CITY OF Vermillion SOUTH DAKOTA

STORM DRAINAGE DESIGN CRITERIA

APRIL 2015

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APPENDIX

IMPERVIOUS SURFACE MITIGATION

Volume mitigation will be required for multifamily, commercial and industrial developments meeting the criteria on Table 1. Additionally, large scale single family developments (more than four houses or townhome structures) that meet the criteria will also be required to provide volume mitigation. The developer shall use the minor storm event to determine the volume of runoff that will need to be mitigated using Best Management Practices (BMPs) such as rain gardens, infiltration swales, discharge of runoff onto pervious surfaces. Depending on the size of the development, and the amount of impervious material, the developer may be required to construct a detention pond rather than a smaller BMP to mitigate the storm runoff. Any construction that started on April 6th, 2015, or after, will have to meet the drainage requirements for new developments when any additional impervious areas are constructed. This will include, but is not limited to, construction of new phases, additions to buildings, extension to parking lots (gravel or hard surface), etc...

Table 1

	IMPERVIOUSNESS	DEVELOPMENT AREA	MITIGATION REQUIREMENT
NEW DEVELOPMENT (BARE GROUND)	greater than 50% of area	less than 1-acre	Grass buffer, grass swale, porous landscape detention
NEW DEVELOPMENT (BARE GROUND)	greater than 50% of area	1-acre or more	detention pond
NEW DEVELOPMENT (BARE GROUND)	50% or less of area	any amount	nothing is required
REDEVELOPMENT	greater than 75% of area	less than 1-acre	Grass buffer, grass swale, porous landscape detention
REDEVELOMENT	greater than 75% of area	1-acre or more	detention pond
REDEVELOPMENT	75% or less of area	any amount	nothing is required

DESIGN REQUIREMENTS

The preferred methods of design will be the rational method (Q = CIA), or the NRCS design methodology. These methods are preferred since final computations will be checked using the HydroCAD model which is consistent with both these methods. The City of Yankton's Intensity-Duration-Frequency (IDF) curve will be used for all storm sewer or minor drainage computations. The IDF curve can be found in South Dakota Drainage Manual, October 2011, Chapter 7, Figure 7.13-S. The storm event shall be based on Table 2. The IDF curve based on Yankton, SD is consistent with computation that can be done using Soil Conservation Service (SCS) (now National Resources Conservation Service or NRCS) methods.

Table 2

MAJOR WATERSHED	MINOR STORM	MAJOR STORM	DETENTION REQUIREMENT
Highway 50 Watershed	5-year developed	100-year developed	Capture the major and release the minor
West Cherry Watershed	5-year developed	100-year developed	Capture the major and release the minor
12th Street Watershed	2-year developed	25-year developed	Capture the major and release the minor
West Vermillion Watershed	5-year developed	100-year developed	Capture the major and release the minor
Dakota Watershed	2-year developed	25-year developed	Capture the major and release the minor
University Street Watershed	2-year developed	25-year developed	Capture the major and release the minor

Table 2 *continued*

MAJOR WATERSHED	MINOR STORM	MAJOR STORM	DETENTION REQUIREMENT
East Burbank Watershed	2-year developed	25-year developed	Capture the major and release the minor
USD Watershed	2-year developed	25-year developed	Capture the major and release the minor
New Areas Not Identified	5-year developed	100-year developed	Capture the major and release the minor

The NRCS runoff curve numbers to be used in the design shall be according to Table 3.

Table 3

LAND USE	CURVE NUMBER (SOIL GROUP B – FOR USE ABOVE THE BLUFF)	CURVE NUMBER (SOIL GROUP D – FOR USE BELOW THE BLUFF)
Open space (parks, golf course, cemetery, etc…)	61	80
Commercial (Avg. of 85% impervious)	92	95
Industrial (Avg. of 72% impervious)	88	93
Townhouses and multifamily (Avg. of 65% impervious)	85	92
Single Family Residential (Avg. of 30% impervious)	72	86
Agricultural (row crop with crop residue)	75	85

The Time of Concentration shall be calculated using the following methods:

When calculating the Time of Concentration, the longest route possible shall be used. If when calculating the Time of Concentration, and the length is more than 150-feet, then first use the Sheet Flow Procedure and secondly the Shallow Concentrated Flow. Only one Sheet Flow Procedure may be used per route, while multiple Shallow Concentrated Flows may be required.

