



Design Standards Manual

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Section 1: General Information

1.1 Concept

This section contains storm water management criteria. Emphasis should be placed on detention and storage of rainfall to mitigate increased runoff due to development. This should result in a reduction of increased development runoff and related damage to downstream properties.

1.2 Conditions

1. The design provided by the Project Engineer should demonstrate:
 - A. The streets function as part of the storm water system. The computed amount of runoff in streets should not exceed the requirements set forth herein.
 - B. Gutters and intakes are adequately designed to prevent excessive flooding of streets and parking.
 - C. Culverts and storm pipes are designed to accommodate the design storm.
 - D. Adequate overland relief is present for storms larger than the design storm. Channels and respective easements are adequately sized.
 - E. Street grades are coordinated with lot drainage. Lot drainage slopes should not be less than 1.5 percent.
 - 1) Where such slopes are not possible in rear and side yards, spot elevations and flow arrows should be included at each rear lot corner and at the midpoint of the side yard line. Plans should note the builder will grade rear and side yard swales to drain to the right-of-way.
 - F. The storm drainage system design should consider surface and subsurface sources. The discharge from subdrain systems should not flow over sidewalks or onto streets.
2. The Project Engineer should evaluate storm water management alternatives and select a design to best balance initial capital costs, maintenance costs, safety, and environmental protection.
3. Runoff analysis should be based upon proposed (including future where applicable) land use and consider contributing runoff from offsite areas.
4. The Project Engineer should consider the future land use of all undeveloped land tributary to the study area and develop assumptions for runoff and stormwater management.
 - A. The probable future flow pattern in the undeveloped areas should be based on existing natural topographic features (existing slopes, drainage ways, etc.)
 - B. Average land slopes in both developed and undeveloped areas may be used in computing runoff. Known and proposed drainage patterns and slopes should be utilized where possible.
5. Flows and velocities which may occur when the upstream area is fully developed should be considered. Drainage facilities should be designed to prevent erosion damage.

6. The preservation of natural drainageways is recommended and encouraged whenever possible, in accordance with City of Bettendorf code. The changing of natural drainageway locations may not be approved unless shown to be without unreasonable hazard and liability, substantiated by thorough analysis and investigation. Deteriorated drainageways may be required to be stabilized as determined by the City Engineer.
7. Drainage and stormwater detention easements may be required for the protection and maintenance of drainage swales and detention areas. The Project Engineer should show that natural and constructed channels will have no adverse effect on adjacent properties and downstream areas.
8. Grading of the project site should take advantage of existing contours and minimize soil disturbance. Steep slopes (>3:1) should be avoided. If steep slopes are necessary, an attempt should be made to save natural grasses, shrubs and trees on these slopes and reestablish ground cover and permanent erosion control measures as soon as possible.
9. During construction grading, temporary diversions, contour furrows, terraces and other remedial conservation practices should be used to reduce erosion and excessive water drainage to downstream adjacent properties. Sediment traps and basins should be used and maintained at the lower end of the drainage ways.
10. Plan and design drainage systems so erosion and/or flooding problems are not transferred from one property to another.
11. Floodplain and floodway information will be required on drainage plans when known, and should include the area inundated by the major storm headwater.
12. Where a master drainage plan for a City is available, the flow routing for both the minor storm and major storm runoff should conform to this plan. Drainage easements conforming to the master plan will be required and should be designated on drainage plans and subdivision plats.
13. The design for storm water management facilities shall conform to this Manual and applicable regulations of the Iowa Department of Natural Resources and US Environmental Protection Agency. In case of a conflict between the design criteria, the more restrictive requirement shall apply.
14. Construction standards shall be the City of Bettendorf Standard Specifications for Public Improvements.
15. Possible wetland areas shall be investigated and identified as appropriate.

Section 2: Drainage Report

2.1 Purpose

The purpose of the drainage report is to estimate and propose solutions for increased runoff due to proposed development. The report must include adequate analysis and discussion of off-site drainage and the capacity of downstream drainage systems to determine their ability to convey the developed discharge.

The drainage report and plan shall be reviewed and accepted by the City Engineer prior to approval of the construction plans. The Project Engineer may be required to submit a drainage report, plan, and permit application to the Iowa Department of Natural Resources and/or Corps of Engineers. The drainage report shall be certified by a Professional Engineer licensed to practice in the State of Iowa.

2.2 Instructions for Preparing the Drainage Report

1. Include a cover sheet with project name and location, name of firm or agency preparing the report, Professional Engineer's signed and sealed certification, and table of contents. Number each page of the report.
2. All analyses shall be performed according to the intent of professionally recognized methods. Any modifications to these methods shall be supported by well-documented and industry accepted research.
3. It is the designer's responsibility to provide all data requested. If the method of analysis (for example, a computer program) does not provide the required information, then the designer shall select alternate or supplemental methods to ensure the drainage report is complete and accurate.
4. Acceptance of a drainage report implies the City concurs with the project's overall stormwater management concept. This does not constitute a full approval of the improvement plans, alignments, and grades, since constructability issues may arise in plan review.
5. The report format is shown in Appendix A. Use all headings listed in the order given. A complete report will include all the information requested in this format. If a heading listed does not apply, include the heading and briefly explain why it does not apply. Include additional information and headings as required to develop the report.
6. This Design Standards Manual does not preclude the utilization of methods other than those referenced nor does it relieve the designer of responsibility for analysis of issues not specifically mentioned.

Section 3: Rainfall and Runoff Analysis

Preferred Design Assumptions NOAA Atlas 14 Rainfall Data - January 2015

Bettendorf is located within Climate Section 6 as shown in Figure 1 of ISWMM Section 2C-2. Rainfall values used for stormwater design analysis should be taken from values from NOAA Atlas 14 Rainfall Data as shown below. It is recommended to interpolate as needed to obtain rainfall amounts for storm durations which are not listed within this table.

**Generally, rainfall intensities are used for the Rational Method and rainfall depths are used for NRCS TR-20 and TR-55.*

Rainfall Depth and Intensity for Various Return Periods

Duration	Return Period															
	1 year		2 year		5 year		10 year		25 year		50 year		100 year		500 year	
	D	I	D	I	D	I	D	I	D	I	D	I	D	I	D	I
5 min	0.38	4.56	0.44	5.30	0.54	6.56	0.63	7.65	0.76	9.18	0.86	10.3	0.97	11.6	1.23	14.8
10 min	0.55	3.33	0.64	3.87	0.8	4.8	0.93	5.58	1.11	6.70	1.26	7.60	1.42	8.54	1.80	10.8
15 min	0.67	2.70	0.78	3.14	0.97	3.88	1.13	4.53	1.36	5.45	1.54	6.18	1.73	6.94	2.20	8.81
30 min	0.95	1.90	1.11	2.22	1.38	2.76	1.61	3.22	1.94	3.88	2.20	4.40	2.47	4.95	3.14	6.29
1 hr	1.23	1.23	1.44	1.44	1.80	1.80	2.11	2.11	2.58	2.58	2.96	2.96	3.36	3.36	4.37	4.37
2 hr	1.51	0.75	1.77	0.88	2.22	1.11	2.62	1.31	3.22	1.61	3.71	1.85	4.24	2.12	5.60	2.80
3 hr	1.68	0.56	1.96	0.65	2.47	0.82	2.93	0.97	3.63	1.21	4.22	1.40	4.85	1.61	6.50	2.16
6 hr	1.97	0.32	2.30	0.38	2.89	0.48	3.45	0.57	4.3	0.71	5.02	0.83	5.8	0.96	7.87	1.31
12 hr	2.28	0.19	2.65	0.22	3.31	0.27	3.93	0.32	4.88	0.40	5.68	0.47	6.56	0.54	8.87	0.73
24 hr	2.60	0.10	3.01	0.12	3.75	0.15	4.42	0.18	5.44	0.22	6.29	0.26	7.22	0.30	9.64	0.40
48 hr	2.98	0.06	3.43	0.07	4.22	0.08	4.93	0.10	6.01	0.12	6.90	0.14	7.86	0.16	10.3	0.21
3 day	3.28	0.04	3.72	0.05	4.51	0.06	5.24	0.07	6.32	0.08	7.22	0.10	8.19	0.11	10.7	0.14
4 day	3.53	0.03	3.98	0.04	4.78	0.04	5.50	0.05	6.58	0.06	7.49	0.07	8.46	0.08	10.9	0.11
7 day	4.17	0.02	4.67	0.02	5.53	0.03	6.29	0.03	7.39	0.04	8.30	0.04	9.25	0.05	11.6	0.06
10 day	4.75	0.01	5.30	0.02	6.24	0.02	7.04	0.02	8.20	0.03	9.12	0.03	10.0	0.04	12.4	0.05

D= Total depth of rainfall for given storm duration (inches)

I= Rainfall intensity for given storm duration (inches/hour)

Addressing Small Storm Hydrology:

Note per the table above, 90% of the rainfall events that typically occur in Central Iowa have been of 1.25" depth or less. Without proper planning and installation of appropriate best management practices (BMPs) that address these types of events, runoff from these storms will go largely unmanaged, leading to more frequent storm discharges and greater runoff volumes being released to urban stream corridors.

