Chapter 7: Stormwater

7.1 INTRODUCTION

This Manual establishes design criteria required for stormwater facilities within the City of Hilliard in conjunction with City Ordinance Part Eleven, Titles Three and Seven and the Ohio Environmental Protection Agency's (OEPA) National Pollution Discharge Elimination System (NPDES) Phase II Stormwater Program. While adherence to this Manual will not stop flooding or prevent all damage caused by flooding, it does establish a basis for design which will:

- Minimize the damage and inconvenience of flooding;
- Provide drainage systems which continue to provide benefit over the long term;
- Minimize the expense of maintaining the drainage facilities within the City;
- Reduce non-point-source pollution;
- Minimize new impacts on engineered and natural drainage systems;
- Prevent or reduce impacts to stream and river ecosystems.

An Ohio EPA Permit-To-Install (PTI) is needed when a person wishes to construct any wastewater collection, storage or treatment system or wishes to modify any existing wastewater collection, storage or treatment system.

7.1.1 Administration

The ***City Engineer or their designee*** is authorized to administer, implement and enforce the provisions of this Manual. The City Engineer shall serve as the principal executive officer for stormwater management for the purposes of fulfilling the requirements of the OEPA's NPDES Phase II Stormwater Program. Compliance with this Manual will be determined by the City Engineer and his/her office. The City Planning Commission shall not recommend for approval the final plat of any development or subdivision over which it has jurisdiction without documentation from the City Engineer, that such the development or subdivision has been designed to be in compliance with the design requirements herein.

7.1.2 Drainage Policy

7.1.2.1 This drainage policy, control guidelines and criteria do not provide solutions to all drainage problems, nor is the engineer restricted to these designs or procedures exclusively. Although the policies as stated will hold true for most development work, the City realizes that there may be individual projects involving special or unusual drainage design problems that should be reviewed prior to completing the requisite Master Drainage Plan. Exceptions may be granted by the City Engineer to the policies and criteria in such cases when engineering study(s) justify modification.

7.1.2.2 Master Drainage Plan Requirement. For all new development, a Master Drainage Plan for the total development area shall be prepared and presented to the City Engineer for review and approval with the preliminary site development plan submitted to the Planning and Zoning Commission. The Master Drainage Plan does not constitute a detailed working design or plan from which storm sewer improvements can be constructed, nor is such detail necessary to meet the objectives of preliminary drainage review. The Master Drainage Plan shall be reviewed and approved by the City Engineer prior to initiating detailed site engineering designs. The required content of the Master Drainage Plan is as follows:

a. A topographic contour map, with the drainage area delineated, with a plan for draining the total upstream tributary watershed through the proposed development.

b. A topographic map with at least 2-foot contour interval, with general layout of the proposed inlets and storm sewers for the total development showing all existing drainage structures with size and invert elevations.

c. The capacity of the downstream open channel, culvert or storm sewer that may be used for an outlet.

d. The points downstream that may be used as a control to affirm the maximum allowable release rate of stormwater runoff for the design storm.

e. The routing path to be provided for runoff in the event the drainage facilities' capacity is exceeded. This path will become part of a grading plan, which will be submitted with detail plans. The routing path should be continuous from one development to the next.

f. A general delineation of all easements, conservation areas, Stream Corridor Protection Zone (SCPZ), reserves, etc. to be provided as part of the master stormwater plan. The width of easement to be shown on the plans.

g. Stormwater management quantitative and qualitative controls shall be located on the plan and shall become part of the routing path. Excess stormwater shall be kept out of proposed habitable structures.

7.1.2.3 Land uses and developments which increase runoff rate or volume shall control the discharge rate of runoff prior to its release to off-site land or the Municipal Separate Storm Sewer System (MS4).

a. Land uses and developments which increase runoff rate or volume shall control the discharge rate of runoff prior to its release to off-site land.

b. Surface water runoff from a development shall be drained off site to an adequate drainage outlet. The location of the outlet shall be approved by the City Engineer and may consist of a ditch, stream, storm sewer, or approved detention basin having sufficient capacity to accommodate the surface water runoff in an engineered manner.

c. It is the responsibility of the property owner to not change or alter any drainage course, ditch, flood routing path or drainage system on his/her property that will cause increased runoff, or will damage or cause flooding to adjacent, upstream or downstream property owners.

d. All stormwater drainage systems, including conveyances, within a development shall be designed to have capacity and depth, including sufficient invert elevations to permit future connections, to serve that total tributary area at the design storm frequency, and based on the rate of single family, residential runoff. The system for the upstream tributary area must be extended through the development.

e. All proposed development with a runoff rate greater than that which the downstream system has capacity for, or will be designed for, will be required to control the rate of stormwater discharge based upon the capacity of the downstream system.

f. All developments will be required to control the peak flow rate of stormwater discharge, in accordance with critical Storm method. (See Section 2.0)

g. A Stormwater Plan shall be submitted to the City for review and approval prior to the commencement of work at any proposed development site.

h. All information necessary shall be submitted to the City to determine how stormwater runoff should be controlled within the development prior to its release to downstream properties. The tributary area and the upstream watersheds should be determined using natural land divides unless man-made alterations are approved by the City Engineer as the basis for watershed delineations.

i. This Stormwater Design Manual applies to all land developments not specifically exempted or granted a waiver as provided under City Ordinance 1179.09 (c) and (d), and 1131.01.

7.1.3 Stream Corridor Protection

The Stream Corridor Protection Zone (SCPZ) is established through designation of a riparian setback that will be required on all stream channels (refer to definition in Glossary). The applicant shall identify and label all streams within the project site along with the appropriately defined SCPZ, relying on published data and/or site specific information collected by the Applicant. The SCPZ shall be kept in as natural a state as possible so that it can perform its inherent function of erosion protection, flood storage, and water quality protection. The SCPZ for streams within the City of Hilliard has been mapped by the City. A copy of the mapped protection zones may be obtained from the City Engineer and is also found on the City's website. The map provided by the City of Hilliard should only be used for reference purposes.

7.1.3.1 Locations Within the Big Darby Creek Watershed

For locations within the Big Darby Creek watershed, the actual designation of the SCPZ on any specific parcel shall be determined by the applicant using the 'Riparian Setback Requirements' provided in the most current version of the OEPA's General Permit for Stormwater Discharges Associated with Construction Activity within the Big Darby Creek watershed.

The SCPZ map provided by the City for areas within the Big Darby Watershed illustrates a 'Priority Stream Restoration Zone' identified within the Big Darby Accord Watershed Master Plan. The OEPA's General Permit provides a contingency for stream restoration that would redefine the SCPZ boundary, which is approximately shown on the map as "SCPZ w/Stream Restoration". The actual SCPZ boundary associated with a stream restoration project would be determined as part of the project development process.

7.1.3.2 Locations Outside of the Big Darby Creek Watershed

For locations outside of the Big Darby Creek watershed, the SCPZ shall be determined using the criteria described below.

a. The width of the SCPZ shall be based upon the following formula and also considering site specific conditions or the Federal Emergency Management Agency (FEMA) designated floodway, whichever is wider:

$$SW = 147 \times DA^{0.37}$$

Where:
SW= Setback (streamway) width measured in feet, being the total width of the protection setback at a stream channel cross-section,

DA= Drainage area in square miles

Using this formula, the SCPZ is approximately 10 channel widths (bank-to-bank).

b. Mapping:
The SCPZ setback will be centered on the channel centerline. However, the position of the boundary may be modified at the City Engineer's discretion to include known areas of environmental sensitivity in close proximity to channels banks, to include sensitive steep slopes adjacent to a channel edge or to exclude high terrain that is adjacent to a stream channel. In areas where the channel meanders, the SCPZ may not always be centered over the stream. In this case, it is better visualized as a flood path or roughly the floodway. Thus, setback areas should be fit to the channel valley. They shall be positioned so that corresponding left and right boundary elevations match and the setback area incorporates the lowest elevations in the valley.

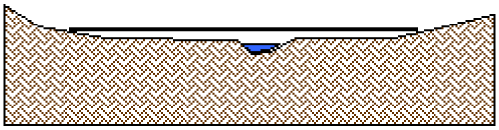


Figure 7-1. SCPZ Centered over Floodway with Matching Elevations at either Boundary.

The SCPZ shall be a combination of two overlapping areas, one based on the calculated setback (streamway) width and the other based on a minimum distance from the channel bank, equivalent to one (1) channel width as illustrated in Figure 7-1.

In addition, at no point shall the distance between the setback boundary and the channel be less than:

$$Md = 14.7 \times DA^{0.38}$$

Where:

Md= The minimum distance from the channel bank.

DA= Drainage area in square miles

This formula estimates a minimum distance of approximately one channel width.

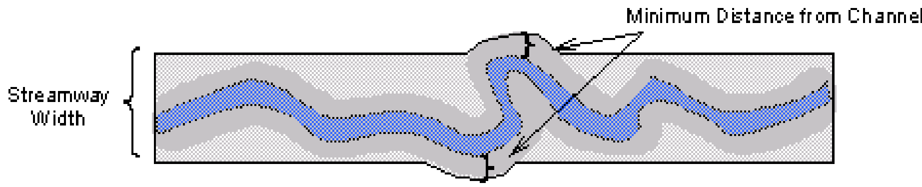


Figure 7-2. SCPZ as a Combination of the Streamway and Minimum Distance from Channel.

c. Considering all of the criteria in paragraphs a. and b., the minimum width will be 50 feet plus the width of the channel (i.e., 25-feet on each side of the channel, measured from the channel bank). The maximum width will be 250 feet plus channel width, or the width of the floodway.

d. The SCPZ must be clearly shown on site development plans.

7.1.3.3 Construction Limitations

The following conditions shall apply to all Stream Corridor Protection Zones:

a. Except as otherwise provided in this regulation, the SCPZ shall be preserved in its natural state.

b. Prior to any earthmoving or clearing and grubbing activity on a development property, the SCPZ shall be clearly delineated on the site by the applicant or their designated representative. Such delineation shall also be identified on the Erosion and Sediment Pollution Control Plan (see City Code Section 1179.011) and this delineation shall be maintained throughout soil disturbing activity.

c. No later than the conclusion of construction, the applicant shall permanently delineate the SCPZ in an aesthetically harmonious manner, approved by the City Engineer, such that the location of the riparian setback boundary defining the SCPZ is apparent to the casual observer,

d. Language prohibiting property owners from constructing facilities and performing activities that are prohibited within the SCPZ shall be shown on the plat or separate instrument and reflected on all deeds.

e. Land contained within the SCPZ may, at the applicant's option and if approved by the City of Hilliard's Council, be deeded in fee simple to the City of Hilliard. Alternatively, the land contained within the SCPZ shall be preserved via dedicated conservation easement, environmental covenant or reserve.

f. Any proposed encroachments within a SCPZ that are not permissible as defined in paragraph 1.3.4a., must be first granted a waiver by the City as described in Section 1131.01 (c) of the City's Code. The granting of a waiver will require demonstration of suitable mitigation as referenced in the code and required under the Ohio EPA's General Permit for Stormwater Discharges Associated with Construction Activities within the Big Darby Creek Watershed.

7.1.3.4 Permitted, Conditional and Prohibited Uses

The permitted, condition and prohibited uses described below are derived from the OEPA's State Water Quality Management (Section 208) Plan, Appendix 9-3.

a. Permitted uses and activities. No use or activity permitted shall be construed as allowing trespass on privately held lands. The following uses are permissible within the SCPZ.

1. Passive Uses. Uses that are passive in character shall be permitted in the SCPZ, including, but not limited to, passive recreational uses, as permitted by federal, state and local laws, such as hiking, fishing, picnicking, and similar uses. Construction of unimproved, pervious trails less than five feet wide that are no closer than 125 feet from the edge of the stream to further such passive recreation uses is also permitted, as are river access points. However, trails that become damaged due to natural erosion shall not be repaired but shall be moved upland or removed altogether.

