STORMWATER DESIGN MANUAL

for the

CITY OF REYNOLDSBURG, OHIO

A. DESIGN STANDARDS

1) The design standards contained in the most current edition of the Rainwater and Land Development Manual by ODNR and the Best Management Practices listed within the State General Construction Permit (OEPA Permit OHC 000002) or its subsequent OEPA-issued revision shall be used to determine technical acceptability of land development stormwater management methods. The City Engineer shall determine the acceptability of the hydrologic design.

2) The United States Department of Agriculture Soil Conservation Service soil classification mapping of the City shall be used to determine soil classification for the purpose of all stormwater management design unless more detailed data is prepared by competent authority and reviewed by the City Engineer, and accepted by the Service Director.

3) Predevelopment site runoff will be calculated using the curve number method with a curve number reflecting existing land use.

B. STORMWATER RUNOFF CONTROL CRITERIA

1) Quantitative Control. Stormwater quantity control shall be implemented pursuant to the criteria specified as follows:
   a) 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 frequency, 24-hour storm. In addition, if it is found *that* 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 three reasons why increases in volume of runoff require a control standard more restrictive than controlling to the predevelopment condition. Firstly, increases in volume mean runoff requires a control standard more restrictive than controlling to the predevelopment condition. Secondly, 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 the problems associated with peak flow (flooding). This is known as the "Routing Problem." Thirdly, 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:

i. Determine the total volume of runoff from a 1-year frequency 24-hour storm, occurring over the area before and after development.

ii. Determine the percentage of increase in volume due to development and using this percentage, pick the critical storm from the following table (Table A):

Table A. Critical Storm for Discharge 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

b) 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 peak rate 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 an l-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.

c) Storage volume, generally, does not have to be provided for off-site upstream drainage areas. However, flow from such areas must be routed through the drainage systems in the development under consideration, at its existing rate of flow.

2) Qualitative Control. Stormwater quality control shall be implemented into sites within developing areas in accordance with the general and specific requirements outlined in the Ohio EPA-issued General Permit for Stormwater Discharges associated with Construction Activity (OEPA Permit No. OCH000002, Part IIIG.2.e or its subsequent OEPA-issued revision.

C. STORMWATER SYSTEM GENERAL DESIGN CRITERIA

1) Design Storms:
    a) The initial drainage system is that part of the storm drainage system which is used regularly for collecting, transporting, and disposing of storm runoff, 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 portion of the drainage system shall be designed to carry 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.

2) Initial Storm: Physical Design Criteria for On-Site Improvements:
    a) Depth of flow in natural channels shall not exceed bank full stage with backwater effects considered.
    b) Depth of flow in artificial channels shall not exceed 0.8 bank full stage. Velocity of flow shall be determined in accordance with the design criteria for open channels and shall not exceed 5 feet per second. Where flows exceed this rate, special channel lining and erosion protection shall be provided.
    c) 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 five feet per second for grass swales ~~of~~ *or* ten feet per second for pave*d* ditches.
    d) 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 minimum five-year initial design storm onto the pavement.
        i. For Neighborhood Collector streets carrying traffic from the individual residence to collector and secondary streets, the flow may spread to the crown of the street.
        ii. For Minor Arterial streets, one lane shall be free from water.
        iii. For Major Arterial streets, one lane in each direction shall be free from water.
        iv. For freeways, no encroachment is allowed on traffic lanes.

    e) In design of conduit, the conduit shall be designed on the basis of flowing full with surcharge to gutter line. Backwater effects shall be considered.