Section 4: Time of Concentration

Reference: Section 2C-3 of the Iowa Stormwater Management Manual (ISWMM)

4.1 Preferred Design Assumptions

The following values and methods are recommended for use in completing calculations for time of concentration within the City of Bettendorf.

1. *Design calculations shall include a detailed explanation and evidence supporting any variation from these recommended methods or values.*

4.2 Existing conditions analysis for areas of undeveloped agricultural lands:

To better reflect the retention of rainfall on large areas of undeveloped landscapes, use the NRCS lag method.

1. *Note that the value for “Y” in the equation given is average watershed land slope, not slope along the stream length. Slope data from county soil surveys or LIDAR topographic information can often be used to compute this value.*
2. *Be aware of the limitations of this method as listed in note 2d of ISWMM Section 2C-3.*

4.3 Existing and proposed conditions near or within urbanized areas:

Use Manning’s Kinematic Solution Method.

Apply the following additional information:

1. **Sheet flow.** Sheet flow is very shallow, uniform flow that usually occurs along the upper edges of a watershed. It only occurs until water reaches a point where flow will concentrate in a small depression or swale.

**Sheet flow should never be measured past the point where contours indicate flow will begin to funnel to a common path. Follow the following guidelines for sheet flow calculation:*

2. **Flow Length (maximum values – stop at point of concentration for each sub-area)**

A. **Pre-development conditions:** No greater than 100 feet.

B. **Post-development conditions:** No greater than 50 feet of lawn, grass or wooded area unless specific practices are installed that encourage sheet flow conditions (level spreader, etc.) Total including paved surfaces no greater than 100 feet.

3. **Roughness coefficient.** Use values listed in the table below.

**Note that these values for “n” are different than those to be used for Manning’s equation used for open channel flow.*

Surface Description	Manning’s “n”
Smooth Surfaces (Pavement)	0.011
Cultivated agriculture	0.17
Prairie grasses	0.15
Turf grass lawns	0.24
Woods	0.40

4. **Shallow concentrated flow.** Use the following equation to calculate flow velocity (from FHWA Hydraulic Engineering Circular No.22, Third Edition, September 2009):

$$V = K_u * k * \sqrt{S_p}$$

(From equation 3-4, page 3-9 of HEC-22)
 Where $K_u = 3.28$ (for English units)
 V = Velocity (ft/s)
 k = Intercept coefficient (from Table)
 S_p = Slope along flow path (% , i.e. 2% = 2)

Intercept Coefficients from Equation 3-4 (from Table 3-3 of HEC-22)

Land Cover	k
Forest with Heavy ground liter, hay meadow	0.076
Trash fallow or minimum tillage cultivation; contour or stripped cropped; woodland	0.152
Short pasture grass	0.213
Cultivated straight row	0.274
Nearly bare and untilled	0.305
Grassed waterway	0.457
Unpaved	0.491
Paved areas; small upland gullies	0.619

5. **Open Channel flow.** Use Manning's equation for open channel flow – Equation 4 (ISWMM Section 2C-3, page 6) based on channel cross-section properties and surface conditions.

- A. Refer to Table 2 for values of “n” for this equation (ISWMM Section 2C-3, page 12).
- B. Include with submitted calculations details on the assumed cross-section of the channel and surface conditions used to select value of “n”.

Note that these values for “n” are different than those to be used for sheet flow discussed earlier.

- C. *Caution: Improper calculation of time of concentration can dramatically affect calculated peak flow rates, especially when the Rational Method is being used. To a lesser extent, it will affect the shape and peak of hydrographs developed using the NRCS TR-20 or TR-55 methods.*
- D. *Note: NRCS WinTR-55 may be utilized to determine time of concentration. Parameters set forth previously in this section shall be used as inputs when using WinTR-55.*

Section 5: Storm Sewer System Design

5.1 Minor and Major Storms

Every urban area has two distinct drainage systems. One is the minor system corresponding to the minor storm event having a return frequency of 10 years. The other is the major system corresponding to the major storm event having a return frequency of 100 years. Since the effects and routing of the major storm runoff may not be the same for the minor storm, storm drainage plans submitted should include the routing path and effects of both the minor and major storm.

Table 5.1 Chance of a Storm Equaling or Exceeding A Given Frequency for a Given Time Period
Time Period (years)

Frequency (years)	1	10	25	50	100
5	20%	89%	99.9%	99.9%	99.9%
10	10%	65%	94%	99.9%	99.9%
25	4%	34%	64%	87%	98%
50	2%	16%	40%	60%	86%
100	1%	9.6%	22%	39%	64%

1. Minor Storm Provisions

The minor storm drainage system should be designed to protect against regularly recurring damage, reduce street maintenance costs, and provide an orderly urban drainage system and to provide public convenience. Storm sewer systems consisting of underground piping, natural drainageways and other required conveyance should be considered part of the minor storm drainage system.

2. Major Storm Provisions

The major storm drainage system should be designed to prevent major property damage or loss of life from storm runoff expected from the major storm. The effects of the major storm on the minor drainage system should be noted in the drainage report.

5.2 Location of Storm Sewer

1. Storm Sewers in Public Right-of-Way:

A. Storm Sewers parallel to the street and in the right-of-way should be placed behind the back of curbs, as close as practical to fit specific manhole or intake connections and to avoid conflicts with other utilities.

B. Storm sewers perpendicular to the street are to connect at each end by intakes or manholes.

2. Storm Sewer and/or Drainage Easements:

A. Easements must be exclusively for the City.

B. Width of permanent easements for storm sewer pipe shall be required based on depth of invert, size of pipe, soil types, construction limits required to remove and replace pipe, and overflow conveyance requirements. At a minimum, the easement shall be twenty feet (20') wide. The pipe should be located in the center of the easement.

C. No permanent structures, fencing or landscaping shall be placed in any drainage easement.

D. Storm sewers at intersection corners may require additional corner easements.

5.3 Pipe Material:

Pipe material and pipe strength for sewers within the public right-of-way shall conform to the City of Bettendorf Standard Specifications for Public Improvements.

5.4 Physical Requirements:

1. Recommended minimum cover on storm sewers outside of pavement is 2'-0". Recommended minimum cover under six inch (6") local street pavement for cross runs is 1'-6" from top of pavement. For greater pavement thickness or street classification other than local, provide structural calculations for minimum cover.
2. Minimum cover on subdrain within public right-of-way is 3'-0".
3. Minimum and maximum cover based on structural calculations and manufacturers' recommendations.
4. Minimum pipe size for public storm sewers – 15" diameter.
5. Minimum pipe grades:
 - A. Storm Sewer Mains: Minimum grade is set by the required velocity for storm sewers and footing drain sewers- 3 fps for the design storm.
 - B. Cross Runs: Minimum grade of 1%. Desired minimum velocity of 3 fps for the design storm.
 - C. Building Storm Sewer Stubs: Minimum grade of 1%.
 - D. Subdrains: Grade equal to the centerline profile grade of the roadway.

5.5 Separation of Water Mains from Sewer Mains:

The following comply with the Iowa Department of Natural Resources (IDNR) separation requirements.

1. Horizontal Separation of Gravity Sewers from Water Mains:

Separate gravity storm sewer mains from water mains by a horizontal distance of at least ten feet (10') unless:

- A. The top of a sewer main is at least eighteen inches (18") below the bottom of the water main, and,
- B. The sewer is placed in a separate trench or in the same trench on a bench of undisturbed earth at a minimum horizontal separation of three feet (3') from the water main.

When it is impossible to obtain the required horizontal clearance of three feet (3') and a vertical clearance of eighteen inches (18") between sewers and water mains, the sewers must be constructed of water main materials meeting the requirements of the City of Bettendorf Standard Specifications for Public Improvements. However, provide a linear separation of at least two feet (2').

2. Separation of Sewer Force Mains from Water Mains:

Separate storm sewer force mains and water mains by a horizontal distance of at least ten feet (10') unless:

- A. The force main is constructed of water main materials meeting a minimum pressure rating of 150 psi and the requirements of City of Bettendorf Standard Specifications for Public Improvements, and
- B. The sewer force main is laid at least four (4) linear feet from the water main.

3. Separation of Sewer and Water Main Crossovers:

Vertical separation of storm sewers crossing under any water main should be at least eighteen inches (18") when measured from the top of the sewer to the bottom of the water main. If physical conditions prohibit the separation, the sewer may be placed not closer than six inches (6") below a water main or

eighteen inches (18") above a water main. Maintain the maximum feasible separation distance in all cases. The sewer and water pipes must be adequately supported and have watertight joints. Use a low permeability soil for backfill material within ten feet (10') of the point of crossing.

