**

Hydrology Requirements

Dry extended detention swales shall be designed to capture and release 50 percent of the WQ_v in 8 hours and 100 percent of the WQ_v in 24 hours. Water retained within the swale may be released through an outlet at the downstream end of the swale and/or by infiltration into the soil. The native soils shall be replaced with a 30-inch deep layer of permeable soils underlain with an underdrain system. The following criteria shall apply to the design of dry extended detention swales.

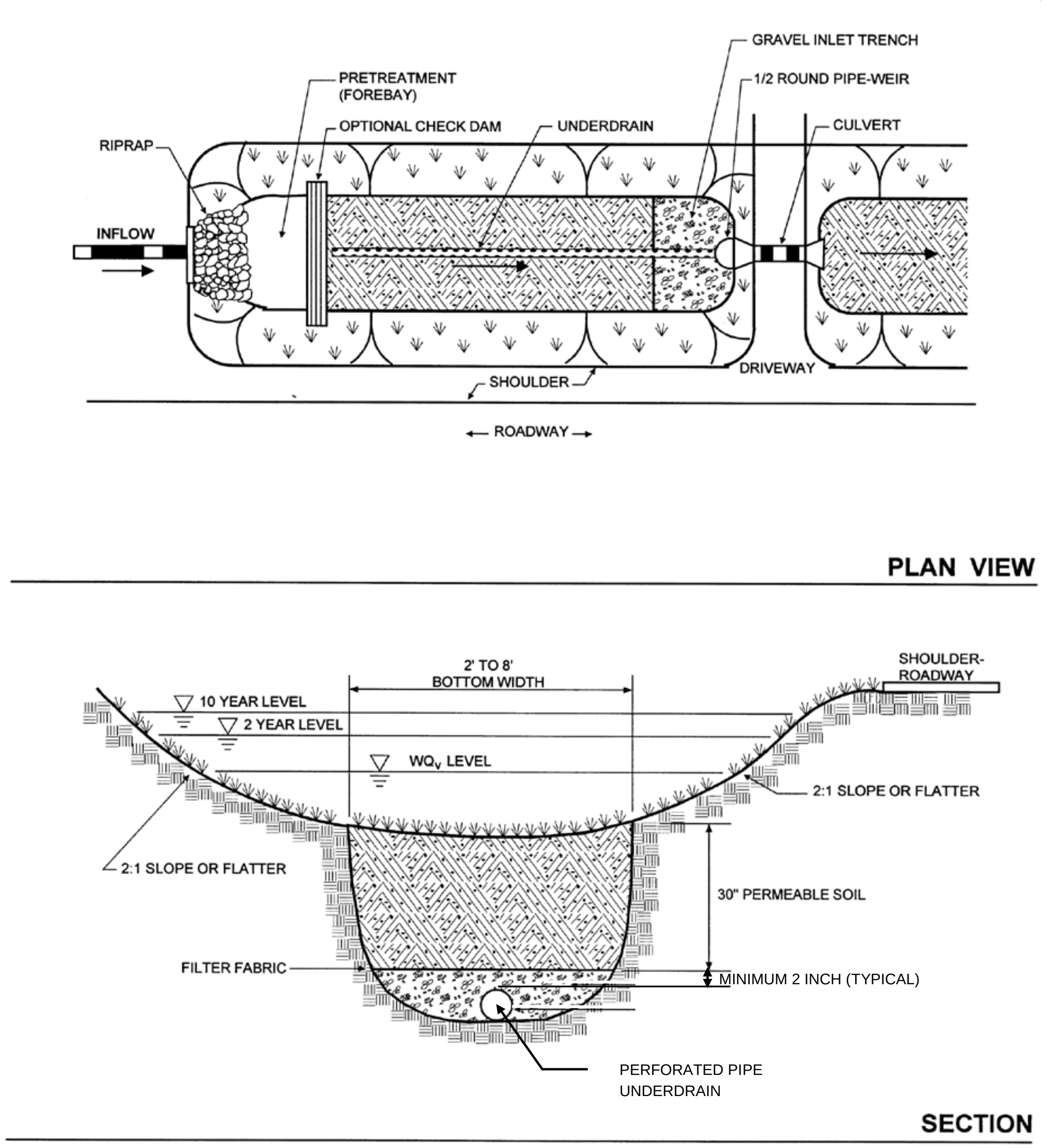

Figure 3-12

Schematic of Typical Dry Extended Detention Swale[22]

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[22] Maryland Department of the Environment, Maryland Stormwater Design Manual, Volume I, 2000, Pg. 3.43

Layout and Geometry Requirements

1) The total recommended drainage area of a dry extended detention swale is 5 acres, with a total drainage area of 1 to 2 acres preferred. Multiple cells should be considered to distribute the flow and facilitate proper drainage of the facility.

2) Dry extended detention swales shall not be allowed in areas where the water table or bedrock is above the invert of the underdrain system.

3) In order to maximize treatment effectiveness, the site must be graded in such a way that minimizes erosion as sheet flow is conveyed to the treatment area.

4) Dry extended detention swales should maintain a maximum ponding depth of one foot at the "mid-point" of the channel's longitudinal profile, and a maximum depth of 18 inches at the downstream end point of the channel for storage of the WQ_v. Check dams or similar structures may be installed along the longitudinal profile to meet this criteria.

5) The side slopes for dry extended detention swales shall not exceed 4 (H) to 1 (V).

6) Swales may be designed to safely convey storms generating more than the WQv according to criteria provided in Section 2.3.7. The peak velocity of the 10-year design storm through the swale shall be non-erosive for the soil and vegetative cover provided (See **Table 2-17** for maximum allowable velocities). Three inches of freeboard should be provided.

Permeable Soil Requirements

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

1) The permeable soil for dry extended detention swales shall consist of a mixture of sand, topsoil, and compost with a pH range of 5.5 and 6.5, a range where pollutants such as organic nitrogen and phosphorus can be adsorbed by the soil and microbial activity can flourish. In addition, the soil shall have infiltration rates greater than 0.5 inches per hour when saturated, achieved through the following standards[23]:

    a. 4 parts sand (per CMSC 703.06)

    b. 2 parts topsoil (per CMSC 653.02)

    c. 2 parts compost (per ODOT CMSC 659.06). Note: Com-Til Compost from the City of Columbus DOSD's Compost Facility is acceptable for use in dry extended detention swales.

[23] ODOT, "Location and Design Manual, Volume 2, Drainage Design", Section 1116.7

2) Soil tests shall be performed for every 500 cubic yards of soil, with the exception of pH and organic content tests, which are required only once per dry extended detention swale.

3) The minimum depth of the filter media shall be at least 30 inches.

4) Dry extended detention swales shall be planted with grass that can withstand prolonged periods in a wet environment. No vegetation with a deeper root zone shall be allowed within the swale.

Underdrain and Outlet Requirements

1) A perforated pipe underdrain shall be provided beneath the permeable soil. The underdrain shall have a minimum grade of 0.5 percent. The perforated pipe shall have a diameter of 4 or 6 inches, and shall meet the requirements of CMSC Section 720.07 or 720.12. A granular backfill of durable No. 57 aggregate in accordance with CMSC Section 703.01 shall be provided up to a minimum of 4 inches above the outside diameter of the pipe.

2) The swale shall be designed to convey or divert all storms larger than the WQ_v up to and including the 100 year event. Storms larger than the WQ_v may be directed into a storm sewer system. Use of a vertical stand pipe or catch basin is recommended.

Pretreatment

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

3.3.7 Group 4 – Water Quality Controls for Commercial Activity Areas

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

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

3.3.7.1 Businesses Subject to Controls for High-Risk Pollutant Sources

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

1) Any business considered by U.S. EPA and Ohio EPA to involve industrial activities and require an NPDES permit for stormwater discharges from industrial activities. Such businesses are defined by Standard Industrial Classification (SIC) under 40 CFR 122.26. A comprehensive list of these businesses is not provided here, but largely falls within the following SIC Divisions:

   a. Division B: Mining

   b. Division C: Construction

   c. Division D: Manufacturing

   d. Division E: Transportation, Communications, Electric, Gas, and Sanitary Services

   e. Division F: Wholesale Trade

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

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

   A copy of the NOI shall be submitted to 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

3.3.7.2 Commercial Activity Areas Requiring Control

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

1) Processing, manufacturing, fabrication, cleaning, or other permanent outdoor equipment or work areas,

2) Areas where vehicles and equipment are repaired, maintained, stored, disassembled, or disposed, and

3) Areas where the high-risk materials defined in **Table 3-8**[24] 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.

Table 3-8

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 BMPs for the site.	***Required controls***: Direct runoff to approved BMPs for the site.
Materials to control: • Recycled materials with potential effluent • Corrosive materials (i.e. lead-acid batteries • Storage and processing of food items • Chalk/gypsum products • Feedstock/grain • Material by-products with potential effluent • Asphalt • Fertilizer • Pesticides • Lime/lye/soda ash • Animal/human waste	***Materials to control:*** • Recycled materials with potential effluent • Scrap or salvage goods • Metal • Sawdust/bark chips • Sand/dirt/soil (including contaminated soil piles) • Material by-products with potential effluent • Unwashed gravel/rock • Compost	***Materials to control:*** • Washed gravel/rock • Finished lumber • Rubber and plastic products (hoses, gaskets, pipe, etc.) • Glass products (new, non-recycled) • Inert products • Materials with no measurable solubility or mobility in water • Materials with no hazardous, toxic, or flammable properties • Gaseous materials

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

3.3.7.3 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.

    b. An oil/water separator to remove uncharacteristically high concentrations of oil and grease, with treated effluent discharged to the separate sanitary sewer system.

    c. A system appropriate for the containment of hazardous material spills, designed as specified in Ohio Fire Prevention Code Section 1301: 7-7.

    d. An industrial treatment system covered by a discharge permit issued by Ohio EPA.

4) The following basic principles for integrated stormwater/wastewater management for commercial activity areas shall be followed:

    a. Only stormwater (i.e., runoff directly caused by a precipitation event) should enter storm drains (e.g., no wash water, spills, leaks, etc.) unless specifically allowed under the 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.

5) Minimize potential exposure of commercial activity areas to stormwater by the following methods[25]:

   a. Minimize the size of the commercial activity area.

   b. Prevent rainfall from entering the area using a cover or roof, with a minimum overhang of 3 feet on each side for covers 10 feet high or less, a minimum overhang of 5 feet on each side for covers higher than 10 feet, and rooftop drainage directed to the storm drainage system.

   c. Surround above ground liquid containers with a containment device with enough capacity to capture at least 110 percent of the product's largest container or 10 percent of the total volume of product stored, whichever is larger.

   d. Isolate high-risk pollutant areas from stormwater run-on by berming or providing grade breaks around the area perimeter.

6) Where wash waters are unavoidable, the Applicant shall propose one of the following disposal options depending upon the nature of the activity, the constituents involved, and other pertinent Federal, State, or County regulations:

   a. Dispose in a sanitary sewer, with appropriate restrictions and/or pretreatment.

   b. Direct to sump/containment, allow to evaporate, and sweep up residual.

   c. Direct to sump/containment, pump out, and haul to appropriate disposal facility.

7) When contamination of stormwater runoff from commercial activity areas is unavoidable (according to building codes, etc.), it may be directed to a sanitary sewer at the discretion of the Stormwater and Regulatory Management Section.

