City of Hamilton
BUTLER COUNTY OHIO

Storm Water Drainage Policy Manual

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Prepared By:

STRAND ASSOCIATES®

City of Hamilton BUTLER COUNTY OHIO

City of Hamilton, Ohio
Storm Water Drainage Policy Manual
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Section 1 - Introduction

Section 1.1: Purpose

The City of Hamilton's Chapter 929 ordinance "Storm Water Management System" and Chapter 1197.06 ordinance "Storm Drainage System" stipulates that "every development shall be provided with a storm drainage system that provides adequate, complete and satisfactory drainage service for the entire area being platted for all projected land uses and otherwise meeting the approval of the officials having jurisdiction." This Storm Water Drainage Policy Manual shall be used as a technical resource and to document the City of Hamilton's standards to meet the requirements of the storm water ordinances. These should be considered minimum standards and certain conditions may require exceeding these standards. The Ohio Department of Natural Resources "Rainwater and Land Development" manual is a comprehensive source of general standards to use to avoid, minimize, or compensate for impacts to water resources.

This Manual:

1. Establishes design standards that have been authorized by the City of Hamilton to facilitate the City's compliance with local, state, and federal regulations.

2. Serves as a reference document for professional consultants in the design of storm system infrastructure projects within the City of Hamilton's service area.

3. Identifies a single set of standards to be used in the planning and design of storm water projects within the City of Hamilton's service area.

The Manual is not intended to serve as a step-by-step design methodology nor can this Manual address every situation which may arise. The application of sound engineering/surveying principles and judgement combined with the information contained herein are necessary to complete the planning, design, and preparation of related construction documents for storm water projects.

Section 1.2: Applicability

Every development project within the City shall have an adequate drainage system to provide complete drainage for the entire development. Construction activities disturbing one or more acres of total land or will disturb less than one acre of land but are part of a larger common plan of development or sale that will ultimately disturb one or more acres of land, shall be required to implement erosion and sediment controls or Best Management Practices (BMPs). The threshold acreage includes the entire area disturbed in the larger common plan of development or sale. Construction activities that meet this threshold shall obtain coverage through the Ohio Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System General Storm Water Permit for Construction Activities (Ohio EPA OHC00005 or latest version). Erosion and sediment controls or BMPs shall comply with the Storm Water Pollution Prevention Plan (SWP3) Requirements prescribed in the Ohio EPA General Storm Water Permit for Construction Activities.

Additionally, construction activities disturbing one or more acres of total land, or will disturb less than one acre of land but are part of a larger common plan of development or sale that will ultimately disturb one or more acres of land, shall be required to implement post-construction storm water management facilities or BMPs. The threshold acreage includes the entire area disturbed in the larger common plan of development or sale. Construction activities that meet this threshold shall obtain coverage through the Ohio EPA National Pollutant Discharge Elimination System General Storm Water Permit for Construction Activities (Ohio EPA OHC00005 or latest version). Post-construction storm water management facilities or BMPs shall comply with the Post-Construction Storm Water Management Requirements prescribed in the Ohio EPA General Storm Water Permit for Construction Activities.

Section 1.3: Submittal Documents

All design calculations or storm water modeling results, design drawings, and technical specifications corresponding to the storm system improvements shall be submitted to the City Engineer for review. This submittal of documents shall be known as the Official Drainage Plan for the development as described in the City's Chapter 1197.06 ordinance "Storm Drainage System."

SECTION 2 - DESIGN CRITERIA AND METHODS

Section 2.1: Design Storm Criteria and Methods Overview

The storm drainage system shall be designed to adequately handle the runoff from storms having various frequencies of occurrence from different types of development in accordance with the following general categories. Each category has minimum design criteria and methods that shall be followed in order for approval of the storm drainage system by the City of Hamilton. The criteria and methods for the general categories are summarized below. The design criteria and methods are detailed in later sections.

Additional controls or localized restrictions may be placed on specific sites, as deemed necessary by the City. For example, sites where pre-existing downstream problems or hydrologic and hydraulic models developed for the area exist. Conditions for design in such cases shall be as required by the City.

1. **Closed Pipe Systems:** The 10-Year Storm shall be used for design. The 25-Year Storm shall be used as a Check Storm:

    - **Design Criteria for 10-Year Design Storm**: Hydraulic Grade Line (HGL) shall not exceed the crown of the pipe.
    - **Design Criteria for 25-Year Check Storm**: HGL in any public inlet, catch basin or manhole must be a minimum of 1 foot below the rim elevation of the structure.
    - **Method**: The Rational Method or Soil Conservation Service (SCS) Method may be used to calculate peak flow rates. The SCS Method shall be used for drainage areas greater than 50 acres. Manning’s Equation shall be used to calculate pipe flow and velocity in order to design the pipe system.