Where the storm sewer crosses over or less than eighteen inches (18") below a water main, the entire length of sewer pipe from structure to structure shall be constructed of water main material or reinforced concrete pipe (RCP) with flexible O-ring gasketed joints.

5.6 Horizontal Alignment:

Sewer should be laid with a straight alignment between manholes structures at all times.

5.7 Outlets:

1. Where a storm sewer discharges to a receiving channel, an outlet structure should be provided that will blend the storm sewer discharge into the natural channel flow in a manner to prevent erosion of the bed or banks of the channel. All storm sewer pipe outlets will require flared end sections with curtain walls per the City of Bettendorf Standard Drawings.
2. When the discharge velocity is greater than outlined in Tables 5.2 & 5.3, prevention of erosion of the natural channel bed or banks in the vicinity of the outlet will require an energy dissipating structure, such as riprap, concrete baffles, gabions, or stilling basin. Refer to Section 8, Outlet Revetment Protection.
3. Storm Sewer along a side property line shall run the length of the property line and outlet past the rear property line to a receiving drainageway.
4. Outlets shall drain to a receiving drainageway or connect to an existing storm sewer. Outlets will not drain directly to streets. Outlets shall not be located on slopes without adequate erosion protection and means of conveyance between the outlet and receiving drainageway or storm sewer. Erosion protection on slope only at the outlet is often inadequate, as runoff velocity will increase down grade of the outlet.

5.8 Storm Sewer Structures

1. Location:
Manholes or intakes will be required whenever there is a change in size, direction, elevation, grade or a junction of two or more storm sewers. When feasible, access structures should be installed at street intersections. Manholes should be located in areas to allow direct access by maintenance vehicles. Structures will be spaced at distances not greater than four hundred feet (400'), regardless of gutter capacity. The most upstream structure of a storm sewer run shall be located a maximum four hundred feet (400') from a street high point to minimize gutter spread. Intakes near intersections should be located at least ten feet (10') from pedestrian ramps, as measured between near edge of the intake and near edge of ramp, to avoid ponding water at the ramps.
2. Invert Drop
When there is a change in pipe size at a structure, the invert of the smaller sewer must be raised to maintain the same energy gradient. An approximate method of doing this is to place the 0.8 depth point of both sewers at the same elevation. When there is a change in alignment between storm sewer of 45° or greater the suggested minimum manhole drop is 0.10'.

5.9 Hydraulic Design

Storm sewers should be designed to convey the 10-year storm peak runoff without surcharging the sewer. Where surcharging is a concern, the hydraulic grade line may be calculated by accounting for energy losses. Total hydraulic losses will include friction, expansion, contraction, bend and junction losses. The design method shall generally follow procedures in FHWA Hydraulic Engineering Circular No. 22, "Urban Drainage Design Manual", or as approved by the City.

1. Pipe Friction Losses

The Manning's "n" values to be used in the calculation of storm sewer capacity and velocity are shown as follows:

Type of Pipe	Manning's "n"
PVC/HDPE Pipe (Smooth Interior Wall)	0.011
Concrete Pipe	0.013
PVC/HDPE Pipe (Corrugated Single Wall)	0.020

*Values for materials other than listed above shall be approved by the City Engineer.

2. Velocity within Storm Sewer Pipe:

- A. Minimum flow (1/2 full pipe) for 10-year design storm flow = 3 fps
- B. Maximum for 10-year design storm flow = 15 fps

3. Velocity at Outlet of Pipe:

- A. Energy dissipation is required when discharge velocities exceed those allowed for downstream channel. (See Tables 5.2 & 5.3)
- B. Max. with flared end section = 5 fps
- C. Max. with flared end section and rip-rap = 10 fps
- D. Max. with energy dissipation device = 20 fps

Table 5.2- Permissible Velocities for Channels Lined With Erodible Linings, Based on Uniform Flow in Continuously Wet, Aged Channels

Soil Type or Lining (earth; no vegetation)	Maximum Permissible Velocities for the following		
	Clean Water (fps)	Water Carrying Fine Silts (fps)	Water Carrying Sand and Gravel (fps)
Fine sand (non-colloidal)	1.5	2.5	1.5
Sandy loam (non-colloidal)	1.7	2.5	2.0
Silt loam (non-colloidal)	2.0	3.0	2.0
Ordinary firm loam	2.5	3.5	2.2
Volcanic ash	2.5	3.5	2.0
Fine gravel	2.5	5.0	3.7
Stiff clay	3.7	5.0	3.0
Graded, loam to cobbles (non-colloidal)	3.7	5.0	5.0
Graded, silt to cobbles (colloidal)	4.0	5.5	5.0
Alluvial silts (non-colloidal)	2.0	3.5	2.0
Alluvial silts (colloidal)	3.7	5.0	3.0
Coarse gravel (non-colloidal)	4.0	6.0	6.5
Cobbles and shingles	5.0	5.5	6.5
Shales and hard pans	6.0	6.0	5.0
Fabric and excelsior mat	7.0	7.0	7.0
Dry rip-rap/ gabions	10.0	10.0	10.0
Concrete pilot channel	Use grass permissible velocity- Table 5.3		

Table 5.3- Permissible Velocities for Channels Lined With Uniform Stands of Various Grass Covers, Well Maintained¹

Cover	Slope Range (%)	Permissible Velocity on...	
		Erosion Resistant Soils (fps)	Easily Eroded Soils (fps)
Bermuda grass	0 to 5	8	6
	5 to 10	7	5
	Over 10	6	4
Buffalo grass	0 to 5	7	5
Kentucky Bluegrass	5 to 10	6	4
Smooth brome			
Blue grama	Over 10	5	3
Grass mixture	0 to 5	5	4
	5 to 10	4	3
Lespedeza sericea	0 to 5	3.5	2.5
Weeping lovegrass			
Yellow bluestem			
Kudzu			
Alfalfa			
Crabgrass			
Common lespedeza ²	0 to 5	3.5	2.5
Sudangrass ³			

¹Use velocities of 5 fps only where good covers and proper maintenance can be obtained.

²Annuals, used on mild slopes or as temporary protection until permanent covers are established.

³Use on slopes steeper than 5% is not recommended

Section 6: Storm Sewer Intakes

6.1 Introduction

1. A storm intake is an opening into a storm sewer system to collect surface storm runoff. There are three (3) basic types of intakes:
 - A. Curb-grate opening
 - B. Open Throat (Iowa DOT SW intake)
 - C. Area Intake
2. Intakes are further classified as being at grade or at a low point. The term "at grade" refers to an intake located on the street grade with continuous slope, where ponding does not occur at the intake. The sump or low point condition exists whenever water is restricted to the inlet area because the intake is located at a low point. A low point condition can occur at a sag vertical curve or due to the crown slope of a cross street when the intake is located at an intersection.

6.2 Definitions

1. Design flow is the calculated quantity of storm runoff at a given point for the minor storm event having a return frequency of 10 years. For gutter applications, design flow shall include bypass flow from upstream intakes.
2. Bypass flow is gutter flow not intercepted by a given upstream intake. Bypass flow is calculated by subtracting the allowable capacity of the given intake from the design flow assigned to that intake. Bypass flow shall be added to the design storm runoff for the next downstream intake. As a minimum, intakes at a low point shall have design capacity to intercept all storm runoff including upstream bypass flows.

6.3 Intercepting Flows

Storm sewer intakes shall be designed to intercept design flow with the following allowable bypass from the system:

1. Streets on Continuous Grade – The final downstream intake or intakes shall be designed to intercept no less than 50% of the design flow.
2. Temporary Dead-End Streets on Down Grade – Unless otherwise approved by the City Engineer, intakes shall be designed to intercept no less than 100% of the design flow.
3. Cul-de-sac Streets on Down Grade and Low Points – Intakes shall be designed to intercept no less than 100% of the design flow. Depending on downstream conditions, the City Engineer may require oversized or additional flanker intakes at low points to account for potential plugging or blockage.
4. Intersections – Intakes near intersections should be located at least ten feet (10') from pedestrian ramps, as measured between near edge of the intake and near edge of ramp, to avoid ponding water at the ramps.
5. Emergency overflow flow paths shall be provided to safely pass the 100 year storm event overland without causing damage to the surroundings. No buildings or structures shall be placed within the overland flow path.

6.4 Street Capacity

Storm sewers shall be designed for a 10-year storm in such a manner that the flooded street width shall not exceed:

Street Width (ft) (BOC to BOC)	Allowable Flooded Width Each Side (ft)	Required non-flooded Lanes
27	8	1- 10' Lane
29	9	1- 10' Lane
31	10	1- 10' Lane
45	11	2- 11' Lanes
49 & wider	12	2- 12' Lanes

Section 7: Culvert Design

7.1 Limitation of Culvert Use:

Culverts with outlet control will only be allowed by approval of the City Engineer.

