Stormwater Design Standards Manual

City of Dickinson, ND

Approved: August 2026

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1.0 INTRODUCTION

1.1 PREFACE

The City of Dickinson (City) adopted this Stormwater Design Standards Manual as a guide to engineers and developers for the implementation of infrastructure related to the collection, conveyance and discharge of stormwater. The City is also designated as a Municipal Separate Storm Sewer System (MS4) under the North Dakota Pollutant Discharge Elimination System (NDPDES), necessitating a Stormwater Design Standards Manual. It is anticipated that not every situation can be contemplated in a design manual and that engineering judgement will need to be applied to some projects. The standards included in this document do not replace judgement or standard of care for the Design Engineer. All references to the City Municipal Code are subject to Chapter 60.VI. The word "shall" is always mandatory and never permissive.

Approval of any plan submitted under the provisions of this article shall expire one year after the date of approval unless construction has commenced in accordance with the plan. However, if prior to the expiration of approval, the applicant makes a written request to the City Engineer for an extension of time to commence construction setting forth the reasons for the requested extension, the City Engineer may grant one extension of not greater than one year. Any plan may be revised in the same manner as originally approved. Any denied application may be resubmitted with additional information addressing the concerns contained within the denial. The resubmitted plan is subject to all applicable fees and shall be considered as a new application.

Development and redevelopment projects within the City of Dickinson or those projects deemed applicable in the City of Dickinson extraterritorial jurisdiction shall control or collect stormwater runoff consistent with the performance requirements, design standards and analysis methods described in this SWDM. Failure to do so may result in the denial of a mandatory stormwater management permit applied for in accordance with Municipal Code (Stormwater Management). Stormwater management is not a one size fits all process and the City has selected a BMP approach to meet the requirements of the MS4 General Permit and Municipal Code.

1.2 PURPOSE

This Stormwater Design Standards Manual (SWDM) has the primary purpose of providing uniform requirements for obtaining mandatory stormwater permits (construction-time and post-construction stormwater management) for development activities within the City and its extraterritorial jurisdiction. This SWDM is developed to:

1. Provide uniform requirements to demonstrate compliance with Chapter 60 of the City Municipal Code (Utilities) and the MS4 General Permit.
2. Decrease durations of project review and approvals.
3. Clearly define submittal requirements and timing to obtain mandatory stormwater permits for plat and site plan applications.

4. Define the materials required for a stormwater permit application package to be deemed complete and ready for review.
5. Define City review timelines for mandatory stormwater permit applications to provide applicants with a greater level of certainty for planning their projects.
6. Clearly and concisely define the Performance Requirements for stormwater management.
7. Summarize the Design Standards for commonly used construction and post-construction stormwater best management practices.
8. Clearly and concisely define acceptable analysis methodologies.

Content included in this SWDM is based on the following general assumptions:

1. The Design Engineer and reviewer are experienced Professional Engineers with a working knowledge of stormwater management, hydrologic analysis and hydraulic design applicable to the subject project.
2. Primary users of the manual will consist of Design Engineers preparing applications for mandatory stormwater permits in support of plat and site plan land use approvals.
3. The SWDM requirements and standards are intended to apply to the majority of development situations.
4. Large flood protection projects, floodplain management, regulated dams, roadway bridge hydraulics and other large scale regional drainage projects will have additional performance requirements and design standards that are outside the scope of this SWDM.

This SWDM is focused on clarifying the requirements for the application and approval of mandatory stormwater permits with an emphasis on the Design Engineer having a strong working knowledge of the theory behind stormwater management.

1.3 USE OF THE MANUAL IN THE ETZ

This SWDM is intended to be utilized for all development and redevelopment projects inside of the corporate limits of the City of Dickinson.

For development and redevelopment projects that occur within the City of Dickinson extraterritorial jurisdiction (ETZ), only the following situations will require this SWDM to apply for the development application. The City Engineer has authority to determine which projects meet these criteria or if there are unique criteria that justify the need for the SWDM requirements to be applied to the project.

- The project is located within the City of Dickinson Urban Reserve area designated in the Comprehensive plan.
- The project is located within a watershed area that has probability to flow into City corporate limits.

1.4 ACRONYMS

The following acronyms and corresponding terms may be referenced in this SWDM by use of the acronym.

Acronym	Term
BMP	Best Management Practice
CMP	Corrugated Metal Pipe
SWPPP	Construction Stormwater Management Permit
EGL	Energy Grade Line
EPA	Environmental Protection Agency
ETZ	Extraterritorial Zone
FEMA	Federal Emergency Management Administration
HDPE	High-Density Polyethylene Pipe
HGL	Hydraulic Grade Line
MS4	Municipal Separate Storm Sewer System
NDDEQ	North Dakota Department of Environmental Quality
NDDOT	North Dakota Department of Transportation
NDPDES	North Dakota Pollutant Discharge Elimination System
NOI	Notice of Intent
NOT	Notice of Termination
SWPPP	Construction Stormwater Management Permit
PVC	Polyvinyl Chloride
RCP	Reinforced Concrete Pipe
SWDM	Stormwater Design Standards Manual
SWMP	Stormwater Management Plan

Acronym	Term
USACE	United States Army Corps of Engineers

1.5 DEFINITIONS

The following terms, phrases, and words, or their derivatives, are applicable to stormwater management in the City. Refer to Chapter 60.VI of the City of Dickinson Municipal Code and the MS4 General Permit as a reference for use in this SWDM for all terms that have meanings as stated in this section.