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 U.S. Army Corps of Engineers, the U.S. Department of Housing and Urban Development, or the Ohio Department of Natural Resources, where such determinations have been made.
   b) Many of the drainageways 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. Corps of Engineers HEC-2 method or other accepted methods of determining water profiles using the major design storm runoff. One-half foot elevation shall be added to the flood profile as freeboard for protection in the event of future encroachments into the floodway fringe or in the drainageway.
   c) Where the street is designed as the major drainageway, the depth of flow shall not exceed 12-inches at gutter line for local and collector streets and shall not exceed 6-inches depth at crown for primary streets. The same maximum depth criteria will apply where major drainageway crosses the street. Where a major drainageway is located outside a street, right-of-way easements will be provided.
   d) In determining the required capacity of surface channels and other drainageways provided for the major storm runoff, the street storm inlets and conduit provided for the initial design storm shall 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

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

Where:

$Q_{flood\ routing\ path}$ = *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)*

e) Retention and Storage: Areas designed for storage of stormwater by retention should be incorporated into the natural features of the general area, where possible. Cooperative planning and joint owner construction of detention or retention facilities and use of natural land contours is encouraged. No such facilities will be permitted which may become construction, or maintenance problems. The City encourages that detention or retention facilities be designed as multipurpose spaces such as open space, recreation and/or scenic areas. Requirements for easements, access and maintenance are stated in subsequent sections of this Manual.

H. STORMWATER SYSTEM SPECIFIC DESIGN SPECIFICATIONS

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 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 acceptable

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

e) Drainage area. The drainage area in acres, and 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:

i. 10-year frequency 24-hour storm event for private drives, local and collector streets.

ii. 25-year frequency 24-hour storm event for arterial streets.

h) Design flow. For method of calculation, refer to Table B at the end of this chapter.

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

i. 18-inches below the top of curb;

ii. 12-inches below the edge of pavement;

iii. 1.2 times the diameter of culvert; or

iv. Diameter or rise plus two feet, in deep ravines.

v. Property Damage – 100-year frequency headwater plus 1-foot, shall not exceed any existing or proposed building first floor elevation.

j) Manning’s roughness coefficient (n). (See Table C at end of this chapter) Manning’s Roughness Coefficient (n) should be as given in Table B unless an alternate value is approved by the City Engineer.

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

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

m) Maximum allowable outlet velocity, shall be:

Turf Channel	5 f.p.s.
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 manner in which flows greater than the design storm will route over or around the culvert, shall be demonstrated to not create a hazard or to cause potential for erosion or personal property damage. Additional scour protection may be required.

p) End protection should be as follows:

i. 12-inch through 36-inch culverts – full-height headwall.
ii. 42-inch through 84-inch culverts – full height headwall with flared wings.
iii. Other special type headwalls must be approved before use.

2) Storm Sewers. The criteria for designing storm sewer systems are listed:

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 (c.f.s.)
A = Area of cross-section of flow (sq.ft.)
V = Mean velocity of flow (f.p.s.)
n = Manning’s roughness coefficient (n=0.013 for all storm sewers)
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

- 72" and under - flowing full for 2-year storm
- Over 72" diameter - flowing full for 10-year storm

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

d) Design Flow:
   i. Areas under 200 acres use Rational Method Q = CiA.
   ii. Areas between 200 and 300 acres transition between Rational Method and Technical Release 55.
   iii. Areas over 300 acres use Technical Release 55.
   iv. Minimum times of Concentration:
      - Curb inlet - 10 minutes
      - Catch basin - 10 minutes

e) Runoff Coefficient: Based on Table D, with 0.4 as a minimum.

f) Manning's "n" Value: All storm sewers shall be based on an "n" of 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, reference Subsection 2) b) listed above, with the 5-year storm hydraulic grade line contained to the system.

i) Solids: The gradient of the sewer must be sufficient to avoid deposition of solids. Reference minimum velocity requirement specified in s) below.

j) Material: The storm sewer material for municipally maintained sewers shall be concrete, 12-inch minimum size. 8-inch through 15-inch PVC or 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 allowed.

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's 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 invert to the top-of-casting elevation.

l) Flow Line: Unless otherwise approved by the City's 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.

m) Specifications: Methods of construction and trench backfill shall be as per the requirements of the City and the City of Columbus "Construction and Materials Specifications", latest edition, as approved for use by the City's 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 the ½ the pipe diameter or a depth of two-feet at the outlet, whichever is less. When submergence is allowed upon approval by the City's Engineer, special requirements shall include, but may not be limited to:
   i. Submergence "zone" shall not extend beneath pavement.
   ii. Submergence "zone" shall not extend beyond the first manhole.
   iii. "O-ring" sealed gasketed pipe joints shall be installed along the storm sewer for the full length of the submergence zone.
   iv. Anti- seepage collars shall be installed in the submergence "zone".