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

3.3.8 Applicant-Proposed Stormwater Controls

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

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

The technology for alternate and manufactured BMPs is rapidly evolving as new products are developed and more vendors provide products and services. Information and design criteria relative to alternative BMPs including manufactured stormwater treatment technologies is provided by the Appendix G Alternative Manufactured BMP Guideline. The County may amend the guide as circumstances warrant. The most current version shall apply. Modifications may include but are not limited to: targeted pollutants, removal efficiency, influent concentration, minimum/maximum particle size, testing protocols, and may also include development or reference to a list(s) o acceptable BMPs by manufacturer and device name. Criteria presented in the Policy are also subject to separate requirements imposed by other agencies such as the Ohio EPA; in case of conflict, the more stringent criteria shall apply.

Required Standards Other than Treatment Performance

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

1) ***Quantity Control —*** In accordance with Ohio EPA requirements, controls for sites five (5) acres and greater shall provide an equivalent level of stormwater quantity control during the WQv event as is achieved by the controls included in the Manual. An equivalent level of quantity control involves controlling the increase in the peak flow rate of stormwater runoff during the WQv event, either by preventing volume increases and/or reducing the post-development peak flow:

    a. Preventing runoff volume increases typically is achieved with stormwater infiltration, defined as a control that discharges the entire WQv either into the ground or through evapo-transpiration. Infiltration controls are generally not feasible in the hydrologic soil groups C and D that predominate most of Franklin County. Infiltration controls may be approved by the County if the applicable NRCS or privately conducted soil survey indicates that the site contains hydrologic soil group A or B soils required for infiltration controls, or if the site will be modified using amended soils that yield infiltration rates and volumes equivalent to those achieved by hydrologic soil group A or B soils. Alternately, the County may approve infiltration in C and D soils if the designer can sufficiently demonstrate that infiltration devices will completely drain between storms. Applicants shall submit appropriate information to demonstrate that stormwater infiltration is achievable in these situations.

b. Other stormwater quality controls prescribed in the Manual for sites equal to or greater than 5 acres reduce peak flow rate by releasing post-development runoff water quality over a 24 to 48 hour period of time. Such decreases reduce the erosive energy that causes stream erosion. Applicants must demonstrate that alternative controls war able to achieve this same decrease in the energy of post-development stormwater flows by demonstrating that the entire WQ_v will be released from the device in no less than 24 hours with 50 percent of the WQ_v being released in no less than 8 hours.

2) ***Site Conditions — The*** facility design shall be appropriate for site conditions in central Ohio. The Applicant shall demonstrate that the control has operated successfully for at least three (3) years in conditions similar to central Ohio, including soils, groundwater, head loss, and climate.

3) ***Durability — The*** control must be made of materials able to withstand climatic and land use conditions in central Ohio, including exposure to stormwater, exposure to light, freeze-thaw cycles, and vandalism. The expected life of the major structural components of the control shall be at least 20 years.

4) ***Access —*** The design of the control shall facilitate maintenance. Access and/or inspection ports shall be provided to all portions of the facility where debris or sediment may collect, or maintenance shall be required. The design shall allow access for a single individual to conduct required maintenance and inspection activities using conventional sewer maintenance equipment.

5) ***Large Storms —*** The facility design shall accommodate storm events larger than the WQ_v by either bypassing its flow around the facility or passing the flow through the facility without re-suspending pollutants and other materials previously captured within the facility.

6) ***Operation and Maintenance —*** A maintenance history shall be provided for at least three (3) years of continuous operation. This history shall illustrate that the level of maintenance required for the facility is equivalent to the other facilities in the Manual.

7) ***Mosquito and Vector Control —*** The Applicant shall demonstrate that the control is designed to minimize and/or control conditions that breed mosquitoes or other vectors, defined in Section 3.3.3 of the Manual.

3.4 As-Built Surveys

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

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

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

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

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

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

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

3.5 Construction Stormwater Quality Controls

Construction stormwater quality control facilities shall be designed to control runoff from construction sites during storm events before being discharged into watercourses, lakes, and/or wetlands. The requirements for construction best management practices (BMPs) are intended to adequately reduce sediment and related pollutants contained in construction stormwater runoff. In general, a Stormwater Pollution Prevention Plan (SWPPP or SWP3) is required for qualifying development sites and must be submitted with the construction plans as part of the plan approval process. Projects that are not required to submit a SWPPP are still required to implement construction BMPs regardless of size.

3.5.1 Additional Requirements

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

1) Franklin County utilizes the ODNR (Ohio Department of Natural Resources) manual: Rainwater and Land Development, latest edition, as the principal reference for erosion and sediment control practices and standards.

2) Stormwater Pollution Prevention Plans – Stormwater Pollution Prevention Plans are required for sites that will disturb at least one acre or more. SWPPPs are not required on sites smaller than one acre; however, the implementation of construction stormwater BMPs is required.

3) Sediment Basins – Sediment basins and appropriately sized risers are required to control sediment discharges for locations receiving runoff from tributary areas of 5 acres or more.

4) The use of straw bales for catch basin and curb inlet protection is not an approved practice in the unincorporated area of Franklin County.

5) Additional requirements are imposed by the Ohio EPA regarding information to be shown on the SWPPP. Information includes but may not be limited to material storage, trash controls, and concrete washout/disposal.

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Stormwater Drainage Manual

Part I

Section IV

Long Term Operation and Maintenance of Stormwater Infrastructure and BMPs

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Section 4

Long-Term Operation and Maintenance of Stormwater Infrastructure and Best Management Practices

This section provides guidance to ensure successful long-term operation and maintenance of stormwater control facilities. Included in this section are requirements for as-built surveys, facility inspection and maintenance, and maintenance and access easement requirements to allow for maintenance in an around stormwater facilities. In general, within low density residential developments, the public entity responsible for maintaining roads will maintain stormwater infrastructure in the road right of way. The County will utilize the ditch petition process to maintain community scale infrastructure, collector tiles and BMP's that are not located in the road right of way. County maintenance shall include the functionality of the BMP's and infrastructure but not the aesthetic maintenance. Home owners or Home Owners Associations (HOA) will be responsible for the aesthetic maintenance of all BMP's and will maintain small scale stormwater control facilities located on private property such as green roofs, rain gardens, vegetated swales, dry detention swales and vegetated filter strips. Stormwater control facilities 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 as outlined in 4.1.3.

4.1 Stormwater Control Facility Maintenance Responsibilities

It is essential that any approved stormwater control facility be properly maintained in order to assure its performance. The County will utilize the County Ditch Petition process (ORC 6131 and 6137) to establish a maintenance fund for the purpose of maintaining eligible infrastructure and BMPs 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 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 specific, dedicated 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.
5) 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.
6) Working with the Franklin County Drainage Engineer's Office, Petition the County to place the infrastructure under maintenance. (See 4.1.5)

Onsite stormwater controls not maintained by the County or in a public road right of way, shall be maintained by the Property Owner or, if applicable, a homeowners association. Onsite facilities constructed to serve other types of development (i.e., high density residential, commercial, and industrial, etc.) shall be maintained by the Property Owner. See section 4.1.3 for maintenance inspection and reporting requirements.

4.1.1 Stormwater Control Facility Easement and Access Requirements

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 such as forebay(s), benches, risers, outlet pipes, etc., and a minimum width of 20 feet around the perimeter of the facility. For basins that are to be publicly maintained, the Property Owner shall provide an easement extending 20 feet beyond the maximum flood limits of the facility around the basin and its appurtenances. A dedicated access easement, having a minimum width of 20 feet, shall also be provided that extends from the facility easement to the nearest public right-of-way.

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

Pipes, ditches, swales, inlet and outlet structures which are not located in a public road right of 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 homeowners association, the developer shall provide to the County a minimum 20-foot wide dedicated drainage easement.

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

4.1.2 Stormwater Control Facility Maintenance Plan

A maintenance plan for stormwater controls must be prepared and submitted for review by the County for the Applicant during the Plan approval process. The maintenance plans must be a stand-alone document that 1) identifies the entity responsible for inspection and maintenance responsibilities, 2) maintenance tasks to be performed, 3) inspection and maintenance schedules, 4) a plan showing all access and maintenance easements. At a minimum, maintenance plans for stormwater controls shall include a method and frequency for the following activities:

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

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

4.1.3 Maintenance Inspection and Reporting Requirements

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

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

Franklin County Drainage Engineer
970 Dublin Road
Columbus, Ohio 43215

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

4.1.4 Stormwater Control Facility 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.

4.1.5 Establishing a Maintenance Fund for Public Maintenance of Stormwater Infrastructure and Best Management Practices

The following process shall be followed to petition for drainage maintenance from the County. Drainage maintenance will apply to stormwater infrastructure including but not limited to swales, inlet structures, pipes and post construction stormwater BMP's.

1) Submit to the clerk of the board of county commissioners and the drainage engineer, the agreement, schedules, cost estimate **(see 4.1.5.1)** 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 his certificate of acceptance and the schedule of maintenance assessments with the board of county commissioners the owner may petition the board to accept the drainage improvement into the ditch 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 date 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 (Post Construction BMP Inspection and Maintenance).

4.1.5.1 Cost Estimate for the Establishment of the County Drainage Maintenance Assessment

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.

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Stormwater Drainage Manual

Part II

Submittal Requirements

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Part II – Submittal Requirements

Part II – Submittal requirements of the Manual contains 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 plan (Plan) accompanying required submittals. Finally, Section 7 presents stormwater management report submittal requirements. Additional questions covering these sections should be directed to the Franklin County Economic Development and Planning Department.

<u>Section 5</u> <u>Private and Public Development Review Processes</u>

<u>Section 6</u> <u>Stormwater Management Report</u>

- Master Drainage Plan Requirements
- Calculation Requirements
  - Impervious Area Calculations
  - Storm Sewer Calculations
  - Culvert Calculations
  - Constructed Open Watercourse Calculations
  - Flood Routing Calculations
  - Stormwater Detention Calculations
  - Water Quality Volume (WQv) Calculations for Extended Detention Ponds, Wetlands, and Bioretention
  - Swale and Filter Strip Calculations
- Stormwater Quality BMP Maintenance Plan Requirements
- Drainage Easement Preparation Requirements
- Subsurface Investigation Reports
- Non-County Submittals/Permits

Section 7 Stormwater Management Report Submittal Requirements

- Minimum Plan Format Requirements
  - Title Sheet
  - Plan View
  - Profile View
  - Details and Cross Sections
  - Stormwater Pollution Prevention Plan

Stormwater Drainage Manual

Part II

Section V

Private and Public Development Review Processes

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Section 5

Private and Public Development Review Processes

Any new development, either public or private, proposing to construct stormwater infrastructure within the County, must receive approval from some or all of the following County departments prior to construction, including: Franklin County Planning Commission, Franklin County Economic Development and Planning Department, Franklin County Engineers Office, Franklin County Drainage Engineers Office, Franklin County Public Health Department and the Franklin County Sanitary Engineer. Stormwater plans will be submitted directly to the Franklin County Economic Development and Planning Department, at 150 South Front Street, FSL Suite 10 Columbus, Ohio 43215. Once received by the Economic Development and Planning Department, the plans are routed to various County departments for review.

Stormwater improvements that are to be publicly owned and operated within public right-of-way or in publicly owned easements are incorporated into, and submitted with, the public roadway plans for the development. In the case of a major subdivision proposal, the applicant is required to procure approval of a preliminary plat 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. State Water Quality (401) certification.
3. Written Ohio EPA approval for use of alternate post-construction BMP on large sites or for small site plans submitted as part of a larger plan of development.
4. Written Ohio EPA approval for any exception, waiver or other variance from conditions contained in the applicable Construction General Permit.