- Sheet Flow Procedure shall be used at the headwaters of the drainage area and strictly on a plane surface. The following parameters shall be used:
  - Manning's coefficient for sheet flow:
    - For any paved surface, n = 0.011
    - For any agricultural land, n = 0.17
    - For any grassed areas, n = 0.24
    - For any wooded areas, n = 0.80
    - Flow length (L) shall not exceed 150-feet
    - The 2-year, 24-hour rainfall shall be 2.7-inches
- Shallow Concentrated Flow shall be used anywhere where the flow is not sheet flowing, or on any lengths larger than 150-feet. The following parameters shall be used:
  - Velocity factor:
    - For any paved surface, 20.33 ft/sec

- For any gravel surface, 16.13 ft/sec
- For any grassed swale, 15.0 ft/sec
- For any agricultural use, 9.0 ft/sec
- For any wooded area, 2.5 ft/sec

At no point shall the Time of Concentration be any less than 10-minutes.

All pipes shall be designed according to Table 4.

Table 4

MAJOR WATERSHED	DESIGN EVENT	MIN. PIPE SIZE	MIN. SLOPE
Highway 50 Watershed	5-year developed	18-inches	0.4%
West Cherry Watershed	5-year developed	18-inches	0.4%
12th Street Watershed	2-year developed	12-inches	0.4%
West Vermillion Watershed	5-year developed	18-inches	0.4%
Dakota Watershed	2-year developed	12-inches	0.4%
University Street Watershed	2-year developed	12-inches	0.4%
East Burbank Watershed	2-year developed	12-inches	0.4%
USD Watershed	2-year developed	12-inches	0.4%
New Areas Not Identified	5-year developed	18-inches	0.4%

COMPUTATION GUIDELINES

Table 5 can be used to determine C values based on NRCS land uses. If the values that are used are not consistent with those of Table 5, the source or reason for not using the City Standard values shall be documented.

Table 5

LAND USE	2-YEAR VALUE (SOIL GROUP B)	2-YEAR VALUE (SOIL GROUP D)	5-YEAR VALUE (SOIL GROUP B)	5-YEAR VALUE (SOIL GROUP D)
Open space (parks, golf course, cemetery, etc…)	0.20	0.30	0.20	0.35
Commercial (Avg. of 85% impervious)	0.60	0.70	0.65	0.70
Industrial (Avg. of 72% impervious)	0.55	0.65	0.60	0.65
Townhouses and multifamily (Avg. of 65% impervious)	0.50	0.60	0.50	0.60
Single Family Residential (Avg. of 30% impervious)	0.30	0.45	0.35	0.45
Agricultural (row crop with crop residue)	0.25	0.35	0.30	0.35

BEST MANAGEMENT PRACTICES

A best management practices, or BMPs, are control measures used to mitigate storm water pollution. Storm water pollution has two main components that are mainly found in urban developments, these are: increase storm water runoff and increase in pollutants in the runoff.

In order to mitigate the amount of runoff reaching our storm sewer system the City will be requiring certain developments to construct BMPs. The BMPs used will depend on the size of the development and on the amount of impervious area (see Impervious Surface Mitigation section).

BEST MANAGEMENT PRACTICE: GRASS BUFFER

Grass buffers are an important part of the storm drainage system as they allow for pollutants to settle on the grass rather than enter the storm sewer system. Additionally, grass buffers allow for some storm water to infiltrate the soil and thus reducing the runoff reaching the storm sewer system.

This type of BMP is typically constructed adjacent to impervious areas. The grass buffer is designed to allow runoff to sheet flow directly over it. Utilize the design procedures and criteria provided in Appendix A for calculating the size of the proposed grass buffer.

BEST MANAGEMENT PRACTICE: GRASS SWALE

Similar to a grass buffer, a grass swale is a conveyance system that collects and slowly conveys runoff. The design of these control measure allows for the settling of pollutants and for storm water to infiltrate back into the ground.

This BMP can be used as an alternative to storm sewer within a development. The grass swale is typically designed as a trapezoidal, or shallow triangular, swale. They are meant to have a low velocity during minor storm events, and to collect and convey the larger runoffs associated with major storm events. Utilize the design procedures and criteria provided in Appendix B for calculating the size of the proposed grass swale.

BEST MANAGEMENT PRACTICE: POROUS LANDSCAPE DETENTION

Porous landscape detention consists of a low vegetated area with drainage media underneath to facilitate drainage. Runoff is meant to be detained in this area and slowly infiltrates down to the drainage media. The drainage media typically consists of a layer of sand with an underdrain to facilitate drainage. The underdrain discharges into a swale or storm sewer. This BMP allows for removal of pollutants and some detention on sites that do not have much open area.

Utilize the design procedures and criteria provided in Appendix C for calculating the size of the proposed porous landscape detention area.