o) End protection should be as follows:
   i. Culverts shall utilize full-height headwalls. If the outlet is not located within a channel bank or within the direct flow path of crossing floodwaters, half-headwalls at the outlet may be used if approved by the City's Engineer. In no instance will half-headwalls be allowed on non-concrete conduit.
   ii. 42-inch through 84-inch culverts – full height headwall with flared wings.
   iii. Other special type headwalls must be approved before use.

p) Minimum Cover to Subgrade:
   i. Desirable, under pavement and within influence of traffic load - 30 inches from top of pipe to subgrade.
   ii. Desirable, beyond influence of traffic loads (standard strength pipe) – 18-inches from top of pipe to ground surface.

q) Maximum Cover over pipe:

   i. The supporting strength of the conduit, as installed, divided by a factor of safety of 3 must equal or exceed the loads imposed upon it by weight of earth plus any superimposed loads, unless otherwise approved by the City Engineer.
   ii. 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.

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's 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. In addition, all PVC and polyethylene pipe allowed to be installed in the right of way shall be concrete encased per CMS 910. Any concrete encasement of flexible pipe shall extend from structure to structure.

s) Velocity in Sewer for Design Flow:
   i. 3 fps Minimum
   ii. 15 fps Maximum
   iii. No minimum for outlets from ponding areas

t) Maximum Length between Access Structures

   i. Pipes under 60-inch – 350 feet
   ii. Pipes 60-inch and over 500 feet

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 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:
      i. Two-year storm frequency.
      ii. Rational method of calculation.
      iii. Ten minutes for minimum time of concentration.
      iv. 0.015 for roughness coefficient for composite roadway paved and gutter section.
      v. Maximum width of spread of flow:

Street Width	Width of Spread
< 26 ft.	7 ft.
> 26 ft.	8 ft.

   c) Underdrains: Four (4) inch curb drains 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.

4) Detention Facilities

   a) Ownership and maintenance. The owner and thus responsible party to provide a maintenance and operation agreement for the stormwater management facility (i.e., detention, retention basin, etc.), prior to the acceptance of plans by the City or the acceptance of the final engineering and construction plan. No lot sales or construction will be permitted until this is done.

   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 other entity. Responsibility shall become the responsibility unless otherwise approved by the City's 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. BMPs acceptable by the OEPA for stormwater management and treatment are listed within the State General Construction Permit OCH000002 or its subsequent OEPA-issued revision. The following types of storage facilities may be considered for detention and are subject to approval by the City's Engineer: rooftops, parking lots, underground tanks and surface basins or ponds (i.e., dry or wet detention) and man-made stormwater wetland systems:

i. 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.

- Ponding areas in parking or traffic areas shall be designed for a maximum potential depth of twelve (12) inches.
- Flood routing or overflow must occur after the maximum depth is reached.

ii. Tank Storage. Tank storage utilizes an underground tank or chamber, either prefabricated or constructed in place, which has a special controlled release feature. Underground storage may only be proposed to the City following OEPA review and approval. 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 materials.

iii. Surface Basin - Wet Retention (pond). 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.

Some problems encountered with wet detention 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. A five (5) foot chain link fence may be required where a wet retention basin is to be constructed adjacent to an existing residential development for that part along the existing single-family section. A liner may be required on sites where there are granular soil conditions.

A. The steepest side slopes for a Wet Retention basin should be:
   - 2:1 horizontal to vertical - below permanent storage, and
   - 6-foot wide, 2-foot deep submerged bench at waters edge around perimeter of pond, and
   - 5:1 horizontal to vertical - above permanent storage.

B. Unless otherwise approved by the City’s Engineer, a minimum of 20 % of the pool area should be ten-feet deep for water-quality benefit.

C. 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.

D. 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 levies over ten feet in height, refer to Section 1521.062, O.R.C.

iv. Surface Basin – Dry Detention: 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 is included to control the rate of discharge.

