STORMWATER DESIGN MANUAL

Effective Date: April 7, 2015
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City of Mansfield

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1.0 INTRODUCTION

This Manual establishes design criteria required for stormwater facilities within the City of Mansfield in conjunction with City Code, Part 13, Chapters 1361 and 1362 and the Ohio Environmental Protection Agency's (OEPA) NPDES Phase II Stormwater Program. While adherence to this Manual will not stop flooding or prevent all damage caused by flooding, it does establish a basis for design which will:

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

1.1 Administration

The City Engineer is authorized to administer, implement and enforce the provisions of this Manual. The Engineer shall serve as the principle executive officer for stormwater management for the purposes of fulfilling the requirements of the OEPA's NPDES Phase II Stormwater Program. Compliance with this Manual will be determined by the Engineer and his/her office.

Stormwater Management Plans shall be designed to meet the requirements of this Manual and submitted to the Bureau of Buildings, Inspections, Licenses and Permits. The Office of the City Engineer shall review the stormwater management plans and indicate the plans approval or disapproval. Earth-disturbing activities shall not commence until an acceptable plan has been filed and approved by the City Planning Commission. Stormwater Management Plans shall be prepared, signed, and sealed by an Ohio Professional Civil Engineer (ORC 4733.01).

1.2 Drainage Policy

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

Experience has shown that most of the more serious flooding situations are "created." Development can lead to ever increasing flooding problems unless well-conceived, cooperative stormwater drainage and flood control programs are undertaken throughout the entire watershed. For this reason, the general policy of the City shall be as follows:

a. Land uses and developments which increase runoff rate or volume shall control the discharge rate of runoff prior to its release to off-site land or the Municipal Separate Storm Sewer System (MS4).
b. It is the responsibility of the property owner to not change or alter any drainage course, ditch, flood routing path or drainage system on his/her property that will cause increased runoff, or will damage or cause flooding to adjacent, upstream or downstream property owners.
c. All stormwater drainage systems, including conveyances, within a development shall be designed to have capacity and depth, including sufficient invert elevations to permit future

connections, to serve that total tributary area up to the 100-year storm frequency. The system for the upstream tributary area shall be extended through the development.

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

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

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

g. This Stormwater Design Manual applies to all land development that adds 20,000 square feet or more of impervious area or disturbs an acre or more of land, or less than one acre if part of a larger common plan of development or sale disturbing one or more acres of total land and performed on land used or land being developed for commercial, industrial, residential, recreational, public service or other nonfarm purposes which are within the jurisdiction of the City.

For developments with earth disturbing activities that add less than 20,000 square feet of impervious area, the City Engineer reserves the right to require previous development, constructed after March 4th, 1986 without stormwater controls, to be included into the stormwater management calculations as "new" impervious area. If the sum total of the developments new impervious area and the previously constructed impervious area is greater than 20,000 square feet, a stormwater management plan may be required and the appropriate stormwater controls shall be incorporated into the development.

Table 1-1: Stormwater Management Requirements

Earth Disturbing Area/Created Impervious area	Stormwater Management Requirements	
	Peak Flow Rate Control	Post-Construction Water Quality
≥ 20,000 SF of created Impervious Area	✓	
≥ 1 AC of Earth Disturbing Area	✓	✓

The following exceptions from the Peak Flow Rate Controls are as follows:

1. Single-family residential lot not part of a larger common development or sale.
2. Two, three, or four unit multi-family structure not part of a larger common development or sale.
3. Managed open space associated with parks, golf courses, cemeteries, and other similar land uses including associated paved trails needed for the function of the land use.
4. Existing public right-of-way improvements including minor road widening increase in impervious area, and bridge crossings.
5. Linear utility line installations.
6. Land preparation for agricultural crops, orchards, woodlots, sod farms, and nursery operations.
7. Land grading or leveling for erosion control under direction of the local soil conservation district.
8. Developments with less than 20,000 square feet of added impervious area as long as the requirements of 1.2(a) through (f) have been complied with.

9. Properly permitted environmental restoration projects including wetlands, stream restoration, and other related activities.
10. Developments within previously approved Stormwater Management Plan.

2.0 STORMWATER SYSTEM DESIGN CRITERIA

2.1 Design Storm Criteria

The following table provides guidance on the full flow design frequency for storm sewers, culverts, and pavement spread. In addition to the design criteria indicated below, the designer shall provide a major flood route for larger rainfall events up to and including the 100-year design storm.

Table 2-1: Design Storm Criteria

	Collector	Local Streets	Commercial, Industrial, Institutional and other Developments
Storm Sewer Open Channel	10-year	10-year	10-year
Storm Sewer Hydraulic Grade Line	10-year	10-year	10-year
Pavement Spread	10-year	10-year	n/a
Roadway Ditch Design	10-year	10-year	10-year
Roadway Culverts (non-FEMA streams)	25-year	10-year	10-year
Roadway Culverts (FEMA streams)	100-year	100-year	100-year

2.2 Peak Discharge Calculation Methodology

The rational method ($Q = CIA$) shall be used to determine peak discharge rates for storm sewers, culverts, pavement spread, and roadway ditch designs with individual tributary areas less than 10 acres using the following formula to determine rainfall intensity.

Intensity $= X / (Y + T)^Z$ (see Table 2-2 for coefficients)
Where T is equal to the time of concentration in minutes

Alternative methods for determining peak flow rates include the National Resources Conservation Service (NRCS) TR-55 methodology and the Green-Ampt Method[1].

[1] Use of the Green-Ampt method shall require prior approval of the City Engineer.

For larger watershed and floodplain studies, the United States Geological Survey (USGS) rural regression equation may be used, specifically Water Resources Investigation Report 03-4164[2] according to the following formulas:

$Q_2 = (58.9)(CONTDA)^{0.785}(SLOPE)^{0.174}(STORAGE+1)^{-0.178}$
$Q_5 = (96.2)(CONTDA)^{0.766}(SLOPE)^{0.202}(STORAGE+1)^{-0.221}$
$Q_{10} = (121.2)(CONTDA)^{0.759}(SLOPE)^{0.217}(STORAGE+1)^{-0.241}$
$Q_{25} = (152.4)(CONTDA)^{0.754}(SLOPE)^{0.232}(STORAGE+1)^{-0.260}$
$Q_{50} = (175.3)(CONTDA)^{0.751}(SLOPE)^{0.240}(STORAGE+1)^{-0.272}$
$Q_{100} = (197.7)(CONTDA)^{0.747}(SLOPE)^{0.248}(STORAGE+1)^{-0.281}$

Where CONTDA is the contributing drainage area in square miles, SLOPE in the main channel slope in feet/mile; and STORAGE is the drainage area as open water and wetlands in percent. Main channel slope (SLOPE), in feet per mile; is computed as the difference in elevation at points 10 and 85 percent of the distance along the main channel from a specified location on the channel to the topographic divide, divided by the channel distance between the two points.

Table 2-2: Rational Method Intensity Formula Coefficients

Storm Frequency (years)	X	Y	Z
2	140.596	25.099	1.015
5	81.276	18.800	0.855
10	275.649	29.499	1.070
25	294.909	28.099	1.044
100	293.888	26.699	1.000

2.3 Pavement Spread

Table 2-3 Pavement Spread Standards for the Design Storm

Street Classification	Maximum Encroachment from Face of Curb	Maximum Inlet Spacing
Local	14 feet	300 Feet
Collector	10 feet	200 Feet

a. Detailed calculations for spread are not required if the area to the inlet does not exceed 0.50 acres of area for local and 0.20 acres of area for collector per inlet.

[2] US Geological Survey. (2003). *Techniques for Estimating Flood-Peak Discharges of Rural, Unregulated Streams in Ohio, Second Edition: Water-Resources Investigations Report 03-4164* by G.F. Koltun.

2.4 Roadway Culverts

a. Design Procedure: The culvert design procedure recommended for use is Hydraulic Design Series No. 5, U.S. Department of Transportation.
b. Preferred Construction: Single span culverts, including concrete box and slab top are preferred. Multiple cell pipe culverts are discouraged, except when they are the only structures that will meet the physical requirements introduced by rigid headwater controls, will they be acceptable.
c. Culvert/Storm Sewer Pipe Material
    1. High Density Polyethylene (HDPE) pipe between 12 inch and 36-inch diameter shall conform to ODOT CMS 707.33 with maximum 15 feet coverage and minimum 2 feet coverage. Concrete encasement shall be provided when the coverage between the top of pipe and the pavement subgrade is less than 30 inches.
    2. Reinforced Concrete Pipe ODOT CMS 706.02 with sealed joints.
    3. Concrete Box ODOT CMS 706.05.
    4. Underdrains: 6-inch diameter pipe underdrains per ODOT CMS 605 installed a minimum of three feet below subgrade shall be required under all pavement in order to provide satisfactory subgrade drainage.
d. 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.
e. Allowable Headwater shall not exceed any of the following controls for the design storm:
    1. 24 inches below the near, low edge of pavement for drainage areas of 1000 acres or more.
    2. 12 inches below the near, low edge of pavement for drainage areas of 1000 acres or less.
    3. 4 feet above inlet crown in deep ravine.
    4. 1 foot below near edge of pavement for bicycle pathways.
    5. Property Damage –
        a. 100-year frequency headwater plus 1 foot, shall not exceed any proposed building first floor elevation.
        b. 100-year frequency headwater shall not be increased at any existing building first flood elevation.
f. Maximum Allowable Outlet Velocity shall be:
    1. Turf Channel: 5 feet per second.
    2. Rock Protection: 18 feet per second.
       Notes:
        a. When the outlet velocity exceeds 18 feet per second, a stilling basin or other such energy dissipation structure shall be used.
        b. The downstream channel shall have the ability to handle the flow satisfactorily.
g. Structural Design Criteria for culverts shall be the same as that required by the Ohio Department of Transportation (ODOT).
h. Emergency Flood Routing shall be capable of routing the 100-year storm over or around the culvert without creating a hazard or causing potential for erosion or personal property damage. Adequate scour protection shall be included in the design.
i. End Protection should be as follows:
    1. 12-inch through 36-inch culverts – full-height headwall.
    2. 42-inch through 84-inch culverts – full height headwall with flared wings.
    3. Other special type headwalls shall be approved before use.