BEST MANAGEMENT PRACTICE: DETENTION POND DESIGN

The accepted method of design will be the NRCS design methodology. The watershed runoff will be based on the CN and travel time methodology to calculate the time of concentration. The storm distribution shall be the 24-hour, Type II storm. Rainfall amounts are summarized below for several recurrence intervals.

EVENT	RAINFALL (INCHES)
1-year	2.2
2-year	2.7
5-year	3.5
10-year	4.1
25-year	4.8

50-year	5.4
100-year	6.0

All ponds will be designed based on Table 2.

There will be no permanent structures built with an opening that has an elevation that is lower than the major storm event. All ponds will have a planned emergency overflow that is at the elevation of the major storm event and shall demonstrate it can pass a minor storm when the pond is at the major storm elevation without any damage to structures around the pond or downstream. The emergency overflow, when possible, will discharge into the City's right-of-way. If this cannot be accomplished then the developer will ensure that any neighbor will not be negatively impacted by the flow exiting the emergency overflow.

If a restrictive outlet is required for water quality or rate reduction, it shall not be smaller than six inches in diameter unless approved by the City. All outlets that are smaller than 15 inches shall be designed so that there is an emergency over flow in case the outlet pipe becomes plugged. If the outlet pipe is plugged, the design shall include an analysis of a plugged outlet conditions (water at the elevation of the emergency overflow) and show protection is provided for the unblocked major storm event.

Hydraulic outlet computation shall be submitted to the City Engineer for each pond outlet structure. If a computer model is used that computes hydraulics of an outlet, the program reference shall be documented; and if it is not readily available (embedded in the program) background on the programs methodology shall be submitted with the computations.

This document replaces all previous versions of the City of Vermillion's Storm Drainage Design Criteria, effective as of the date below. All changes to this document shall be made by an approved motion of the City of Vermillion City Council.

____________________________ Date: ________________

John E. (Jack) Powell, Mayor

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Michael D. Carlson, City Finance Officer

APPENDIX

APPENDIX A: GRASS BUFFER

Design Procedure and Criteria

The following steps outline the grass buffer design procedure and criteria.

Step 1: Design Discharge
Determine the developed two-year flow rate of the area draining to the grass buffer. Also, determine the flow control type: sheet or concentrated.

Step 2: Minimum Length
Calculate the minimum length (normal to flow) of the grass buffer. The upstream flow needs to be uniformly distributed over this length. General guidance suggests that the hydraulic load should not exceed 0.05 cfs/linear foot of buffer during a two-year storm to maintain a sheet flow of less than 1 inch throughout dense grass that is at least 2 inches high. The minimum design length (normal to flow) is therefore calculated as:

$$L_G = \frac{Q_{2-year}}{0.05}$$

In which:

L_G = Minimum design length (feet)

Q_{2-year} = Peak discharge supplied to the grass buffers by a 2 year event (cfs)

Longer lengths may be used.

Step 3: Minimum Width
The minimum width (WG) (the distance along the sheet flow direction) of the grass buffer shall be determined by the following criteria for onsite and concentrated flow control conditions:

- Sheet Flow Control (use the larger value)

  $W_{G=0.2L_1}$ or 10 feet

  In which:

  L_1 = The length of flow path of the sheet flow over the upstream impervious surface (feet)

- Concentrated Flow Control (use the larger value)

  $W_G = 0.15(A_t/L_t)$ or 10 feet

  In which:

  A_t = The tributary area (square feet)

  L_t = The length of the tributary inflow normal to flow spreader (i.e., width of flow spreader (feet))

A generally rectangular-shaped strip is preferred and should be free of gullies or rills that concentrate the overland flow.

Step 4: Maximum Slope
Design slope in the direction of flow shall not exceed 4 percent.

Step 5: Flow Distribution
Incorporate a device on the upstream end of the buffer to evenly distribute flows along the design length. Slotted curbing, modular block porous pavement (MBP), or other spreader devices can be used to apply flows. Concentrated flow supplied to the grass buffer must use a level spreader (or a similar concept) to evenly distribute flow onto the buffer.

Step 6: Vegetation
Vegetate the grass buffer with dense turf to promote sedimentation and entrapment and to protect against erosion.

Step 7: Outflow Collection
Provide a means for outflow collection. Most of the runoff during significant events will not be infiltrated and will require a collection and conveyance system. In some cases, the use of under-drains can maintain better infiltration rates as the soils saturate and help dry out the buffer after storms or irrigation periods.

APPENDIX B: GRASS SWALE

Design Procedure and Criteria

The following steps outline the grass swale design procedure and criteria:

Step 1: Design Discharge
Determine the developed two-year flow rate in the proposed grass swale for water quality.