2. **Open Channels:** The 10-Year Storm shall be used for design. The 100-Year Storm shall be used as a Check Storm:

    - **Design Criteria for 10-Year Design Storm**: The peak flow rate resulting from the 10-Year Storm shall be confined within the open channel’s banks.
    - **Design Criteria for 100-Year Check Storm:** The peak flow rate resulting from the 100-Year Storm shall be confined within the defined easement of the open channel.
    - **Method**: The Rational Method or SCS Method may be used to calculate runoff rates. The SCS Method shall be used for drainage areas greater than 50 acres. Manning’s Equation shall be used to calculate channel flow and velocity in order to design the open channel.

3. **Inlets:** Design methodology utilized shall be consistent with requirements listed in Sections 1103.4 through 1103.7 of the Ohio Department of Transportation (ODOT) Location and Design (L&D) Manual Volume Two Drainage Design, latest version.

4. **Culverts:** The 100-Year Storm shall be used for design;

    - **Design Criteria and Method**: Culverts shall be designed in accordance with Section 1006.2 and Section 1105 of the ODOT L&D Manual Volume Two Drainage Design, latest version.

5. **Storm Water Management Systems/Detention Basins:** The methodology and calculations used for the design and sizing of storm water management facilities for detention or retention shall be based on the Critical Storm Method as described below.

- **Design Criteria**: If the post-development storm water runoff volume from a site will be greater than the pre-development storm water runoff volume from the same site, the peak flow rate from the Critical Storm and all more frequent storms shall be less than or equal to the peak flow rate from a 1-Year 24-Hour storm occurring on the same site under pre-development conditions. The post-development peak flow rate from storms of less frequent occurrence (longer return periods) than the Critical Storm up to the 100-Year 24-Hour storm shall be less than or equal to the pre-development peak flow rates from equivalent size storms.

  The Critical Storm for a specific development area shall be determined as follows:

  a. Determine the total volume of storm water runoff from a 1-Year 24-Hour storm for both pre-development and post-development conditions.

  b. Determine the percent increase in the total volume of storm water runoff due to development and select the Critical Storm from Table 2.1.

Storm Water Runoff Volume Increase		Critical Storm
Equal to or Greater	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

Table 2.1 Critical Storm Method

- **Method**: The SCS Method shall be used for the purposes of sizing storm water management systems/detention basins.

6. **Emergency Spillways:** The 100-Year Storm shall be used in the design of emergency spillways for storm sewer systems and detention basins:

- **Design Criteria for Emergency Spillway - Storm Sewer Systems**: Inlets in sag shall have an overland flow path, where possible, such that the storm water resulting from the 100-Year Storm may pass downstream and not exceed the 12-foot spread limit.
- **Design Criteria for Emergency Spillway - Detention Basins:** Assuming the outlet control structure is clogged, the emergency spillway shall convey the 100-Year Storm flow. The 100-Year Storm flow may not overtop the embankment, and downstream impacts must be evaluated and taken into design consideration in order minimize erosion.

- **Method**: The Rational Method or SCS Method may be used to calculate the 100-Year Storm Event. The SCS Hydrograph method shall be used to analyze the HGL in order to meet design criteria.

7. **Channel linings:** The 10-Year Storm shall be used in the design of channel linings to adequately control the erosive flows. Erosive flows are defined as flows produced during the 10-Year Storm event such that the permissible shear stress of the storm water on the channel lining is greater than the applied shear stress.

   - **Design Criteria for 10-Year Storm:** The calculated permissible shear stress must be less than the calculated applied shear stress.
   - **Method**: The Rational Method or SCS Method may be used to calculate and compare runoff rates. The SCS Method shall be used for drainage areas greater than 50 acres. The Applied Shear Stress equation may be used to calculate permissible and applied shear stress for the channel lining.

8. **Easements**: All storm water conveyance systems, including closed pipe systems / storm sewers and open channel systems, shall have a minimum easement width of 20 feet that extends at least 10 feet on both sides of the centerline of the conveyance system.

9. **Stream buffers**: No development shall occur within stream buffers or riparian buffers (also known as stream setback areas) at the discretion of the City. Stream setback areas shall be defined and determined as summarized in Section 2.5 of the Ohio Department of Natural Resources (DNR) Rainwater and Land Development Manual, latest edition.

10. The 100-Year Storm shall be used in comparison with established flood elevations from property owners, observations, Federal Emergency Management Agency (FEMA) maps and other viable records to minimize the impacts of flooding and storm water.

Section 2.2: Runoff Computation Methods

Numerous methods of rainfall-runoff computation are available on which the design of storm management facilities may be based. The Rational Method and the Soil Conservation Service (SCS) hydrologic methods (available in TR-20, TR-55 and HEC-1) are accepted as adequate for determining peak runoff rates for drainage areas totaling 50 acres or less.