2.5 Storm Sewers

The criteria for designing storm sewer systems are listed below:

a. All Storm Sewer Systems shall be designed using Manning's Equation or an EPA SWMM[3] based modeling platform where the design storm flow does not exceed the flowing full capacity of the pipe. For the Manning's Equation use the following formula:

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

and

$$Q = VA$$

Where:

Q = Rate of discharge (cfs)

A = Area of cross-section of flow (sq.ft.)

V = Mean velocity of flow (fps)

n = Manning's roughness coefficient

R = A/wp = Hydraulic radius (ft)

S = Slope of pipe or hydraulic grade line if surcharged (ft/ft)

wp = Wetted perimeter (ft)

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

c. Design Flow Determination:
   1. Areas under 10 acres use Rational Method Q = CiA.
   2. Areas over 10 acres use Technical Release 55.
   3. For appropriate larger areas, use the Rural Regression Equation (USGS 89-4126).

d. Minimum Time of Concentration: 5 minutes.

e. Runoff Coefficient: based on Table 2-4.

f. Manning's "n" Value: based on Ohio Department of Transportation Location and Design Manual, Volume 2.

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

h. Solids: The gradient of the sewer shall be sufficient to avoid deposition of solids by having a minimum full flow open channel velocity of 3.0 feet/second.

i. Material: See Section 2.4(C).

j. Manholes: The main conduit, if over 24 inches in diameter, will be required to be separated from all curb and gutter inlets unless a special design is approved by the City Engineer. Furthermore, the main conduit will be required to be separated from all deep curb and gutter inlets, which have a depth greater than 6.5 feet from invert to the top-of-casting elevation.

[3] Designer shall obtain approval from City Engineer regarding use of EPA SWMM prior to commencing the stormwater plan.

k. Flow Line: Unless otherwise approved by the City Engineer, the flow line of pipes should be set such that the crown of pipes, at junctions, are at the same elevation; if the outlet elevation permits, the crown of the outlet pipe may be lower. The flowline elevations of sewers should be set to avoid using concrete encasement.

l. Specifications: The current Ohio Department of Transportation (ODOT) "Construction and Material Specifications" (CMS) together with the requirements of the City of Mansfield, Ohio, including all supplements thereto shall govern all materials and workmanship involved in the improvements.

m. 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 Engineer, special requirements shall include, but may not be limited to:

1. Submergence "zone" shall not extend beneath pavement.
2. Submergence "zone" shall not extend beyond the first manhole.
3. "O-ring" sealed gasketed pipe joints shall be installed along the storm sewer for the full length of the submergence zone.
4. Anti-seepage collars shall be installed in the submergence "zone".

n. End protection should be as follows:
1. 12-inch through 36-inch culverts – full-height headwall. If the outlet is not located within a channel bank or within the direct flow path of crossing floodwaters, half-headwalls at the outlet may be used.
2. 42-inch through 84-inch culverts – full height headwall with flared wings.
3. Other special type headwalls shall be approved before use.

o. Minimum Cover to subgrade and Maximum Cover over pipe:
See Section 2.4(C).

p. Encasement: See Section 2.4(C).

q. Maximum Length between access structures:
1. Pipes under 60 inch – 350 feet.
2. Pipes 60 inch and over 500 feet.

Table 2-4: Rational Method Runoff Coefficients[4]

Hydrologic Soil Group	A			B			C			D		
Storm Recurrence Interval (YR)	**2-5**	**10**	**100**	**2-5**	**10**	**100**	**2-5**	**10**	**100**	**2-5**	**10**	**100**
Land Use Or Surface Characteristics												
Business												
A. Commercial Area	.75	.80	.95	.80	.85	.95	.80	.85	.95	.85	.90	.95
B. Neighborhood Area	.50	.55	.65	.55	.60	.70	.60	.65	.75	.65	.70	.80
Residential												
A. Single Family	.25	.25	.30	.30	.35	.40	.40	.45	.50	.45	.50	.55
B. Multi-Unit (Detached)	.35	.40	.45	.40	.45	.50	.45	.50	.55	.50	.55	.65
C. Multi-Unit (Attached)	.45	.50	.55	.50	.55	.65	.55	.60	.70	.60	.65	.75
D. ½ Acre Lot or Larger	.20	.20	.25	.25	.25	.30	.35	.40	.45	.40	.45	.50
E. Apartments	.50	.55	.60	.55	.60	.70	.60	.65	.75	.65	.70	.80
Industrial												
A. Light Areas	.55	.60	.70	.60	.65	.75	.65	.70	.80	.70	.75	.90
B. Heavy Areas	.75	.80	.95	.80	.85	.90	.80	.85	.95	.80	.85	.95
Parks, Cemeteries Playgrounds	.10	.10	.15	.20	.20	.25	.30	.35	.40	.35	.40	.45
Schools	.30	.35	.40	.40	.45	.50	.45	.50	.55	.50	.55	.65
Railroad Yard Areas	.20	.20	.25	.30	.35	.40	.40	.45	.45	.45	.50	.55
Streets												
A. Paved	.85	.90	.95	.85	.90	.95	.85	.90	.95	.85	.90	.95
B. Gravel	.25	.25	.30	.35	.40	.45	.40	.45	.50	.40	.45	.50
Drives, Walks & Roofs	.85	.90	.95	.85	.90	.95	.85	.90	.95	.85	.90	.95
Lawns												
A. 50% - 75% Grass (Fair Condition)	.10	.10	.15	.20	.20	.25	.30	.35	.40	.30	.35	.40
B. 75% or More Grass (Good Condition)	.05	.05	.10	.15	.15	.20	.25	.25	.30	.30	.35	.40
Undeveloped Surface (By Slope)												
A. Flat (0-1%)	0.04-0.09			0.07-0.12			0.11-0.16			0.15-0.20		
B. Average (2-6%)	0.09-0.14			0.12-0.17			0.16-0.21			0.20-0.28		
C. Steep	0.13-0.18			0.18-0.24			0.23-0.31			0.28-0.38		

[4] *Iowa Stormwater Management Manual*, Iowa State University, 2009. Available from http://www.intrans.iastate.edu/pubs/stormwater/index.cfm

3.0 PEAK FLOW RATE CONTROL FACILITIES CALCULATION REQUIREMENTS

This section provides guidance on the implementation of the peak flow control requirements consistent with the critical storm method. The NRCS runoff curve number (RCN) method shall be used to determine runoff volumes and peak flow rates to stormwater control facilities. **Calculations shall be performed using the HydroCAD computation software unless otherwise approved by the City Engineer.**

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 the 1, 2, 5, 10, 25, 50, and 100-year return frequency storms. For sites that increase the volume of runoff, determine the percent increase in runoff for the 1-year, 24-hour storm using a rainfall depth from NOAA Atlas 14 and determine the critical storm from the following table. The critical storm shall be detained to the 1-year predeveloped rate.

Table 3-1 Critical Storm Determination

Percent Increase in Runoff Volume	Critical Storm
0-10	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

As an example, if the total volume is shown to be increased by thirty-five percent (35%), the critical storm is a five-year storm. The peak rate of runoff for all storms up to this intensity shall be controlled so as not to exceed the peak rate of runoff from a one-year frequency storm under predevelopment conditions in the area. The runoff from a more intense storm need only be controlled so as not to exceed the predevelopment peak rate from the same frequency of storm.

3.1 Runoff Curve Number

a. For the purpose of determining site pre-development conditions for previously undeveloped land, runoff curve numbers identified within table 3-2 are to be used based upon the site's current conditions. For redevelopment sites, the current land use conditions at the time of the proposed improvements shall be used in determining the existing conditions runoff curve number.

b. Hydrologic Soil Group (HSG). Hydrologic soil group classifications are based on undisturbed, naturally occurring soils. During construction, soils are dramatically changed by the removal of topsoil, compaction of the underlying soil profile, and removal of vegetation. The runoff potential of these soils increase; therefore, for post-developed conditions the hydrologic soil group may require adjustment. The Ohio Department of Natural Resources has created a chart, Appendix 9 of the Rainwater and Land Development Manual, for adjusting the hydrologic soil group following construction. For the disturbance area of a project, the hydrologic soil group shall follow the guidelines set forth by the Rainwater Manual. Please see link below:

https://epa.ohio.gov/dsw/storm/rainwater

Table 3-2: NRCS Runoff Curve Numbers[5]

Description of Land Use	Hydrologic Soil Group			
	A	B	C	D
Paved parking lots, roofs, driveways	98	98	98	98
Streets and Roads:				
Paved with curbs and storm sewers	98	98	98	98
Gravel	76	85	89	91
Dirt	72	82	87	89
Cultivated (Agricultural Crop) Land:				
With or without conservation treatment (terraces, contours)	62	71	78	81
Pasture or Range Land:				
Poor (<50% ground cover or heavily grazed)	68	79	86	89
Good (50-75% ground cover; not heavily grazed)	39	61	74	80
Meadow (grass, no grazing, mowed for hay)	30	58	71	78
Brush (good, >75% ground cover)	30	48	65	73
Woods and Forests:				
Poor (small trees/brush destroyed by over-grazing or burning)	45	66	77	83
Fair (grazing but not burned; some brush)	36	60	73	79
Good (no grazing; brush covers ground)	30	55	70	77
Open Spaces (lawns, parks, golf courses, cemeteries, etc.):				
Fair (grass covers 50-75% of area)	49	69	79	84
Good (grass covers >75% of area)	39	61	74	80
Commercial and Business Districts (85% impervious)	89	92	94	95
Industrial Districts (72% impervious)	81	88	91	93
Residential Areas:				
1/8 Acre lots, about 65% impervious	77	85	90	92
1/4 Acre lots, about 38% impervious	61	75	83	87
½ Acre lots, about 25% impervious	54	70	80	85
1 Acre lots, about 20% impervious	51	68	79	84

3.2 Directly Connected Impervious Area

The runoff volume and peak flow rates for all directly connected impervious areas should be calculated independently of other land uses and disconnected impervious area. Sites with disconnected impervious areas may be permitted to use a composite runoff curve number to determine runoff volumes and peak flow rates. Directly connected impervious areas are those impervious areas that are hydraulically connected to the conveyance system (i.e. streets with curbs, catch basins, storm drains, etc.) and thence to the basin outlet point (i.e. a retention/detention pond, existing storm sewer/ditch system, natural water body, etc.) without flowing over pervious areas. For example, roof drains that are piped to the back of curb, which then flows to a curb and gutter inlet, which conveys the runoff to a storm sewer system that conveys the runoff to a wet detention basin is considered a directly connected impervious area.

[5] Chow, Ven Te (1988). *Open Channel Hydraulics*, McGraw Hill, Inc.