2. Removal of Damaged or Diseased Trees. Damaged or diseased trees may be removed. Due to the potential for felled logs and branches to damage downstream properties and/or block watercourses or otherwise exacerbate flooding, logs and branches resulting from the removal of damaged or diseased trees that are greater than six (6)-inches in diameter at the cut end shall be cut into sections no longer than six (6)-feet, anchored to the shore or removed.

3. Revegetation and/or Reforestation. Revegetation and/or reforestation of the riparian setback will be permissible using species identified in Table 1. Table 1 lists species of plants and shrubs recommended for stabilizing flood prone areas. Proper selection of species is dependent on soil conditions, available water and amount of sun exposure. Proper species selection will take into account these factors.

Table 7-1. Species of Plants & Shrubs Recommended for Stabilizing Flood Prone Areas

Riparian Corridor- Trees

Botanical Name	Common Name
Acer spp.	Maple(s)
Betula nigra	River Birch
Carya spp.	Hickory(s)
Celtis occidentalis	Common hackberry
Cercis canadensis	Eastern redbud
Crataegus phaenopyrum	Washington hawthorne
Crateaegus crusgalli	Cockspur hawthorne
Fagus grandiflora	Beech
Gleditsia triacanthos	Honeylocust
Hamamelis virginiana	Common witchhazel
Liriodendron tulipifera	Tulip poplar
Liquidambar styraciflua	Sweetgum
Platanus occidentalis	Sycamore
Populus deltoids	Eastern cottonwood
Prunus serotina	Black cherry
Quercus alba	White oak

Quercus palustris	Pin oak
Quercus rubra	Red Oak
Ulmus rubra	Slippery elm

Riparian Corridor- Shrubs

Botanical Name	Common Name
Aronia melanocarpa	Black chokeberry
Cornus racemosa	Gray dogwood
*Cornus stolonifera**	Red-osier dogwood
Lindera benzoin	Spicebush
*Salix spp.**	Willow(s)
Sambucus canadensis	Elderberry
Viburnum dentatum	Southern arrowwood
Viburnum prunifolium	Blackhaw viburnum
Viburnum lentago	Nannyberry viburnum
Viburnum trilobum	American cranberrybush

*Instream plantings for rapid shade cover and bank stabilization.

4. Public Utilities. Sanitary sewer, storm sewer, and/or water lines and public utility transmission lines may be located within the SCPZ and disturbances of the SCPZ necessary to place and/or maintain such utilities are also authorized. The placement, construction and maintenance of such utilities shall minimize disturbance to riparian areas and shall mitigate any necessary disturbances. The developer and/or landowner shall secure the appropriate state and federal permits required for installation of the specific utility(s). Utilities that are parallel to the stream shall not be constructed or placed within the SCPZ.

5. Public Roadways. Public roadways may cross the SCPZ and disturbances of the SCPZ necessary to place and/or maintain the roadways are authorized. The placement, construction and maintenance of the roadway shall minimize disturbance to riparian areas and shall mitigate any necessary disturbances. There shall be no more than two roadway crossings of the setback within any proposed development. The developer and/or landowner shall secure the appropriate state and federal permits required for watercourse impacts attributed to this activity.

6. Construction activities associated with permitted stream restoration projects.

7. Disturbances resulting from permitted stream and/or wetland mitigation projects.

8. “Emergency Channel Maintenance Activity” may be authorized by the City Engineer, as needed, to restore and/or maintain the flood carrying capacity of the main channel area. Such activity may include, but not be limited to, removal of trees or brush or the accumulation of sediment in the main channel as necessary to restore flood flow carrying capacity of the main channel.

b. Conditional Uses. These uses are not explicitly permitted but may be allowed subject to review and approval of the City. The City’s review of these activities will consider the extent to which disturbances will occur within the SCPZ and how those disturbances will be mitigated. A conditional use activity will be denied by the City if it is found to be inconsistent with the need to protect the stream channel from impacts that impair water quality and or channel stability, or if the activity may require future maintenance that would further disturb the SCPZ.

1. Streambank stabilization/erosion control work. Localized or large-scale stream channel and riparian buffer restoration work that is ecologically compatible with the surrounding features and substantially uses natural and native materials.

2. Construction of paved (asphalt) or unpaved (gravel) trails to further passive recreation uses. Such trails that become damaged due to natural erosion shall not be repaired, but shall be relocated upland and outside of the SCPZ. Specific conditions applicable to paved trails can be found in the Appendix 9-3 of the Section 208 Plan.

3. A driveway or non-arterial roadway. This activity is limited to projects where the proposed roadway is the only access for the parcel and/or the roadway provides some ecological protection to surrounding areas by preserving existing ecologically sensitive areas.

c. Prohibited Uses. Any use not authorized under these regulations shall be prohibited in the SCPZ. The following is a list of specific uses prohibited in the SCPZ, but is not inclusive of all uses prohibited in the SCPZ:

1. Construction. There shall be no structures of any kind except as required for the permitted or conditional uses listed previously.

2. Dredging or Filling. There shall be no drilling, filling, dredging, grading, or dumping of soils, spoils, liquid or solid materials. No floodplain fill permits will be granted for areas within the SCPZ except those that are required for activities listed as permitted uses.

3. Motorized Vehicles. There shall be no use of motorized vehicles except as needed for activities associated with the permitted uses listed previously

4. Parking Lots. There shall be no parking lots or other man-made impervious cover.

5. Stormwater Detention Facilities. Stormwater detention facilities may be located adjacent to, but not within the SCPZ.

6. Watercourse Enclosures: No open channels (natural or man-made) in the SCPZ will be enclosed within a storm sewer or conduit.

7. Developed or Platted Lots. No part of any lot to be developed or platted will be located within the SCPZ.

d. Non-conforming Uses and Structures within the SCPZ.

1. Any pre-existing non-conforming use within a SCPZ may be continued, but shall not be changed to a new use or enlarged unless changed to a use permitted under this regulation.

2. A non-conforming use within a SCPZ may be continued, but shall not have the existing building footprint or roofline expanded or enlarged.

3. A non-conforming use within a SCPZ that has substantial damage and that is discontinued, terminated, or abandoned for a period of six (6) months or more may not be revived, restored or re-established.

7.1.3.5 Maintenance of the Stream Corridor Protection Zone

a. Disturbance of Natural Vegetation. There shall be no disturbance of the natural vegetation at any time, including during construction of the remainder of the site, except for such conservation maintenance that the landowner and the City deem necessary to control noxious weeds; for such plantings as are consistent with the guidance in this Manual for removal of invasive species and their replacement with native vegetation.

b. Recommended Vegetation for Stabilizing Flood prone Areas. Proper selection of species for stabilization of flood prone areas is dependent on several factors, including soil conditions, available water and amount of sun exposure. Proper species selection and installation will take into account these factors. A list of appropriate plant species is given in Table 1.

7.1.4 Drainage Easements

In order to provide access for City personnel for inspection and maintenance, the Developer is required to procure and convey to the City an easement for any tile, pipe, detention basin, drainage way, flood routing path, ditch, watercourse, natural stream, man-made stream, storm sewer, or other stormwater component or facility not already within the City right-of-way. The Owner and/or Developer will be required to follow City Code Section 1179.04 with regard to the procurement, execution, and maintenance of the Easement. The easement must be of sufficient width to allow cleaning, widening, deepening, replacing or other general maintenance of such drainage course or piped system.

When it is necessary to convey stormwater outside the property lines of a proposed improved area in order to discharge into an adequate outlet, the Developer:

a. is required to obtain easements and/or maintenance agreements, in a form and substance satisfactory to the City Engineer, from abutting property owners, and

b. is responsible for maintenance agreements for such drainage course unless the easements and/or maintenance agreements require the abutting property owners to repair and maintain the drainage course satisfactorily.

All drainage easements, preservation areas, reserves and other similar areas must be shown on the "final engineering and construction plan(s)". Drainage easements for all on-site drainage system improvements shall be recorded for public use by final plat and deed. For off-site drainage system improvements, easements should be recorded for public use by either final plat or separate instrument. The maintenance of such drainage easements shall be undertaken in the manner set forth in Section 1179.091 of the City Code and as specified in Section 4.10, below.

7.2 STORMWATER RUNOFF CONTROL CRITERIA

Post-construction and construction stormwater control criteria within the City of Hilliard differ for areas located within the Big Darby Watershed. Sections 2.1 and 2.2, below, represent the general stormwater control criteria which are applicable to all areas within the City limits. Section 2.3 references the additional control criteria required for developing areas within the Big Darby Creek Watershed. The OEPA recommends that stormwater management practices meet the standards and specifications in the most current edition of the Rainwater and Land Development Manual provided by the Ohio Department of Natural Resources (ODNR).

7.2.1 Quantitative Control

Stormwater runoff control shall address both peak rate and total volume of runoff. The peak rate of runoff from an area after development shall not exceed the peak rate of runoff from the same area before development for all storms from one year up to a 100-year return frequency storm. In addition, if it is found a proposed development will increase the volume of runoff from an area, the peak rate of runoff from certain more frequent storms must be controlled further. There are two reasons why increases in volume of runoff require a control standard more restrictive than controlling to the predevelopment condition. First, increases in volume mean runoff will be flowing for a longer period of time. When routed through a watershed, these longer flows may join at some point or points downstream thereby creating new peak flows and problems associated with peak flow (flooding and erosion). This is known as the “Routing Problem”. Second, longer flow periods of large runoff quantities place a highly erosive stress on natural channels. This stress can be minimized by reducing the rate of discharge. The permissible peak rate shall be determined as follows:

a. For the purpose of determining the critical storm for all projects and allowable peak flow rates for all projects other than redevelopment projects, a maximum runoff curve number of 77 shall be used. Areas with land use and soil types that correlate to a runoff curve number less than 77 shall use the lower runoff curve number for all pre-developed calculations, see Table 7-3 for runoff curve number values.
b. Determine the total volume of runoff from a 1-year frequency 24-hour storm, occurring over the area both before and after development.

c. Determine the percentage of increase in volume due to development and using this percentage, pick the critical storm from Table 2.

d. The peak rate of runoff from the critical storm occurring over the development shall not exceed the peak rate of runoff from a 1-year frequency storm occurring over the same area under predevelopment conditions. Storms of less frequent occurrence (longer return period) than the critical storm, shall have a peak rate of runoff not greater than for the same storm under predevelopment conditions. As an example, if the total volume is to be increased by 35%, the critical storm is a 5-year storm. The peak rate of runoff for all storms up to this intensity shall be controlled so as not to exceed the peak rate of runoff from a 1-year frequency storm under predevelopment conditions in the area. The runoff from a more intense storm up to a 100-year storm need only be controlled so as not to exceed the predevelopment peak rate from the same frequency of storm.

Table 7-2. Critical Storm for Stormwater Volume Calculations

If the percentage of increase in VOLUME [of] runoff is		The Critical Storm for discharge limitations will be:
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

e. For the purpose of determining the pre-development and post development peak flow rates, calculate the curve numbers using Table 7-3. The pre-developed runoff curve number determination for both new development and redevelopment projects shall be based upon the project area current land use.

Table 7-3: NRCS Runoff Curve Numbers[1]

Description of Land Use	Hydrologic Soil Group			
	A	B	C	D
Paved parking lots, roofs, driveways	98	98	98	98
Streets and Roads:				
Paved with curbs and storm sewers	98	98	98	98
Gravel	76	85	89	91
Dirt	72	82	87	89
Cultivated (Agricultural Crop) Land*:				
With or without conservation treatment (terraces, contours)	62	71	78	81
Pasture or Range Land:				
Poor (<50% ground cover or heavily grazed)	68	79	86	89
Good (50-75% ground cover; not heavily grazed)	39	61	74	80
Meadow (grass, no grazing, mowed for hay)	30	58	71	78
Brush (good, >75% ground cover)	30	48	65	73
Woods and Forests:				
Poor (small trees/brush destroyed by over-grazing or burning)	45	66	77	83
Fair (grazing but not burned; some brush)	36	60	73	79
Good (no grazing; brush covers ground)	30	55	70	77
Open Spaces (lawns, parks, golf courses, cemeteries, etc.):				
Fair (grass covers 50-75% of area)	49	69	79	84
Good (grass covers >75% of area)	39	61	74	80
Commercial and Business Districts (85% impervious)	89	92	94	95

Industrial Districts (72% impervious)	81	88	91	93
Residential Areas:				
1/8 Acre lots, about 65% impervious	77	85	90	92
1/4 Acre lots, about 38% impervious	61	75	83	87
1/2 Acre lots, about 25% impervious	54	70	80	85
1 Acre lots, about 20% impervious	51	68	79	84

[1] **Chow et al. (1988)**

7.2.2 Qualitative Control

Stormwater qualitative control must be implemented into sites in accordance with general and specific requirements outlined in the current version of the OEPA's permit for stormwater discharges associated with construction activity or any subsequent OEPA-issued revision.