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Stormwater Drainage Manual

Part II

Section VI

Stormwater Management Report

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Section 6

Stormwater Management Report

A stormwater management system shall be designed and incorporated into each development project proposed within the County. The design of proposed stormwater management systems shall be summarized in a bound stormwater management report (Report) and submitted 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 best management practices (BMPs) as specified in Part I of this document. The following components shall be included in, and considered part of, the Report:

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

The master drainage plan shall be folded and inserted in a separate sleeved page(s) or pocket(s) of the Report. Construction plans, including Stormwater Pollution Prevention Plans, 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 should show all features indicated in the Manual, including but not limited to:

1) Project title,
2) North arrow and scale,
3) Project boundaries,
4) Existing and proposed topography at two-foot contour intervals covering the total development area and any offsite drainage areas tributary to the development site. The total upstream watershed(s) tributary to the development site shall be delineated,
5) 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 system, if requested by the County,

7) Predevelopment and post development major 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 Table 2-10 without surcharging. Calculations shall be prepared on the tabulation sheet provided in Appendix C.
2) ***Hydraulic and Energy Grade Line*** — Demonstrate that the sewer system is designed to convey the design storm on Table 2-10 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. The HGL and EGL shall be shown on the tabulation sheet provided in Appendix C
3) ***Tailwater*** — List all tailwater assumptions and their source for applicable design storm events.
4) ***Velocities*** — Tabulate the storm sewer flow velocities in each segment, and demonstrate that the sewers are designed to produce velocities within the limits specified in Section 2.3.1.2.
5) ***Pavement Spread*** — Provide calculations that demonstrate that the pavement spread limits do not exceed the criteria presented in Section 2.3.2.

6.2.3 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, 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 10-year peak pre-developed flow rate.

3) ***Basin Inflow and Outflow Hydrograph Calculations*** — Show the calculations or model input/output that produced the inflow and outflow hydrographs to and from the retention/detention basin. Hydrographs should be shown graphically, with a tabular summary of the peak flow and volume, for all design storms that were considered in the design process. The 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 (WQ_v) Calculations for Extended Detention Ponds, Wetlands, and Bioretention Facilities

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

1) ***Water Quality Volume Calculations*** — Show the calculations of extended detention, permanent pool, forebay, and sediment storage volumes and depths, as described in Section 3.3.2.

2) ***Water Quality Drawdown*** — Show calculations or model output that demonstrates the release of the WQ_v over the time period(s) specified in Section 3.3.2.

3) ***Area of Sand Filter and Bioretention Facilities*** — Provide calculations used to determine the size of sand filter and bioretention facilities as specified in Section 3.3.5.

6.2.8 Swale and Filter Strip Calculations

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

1) ***Water Quality Flow Calculations*** — Show the calculations of the water quality flow (WQ_f) as described in Section 3.3.2.3.

2) ***Intensity-Duration-Frequency Curve*** — Use Figure 2-1 to determine the intensity corresponding to the time of concentration.

3) ***Design Flow Rate*** — Show the calculations of the swale/filter strip design flow rate using the Rational Formula. The intensity used in the calculation is obtained from the curve drawn in Step 2 above, at a duration equal to the time of concentration for the tributary area.

4) ***Geometry*** — Show the calculations of the swale/filter strip cross-section geometry using the Manning Equation. Demonstrate that the flow depth is no greater than the maximum flow depth specified in Section 3.3.6 for the design storm calculated above.

6.3 Stormwater Quality BMP Maintenance Plan Requirements

The maintenance plan for the water quality BMPs on single-family residential, commercial, or industrial sites shall define the specific maintenance requirements for each type of control facility designed for the site. Criteria for preparing the maintenance plan are contained in Section 4, and specific maintenance requirements for each type of control are included in **Appendix A.**

6.4 Drainage Easement Preparation Requirements

Dedicated drainage easements to the County shall be provided to allow maintenance and access to all stormwater facilities located outside of public right-of-way that are to be publicly owned or operated. Easements shall be designated on the construction plans as platted or deeded, existing or proposed. All existing easements shall be identified by the plat book and page number, or official record number of the deed. Preliminary 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 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.
3) ***Format*** — Documents are not to be labeled or referenced to as exhibit A, B, or so on.
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, ditch or basin.
5) ***Contacts*** — For private stormwater development plans, the name, mailing address and phone number of the person who will sign or obtain the signatures on the easement document shall be provided.

When approved by the Franklin County Drainage Engineer, easement information will be sent to the Real Estate Division of the County Engineers Office for Deed of Easement preparation. When the deed is prepared, the Real Estate Division will contact the designated contact person to obtain the signatures and return the signed originals. The Real Estate Division will record the deeds and process them for acceptance by the County Commissioners. Signed Deeds of Easement must be returned to the Real Estate Division 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 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 Ohio Department of Natural Resources (ODNR) for detention pond embankments meeting ODNR dam criteria,
2) 401 Water Quality Certification Permits issued by the Ohio Environmental Protection Agency,
3) Industrial NPDES Stormwater Permit application to Ohio Environmental Protection Agency,
4) 404 Permits for impacts to regulated streams and wetlands issued by the U.S. Army Corps of Engineers, and
5) Notice of Intent for coverage under the Ohio Environmental Protection Agency NPDES Construction General Permit, and a copy of the stormwater pollution prevention plan prepared under this permit.

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Stormwater Drainage Manual

Part II

Section VII

Stormwater Management Report Submittal Requirements

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Section 7

Stormwater Management Report Submittal Requirements

All stormwater improvement plans submitted for approval by the County shall be prepared, signed, and sealed by a Professional Engineer who is licensed in the State of Ohio. Final plans shall be prepared and submitted on 22-inch by 34-inch high quality 4-mil thickness mylar using ink especially adapted to mylar. High quality photographic or mylar reproductions will be accepted with prior approval. Title blocks shall be in accordance with Franklin County Engineer's Office standard. Stick on notes, 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 Planning Commission. Copies of approved plans can be obtained from the Franklin County Engineer's Office.

All revisions to the tracings, after they have been signed by the County Engineer, shall be made in black ink. The original approved alignment, easement limits, manholes, structure numbers, etc., shall be revised as directed by the County 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.

Five sets of prints (check prints), one reduced size 11-inch by 17-inch, electronic .pdf and CAD and a completed and signed Plan Review Checklist Appendix E shall be submitted to the Franklin County Economic Development and Planning Department (FCEDP) for review by the various County Departments. In addition to hard copy plans, the County will require the submission of plans and any plan revisions in accordance with the City of Columbus digital submission standards, current version. The consultant will be notified when all check prints have been returned to FCEDP.

7.1 Minimum Plan Format Requirements

The following minimum for requirements apply to all construction plans submitted for review to the Franklin County Economic Development and Planning Department and are included in the Plan Submittal Checklist as shown in Appendix E.

7.1.1 Title Sheet

The Title Sheet shall contain the following items:

1) ***Title*** — All private storm sewer plan titles shall be formatted in the title block as follows:
   "Private Storm Sewer and Stormwater Facilities for [Insert Project Title]"
   The Project Title shall include the street address of the project site.

2) ***Location Map*** — This map shall show the relative location of the project to area streets and well known landmarks so as to determine the location of the project within the County at a quick glance.

3) ***Benchmarks*** — A suitable benchmark shall be provided for every 1,000 lineal feet of sewer shown on the plan, with a minimum of two (2) on each plan. The benchmarks shall be established through a bench circuit with elevations based on the most recent North American Vertical Datum (NAVD) determination.

4) ***Estimate of Quantities*** — An accurate estimate of those items being constructed under the stormwater plan shall be included. The description of the item shall be the same as that under the item description in the CMSC, current edition. The quantities for each phase of a phased project shall be shown separately.

5) ***Standard Drawings*** — All plans shall have a listing of the applicable Standard Construction Drawings which apply to the proposed work.

6) ***General Notes*** — The general notes 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."

7.1.2 Plan View

All plan sheets shall contain the following items:

1) ***North Arrow*** — Plans shall be orientated so that the north arrow is toward the top or left margin of the sheet. Slope of the sewer may be shown from either the left or the right side of the sheet but shall be consistent throughout the plan.

2) ***Structure Numbering*** — All sewer plans shall be submitted with continuous numbering for each stormwater structure included in the project. The lowest structure number shall be assigned to the most downstream structure on the longest run of sewer. Increasing structure numbers shall be assigned to each structure as the sewer run progresses upstream. Once all structures are assigned a number along the first sewer run, the next number is assigned to the most downstream manhole on the next longest sewer run. The process is repeated until all stormwater structures have been assigned a number.

3) ***Scale*** — Plan views shall be prepared at horizontal scale of sufficient size as to show necessary detail. A horizontal scale of 1"=30' is recommended.

4) ***Line Weights*** — Appropriate line weights are to be used for the various items shown on the plan. All items shown on the plan are to be labeled and clearly distinguishable from each other. For ease of distinction, the proposed sewer should be the heaviest line weight used.

5) ***Point of Reference*** — All plans shall show a distance from some point of the proposed sewer system to an existing reference point outside the project site, accurate to within one foot. (Example: Street Intersection).

6) ***Property Information*** — All properties through which a stormwater management facility passes shall have indicated on the plans the Property Owner's name, parcel acreage, parcel identification number, and the deed book and page number of the title instrument. This includes onsite and offsite properties. All iron pins found during the field survey shall be shown on the plans as "found iron pin".

7) ***Impervious Surfaces*** — All impervious areas on the project site shall be shown. The impervious surfaces shall be prepared digitally using polygons on a separate overlay, or layer, and shall include all building footprints, paved parking, private drives and sidewalks.

8) ***Streams*** — All streams shall be identified and shown on the plan.

9) ***Stormwater Best Management Practices*** — The size, location, and maximum ponding limits of all proposed stormwater BMPs shall be provided on the plans. Easements for 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.

7.1.3 Profile View

All profile sheets shall contain the following items:

1) ***Scale*** — The horizontal scale of the sewer profile shall always be the same as the scale of the corresponding plan view unless approved otherwise by 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 right-of-ways crossed by the storm sewer centerline shall be indicated.

3) ***Utility and Other Crossing*** — All utility crossings, whether existing or proposed, shall be shown as accurately as possible (based on existing available records) on the sewer profiles and identified as to their type and size. Other crossings such as streets, alleys, driveways, streams, ditches, etc. shall be shown and identified by name, centerline, edge of pavement, etc.

4) ***Structure and Pipe Annotation*** — All structures shall be labeled as to type, centerline station location, invert and top of casting elevations, and all other pertinent information. Pipes shall be labeled with their respective sizes, slopes, and distances. Pipe distances and slopes shall be determined from center-of-structure to center-of-structure stationing. Existing structures shall be drawn using dashed lines and proposed structures shall be drawn using solid lines.

5) ***Backfill, Backing, and Encasement*** — If the proposed backfill for the proposed sewer line is to be different from that specified under Item 901 in the CMSC, the type of backfill, and the limits thereof, shall be identified in the profile. Concrete encasement, when used, shall also be shown in the profile with the limits specified.

   Ground Surfaces — Existing and proposed ground surfaces shall be shown and clearly marked. Existing surfaces shall be shown as a dashed line. Proposed ground surfaces shall be shown as a solid line.

7.1.4 Details and Cross Sections

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

1) ***Open channels*** — Typical cross sections shall be shown for all proposed open channel systems including, but not limited to, flood routing swales, roadside ditches, and minor storm conveyance channels. Typical cross sections shall show the appropriate dimensions and side slope values for each channel.