3.3 Rainfall Depths and Rainfall Distributions

For the most accurate, up-to-date, location-specific rainfall data for storm water design, use the Precipitation-Frequency Atlas of the United States, NOAA Atlas 14, available online: http://hdsc.nws.noaa.gov/hdsc/pfds/.

3.4 Time of Concentration Calculation

Use the following formulas to determine pre-developed and post-developed time of concentration with no more than 100' permissible for the overland sheet flow calculation for both existing and proposed conditions unless it is a paved surface. Time of concentration calculations should be calculated independently for directly connected impervious areas where applicable with a minimum time of concentration of 5 minutes. The time of concentration may include up to three components, overland sheet flow, shallow concentrated flow, and channel flow.

3.4.1 Overland Sheet Flow ($T_{c\ sheet}$)

Overland sheet flow is the shallow mass of runoff over plane surfaces (e.g. parking lots, lawns). Overland sheet flow usually occurs over a short distance at the hind end of a drainage area. NRCS recommends limiting overland sheet flow to 100 feet for unpaved areas. For paved surfaces, the maximum is 300 feet. Use the following equation to estimate $T_{c\ sheet}$:

$$T_{c\,sheet} = 0.014\left(\frac{nL}{\sqrt{s}}\right)^{0.75}$$ [6]

Where:

n = Manning's roughness coefficient for overland flow (see Table 4-3), based on very shallow flow depth of up to 0.10 feet

L = Overland flow path length, ft

s = Slope of overland flow path, ft/ft

[6] Zomorodi, Kaveh, *Revising the NRCS Sheet Flow Travel Time Equation for Flatlands*, AWRA 2005 Annual Water Resources conference, Seattle Washington.

Table 3-3: Manning's Roughness Coefficient (n) for Overland or Sheet Flow

Surface description	N
Asphalt and concrete: New Existing	0.016
Cement rubble surface	0.024
Fallow (no residue)	0.05
Cultivated Soils: Residue cover ≤ 20% Residue cover > 20% Range (natural)	 0.06 0.17 0.13
Grass: Short grass prairie (fields) Dense grasses (lawns)	 0.15 0.24
Woods: Light underbrush Dense underbrush	 0.40 0.80

3.4.2 Shallow Concentrated Flow ($T_{c\ shallow}$)

After a short distance (depending on ground cover, but always less than 100 feet), overland sheet flow starts to concentrate in rills, and then in gullies. This flow is referred to as shallow concentrated flow. The velocity of this flow is estimated using a relationship between velocity and slope. To calculate the shallow concentrated flow time of concentration or $T_{c\ shallow}$, first estimate the velocity of flow using the following equation:

$V = K_u k\sqrt{S}$

Where:

V = Velocity of flow, ft/s

S = Slope, ft/ft

k = intercept coefficient (see Table 4-4)

K_u = Units conversion factor, 33

Table 3-4: Intercept Coefficient for Shallow Concentrated Flow[7]

Land cover/flow regime	k
Forest with heavy ground litter; hay meadow	0.076
Trash fallow or minimum tillage cultivation; contour or strip cropped, woodland	0.152
Short Grass Pasture	0.213
Cultivated straight row	0.274
Nearly bare and untilled	0.305
Grassed waterway	0.457
Unpaved	0.491
Paved Area; small upland gullies	0.619

Once velocity has been determined, use the equation below to calculate $T_{c\ shallow}$.

$$T_{c\ shallow} = \frac{L}{60V}$$

Where:
$T_{c\ shallow}$ = Shallow concentrated flow travel time, minutes
L = Flow length, ft
V = Velocity of flow, ft/s

3.4.3 Open Channel Flow ($T_{c\ channel}$)

Open channel flow may consist of gutter flow, pipe flow, or flow through a drainage swale. Various forms of the Manning's equation may be used to estimate the velocity in the channel. Use Table 3-6 for Manning's 'n' value for open channel flow through vegetation and used to determine a travel time using the following equation:

$$T_{c\ channel} = \frac{L}{60V}$$

Where:
$T_{c\ shallow}$ = Shallow concentrated flow travel time, minutes
L = Flow length, ft
V = Velocity of flow, ft/s

[7] Iowa Department of Transportation Office of Design, Design Manual, Chapter 4, November 2010. Available from http://www.iowadot.gov/design/dmanual/04a-05.pdf

Table 3-5: Values of Manning's Coefficient (n) for Open Channel Flow[8]

Channel material	Manning's 'n'
Concrete	
Trowel finish	0.013
Float finish	0.015
Concrete bottom with rubble or riprap sides	0.030
Vegetation	
Depth of flow up to 0.7 feet	
Lawns cut 4 to 8 inches	0.070
Good stand cut to 12 inches	0.140
Good stand cut to 24 inches	0.250
Fair stand cut to 12 inches	0.120
Fair stand cut to 24 inches	0.200
Depth of flow from 0.7 to 1.5 feet	
Lawns cut 4 to 8 inches	0.050
Good stand cut to 12 inches	0.100
Good stand cut to 24 inches	0.150
Fair stand cut to 12 inches	0.080
Fair stand cut to 24 inches	0.140
Bare Soil	
Recently completed	0.035
Clean after weathering	0.040

[8] Iowa Department of Transportation Office of Design, Design Manual, Chapter 4, November 2010. Available from http://www.iowadot.gov/design/dmanual/04a-05.pdf

4.0 WATER QUALITY CONTROL CRITERIA

Stormwater qualitative control shall be implemented into sites in accordance with general and specific requirements outlined in the current OEPA's general permit for stormwater discharges associated with construction activity. Water quality BMPs shall be designed according to the latest design standards as set forth by the Ohio Department of Natural Resources Rainwater and Land Development Manual. In addition to the minimum standards set forth by the Ohio EPA, the following BMPs are not permitted to be used in providing water quality control within the City:

a. Constructed wetlands, bioretention, sand and other media filtration, and pocket wetlands as defined by the ODNR Rainwater and Land Development Manual and Ohio EPA are not permitted as a water quality BMP's within the City for development projects unless otherwise approved by the City Engineer.

The Ohio EPA General Construction permit can be found at the following link:

http://www.epa.state.oh.us/dsw/permits/GP_ConstructionSiteStormWater.aspx

Clarifications regarding specific sections of the Construction General Permit are found in a Q&A document at the following link:

http://www.epa.state.oh.us/dsw/storm/CGPPCQA.aspx

The Ohio EPA refers to the Ohio Department of Natural Resources (ODNR) Rainwater and Land Development Manual for technical design standards for individual Best Management Practices (BMPs) to meet General Construction Permit requirements. The manual is available at the following link:

https://epa.ohio.gov/dsw/storm/rainwater

4.1 Ohio EPA Water Quality Permit Supplemental Information

The following sections provide guidance pertinent to the design of water quality BMPs within the City of Mansfield.

4.1.1 Water Quality Volume (WQv):

The selected BMP(s) shall be sized to treat the water quality volume and ensure compliance with Ohio EPA General Construction Permit. The BMPs chosen must be compatible with site and soil conditions. The BMPs chosen must be sized to treat the water quality volume (WQv) and ensure compliance with Ohio's Water Quality Standards in OAC Chapter 3745-1. WQv as determined by the methodology provided in the current edition of the Ohio EPA Construction General Permit. All BMPs shall be designed as a minimum in accordance with the ODNR Rainwater and Land Development Manual.

4.1.2 Approval For Use of Proprietary BMPs

Approval of alternative BMPs by the Ohio EPA is required prior to approval from the City Engineer except for the following:

a. For sites that meet the size limit imposed in the Ohio EPA Construction General Permit, alternative BMPs can be approved by the City Engineer with sufficient evidence from the manufacturer that the BMP is able to achieve 80% TSS removal on an average annual basis or current state standard.

For a list of possible proprietary BMPs approved by the Ohio Department of Transportation, please view the following link:

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

The applicant may request approval from the City Engineer for the use of alternative structural post-construction BMPs if the applicant shows to the satisfaction of the City Engineer these BMPs are equivalent in pollutant removal and runoff flow/volume reduction effectiveness to those approved by the current edition of the Ohio EPA Construction General Permit and with prior approval from the Ohio EPA. To demonstrate the equivalency, the applicant must show:

a. The alternative BMP has a minimum total suspended solid (TSS) removal efficiency of eighty percent (80%), using the Level-II Technology Acceptance Reciprocity Partnership (TARP) testing protocol.

b. The water quality volume discharge rate from the selected BMP is reduced to prevent streambed erosion, unless there will be negligible hydrologic impact to the receiving Surface Waters of the State. The discharge rate from the BMP will have negligible impacts if the applicant can demonstrate one of the following conditions:

    i. The entire water quality volume is recharged to groundwater.

    ii. The development will create less than one (1) acre of impervious surface.

    iii. The development project is a redevelopment project with an ultra-urban setting, such as a downtown area, or where one-hundred percent (100%) of the project area is already impervious surface and the storm water discharge is directed into an existing storm sewer system. The storm water drainage system of the development discharges directly into a large river of the fourth order or greater or to a lake, and where the development area is less than five percent (5%) of the water area upstream of the development site, unless a Total Maximum Daily Load (TMDL) has identified water quality problems in the receiving surface water of the State.

5.0 WATER QUALITY AND DETENTION SYSTEM DESIGN CRITERIA

Although every water quality and peak flow rate control BMP is unique and designed based on specific site conditions, the standards set forth within this section are intended to establish the guidelines for the layout and design of public or residential BMPs within the City of Mansfield.

The design of all stormwater BMPs shall conform to the standards set forth within this section and those in Section 4 of this manual. The site and/or construction plans, engineering documents and specifications shall include all pertinent details for any permanent BMP feature.

5.1 Parking Lot Storage

Parking lot storage is not a preferred BMP but may be approved by the City Engineer on a case by case basis.

5.2 Water Quality Basins (Wet or Dry)

Please refer to the latest version of the Ohio Department of Natural Resources Rainwater and Land Development Manual at the following link:

https://epa.ohio.gov/dsw/storm/rainwater

5.3 Bioretention Basins

For sizing and construction of bioretention basins, please refer to the latest version of the Ohio Department of Natural Resources Rainwater and Land Development Manual at the following link:

https://epa.ohio.gov/dsw/storm/rainwater

For the materials to be used in a bioretention basin, supplemental information has been provided for the mulch and bioretention soil. The bioretention soil specification is the most important aspect of the design. An improperly designed soil that lacks sufficient infiltration capacity can have long periods of standing water rendering the basin ineffective and adding stress to the vegetation. Improper organics can also have detrimental consequences on the health of selected vegetation.