7.2 Culvert Capacity:

100-year flood headwater at culverts shall not overtop roadways or encroach beyond prescribed drainage easements.

7.3 Culvert Material:

1. RCP- Minimum strength Class 3 under all streets and entrance pavement and Class 5 under railroad crossings.
2. Multi-plate, PVC, and HPDE are to be approved by the City Engineer. CMP material will not be allowed in the City of Bettendorf.

7.4 Physical Requirements:

1. Minimum grade shall be one percent (1%) for inlet control.
2. Maximum length shall be two hundred feet (200') for inlet control.
3. Fencing typically required around headwalls.
4. Headwalls located to avoid steep slopes (>3:1) between headwall and top of bank.
5. The minimum culvert size will be determined by design and not less than fifteen inch (15") inside diameter.

7.5 Erosion Control at Inlet and Outlet:

Energy dissipation shall be required for velocities higher than those outlined in table- "Permissible Flow Velocity for Channels" (Tables 5.2 and 5.3)

7.6 Design Method:

The design method shall be FHWA Hydraulic Design Series No. 5, "Hydraulic Design of Highway Culverts", or other method approved by the City Engineer.

Section 8: Outlet Rip Rap Protection

Reference: Chapter 7, Section 7E-10 “Rip Rap” of the Iowa Statewide Urban Design and Specifications (SUDAS) Design Manual.

The information in this section should be considered as a general overview only of the rip rap design process. Chapter 7 of the SUDAS Design Manual provides comprehensive guidance on the design of rip rap basins and aprons and should be followed for all project submittals.

8.1 Introduction

The most common method of protecting a channel at an outlet is to place a layer of crushed stone along the bottom and sides of the channel. The purpose of the stone is to protect the channel until the outlet flow loses sufficient velocity and energy, so that erosion will not occur in the downstream channel. Rip rap is provided by constructing a blanket of crushed stone, to a specified depth at the outlet.

8.2 Sizing

1. Most crushed stone used for outlet protection is specified by weight, not by diameter. The following table lists the standard SUDAS and Iowa DOT revetment and erosion stone weights and corresponding d₅₀ diameters. These gradations are also shown on Figures 7E-10.03 and 7E-10.04 in SUDAS. Alternative gradations may be selected and specified if available from local aggregate suppliers.

Table 8.1- Standard Revetment and Erosion Stone Properties

Standard Classification	d ₅₀ Weight (lbs)	Average d ₅₀ Diameter ¹ (feet)	Maximum Weight (lbs)	Avg. Max. Diameter ¹ (feet)
Class A Revetment Stone	125 ²	1.1 ²	400	1.7
Class B Revetment Stone	275	1.5	650	2
Class D & E Revetment Stone	90	1	250	1.4
Erosion Stone	---	0.5	---	0.8

¹ Diameters based upon assumed specific gravity of 2.65

² Approximate values for design purposes. Actual d₅₀ value is not specified (d₇₅ = 75 lbs)

2. **Apron Length:**

A sufficient length of protection must be provided in order to reduce the velocity and energy of the flow to the level anticipated in the downstream channel. This length is dependent on the volume and velocity of the flow at the discharge point. It is also dependent on the tailwater condition of the downstream channel. The length, L_a , is found from Figure 7E-10.03 or 7E-10.04 (SUDAS) for the appropriate tailwater condition. From the intersection of discharge and pipe diameter, or for velocity and flow depth found in the previous step, a vertical line is projected to the appropriate discharge depth/pipe diameter in the upper set of curves. From this intersection, a horizontal line is projected to the left to determine the minimum length of rock protection required.

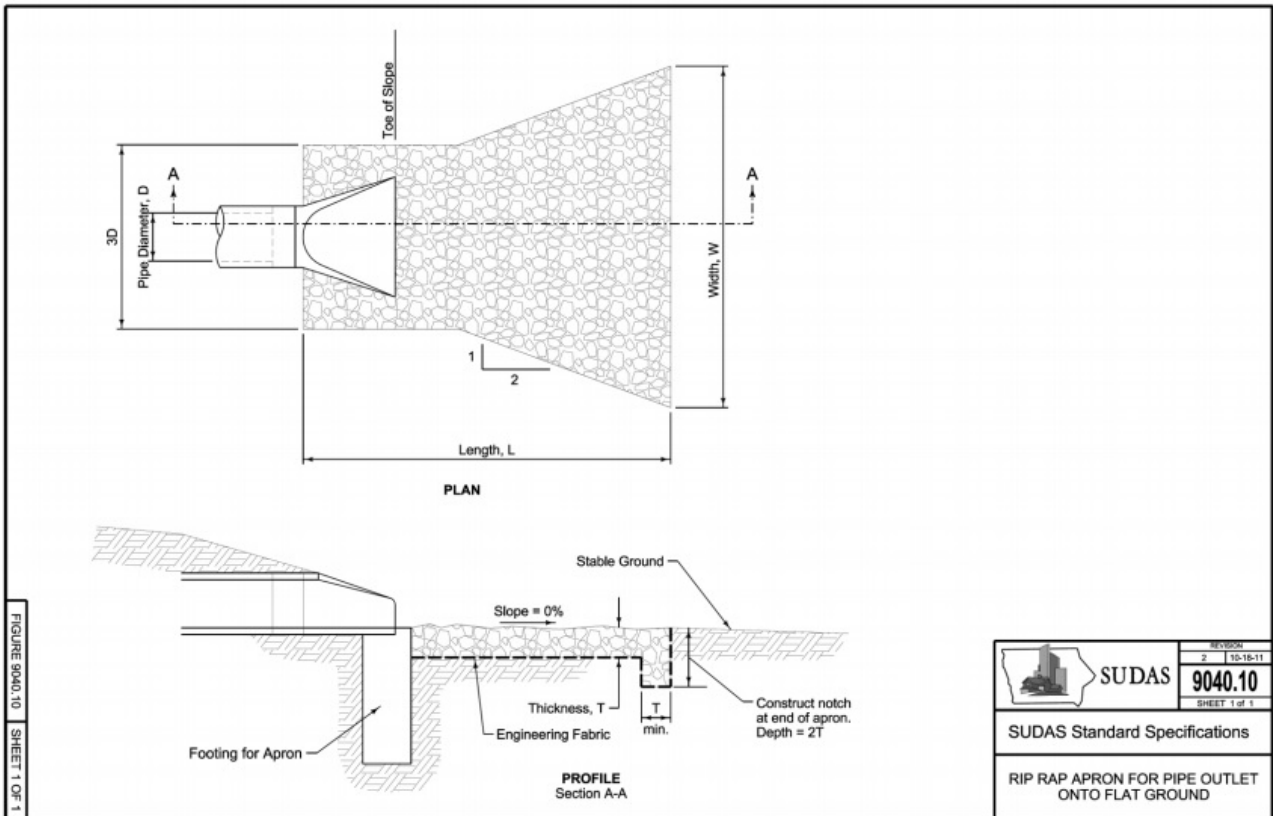
3. **Apron Width:**

For pipes that discharge into a well-defined channel, the width of the apron should extend to the top of the bank, or at least 1-foot above the maximum tailwater depth, whichever is less, along the entire length of the apron. For outlets that discharge onto flat areas, the width of the apron at the upstream end of the culvert should be three times the diameter of the pipe, or equal to the width of the concrete pipe apron if one is provided. The width of the apron at the downstream end should be equal to the length of the apron, L_a , plus the diameter of the pipe, D .

4. **Apron Depth:**

The depth of the apron should be equal to one and one-half times the maximum stone diameter (see Table 7E-10.01 (SUDAS) for maximum diameter). The channel downstream of the rock apron must be analyzed to ensure that existing or proposed channel liner is sufficient and that it will not be eroded under the anticipated flow depths. Methods for analyzing channel liners can be found in Section 7E-23.

5. Shape the revetment to generally comply with the following figure (SUDAS 9040.10)



Section 9: Subdrain System Design

9.1 Subdrain Design Criteria

1. All roadways shall be provided with a subsurface drainage system to drain roadway subgrade.
2. Down spouts from buildings or yard surface drainage are not allowed to be directly connected to the subdrain or tiled to the sump pump pit.
3. Subdrain shall be installed to the same grade as the roadway.
4. Increased flow into the storm sewer from subdrains will not be considered in the design of storm sewers.
5. Subdrains shall be located according to the City of Bettendorf Standard Drawings.