1.6 DESIGN EXCEPTIONS AND DEVIATIONS

This SWDM is not intended to limit innovation or creativity, particularly when such efforts result in more efficient solutions. Departure from the required standards shall be determined by the City Engineer on a per project basis.

The City Engineer's decision to grant, deny, or modify the proposed deviation shall be based upon evidence that the deviation request meets all of the following criteria:

1. The change will meet the applicable performance requirement.
2. The change will achieve the intended result in a comparable or superior design.
3. The change will not adversely affect safety and/or operation of the Public Storm Sewer System.
4. The change will not adversely affect maintainability of the Public Storm Sewer System.

A non-standard system may take longer to review and the deviation shall be requested during the Mandatory Stormwater Scoping Sheet described in ***Section 3.0***.

1.7 ERRORS & OMISSIONS

Any errors or omissions in the approved plans or information used as a basis for the approval of mandatory stormwater management permits may constitute grounds for withdrawal of approvals and/or stoppage of any or all of the permitted work, as determined by the City. It shall be the responsibility of the Applicant and assigned agents to demonstrate why such work should continue, and to make changes to the plans as may be required by the City before approval of the plans is reinstated.

2.0 STORMWATER MANAGEMENT PROGRAM

2.1 STORMWATER PROGRAM OVERVIEW

The City's stormwater program has been established with the goals of increasing public safety, providing protection of public and private property, and meeting the Municipal Separate Storm Sewer System (MS4) requirements per State and Federal water regulations. The City is a designated MS4 under the EPA's Stormwater Phase II Final Rule and is regulated under the North Dakota Pollutant Discharge Elimination System (NDPDES) by the NDDEQ. The City's MS4 system includes open and closed drainage systems that:

1. Are owned or operated by the City and are designed to collect and convey stormwater; and
2. Discharge, either directly or indirectly, to an MS4 owned or operated by another public body or to other receiving waters.

To meet these goals and requirements, the City has adopted and enforced Municipal Code (Stormwater Management), which sets forth uniform requirements for the stormwater management systems within the City and its extraterritorial jurisdiction. Refer to ***Section 1.3*** for additional information on use of the SWDM in the extraterritorial areas.

2.2 MANDATORY STORMWATER MANAGEMENT PERMITS

To demonstrate compliance with the requirements of the MS4 General Permit and Municipal Code, all development activities are required to:

1. Obtain the necessary mandatory stormwater permits;
2. Provide an acceptable method of mitigating increased stormwater flows from new impervious surfaces;
3. Provide an acceptable method of mitigating stormwater quality impacts from development and redevelopment activities;
4. Safely and efficiently convey stormwater flows to the City's Public Storm Sewer System; and
5. Provide management of stormwater runoff during construction disturbance activities.

Municipal Code requires mandatory stormwater permits for development inside of the City's zoning jurisdiction. The permit consist of a Construction Stormwater Management Permit (SWPPP) is further detailed in ***Section 3.0***. This SWDM is a refinement of the requirements of Municipal Code and provides detailed procedures, performance requirements, design standards and analysis methodologies for the application and approval of mandatory stormwater permits.

2.3 CONFORMANCE WITH LOCAL, STATE AND FEDERAL REGULATIONS

The purpose of this SWDM is to provide requirements for the application for, and approval of, mandatory stormwater permits for developments within the City of Dickinson's zoning jurisdiction. Approval of a City SWPPP does not constitute project approval for all required local, State and Federal regulations and permits.

It is the responsibility of the Owner, or Applicant, to obtain all necessary approvals from local, State and Federal agencies for the proposed project. Agencies that may require consultation include, but are not limited to, other City of Dickinson departments (i.e. flood plain development) Stark County, Stark County Water Resource District, NDDOT, State Water Commission, NDDEQ, USACE, FEMA and the EPA.

3.0 SUBMITTAL AND REVIEW PROCEDURES

The applicant is required to submit the following documents to the NDDEQ; Notice of Intent, Storm Water Pollution Prevention Plan, and Notice of Termination. These document shall be submitted to the City of Dickinson as they are approved by the NDDEQ. The applicant is responsible of ensuring system performance, safety, and compliance with other local, State, and Federal regulations.

4.0 POST-CONSTRUCTION PEAK DISCHARGE COMPLIANCE

The goal of this section is to provide guidance on the design, performance, and analysis requirements of the City of Dickinson regarding Post-Construction Peak Discharge Compliance.