5.4 Infiltration Trenches

Please refer to the latest version of the Ohio Department of Natural Resources Rainwater and Land Development Manual at the following link:

https://epa.ohio.gov/dsw/storm/rainwater

5.5 Permeable Pavement

For general requirements of pervious pavement systems, please refer to the latest version of the Ohio Department of Natural Resources Rainwater and Land Development Manual at the following link:

https://epa.ohio.gov/dsw/storm/rainwater

To meet Ohio Department of Natural Resources Rainwater Manual guidance, maximum ratio of impervious area draining onto the surface area of the pervious paver system shall be no greater than 2:1 especially in areas with high potential for organic contaminants such as leaves and tree

nuts for example. Higher ratios up to 5:1 may be permissible on a case-by-case basis for areas with minimal contamination potential.

For all pervious pavement systems, do not use sand or cinders for deicing. Moreover, when this green infrastructure practice is used in areas with potential for organic matter to accumulate such as nuts and leaves, monthly maintenance using a vacuum/regenerative air sweeper may be required during growing season.

For frost depth considerations, the pavement thickness from surface to subgrade is recommended to be ½ of the frost depth; however, research has shown that as long as there is sufficient void space for water to expand (9%), it can freeze without movement (Smith, p. 23).[9] For the Mansfield area, the frost depth is approximately 34"; therefore, a minimum section thickness of 17" should be used.

It is recommended that impervious areas sheet flow onto pervious pavement surfaces and not be point loaded onto a small area. The maximum surface slope for pervious pavement surface is 5% (Smith, p. 14).[10]

The following information is in addition to the ODNR guidelines providing additional detail on the use of various types of pavement systems.

5.5.1 Pervious Pavement Stone Aggregate

a. Aggregates should be crushed with minimum 90% fractured faces and a minimum Los Angeles (LA) abrasion <40 per ASTM C131 and C535 (Smith, p. 28).[11]

b. All shall be clean, washed and free of fines with <2% passing the No. 200 sieve per ASTM C 136 (Smith, p. 28). [12]

c. A porosity of at least 30% for the No. 8, 89, or 9 jointing material using ASTM C 29 (Smith, p. 28).[13]

d. A porosity of at least 32% for the No. 57 bedding and No. 2, 3, or 4 subbase and base layers approximately using ASTM C 29 (Smith, p. 28).[14]

e. No. 8 Setting Bed Material: Narrowly graded mixture of washed, crushed stone, or crushed gravel; in accordance with CMSC Section 703.01; coarse-aggregate grading Size 8; with 100 percent passing a ½-inch (12.5-mm) sieve and 0 to 5 percent passing a No. 16 (1.18-mm) sieve. Setting bed material shall be installed with a screed to the maximum extent possible to achieve a level surface for placement of pervious paver clay or concrete bricks.

f. No. 8, 89, or 9 Jointing Material: Narrowly graded mixture of washed, crushed stone, or crushed gravel; in accordance with CMSC Section 703.01; coarse-aggregate grading Size 8; with 100 percent passing a ½-inch (12.5-mm) sieve and 0 to 5 percent passing a No. 16 (1.18-mm) sieve; grading Size 89; with 100 percent passing a ½-inch (12.5-mm) sieve and 0 to 10 percent passing a No. 16 (1.18-mm) sieve; grading Size 9; with 100 percent passing a 3/8-inch (9.5-mm) sieve and 0 to 10 percent passing a No. 16 (1.18-mm) sieve.

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[9] Smith, David R., *Permeable Interlocking Concrete Pavements*, Interlocking Concrete Pavement Institute, Herndon, VA, Fourth Edition, 2011.
[10] Ibid
[11] Ibid
[12] Ibid
[13] Ibid
[14] Ibid

g. No. 57 Bedding Layer: Narrowly graded mixture of washed, crushed stone, or crushed gravel; in accordance with CMSC Section 703.01; coarse-aggregate grading Size 57; with 100 percent passing a 1½-inch (37.5-mm) sieve and 0 to 5 percent passing a No. 8 (2.36 mm) sieve.

h. No. 2, 3 or 4 Subbase and Base Layer: Narrowly graded mixture of washed, crushed stone, or crushed gravel; in accordance with CMSC Section 703.01; coarse-aggregate grading Size 2 with 100 percent passing a 3-inch (100-mm) sieve, 0 to 5 percent passing a ¾-inch (19-mm) sieve, and less than 2 percent passing the No. 200 sieve. Grading size 3 with 100 percent passing the 2 ½-inch (63 mm) sieve, 0 to 5 percent passing a ½ inch (12.5 mm) sieve, and less than 2 percent passing the No. 200 (75 um) sieve. Grading size 4 with 100 percent pass the 2-inch (50 mm) sieve, 0 to 15 percent passing the ¾-inch (19 mm) sieve, and less than 2 percent passing the No. 200 (75 um) sieve.

i. Compaction of the bedding, subbase, and base layers of material shall be done with a 10-12 ton vibratory roller with aggregate lifts of no more than 6 inches. Compaction of the setting bed material is not required except after placement of pavers and jointing material using walk behind compaction equipment.

5.5.2 Pervious Interlocking Concrete Pavers

Pervious pavers can be used on any surface ranging from pedestrian plazas, low speed roadways to heavy industrial and shipping yards. Pervious pavers are not recommended for high speed roadways with posted speed limits above 25 MPH or high-volume roadways.

a. Pervious concrete pavers are referred to as Permeable Interlocking Concrete Pavements (PICP) in the paver industry. PICP shall conform to ASTM C936 which limits length-to-thickness ratio to no more than 4:1 to provide interlocking effect. It also limits face area to no more than 101 sq. in.

b. A minimum average compressive strength of 8,000 psi is required per ASTM C936; however, an average strength of 8,500 psi is preferred.

c. At a minimum, be resistant to freezing and thawing when tested according to ASTM C1645. It is preferred that the paver meet the higher Canadian standard, CSA A231.2, which is a similar test but at a lower temperature with more testing cycles.

d. For vehicular applications, the majority of the pavers shall have a minimum joint width of 12 mm or larger as joint widths less than 12 mm are harder to maintain, require a smaller stone chip that is more susceptible to washing out or migrating into the underlying No. 57 aggregate. Smaller joints associated with soldier courses or other embedded pavers are acceptable.

e. "L" shape pavers shall be used in all public roadway driving lanes and high traffic areas on private sites. Other geometries may be used for soldier courses, replacement for striping, parking lanes, parking lots, alleys, sidewalks, and other non-vehicular use applications.

f. All paver areas shall have concrete edge restraints.

g. Pavers that can be machine installed are preferred for larger projects.

h. PICP structural design for vehicular applications assumes a minimum soil CBR (96-hour soaked per ASTM D 1883 or AASHTO T 193) of 4%, or a minimum R-value = 9 per ASTM D 2844 or AASHTO T-190, or a minimum Mr of 6,500 psi per AASHTO T-307 to quality for use under vehicular traffic. Compaction or treatment of the subgrade

with cement, lime, or lime/flyash may be required to achieve at least 4% soaked CBR. Expansive soils will need to be treated and will significantly reduce the infiltration capabilities of the native soil. (Ref: Smith Chapter 3)

i. The pavement system from surface to subgrade should be designed using the 1993 AASHTO Method for flexible pavements. The paver and setting bed have a structure layer coefficient of between 0.20 and 0.40, with 0.30 a commonly used value. The No. 57, No. 2, 3 or 4 aggregates have a structural layer coefficient of 0.14. Care should be taken to obtain a subgrade CBR value and an estimation of traffic load. When a CBR value is not available use a value of 3 (Smith, Chapter 3).[15]

j. The soldier course paver shall be a full-length rectangular pervious paver brick of the same thickness as the main system capable of accepting a No 8, 89, or 9 chip material.

k. Color and finish are important decisions that need to be considered during the design process. Specialized face mixes can provide enhanced color durability to prevent fading and alternative textures for specialized applications.

5.5.3 Pervious Clay Brick Pavers

Pervious clay brick pavers are 2¾ inch thick solid interlocking paving units made of fired clay that allows water to flow through joints between the individual paving units. The joints are filled with open graded, small aggregate to allow for the units to interlock and still provide void space for the water to flow through.

Pervious clay brick pavers may be used in all areas where traditional pavement would be considered for pedestrian use. In addition, pervious clay brick pavers may be used in low volume and low speed (less than 25 MPH) vehicular use areas such as public roads, parking lots and roadside parallel parking.

a. Clay brick pavers are categorized as ASTM C902 for Pedestrian and Light Traffic Paving Brick or ASTM C1272 for Heavy Vehicular Paving Brick. For both ASTM C902 and ASTM C1272 application PX shall be specified for pavers with close dimensional tolerance.

b. Provide joint widths of at least 12 mm to allow for adequate infiltration capacity. It is difficult to find clay pavers with joints width of 12 mm or larger as joint widths less than 12 mm are harder to maintain, require a smaller stone chip that is more susceptible to washing out or migrating into the underlying No. 57 aggregate. Smaller joints associated with soldier courses or other embedded pavers are acceptable. If clay pavers are to be used in roadway applications, the setting bed shall be No. 8 stone and the joints filled to the maximum extent practical with the larger of No. 8, No. 89, or No. 9 stone.

c. At a minimum, be resistant to 50 freeze and thaw cycles when tested according to ASTM C67. It is preferred that the paver meet the higher Canadian standard, CSA A231.2, which is a similar test but at a lower temperature with more cycles.

d. All paver areas shall have concrete edge restraint.

e. Structural design for vehicular applications assumes a minimum soil CBR (96-hour soaked per ASTM D 1883 or AASHTO T 193) of 4%, or a minimum R-value = 9 per ASTM D 2844 or AASHTO T-190, or a minimum Mr of 6,500 psi per AASHTO T-307

[15] Smith, David R., *Permeable Interlocking Concrete Pavements*, Interlocking Concrete Pavement Institute, Herndon, VA, Fourth Edition, 2011

to quality for use under vehicular traffic. Compaction or treatment of the subgrade with cement, lime, or lime/flyash may be required to achieve at least 4% soaked CBR. Expansive soils will need to be treated and will significantly reduce the infiltration capabilities of the native soil (Smith, Chapter 3).[16]

f. The pavement system from surface to subgrade should be designed using the 1993 AASHTO Method for flexible pavements. The paver and setting bed have a structure layer coefficient of between 0.20 and 0.40, with 0.30 a commonly used value. The No. 57 and No. 2 aggregates have a structural layer coefficient of 0.14. Care should be taken to obtain a subgrade CBR value and an estimation of traffic load. When a CBR value is not available use a value of 3 (Smith, Chapter 3).[17]

g. Pavers shall be laid in a herringbone pattern to increase interlocking stability.

h. The soldier course paver shall be a full-length rectangular pervious paver brick of the same thickness as the main system capable of accepting a No 8, 89, or 9 chip material.

i. Color and finish are important decisions that need to be considered during the design process.