9.2 Subdrain Standards

1. Subdrain pipe shall be a minimum 4 inch diameter perforated PVC or polyethylene pipe meeting the City of Bettendorf Standard Specifications for Public Improvements.
2. Where required, a separate sump pump collection system shall be provided which includes provisions for connection of private sump hoses. A 4-inch diameter plastic pipe shall be connected and extended to 10 feet beyond the right-of-way at each property line. The property end shall be capped until the building sump hose is installed.
3. Subdrain shall have access from manholes, storm sewer intakes, open channels or cleanouts. The upstream end of subdrain extending into storm sewer intakes shall be capped to prevent conveyance of surface storm drainage through the tile system. Maximum spacing of access is 400 feet.

Section 10: Stormwater Detention Practices

Reference: Iowa Stormwater Management Manual, Section 2B-1, for further guidance.

10.1 Introduction

Standards set by the City are intended to ensure compliance with the City's Post-Construction Stormwater Management Ordinance. The sizing criteria included in this manual is an integrated approach to managing stormwater runoff quality and quantity by addressing the adverse impacts of stormwater runoff from development.

The intent is to comprehensively manage stormwater to remove pollutants and improve water quality, prevent downstream streambank and channel erosion, reduce downstream overbank flooding and safely convey and reduce runoff from extreme storm events.

10.2 Definitions

1. Excess storm runoff shall be judged in comparison to the site in its predevelopment condition and shall include all increases in stormwater resulting from any of the following:
 - A. An increase in the impervious surface of the site, including all additions of buildings, roads, parking lots and wet pond surfaces.
 - B. Changes in soil absorption caused by compaction during development.
 - C. Grade changes including the filling or draining of depression areas, alterations of drainageways or regrading of slopes.
 - D. Clearing woodlands.
 - E. Installation of storm sewer to intercept street flows or to replace existing drainageways.
 - F. Alteration of subsurface flows, including any groundwater dewatering or diversion practices such as curtain drains.
2. Pre-developed conditions are hydraulic and hydrologic site characteristics existing prior to development and shall include all the natural storage areas and drainageways plus existing farm drainage tiles and highway drainage structures. The City Engineer may require the pre-developed condition to be equal to an undeveloped condition if drainage problems are occurring downstream due to existing development at the proposed site or in the basin.
3. Developed conditions are hydraulic and hydrologic site characteristics that occur following the completion of the proposed development.
4. Post-developed peak runoff is expected to exceed pre-developed runoff from a similar storm event. Even if calculated time of concentration or curve number tables suggest lower post-developed runoff, developed sites generally have more impervious areas, compacted soils, change in soil horizon, and differing vegetation from undeveloped conditions. There may be exceptions, but careful consideration of the hydrologic method and sufficient engineering judgment are necessary to ensure calculated results meet reasonable expectations.

10.3 Limitation of Storm Runoff

1. No development shall cause downstream properties, channels or conduits to receive stormwater runoff from the proposed development site at a higher peak flow rate, or at higher velocities than would have resulted from the same storm event occurring over the site in its pre-developed condition.
2. The City shall determine if construction of storm detention facilities are required as a condition for approval of the development. Factors considered in making a determination include but are not limited to:

- A. The drainage report as outlined in Section 2.
 - B. Historical or potential drainage or flood problems adjacent to the site.
 - C. Historical or potential area wide drainage or flooding problems in the watershed.
 - D. Location of the site relative to existing drainageways and/or stormwater conveyances.
 - E. Extent of proposed site increase in impervious surface area.
3. Anticipated future development of the drainage basin.
 4. Existing site features that may facilitate or impede detention design and/or construction.
 5. City's stormwater management ordinance.
 6. City's water quality standard, as applicable.
 7. Parcels of land, of which only part will be initially developed but are contained in the same drainage area, will be evaluated for stormwater facilities, including detention, for the entire drainage area.

10.4 Stormwater Detention Requirements

If stormwater detention is required, the site owner shall construct stormwater detention facilities, designed by a professional engineer licensed in the State of Iowa, which meet the criteria of this section.

Note that detention basins with 10 acre feet or more of storage may require a permit from the Iowa Department of Natural Resources (IDNR). See Iowa Administrative Code Section 567-71.3 for permit thresholds.

1. Design Storm

The design storm is the rainfall event having a return frequency of 100 years and a 24 hour duration unless higher frequencies are required by the IDNR or City. Design storm duration is the critical duration of rainfall requiring the greatest detention volume.

2. Release Requirements

- A. For rainfall events having an expected return frequency of 5 years to 100 years inclusive and a 24 hour duration, the rate of runoff from the developed site will not exceed the existing, pre-developed peak runoff rate from the 5-year frequency storm of the same duration unless if limited by downstream conveyance.

Example #1

A ten-acre site has a peak rate of runoff from a 5-year, 24-hour storm before development of 12 cfs. Discharge from detention during the 100-year, 50-year, 25-year, 10-year and 5-year 24-hour storm events after development shall not exceed 12 cfs.

- B. The single-stage outlet (i.e. one culvert pipe) is not recommended because of its inability to detain post-developed runoff from storms less than the 5- year interval (i.e. channel protection volume storm event). In many cases, runoff from storm events less than the 5-year recurrence interval has created erosion and sedimentation problems downstream of the detention basin.
- C. A more desirable outlet has two or more stages. An orifice structure serves to detain runoff for channel protection purposes and release runoff for low-flow events less than the 5-year storm. Greater storm events are usually discharged by a separate outlet. The minimum orifice size shall be 4 inches in diameter.

- D. Release of runoff generated off-site and routed through the detention basin should not increase the combined off-site and on-site release rate.
- E. Release of stormwater runoff from the detention basins shall not damage private or public properties.

10.5 Detention Facilities Requirements

1. Basin Construction:
 - A. Side slopes shall be at least 4:1 or flatter and should have temporary and permanent erosion control stabilization.
 - B. Detention bottom cross-slopes to the main detention channel will be 2% minimum.
 - C. Subsurface drains from basin inlets to outlets may be required by the City Engineer.
 - D. The embankment top shall be at least 6 ft. wide. Smaller widths may be approved by the City Engineer but shall not be less than 3 feet.
 - E. Freeboard shall be minimum of 1 ft. above the 100-year water surface elevation.
 - F. The embankment shall be protected from catastrophic failure due to overtopping following IDNR requirements where applicable. Overtopping can occur when the pond outlet becomes obstructed or when a larger than 100-year storm occurs. Failure protection for the embankment may be provided in the form of a buried, heavy rip rap layer on the entire downstream face of the embankment or a separate emergency spillway having a minimum capacity of the developed inflow rate for the 100-year storm from contributing on-site and off-site areas. The spillway is also needed to control the release point of the overflows. Structures shall not be permitted in the path of the emergency spillway or overflow. The invert of the emergency spillway should be set equal to or above the 100- year water surface elevation.
 - G. The outlet structure shall be protected by a debris rack. Debris will block most outlet structures at some point, and a well-designed debris rack can help ensure the outlet functions even under a heavy trash load. Debris racks vary in design and include for example, welded wire and hinged metal plates over low-flow orifices, a hinged gate over an outfall culvert, or rack placed over a standpipe. On larger structures, debris racks are locked to prevent children and animals from entering the structure.
2. Parking Lot Storage:
 - A. Paved parking lots may be designed to provide stormwater detention on a portion of their surfaces not to exceed fifty percent (50%) of the parking lot area.
 - B. Outlets shall be designed to drain slowly and storage depth must be limited to nine inches (9") to minimize damage to parked vehicles. The minimum pipe size for the outlet is 12" diameter where a drop inlet is used to discharge to a storm sewer or drainageway. Where a weir and a small diameter outlet through a curb are used, the size and shape are dependent on the discharge/storage requirements. A minimum pipe size of 4" diameter is recommended.
 - C. Maintenance access shall be provided. The potential for pavement overlays shall be considered in the calculated detention.
3. Multipurpose Basins
 - A. Dry bottom basins may be designed to serve secondary purposes for recreation, open space or other use which will not be adversely affected by intermittent flooding.
 - B. Retention basins with potential to improve water quality may be approved by the City Engineer.
4. Underground Storage

- A. Detention systems utilizing chambers and aggregate storage, vaults or other underground methods may be approved by the City Engineer.
- 5. Acceptance of Storm Detention:
 - A. The City shall not guarantee the accuracy of certified engineering calculations and improvement plans, or the performance of the constructed facilities. Acceptance of stormwater detention plans and issuance of any permit should not be interpreted as alleviating the Project Engineer of responsibility for the accuracy and performance of the design and plans.

10.6 Discouraged Design Practices

1. **Passive detention systems.**

These systems direct captured runoff through a storm sewer network to the outlet from the site. At that point, a restriction is placed, such as an orifice plate, which causes water to surcharge and back up out of an intake into a surface depression for temporary storage during large storm events. This design method allows runoff from smaller storm events to leave the site directly, without the opportunity to remove suspended pollutants and debris.

2. **Low flow flumes and directly connected impervious areas.**

These systems prevent infiltration of storm water runoff and reduce or eliminate the possibility of providing water quality treatment or small storm management. Virtually any storm event will direct surface runoff from paved areas to the receiving storm sewer system or stream.