Step 2: Swale Geometry
Select geometry for the grass swale. The cross section should be trapezoidal or triangular. The side slopes shall be flatter than 4:1 (horizontal/ vertical). The wider the wetted area of the swale, the slower the flow and the more effective it is in removing pollutants.

Step 3: Longitudinal Slope
Maintain a longitudinal slope for the grass swale between 0.2 and 1.0 percent. If the longitudinal slope requirements cannot be satisfied with available terrain, grade control checks or small drop structures must be incorporated to maintain the required longitudinal slope. If the slope of the swale exceeds 0.5 percent, the swale must be vegetated with irrigated turf grass to establish the vegetation.

Step 4: Flow Velocity and Depth
Calculate the velocity and depth of flow through the swale. Based on Manning's equation and a Manning's roughness coefficient of n=0.05, find the channel velocity and depth using the 2-year flow rate determined in Step 1.

Step 5: Maximum Flow Velocity
Maximum flow velocity of the channel shall not exceed 1.5 feet per second and the maximum flow depth shall not exceed 2 feet at the two-year peak flow rate. If these conditions are not attained, repeat Steps 2 through 4, each time altering the depth and bottom width or longitudinal slopes until these criteria are satisfied.

Step 6: Vegetation
Vegetate the grass swale with dense turf grass to promote sedimentation, filtration, and nutrient uptake, and to limit erosion through maintenance of low-flow velocities.

Step 7: Drainage and Flood Control
Check the water surface during larger storms such as the minor storm and major storm event to assure that drainage from these larger events is being controlled without flooding critical areas.

APPENDIX C: POROUS LANDSCAPE DETENTION

Design Procedure
The following steps outline the porous landscape detention design procedure and criteria:

Step 1: Basin Storage Volume
Provide a storage volume based on a 12-hour drain time.

- Find the required storage volume (watershed inches of runoff). Using the tributary areas imperviousness, determine the required WQCV (watershed inches of runoff) using Figure 1 in the appendix, based on the porous landscape detention 12-hour drain time.

- Calculate the design volume in cubic feet as follows:

$$Design\ Volume = \left(\frac{WaterQualityCaptureVolume}{12}\right) * Area$$

In which:

$Area$ = The watershed area tributary to the porous landscape detention basin (square feet)

Step 2: Surface Area

- Calculate the minimum required surface area as follows:

$$SurfaceArea = \left(\frac{DesignVolume(ft^3)}{d_{av}}\right)$$

In which:

d_{av} = average depth (feet) of the porous landscape detention basin.

Step 3: Sand-Peat Media
Provide, as a minimum, an 18-inch-thick layer of well mixed sand and peat (2/3 sand and 1/3 peat) for plant growth. Keep the top surface as flat as possible, while avoiding side slopes steeper than 4:1.
When installing below the bluff, or no subdrain outlet is possible, use a total sand-peat mixed layer thickness of 36-inches and no granular subbase.

Step 4: Granular Subbase
Whenever an under-drain is used or when installing above the bluff and an under-drain is not used, use an 8-inch layer of granular subbase with all fractured faces meeting the requirements of AASHTO #67 coarse aggregate.

Step 5: Membrane Liner
If installing below the bluff, install an impermeable 15-mil-thick, or heavier, liner on the bottom and sides of the basin.

If installing above the bluff, use porous geotextile fabric to line the entire basin bottom and sides. Porous membrane liner shall be of woven monofilament as manufactured by Carthage Mills-Carthage 15 percent (or equal) having an open surface area of 12-15 percent, with openings equivalent to AOS U.S. Std. Sieve size of 40-50.