5.5.4 Pervious Concrete

Pervious concrete is a type of pervious pavement that when cast has between 15-25% void space within the concrete. These void spaces are interconnected so that water and air are able to pass through from the top surface of the concrete down into aggregate storage layers below. Pervious concrete does not contain fine aggregates and is sometimes referred to as 'no-fines' concrete. Coarse aggregate, Portland cement, water and admixtures are the component materials of pervious concrete.

Pervious concrete may be used in all areas where traditional concrete would be considered for pedestrian use. In addition, pervious concrete may be used in vehicular use areas such as parking lots and roadside parallel parking. It is not recommended for travel lanes on public roadways, but has been successful in low volume residential streets and alleys. Pervious concrete shall comply with current editions of ACI 522.1 and ASTM C94.

a. A model specification and structural design guidance is available from the Ohio Ready Mixed Concrete Association with the following exceptions:

    1. Wet cure with UltraCure by McTech Group or equivalent;
    2. Placement of concrete should be done with a hydraulically actuated pipe roller and;
    3. Joints shall be saw-cut; rolled joints are not to be permitted.[18]

b. Slump tests and traditional strength tests cannot be used with pervious concrete. Testing shall be for density (unit weight), void content and thickness. These tests include ASTM C 172, ASTM C 29, ASTM C 42 and ASTM C 1688.

c. All pervious concrete areas shall have concrete edge restraints.

[16] Smith, David R., *Permeable Interlocking Concrete Pavements*, Interlocking Concrete Pavement Institute, Herndon, VA, Fourth Edition, 2011
[17] Ibid
[18] Maloney, M. (2013). Pervious pavement as public infrastructure [Powerpoint slides].

d. Structural design for vehicular applications assumes a minimum soil CBR (96-hour soaked per ASTM D 1883 or AASHTO T 193) of 4%, or a minimum R-value = 9 per ASTM D 2844 or AASHTO T-190, or a minimum Mr of 6,500 psi per AASHTO T-307 to quality for use under vehicular traffic. Compaction or treatment of the subgrade with cement, lime, or lime/flyash may be required to achieve at least 4% soaked CBR. Expansive soils will need to be treated and will significantly reduce the infiltration capabilities of the native soil (Smith, Chapter 3).[19]

e. Pervious concrete can be colored with pigment during the mixing process and should be considered during the design process.

5.5.5 Pervious Asphalt

Pervious asphalt is a type of asphalt with approximately 16-20% air void space within the asphalt after installation. These void spaces are interconnected so that water and air are able to pass through from the top surface of the asphalt down into aggregate storage layers below. Pervious asphalt does not contain fine aggregates smaller than a No. 8 aggregate. A polymer modified asphalt binder (6%) is the main component that differentiates standard asphalt from pervious asphalt. Pervious asphalt has been around since the early 1970s and was previously referred to as open graded friction course and used on highways to reduce road spray.

Pervious asphalt may be used in all areas where traditional asphalt would be considered for pedestrian use. In addition, pervious asphalt may be used in low volume and low speed (less than 25 MPH) vehicular use areas such as parking lots and roadside parallel parking. It also has been successful in low volume residential streets and alleys.

a. The ODNR considers The University of New Hampshire Stormwater Center (UNHSC) Design Specification for Porous Asphalt Pavement a reliable specification for pervious asphalt mix design.[20]

b. Asphalt pavement surface course may follow the Flexible Pavement of Ohio Asphalt Pavement Surface Course requirements, October 2007, revised September 2012. However, Flexible Pavements of Ohio should be contacted before the use of this specification as recent projects in Ohio have experienced raveling of the surface course in low impact parking lot applications. Updates to the specification to address these issues are ongoing.

c. Pervious asphalt structural design for vehicular applications assumes a minimum soil CBR (96-hour soaked per ASTM D 1883 or AASHTO T 193) of 4%, or a minimum R-value = 9 per ASTM D 2844 or AASHTO T-190, or a minimum Mr of 6,500 psi per AASHTO T-307 to quality for use under vehicular traffic. Compaction or treatment of the subgrade with cement, lime, or lime/flyash may be required to achieve at least 4% soaked CBR. Expansive soils will need to be treated and will significantly reduce the infiltration capabilities of the native soil. (Smith, Chapter 3).[21]

d. The pavement system from surface to subgrade should be designed using the 1993 AASHTO Method for flexible pavements. The No. 57, No. 2, 3, or 4 aggregates

[19] Smith, David R., *Permeable Interlocking Concrete Pavements*, Interlocking Concrete Pavement Institute, Herndon, VA, Fourth Edition, 2011

[20] University of New Hampshire Stormwater Center (2009). *Design specifications for Porous Asphalt Pavement and infiltration Beds.*

[21] Smith, David R., *Permeable Interlocking Concrete Pavements*, Interlocking Concrete Pavement Institute, Herndon, VA, Fourth Edition, 2011

have a structural layer coefficient of 0.14. Care should be taken to obtain a subgrade CBR value and an estimation of traffic load. When a CBR value is not available use a value of 3 (Smith, Chapter 3).[22]

5.6 Underground Storage

For general requirements for underground storage systems, please refer to the latest version of the Ohio Department of Natural Resources Rainwater and Land Development Manual at the following link:

https://epa.ohio.gov/dsw/storm/rainwater

Underground storage may be used to provide storage volume to meet the peak control rate requirements and water quality requirements in accordance with Ohio EPA's Construction General Permit.

a. Adequate flood routing shall be provided if the system becomes clogged or surcharges onto the surface.

   The preferred minimum orifice size is 4" in diameter. Smaller sizes shall provide adequate protection to protect it from clogging.

b. The maximum ponding depth at any point in the parking lot is 12" for the 100-year storm.

c. The use of perforated pipe to maximize storage volume in the surrounding stone backfill is not permitted without an approved pretreatment device listed in Section 4.1.

[22] Ibid

6.0 PUBLIC AND PRIVATE WET BASIN DESIGN STANDARDS

Although every wet basin is unique and designed based on specific site conditions, the standards set forth within this section are intended to establish the guidelines for the layout and design of public or private wet basins within the City.

Some problems encountered with wet basins are: site reservation (land requirements), permanent easements, complexity of design and construction, safety hazards and maintenance problems. However, the recreational, aesthetic, and water quality benefits of permanent wet basins justify their use in many applications.

All wet basins with a permanent pool depth greater than twenty-four inches (24") shall be enclosed by a fence unless each of the following criteria is met:

- Interior side slopes are no steeper than 3H:1V
- A minimum eight foot (8') wide dry bench and an eight foot (8') wide wet bench are provided adjacent to the full perimeter of the permanent pool, and
- Graded benches are to be no steeper than 8H:1V.

Fencing shall be a minimum forty-eight inches (48") in height and at a minimum be equipped with a double eight-foot (8') swing gate (sixteen feet (16') total) to allow for access.

Reference the standard basin grading figure provided on page 6-7.

6.1 Existing Wet Basin Investigation Requirements

When existing wet basins are proposed to become part of a stormwater management system to meet peak flow rate and water quality requirements and to be incorporated into a development the following information is recommended:

a. Photos of the existing basin.
b. Bathymetry Survey.
c. Discussion of the current conditions, including the presence of trees, inlet/outlet structures, etc.
d. A proposed usage description outlining any changes, including increased embankment height, inlet/outlet structures, etc.

6.2 Dam Safety Classifications

All dams shall adhere to the State of Ohio's Dam Safety Regulations (Title XV, Chap. 1521 of the Ohio Revised Code, Rule 1501:21-13-01).
The following dam types do not require construction permits per Ohio Dam Safety Laws, Section 1521.06:

a. A dam that is or will be less than 10 feet in height and greater than 6 feet and that has or will have a storage capacity of not more than 50 acre-feet at the elevation of the top of the dam, as determined by the ODNR Chief. For the purposes of this section, the height of a dam shall be measured from the natural stream bed or lowest ground elevation at the downstream or outside limit of the dam to the elevation of the top of the dam.
b. A dam, regardless of height, that has or will have a storage capacity of not more than 15 acre-feet at the elevation of the top of the dam.
c. A dam, regardless of storage capacity, that is or will be 6 feet or less in height.
d. A dam, dike or levee that belongs to a class exempted by the ODNR Chief.

6.3 Outlet/Inlet Treatment

a. Submerged Outlet/Inlet Structures

The City encourages the use of submerged storm pipes in lieu of exposed outlet/inlet structures. Submerged Outlets may consist of a siphon pipe where such pipe is no smaller than 6 inches in diameter. Inlet pipes that are equal to or larger in diameter than 36 inches should be submerged to at least the "springline" of the pipe (i.e., normal pool at a depth equal to the elevation at one-half the diameter of the pipe). When an inlet pipe is at least partially submerged at the wet basin, the conditions listed below shall also be met.

1. Submergence of inlet pipes is limited to the next upstream manhole or catch basin along the storm sewer system.
2. All lengths of submerged storm pipe shall include "O-ring" sealed gasket pipe joints.
3. All lengths of the submerged storm pipe shall have bedding and backfill material consistent with the compacted embankment material.

b. Structure Requirements

All headwall and structures shall be in accordance with Ohio Department of Transportation standard drawings (modified as necessary).

c. Bedding/Backfill Material

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

d. Anti-Seep Collars

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

The anti-seep collars shall be located along the length of the outlet pipe within the saturation zone of the embankment at approximately equal spacing and at intervals not exceeding 25 feet. The saturation zone is considered to extend through the embankment from the elevation of the riser (normal pool) to the downstream embankment toe.

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

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

e. Emergency Spillways

Emergency Spillways should meet all of the following criteria unless they are located in areas where a basin is not located adjacent to a stream or roadway, in which case, an emergency spillway is then not required. However, an adequate flood routing path is required from the basin.