For drainage systems larger than 50 acres, the SCS hydrologic method shall be used to determine peak runoff rates. The method of analysis must remain consistent when drainage areas are combined. The method which applies to the largest combined drainage area shall be used. The engineer may use other methods with prior approval by the City.

The SCS hydrologic method shall be used for detention or retention basin routing calculations.

Section 2.3: Rational Method

The Rational Method may only be used to calculate peak discharge rates for drainage areas of 50 acres or less. The Rational Method shall not be used to calculate the volume of storm water runoff or develop runoff hydrographs. The Rational Method shall be performed as follows:

$$\mathbf{Q = C\ i\ A}$$

Where:

Q = peak flow rate, cfs

C = runoff coefficient varying with the amount of imperviousness and other characteristics of the drainage area. Table 2.4 presents ranges for "C" values based on specific land use types.

i = average intensity of precipitation in inches per hour, varying with frequency of storm occurrence, duration or concentration time, and area of the tributary watershed. The rainfall intensity shall be obtained from Rainfall Intensity-Duration-Frequency (IDF) Curves provided in Section 2.6 for the appropriate design storm.

A = area in acres of the tributary watershed

Section 2.4: Rational Method Runoff Coefficients (C)

Runoff coefficients (C) for the land uses shown in Table 2.4 must be used unless actual impervious areas are calculated and composite (C) factors are determined and submitted.

Land Use Description	Average Percent Imperviousness	Runoff Coefficient (C)
Natural and Undisturbed Areas (Open Space Conditions)	Varies	0.40
Single Family Residential Average Lot Size/Width	Varies (See Below for Value)	0.43 - 0.76 (See Below for Value)
3 acres/300 feet	6	0.43
2 acres/200 feet	7	0.44
1 acres/100 feet	12	0.47
1/2 acre/100 feet	23	0.53
12,500 sq. ft./80 feet	34	0.59
9,000 sq. ft./70 feet	42	0.63
7,500 sq. ft./60 feet	44	0.64
6,000 sq. ft./50 feet	48	0.66
<6,000 sq. ft./<50 feet	65	0.76
Industrial	72	0.80
Multi-family Residential	75	0.81
Commercial/Office	85	0.87
Impervious Areas Including; Pavement, Roofs, Drives, Sidewalks, etc.	100	0.95

Table 2.4 Rational Method Runoff Coefficients

Section 2.5: Time of Concentration

The time of concentration is the time associated with the travel of runoff from an outer point that best represents the shape of the contributing areas. Runoff from a drainage area usually reaches a peak at the time when the entire area is contributing, in which case the time of concentration is the time for a drop of water to flow from the hydraulically most remote point in the watershed to the point of interest. Runoff may reach a peak prior to the time the entire drainage area is contributing. Sound engineering judgment should be used to determine the time of concentration. The time of concentration to any point in a storm drainage system is a combination of the sheet flow (overland), the shallow concentrated flow and the channel flow, which includes storm sewers.

The Soil Conservation Service TR-55 method for calculating the time of concentration shall be used for all of pre-construction and post-construction runoff analyses. The minimum time of concentration for any area shall be 10 minutes. The maximum flow path for sheet flow (overland) shall be 100 feet in length.

Section 2.6: Average Intensity of Rainfall (i)

The average rainfall intensity for a particular storm occurrence frequency can be determined using the calculated time of concentration and the appropriate Intensity-Duration-Frequency (IDF) Curve. The City of Hamilton's IDF Curves provided in Figure 2.6, and/or intensity frequency table provided in Table 2.6, shall be utilized to determine intensities for the City of Hamilton.