7.2.2.1 Large Construction Sites

For all construction activities (involving the disturbance of five or more acres of land or will disturb less than five acres, but is a part of a larger common plan of development or sale which will disturb five or more acres of land), the post construction Best Management Practice (BMP) chosen must be able to detain stormwater runoff for protection of the stream channels, stream erosion control, and improved water quality. Structural (designed) post-construction stormwater treatment practices shall be incorporated into the permanent drainage system for the site. **Water Quality Volume (WQv):** The selected BMP(s) must be sized to treat the water quality volume and ensure compliance with Ohio's Water Quality Standards in Ohio Administrative Code (OAC) Chapter 3745-1. The WQv shall be equivalent to the volume of runoff from a 0.75-inch rainfall and must be determined according to one of the two following methods.

a. Through a site hydrologic study approved by the local City permitting authority that uses continuous hydrologic simulation and local long-term hourly precipitation records or;

b. Using the following equation:

$$WQv = C * P * A / 12$$

where:
WQv = water quality volume in acre-feet

C = runoff coefficient appropriate for storms less than 1 inch (see Table 3)
P = 0.75 inch precipitation depth
A = area draining into the BMP in acres

Table 7-4. Runoff Coefficients Based on the Type of Land Use

Land Use	Runoff Coefficient
Industrial & Commercial	0.8
High Density Residential (>8 Dwellings/Acre)	0.5

Medium Density Residential (4 To 8 Dwellings/Acre)	0.4
Low Density Residential (<4 Dwellings/Acre)	0.3
Open Space And Recreational Areas	0.2

Where the land use will be mixed, the runoff coefficient should be calculated using a weighted average. For example, if 60% of the contributing drainage area to the storm water treatment structure is low density residential, 30% is high density residential, and 10% is open space, the runoff coefficient is calculated as follows (0.6)(0.3) + (0.3)(0.5) + (0.1)(0.2) = 0.35.

An additional volume equal to 20 percent of the WQv shall be incorporated into the BMP for sediment storage and/or reduced infiltration capacity. OEPA recommends that BMPs be designed according to the methodology included in the Rainwater and Land Development manual or in another design manual acceptable for use by OEPA.

BMPs shall be designed such that the drain time is long enough to provide treatment, but short enough to provide storage available for successive rainfall events. The outlet structure for the qualitative control is to be designed to meet the minimum total WQv drain times as indicated within the OEPA General Permit and/or Big Darby Creek permit. The outlet control shall provide a total minimum WQv drain time as indicated within Table 7-5. The outlet structure shall additionally not discharge more than the first half of the WQv in less than one-third of the minimum total drain time.

Table 7-5. Target Draw Down (Drain) Times for Structural Post-Construction Treatment Control Practices

	Drain Time of WQv
Infiltration Basin or Trench	48 Hours
Permeable Pavement – Infiltration	48 Hours
Permeable Pavement – Extended Detention	24 Hours
Extended Detention Basin (Dry Basins)	48 Hours
Extended Detention Basin Basin (Wet Basins)	24 Hours
Constructed Wetland (above Permanent Pool)	24 Hours
Sand & Other Media Filtration, Bioretention	24 Hours

The permittee may request approval from the City Engineer or designee and OEPA to use alternative structural post-construction BMPs. The permittee must demonstrate that the alternative BMPs are equivalent in effectiveness to those listed in Table 7-4, above. New construction activities shall be exempt from this condition if it can be demonstrated that the WQv is provided within an existing structural post-construction BMP, located downstream, that is part of a larger common plan of development, before being released into an open watercourse.

For redevelopment projects (i.e., developments on previously developed property), post-construction practices shall either ensure a twenty (20) percent net reduction of the site impervious area, provide for treatment of at least (20) percent of the WQv or a combination of the two.

7.2.2.2 Small Construction Sites

For all small land disturbance activities (which disturb one or more, but less than five acres of land and which are not a part of a larger common plan of development which will disturb five or more acres of land), a description of the measures that will be installed during the construction process to control pollutants in stormwater discharges that will occur after the construction operations have been completed must be included in the Stormwater Pollution Prevention Plan (SWP3). Practices may include but are not limited to stormwater detention storage (including wet basins), stormwater retention, flow attenuation by use of open vegetated swales and natural depressions, infiltration of runoff onsite, and sequential systems which combine several practices. The SWP3 shall include an explanation of the technical basis used to select the practices to control pollution where flows exceed pre-development levels.

Velocity dissipation devices shall be placed at discharge locations and along the length of any outfall channel to provide non-erosive flow velocity from the structure to a water course so that the natural physical and biological characteristics and functions are maintained and protected.

7.2.3 Stormwater Control Criteria Specific to Big Darby Creek Watershed

The stormwater control criteria and design requirements applicable to the entire Big Darby Creek watershed are specified by the OEPA in the current edition of the General Permit for Stormwater Discharges Associated with Construction Activity Located within the Big Darby Creek Watershed notwithstanding any of the requirements of the City of Hilliard, the applicant is responsible for adhering to all of the Ohio EPA's criteria and obtaining a signed Notice of Intent (NOI), along with an approved SWPPP including documentation of post-construction water quality features, from the OEPA.

7.3 STORMWATER SYSTEM GENERAL DESIGN CRITERIA

7.3.1 Design Storms

a. The initial/minor drainage system is that part of the storm drainage system which is used regularly for collecting, transporting, and disposing of stormwater runoff from frequent and low magnitude storm events, snowmelt, and miscellaneous minor flows. The capacity of the initial drainage system should be equal to the maximum rate of runoff expected from a design storm of established frequency (i.e., Initial Storm).

For purposes of design, the initial drainage system portion of the overall storm drainage system shall be designed to contain the runoff from a storm with a return period of not less than five-years.

b. The major drainage system is that part of the storm drainage system which carries the runoff which exceeds the capacity of the initial drainage system. The major drainage system shall have the capacity to carry runoff from a storm with a return period of not less than 100-years (i.e., Major Storm) without posing significant threat to property or public safety.

c. All conveyances and conduits containing a stream (permissible only through granting of a waiver (refer to Section 1.3) shall have the capacity to carry a minimum of a 10-year design storm from the entire upstream drainage area. In addition, a flood routing flow path shall be included to carry the major storm flow as defined in Section 3.3 of this manual (100-year storm). This flood routing path must be clearly shown on the site development plans, and the applicant shall provide storm water calculations for the proposed enclosure and flood routing path to the City of Hilliard for approval.

7.3.2 Initial Storm – Physical Design Criteria for On-Site Improvements

a. Depth of flow in man-made ditches or swales shall not exceed 80% of the channel depth. Velocity of flow shall be determined in accordance with the design criteria for open channels in Section 4.4 (c)(3), and shall not exceed 5 feet per second, or a rate determined by the City Engineer to be detrimental to the watercourse. Where flows exceed this velocity rate, special channel lining and erosion protection shall be provided.

b. Depth of flow in road-side ditch swales shall not exceed one foot or be of such depth that flow would extend out of the right-of-way if the side ditch is less than one foot in depth. Velocity at this depth shall not exceed six feet per second for grass swales or ten feet per second for paved ditches.

c. Depth of flow in streets with curb and gutter shall not exceed the curb height. Velocity of flow in the gutter at design depth shall not exceed ten feet per second. In addition to the above, the following are maximum encroachments of the initial storm onto the pavement. See Section 4.3 for specific design criteria for curb inlet design.

   1. For minor streets carrying traffic from the individual residence to collector and secondary streets, the flow may spread to the crown of the street.

   2. For collector and secondary streets, one lane shall be free from water.

   3. For primary streets, one lane in each direction shall be free from water.

   4. For freeways, no encroachment is allowed on traffic lanes.

d. In design of a storm sewer pipe conduit, the conduit may be designed on the basis of flowing full with surcharge to gutter line. Backwater effects must be considered.

7.3.3 Major Storm – Physical Design Criteria for On-Site Improvements

a. The major storm floodway and floodway fringe for natural streams shall be as defined by the Federal Emergency Management Agency (FEMA), U.S. Army Corps of Engineers, the Ohio Department of Natural Resources, or where such determinations have not been made by these agencies, the major storm floodway and floodway fringe for natural streams may be estimated through a technical analysis by a registered Professional Engineer in the State of Ohio, in a manner found acceptable by the City of Hilliard.

b. Many of the drainage ways associated with the major storm system are in areas beyond those designated as floodway or floodway fringe. For these areas, the major storm flood limits shall be determined by the U.S. Army Corps of Engineers' HEC-RAS model or other accepted methods of determining water profiles using the major design storm runoff. Six (6)-inches of elevation must be added to the flood profile as freeboard to provide protection in the event of future encroachments into the floodway fringe or in the drainage way.

c. Compatible multiple-purpose designs for non-street drainage-ways are encouraged. Pedestrian paths and linear parks are effective uses for drainage-ways.

d. Where the street is designed as the major drainage system, the depth of flow shall not exceed twelve (12)-inches at gutter line for minor, collector and secondary streets, and shall not exceed six (6)-inches depth at crown for primary streets and freeways. The same maximum depth criteria will apply where a major drainage way crosses the street. Where a major drainage way is located outside the street, stormwater management easements will be provided over the drainage way.

e. In determining the required capacity of surface channels and other drainage ways provided for the major storm runoff, the street storm inlets and conduit provided for the initial storm may be assumed to carry a portion of the total runoff volume, if appropriate. The following equation shall be used to determine the required capacity of surface channels and drainage ways in their design, when a portion of the runoff is conveyed within the initial piped system:

$$Q_{100} = C\ I_{10} A + 0.96 (I_{100} - I_{10}) A$$

and

$$Q_{\text{flood routing path}} = Q_{100} - Q_{\text{pipe}}$$

Where:

$Q_{\text{flood routing path}}$ = Design flow, major storm runoff (cfs)
Q_{pipe} = Peak flow within piped system (i.e., 5-year event) (cfs)
Q_{100} = Peak flow for 100-year event (cfs)
C = Rational runoff coefficient, site developed condition
I_{10} = rainfall intensity for 10-year storm event (inches/hour)
I_{100} = rainfall intensity for 100-year storm event (inches/hour)
A = Drainage area contributory to design point (acres)

f. All grassed waterways utilized as major drainage ways shall have a minimum channel slope of one percent (1.0%). Channel slopes flatter than this minimum must be approved by the City Engineer.

7.3.4 Methods of Calculation

The following methods of calculation shall be used unless otherwise approved by the City Engineer:

a. Rainfall volumes shall be in accordance with data for Central Hilliard, Ohio provided in per "Bulletin 71: Rainfall Frequency Atlas of the Midwest", 1992 NOAA Atlas 14 Precipitation-Frequency Atlas of the United States, Volume 2, Version 3.0" and any subsequent updates thereto.

b. Rainfall distribution for stormwater management systems is to be in accordance with SCS Type II Rainfall Distribution.

c. The appropriate Runoff Curve Number (i.e., "RCN" factor) may be determined by using Technical Release No. 55 (S.C.S.) or its Ohio Supplement.

7.3.5 Drainage Area Determination

The drainage area shall be determined from any of the following sources, which are listed in order of priority preference:

a. Actual field investigation;

b. County Auditor, topographic maps;

c. U.S. Geological Survey quadrangle (7.5 minute series) contour maps;

d. Soil Survey of Franklin County, Ohio, U.S.D.A.