1. They shall not operate (convey flow) for any routed design storm less than the 100-year event.
2. They shall be reinforced with concrete or designed erosion control materials (geotextiles) consisting of 100 percent synthetic, non-biodegradable materials (the plans should include a specification for the intended geotextile, referencing the required physical properties or the specific material).
3. They shall be designed to pass the 50-year peak inflow to the basin on its own without attenuation (the plans shall include a detail demonstrating the necessary dimensions of the control section, both width and breadth).

f. Miscellaneous
The following general criteria are preferred:

1. Roof drain (downspout) outlets directly to a wet basin are not permitted.
2. The minimum allowable installed orifice size is 4 inches in diameter unless protected by a means acceptable to the City.
3. All inlet structures (e.g., pipe headwalls) shall be recessed into the adjoining wet basin grading to diminish the amount the structure is visible.

6.4 Geotechnical Considerations

Design of wet basin liners and embankments may require a qualified geotechnical engineer or geologist to design the liner. Acceptable soils used in wet basin liners or embankments shall meet the following minimum criteria:

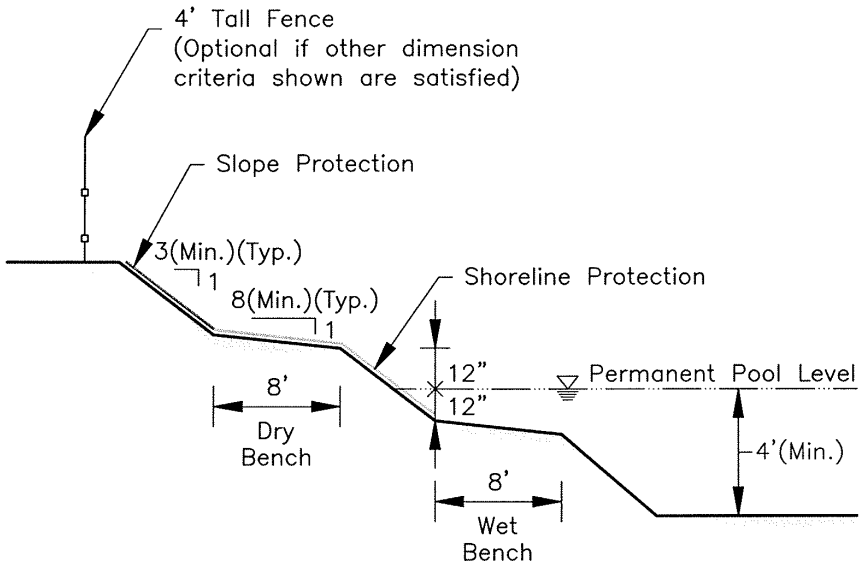
a. Free of large rocks, roots, limbs and other deleterious materials which would adversely affect the design integrity of the liner.
b. Classified under the Unified Soil Classification System as CL, CH or SC.
c. Minimum 15% passing the No. 200 sieve.
d. Have a plasticity index (PI) >= 15.
e. Have a laboratory permeability of 1x10-6 cm/sec or less based on a minimum of two undisturbed core (tube) samples taken from the liner.

1. Wet Basin Liner
Wet basin liners consisting of acceptable soils as described above shall be a minimum of 2 feet in thickness. Localized granular, organic, or other deposits (which would be sources for wet basin leakage) shall be removed and replaced with suitable soils. Disking of up to 6 inches of surface material for re-compaction is acceptable, if necessary. The material shall be compacted at optimum moisture content to (but not exceeding) 3 percent above optimum moisture content in loose lifts not to exceed 8 inches in thickness. The installation of wet basin liners shall be under the supervision of a geotechnical engineer, geologist or other City of Mansfield approved entity who shall certify that the liner was installed in accordance with this policy. Alternative wet basin liners accompanied by a geotechnical report may be used upon review and approval by the City of Mansfield. These include, but are not limited to poly-liners (minimum 30 mil) and bentonite (typically 1 to 3 lb/ft2).

2. Embankment Materials
All outlet embankment materials shall consist of cohesive soils compacted to a minimum of 98 percent of the maximum density obtainable with the Standard Proctor Test method (ASTM Standard D-698). Certified test results shall be submitted to the City prior to installation or the test is to be performed at the time of installation, in the presence of the City or its assigned representative. The

compacted outlet embankment shall be free of vegetative material and other construction debris. The engineering plan shall include notes and other references regarding the conditions and requirements for construction of the outlet embankment, including design information for a key trench, if necessary.

Figure 6-1: Standard Wet Basin Grading Section



STANDARD WET BASIN GRADING SECTION

SCALE: NONE

Notes:

1. Shoreline Protection shall consist of Seeding with Turf Reinforcing Mat, Type 1 (ODOT CMS Item 836).

2. Slope Protection shall consist of Seeding and Erosion Control Matting (ODOT CMS Item 671 and Erosion Control Material 712.11 Type B) installed on a 6" minimum depth of topsoil.

7.0 DRAINAGE EASEMENTS

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

a. Is required to obtain easements and/or maintenance agreements, in a form and substance satisfactory to the City, from abutting property owners; and
b. Is responsible for maintenance agreements of such drainage course unless the easements and/or maintenance agreements require the abutting property owners to repair and maintain the drainage course satisfactorily.

Any required drainage easement, preservation areas, reserves and other similar areas shall be shown on the required plans and reflected on the final plat or a separate recorded document approved by the City. The Owner and/or Developer shall comply with the procurement, execution, and maintenance of the Easement, and their responsibilities to the adjacent and downstream property owners. The easement shall be of sufficient width, minimum of 20-foot, to allow cleaning, widening, deepening, replacing or other general maintenance of such drainage course or piped system. Such declaration of restrictions shall include the operation and maintenance requirements as specified in the City approved plans.

8.0 OPERATION AND MAINTENANCE PLANS

The owner/developer of a site that includes the implementation of structural and nonstructural BMPs to manage stormwater from the site and provide qualitative treatment shall prepare an Operation and Maintenance (O&M) Plan. The O&M plan shall be submitted to the City for review and shall be approved prior to the commencement of construction activities. The O&M Plan shall meet the minimum requirements of the latest version of the Ohio EPA General Construction Permit and include an O&M Agreement signed by the owner/developer and a requirement for annual inspection reports filed on forms provided by the City and conducted by a licensed Ohio Professional Engineer, Certified Professional in Erosion and Sediment Control (CPESC), or Certified Professional in Storm Water Quality (CPSWQ).

The Ohio EPA General Construction permit can be found at the following link:

http://www.epa.state.oh.us/dsw/permits/GP_ConstructionSiteStormWater.aspx

The O&M plan shall be a stand-alone document which contains the following minimum requirements:

a. A designated entity for stormwater inspection and maintenance responsibilities.
b. The routine and non-routine maintenance tasks to be undertaken.
c. A schedule for inspection and maintenance tasks.
d. Any necessary legally binding maintenance easements and agreements.
e. A map showing the location of the BMPs and access and maintenance easements.
f. BMP details.
g. Procedures for properly disposing of collected pollutants within the BMPs in accordance with local, state, and federal regulations.

An O&M plan template and the Inspection and Maintenance Agreement are provided within Appendix A. The post-construction operator of the site that is responsible for maintaining the BMP's per the plan is required to inspect the BMP's and forward a copy of the inspection report to the City Engineer on an annual basis. Post-construction BMP inspection reports are provided within Appendix B.

9.0 STORMWATER MANAGEMENT PLAN SUBMITTAL REQUIREMENTS

The developer shall submit the stormwater management calculations to the City for review in the following format for projects that add 20,000 sf or more impervious area and/or have an acre or more of land disturbing activities. Sections that are not applicable to a specific project shall be omitted.

Section 1 – Project Information

- Engineer's certification
- Project narrative (description of project, existing conditions, and proposed stormwater management design)
- Location map
- Flood Insurance Rate Map
- Copies of other permit applications (401/404, NPDES, Dam Safety, etc.)

Section 2 – Stormwater Conveyance System Calculations

- Narrative description of procedures and assumptions used to calculate hydrologic and hydraulic conditions (including management of off-site runoff)
- Storm sewer design calculations
  - Conveyance calculations
  - Tailwater analysis
  - Outfall scour protection
- Pavement spread calculations
- Open channel design calculations
  - Conveyance calculations
  - Tailwater analysis
  - Shear stress and slope protection design
- Culvert design calculations
  - Conveyance calculations
  - Tailwater analysis
  - Outfall scour protection

Section 3 – Stormwater Control Facility Calculations

- Narrative description of procedures and assumptions used to calculate hydrologic and hydraulic conditions (including management of off-site runoff)
- Stormwater quantity control calculations
  - Existing condition hydrology
  - Allowable release rate calculations
  - Narrative description of proposed facility type and function
  - Proposed condition hydrology
  - Facility tailwater analysis
- Stormwater Quality Control Calculations
  - Required water quality calculations
  - Narrative description of proposed BMP type and function
  - BMP design calculations

Section 4 – Exhibits and Mapping

- Site topographic map
  - Scale 1"=100' or less
  - Existing and proposed contours onsite and within 100 feet of site
  - Delineation of pre-development regulatory floodplain and floodway limits
  - Delineation of post-development regulatory floodplain and floodway limits
  - Location of all wetlands, lakes, and ponds with normal water elevation shown
  - Location of all buildings near the site
  - Identification of lowest floor and lowest point of entry for each building within 100 feet of the development

- Site plan – showing existing and proposed conditions
  - Scale 1"=100' or less
  - Existing major and minor stormwater systems
  - Proposed major and minor stormwater systems
  - Existing wetlands and streams
  - Proposed wetland and stream mitigation
  - Existing roadways, structures, parking lots, driveways, sidewalks, and other impervious surfaces
  - Proposed roadways, structures, parking lots, driveways, sidewalks, and other impervious surfaces
  - Nearest base flood elevations
  - Design details for stormwater management facilities
- Tributary drainage area mapping
  - Watershed boundaries for areas draining through the development
  - Soil types, vegetation, and land cover affecting runoff upstream of the property for any area drainage through the site
  - Existing and proposed time of concentration
- Miscellaneous exhibits

Section 5 – Erosion and Sediment Control

- Erosion and sediment control plan
- Storm water pollution prevention plan

Section 6 – Operation and Maintenance

- Long term operation and maintenance plan
  - Scheduled maintenance program for stormwater facilities
  - Planned maintenance tasks and schedule
  - Indication of persons responsible for maintenance
  - Permanent access and maintenance easements
  - Inspection and Maintenance Agreement