3. **Flow path shortcutting.**

When runoff enters a basin or treatment practices at nearly the same point where it outlets from the practice, the opportunity for absorption, infiltration or treatment of storm water runoff is severely reduced. For this reason, it is recommended that storm water runoff enter a basin or other treatment practice as far from the outlet as possible. Pipe outlets, flumes or other points of concentrated stormwater flows should enter a treatment practice or basin at a distance from the outlet of no less than twice the width of the practice (a pipe entering a 15' wide bioretention cell should be located no closer than 30' from the point where water would leave the treatment area).

10.7 Water Quality Volume and Channel Protection Design Standard

All stormwater detention facilities shall address the following in addition to the extreme flood (100 year, 24 hour event) protection:

- 1. **Capture and treat the Water Quality Volume [WQv]**, or the runoff that is expected to be generated from a given site after development from a 1.25" rainfall event. Approximately 90% of the rainfall which falls in Eastern Iowa is from storm events which are less than this amount. Using BMPs to properly manage runoff from these events could potentially eliminate direct surface runoff from a given site during most rainfall events, effectively managing many of the "first flush" pollutants of concern on-site. Treatment shall provide 80 percent reduction in the total suspended solids (TSS) of the runoff.
- 2. **Provide extended detention of the 1-year, 24-hour storm event or Channel Protection Volume [CPv]** (with a drawdown time of 24 to 48 hours) to reduce rapid fluctuations of flows in urban stream corridors that lead to erosive velocities and unstable stream conditions. In Bettendorf, the rainfall depth for such an event is 2.60 inches. Practices which address this criteria will capture this volume of runoff and slowly release it over a period of no less than 24 hours.

10.8 Description of Water Quality Practices

- 1. This section describes typical water quality practices and provides general guidelines for their use.
 - A. **Infiltration trench/French drain** – A rock-filled trench with no outlet that receives storm water runoff. Storm water runoff passes through some combination of pretreatment measures, such as a swale into the trench. Runoff is stored in the void space between the aggregate and infiltrates into the surrounding soil. The desired infiltration time is 24 hours. The primary pollutant removal mechanism of this practice is filtering through the soil. Infiltration trenches have select

applications due to concerns such as potential ground water contamination, soils, and clogging. Infiltration trenches generally can be applied to relatively small sites less than 5 acres, with relatively high impervious cover. Application to larger sites generally causes clogging, resulting in high maintenance. A French drain is a rock-filled trench with subdrain for overflow.

- B. **Dry well** – A subsurface storage facility that receives and temporarily stores roof runoff. This runoff is discharged through infiltration to the surrounding soil. A dry well may be either a structure and/or excavated pit filled with aggregate. A dry well is not considered for pollutant removal due to relatively low level of expectant pollutants in roof runoff. Runoff should drain within 72 hours. The maximum drainage area to a dry well is 1 acre and dry wells should be applied to relatively small sites.
- C. **Porous pavement** – A permeable pavement surface with an underlying stone reservoir to temporarily store surface runoff before it infiltrates into the subsoil. This porous surface replaces traditional pavement, allowing parking lot storm water to infiltrate directly and receive water quality treatment. Porous pavement options include porous asphalt, and pervious concrete. Porous asphalt and pervious concrete appear to be the same as traditional pavement from the surface, but are manufactured without "fine" materials, and incorporate void spaces to allow infiltration. The ideal application for porous pavement is for low-traffic or overflow parking areas. The base of the stone reservoir should be below the frost line to reduce the risk of frost heave. Porous pavement cannot be used where sand is applied because sand will clog the surface of the material. Care must also be taken when applying salt to a porous pavement surface as chlorides from road salt may migrate into the ground water.
- D. **Vegetated filter strip** – Treats sheet flow from adjacent surfaces. Filter strips function by slowing runoff velocities and filtering out sediment and other pollutants, and by providing some infiltration into underlying soils. With proper design and maintenance, filter strips can provide relatively high pollutant removal. However, it is difficult to maintain sheet flow, so the practice may be "short circuited" by concentrated flows, receiving little or no treatment. In some situations filter strips may consume a large amount of space relative to other practices. Filter strips are best suited to treating runoff from streets, roof downspouts, small parking lots, and pervious surfaces. Typically, filter strips are used to treat very small drainage areas. The limiting design factor, however, is not the drainage area but the length of flow leading to it. As storm water runoff flows over the ground's surface, it changes from sheet flow to concentrated flow. When flow concentrates, it moves too rapidly to be effectively treated by a grassed filter strip. As a rule, flow concentrates within a maximum of 75 feet for impervious surfaces, and 150 feet for pervious surfaces. Using this rule, a filter strip can treat one acre of impervious surface per 580-foot length.
- E. **Vegetated swale** – Vegetated, open channel management practices designed specifically to treat and attenuate storm water runoff. As storm water runoff flows through these channels, it is treated through filtering by the vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils. Variations of the grassed swale include the grassed channel, dry swale, and wet swale. The specific design features and methods of treatment differ in each of these designs, but all are improvements on the traditional drainage ditch. Swales are well suited for treating street runoff. Vegetated swales should generally treat small drainage areas of less than 5 acres. If the practices are used to treat larger areas, the flows and volumes through the swale become too large to design the practice to treat storm water runoff through infiltration and filtering.
- F. **Bioretention** – Landscaping features adapted to provide on-site storm water treatment. They are commonly located in parking lot islands or within small pockets of residential land. Surface runoff is directed into shallow, landscaped depressions. These depressions are designed to incorporate many of the pollutant removal mechanisms that operate in forested ecosystems. During storms, runoff ponds above the mulch and soil in the system. Runoff from larger storms is generally diverted past the facility to the storm sewer system. The remaining runoff filters through the mulch and prepared soil mix. Typically, the filtered runoff is collected in a perforated subdrain and returned to the storm sewer system. Bioretention should be used on small sites of 5 acres or less.

When used to treat larger areas, they tend to clog. In addition, it is difficult to convey flow from a large area to a bioretention area.

- G. **Wet pond (a.k.a. storm water pond, retention pond, wet extended detention pond) -** Constructed basins that have a permanent pool of water. Ponds treat incoming storm water runoff by settling and algal uptake. The primary removal mechanism is settling as storm water runoff resides in this pool, and pollutant uptake, particularly of nutrients, also occurs through biological activity in the pond. Wet ponds are among the most cost-effective and widely used storm water practices. While there are several different versions of the wet pond design, the most common modification is the extended detention wet pond, where storage is provided above the permanent pool in order to detain storm water runoff to provide settling. Wet ponds need sufficient drainage area to maintain the permanent pool, typically about 25 acres.

- H. **Level Spreader** – An outlet constructed at zero grade consisting of a vegetated or rock-surfaced structure, used to disperse or “spread” concentrated flow thinly over a receiving area. The purpose is to spread runoff over a wide area to prevent erosion of the receiving area. Additional benefits of infiltration and filtration may also occur. This practice applies where concentrated flow is dispersed within wooded areas adjacent to bodies of water and in areas requiring a filter strip to treat water. Its use should also be limited to drainage areas less than ten acres and where receiving areas have relatively flat slopes of four percent or less; 1 to 2 percent slope is recommended.

- I. **Soil amendment** – Material added to a soil to improve its physical properties, such as water retention, permeability, infiltration, drainage, aeration and structure. Soil amendments increase the spacing between soil particles so that the soil can absorb and hold more moisture. This in turn reduces runoff. The amendment of soils changes physical, chemical and biological characteristics so the soils become more effective in maintaining water quality. Compared to compacted, un-amended soils, amended soils provide greater infiltration and subsurface storage and thereby help to reduce a site's overall runoff volume, helping to maintain the predevelopment peak discharge rate and timing. The volume of runoff that needs to be controlled to replicate natural watershed conditions changes with each site based on the development's impact on the site's curve number (CN). Organic amendments include peat, grass clippings, straw, compost and manure.

Section 11: Channel and Storage (Reservoir) Routing

11.1 Introduction

Given the variety of available software packages capable of performing calculations consistent with the routing methods described within this section, it is assumed that designers will rarely use techniques to manually perform these calculations as described within this section. The designer should be familiar with the basis of such calculations, and the following information should be clearly indicated in storm water drainage reports:

11.2 Channel Routing:

1. Clearly identify the **channel length, slope** (along channel length) **and Manning roughness coefficient** (n) used for design. Document surface conditions considered for selection of “n” and identify length and elevation used for slope calculation on drainage map.
2. Provide a **sketch showing the assumed cross-section of the channel** (triangular, rectangular, trapezoidal, etc.) with bottom width and side slopes clearly labeled.

11.3 Reservoir Routing:

For detention design analysis, a stage-storage hydrograph routing is required for the 1-, 5-, 10-, and 100-year events to verify that after development, a given site does not violate peak release rate restriction requirements for these storms.