Dry detention basins are a widely used method of stormwater management. The soil permeability and water storage potential are not as important with dry detention basins as with wet retention. Therefore, dry detention basins have the greatest potential for broad applications. 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-use purposes such as recreation and parks.

A. The steepest side slopes for a Dry Detention basin should be 5:1.

B. 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 the bottoms of such facilities shall be 0.50 %, and 2.0 % is the recommended transverse slope. All transverse bottom slopes flatter than 1 ½ % to and including 0.5 %, should be lined with 6-inch minimum thickness concrete, reinforced with steel mesh to accommodate temperature stresses, of air-entrained Class C concrete, and with synthetic linseed oil waterproofing treatment.

C. Invert ditches within dry detention basins, from the inlet to the outlet of all structures shall be paved if the slope is less than 0.50 %. Such ditches shall be paved with 6-inch minimum thickness concrete paving reinforced with steel mesh to accommodate temperature stresses, of air-entrained Class C concrete, and with synthetic or linseed oil waterproofing treatment. Minimum depth of paved invert ditch should be 1 foot.

D. 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 levies over ten feet in height, refer to Section 1521.062, O.R.C.

v. Man-made Stormwater Wetland system: This technique involves 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's Engineer prior to design to determine acceptance by the City. Suggested design guidelines include:

- Urban Runoff Quality Management: WEF Manual of Practice No. 23 and ASCE Manual and Report on Engineering Practice No. 87,. Water Environment Federation and American Society of Civil Engineers, 1998.
- Design of Stormwater Wetland Systems: Guidelines for Creating Diverse and Effective Stormwater Wetland Systems, Thomas R. Schueler, Anascotia Restoration Team, Department of Environmental Programs, Metropolitan Washington Council of Governments, October 1992.

vi. Infiltration and Alternative Technologies Best Management Practices: The City would like to encourage the use of alternative storm water handling technologies. Such technologies include (but are not limited to) infiltration swales, permeable pavements/pavers, and rain gardens. The proposed alternative treatments must be acceptable to the Ohio EPA, reflect good engineering practices, and be accepted by the City and it's administration.

Table B. Acceptable Methods of Calculation for Design Flow in Roadway Culverts

<table>
<tr><td rowspan="3">DRAINAGE AREA (ACRES)</td><td colspan="5">STORMWATER QUANTITY</td></tr>
<tr><td rowspan="2">PEAK DISCHARGE ONLY</td><td colspan="2">PEAK DISCHARGE AND TOTAL RUNOFF VOLUME</td><td colspan="2">STORAGE VOLUME</td></tr>
<tr><td>HOMOGEN. LAND USE</td><td>NON-HOMOGEN.</td><td>HOMOGEN.</td><td>NON-HOMOGEN.</td></tr>
<tr><td>LESS THAN 200</td><td>RATIONAL OR PEAK DISCHARGE</td><td>PEAK DISCHARGE</td><td rowspan="2">(*) TABULAR HYDRO-GRAPH</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 Village 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 Hydrography: 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

Table C. 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

Table D: 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

Glossary:

The following definitions shall apply to this Manual:

Attenuation: to reduce the amount, volume or concentration of pollutants or surface water.

100-year flood: A flood which has the probability of occurring once every one-hundred (100) years or having a one (1) percent chance of occurring each year.

Baseflow: Minimum, long-persistence flow in streams produced mainly by seepage; sometimes called subsurface flow.

Best management practice(s) (BMP): Measures including structural and non-structural BMPs that are determined to be the most effective, practical means of preventing or reducing point source or non-point source pollution inputs to storm water runoff and water bodies (see Practices).

Channel: Natural or artificial watercourse of perceptible extent, with a definite bed and banks to confine and conduct continuously or periodically flowing water. Channel flow thus is that water which flows by gravity and is characterized by a free water surface within the banks of a defined channel.

Water Quality Volume (CPWQv): The volume of storm water runoff which shall be captured and treated prior to discharge from the developed site after construction is complete. CPWQv is equivalent to the volume generated by a 0.75 inch rainfall.

City: The City of Reynoldsburg.

City Engineer: The City of Reynoldsburg, City Engineer.