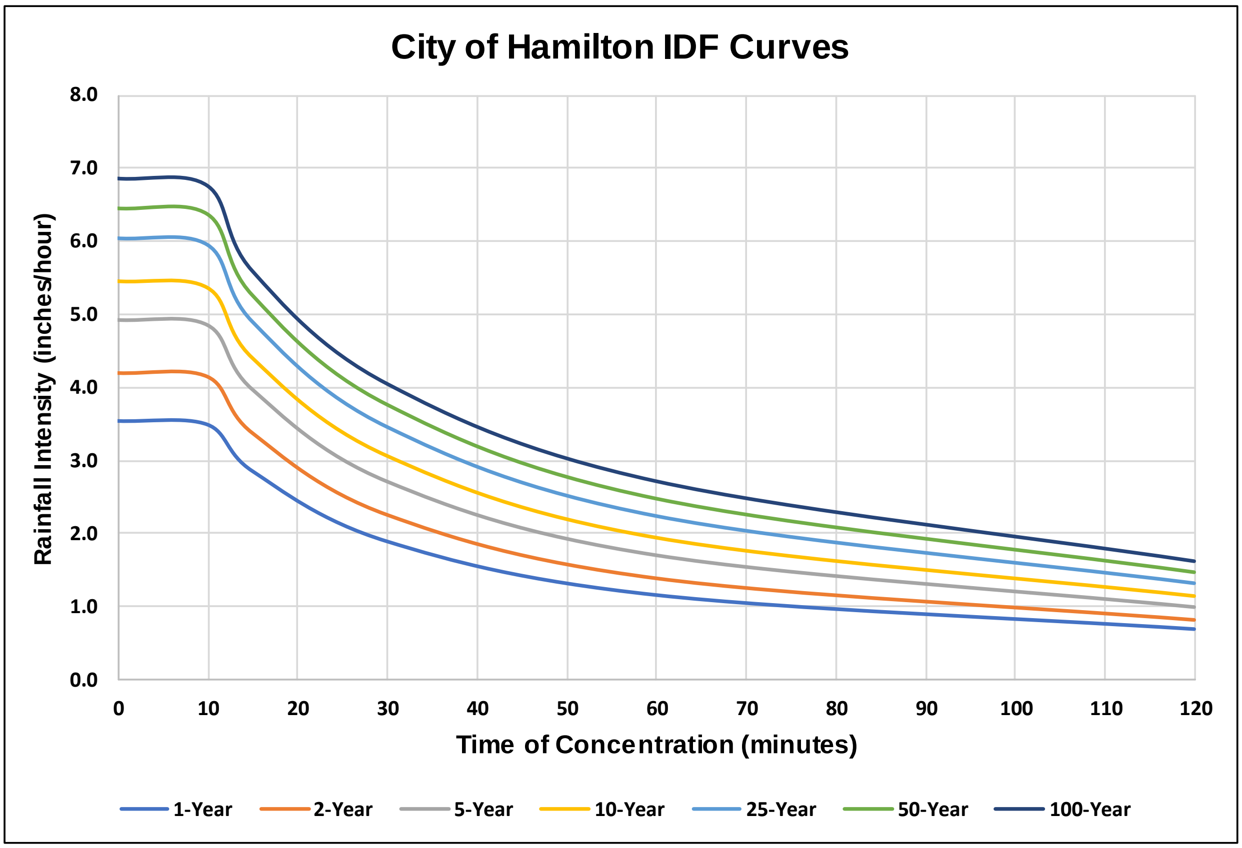

Figure 2.6 City of Hamilton IDF Curves Created from NOAA Atlas 14 Rainfall Data

Duration	Average Recurrence Interval (years)						
	1	2	5	10	25	50	100
10-min:	3.50	4.15	4.86	5.36	5.96	6.38	6.77
15-min:	2.86	3.38	3.98	4.40	4.91	5.27	5.60
30-min:	1.89	2.26	2.72	3.06	3.47	3.77	4.05
60-min:	1.15	1.39	1.71	1.94	2.25	2.48	2.71
2-hr:	0.68	0.82	1.00	1.14	1.33	1.47	1.61
	Data from NOAA Atlas 14, Volume 2, Version						

Table 2.6 City of Hamilton Intensity Frequency Estimates (Inches per Hour)

Section 2.7: Soil Conservation Service (SCS) Method

The Soil Conservation Service (SCS) Method may be used to calculate the peak discharge rates; develop runoff hydrographs for basins and sub-basins; determine runoff volumes; and provide inflow information to determine the required storage volume for detention and retention basins. The SCS Method is the preferred method for performing hydrologic analysis. The SCS Method will utilize the formulas, constants, and data as currently provided by the U.S. Natural Resources Conservation Service. The SCS method utilizes a 24-hour storm duration. When SCS methods are used, the Type II rainfall distribution shall be used. The rainfall depths for the 24-Hour storm can be found in the Midwestern Regional Climate Center Bulletin 71 - Rainfall Frequency Atlas of the Midwest and are included in Table 2.7 below. The Curve Number (CN) needed for SCS computations is based on the surface conditions of the project site. The CN can be determined from tables in SCS TR-55.

Storm Frequency	24-Hour Rainfall Depth (in.)
1-Year	2.33
2-Year	2.86
5-Year	3.49
10-Year	3.99
25-Year	4.70
50-Year	5.32
100-Year	6.04

Table 2.7 City of Hamilton 24-Hour Storm Rainfall Depths

Section 2.8: Channel Lining Hydraulic Method - Permissible Shear Stress

Permissible shear stress, T_d, indicates the stress that a lining material can withstand before erosion of the lining will occur. For a channel lining to be stable, the permissible shear stress must be less than the applied shear stress. Permissible shear stress of the most common linings can be found in Section 1102.3.2 of the ODOT L&D Manual Volume Two Drainage Design, latest version.