2) ***Culverts*** — A profile along each roadway culvert shall be provided showing invert, roadway edge of pavement and/or top of curb, roadway centerline, and design storm and 100-year headwater surface elevations. A table with each profile shall also be provided showing the design and 100-year storm discharge values and their respective outlet velocities.

3) ***Stormwater Quality BMPs*** — Dimensioned cross sections, elevation views and plan views for each water quality BMP shall be shown. A table showing the required WQ_v and drawdown time as well as the designed storage and designed drawdown time of the facility shall be shown. A list of the types and number of any plantings, if required, shall be included on the plans.

4) ***Detention Basins*** — Cross sections of detention basins, wet or dry, shall be provided and dimensioned. Side slopes, basin bottom slope, the elevation of each inlet and outlet structure, and maximum water surface elevations for WQ_v storage, the critical storm, and the 100-year storm shall be annotated. An elevation view and plan view of each outlet riser structure shall be provided and annotated. Cross sections showing side slope, side slope information, bottom width dimensions, overflow weir elevations, bottom lining etc. shall also be shown.

7.1.5 Stormwater Pollution Prevention Plan

The Applicant shall include a copy of the Stormwater Pollution Prevention Plan (SWPPP) prepared in compliance with Ohio EPA's Construction General Permit and Section 3.5 of the Manual.

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Appendix A

Operation and Maintenance Inspection Report Checklist

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Operation and Maintenance Inspection Report for Stormwater Basins and Wetlands (*)

Inspector Name ______________________________

Inspection Date/Time __________________________

Stormwater Pond:

Normal Pool _______________

Normal Dry _______________

Project Location (inc. SP coordinates):

____

____

Watershed__________________________

Owner Name________________________

Inspection Items	**Checked? Yes/No**	**Maintenance Needed? Yes/No**	**Inspection Frequency**	**Comments**
Pond Components				
1. Embankment and Emergency Spillway				
a. Adequate vegetation and ground cover			A	
b. Embankment erosion			SA	
c. Animal burrows			A	
d. Unauthorized plantings			A	
e. Cracking, bulging, or sliding of dam				
i. Upstream face			A	
ii. Downstream face			A	
iii. At or beyond toe				
Upstream			A	
Downstream			A	
iv. Emergency spillway			A	
f. Pond, toe & chimney drains clear and functioning			A	
g. Leaks on downstream face			A	
h. Abutment protection or riprap failures			A	
i. Visual settlement or horizontal misalignment of top of dam				
j. Emergency spillway clear of debris			A	
k. Other (specify)			A	
2. Riser and principal spillway				
Type: Reinforced concrete _______ Corrugated pipe _______ Masonry ________ a. Low flow orifice obstructed			A	
b. Low flow trash rack i. Debris removal necessary			A	
ii. Corrosion control			A	

Inspection Items	Checked? Yes/No	Maintenance Needed? Yes/No	Inspection Frequency	Comments
c. Weir trash rack i. Debris removal necessary			A	
ii. Corrosion control			A	
d. Excessive sediment accumulation inside riser			A	
e. Concrete/Masonry condition Riser and barrels				
i. Cracks or displacement			A	
ii. Minor spalling (<1")			A	
iii. Major spalling (rebars exposed)			A	
iv. Joint failures			A	
v. Water tightness			A	
f. Metal pipe condition			A	
g. Control valve				
i. Operational/exercised			A	
ii. Chained and locked			A	
h. Pond drain valve			A	
i. Operational/exercised			A	
ii. Chained and locked			A	
i. Outfall channels flowing			A	
j. Other (specify)			A	
3. Permanent pool (wet ponds)				
a. Undesirable vegetative growth			M	
b. Floating or floatable debris removal required			M	
c. Visible pollution			M	
d. High water marks			M	
e. Shoreline problems			M	
f. Sediment accumulation			M	
g. Other (specify)			M	
4. Sediment forebays				
a. Sedimentation noted			M	
b. Sediment removal when depth <20% design depth			M	
5. Dry pond areas				
a. Vegetation adequate			M	
b. Undesirable vegetative growth			M	
c. Undesirable woody vegetation			M	
d. Low flow channels clear of obstructions			M	
e. Standing water or wet spots			M, S	
f. Sediment and/or trash accumulation			M	
g. Other (specify)			M	

Inspection Items	Checked? Yes/No	Maintenance Needed? Yes/No	Inspection Frequency	Comments
6. Condition of outfalls into pond				
a. Riprap failures			A,S	
b. Slope erosion			A,S	
c. Storm drain pipes			A.S	
d. Endwalls/headwalls			A,S	
e. Other (specify)			A,S	
7. Other				
a. Encroachments on ponds or easement area			M	
b. Complaints from residents (describe on back)			M	
c. Aesthetics				
i. Grass height			M	
ii. Graffiti removal necessary			M	
iii. Other (specify)			M	
d. Any public hazards (specify)			M	
e. Maintenance access			M	
f. Monitor mosquito larvae presence (seasonal)			M	
8. Constructed wetland areas				
a. Vegetation healthy and growing (50% surface area coverage)			M	
b. Evidence of invasive species			M	
c. Excessive sedimentation in wetland area			M	

Inspection Frequency Key A = Annual, SA = Semi-annual, M = Monthly, S = After major storm

(*) Source: Georgia Stormwater Management Manual – Adapted from Watershed Management Institute, Inc. (1997)

Summary

1. Inspectors Remarks: ____
____
____
____
____
____

Overall condition of Facility (Check one)
_____ Acceptable
_____ Unacceptable

2. Dates any maintenance must be completed by: ____
____

CERTIFICATION STATEMENT

I CERTIFY UNDER PENALTY OF LAW THAT I HAVE PERSONALLY EXAMINED AND AM FAMILIAR WITH THE INFORMATION ON THIS FORM AND BELIEVE THE INFORMATION IS TRUE, ACCURATE AND COMPLETE.

______________________________	______________________	____________________
Authorized Representative Signature	Title	Date

Operation and Maintenance Inspection Report for Media Filters (*)

Inspector Name ________________________________

Inspection Date/Time ___________________________

Site Status/Owner Name_________________________

Project Location (Inc. SP coordinates)

____

____

Watershed __________________________

Inspection Items	Checked? Yes/No	Maintenance Needed? Yes/No	Inspection Frequency	Comments
Bioretention and Sand Filter (if applicable) Facilities				
1. Debris removal				
a. Bioretention and contributing areas clean of debris			M	
b. No dumping of yard wastes into practice			M	
c. Any dumping of yard wastes into facility			M	
d. Litter (branches, etc.) been removed			M	
2. Vegetation (if applicable)				
a. Plant height not less than design water depth			M	
b. Fertilized per specification			M	
c. Plant composition according to approved plans			M	
d. No placement of inappropriate plants			M	
e. Grass height not greater than 6 inches			M	
f. No evidence of erosion			M	
3. Check dams/energy dissipators/sumps				
a. No evidence of sediment buildup			A,S	
b. Sumps should not be more than 50% full of sediment			A,S	
c. No evidence of erosion at downstream toe of drop structures			A,S	
4. Dewatering				
a. Dewaters between storms			M	
b. No evidence of standing water			M	
5. Sediment deposition				
a. Swale clean of sediments			A	
b. Sediments should not be > than 20% of swale design depth			A	
6. Outlets/overflow spillway				
a. Good condition (no need for repair)			A,S	
b. No evidence of erosion			A,S	
c. No evidence of blockages			A,S	

Inspection Items	Checked? Yes/No	Maintenance Needed? Yes/No	Inspection Frequency	Comments
7. Integrity of facility				
a. Filter bed has not been blocked or filled inappropriately			A	
b. Vandalism			A	
Sand Filter Facilities				
1. Media / Filtration Chamber				
a. Media removal/disposal if drain time > 72 hours			M	
b. Media replacement if < 90% of design depth			SA	
c. Check for cracks/ leakage			SA	
2. Sedimentation Chamber				
a. Clear of sediment buildup (7 to 10-year cleanout recommended)			A	
b. Check for cracks/leakage			SA	

Inspection Frequency Key A = Annual, SA = Semi-annual, M = Monthly, S = After major storm

(*) Source: New York State Stormwater Management Design Manual; ETA & Biohabitats (1993); Watershed Management Institute, Inc. (1997); California Stormwater BMP Handbook – TC-40 (2003).

Summary

1. Inspectors Remarks: ______________________________________
____
____
____
____
____

Overall condition of Facility (Check one)

_____ Acceptable

_____ Unacceptable

2. Dates any maintenance must be completed by: ______________________________________
____

CERTIFICATION STATEMENT

I CERTIFY UNDER PENALTY OF LAW THAT I HAVE PERSONALLY EXAMINED AND AM FAMILIAR WITH THE INFORMATION ON THIS FORM AND BELIEVE THE INFORMATION IS TRUE, ACCURATE AND COMPLETE.

___________________________ ____________________ __________________

Authorized Representative Signature Title Date

Operation and Maintenance Inspection Report for Vegetated Swales, Filter Strips and Level Spreaders (*)

Inspector Name ________________________________

Inspection Date/Time __________________

Watershed ___________________________

Project Location (Inc. SP coordinates)

____

____

Owner Name_________________________

Inspection Items	Checked? Yes/No	Maintenance Needed? Yes/No	Inspection Frequency	Comments
Vegetated Swales and Filter Strips (Vegetated Swales, as applicable)				
1. Debris removal				
a. Facility and adjacent area clear of debris			M	
b. Inlets and outlets clear of debris			M	
c. Any dumping of yard wastes into facility			M	
d. Has litter (branches, etc.) been removed			M	
2. Vegetation				
a. Adjacent area stabilized			M	
b. Grass mowed to height of 3 inches			M	
c. Plant height not less than design water depth			M	
d. Fertilized per specification			M	
e. Any evidence of erosion			M	
f. Is plant composition according to approved plans			M	
g. Any unauthorized or inappropriate plantings			M	
h. Any dead or diseased plants			M	
i. Any evidence of plant stress from inadequate watering			M	
j. Any evidence of deficient stakes or wires			M	
3. Oil and grease				
a. Any evidence of filter clogging			M	
4. Dewatering				
a. Facility dewaters between storms			M	
5. Check dams/energy dissipators/sumps				
a. Any evidence of sedimentation buildup			A,S	
b. Are sumps greater than 50% full of sediment			A,S	
c. Any evidence of erosion at downstream toe of drop structures			A,S	
6. Sediment deposition				
a. Swale clean of sediments			A	
b. Sediments should not be > than 20% of swale design depth			A	

Inspection Items	Checked? Yes/No	Maintenance Needed? Yes/No	Inspection Frequency	Comments
7. Outlets/overflow spillway				
a. Good condition (no need for repair)			A,S	
b. Any evidence of erosion			A,S	
c. Any evidence of blockages			A,S	
8. Integrity of facility				
a. Has facility been blocked or filled inappropriately			A	
b. Check for evidence of erosion/washout of inlet/outlet filter media			A	
9. Bioretention planting soil				
a. Any evidence of planting soil erosion			A	
10. Organic layer				
a. Mulch covers entire area (NO voids) and to specified thickness			A	
b. Mulch is in good condition			A	
Level Spreaders				
a. Vegetated area has vigorous stand of grass			SA, S	
b. Spreaders uniformly distributes flow over level lip.			SA, S	
c. Check for evidence of erosion/washout of inlet/outlet filter media			A	

Inspection Frequency Key: A=Annual, SA = Semi-Annual, M=Monthly, S=After major storm

(*) Source: Georgia Stormwater Management Manual – Adapted from Watershed Management Institute, Inc. (1997)

Summary

1. Inspectors Remarks: ____

____

____

Overall condition of Facility (Check one): _____ Acceptable or _____ 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 Best Management Practices

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Appendix B
Native Plant Species
For Stormwater Quality Best Management Practices

Selection of Native Plant Species
We are fortunate in Ohio to have a great diversity of plants to choose from, including many that thrive under adverse conditions. Native plants can be found to suit a variety of sites: wet or dry, sun or shade, high or low fertility, and acidic or calcareous 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, in the long run, natives will, in most cases, form self-sustaining plant communities that provide the keystone elements for ecosystem restoration. They are a vital component of any native ecosystem.