7.4 STORMWATER SYSTEM SPECIFIC DESIGN SPECIFICATIONS

7.4.1 Roadway Culverts

a. General specifications. The size and shape of the culvert should be such that it will carry a predetermined design peak discharge need to specify without the depth of water at the entrance or the velocity at the outlet exceeding allowable limits.

b. Design procedure. The culvert design procedure recommended for use is Hydraulic Design Series No. 5, U.S. Department of Transportation. http://www.fhwa.dot.gov/engineering/hydraulics/library_listing.cfm (publication code HDS 05)

c. Preferred construction. Single span culverts, including concrete box and slab top are preferred. Multiple cell pipe culverts, when they are the only structures that will meet the physical requirements introduced by rigid headwater controls, will be permitted.

d. Material**.** The culvert material shall be concrete, at a minimum diameter of 12 inches. Corrugated steel or metal pipe material will not be permitted.

e. Drainage area. The drainage area in acres, the estimated runoff or design discharge in cubic feet per second, and the storm frequency in years shall be shown on the plan for each culvert.

f. Inlet elevation. The flowline elevation at the culvert inlet should be set deep enough to provide an adequate outlet for future storm sewer improvements upstream.

g. Design storm frequency (roadway culverts), shall be:

    1. 10-year frequency 24-hour storm event for private drives, local and collector streets.
    2. 25-year frequency 24-hour storm event for arterial streets.

h. Design flow. For method of calculation, refer to Table 5.

i. Maximum allowable headwater. The maximum allowable headwater for the design storm shall not exceed or cause any of the following:

    1. 18-inches below the top of curb
    2. 12-inches below the edge of pavement
    3. 1.2 times the diameter of culvert
    4. Diameter or rise plus two feet, in deep ravines
    5. Property Damage – 100-year frequency headwater plus 1-foot, shall not exceed any existing or proposed building first floor elevation

Table 7-6. Acceptable Methods of Calculation for Design Flow in Roadway Culverts

<table>
<tr><th rowspan="3">DRAINAGE AREA (ACRES)</th><th colspan="5">STORMWATER QUANTITY</th></tr>
<tr><th rowspan="2">PEAK DISCHARGE ONLY</th><th colspan="2">PEAK DISCHARGE AND TOTAL RUNOFF VOLUME</th><th colspan="2">STORAGE VOLUME</th></tr>
<tr><th>HOMOGENEOUS LAND USE</th><th>NON-HOMOGENEOUS</th><th>HOMOGENEOUS LAND USE</th><th>NON-HOMOGENEOUS</th></tr>
<tr><td>LESS THAN 200</td><td>RATIONAL OR PEAK DISCHARGE</td><td>PEAK DISCHARGE</td><td rowspan="2">(*) TABULAR HYDROGRAPH</td><td rowspan="2">GRAPHICAL</td><td rowspan="2">(*) STORAGE-INDICATION</td></tr>
<tr><td>200 TO 300</td><td colspan="2">PEAK DISCHARGE</td></tr>
<tr><td>GREATER THAN 300</td><td colspan="3">(*) TABULAR HYDROGRAPH</td><td colspan="2">(*) STORAGE-INDICATION</td></tr>
</table>

*Note: The “Tabular Hydrograph” and “Storage-indication” methods are preferred and are normally used to check drainage calculations submitted to the City Engineer

Method References:

Rational: (Q = CIA); MORPC, Stormwater Design Manual, 1977

Graphical: Ibid., Pg. 143

Peak Discharge: U.S. Department of Agriculture, Soil Conservation Service, Urban Hydrology for Small Watersheds, Technical Release No. 55, 1986

Storage– Indication: MORPC, Stormwater Design Manual, 1977, Pg. 143.

SCS TR-20 and US Army COE HEC-1

Tabular Hydrograph: SCS TR-55, Chap. 5 SCS TR-20, US Army COE’s HEC-1

USGS regression equations for Central Ohio may be used where applicable, for estimating peak flows for culvert design and to estimate peak release rates.

j. Manning’s roughness coefficient (n). Manning’s Roughness Coefficient (n) should be as given in Table 6 unless an alternate value is approved by the City Engineer.

k. Entrance loss coefficient (Ke). The Entrance Loss Coefficient (Ke) should be as given in Table 6 based upon the headwall configuration unless an alternative value is approved by the City Engineer.

Table 7-7. Design Coefficients for Roadway Culverts

TYPE STRUCTURE	MANNING'S ROUGHNESS COEFFICIENT (n)	ENTRANCE LOSS COEFFICIENT (Ke)*
CONCRETE PIPE	0.013	0.2
BOX: 4-sided BOX: 3-sided	0.013 weighted by wetted perimeter minimum 0.018	0.2 TO 0.5 0.2 TO 0.5
SLAB TOP	0.03 TO 0.05	0.2 TO 0.5

* As a function of the headwall configuration

l. Minimum cover to subgrade. Should be 30 inches from top of pipe to subgrade.

m. Maximum allowable outlet velocity, shall be:
1. Turf Channel 5 f.p.s.
2. Rock Protection 18 f.p.s

Notes:
- When the outlet velocity exceeds 18-feet per second, a stilling basin or other such energy dissipation structure must be used.
- The downstream channel must have the ability to handle the flow satisfactorily.

n. Structural design criteria. The structural design criteria for culverts shall be the same as that required by the Ohio Department of Transportation (ODOT).

o. Emergency flood routing. The emergency flood routing shall be capable of routing the 100-year storm over or around the culvert without creating a hazard or causing potential for erosion or personal property damage. Adequate scour protection must be included in the design.

p. End protection should be as follows:
1. 12-inch through 36-inch culverts – full-height headwall
2. 42-inch through 84-inch culverts – full height headwall with flared wings
3. Other special type headwalls must be approved before use

7.4.2 Storm Sewers

The criteria for designing storm sewer systems are listed below:

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

$$Q = \frac{1.49}{n} R^{2/3} S^{1/2} A$$

and

$$Q = AV$$

where:

Q = Rate of discharge (cfs)
A = Area of cross-section of flow (sq.ft.)
V = Mean velocity of flow (fps)
n = Manning's roughness coefficient
R = A/wp = Hydraulic radius (ft)
S = Slope of pipe or hydraulic grade line if surcharged (ft/ft)
wp = Wetted perimeter (ft)

b. Design Storm Frequency shall be:
   1. 72" and under - flowing full for 2-year storm
   2. Over 72" diameter - flowing full for 10-year storm

c. Hydraulic Gradient Requirement shall be:
   1. Based on a 5-year storm, shall not exceed window or grate elevation for an inlet or catch basin.
   2. Grade line based on tailwater or 0.8 D at outlet (whichever is greater) or other critical points within the system.

d. Design Flow Determination:
   1. Areas under 200 acres use Rational Method Q = CiA
   2. Areas between 200 and 300 acres transition between Rational Method and Technical Release 55

   3. Areas over 300 acres use Technical Release 55
   4. Minimum times of Concentration:
      - Curb inlet - 10 minutes
      - Catch basin - 15 minutes

e. Runoff Coefficient
   1. Based on Table 7, with 0.4 as a minimum.

f. Manning's "n" Value
   1. All storm sewers shall be based on an "n" of 0.010 to 0.013.

g. Off-site Area: The sewer must be deep enough to receive the flow from all its sources within the watershed.

h. Size: The size of the sewer must be adequate for flowing full, based on the design storm (see Subsection 4.2 (b), listed above) with the 5-year storm hydraulic grade line contained to the system. A minimum pipe size of 12-inch diameter shall be required for all City of Hilliard maintained sewers.

Table 7-8: Runoff Coefficients "C" for Typical Land Uses in Columbus

Cover Type and Hydrologic Condition	Average percent impervious area (5)	Runoff Coefficient for Hydrologic Soil Group (7) A	B	C	D
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 (TND – TC) (6)					
Industrial					
Residential Districts by Average Lot Size (6):					
Multi-family (TND – NC)	80	0.63	0.75	0.80	0.83
1/12 to 1/6 acre lots (TND – NG)	75	0.56	0.70	0.77	0.83
1/8 acre (TND – NE)	65	0.44	0.60	0.72	0.77
1/4 acre	38	0.19	0.40	0.56	0.65
1/2 acre	25	0.11	0.32	0.50	0.60
1 acre	20	0.08	0.29	0.48	0.58
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	0.47	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	0.37	0.48
	Good	NA	0.06	0.25	0.37
Woods. (4)	Poor	0.04	0.26	0.44	0.56
	Fair	NA	0.18	0.37	0.48
	Good	NA	0.12	0.32	0.44
Farmsteads – buildings, lanes, driveways, and surrounding lots.	--	0.17	0.39	0.54	0.63

Notes:
NA – Method to derive value is not applicable for curve number values less than 40.
(1) Average runoff condition, and Ia=0.2s.
(2) Poor: <50% ground cover or heavily grazed with no mulch; Fair: 50 to 75% ground cover and not heavily grazed; Good: >75% ground cover and lightly or only occasionally grazed.
(3) Poor: <50% ground cover; Fair: 50 to 75% ground cover; Good: >75% ground cover.
(4) Poor: Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning; Fair: Woods are grazed but not burned, and some forest litter covers the soil; Good: Woods are protected from grazing, and litter and brush adequately cover the soil.
(5) The average percent impervious area shown was used to develop the composite CN's which were then used to derive runoff coefficient values. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a runoff coefficient of 0.94 (or CN of 98), and pervious areas are considered equivalent to open space in good hydrologic condition.
(6) Acronyms for zoning of residential districts are as follows:
TND – TC: Traditional Neighborhood Development – Town Center; TND – NC: Traditional Neighborhood Development – Neighborhood Center; TND – NG: Traditional Neighborhood Development – Neighborhood General; TND – NE: Traditional Neighborhood Development – Neighborhood Edge

(7) These runoff coefficients were calculated from CN's drawn from the NRCS (SCS) Peak Discharge Method from TR-55 assuming a 10-year, 24-hour storm. For larger design storms, the runoff coefficients should be increased using the following C value correction factors: 1.0 for the 10-year design storm and less; 1.1 for the 25-year design storm; 1.2 for the 50-year design storm; 1.3 for the 100-year design storm

i. Solids: The gradient of the sewer must be sufficient to avoid deposition of solids.

j. Material: The storm sewer material for City maintained sewers shall be reinforced concrete, per Item 706.02 or smooth-lined corrugated polyethylene pipe per Item 720.12 of City of Columbus "Construction and Materials Specifications latest Edition. 8-inch through 15-inch PVC or high density polyethylene may be used on privately maintained storm sewers. Other material may be used for special design, only if approved for use by the City Engineer. Corrugated metal or steel material will not be permitted.

k. Manholes: The main conduit, if over 24-inches in diameter, will be required to be separated from all curb and gutter inlets unless a special design is approved by the City Engineer. Furthermore, the main conduit will be required to be separated from all deep curb and gutter inlets, which have a depth greater than 6.5 feet from the invert to the top-of-casting elevation. No storm sewer will be constructed parallel to and underneath curb and gutter.

l. Flow Line: Unless otherwise approved by the City Engineer, the flow line of pipes should be set such that the crown of pipes, at junctions, are at the same elevation. If the outlet elevation permits, the crown of the outlet pipe may be lower. The flowline elevations of sewers should be set to avoid using concrete encasement. No storm sewer will be constructed parallel to and underneath curb and gutter.

m. Specifications: Methods of construction and trench backfill shall be as per the requirements of the City of Hilliard and the City of Columbus "Construction and Materials Specifications", latest edition, as approved for use by the City Engineer.

n. Submerged pipe outlets: The submergence of a permanent pool of water above the flowline invert elevation of a storm sewer at the outlet is discouraged and shall not be permitted to a depth greater than one-half (½) the pipe diameter or to a depth of two-feet at the outlet, whichever is less. When submergence is allowed upon approval by the City Engineer, special requirements shall include, but may not be limited to:

   1. Submergence "zone" shall not extend beneath pavement;

   2. Submergence "zone" shall not extend beyond the first manhole;

   3. "O-ring" sealed gasketed pipe joints shall be installed along the storm sewer for the full length of the submergence "zone";

   4. Anti- seepage collars shall be installed in the submergence "zone".

o. End protection should be as follows:

   1. 12-inch through 36-inch culverts – full-height headwall. If the outlet is not located within a channel bank or within the direct flow path of crossing floodwaters, half-height-headwalls at the outlet may be used if approved by the City Engineer. Half-height-headwalls will not be permitted on non-concrete conduits.