The Applied Shear Stress equation is below:

$$T_d = 62.4\ d\ S_o$$

Where:

T_d = Shear stress in a channel at maximum depth, lb/ft^2

d= Maximum depth of flow in the channel for the design discharge, ft

S_o = Average bottom slope, ft/ft

Section 2.9: Channel and Pipe Hydraulic Method - Manning's Equation

Overland and/or shallow concentrated flow empties into channels or pipes where it is conveyed to the outlet point. The Manning's equation shall be used to estimate average flow velocity in the channel or pipe. A channel section typical of the entire channel length shall be used to estimate channel velocity.

Manning's Equation:

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

Where:

Q = storm water flow in cubic feet per second

n = Manning's roughness coefficient (see Table 3.3)

A= cross-sectional area of flow in square feet

R = hydraulic radius (equal to A/P) in feet

P = wetted perimeter in feet

S = channel slope, in feet/feet

SECTION 3 - STORM SEWER SYSTEM DESIGN

Section 3.1: Purpose of Storm Sewer Systems

Storm sewer systems are designed to collect and convey storm water runoff from street inlets, storm water management facilities, and other locations where the accumulation of storm water is undesirable. The objective is to remove runoff from an area fast enough to avoid unacceptable amounts of ponding damage and inconvenience while preventing adverse off-site impacts.

Section 3.2: Peak Discharge Calculations

The method of runoff calculation for determining peak discharge (Q) for a drainage area shall be the methods described in Section 2.

Section 3.3: Design Methodology/Design Storm

Public storm sewer pipes shall be designed to carry peak flows as determined by methods previously described. All storm sewers shall be designed for the 10-Year Storm event, such that the HGL remains below the crown of pipe during peak flow. The 25-Year Storm shall be used as a check storm to confirm storm water containment at a minimum of 1 foot below the rim opening to prevent surcharging.

The Rational Method or SCS Method may be used to calculate runoff rates. The SCS Method shall be used for drainage areas greater than 50 acres. Manning's Equation shall be used to calculate pipe flow and velocity in order to design the pipe system.

Storm sewer pipe material shall be reinforced concrete if under pavement or roadways, and may be concrete, HDPE, or PVC if not under pavement. Corrugated metal pipe may only be allowed at the City's discretion. A listing of the Manning's Equation roughness coefficients for various pipe materials may be found in Table 3.3 below.

Storm Sewer Material	Roughness Coefficient
Concrete	0.013
PVC and HDPE	0.010
Corrugated Metal Pipe	0.024

Table 3.3 Storm Sewer Roughness Coefficients, "n"

Storm sewers shall have a minimum pipe cover of 12 inches between the top of the pipe and the pavement subgrade if under pavement, and shall have a minimum pipe cover of 24 inches between the top of the pipe and the ground surface in unpaved areas. Storm sewers shall be designed to provide a minimum 10-foot horizontal clearance from other utilities and an 18-inch vertical clearance from other utilities.

Section 3.4 Hydraulic Grade Line (HGL) for Design Storm

The hydraulic design of a storm sewer system consists of determining the location, sizes, slopes, and elevations for a system of underground conduits necessary to transport surface runoff to a downstream location. Storm sewers shall be designed such that storm water flows by gravity in the pipe, rather than pressure. The crown line of the upstream pipe shall match the crown line of downstream pipe.

Section 3.5: Pipe Velocities

The minimum velocity in public storm sewer pipes shall be 3.0 feet per second at full flow. The maximum velocity in public storm sewer pipes shall be 15.0 feet per second. Excessive velocities shall be avoided to prevent hydraulic problems and to prevent erosion at system outfalls. Velocities shall be non-erosive at the re-entrance into the receiving channel. An outlet velocity of 5.0 feet per second or less is generally considered to be non-erosive.

In cases where the outlet velocity is greater than 5.0 feet per second, the downstream receiving channel or stream must receive adequate protection against erosion through the use of erosion prevention practices or energy dissipation devices.

Section 3.6: Pipe Slopes

Storm sewers shall have a minimum slope of one-half percent (0.5%). A slope of less than one half percent may only be permitted upon prior review and approval by the City. Storm sewers shall have a maximum slope of 25 percent provided the maximum velocities are not exceeded. Storm sewers on slopes over 20 percent shall be anchored securely with concrete anchors. Drop manholes may be permitted to avoid excessive storm sewer slopes.

Section 3.7: Minimum Pipe Sizing

Minimum storm sewer pipe size shall be 12 inches in diameter. The only circumstance when smaller diameter pipes may be used are for flow attenuation purposes within a post-construction storm water management facility.