What are invasive plants?
Invasive species are aggressive non-native plants introduced into environments where they did not evolve. These species are also referred to as exotics, aliens, weeds, and non-indigenous species.

Invasive species spread rapidly because they often have no natural pests to limit their spread, displacing native species and disrupting natural ecosystems by changing the composition, structure and function of natural plant communities. Table B-1 lists common invasive plant species found in Franklin County that should be avoided.

[1] The Ohio State University Extension Bulletin 865

Table B-1
Common Invasive Plants
Found in Franklin County

Botanical Name	Common Name
Ailanthus altissima	Tree of Heaven
Alliaria petiolata	Garlic mustard
Berberis thunbergii	Japanese barberry
Coronilla varia	Crown vetch
Euonymous alatus	Burning bush
Euonymous fortunei	Wintercreeper vine
Hemerocallis fulva	Day lily
Ligustrum vulgare	Common privet
Lonicera maackii, L. morrowii, L. tatarica	Bush honeysuckle
Lonicera japonica	Japanese honeysuckle
Lythrum salicaria	Purple loosestrife
Ranunculus ficaria	Lesser celandine
Rosa multiflora	Multiflora rose
Polygonum cuspidatum	Japanese knotweed
Vinca minor	Periwinkle, Myrtle

Table B-2 lists native plant species that are approved for use in stormwater best management 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 Saturated	Wooded Wetland Shallow	Edge Shallow	Emergent Deep	Stormwater Basin Tested[3]	Salt Tolerant
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 Saturated	Wooded Wetland Shallow	Edge Shallow	Emergent Deep	Stormwater Basin Tested[3]	Salt Tolerant
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

Citations and References for Native Plant Species:

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http://www.epa.ohio.gov/dsw/wetlands/WetlandEcologySection.aspx

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Stormwater Drainage Manual

Appendix C

Calculation Worksheets

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Storm Sewer Computation Sheet

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)								

DITCH COMPUTATION SHEET

Project ___________________

Sheet ____ of ____

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		Side	Drainage Area		Time			Intensity		Runoff Coef	Coe. X A		CiA		l depth dc (ft.)	Slope ft./ft.	Velocity in f.p.s	Depth in ft.	Ditch Time Check	Treatment		
	High Point	Point of Solution		(acres)	ε A (acres)	Overland	Ditch	ε t	Velocity	Depth		Δ CA	ε CA	Qv	Qd						Lining	Station From	To

Appendix D

Example Calculations for Stormwater Quality Control

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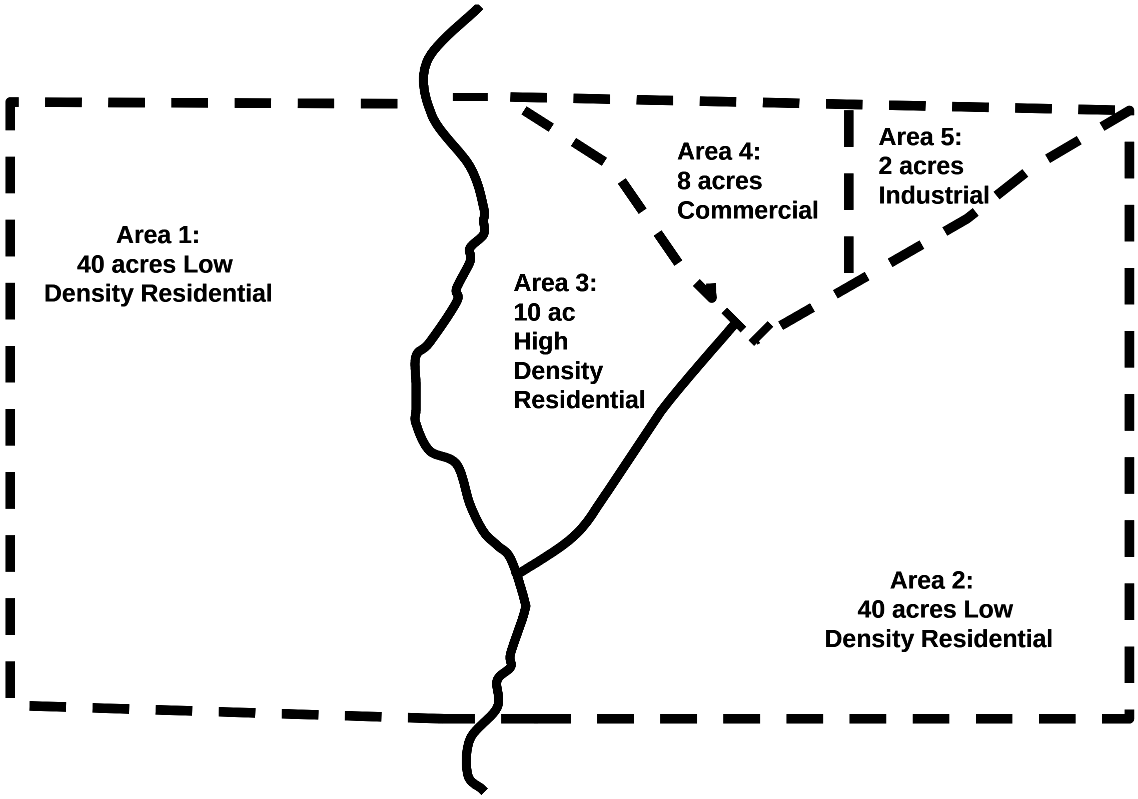
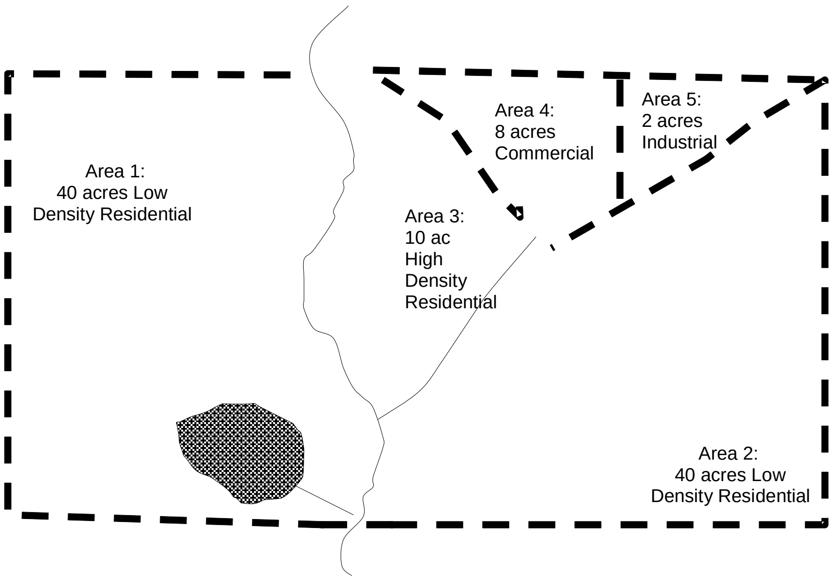
Example 110 Acre Development Site: Area Details



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

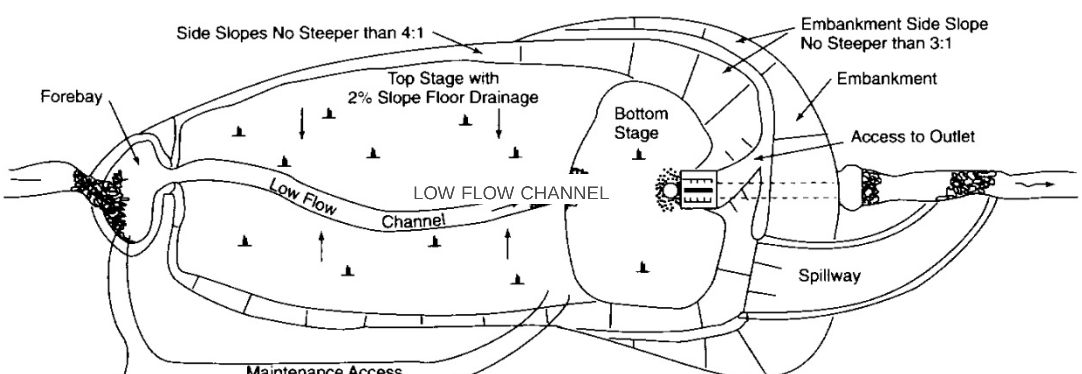
Example 110 Acre Development Site:
Dry Extended Detention Basin Sizing for Area 1



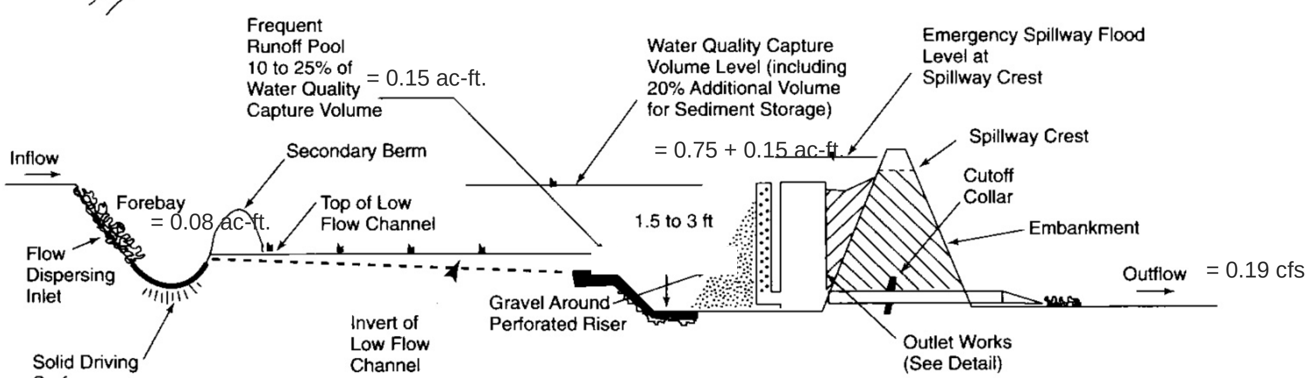
Area 1:
Extended Dry Detention Pond

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



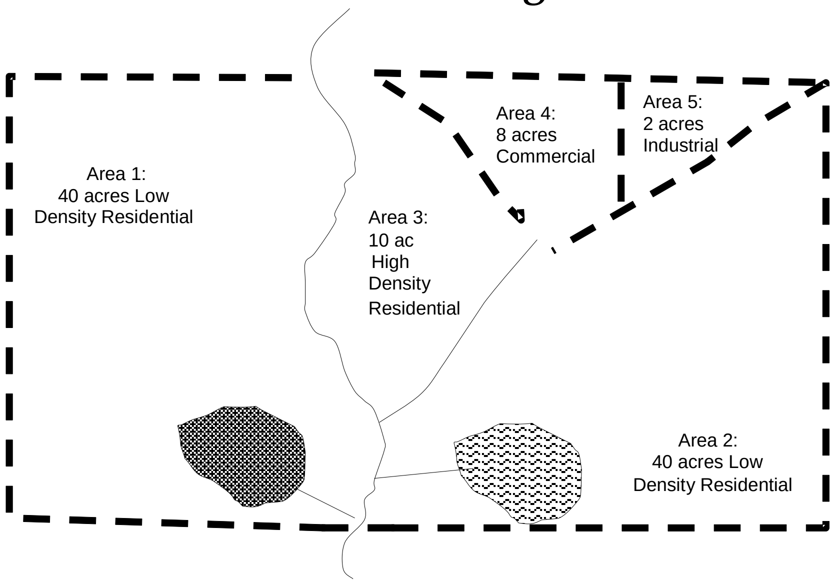
(a)