**Additional routing of the WQv event may be required if selected practices intended to meet the Water Quality Volume requirements for a given area have inadequate capacity to capture and infiltrate the required volume and therefore use extended detention (slow release through a surface inlet) to allow settling of suspended pollutants and treatment to occur.*

1. **Inflow hydrograph** (numeric or graphic) through the duration of the storm event. Maximum time steps of 0.1 hour or 6-minutes (2-minutes preferred).
2. **Stage-storage volume relationship** of the reservoir area. No less than one foot intervals.
3. **Stage-discharge relationship of basin outlet**. Calculations should identify all stages of outflow design (riser pipe, orifice, weir, discharge pipe, etc.) and include characteristics of each (elevation, size, etc.) that match plan dimensions. Calculations should include either detailed calculations of flow through each outlet stage, or graphical representation of stage-discharge relationship from calculation output from used software package.
4. **Energy loss coefficients** for weir and orifice conditions.
5. **Target peak discharge allowed** from the reservoir (for each event to be considered).
6. **Outflow hydrograph** from routing output identifying flow rate (in cfs) versus time, the peak flow rate, time of occurrence in relation to the rainfall event. For analyses involving the design events identified in this report provide a numeric or graphic representation of the entire outlet hydrograph through the duration of the storm event.
7. **A graph of storage volume or elevation versus time** for the key design events. Review drawdown for extended detention of small storms. (minimum 24-hour drawdown after storm event)
8. **Identify maximum storage volume and water surface elevation for each event reviewed.**

Section 12: Inlet Sediment Forebays

12.1 Introduction

Sediment forebays are essential to long-term maintenance and performance of proposed stormwater management BMPs. A forebay is an area near a concentrated point of discharge to a certain BMP, where stormwater flows can be slowed to an extent where heavier sediments and debris can be captured before they enter the BMP itself.

These should be located in areas where they can be accessed for maintenance and sediment (and debris) removal. This helps reduce the amount of heavy pollutants that enter a proposed treatment practice (pollutants that could clog or otherwise negatively affect the performance or appearance of those practices).

12.2 Key design considerations:

1. Sediment forebays should be sized for 0.10 – 0.25 inches of runoff per impervious acre within the watershed upstream of the forebay. A typical sizing criterion is 10% of the WQv to be treated.
2. Forebays are often separated from the BMP they protect by a physical barrier of some type (berm, spillway, gabion or revetment stone wall, etc.) that forces water entering the BMP to pool temporarily near the entrance to the facility, reducing velocities and allowing suspended materials to settle out.
3. Forebays should be located where they can be directly accessed for maintenance. Provide clear paths from adjacent streets to the facility that can accommodate expected maintenance equipment (trucks, small excavators, etc.). In some cases this may require a hard surface access path.
4. A hardened bottom surface should be considered to help avoid over-excavation during cleanout operations.
5. Plan for sediment cleanout at least every 3-5 years (for stabilized watershed), or when 6-12 inches of sediment has accumulated, whichever is first.

Appendix A: Drainage Report Format

1. Executive Summary

Summarize report results with a narrative and tabular data. Provide tabular data for peak discharge, detention pond characteristics, and release rates according to the format below:

Table 1: Runoff Summary

Runoff Recurrence Interval	Onsite		Contributing Offsite	
	Pre-Developed Peak Discharge (cfs)	Post-Developed Peak Discharge (cfs)	Existing Discharge (cfs)	Developed Discharge (cfs)
1 yr				
5 yr				
10 yr				
25 yr				
50 yr				
100 yr				

Table 2: Detention Basin Characteristics

Stage (ft)	Storage (acre-feet)	Inflow (cfs)	Outflow (cfs)
Max. (1 foot Intervals)			

Table 3: Allowable Release Rate

Allowable Release Rate (cfs)		On Site Pre-Developed Peak Discharge Rate - 5 yr		Contributing Off Site Pre-Developed Peak Discharge Rate - 100 yr ⁽¹⁾		Onsite Post-Development By-Pass Peak Discharge Rate - 100 yr
	=		+		-	

Table 4: Overflow Release Rate

Overflow Release Rate (cfs)		On Site Post-Developed Peak Discharge Rate - 100 yr		Contributing Off Site Post-Developed Peak Discharge - 100 yr ⁽²⁾
	=		+	

- (1) From offsite areas that are routed through the basin.
- (2) This value is the larger of either the existing peak discharge or developed peak discharge.
- (3) Post-developed peak discharge may be reduced with water quality best-management practices. Any proposed reduction must be adequately justified in the drainage report with narrative and calculations.

2. Site Characteristics

A. Pre-Developed Conditions

Describe pre-developed land use, topography, drainage patterns including overland conveyance of the 100-year storm event, natural and man-made features. Describe ground coverage, soil type, and physical properties, such as hydrologic soil group and infiltration. If a geotechnical study of the site is available, provide boring logs and locations in the appendix of the Drainage Report. If a soil survey was used, cite it in Section VIII, References.

B. Post-Development Conditions

Describe post-developed land use and proposed grading, change in percent of impervious area, and change in drainage patterns. Note if an existing drainage way is filled, the runoff otherwise stored by the drainage way shall be mitigated with storm water detention, in addition to the post-development runoff.

C. Contributing Off-Site Drainage

Describe contributing off-site drainage patterns, land use, and storm water conveyance. Identify undeveloped contributing areas with development potential and list assumptions about future development runoff contributed to the site.

D. Identify areas of the site located within the floodway or floodplain boundaries as delineated on Flood Insurance Rate Maps, or as determined by other engineering analysis. Identify wetland areas on the site, as delineated by the National Wetlands Inventory, or as determined by a specific wetland study.

3. Pre-Development Runoff Analysis

A. Watershed Area

Describe overall watershed area and relationship between other watersheds or sub-areas. Include a pre-development watershed map in the report appendix.

B. Time of Concentration

Describe method used to calculate the time of concentration. Describe runoff paths and travel times through sub-areas. Show and label the runoff paths on the pre-development watershed map.

C. Precipitation Model

Describe the precipitation model and rainfall duration used for the design storm. Typical models may include one or more of the following:

1. NRCS MSE3 Rainfall Distribution
2. Rainfall Intensity Duration Frequency (IDF) Curve.
3. User-defined model based on collected precipitation data, subject to City Engineer's approval. Total rainfall amounts for given frequency and duration shall be obtained from NOAA Atlas 14 as shown in Section 3.

D. Rainfall Loss Method

List runoff coefficients or curve numbers applied to the drainage area.

E. Runoff Model

Describe method used to project runoff and peak discharge. Typical models are as follows:

- 1) Rational Method – for drainage areas up to 20 acres. Often used in storm sewer design.
- 2) For drainage areas larger than 20 acres and flow routing is required, use one of the following methods:
 - a. TR-20 Model
 - b. TR-55 Tabular Hydrograph Method
 - c. Routines contained in HEC-1 or HEC-HMS computer models
 - d. Regression Equations and other hydrologic models approved by the City.

F. Summary of Pre-Development Runoff

Provide table(s) including drainage area, time of concentration, frequency, duration, and peak discharge.

4. Post-Development Runoff Analysis

A. Watershed Area

Describe overall watershed area and sub-areas. Discuss if the post-development drainage area differs from the pre-development drainage area. Include a post-development watershed map in the report appendix.

B. Time of Concentration

The method used will be the same as used in the pre-development analysis. Describe change in times of concentration due to development (i.e. change in drainage patterns). Show and label the runoff paths on the post-development watershed map.

C. Precipitation Model

Storm event, total rainfall, and total storm duration will be the same as used for the pre-development model. If IDF curves are used, describe the change in design rainfall intensity.

D. Rainfall Loss Method

Method will be the same as pre-development analysis. Describe the change in rainfall loss due to development.

E. Runoff Model

The runoff method will be the same as used in the pre-development analysis, except for variables changed to account for the developed conditions.

F. Summary of Post-Development Runoff

- 1) Provide table(s) including drainage area, time of concentration, frequency, duration, and peak discharge. Summarize in narrative form the change in hydrologic conditions due to the development. Provide a runoff summary table in Section I, Executive Summary.
- 2) Post-developed discharge should take into account any upstream offsite detention basins and undeveloped offsite areas assumed to be developed in the future with storm water detention.
- 3) Calculate the allowable release rate from the site. This equals the onsite 5-year pre-developed peak discharge plus the contributing offsite 100-year pre-developed peak discharge minus the onsite 100 year post-development by-pass peak discharge. Include this calculation in Section I, Executive Summary.