Section 3.8: Manhole Placing, Spacing and Sizing

Storm sewer manholes shall have a maximum spacing and sizing as follows:

1. Place manholes at the following locations:

    a. Where two storm sewers intersect.
    b. At changes in pipe size.
    c. Where slope changes.
    d. Where horizontal alignment changes.

2. The minimum diameter of manholes shall be 48 inches. Refer to the National Precast Concrete Associate (NPCA) manhole sizing standards and recommendations.

3. For storm sewers less than or equal to 48 inches in diameter, maximum spacing of manholes shall be 300 feet.

4. For storm sewers greater than 48 inches in diameter, maximum spacing of manholes shall be 400 feet.

Section 3.9: Inlet Capacity

Inlets shall be designed according to requirements listed in Sections 1103.4 through 1103.7 of the Ohio Department of Transportation (ODOT) Location and Design (L&D) Manual Volume Two Drainage Design, latest version.

Inlets at low points or sags shall have extra capacity as a safeguard for street flooding from flows overtopping the street curb. An emergency spillway designed for the 100-Year Storm shall be placed at all low points or sags. Curb openings or combination inlets should be used for overflows in the event that the grate is clogged. Special inlets may be required for streets with steep gradients to provide the extra capacity such situations require. Where avoidable, inlets shall not be placed along streets where driveways and/or aprons conflict with mountable roll or depressed curbing. Roll curb and gutter inlet grates, as a general rule, shall be placed at a maximum interval of 300 feet, provided a minimum 10-year design storm flow capacity has also been achieved. Inlets within wooded areas or locations prone to receiving larger debris shall be protected by trash racks.

Section 3.10: Storm Sewer Outfalls

When a storm sewer system outfalls into a floodplain of any major watercourse, the outfall must be high enough to prevent tailwater conditions that impact HGL requirements of the storm sewer system. Headwalls and/or headwalls with wingwalls including rock channel protection and aprons as erosion control shall be constructed for all outfalls. Suitable baffles or other energy dissipaters shall be provided if the velocity of the storm water discharge is greater than 6.0 feet per second. Outlet pipes that are smaller than 6 inches shall be adequately protected from clogging by an acceptable external trash rack.

Section 3.11: Culvert and Bridge Design Criteria

Culverts, including proper backfill, shall be designed in accordance with Section 1105 of the ODOT L&D Manual Volume Two Drainage Design, latest version. The maximum allowable headwater shall not exceed 1.2 times the structure rise unless specifically approved by the City of Hamilton on a case-by-case basis. Downstream channels must receive appropriate protection or energy dissipation if the design outlet discharge would cause erosive conditions (velocity of discharge is greater than 5.0 feet per second). Any culvert or bridge that is located in a FEMA floodplain must be analyzed using methodologies acceptable to FEMA and the City.

Section 3.12: Design of Private Storm Sewer Systems

Storm drainage systems on private sites that will not be accepted for maintenance and operation by the City of Hamilton shall be designed to mitigate impacts of flooding and property losses on off-site properties and drainage facilities. Storm sewer systems on these sites shall be designed using the design criteria and methods previously described in Section 2 and shall be submitted to the City of Hamilton for review.

SECTION 4 - OPEN CHANNEL DESIGN

Section 4.1: Purpose of Open Channels

This section describes the technical criteria necessary to design open channels using conventional design procedures. These procedures shall be applied to roadside and rear yard ditches and highly urbanized channels. The objective of open channel flow design is to determine a channel slope and size that will have sufficient capacity to prevent flooding damage during the anticipated peak runoff period; and to determine the degree of protection based on stream velocity to prevent erosion in the drainage channel.

Open channels shall be avoided wherever possible in residential subdivisions. Channels may be permitted when the required pipe size exceeds 36 inches. Natural streams and water courses should be left as undisturbed as practical.

Section 4.2: Design Storm/Methodology

For all developments, drainage channels and ditches shall be capable of conveying the 10-Year Storm flow within their banks, such that the HGL is below the top of the channel. The peak flow rate resulting from the 100-Year Storm shall be confined within the defined easement of the open channel.

The Rational Method or SCS Method may be used to calculate runoff rates. The SCS Method shall be used for drainage areas greater than 50 acres. The SCS Hydrograph method shall be used to analyze the HGL in order to meet design criteria. Manning's Equation shall be used to calculate channel flow.

Section 4.3: Peak Flow Capacity

Each portion of the storm water system of drainage channels and watercourses shall be capable of handling the peak flows as determined by the proper method previously described in Section 2. Manning's Equation is recommended to calculate the flow rates and is listed in Section 3.3. Typical roughness coefficients applicable to open channels and ditches may be found in the latest version of the HEC-RAS Hydraulic Reference Manual.