   2. 42-inch through 84-inch culverts – full height headwall with flared wings

3. Other special type headwalls must be approved before use

p. Minimum cover to subgrade:

1. Desirable, under pavement and within influence of traffic load - 30 inches from top of pipe to subgrade.

2. Desirable, beyond influence of traffic load – 18 inches from top of pipe to ground surface.

q. Maximum cover over pipe:

1. The supporting strength of the conduit, as installed, divided by a suitable factor of safety must equal or exceed the loads imposed upon it by weight of earth plus any superimposed loads.

2. The design procedure recommended for use in structural design of storm sewers is outlined within the Design Manual Concrete Pipe, available from American Concrete Pipe Association, wide trench installation. http://www.concrete-pipe.org/designmanual.htm

r. Encasement: Class A concrete encasement shall be required within the limits of existing or proposed paved areas inside right of way, in areas influenced by traffic loading, or under paved driveway entrances adjacent to right of way as directed by the City Engineer, where the minimum cover during construction or proposed cover over the outside top of the pipe to top of subgrade is 30 inches or less. Any concrete encasement of flexible pipe shall extend from structure to structure.

s. Velocity in sewer for design flow:

1. 3 fps Minimum

2. 15 fps Maximum

3. No minimum for outlets from ponding areas

t. Maximum Length between access structures:

1. Pipes under 60-inch – 350 feet

2. Pipes 60-inch and over 500 feet

7.4.3 Curb Inlets

a. General: The satisfactory removal of surface water from curbed pavement is as important as any other phase of stormwater control. The spread of water on the pavement for the design storm is considered as the best control for pavement drainage. The design procedure recommended for use is FHWA Hydraulic Engineering Circular No. 12, available from the Superintendent of Documents, U.S. Government Printing Office. On combined runs of over 600 feet contributing to a sag vertical curve, an additional inlet may be required near the low point, plus or minus two-tenths foot above the inlet at the sag.

b. Design storm (curb inlets). The following shall be used:

1. Two-year storm frequency
2. Rational method of calculation
3. Ten minutes for minimum time of concentration
4. 0.015 for roughness coefficient for composite roadway paved and gutter section
5. Maximum width of spread of flow:

Street Width (F/C to F/C)	Width of Spread
≤ 26 ft.	8 ft.
> 26 ft.	9 ft.

c. Underdrains: Four (4)-inch curb drain connections shall be placed 30-inches below the top of the curb on the up-grade side of the inlet. It is desirable to have the storm sewers, draining to the inlets, set such that the elevation of the top of the sewer is not higher than the top of the 4-inch curb drain.

7.4.4 Open Water Courses

a. General Requirements. 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. Handbook 667, Stability Design of Grass-lined Open Channels
4. Federal Highway Administration, 1988, Design of Roadside Channels with Flexible Linings. Hydraulic Engineering Circular No. 15.

b. Channel Hydrology Requirements. Open watercourses shall be designed according to the same method used to design other onsite drainage facilities.

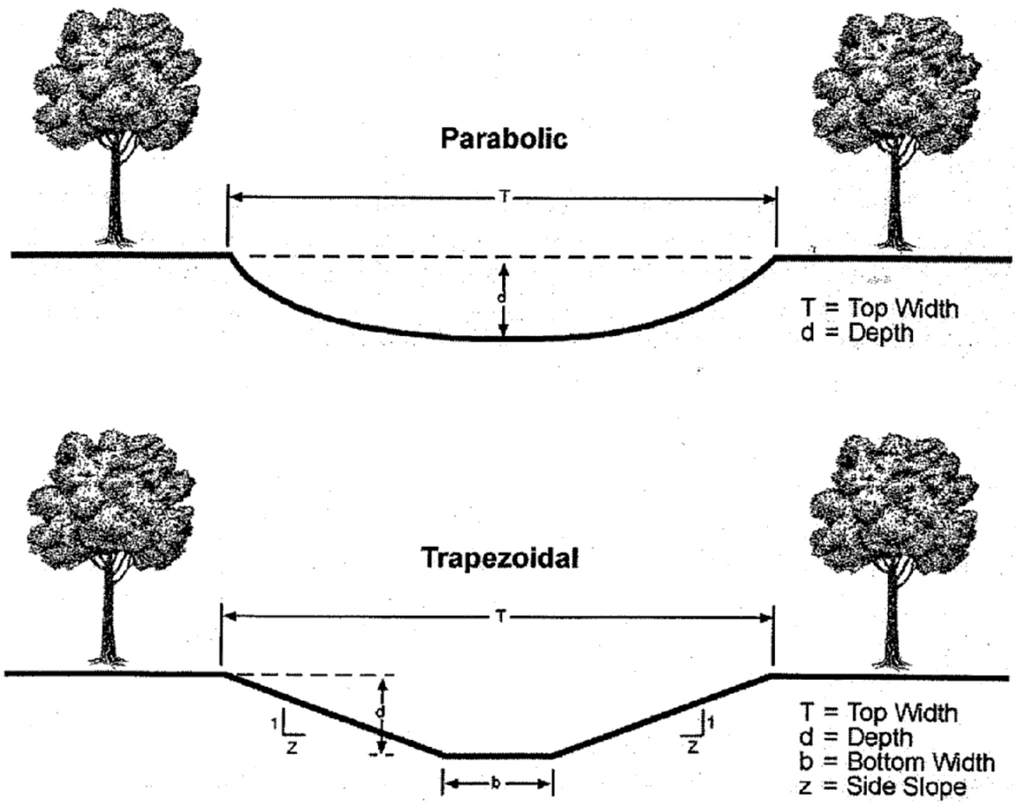
c. Channel Hydraulic Requirements.

1. 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. Major Storm Physical Design Criteria (Section 3.3 of this Manual) 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. ODOT’s L&D Manual,

Drainage Design aids may be used for sizing open conveyances (at various side slopes). A ditch computation sheet shall be used to present open channel calculations.

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

Figure 7-3. Parabolic and Trapezoidal Channel Shapes for Open Watercourses.



3. <u>Design Velocity</u>: 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, such as concrete, are generally not recommended and shall be avoided to the extent possible. Rigid linings may not be accepted within a public drainage easement unless prior approval is obtained from the City.

   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 7. 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 7.

4. 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 = 32.2 ($feet/sec^2$)

The Developer/Owner shall demonstrate that the calculated Froude Number is less than 1 over the anticipated range of flow conditions within the channel.

5. Rock Channel Protection Shear Stress Analysis: Type B, C or D rock channel protection shall be provided in accordance with Construction and Material Specifications City of Columbus (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 (r_{ac}) must be less than or equal to the allowable sheer stress (r_a) listed in Table 9 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%:

$$r_{ac} = 62.4 * D * S$$

where:

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

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

Table 7-9. Manning's Roughness Coefficients for Vegetative and Artificial Channels

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

Table 7-10. Allowable Sheer Stress for Rock Channel Protection

Type of Rock Channel Protection	r_{ac} (lbs/sq.ft)
B	6
C	4
D	2

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

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

7. Natural Channel Design:
   Natural channel design shall be used for open channel stormwater conveyance, in appropriate locations, with plan approval of the City Engineer. See ODNR Rainwater and Land Development Manual.

7.4.5 Detention Facilities

Areas designed for storage of stormwater by retention should be incorporated into the natural features of the general area, when possible. Cooperative planning and joint owner construction of detention and/or retention facilities and use of natural land contours is encouraged. The City encourages that detention or retention facilities be designed as multipurpose spaces such as open space, recreation and/or scenic areas. The City encourages use of fountains for aeration and reserves the right to require such an appurtenance as a condition to plan approval.

a. Ownership and maintenance. The owner and thus responsible party to provide maintenance and operation of a stormwater management facility (i.e., detention, retention basin, etc.), whether public or private, shall be determined prior to the acceptance by the Hilliard City Council of the relevant subdivision plat and the acceptance of the final engineering and construction plan. No lot sales will be permitted until this is done. Maintenance requirements and final design of all detention basins must be followed as specified in City Code Section 1179.091.

b. Location: All stormwater management facilities will be located in a reserve/open space as shown on the preliminary plat and final plat and will be owned by a homeowners association or an entity otherwise approved by the Hilliard City Council.

c. Types of facilities: In development and developing urban and suburban areas, several means for controlling stormwater runoff could be used. This usually involves storing runoff on or below the ground surface. The following types of storage facilities may be considered for detention and are subject to approval by the City Engineer and OEPA: rooftops, parking lots, underground tanks and surface basins or ponds (i.e., dry detention or wet retention) and man-made stormwater wetland systems.

7.4.5.1 Parking Lot Storage.

Parking lot storage is surface storage where shallow ponding is designed to flood specific graded areas of the parking lot. Controlled release features are incorporated into the surface drainage system of the parking lot. Parking lot storage is a convenient multi-use structural control method where impervious parking lots are planned. Design features include small ponding areas with controlled release by pipe-size and slope, and increased curb heights.

The major disadvantage is the inconvenience to users during the ponding function. This inconvenience can be minimized with proper design consideration. Clogging of the flow control device and icy conditions during cold weather are maintenance problems. Parking lot design and construction grades are critical factors. This method is intended to control the runoff directly from the parking area, and is usually not appropriate for storing large runoff volumes.

a. Ponding areas in parking or traffic areas shall be designed for a maximum ponding depth of twelve (12) inches.

b. Flood routing or overflow must occur after the maximum ponding depth is reached.

7.4.5.2 Underground Storage

Tank storage utilizes an underground tank or chamber, either prefabricated or constructed in place, which has a special controlled release feature. This method is most applicable where land area is valuable, such as in industrial and commercial areas. Construction cost and operation costs make this method relatively expensive. Storage trenches, a variation on basic tank storage, are rock-filled underground storage tanks. The storage is provided within the void spaces between the rock material.

7.4.5.3 Retention Basins (Wet)

Wet Retention Basins (Ponds) are permanent ponds where functional stormwater management storage is provided above the normal water level with special features for controlled release. Historically, wet retention basins have proven extremely effective in abating increased runoff and channel erosion from urbanized areas. They are a major Soil Conservation land treatment practice.

Wet retention basins must be constructed outside any existing stream channels and outside the SCPZ.