5. Stormwater Detention Design

A. All stormwater detention facilities shall be designed according to the City of Bettendorf Design Standards Manual at a minimum. The following references may provide helpful design information for stormwater detention and water quality issues:

- 1) Federal Highway Administration (1996) Urban Drainage Design Manual. Hydraulic Engineering Circular No. 22, Washington D.C.
- 2) American Society of Civil Engineers (1985) Final report of the Task Committee on Stormwater Detention Outlet Control Structures. Am. Soc. Civ. Eng., New York, N.Y.
- 3) American Society of Civil Engineers (1992) Design and Construction of Urban Stormwater Management Systems. Manual of Practice No.77, New York, N.Y.
- 4) American Society of Civil Engineers (1998) Urban Runoff Quality Management. Manual of Practice No. 87, New York, N.Y.
- 5) Stahre, P and Urbonas, B (1990) Stormwater Detention for Drainage, Water Quality, and CSO Management. Prentice-Hall, Englewood Cliffs, N.J.

- 6) American Public Works Association (1991) Water Quality Runoff Solutions. Special Report No. 61, Chicago, IL.

B. Detention Basin Location

Describe basin site. Discuss existing topography and relationship to basin grading. Determine if construction will be affected by rock deposits. Also determine if a high water table precludes basin storage. Floodplain locations should be avoided.

C. Detention Basin Performance

- 1) For rainfall events having an expected return frequency of 5 years to 100 years inclusive, the rate of runoff from the developed site will not exceed the existing, pre-developed peak runoff from the 5-year frequency storm of the same duration unless if limited by downstream conveyance. Provide a table summarizing these release rates. Also provide a stage-storage discharge table. These tables are also to be shown in Section I, Executive Summary. State the minimum freeboard provided, and at what recurrence interval the basin overtops.
- 2) Discuss the effects on the overall storm water system by detention basins in contributing offsite areas. If contributing offsite areas are presently undeveloped, discuss assumptions about future development and storm water detention.
- 3) Calculate the basin overflow release rate. This equals the onsite 100-year post-developed peak discharge plus the contributing offsite 100-year post developed peak discharge. Include this calculation in Section I, Executive Summary.

D. Detention Basin Outlet

- 1) The single-stage outlet (i.e. one culvert pipe) is not recommended because of its inability to detain post-developed runoff from storms less than the 5- year interval (i.e. channel protection volume storm event). In many cases, runoff from storm events less than the 5-year recurrence interval has created erosion and sedimentation problems downstream of the detention basin.
- 2) A more desirable outlet has two or more stages. An orifice structure serves to detain runoff for channel protection purposes and release runoff for low-flow events less than the 5-year storm. Greater storm events are usually discharged by a separate outlet. The minimum orifice size shall be four inches (4") in diameter.
- 3) Discuss the basin outlet design in terms of performance during low- and high-flows, downstream impact (discuss in Section V), and improvement of water quality (discuss in Section VI. G).
- 4) State whether the detention basin volume is controlled by the required flood control volume or the water quality volume.

E. Spillway and Embankment Protection

- 1) Design the spillway for high flows using weir and/or spillway design methods. The steady-state open channel flow equation is not intended for use in spillway design.
- 2) Describe methods to protect the basin during overtopping flow.

F. Note the TR-55 method of sizing detention basins may result in storage errors of 25%, and shall not be used in final design unless approved by the City Engineer. The detention basin size in final design shall be based upon actual hydrograph routing.

6. Stormwater Conveyance Design

A. All stormwater conveyances shall be designed according to the City of Bettendorf Design Standards Manual at a minimum. The following references may be used for supplemental design information:

- 1) Federal Highway Administration (1996) Urban Drainage Design Manual. Hydraulic Engineering Circular No. 22, Washington D.C.

- 2) Federal Highway Administration (1988) Design of Roadside Channels with Flexible Linings. Hydraulic Engineering Circular No. 15, Washington D.C.
- 3) Federal Highway Administration (1985) Hydraulic Design of Highway Culverts. Hydrologic Design Series Number 5, Washington D.C.
- 4) US Geological Survey (1968) Measurement of Peak Discharge at Culverts by Indirect Methods. Book 3, Applications of Hydraulics, Washington D.C.
- 5) American Society of Civil Engineers (1986) Design and Construction of Sanitary and Storm Sewers. Manual of Practice No. 37, New York, N.Y.

B. Storm Sewer

- 1) List design criteria, including storm event and runoff model. Describe the hydraulic grade line and whether pressure flow or surcharging is possible. Provide a graphic of the hydraulic grade line.
- 2) List design criteria for intake size and spacing. Describe the anticipated gutter flow and spread at intakes.
- 3) List any special considerations for sub-drainage design, such as high water tables.
- 4) Provide tables of storm sewer and intake design data.

C. Culverts

- 1) Describe culvert capacity, inlet or outlet control conditions, estimated tailwater and headwater. Determine if 100-year or lesser storm event will flood roadway over culvert.
- 2) Sketch a contour of the 100-year headwater elevation on a topographic map and/or grading plan. This delineated 100-year flood elevation is used to determine drainage easement and site grading requirements.

D. Open Channel Flow – Swales and Ditches

- 1) Describe swale and ditch design. State the assumed Manning's roughness coefficients. State the anticipated flow velocity, and whether it exceeds the permissible velocity based on soil types and/or ground coverage. If the permissible velocity is exceeded, describe channel lining or energy dissipation.
- 2) Discuss design calculations. Depending on the complexity of the design, these may range from a single steady-state equation (i.e. Manning's) to a step calculation including several channel cross-sections, culverts and bridges.
- 3) Discuss the overall grading plan in terms of controlling runoff along lot lines and preventing runoff from adversely flowing onto adjacent lots.

E. Storm Drainage Outlets and Downstream Analysis

- 1) Discuss soil types, permissible and calculated velocity at outlets, energy dissipator design, and drainage impacts on downstream lands. Provide calculations for the energy dissipator dimensions, size, and thickness of riprap revetment (or other material) and filter layer.
- 2) Include a plan and cross-sections of the drainage way downstream of the outlet, indicating the flow line slope and bank side-slopes. Identify soil types on the plan.
- 3) Downstream Analysis The downstream analysis will show what impacts, if any, a project will have on the drainage systems downstream of the project site. The analysis consists of three elements: review of resources, inspection of the affected area, and analysis of downstream effects.
 - a. During the review of resources, review any existing data concerning drainage of the project area. This data will commonly include area maps, floodplain maps, wetland inventories, stream surveys, habitat surveys, engineering reports concerning the entire drainage basin, known drainage problems, and previously completed downstream analyses.

- b. Physically inspect the drainage system at the project site and downstream of it. During the inspection, investigate any problems or areas of concern that were noted during the review of resources. Identify any existing or potential capacity problems in the drainage system, flood-prone areas, areas of channel destruction, erosion and sediment problems, or areas of significant destruction of natural habitat.
- c. Analyze the information gathered during the review of resources and field inspection, to determine if the project will create any drainage problems downstream or will make any existing problems worse. Note there are situations that even when minimum design standards are met the project will still have negative downstream impacts. Whenever this situation occurs, mitigation measures must be included in the project to correct for the impacts.

F. Hydraulic Model

If the design warrants hydraulic modeling, state the method used. Typical modeling programs include:

- 1) HEC-RAS - River Analysis Systems
- 2) HEC-2 - Water Surface Profiles
- 3) SWMM - Storm Water Management Model
- 4) WSPRO - Water Surface Profiles
- 5) HY-8 – Hydraulic Design of Highway Culverts
- 6) Other commercial or public domain programs approved by the City.

7. Permits

Indicate what permits have been applied for and received. Submit IDNR approval letter and report for sites affecting unnumbered A-zones, as delineated on Flood Insurance Rate Maps.

8. References

Provide a list of all references cited

9. Appendix

A. Provide the following exhibits and calculations in the Appendix:

- 1) Exhibits
 - a. Pre- and post-developed drainage area maps, including all contributing areas, both on-site and off-site. Also label flow patterns used to determine times of concentration.
 - b. Soils map or geotechnical information.
 - c. Drainage schematics - Indicate flow routings through drainage areas and detention basins.
 - d. IDF Curves
 - e. List rainfall totals and distributions in tabular format
 - f. Delineated 100-year flood elevation as warranted by culvert or bridge analysis, or special drainage considerations (i.e. existing roadway with history of flooding).
 - g. Grading plan
 - h. Map showing extents of downstream analysis.
 - i. Wetlands report as applicable.
- 2) Calculations
 - a. Determine runoff coefficients and curve numbers

- b. Determine times of concentration
 - c. Calculations for intake capacity, sewer design, and culvert design
 - d. Peak discharge calculations – Show results in tabular format and pre- and post-developed hydrographs
 - e. Detention basin design – Show tabular stage-storage-discharge results and inflow/outflow hydrographs
 - f. Detention basin outlet design
 - g. Open channel flow calculations
 - h. Erosion protection design
- 3) Computer Calculations
Attach computer-generated reports and output if software was used. Underline and label results, such as the peak discharge.