Section 4.4: Open Channel Linings, Design Slopes, and Velocities

When open drainage channels require various lining types to attain ultimate design capacity, the earth sections of the drainage channel and its structure shall be designed and constructed to the ultimate design capacity required. Lining is required in initial construction and must be maintained throughout construction. Durable channel linings shall be designed to control flows resulting from the 10-Year Storm Event. The design of channel linings shall meet both the velocity and shear stress requirements, using the methodology described in Section 2.

Durable channel lining is required along the side slopes and bottom of the open channel up to the peak elevation of the 10-Year Storm Event. Durable channel lining may be low maintenance ground cover, sod, soil bioengineered systems, turf reinforcement mats or concrete. Rip-Rap, Aggregate Channel Lining and Gabion Baskets are to be limited to areas immediately downstream of an outlet pipe to reduce velocities and erosion potential.

Open channels shall have side slopes no steeper than 4:1 (horizontal to vertical). The minimum slope for open channels shall be 1.0 percent except for natural streams or paved ditches. All open channels having a velocity of 5 feet per second or less shall be sodded, except that channels may be seeded if the velocity is under 2 feet per second. All open channels with a velocity over 5 feet per second shall be lined. If the design parameters are beyond the limits of natural vegetation, then a non-degradable durable material must be used.

SECTION 5 - POST-CONSTRUCTION STORM WATER MANAGEMENT FACILITIES

Section 5.1: Purpose of Storm Water Management Facilities

The purpose of post-construction storm water management facilities is to mitigate damage caused by flooding. Retention and detention basins are important storm water management facilities for flood control purposes.

Storm water management facilities shall be designed so that no standing water remains in detention basins during dry weather (72 hours following most recent rainfall) or that standing water in retention basins shall not be allowed to stagnate and present health hazards. The use of other methods of controlling peak discharge rates, such as bioretention swales and structures, may be used if approved by the City. The amount of water to be detained shall be determined by the methods described herein using the design criteria described in Section 2.

Based upon location in the contributing watershed, alternative storm water management practices may be required by the City if it is determined or can be demonstrated that detention of runoff will be detrimental to the overall hydrologic response of the watershed.

Section 5.2: Design Methodology/Design Storm

The methodology and calculations used for the design and sizing of storm water management facilities for detention or retention shall be based on the Critical Storm Method as described below. The SCS Method shall be used for the purposes of sizing storm water management systems/detention basins.

If the post-development storm water runoff volume from a site will be greater than the pre-development storm water runoff volume from the same site, the peak flow rate from the Critical Storm and all more frequent storms shall be less than or equal to the peak flow rate from a 1-Year 24-Hour storm occurring on the same site under pre-development conditions. The post-development peak flow rate from storms of less frequent occurrence (longer return periods) than the Critical Storm up to the 100-Year 24-Hour storm shall be less than or equal to the pre-development peak flow rates from equivalent size storms.

The Critical Storm for a specific development area shall be determined as follows:

1. Determine the total volume of storm water runoff from a 1-Year 24-Hour storm for both pre-development and post-development conditions.

2. Determine the percent increase in the total volume of storm water runoff due to development and select the Critical Storm from Table 2-1.

Storm Water Runoff Volume Increase		Critical Storm
Equal to or Greater	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

Table 5.2 Critical Storm Method

Hydrographs for the 1-Year, 2-Year, 5-Year, 10-Year, 25-Year, 50-Year, and 100-Year Storm events shall be routed through the proposed storm water management facilities using the SCS Method to confirm the Critical Storm method requirements are achieved.

Section 5.3: Detention/Retention Basin Design Standards

The following conditions are required for storm water runoff control facilities:

1. The outlet control structure shall be sized to accommodate a flow equal to the 100-Year Storm post-development discharge.

2. The outlet control structure shall be designed to handle the 100-Year Storm event so that no flow passes through the emergency spillway. The emergency spillway shall be designed to handle the 100-Year Storm event without overtopping the embankment. Erosion protection and any necessary energy dissipation shall be provided for spillways and any receiving watercourse. Spillways shall not be placed over a dam. Vegetated emergency spillways shall be embedded in in-situ soils.

3. The dam crest elevation shall not be less than one foot above the highest water surface elevation during the 100-Year Storm event.

4. Detention basins shall be fully discharged within 72 hours after the storm event.

5. The detention basin shall be the first item of construction and shall be designed to function as the sediment basin throughout construction. The basin design must be checked for capacity due to additional runoff generated by disturbed site conditions.

6. The detention basin shall be easily accessible for maintenance. All basins shall be designed and constructed with side slopes no greater than 3:1 (horizontal to vertical).

7. Fencing will be required around all basins which are within lots to be deeded to the City or within easements to be granted to the City.