(b)

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

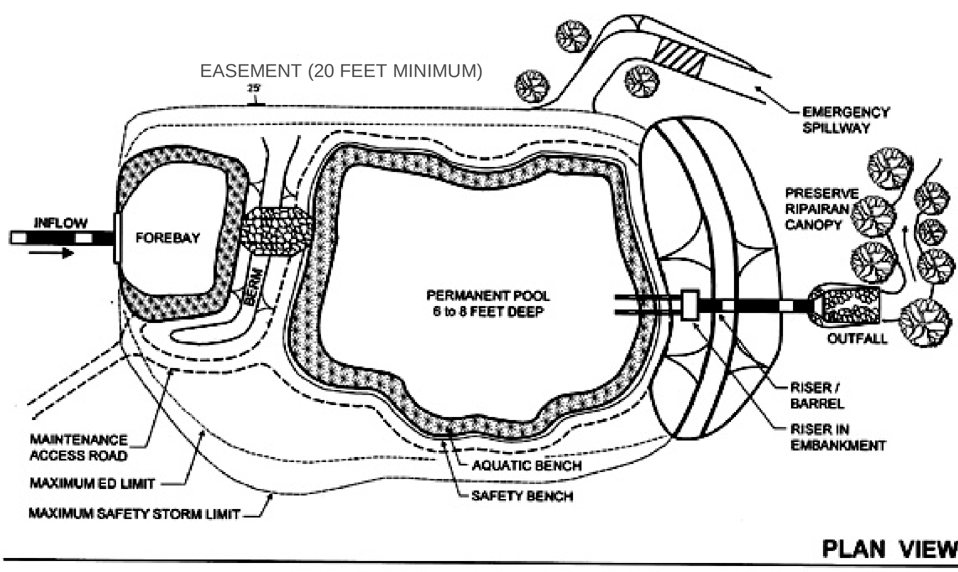
Example 110 Acre Development Site: Wet Detention Basin Sizing for Area 2

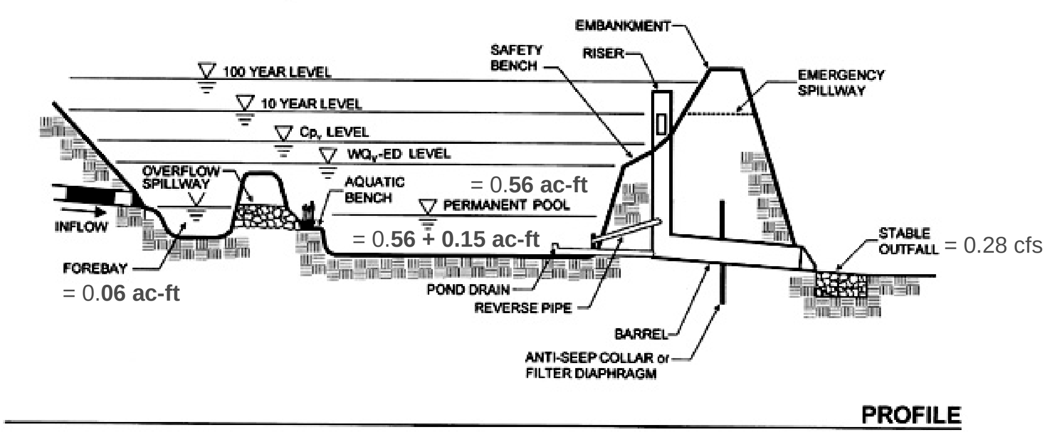


Area 2:
Wet Detention Pond

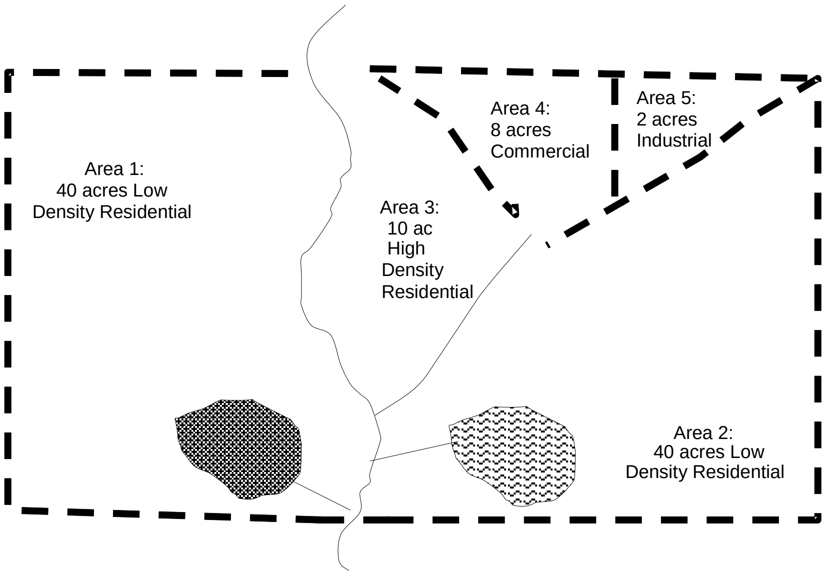
WQV = P * C * A / 12 (Sec. 3.3.2)
WQV = (0.75' * 0.3 * 40 ac) / 12
= .75 ac-ft
Extended Detention = 0.75 * WQV (Sec. 3.3.4)
= .56 ac-ft
Permanent Pool = 0.75 * WQV (Sec. 3.3.4)
= .56 ac-ft
Sediment Storage = 0.2 * WQV (Sec. 3.3.4)
= .15 ac-ft
Forebay = 0.1 * WQV (Sec. 3.3.4.1)
= 0.08 ac-ft
Discharge = 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





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

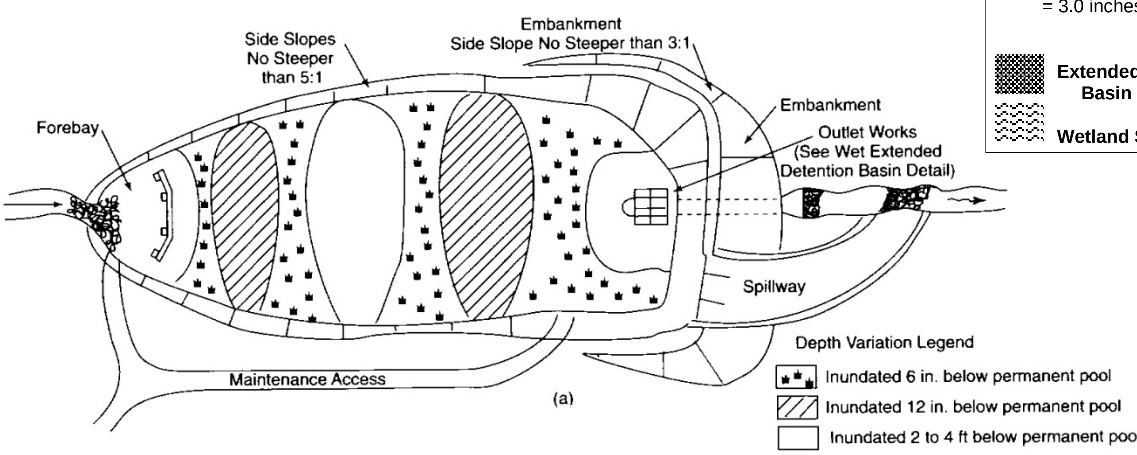


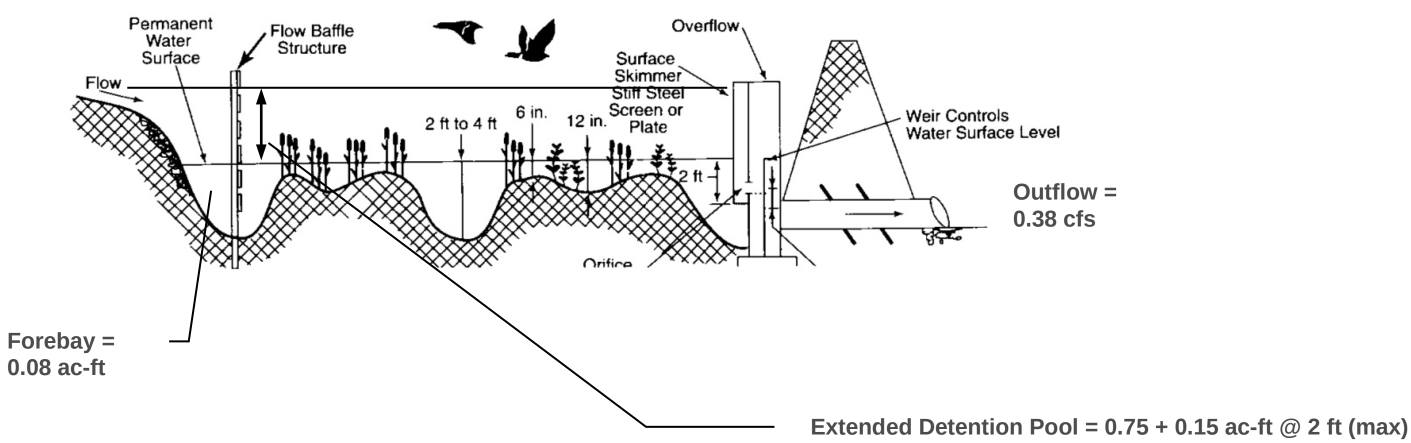
Area 2 (Alternative):
Wetland

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





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[1]
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:

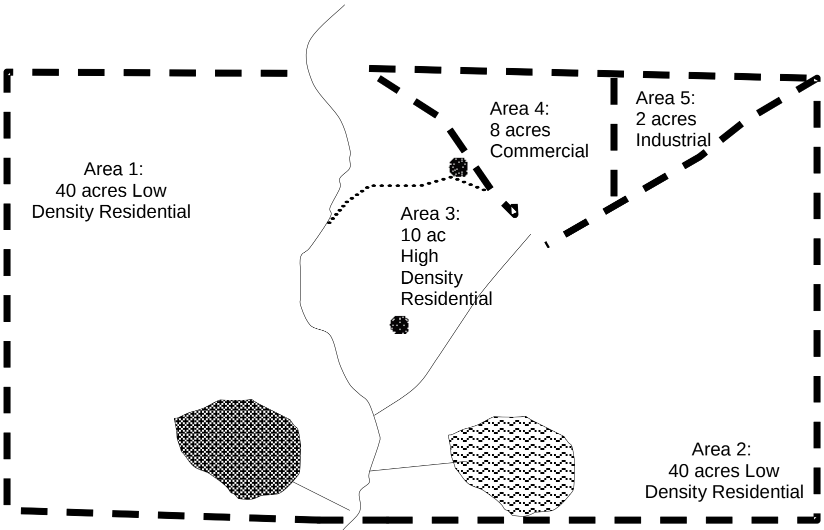
$$\Delta V = -(0.75*0.2 \text{ inches / day}) * A *30 \text{ days} *1 \text{ foot}/12 \text{ inches}$$

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

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 evapotranpiration volume, i.e., 0.75 times the area of the wetland, or 0.75 times the WQ_v, whichever is greater. Vegetation selected for constructed wetlands must be able to tolerate a drawdown of this depth.