Some potential problems encountered with wet retention basins are: site reservation (land requirements), permanent easements, complexity of design and construction, safety hazards, and maintenance problems. Because of large land requirements, and the necessity of maintaining a permanent pool of water, wet retention basins have a broader application for in-stream control where large watershed areas are involved compared to their use as on-site facilities for small urban areas. However, the recreational and aesthetic benefits of permanent wet retention ponds may justify certain on-site applications. Gradual slopes of 4:1 are required where a wet retention basin is to be constructed adjacent to an existing single-family development for that part along the existing single-family section, if a sufficient submerged bench cannot be constructed in the basin (see Section 4.5.3 b below).

a. The City encourages use of fountains for aeration and reserves the right to require such an appurtenance as a condition of plan approval.

b. The side slopes for a wet retention basin should be:

- A minimum five (5)-foot wide, two (2)-foot maximum depth submerged bench at waters edge around perimeter of the permanent storage pool;
- A maximum slope of 3:1 horizontal to vertical above the submerged bench.
- A maximum slope of 2:1 horizontal to vertical below the submerged bench;

c. Unless otherwise approved by the City Engineer, a minimum of twenty percent (20 %) of the pool area should be ten (10)-feet deep for water-quality benefit.

d. Rock Channel Protection Type D, may be required to be placed at the normal water elevation, around the entire perimeter of the basin, five feet wide, centered on the normal water elevation.

e. Wetland Perimeter A wetland shelf may be constructed around the perimeter of the basin. The wetland shelf should have a minimum width of 10 feet, and a maximum depth of 8 inches, and be planted in wetland plants (see Section 4.6.3 below).

f. Debris-control structures: Debris-control structures may be required and should be considered as an essential part of the design. The procedure recommended for use is Hydraulic Engineering Circular No. 9, available from the Superintendent of Documents, U.S. Government Printing Office, Washington D.C. For dams and levees over ten feet in height, refer to Section 1521.062, O.R.C.

g. Submerged Outlet/Inlet Structures:
   1. The City permits the use of submerged storm sewer outlets. Submerged Outlets may consist of a siphon pipe where such pipe is no smaller than twelve (12)-inches in diameter. For smaller outlet requirements, a bolted-on orifice plate may be used as the control feature, to be placed at the structure within the embankment. The siphon pipe material must be concrete. When using a submerged outlet, a stormwater retention basin must also include one or more additional stage outlet(s) with sufficient capacity to convey the 100-year storm discharge without overtopping the pond embankment.

   2. Inlet pipes that are equal to or larger in diameter than thirty-six (36)-inches must be submerged to at least the “springline” of the pipe (i.e., normal pool at a depth equal to the elevation at one-half the diameter of the pipe). When an inlet pipe is at least partially submerged at the pond, the conditions listed below must also be met.

   3. Submergence of inlet pipes is limited to the next upstream manhole or catch basin along the storm sewer system.

   4. All lengths of submerged storm sewer pipe shall include “o-ring” sealed gasket pipe joints.

   5. All lengths of the submerged sewer storm pipe shall have bedding and backfill material consistent with the City compacted embankment material specifications.

   6. Riser Outlet Structures: Catch basins and manholes used as the outlet structures may have a maximum elevation that is no more than 1.5 feet above the normal pool elevation and may include windows and grate-top openings. Where a catch basin is used as a second-stage outlet structure, the slope of the pond embankment must be graded to reduce the visibility of the structure.

Calculations must show that the capacity of the window(s) and/or grate top does not exceed the capacity of the "barrel" of the riser structure (calculated using the orifice equation).

7. Structure Requirements: All headwall structures shall be in accordance with City Standard Drawing XX (36-inch diameter or less). All riser structures shall be in accordance with City Standard Drawing XX (modified as necessary.)

8. Bedding/Backfill Material: The bedding and backfill material for all storm pipe outlets shall consist of 100 percent cohesive embankment material or controlled-density fill. Where inlet storm pipes are submerged, bedding and backfill material for those pipes shall consist of 100 percent cohesive embankment material to the next structure upstream along the storm sewer system.

9. Anti-Seep Collars:
    - Anti-seep collars shall be used at all outlet storm pipe locations and shall be located (spaced) and sized in accordance with the criteria provided below. All anti-seep collars shall be constructed with material that provides a watertight connection to the pipe and is of a material that is compatible to the pipe. Anti-seep collars shall also be used along the submerged portion of any storm inlet pipes.

    - The anti-seep collars shall be located along the length of the outlet pipe within the saturation zone of the embankment (refer to Exhibit No. 1), at approximately equal spacing and at intervals not exceeding 25 feet. The saturation zone is considered to extend through the embankment from the elevation of the riser (normal pool) to the downstream embankment toe.

    - The anti-seep collars shall be designed to increase the length along the line of seepage (along the outlet pipe) by at least 15 percent. The proper design of the anti-seep collars may be achieved by either:

        - Selecting the number of collars and determining the minimum projection of the collar away from the outlet pipe: $V = 0.075 \times (L/N)$; or

        - Selecting the projection of the collar away from the outlet pipe and determining the minimum number of collars:

$$N = 0.075 \times (L/V)$$

Where:

V = collar projection in feet
N = number of collars
L = length of outlet pipe within the saturation zone

10. Emergency Spillways: Emergency Spillways, when included in the designed pond outlet feature, must meet all of the following criteria:
    - They shall not operate (convey flow) for any design storm less than the 50-year event.

- They shall be reinforced with concrete or designed erosion control materials (geotextiles) consisting of 100 percent synthetic, non-biodegradable materials [the plans should include a specification for the intended geotextile, referencing the required physical properties or the specific material. Reference the State of Ohio, Department of Transportation Construction and Material Specifications Section 712.11, Type "E."

- They must include a designed "control section" that, when combined with the capacity of the principal spillway, will pass the major storm flood discharge up to the 100-year event [the plans must include a detail demonstrating the necessary dimensions of the control section, both width and breadth.

11. Miscellaneous: The following general criteria must be met:
    - Roof drains (downspouts) that outlet directly to the pond are not permitted.
    - All orifice plates shall conform to the requirements of City of Columbus Standard Drawing, No. AA-S145.
    - All inlet structures (e.g., pipe headwalls) must be recessed into the adjoining pond grading to diminish the amount the structure is visible.

7.4.5.4 Detention Basins (Dry)

a. Dry detention basins are surface storage areas created by constructing a typical excavated or embankment basin. There is no normal pool level and a specific controlled release feature included to control the rate of discharge.

b. Dry detention basins have been a widely used method of stormwater management in the past. However, current OEPA *guidelines* now *discourage* the use of dry detention due to problems with scour and re-suspension of deposited sediment. Dry detention basins are therefore discouraged and will require review and approval by the City Engineer.

c. The soil permeability and water storage potential are not as important with dry detention basins as with wet retention. They can be utilized in small developments because they can be designed and constructed as small structures or can be integrated into open, usable spaces for multi-purpose uses such as recreation and parks.

    1. The steepest side slopes for a dry detention basin should be 3:1 horizontal to vertical.

    2. Dry detention basin bottoms shall be sloped to drain, and such slopes shall be sufficient to mitigate against "flat spots" developing due to construction errors and soil conditions; or, bottoms shall be paved. The absolute minimum transverse slope for the bottoms of such facilities shall be one-half percent (0.50 %), with two percent (2.0 %) being the recommended

transverse slope. All transverse bottom slopes between one and one-half percent (1.5%) and one-half percent (0.5%) shall be lined with a minimum six (6)-inch thick air-entrained Class C concrete, reinforced with steel mesh to accommodate temperature stresses. Concrete shall have a synthetic linseed oil waterproofing treatment.

3. Dry detention basins must include a forebay and micropool each sized at 10% of the calculated WQv if the basin will be used for stormwater runoff qualitative control.

4. Invert ditches within dry detention basins, from the inlet to the outlet of all structures shall be paved if the slope is less than one-half percent 0.50 %. Such ditches shall be paved with a minimum six (6)-inch thick air-entrained Class C concrete, reinforced with steel mesh to accommodate temperature stresses. Concrete shall have a synthetic linseed oil waterproofing treatment. Minimum depth of paved invert ditch should be one (1)-foot.

5. Debris-control structures. Debris-control structures may be required and should be considered as an essential part of the design. The procedure recommended for use is <u>Hydraulic Engineering Circular No. 9</u>, available from the Superintendent of Documents, U.S. Government Printing Office, Washington D.C. For dams and levees over ten feet in height, refer to Section 1521.062, O.R.C.

7.4.6 Stormwater Treatment Wetlands

This technique involves design of a stormwater management facility that is intended to provide a water-quality benefit and incorporates a wetland system for water treatment. Use of this type of system must first be discussed with and reviewed by the City Engineer prior to design to determine acceptance by the City of Hilliard. Suggested design guidelines include:

a. <u>Urban Runoff Quality Management: WEF Manual of Practice No. 23 and ASCE Manual and Report on Engineering Practice No. 87,</u>. Water Environment Federation and American Society of Civil Engineers, 1998.

b. <u>Design of Stormwater Wetland Systems: Guidelines for Creating Diverse and Effective Stormwater Wetland Systems,</u> Thomas R. Schueler, Anascotia Restoration Team, Department of Environmental Programs, Metropolitan Washington Council of Governments, October 1992. E.

Proper wetlands design must create the proper conditions for wetland plants to thrive, as well as the proper hydrologic conditions to detain the water quality volume of runoff, and perhaps the flood control volume as well.

7.4.6.1 Design Consideration

a. <u>Detention Volumes</u>: Wetland extended detention ponds detain a volume equal to the water quality volume (WQv) found in Section 2.2.1.b.

The City may require additional detention volumes for peak discharge control (flood control). This additional storage volume shall use the top of the extended detention volume as a base elevation as shown in Figure 4.

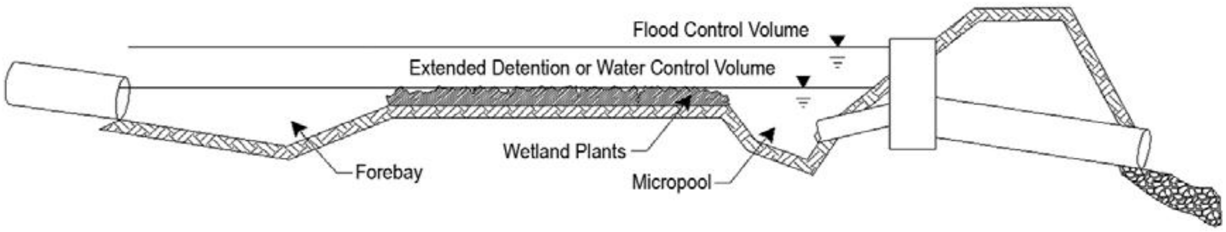


Figure 7-4. Wetland Stormwater Pond with Extended Detention and Flood Control Volumes (Rainwater and Land Development Manual, ODNR)

b. Outlet Design:

1. Design the outlet structure (principal spillway) to draw down the extended detention volume over a 24-hour period. The outlet should empty less than 50% of this volume in the first 8-hours.

2. Peak discharge control (flood control) required by local government can be incorporated into the spillway with additional control devices (e.g. orifices or weirs) above the extended detention outlet. This type of multiple outlet spillway incorporates outlet controls for each attenuation goal.

c. Permanent Wetland Pool Volume:

1. The permanent pool volume is based on the designer's assessment of sufficient runoff and base flow to sustain a wetland pool. The designer should assess the change in storage volume over time based on water entering and leaving the wetland. This water budget should include water entering from precipitation, runoff, base flow, groundwater and any water to be pumped. Water leaving should include evaporation, expected plant transpiration, stormwater outflow, and seepage or percolation. Greater guidance on wetland creation and water budgets can be found in the Natural Resource Conservation Service Engineer Field Manual Chapter 13.

2. A micropool, that is a deep area, greater than three (3)-feet, should be created at the outlet structure so that vegetation and sediment buildup do not interfere with outflow from the basin. Incorporating a deep pool at the inlet to the pond may be used to promote initial settling and dissipate concentrated inflow.

7.4.6.2 Establishing Wetland Vegetation

Six to eight species of wetland plants should be planted. Species that have worked well in constructed urban wetlands include: common three square, arrowhead, soft stem bulrush, wild rice, pickerelweed, sweetflag, smartweeds, spike rush, soft rush, and a number of other sedges.