8. Dam permit if required by the latest regulations available from the Ohio Department of Natural Resources.

Section 5.4: Maintenance Responsibilities

The owner of a storm water runoff control facility and/or the developer of each subdivision shall be responsible for properly maintaining each storm water runoff control facility in order for such facility to function according to its design and purpose. Maintenance provisions for each facility shall be noted on the submittal plans, including suitable access as approved by the City.

Post-construction storm water management facilities and BMPs that have been reviewed and approved by the City shall be required to enter into a maintenance agreement following construction to ensure adequate long-term operation and maintenance. The City shall utilize its Post-Construction Storm Water Management Facility Maintenance Agreement as the mechanism for long-term operation and maintenance requirements of post-construction storm water management facilities or BMPs. Failure to comply with the requirements of the Post-Construction Storm Water Management Facility Maintenance Agreement by the owner of the storm water management facility or BMP will be subject to the penalties prescribed in Section 929.99 of the City's ordinances.

SECTION 6 - WATER QUALITY BEST MANAGEMENT PRACTICES (BMPs)

Section 6.1: Purpose of Water Quality BMPs

The purpose of post-construction water quality BMPs is to reduce the pollution associated with storm water runoff from new development and re-development projects. Post-construction storm water runoff treatment requirements are the result of Ohio EPA storm water regulations that require the City to develop a storm water runoff quality treatment standard for all applicable new development and re-development projects.

Construction activities disturbing one or more acres of total land or will disturb less than one acre of land but are part of a larger common plan of development or sale that will ultimately disturb one or more acres of land, shall be required to implement post-construction water quality BMPs. The threshold acreage includes the entire area disturbed in the larger common plan of development or sale. Construction activities that meet this threshold shall obtain coverage through the Ohio EPA National Pollutant Discharge Elimination System General Storm Water Permit for Construction Activities, latest version. Post-construction water quality BMPs shall comply with the Post-Construction Storm Water Management Requirements prescribed in the Ohio EPA General Storm Water Permit for Construction Activities.

Section 6.2: Water Quality Design Standards

The design of water quality BMPs are required to be consistent with all standards and specifications included in the Ohio DNR Rainwater and Land Development manual, latest edition. Post-construction water quality BMPs shall be selected, sized, and designed to completely capture the water quality volume (WQ_v) prior to discharging from the site. The WQ_v used for sizing post-construction water quality BMPs shall be computed as follows:

$$\mathbf{R_v = 0.05 + 0.9i}$$

Where:

R_v = volumetric runoff coefficient

i = the fraction of post-construction impervious surface

$$\mathbf{WQ_v = R_v \times P \times A / 12}$$

Where:

WQ_v = water quality volume (acre-feet)

R_v = volumetric runoff coefficient;

P = 0.90 inch rainfall depth; and

A = drainage area to BMP (acres).

Post-construction water quality BMPs typically include, but are not limited to, the following:

- Wet extended detention basins;
- Dry extended detention basins;
- Constructed extended detention wetlands;
- Permeable pavements;
- Sand and other media filtration;
- Bioretention areas/cells;
- Infiltration basins; and
- Infiltration trenches.

For detailed requirements and design guidance on these types of post-construction water quality BMPs, refer to the following documents:

- Ohio Environmental Protection Agency (EPA) National Pollutant Discharge Elimination System General Storm Water Permit for Construction Activities, latest version.
- Ohio Department of Natural Resources (DNR) Rainwater and Land Development manual, latest edition.
- Ohio Department of Transportation (ODOT) Location and Design (L&D) Manual Volume Two Drainage Design (Section 1117), latest version.

For those areas of development and re-development that result in a new or expanded discharge from the MS4 to high-quality waters, additional provisions may be required to protect existing in-stream water uses and the level of water quality necessary to protect the existing uses.

SECTION 7 - EROSION AND SEDIMENT CONTROL

Construction activities disturbing one or more acres of total land, or will disturb less than one acre of land but are part of a larger common plan of development or sale that will ultimately disturb one or more acres of land, shall be required to implement erosion and sediment controls or Best Management Practices (BMPs). The threshold acreage includes the entire area disturbed in the larger common plan of development or sale. Construction activities that meet this threshold shall obtain coverage through the Ohio EPA National Pollutant Discharge Elimination System General Storm Water Permit for Construction Activities (Ohio EPA OHC00005 or latest version). Erosion and sediment controls or BMPs shall comply with the Storm Water Pollution Prevention Plan (SWP3) Requirements prescribed in the Ohio EPA General Storm Water Permit for Construction Activities. Erosion and sediment controls shall be selected and designed to be consistent with standards and specifications included in the Ohio DNR Rainwater and Land Development manual, latest edition.