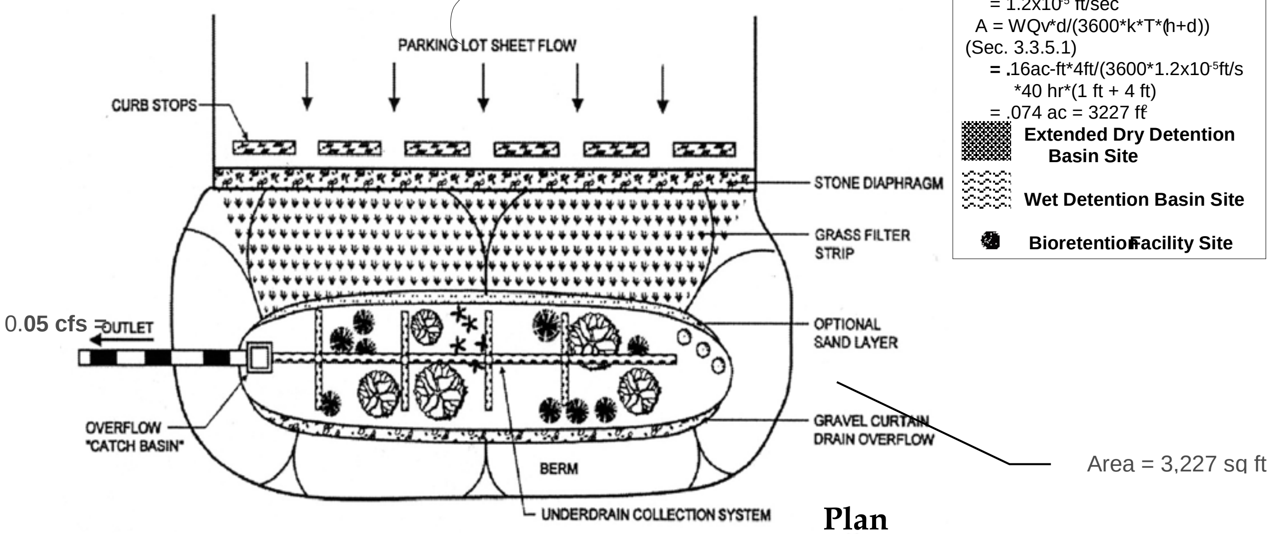
[1] *Treatment Wetlands*, pg. 192.

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

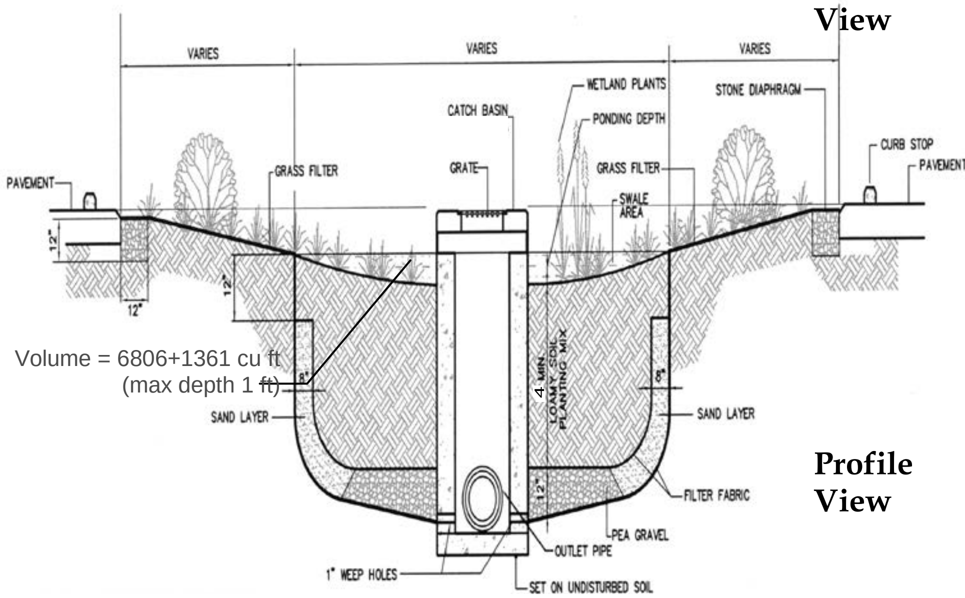


Area 3:
Bioretention
WQV = P * C * A / 12 (Sec. 3.3.2)
WQV = (0.75" * 0.5 * 10 ac) / 12
= .31 ac-ft = 13,612 cu. ft.
Maximum Drainage Area = 5 ac.
→ 10 ac / 5 ac per filter = 2 units
Volume per Unit = WQV / 2
= 6,806 cu. ft.
Sediment Storage = 0.2 * vol (Sec. 3.3.4)
= 1,361 cu. ft.
Discharge = Volume / Drawdown (Sec. 3.3.5.1)
= 6,806 cu. ft. / 40 hrs
= .05 cfs
Surface Area of each Facility
d = planting media depth = 4 ft
h = max depth water = 1 ft
K = planting media permeabilty
= 1.2×10^{-5} ft/sec
A = WQv*d/(3600*k*T*(h+d)) (Sec. 3.3.5.1)
= .16ac-ft*4ft/(3600*1.2×10^{-5}ft/s *40 hr*(1 ft + 4 ft)
= .074 ac = 3227 ft^2

Extended Dry Detention Basin Site
Wet Detention Basin Site
Bioretention Facility Site

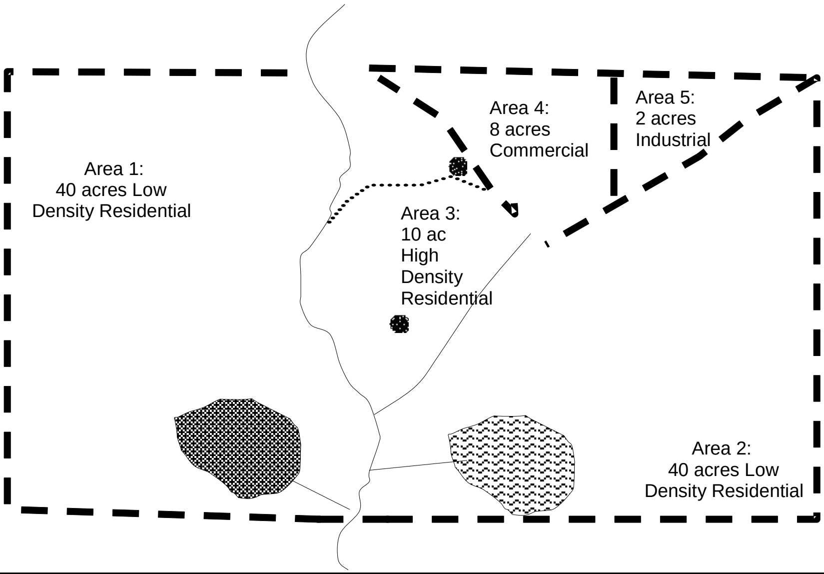


Plan View



Profile View

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

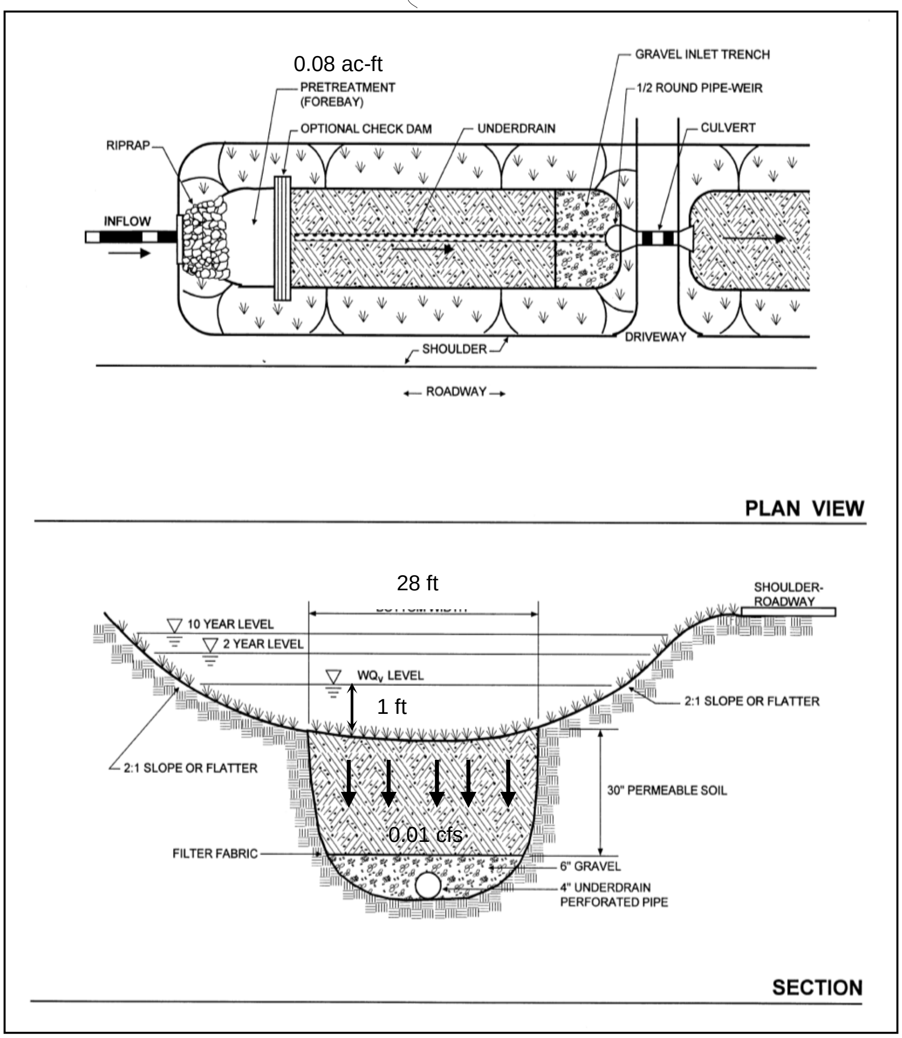


<u>Extended Dry Detention Swales:</u>

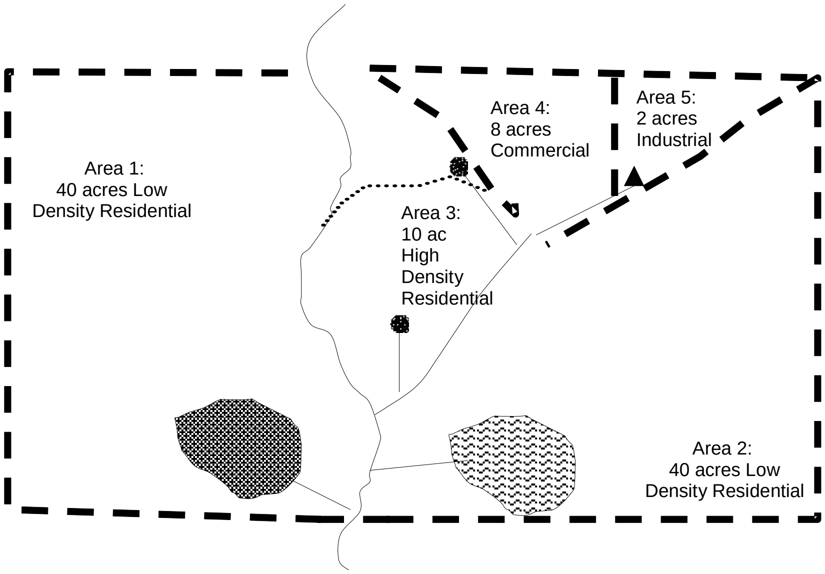
WQV = P * C * A / 12 (Sec. 3.3.2)
WQV = (0.75' * 0.75 * 8 ac) / 12
= .38 ac-ft = 16,335 cu. ft.
Extended Detention = WQV
= 0.38 ac-ft
Sediment Storage = 0.2 * WQV
= 0.08 ac-ft.
Discharge = Volume / Drawdown Time
= 0.38 ac-ft / 40 hrs
= .01 cfs