Contamination: The presence of or entry into a public water supply system, the MS4, Waters of the State, or Waters of the United States of any substance which may be deleterious to the public health and/or the quality of water.

Conveyance: Any pipe, channel, inlet, drain, or other structure that facilitates the movement or removal of water.

Dam: an artificial barrier usually constructed across a stream channel to impound water.

Design Storm: A rainfall event of specified size and return frequency (e.g., a storm that occurs only once every 2 years), which is used to calculate the runoff volume and peak flow rate.

Detention: Runoff enters an area of detention faster than it leaves. It occurs in depressions, the natural landscape, or constructed stormwater facilities. While detention can be designed into ponds with or without a permanent pool, dry ponds often are referred to as detention ponds.

Detention Basin: a facility designed for the temporary storage of stormwater runoff for the purpose of delaying and attenuating flow to the downstream receiving system.

Detention Storage: Storm runoff collected and stored for a short period of time and then released at a rate much less than the inflow rate. (e.g. a dry reservoir)

Development: Any action in preparation for construction activity which results in an alteration of either land or vegetation, including but not limited to clearing, grubbing, grading, filling, excavation or any other operations and the construction of new facilities, buildings, parking areas, recreational areas, etc.

Discharge: Any substance introduced to the Waters of the State or to surface runoff which is collected or channeled by the MS4 which do not lead to treatment works and/or the addition of any pollutant to the Waters of the State from a point source.

Disturbed: Earth surface subject to erosion due to the removal of vegetative cover and/or earthmoving activities.

Ditch: An open channel constructed for the purpose of drainage or irrigation with intermittent flow.

Drainage: A general term applied to the removal of surface or subsurface water from a given area, either by gravity or by pumping, commonly applied herein to surface water.

Drainage system or drainage way: The surface and subsurface system for the removal of water from the land, including both the natural elements of streams, marshes, swales and ponds, whether of an intermittent or continuous nature, and man-made elements which include culverts, ditches, channels, storage facilities and the storm sewer system.

Easement: Property titled to the city for the operation and maintenance of storm water drainage and management systems.

Engineer: A Professional Engineer registered in the State of Ohio as required by Chapter 4733 of the Ohio Revised Code.

Environmental Protection Agency (EPA): The U.S. Environmental Protection Agency or, where appropriate, a designation for the City Engineer or other duly authorized official of such Agency.

Erosion: The general process whereby soil or surface material is moved by flowing surface or subsurface water or is worn away by the action of wind, water, ice or gravity.

Erosion control: Measures that reduce or prevent erosion.

Extended Detention: A stormwater design feature that provides for the gradual release of a volume of stormwater (typically 0.25 - 0.75 inch per impervious acre) over a 24 to 48-hour interval to increase settling of urban pollutants and protect channels from degradation.

Facility: Any operation, including construction sites, required by the Federal Clean Water Act to have a permit to discharge storm water associated with activities subject to NPDES Permits as defined in 40 CFR, Part 122.

Flood: A temporary rise in the level of rivers, streams, watercourses and lakes which results in inundation of areas not ordinarily covered by water.

Flood Plain: The relatively level land to either side of a channel, which is inundated during high flows. It is often used to reference the 100-year flood plain.

Forebay: A distinct area near an inlet of a pond to enhance deposition of incoming sediments.

Geotextile: A woven or nonwoven, water-permeable fabric generally made of synthetics such as polypropylene. It's used to slowly pass runoff or as bedding for rock to keep the rock separate from adjacent soil.

Grading: Changing the ground surface condition, elevation, and/or slope through excavation or fill of material.

Hydrologic Soil Group: One of four classifications of soil based on the minimum infiltration characteristics for bare soil after prolong wetting as used by the United States Department of Agriculture Natural Resources Conservation Service *Technical Release No. 55, Urban Hydrology for Small Watersheds.*

Impervious Surface: Any constructed surface; including but not limited to, rooftops, sidewalks, roads, and parking lots; covered by impenetrable materials such as asphalt, concrete, brick, and stone. These materials seal surfaces, repel water and prevent precipitation and runoff from infiltrating soils. Soils compacted by urban development are also highly impervious.