ITEM	TO BE COMPLETED BY APPLICANT'S ENGINEER		TO BE COMPLETED BY CITY'S REVIEWER
	APPLICABLE (Y/N)	PROVIDED (Y/N)	REVIEWED (Y/N)
Section 1 – Project Information			
Engineer's Certification			
Project Narrative			
Location Map			
Flood Insurance Rate Map			
Wetland Delineation			
Copies of Other Permit Applications (401/404, NPDES, etc.)			
Section 2 – Stormwater Conveyance System Calculations			
Narrative description of procedures and assumptions used to calculate hydrologic and hydraulic conditions (including management of off-site runoff)			
Storm sewer design calculations			
Conveyance calculations			
Tailwater analysis			
Outfall scour protection			
Pavement spread calculations			
Open channel design calculations			
Conveyance calculations			
Tailwater analysis			
Shear stress and slope protection design			
Culvert design calculations			
Conveyance calculations			
Tailwater analysis			
Outfall scour protection			
Section 3 – Stormwater Control Facility Calculations			
Narrative description of procedures and assumptions used to calculate hydrologic and hydraulic conditions (including management of off-site runoff)			
Stormwater quantity control calculations			
Existing condition hydrology			
Allowable release rate calculations			
Narrative description of proposed facility type and function			
Proposed condition hydrology			
Facility tailwater analysis			
Stormwater Quality Control Calculations			
Required water quality calculations			
Narrative description of proposed BMP type and function			
BMP design calculations			
Section 4 – Exhibits and Mapping			
Site topographic map			
Scale 1"=100' or less			
Existing and proposed contours onsite and within 100 feet of site			
Delineation of pre-development regulatory floodplain and floodway limits			
Delineation of post-development regulatory floodplain			

ITEM	TO BE COMPLETED BY APPLICANT'S ENGINEER		TO BE COMPLETED BY CITY'S REVIEWER
	APPLICABLE (Y/N)	PROVIDED (Y/N)	REVIEWED (Y/N)
and floodway limits			
Location of all wetlands, lakes, and ponds with normal water elevation shown			
Location of all buildings near the site			
Identification of lowest floor and lowest point of entry for each building within 100 feet of the development			
Site plan – showing existing and proposed conditions			
Scale 1"=100' or less			
Existing major and minor stormwater systems			
Proposed major and minor stormwater systems			
Existing wetlands and streams			
Proposed wetland and stream mitigation			
Existing roadways, structures, parking lots, driveways, sidewalks, and other impervious surfaces.			
Proposed roadways, structures, parking lots, driveways, sidewalks, and other impervious surfaces.			
Nearest base flood elevations			
Design details for stormwater management facilities			
Tributary drainage area mapping			
Watershed boundaries for areas draining through the development			
Soil types, vegetation, and land cover affecting runoff upstream of the property			
Existing and proposed condition time of concentration mapping			
Miscellaneous exhibits			
Section 5 – Erosion and Sediment Control			
Erosion and Sediment Control Plan			
Storm Water Pollution Prevention Plan			
Section 6 – Operation and Maintenance			
Long term operation and maintenance plan			
Scheduled maintenance program for stormwater facilities			
Planned maintenance tasks and schedule			
Indication of persons responsible for maintenance			
Permanent access and maintenance easements			
Location of all wetlands, lakes, and ponds with normal water elevation shown			
Inspection and maintenance agreement			

10.0 GLOSSARY

The following definitions shall apply to this Manual:

100-year flood: A flood which has a one (1) percent chance of occurring each year, otherwise known as the base flood.

Attenuation: Is the gradual loss of intensity of 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 stormwater runoff and water bodies and reduction in peak flow rates.

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. Dams shall have spillway systems to safely convey normal stream and flood flows over, around, or through the dam. Spillways are commonly constructed of non-erosive materials such as concrete. Dams should also have a drain or other water withdrawal facility to control the pool or lake level and to lower or drain the lake for normal maintenance and emergency purposes. A permit from ODNR is not required for impoundments with a total storage volume of less than 15 ac-ft., or less than 50 ac-ft. for impoundments with a height of less than 10 feet, or unlimited storage for heights of less than 6 feet.

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. For the purpose of this design manual, this definition excludes storage in areas of parking lots, rooftops, underground tanks and other water quality-based applications, such as bio-retention basins.

Design Storm: A rainfall event of specified size and return frequency which is used to calculate the runoff volume and peak flow rate.

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 development operations and the construction of new facilities, buildings, parking areas, recreational areas, etc.

Development Area: Any contiguous (abutting) area owned by one person or operated as one development unit and used or being developed for nonfarm commercial, industrial, residential or other nonfarm purposes upon which earth-disturbing activities are planned or underway.

Dike: An artificial barrier used to divert or restrain flood waters from tidal bodies of water.

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

Disturbance: 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 Area: The contributing area to a single drainage basin, expressed in acres, square miles or other unit or area. Also called, "catchment area", "watershed" and "river basin", or the area served by a drainage system receiving storm and surface water or by a watercourse.

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

Earth-Disturbing Activity: Any grading, excavating, filling or other alteration of the earth's surface where natural or man-made ground cover is destroyed and which may result in increased rate and/or volume or runoff and/or contribute to erosion and sediment pollution.

Easement: Property titled to the City for the operation and maintenance of stormwater 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 United States Environmental Protection Agency, including but not limited to the Ohio Environmental Protection Agency (Ohio EPA), or any duly authorized official of said 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 (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 stormwater associated with activities subject to NPDES Permits as defined in 40 Code of Federal Regulations (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.

Floodplain: 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 wet, dry or wetland basin and in some cases bioretention basins, 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.* The Richland County Soil Survey should be used as the reference source for soils types and hydrologic soil groups within the City of Mansfield.

Impervious: 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.

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 Development of Sale: A contiguous area where multiple separate and distinct construction activities may be taking place at different times on different schedules under one plan. A common plan is broadly defined as any announcement or piece of documentation (including a sign, public notice or hearing, sales pitch, advertisement, drawing, permit application, zoning request, computer design, etc.) or physical demarcation (including boundary signs, lot stakes, surveyor, markings, etc.) indicating that construction activities may occur. A larger common plan or sale needs to also consider spoil areas, staging areas and borrow sites. A public body need not consider all their construction projects within their entire jurisdiction to be part of an overall common plan. Discrete construction projects within a larger common plan or development or sale are located at least ¼ mile apart and the area between the two projects is not being disturbed, each individual project can be treated as a separate plan of development or sale provided any interconnecting road, pipeline, or utility project that is part of the same "common plan" is not concurrently being disturbed.

Levee: An artificial barrier that diverts or restrains flood waters from streams and lakes. Per the Ohio Department of Natural Resources, sufficient freeboard shall be provided to prevent overtopping of the levee due to passage of the design flood or due to severe frost damage, ice damage, stream obstruction or wave action. The design freeboard shall not be reduced without the approval of the ODNR Chief.

- For levees in Class I, the minimum elevations of the top of the levee shall be three feet higher than the maximum adjacent water surface elevation during passage of the design flood.
- For levees in Class II and Class III, the minimum elevations of the top of the levee shall be two feet higher than the maximum adjacent water surface elevations during passage of the design flood.
- Where special conditions of severe frost damage, ice damage, stream obstruction, wave action, or impact of other structures may occur, the ODNR Chief may require elevations higher than required Item 1 above.

Managed Open Space: Land that is regularly maintained via mowing, fertilizing, landscaping, and other actions that prevent the land from being in a natural state such as single-family residential lawns, golf courses, cemeteries, and other similar types of development.

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

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):

- Owned or operated by a state, city, town, borough, county, parish, district, municipality, township, county, district, association, or other public body (created by or pursuant to State law) having jurisdiction over sewage, industrial wastes, including special districts under State law such as a sewer district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the Clean Water Act that discharges to waters of the United States;
- Designed or used for collecting or conveying stormwater;
- Which is not a combined sewer; and
- 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.

National Pollutant Discharge Elimination System (NPDES) Stormwater Discharge 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.

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 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.

Person: Any individual, owner, operator, association, organization, partnership, firm, corporation, municipal 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 that causes or contributes to pollution. Pollutants may include, but are not limited to, paints, varnishes, solvents, oil and other automotive fluids, non-hazardous liquid and solid wastes, yard wastes, refuse, rubbish, garbage, litter or other discarded or abandoned objects, floatable materials, pesticides, herbicides, fertilizers, hazardous materials, wastes, sewage, dissolved and particulate metals, animal wastes, residues that result from constructing a structure, and noxious or offensive matter of any kind.

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.

Post-development: The state of condition of the earth's surface after urbanization occurs. Other terms are "developed", "future", and "after development".

Practices: Schedules of activities, prohibitions of practices, maintenance procedures and other management practices 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 practices 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.

Pre-development: The state of condition of the earth's surface averaged over the last five years prior to urbanization. Other terms are "developed", "present", and "before development".

Rainwater and Land Development Manual: A manual describing construction and post-construction BMPs 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 methods of controlling construction related surface runoff, erosion and sedimentation. A copy of the manual may be obtained by contacting the Ohio Department of Natural Resources, Division of Soil & Water Conservation.

Return frequency: 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.

Routine Maintenance: Routine maintenance that does not require Ohio EPA General Permit Coverage that disturbs less than 5 acres of land and meets the definition of small construction at 40 CFR 122.26(b)(15)(i) which states: "Small construction activity does not include routine maintenance that is performed to maintain the original line and grade, hydraulic capacity, or original purpose of the facility". The land disturbance shall also not go beyond the original footprint of the facility. Examples of routine maintenance are as follows:

- Berm repair or topsoil placement.
- Berm repair or topsoil placement along shoulders - placing berm material or topsoil on shoulders adjacent to pavement to eliminate drop-offs.
- Bridge abutment repairs.
- Bridge deck overlays.
- Bridge deck replacement.
- Chip sealing - placing asphalt or polymer binder and stone on existing roads.
- Culvert repair/lining - repairing or lining existing culvert maintaining same line, grade, and hydraulic capacity and within USAC Nationwide Permit (NWP) #3 parameters.
- Culvert replacement - replacing a culvert with the same line, grade, and hydraulic capacity and within USAC NWP #3 parameters.
- Curb repairs - repairing existing curbing along a roadway.
- Ditch cleanout - maintaining or restoring original flow line and cross-section only.
- Fence repair/replacement.
- Full depth pavement repairs - isolated repairs of pavement build-up down to sub-grade (soil).
- Guardrail installation/replacement - installing or repairing with minor grading work to create proper grade for end assemblies.
- Lighting maintenance.
- Linear grading - reshaping of graded shoulders to establish proper drainage away from pavement.
- Loop detector repairs - repairing loop detectors in existing pavement.
- Noise wall repair.
- Partial depth pavement repairs - isolated repairs of surface courses of pavement.
- Pothole filling.
- Resurfacing - replacing several inches of asphalt wearing course by milling existing asphalt and replacing with new.
- Sign repair/maintenance - installing or repairing traffic signs and poles/posts.
- Signal installation/maintenance - installing or repairing traffic signals and poles/posts.
- Tree/brush removal.