Vegetation may be established one or a combination of the following methods: planting nursery stock (plants or rhizomes), mulching with soils from an existing wetland or allowing volunteer establishment. Using only volunteer establishment is discouraged since it often leads to mono-typical stands of invasive or undesirable species.

a. Planting Layout – Initial planting should cover at least thirty percent (30%) of the wetland area, concentrated in several portions of the pond and have densities of four to five plants/square yard. Planting clusters of single species will improve the quality and diversity plantings. Plants should be planned for their appropriate depth within the permanent wetland pool.

b. Grading or Disking the Basin – The basin substrate should be soft enough to permit relatively easy insertion of the plants into the soil. If the basin has been recently graded or excavated, the soil should be sufficiently soft. However, if the basin soil is compacted or hard subsoil is encountered, planting will be difficult. In these cases, it is recommended that the basin soil be disked or otherwise loosened before planting.

c. Flood and Drain Prior to Planting – If nursery stock will be used, it is recommended that the wetland area be flooded for a period of time (6-9 months, USEPA) prior to draining and planting.

d. Treatment of Plant Material – For successful establishment of wetland vegetation the nursery stock must be correctly handled prior to planting. For growing plants, this consists of keeping the roots moist at all times, and in keeping the plants out of direct sunlight as much as possible. Vegetation should be planted as soon as possible to avoid damage during on-site storage. Dormant plant material should be stored under conditions similar to those under which the material was stored at the nursery.

e. When planting container plants dig holes about one third larger then the container to allow root systems to have an un-compacted area in which to develop.

f. Mulching with Wetland Soils – If an area is mulched with soil from an existing wetland, plants should be allowed to germinate and grow for a period prior to fully inundating the wetland pool. Care should be taken to prevent the newly germinated plants to dry out.

7.4.6.3 Transition from Temporary Sediment Control Basin to Permanent Stormwater

Often permanent stormwater management ponds are used for sediment control during construction. In most cases, these facilities will need dewatering and sediment removal in order to insure that the pond has the appropriate volume for permanent stormwater design. This includes removal of temporary risers and skimmer structures used for sediment control and reseeding bare soil or establishing wetland vegetation in designated areas within the pond.

7.4.7 Bioretention (from Rainwater and Land Development Manual, ODNR)

Bioretention practices are stormwater basins that utilize a soil media, mulch and vegetation to treat runoff and improve water quality for small drainage areas. Bioretention BMPs provide effective treatment for many runoff quality problems including reduction of total suspended solids, heavy metals, organic compounds, bacteria and nutrients (phosphorous and nitrogen) by promoting settling, adsorption, microbial breakdown, and nutrient assimilation by plants.

7.4.7.1 Description

A bioretention area consists of a depression that allows shallow ponding of runoff and gradual percolation through a soil media, after which it either infiltrates through undisturbed soils or enters the storm sewer system through an underdrain system. Bioretention BMPs are sized for common storm events (the water quality volume) with runoff volumes from larger events typically designed to bypass the BMP.

A bioretention BMP is generally applicable for limited contributing drainage areas, generally less than 2 acres.

7.4.7.2 Design Considerations

a. Suitable soils: The bioretention BMP must be designed so that the runoff storage capacity will be drained within 24 hours either through infiltration into the existing soils under the facility. Facilities designed without an underdrain system shall have a qualified professional certify that in-situ soils are appropriate for infiltration. This certification shall include a description of the soil depth and horizons that correspond to the design elevations of the bioretention practice.

b. Setbacks to Prevent Water Damage: Appropriate setbacks from property lines, wells, septic systems, basements and building foundations shall be maintained to prevent damage to these systems or offsite areas.

c. Long Term Maintenance and Easements: Since bioretention combines plant materials with the temporary storage and filtering of stormwater, frequent regular maintenance is required. A legal and enforceable maintenance agreement shall be in place.

d. Surface Area: The surface area of the bioretention cell will generally be between five (5) and ten (10) percent of the contributing drainage area.

e. Construct Bioretention after Site Stabilization: Bioretention facilities shall be constructed after all other areas of the drainage area have been constructed and finally stabilized. Sediment-laden runoff from actively eroding sites will cause the premature failure of bioretention facilities and shall not be allowed to enter the bio-retention facility.

f. Detention: All bioretention practices shall be designed to treat the water quality volume by initially ponding that volume and allowing it to infiltrate through a soil medium within the practice. OEPA requires that runoff treated with a bioretention practice have a minimum drawdown time of 24 hours. While detention practices begin discharging soon after water begins to pond, each practice shall regulate the release of water such that no more than one-half of the water quality volume (see

Section 2.2.1.b.) is released in less than one-third of the drawdown period (24 hours).

g. Area Dimensions: The minimum recommended width of the landscaped ponded area shall be ten (10)-feet, with the length generally exceeding 2:1 (length:width). Pretreatment and conveyance areas may increase the overall size dedicated to the practice.

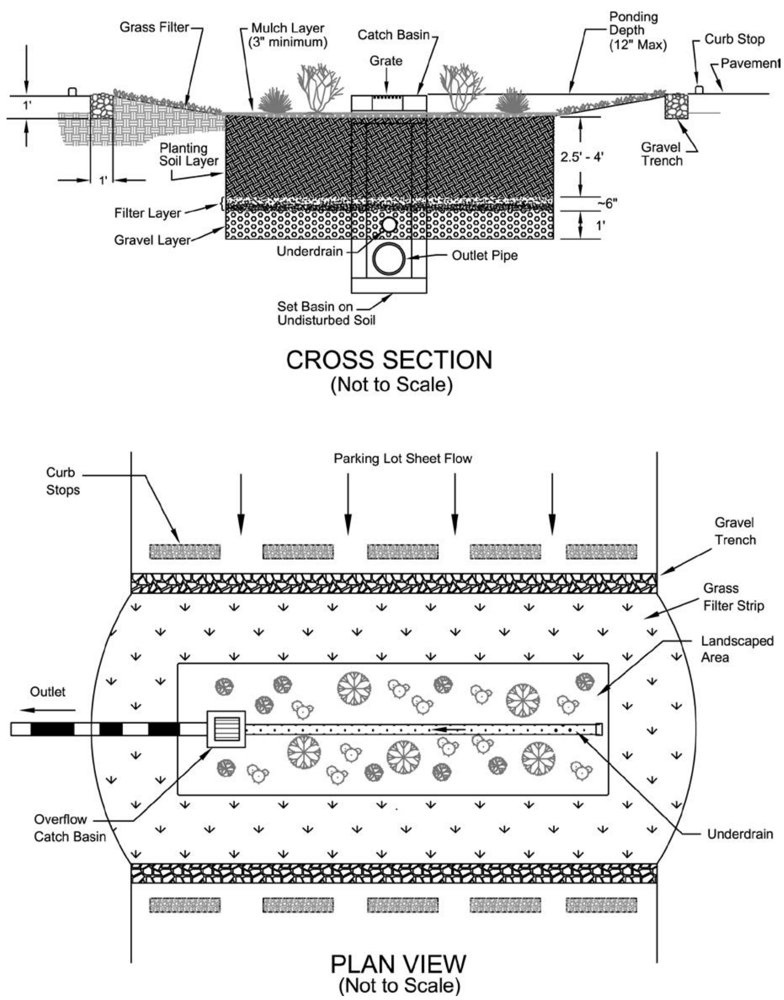


Figure 7-5. Bioretention Cell Layout
(Rainwater and Land Development Manual, ODNR)

7.4.7.3 General Components of Bioretention Practices

a. Pretreatment Area: Sediment or other pollutants before runoff enters the practice. A level stone trench at the edge of pavement, perpendicular to flow and a grassed area are typical options for pretreatment. Where flow is concentrated, a grassed swale, stabilized flow entrances, or forebay may be necessary.

b. Landscaped ponding area: The depth of ponding should generally be less than six (6)-inches, but may be designed for a depth to twelve (12)-inches maximum. The depth of ponding is controlled by the height of the overflow structure or berm containing runoff.

c. Mulch: A minimum of three (3)-inches of coarse shredded hardwood mulch is provided around plants and over the planting soil. Pine mulches and fine or chipped hardwood mulches may not be used since they tend to float and move. Grass may be planted instead of a mulch layer, especially in circumstances where maintenance is problematic.

d. Planting Soil: The planting soil filters and detains runoff, and much of the pollutant removal occurs in this zone. The planting soil or created soil mix shall be 2.0 feet in depth (settled). Soils and soil mixes must be certified by a qualified laboratory (1 test per 100 cu.yd.. of soil), and should consist of sand, organic amendment and topsoil per the following specifications:

e. Filter Layer: Designers may choose to use either geotextile or a combination of sand and pea gravel to prevent fines from the planting soil from migrating down through the underdrain or to the subsoil below the practice.

f. Gravel Layer and Underdrain system:
   1. A gravel bed eight (8) to twelve (12) inches consisting of # 57 washed stone shall be provided as a drainage medium and bedding material for underdrain pipes.

   2. Underdrains shall be a perforated pipe capable of withstanding the expected load above it and sized to exceed the drainage capacity of the planting soil layer.

g. Overflow and Routing: Bioretention facilities shall have a non-erodible means of discharging flow exceeding the capacity of the practice such as an overflow pipe or drop inlet set at the maximum ponding elevation.

h. Planting Materials: Species planted in bioretention practices should be adapted to the region, pollution tolerant, and able to survive the variable moisture conditions. Most plants should be facultative (found equally in wetland or upland conditions) though some species found in either environment may be acceptable. Native and non-invasive plants shall be used.

7.4.8 Infiltration Trenches (Rainwater and Land Development Manual, ODNR)

7.4.8.1 Description

An infiltration trench is a rock-filled trench that receives stormwater runoff, allowing it to infiltrate into the ground. These structures provide temporary underground storage in the form of a trench or other storage chamber filled with uniform graded stone.

Infiltration is an efficient post-construction stormwater practice, providing several benefits other control practices don't. Most notably, infiltration tends to reverse the hydrologic consequences of urban development by reducing peak discharge and increasing base flow to local streams. Unfortunately, infiltration trenches must be very carefully constructed to ensure they will continue to function, and they often have high long-term maintenance requirements.

7.4.8.2 Conditions Where Practice Applies

a. Smaller Sites: Infiltration trenches are generally not considered practical for sites larger than five (5)-acres. Used in small areas they offer flexibility in incorporating water quality treatment into a site's drainage system.

b. Soil Hydraulic Conductivity: Hydraulic conductivity describes the ability of water to move through a soil. Hydraulic conductivity should be at least fifty-two-hundredths (0.52) inches per hour but not more than two and four-tenths (2.4) inches per hour for infiltration trenches. Trenches should not be constructed on undisturbed soils that have been filled. On-site evaluation of soil parameters related to hydraulic conductivity and groundwater by a trained professional is recommended.

c. Industrial or Other Areas of Potential Ground Water Contamination – This practice should not be used in heavy industrial developments, areas with chemical storage, pesticide storage or fueling stations.

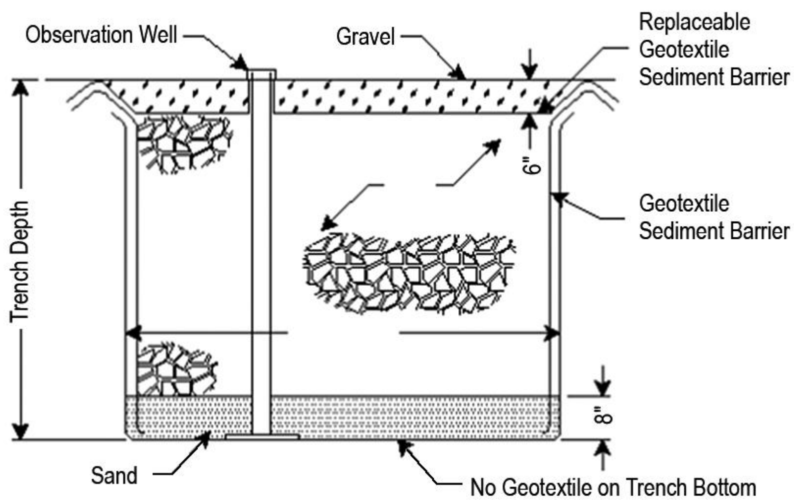


Figure 7-6. Typical Infiltration Trench Cross Section
(Rainwater and Land Development Manual, ODNR)

d. Stable Slope: Trenches should not be used in slip prone areas where they may cause slope instability.

e. Hydrologic Recharge: Infiltration practices help reduce runoff and may help support recharge of groundwater and baseflow to streams. This practice may be a particularly desirable option when the receiving stream is a cold water habitat.