Infiltration: The gradual downward flow of water from the surface through soil to groundwater.

Landscape: To mow, seed, sod, plant, and to do other activities which are not earth changes.

Larger common plan of development or sale: means a contiguous area where multiple separate and distinct construction activities may be taking place at different times on different schedules under one plan.

Levee: an artificial barrier that diverts or restrains flood waters from streams and lakes.

Material: Soil, sand, gravel, clay, or any other organic or inorganic substance.

City: The City of Reynoldsburg.

Municipal Separate Storm Sewer System (MS4): As defined at 40 CFR 122.26(b)(8), "means a conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains):

A. Owned or operated by a State, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State law)…including special districts under State law such as a sewer district, flood control district or drainage district, or similar entity.

B. Designed or used for collecting or conveying storm water;

C. Which is not a combined sewer; and

D. Which is not part of a Publicly Owned Treatment Works (POTW) as defined at 40 CFR
122.2."

National Pollutant Discharge Elimination System (NPDES): A national program under Section 402 of the Clean Water Act for regulation of discharges of pollutants from point sources to Waters of the United States. Discharges are illegal unless authorized by an NPDES permit.

NPDES Permit: A permit issued by the EPA (or by a State under authority delegated pursuant to 33 USC § 1342(b)) that authorizes the discharge of pollutants to Waters of the United States, whether the permit is applicable on an individual, group, or general area-wide basis.

OAC: Ohio Administrative Code.

OEPA: The Ohio Environmental Protection Agency.

Operate: To drive, conduct, work, run, manage, or control a tool, piece of equipment, vehicle, or facility.

Owner: Any person with a legal or equitable interest in a piece of the land or parcel.

Permeability: The capacity for transmitting runoff through a material or into soil. The relevant soil property is the saturated hydraulic conductivity, which is the amount of water that would move vertically through a unit of saturated soil per unit time under hydraulic gradient.

Permittee: The applicant in whose name a valid permit is duly issued.

Person: Any individual, owner, operator, association, organization, partnership, firm, corporation, City corporation, joint venture, agency, County or State agency, unincorporated associate, party, the federal government, any combination thereof or other entity recognized by law.

Pollutant: Anything which causes or contributes to pollution

Pollution: The alteration of the physical, thermal, chemical, or biological quality of, or the contamination of, any Water of the State or Water of the United States, that renders the water harmful, detrimental, or injurious to humans, animal life, vegetation, or property, or to the public health, safety, or welfare, or impairs the usefulness or the public enjoyment of the water for any lawful or reasonable purpose.

Practices: Schedules of activities, prohibitions of activities, maintenance procedures and other management activities and techniques (both structural and non-structural) used to lessen the environmental impacts of land use and to prevent or reduce the pollution of Waters of the State. BMPs also include treatment requirements, operating procedures and methods to control facility and/or construction site runoff, spillage or leaks, sludge or waste disposal or drainage from raw material storage. Techniques may involve basins, vegetation, altering construction operations, open space development, riparian buffers or other means of limiting environmental impacts.

Rainwater and Land Development Manual: A publication describing construction and post-construction best management practices and associated specifications prepared by the Ohio Department of Natural Resources Division of Soil and Water Conservation. The compilation of technical standards and design specifications are for methods of controlling construction related surface runoff, erosion and sedimentation. A copy of the manual may be obtained by contacting the City Engineer or the Ohio Department of Natural Resources, Division of Soil & Water Conservation.

Return period: Also known as the *recurrence interval*, it is the average period between precipitation events or flood events of a certain size based on the records and statistics.

Riparian Corridor: An area of trees, shrubs, and surrounding vegetation located adjacent to streams, rivers, lakes, ponds, and wetlands which serve to stabilize erodible soil, improve both surface and ground water quality, increase stream shading and enhance wildlife habitat.

Riprap: Rock or stone placed over a bedding of geotextile, sand or gravel used to armor slopes against flowing water or wave action.

Runoff: The portion of rainfall, precipitation, melted snow or irrigation water that flows across the ground surface and is eventually returned to streams.