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 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.

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.

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

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.

Storm Drainage System: All facilities, channels, and areas which serve to convey, filter, collect and/or receive stormwater, either on a temporary or permanent basis.

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

Stormwater Management Facilities: The drainage system and control facilities necessary to meet the runoff criteria of these regulations.

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. To be classified as a stream, the waterway shall meet certain requirements as defined by the Ohio EPA and/or US Army Corps of Engineers and may then be classified as either an ephemeral, intermittent, or perennial stream.

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.

Water Quality Volume: A volume captured for the purposes of treating pollutants and protecting stream stability. This volume is prescribed by the Ohio EPA Construction General Permit and is equivalent to the volume generated by a 0.75 inch rainfall.

Watershed: A region draining to a specific river.

Wetland: An area that is inundated or saturated by surface or groundwater at a frequency and duration sufficient to support a prevalence of vegetation typically adapted for life in saturated or hydric soil conditions as defined by the Ohio EPA and/or US Army Corps of Engineers.

Post-Construction Water Quality
Best Management Practice
Operation and Maintenance Plan

Project Name:

Project Address:

Site Contact:

Plan Prepared By:

Date:

TABLE OF CONTENTS

APPENDICES

EXHIBITS

1.0 BEST MANAGEMENT PRACTICE OVERVIEW

Identify and discuss the Best Management Practices (BMPs) that will be used to manage the stormwater runoff from the site. Describe the location of the BMPs and associated treatment tributary areas. Identify the location of the BMPs on the site plan that is to be included on Exhibit B. Indicate any necessary legally binding maintenance easements and agreements that are necessary to adequately maintain the BMPs and provide copies within Appendix A.

2.0 INSPECTION & MAINTENANCE PROCEDURES

Discuss the frequency of which the BMPs will be inspected and provide an inspection. Inspections are to be conducted on a quarterly basis during the first year of operation and then, at a minimum, annually after the first year of operation. Identify the personnel responsible for conducting the site inspections and provide contact information. Include inspection and maintenance procedures for each BMP and indicate the means of which collected pollutants will be removed from the site and properly disposed of. Copies of inspection reports are to be submitted to the City of Mansfield Engineer by June 30th on an annual basis.

APPENDIX A:

Inspection and Maintenance Agreement

INSPECTION AND MAINTENACE AGREEMENT FOR POST-CONSTRUTION STORMWATER BEST MANAGEMENT PRACTICES

PROJECT: [Click here and type Project Name]

This Inspection and Maintenance Agreement, made this _____day of _____20__, by and between the **[Click here and type responsible party for the best management practices]** (hereafter referred to as the Owner) and the **[Click here and type Community Name]** (hereafter referred to as the Community), provides as follows:

WHEREAS, the Owner is responsible for certain real estate shown as Tax Map No. **[Click here and type parcel number]** that is to be developed as **[Click here and type Project Name]** and referred to as the Property; and,

WHEREAS, the Owner is providing a stormwater management system consisting of the following Best Management Practices:

1. **[Click here and type Practices]**

as shown and described within the Community approved stormwater management plan pertaining to the Property; and,

WHEREAS, to comply with the City of Mansfield Stormwater Management Design Manual, pertaining to this project, the Owner has agreed to maintain the stormwater Best Management Practices in accordance with the terms and conditions hereinafter set forth.

NOW, THEREFORE, for and in consideration of the mutual covenants and undertaking of the parties, the parties herby agree as follows:

FINAL INSPECTION REPORTS AND AS BUILT CERTIFICATION

The Owner shall certify in writing to the Community within 30 days of completion of the stormwater Best Management Practices that the Best Management Practices are constructed in accordance with the approved plans and specifications. The Owner shall further provide As Built Certifications of the locations of all access and maintenance easements and each Best Management Practices.

OPERATION AND MAINTENANCE PLANS FOR THE BEST MANAGEMENT PRACTICES

1. The Owner agrees to maintain in perpetuity the Best Management Practices in accordance with the approved Operation and Maintenance Plan listed in #2 in a manner that will permit the Best Management Practices to perform the purposes for which they were designed and constructed, and in accordance with the standards by which they were designed and constructed, all as shown and described in the Community approved stormwater management plan pertaining to the Property. This includes all pipes and channels built to convey stormwater to the Best Management Practices, as well as structures, improvements, and vegetation provided to control the quantity and quality of the stormwater runoff.

2. The Owner shall provide an Operation and Maintenance Plan for all of the Post-Construction Best Management Practices located on the Property as identified within this agreement to the community. The Operation and Maintenance Plan shall contain the following:

    - Identify the entity for Best Management Practice inspection and maintenance responsibilities;
    - the maintenance tasks to be undertaken;
    - a schedule for inspection and maintenance;
    - any necessary legally binding maintenance easements and agreements; and
    - a site map showing the location of the Best Management Practices and all access and maintenance easements.

3. The Owner shall perform all maintenance in accordance with the above Operation and Maintenance Plan and shall complete all repairs identified through regular inspections, and any additional repairs as requested in writing by the Community.

BEST MANAGEMENT PRACTICE INSPECTION AND REPAIRS

1. The Owner shall inspect all Best Management Practices identified within the Operation and Maintenance Plan every three (3) months during the first year of operation.

2. The Owner shall inspect all Best Management Practices identified within the Operation and Maintenance Plan annually prior to June 30th after the first year of operation.

3. The Owner shall submit written inspection reports to the Community within 30 days after each inspection.

    Inspection reports to be submitted to:

    City of Mansfield Engineering Department
    Mr. Bob Bianchi, PE
    30 North Diamond Street
    Mansfield, OH 44902

    Inspection reports prepared for each Best Management Practice and shall include the following information at a minimum:

    - Project Name
    - Inspection Date
    - Indicate the Best Management Practice inspected and identify the inspected components
    - Summary of inspection results including necessary repairs and maintenance
    - Best Management Practice pictures taken during the time of the inspection

4. The Owner grants permission to the Community to enter the Property and to inspect all aspects of the Best Management Practices whenever the Community deems necessary. The Community shall provide the Owner copies of the inspection findings and a directive to commence with necessary repairs.

5. The Owner shall make all repairs within thirty (30) days of their discovery as identified within the Owner inspections or through a request for the Community resulting from the Community conducted inspections. If repairs will not occur within this thirty (30) day period, the Owner must present a schedule to the Community for approval and the Owner must receive written approval from the Community for a repair schedule.

6. In an event of any default or failure by the Owner in properly maintaining the Best Management Practices in accordance with the approved stormwater management plan and the Post-Construction Operation and Maintenance Plan, or, in the event of an emergency as determined by the Community, it is the sole discretion of the Community, after providing reasonable notice to the Owner, to enter the property and take whatever steps necessary to correct deficiencies and to charge the cost of such repairs to the Owner. The Owner shall reimburse the Community upon demand, within costs expended by the Community in performing such necessary maintenance or repairs shall constitute a lien against the properties of the Owner. Nothing herein shall obligate the Community to maintain the Best Management Practices.

OPERATION AND MAINTENANCE FUNDING

The Owner shall specify the method of funding for the perpetual inspection, operation, and maintenance of all of the Best Management Practices listed in this agreement. This funding mechanism shall be approved by the Community.

INDEMNIFICATION

The Owner herby agrees that it shall save, hold harmless, and indemnify the Community and its employees and officers from and against all liability, losses, claims, demands, costs and expenses arising from, or out of, default or failure by the Owner to maintain the Best Management Practices, in accordance with the terms and conditions set forth herein, or from acts of the Owner arising from, or out of, the construction, operation, repair or maintenance or the Best Management Practices.

The Owner hereby releases the Community from all damages, accidents, casualties, occurrences, or claims that might arise or be asserted against the Community from the presence, existence, or maintenance of the Best Management Practices.

The parties hereto expressly do not intend by execution of this Inspection and Maintenance Agreement to create in the public, or any member thereof, any rights as a third-party beneficiary or to authorize anyone not a party hereof to maintain a suit for any damages pursuant to the terms of this Inspection and Maintenance Agreement.

This inspection and maintenance agreement shall be a covenant that runs with the land and shall inure to the benefit of and shall be binding upon the parties hereto, their respective successors and assigns, and all subsequent owners or the property.

The current Owner shall promptly notify the Community when the Owner legally transfers any of the Owners responsibilities for the Best Management Practices. The Owner shall supply the Community with a copy of any document or transfer, executed by both parties.

Upon execution of this Inspection and Maintenance Agreement, it shall be recorded in the Recorder's Office of Richland, Ohio, at the Owner's expense.

IN WITNESS WHERE OF, the Owner has caused this Inspection and Maintenance Agreement to be signed in its names by duly authorized person.

_____

Owners Printed Name

_____ _____

Owners Signature Date

By: _____

City Official

APPENDIX B:

Inspection Reports

BMP example inspection reports are provided within this Appendix B of the City of Mansfield Stormwater Design Manual. These reports can be adjusted based upon site specific BMPs or additional reports created. Reference the Ohio Department of Natural Resources (ODNR) "Rainwater and Land Development" manual for BMP inspection and maintenance guidelines.

ODNR Rainwater and Land Development Manual:

http://soilandwater.ohiodnr.gov/water-conservation/stormwater-management

EXHIBIT A:

Legal Description

Insert the project area legal description

EXHIBIT B:

Maintenance Plan

Provide a site plan to scale indicating the proposed site features and locations of the Best Management Practices. Indicated the site boundary and any necessary easements that are required to access the site and properly maintain the BMPs.

Provide BMP details and specifications identifying the various components that are to be inspected, maintained or replaced, such as:

- *Planting plans*
- *Seed mixes and application rates*
- *Manufactured structures*
- *Engineered soil mixes*
- *BMP cross sections*
- *Basin outlet structures*