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



Area 5:
Sand Filter

WQV = P * C * A / 12 (Sec. 3.3.2)
WQV = (0.75" * 0.8 * 2 ac) / 12
= .1 ac-ft (43560sf/ac)
= 4,356 cu ft

Sedimentation Basin = WQV (Sec. 3.3.5.2)
= 4,356 cu ft

Sediment Storage = 0.2 * WQV (Sec. 3.3.4)
= 871 cu ft

Discharge = Extended Detention Volume / Drawdown time (Sec. 3.3.5.2)
= 4,356 cu ft / 40 hrs
= .03 cfs

Assume depth on filter = 4 ft (Sec. 3.3.5.2, L&G#2)

Surface area, sand filter

Af = WQv*d/(k*t*(h+d)) (Sec. 3.3.5.2)

$= \frac{4{,}356 \text{ cu ft} * 1.5 \text{ ft}}{(3.5 \text{ ft/day} * 1.67 \text{ day} * (2 \text{ ft} + 1.5 \text{ ft}))}$

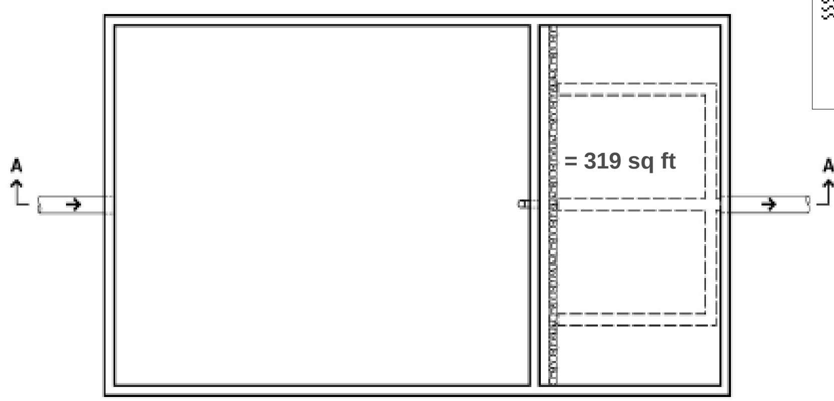
= 319 sq ft

Extended Dry Detention Basin Site

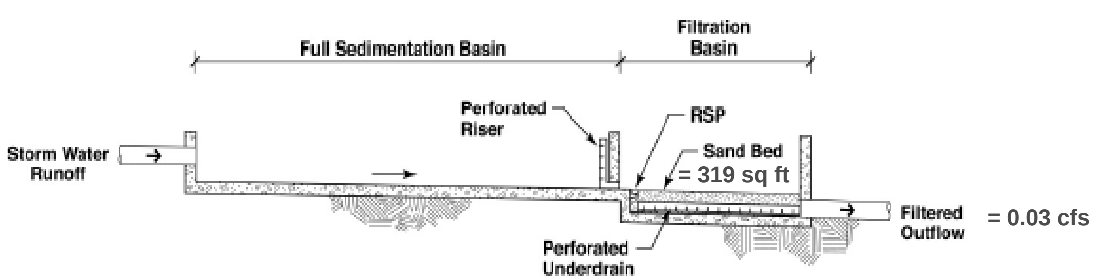
Wet Detention Basin Site

Bioretention Facility Site

Sand Filter Site



PLAN



SECTION A-A

Example < 5 Acre Development Site:
Vegetated Swale for 4 acre Development Site

Vegetated Swales

WQV = P*C*A/12

WQV = (0.75"*0.75*4ac)/12

= 0.19 ac-ft = 8,168 cu.ft.

$t_o = 1.8(1.1\text{-}C)L^{1/2} / s^{1/3}$

$t_o = 1.8(1.1\text{-}0.75)100^{1/2} / 0.03^{1/3}$

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

$Q = (1.49/n)\ A\ R^{2/3}\ S^{½}$

$0.82\ \text{cfs} = (1.49/0.25)\ A\ R^{2/3}\ 0.03^{½}$

$0.79 = A\ R^{2/3}$

Max depth, d, is 2 in (0.17ft)

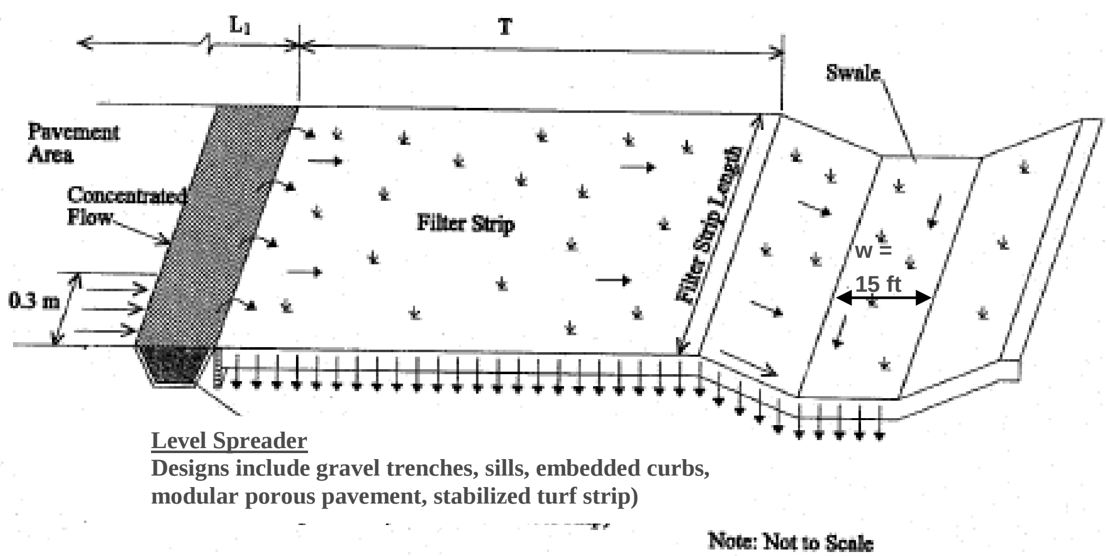
With wide channel assumption:

A = wd

R = d

$0.79 = w*(0.17)^{5/3}$

w = 15 ft



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Stormwater Drainage Manual

Appendix E

Stormwater Management Plan Checklist

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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-ways, 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 BMPs**
- ____ **Water quality volume (WQv) calculations**
- ____ **Drawdown calculations**
- ____ **Required areas for media filters (Group 2)**
- ____ **Design and design flow rate for swale and filters strips (Group 3)**
- ____ **BMP Maintenance plan**
- ____ **Commercial Activity Areas**
  - ____ **Location shown and area clearly delineated**
  - ____ **Standard Industrial Classification (SIC) identified**
  - ____ **Materials handling areas clearly delineated**
  - ____ **High-risk and low-risk pollutant source identified**
  - ____ **On-site storm and sanitary sewer systems including discharges and outfalls shown**
  - ____ **If applicable, oil/water separator, spill containment (110% of volume stored) and treatment systems shown**
  - ____ **Area covered from rainfall with cover or roof of required dimensions**
  - ____ **Area graded to minimize runoff**
  - ____ **Appropriate methods for material disposal shown including sanitary sewer or other**

Easement Descriptions

_____ Legal Descriptions
- **____ Legal size paper**
- **____ Registered surveyor signature and seal**

____ Exhibits
- **____ Legal size paper**
- **____ Registered surveyor signature and seal**

____ Owner Name
____ Mailing address
____ Phone number

Title Sheet

____ Correct project title
____ Location map
____ Bench marks
____ Estimated quantities
____ Standard drawings
____ General notes
____ Signature block

Plan View

____ North Arrow orientation
____ Proper structure numbering
____ Scale
____ Reference point
____ Property information
____ Stream identification
- **____ 100 year flood plain limits**

____ Stormwater facilities size, types, and location
- **____ Water quality BMPs**
- **____ Detention facilities (include maximum ponding limits)**
- **____ Storm sewers**
- **____ Open channels**
- **____ Flood routing**
- **____ Culverts**

____ Proposed and existing easements
____ Agricultural field tiles
____ Existing and proposed utilities
____ Proper structure and pipe annotation
____ Stormwater Pollution Prevention Plan (SWP3)

Profile View

____ Scale
____ Stationing
____ Utility, street, driveway, and stream crossings
____ Proper structure and pipe annotation
____ Granular backfill and encasement limits
____ Proper ground surface line types

Details and Cross Sections

- **____ Open channel and flood routing swale cross-sections**
- **____ Culvert profiles**
  - **____ Elevation information**
  - **____ Flow and velocity data**
- **____ Stormwater BMP details**
  - **____ Plan view**
  - **____ Elevation view**
  - **____ Volume and drawdown data**
  - **____ Planting list**
- **____ Detention Ponds**
  - **____ Cross section(s)**
  - **____ Elevation information**
  - **____ Forebay details**
  - **____ Outlet structure details**

Stormwater Drainage Manual

Appendix F

As – Built Location Forms

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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

Stormwater Outfall As-built Location

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

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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 BMP only

______ overflow catch basin or standpipe for dry extended detention swales

Northing _____________

Easting ______________

Is facility intended to provide (check those that apply):

______ water quality control only
______ water quantity control only, or
______ water quality control and water quantity control

For office use only: Work Manager asset no. assigned _________________
Maintenance responsibility: ______ Franklin County or _________Township or ______ Private property owner/Home Owners Association

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Stormwater Drainage Manual

Appendix G

Alternative Manufactured BMP Approval Guideline

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Alternative Manufactured Best Management Practices Policy (BMPs)

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 BMPs SWDM* 2.) Applicant must adequately explain why the use of Group 1, 2, or 3 BMPs 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 BMPs from the Franklin County SWDM.* 2.) Must provide drawdown time.
Redevelopment	1.) Reduce impervious area by 20%. 2.) Use Group 1, 2, or 3 BMPs 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 BMPs 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 BMPs 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 BMPs 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 BMPs 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 BMP 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 BMPs on sites greater than 5 acres ***must*** explain to the OEPA why other BMPs 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.

Commissioners
Paula Brooks
Marilyn Brown
John O'Grady

Dean C. Ringle PE, PS
Franklin County Drainage Engineer
970 Dublin Road
Columbus, Ohio 43215

Tel. 614-525-3030
Fax 614-525-3359
http://www.franklincountyengineer.org/