Runoff coefficient: The fraction of total rainfall that will appear at the conveyance as runoff.

Sediment: Soils or other surface materials (including, but not limited to rock, sand, gravel and organic material or residue associated with or attached to the solid) that can be transported or deposited by the action of wind, water, ice or gravity as a product of erosion or sedimentation.

Sediment pollution: Degradation of Waters of the State by sediment as a result of failure to apply management or conservation practices to abate wind or water soil erosion, specifically in conjunction with earth-disturbing activities on land used or being developed for commercial, industrial, residential or other non-farm purposes.

Sediment settling pond: A sediment trap, sediment basin or permanent basin that has been temporarily modified for sediment control, as described in the latest edition of the Rainwater and Land Development manual.

Sedimentation: The processes that operate at or near the surface of the ground to deposit soils, debris and other materials either on the ground surfaces or in water channels or the action of deposition of sediment that is determined to have been caused by erosion.

Sheet Flow: Diffuse runoff flowing overland in a thin layer not concentrated and not in a defined channel.

Site: The entire area of land surrounding the discharge activity.

Site map: A plan or set of plans showing the details of any earth-disturbing activity of a site.

Soil erosion: The movement of soils that occurs as a result of wind, rain, precipitation, or flowing water.

Soil Hydraulic Conductivity: The property describing permeability or the ability of water to move through soils, typically measured in saturated conditions (Ks).

Stabilization: Vegetative or structural soil-cover controlling erosion (including but not limited to permanent and temporary seed, mulch, sod, pavement, etc.) or the use of vegetative and/or structural practices that prevent exposed soil from eroding.

State: The State of Ohio.

Storm drainage system: All facilities, channels, and areas which serve to convey, filter, collect and/or receive storm water, either on a temporary or permanent basis.

Stormwater: **W**ater runoff resulting from precipitation, snow melt, or irrigation runoff as defined in 40 Code of Federal Regulation 122.26(b)(13).

Stormwater conveyance system: All storm sewers, channels, streams, ponds, lakes, etc. used for conveying concentrated storm water runoff or storing storm water runoff and filtering pollutants

Stormwater Pollution Prevention Plan (SWP3): A set of plans and specifications, prepared and approved in accordance with the specific requirements of the City Engineer and the OEPA, NPDES Permit #OHC000003. The SWP3 shall be certified by an Engineer, and shall indicate the storm water management strategy, including the specific measures and sequencing to be used to manage storm water on a development site before, during and after construction and shows the details of any earth-disturbing activity on the site.

Stormwater retention/detention BMPs: Retention storage and detention storage that control storm water by gathering runoff in wet ponds, or dry basins, and slowly releasing it to receiving waters or drainage systems. These practices can be designed to both control storm water volume and settle out particulates for pollutant removal.

Stormwater runoff: Surface water runoff which converges and flows primarily through water conveyance features such as swales, gullies, waterways, channels or storm sewers.

Stormwater Treatment: The removal of pollutants from urban runoff and improvement of water quality, accomplished largely by deposition and utilizing the benefits of natural processes.

Stream: A system including permanent or seasonally flowing water, often with a defined channel (bed and bank), flood plain, and riparian ecosystem.

Structure: Anything manufactured, constructed or erected which is normally attached to or positioned on land, including, but not limited to buildings, portable structures, earthen structures, roads, parking lots, and paved storage areas.

Topography: The relative slopes, positions and elevations of the landscape's surface.

Underdrain System: The drainage system utilized in bioretention and occasionally detention practices to maintain positive drainage.

Watercourse: any natural or constructed conveyance of water including, but not limited to lake, pond, stream, river, creek, ditch, channel, canal, conduit, gutter, culvert, drain, gully, swale, or wash in which water flows either continuously or intermittently which are delineated by the City of Reynoldsburg.

Water Quality Volume: The extended detention volume captured for the purposes of treating pollutants and protecting stream stability downstream. This volume is prescribed by the OEPA Construction General Permit.

Watershed: A region draining to a specific river, river stream or body of water.

Wetland: An area that is inundated or saturated by surface or ground-water at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of vegetation typically adapted for life in saturated or hydric soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.