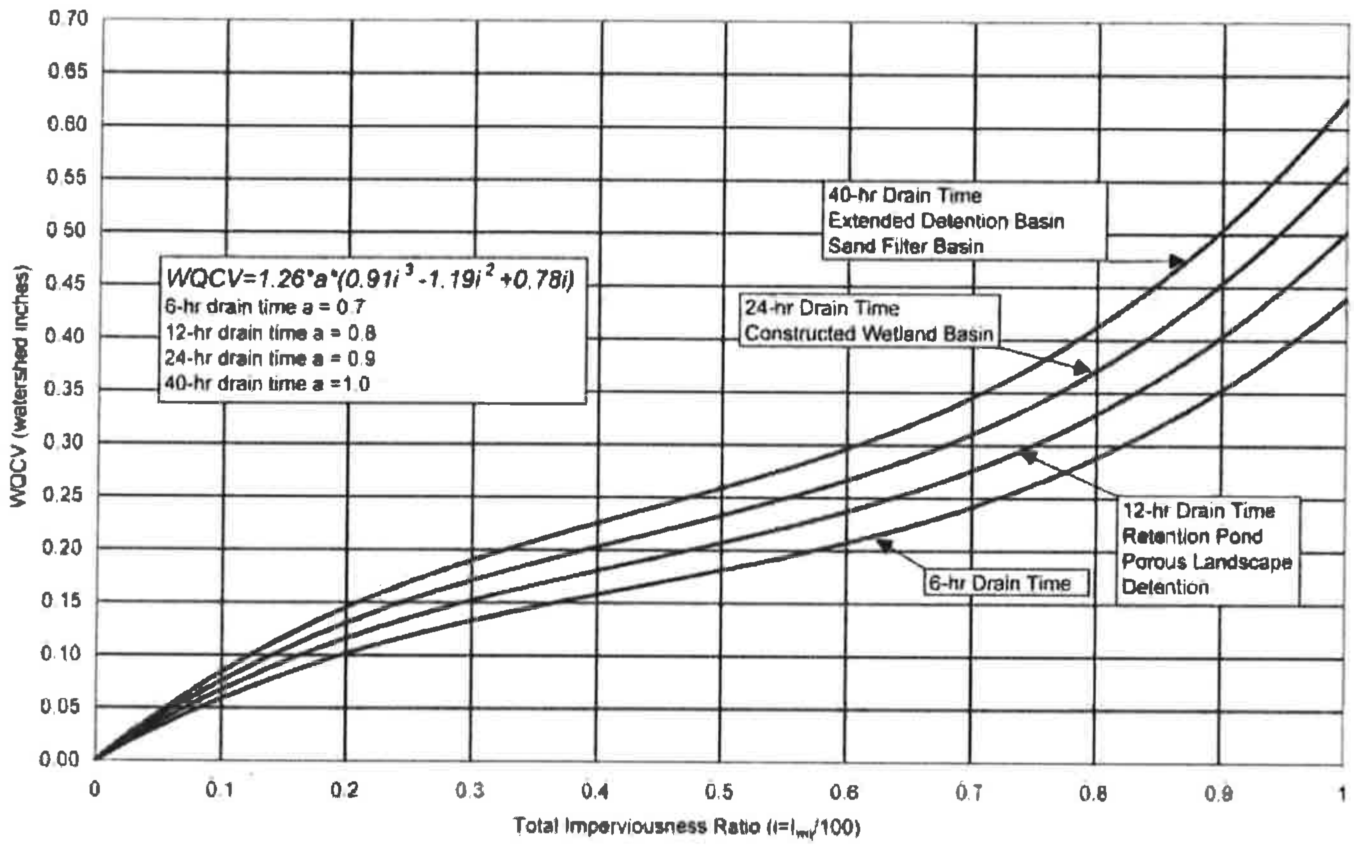
Step 6: WQCV Depth

Maintain an average WQCV depth between 6 inches and 12 inches. Average depth is defined as water volume divided by the water surface area.

Step 7: Drainage and Flood Control

Check the water surface during larger storms such as the minor storm and major storm event to assure that drainage from these larger events is being controlled without flooding critical areas.

FIGURE 1



NOTE: Figure 11.48 from the City of Sioux Falls Engineering Design Standards. WQCV adjusted to Sioux Falls based upon Urban Drainage and Flood Control District Volume 2 procedure page SQ-23.

RESOLUTION ADOPTING THE STORM DRAINAGE DESIGN CRITERIA

WHEREAS, on March 16, 2015 the City adopted the City of Vermillion's Storm Water Management Program, dated March 2015, as required by the Clean Water Act; and,

WHEREAS, this program required that the City adopt requirements in order to address storm water runoff and pollution created by developments; and,

WHEREAS, the City of Vermillion over the years has experienced localized flooding due to development not being required to mitigate any storm water generated on the site; and,

WHEREAS, the Storm Drainage Design Criteria will reduce localized flooding and minimize the amount of pollutants reaching the Vermillion River by requiring that some developers to construct facilities designed to mitigate storm water.

NOW, THEREFORE, BE IT RESOLVED, by the Governing Body of the City of Vermillion, South Dakota that the City adopts as policy the City of Vermillion's Storm Drainage Design Criteria, dated April 2015.

Dated at Vermillion, South Dakota this 6th day of April, 2015.

THE GOVERNING BODY OF THE
CITY OF VERMILLION, SOUTH DAKOTA

By____________________
John E. (Jack) Powell, Mayor

ATTEST:

By____________________
Michael D. Carlson, Finance Officer