7.4.8.3 Planning and Considerations

a. Sediment Clogging: The principle threat to infiltration trenches and a common reason for their failure is sediment clogging and sealing off of the permeable soil layer. An effective sediment trapping system, such as a vegetated swale, a buffer strip or a sediment settling pond, is an essential part of all infiltration trench designs.

b. Infiltration trenches may not be installed until disturbance from construction has ended and soils are stabilized.

c. Groundwater Protection: Precautions must be taken to guard against the facility introducing contaminants into water supply aquifers. Excessively permeable soils will not effectively stop pollutants and shall not be used for infiltration practices.

7.4.8.4 Design Criteria

a. Diversion: Storm water runoff shall be directed to the infiltration trench via dispersed sheet flow wherever possible. Where runoff is directed to the infiltration trench as concentrated flow (via a swale, storm sewer or other discrete conveyance), the infiltration trench must be designed “off-line” such that flows in excess of the Water Quality Volume (WQv) are diverted around the infiltration trench.

b. Soil Hydraulic Conductivity: Soil infiltration rates within the trench must be between 0.52 and 2.4 inches per hour. The soil shall have no greater than 20 percent clay content and less than 40 percent silt/clay content. A certified Soil Scientist or other trained professional shall be used to perform site-specific soil tests.

c. Pretreatment: The potential for failure of infiltration practices due to clogging by sediments is high. Thus, it is imperative that the facility design includes a durable, maintainable pretreatment system for removing sediment from stormwater before the trench.

d. Sizing the Pretreatment Facility: The size of the pretreatment facility is based on the infiltration rate of the soil in which the infiltration trench is built. For soils with infiltration rates of 2.0 inches per hour or less, the pretreatment facility shall be sized to contain 25% of the WQv. For infiltration rates greater than 2.0 inches per hour, the pretreatment facility shall be sized to contain 50% of the WQv.

e. Exit Velocity from Pretreatment Facility: The velocity of runoff as it exits from the pretreatment device must be non-erosive.

f. Drain Time Requirements: The practice is to be designed to infiltrate the Water Quality Volume (WQv) through the bottom floor of the structure in 24 to 48 hours. Drain times in excess of 72 hours should be avoided to prevent mosquito-breeding habitat from forming.

g. Dimensions: The dimensions of the storage reservoir (infiltration trench) are made by fitting the length, width and depth into a configuration, which satisfies drain time and storage volume requirements. Dimensional considerations include initial storage depth, area of trench bottom, and the trench length and width. The trench dimensions shall be sized by accepted engineering methods. See ODNR's Rainwater and Land Development Manual for dimensional and other design considerations.

h. Additional Information: designers considering the use of infiltration trenches should consult the ODNR Rainwater and Land Development Manual.

7.4.8.5 Infiltration Trench Components

a. Stone: The infiltration trench is filled with clean, washed aggregate. Stone with a diameter of between one (1) and three (3) inches should be used.

b. Geotextile: The sides and top of the trench must be lined with a non-woven geotextile to restrict the amount of sediment entering the structure.

c. Bottom Sand Filter: To promote continued infiltration, the bottom of the trench shall be covered with a clean layer of sand, approximately six (6)-inches deep.

d. Observation Well: An observation well, consisting of a perforated vertical 6-inch diameter PVC pipe with lockable cap shall be installed in the trench to monitor performance. The original depth of the well must be marked on the top of the well.

e. Overflow: Off-line infiltration trenches must have an overflow structure to handle discharge that exceeds the storage capacity of the trench.

f. Construction Sediment: Due to their sensitivity to sediment, infiltration trenches shall not receive runoff from disturbed areas of the site. It is advisable to construct the infiltration trench only after the contributing drainage area has been stabilized.

7.4.9 Grass Filter Strips (Rainwater and Land Development Manual, ODNR)

7.4.9.1 Description

Grass Filter Strips (GFS), also known as vegetated filter strips, treat the water quality of small sheet flows from developed areas. They are uniform strips of dense turf or meadow grasses with minimum slope, best suited to accept diffuse flows from roads and highways, roof downspouts, and very small parking lots. Although grass filter strips alone do not meet OEPA treatment standards for water quality, they are an ideal component of stream buffers or as pretreatment to a structural practice.

Natural meadow areas also may be used for grass filter strips. Grass filter strips are most often located in landscaping areas around building and parking lot perimeters, in greenbelts or along conservation easements, and median strips in parking lots and streets. The site's topography must allow shallow slopes and sheet flow runoff through the filter strip.

7.4.9.2 Conditions Where Practice Applies

a. Smaller Sites: Grass filter strips are not considered practical for sites larger than five (5)-acres. Used in small areas they offer flexibility in incorporating water quality treatment into a site's drainage system. The grass filter strips can be used as a supplemental practice or a pretreatment when combined with another structural treatment practice.

7.4.9.3 General Criteria for Grass Filter Strips

a. Grass Filter Strip design should be based on Rainwater and Land Development Manual (Ohio ODNR, etc).

b. Submittals/Plans: Runoff calculations, drainage area, slope of drainage & GFS, planting plan, soil information, slope length, schedule, other design components (spreader bar, etc).

c. The filter strip must abut the contributing drainage area.

d. The limiting design factor for grass filter strips is not the drainage area to the practice, but rather the length of flow leading to it. In general, the length of flow from impervious surfaces should not exceed 75 feet, and the length of flow from pervious surfaces should not exceed 150 feet.

e. The slope of grass filter strips should be one percent (1%) to five percent (5%).

f. Slope Length: A higher level of pollutant removal is achieved the longer the slope length (the distance water flows through a filter strip). Grass filter strips must have a minimum slope length of twenty-five (25)-feet, but should be designed to provide a slope length based on their slope within the ranges noted in the table below:

Table 7-11. Filter Strip Flow Length

Slope of Filter Strip	75% Particulate Trap Efficiency	90% Particulate Trap Efficiency
1%	25 ft	50 ft
2%	30 ft	120 ft
3%	40 ft	135 ft
4%	60 ft	170 ft
5%	75 ft	210 ft

g. Ground Water: Filter strips should be separated from ground water by at least two (2) to four (4) feet to prevent contamination and to assure that the filter strip does not remain wet between storms.

h. Soils: Filter strips will be less effective as the clay fraction of the soil increases, since this limits the infiltration of runoff associated with proper treatment. Filter strips are not suitable in very poor soils that cannot sustain a grass cover.

i. Assuring Sheet Flow: Level spreaders should be used if needed to assure an even flow onto the grass filter strip.

j. Establishing Vegetation: Dense vegetation is critical to effective filter strips. Poor stands of vegetation may even result in a grass filter strip eroding and becoming a source of pollution. A tool to select the appropriate vegetation based on site specific conditions is available on the internet from the USDA Natural Resource Conservation Service at: http://ironwood.itc.nrcs.usda.gov/Netdynamics/Vegspec/pages/HomeVegspec.htm.

   Some common grasses suitable for use in Ohio include perennial ryegrass, tall fescue, red fescue and Kentucky bluegrass as well as Canada wildrye, Chinese silvergrass, orchardgrass, smooth brome, switchgrass, timothy and western wheatgrass. Salt-tolerant vegetation such as creeping bentgrass should be selected in areas that may be salted in the winter.

   Seeding of the filter strip shall be completed no later than September 30th to assure establishment of sufficient vegetation by October 31st.

k. Pedestrian and Vehicular Traffic: Heavy use should be avoided to minimize soil compaction and maintain quality dense vegetation.

l. Maintenance: Only a minimum amount of maintenance should be necessary to ensure continued functioning of grass filter strips.

   1. The most significant concern is gully formation from unexpected concentrated flows. If rills and gullies occur, they must be repaired and stabilized with seed or sod. Measures must be taken to eliminate the concentrated flow.

   2. Filter strips shall be inspected annually to assure that the level spreader is not clogged and to remove built-up sediment.

   3. Grass within the filter strip should be maintained as lawn. Grass height shall be approximately three (3) to four (4) inches. Vegetation must be kept healthy.

7.4.9.4 Specifications for Filter Strips

a. Filter strips shall be graded to prevent runoff from concentrating. Depressions, ridges and swales shall be graded out to achieve a uniform slope having a level grade across the slope.

b. To assure that runoff remains as sheet flow through the filter strip, a level spreader shall be used at the top of the slope. The rock or grass level spreader must be placed on a contour, and shall have a minimum width and depth of one (1) foot.

c. Soil compaction shall be minimized in the filter strip area. Work shall be performed only when the soil moisture is low.

d. A subsoiler, plow, or other implement shall be used to decrease soil compaction and allow maximum infiltration. Subsoiling shall be done when the soil moisture is low enough to allow the soil to crack or fracture.

e. Because a dense vegetation is critical for effective filter strips, only a dense stand of vegetation without rills or gullies shall be acceptable. If rills or gullies form, or if vegetative cover is not dense, a new seedbed shall be prepared and replanted.

f. The filter strip shall be seeded no later than September 30th to assure that vegetation establishes prior to the onset of winter weather.

7.4.10 Operation and Maintenance

7.4.10.1 Operation and Maintenance Plan

For the various storm water Best Management Practices (BMPs) described in this Manual, or any others that are proposed for a site, and for which the City has not accepted maintenance responsibility, a stand-alone Operation and Maintenance Plan document must be prepared to address the items listed below. A preferred template of this document is available for use on the City's website.

a. Designate the entity associated with providing the BMP(s) inspection and maintenance.

b. Indicate routine and non-routine maintenance tasks to be undertaken.

c. Indicate a schedule for inspection and maintenance tasks.

d. Provide proof of any necessary legally binding maintenance easements and agreements that are necessary to properly inspect and maintain the BMP(s).

e. Provide a map showing the location of the BMP(s) that are indicated on the approved Storm Water Pollution Prevention Plan (SWPPP) and any necessary access and maintenance easements.

f. Provide detailed BMP drawings and inspection and maintenance procedures.

g. Ensure that the collected pollutants resulting from BMP maintenance activities are disposed of in accordance with local, state and federal guidelines.

7.4.10.2 Inspection and Maintenance Agreement

a. An Inspection and Maintenance Agreement shall be made between the Owner and the City of Hilliard ensuring that the BMP(s) shall be properly inspected and maintained and shall be included within the Operation and Maintenance Plan.

b. Personnel identified within the Operation and Maintenance Plan shall inspect the BMP(s) to ensure proper functionality and determine if maintenance is necessary.

c. At a minimum, inspections are to be conducted annually, or more frequently as specified within the Operation and Maintenance Plan.

d. Written inspection reports summarizing the BMP(s) inspection observations and maintenance requirements are to be submitted to the City of Hilliard within thirty days after each inspection.

7.4.10.3 Maintenance

a. All BMPs are to be maintained according to the measures outlined within the Operation and Maintenance Plan.

b. Ensure that the collected pollutants resulting from BMP maintenance activities are disposed of in accordance with local, state and federal guidelines.

c. The Owner shall make necessary repairs within thirty days of their discovery as identified within the inspection reports or through a request from the City of Hilliard resulting from City conducted inspections.

d. Maintenance activities performed are to be documented in a written report and submitted to the City of Hilliard.

e. The Owner shall grant permission to the City of Hilliard to enter the property and inspect the BMP(s) whenever the City deems necessary. In an event of any default or failure by the Owner in properly maintaining the BMP(s) in accordance with the approved Operation and Maintenance Plan, or, in the event of an emergency as determined by the City of Hilliard, it is the sole discretion of the City, after providing reasonable notice to the Owner, to enter the property and take whatever steps necessary to correct deficiencies and to charge the cost of such repairs to the Owner. Nothing herein shall obligate the City to maintain the BMP(s).

7.5 REFERENCES

National Menu of Best Management Practices for Storm Water Phase II, United States Environmental Protection Agency, August 2002

VegSpec and PLANTS Database, United States Dept. of Agriculture, Natural Resource Conservation Service, http://plants.usda.gov

State Water Quality Management Plan, State of Ohio, Environmental Protection Agency, Division of Surface Water, 2006

Rainwater and Land Development, Ohio's Standards for Stormwater Management, Land Development and Urban Stream Protection, Ohio Department of Natural Resources, Division of Soil and Water Resources, Third Edition 2006