4.1 POST-CONSTRUCTION BMP PERFORMANCE REQUIREMENTS

Projects that require a SWPPP are subject to Peak Discharge Control requirements and shall include peak discharge post-construction structural or non-structural BMPs to conform to the requirements of ***Table 4-1*** and ***Section 4.1.1*** of this SWDM. Note that these are underlying basic requirements and additional analysis and design requirements for specific components of the City's Public Storm Sewer System are provided within the following sections of this SWDM.

Table 4-1 *– Point of Discharge Peak Flow Compliance*

Point of Discharge Location	***Peak Discharge Control Requirement***
Public Storm Sewer System and new Outfalls to surface waters	Post-Construction runoff resulting from the 2-, 5-, 10-, and 100-year 24-hour rainfall events shall not exceed the runoff rate of the existing conditions.

4.1.1 HYDROLOGIC REQUIREMENTS FOR PROJECTS

Projects that require a SWPPP and are not located in a Stormwater Master Plan or previously approved SWPPP\SWMP are required to provide on-site post-construction BMPs to address peak discharge compliance performance requirements of ***Table 4-1.***

Projects that require a SWPPP and are located in an area that has an adopted Stormwater Master Plan or previously approved SWPPP\SWMP shall provide documentation that the project meets the requirements for Peak Discharge Compliance by utilizing one of the scenarios described below and summarized in *Error! Reference source not found.*.

4.2 POST-CONSTRUCTION BMP ANALYSIS & REQUIREMENTS

4.2.1 HYDROLOGIC ANALYSIS & REPORTING

All Projects that require the analysis and sizing of post-construction BMPs shall document the following minimum information for the hydrologic analysis in the SWPPP application. The SWMP shall clearly documents the application meets the Performance Requirements for Peak Flow Compliance; and hydrologic analysis requirements.

4.2.2 DETENTION BASINS ANALYSIS & REPORTING

When detention basins are proposed as a post-construction BMP to mitigate for peak discharge compliance, the following minimum performance standards shall be documented in the SWPPP application.

Engineered Outlets

All proposed detention basins shall include an outflow structure to limit the post-construction peak flow discharge less than or equal to the existing condition peak flow discharge for the events required by ***Table 4-1***.

Infiltration as an Engineered Outlet

When infiltration is used as an engineered outlet the Applicant shall include the proposed use of infiltration as a peak discharge compliance post-construction BMP, the Design Engineer shall obtain City approval on the approach, analysis methods, and field investigation requirements, and the City Engineer shall provide Project specific analysis and reporting requirements.

Emergency Spillway and\or Overflow Requirement

All proposed detention basins shall have an emergency spillway or overflow path that will route overflow without causing a failure of the detention basin berm or embankment. When approved by the City Engineer, small basins may utilize an oversized riser structure and outlet culvert for the emergency overflow path.

4.3 POST-CONSTRUCTION BMP MINIMUM DESIGN STANDARDS

The following sections include minimum standards that stormwater structures and BMPs shall meet within the City of Dickinson jurisdiction.

4.3.1 DETENTION BASINS

The following minimum design standards are provided as a general guide for small detention basins associated with local and on-site post-construction BMPs. Design of large regional basins and dams requires engineering experience and knowledge outside of the scope of this SWDM.

Detention basins proposed as post-construction peak discharge BMPs shall meet the following minimum design requirements:

Regulatory Permit Required:

Detention basins shall be designed such that the facility does not meet the requirement of a regulated dam per the applicable ND Administrative Code and State Statutes.

1. Regulated dams and water rights are administered by the State Water Commission and the office of the State Engineer.
2. In the event of a design variation allowing a State regulated facility, it is the Applicants responsibility to coordinate all required permits with the office of the State Engineer.

Design and Construction Standards:

Public and private basins shall meet the requirements of the current edition of the City of Dickinson Construction Specifications and the following minimum construction standards:

1. **Side Slopes and Slope Stability**: Slopes of detention basins shall meet the following minimum requirements:
    a. **Maximum Side Slopes**: 3H:1V
    b. **Minimum Bottom Grade**: 0.5 percent
    c. **Maximum Bottom Grade**: 5 percent
2. **Seepage Control**: A seepage control system should be provided for all embankments where a reservoir pool will be maintained for more than 72 hours, regardless of the depth of pond, height of embankment, or foundation materials.
3. **Geotechnical Engineering Requirements**: Fill material shall meet the minimum standards defined in the Geotechnical Engineering report for the project to include the infiltration calculations.
4. **Engineered Outlets:** The detention basin minimum freeboard requirements is 1.0 feet calculated from 100-year 24-hour water surface elevation to the lowest uncontrolled overflow structure. All detention basins shall include an emergency overflow spillway to prevent the berm structure integrity.All basins shall have an engineered outlet that conforms to the following minimum standards:
    a. Minimum orifice size of 4 inches (note that water quality outlets have a smaller allowable orifice size);
    b. Trash protection for all orifices and\or structural overflows; and
    c. A direct connection to the Public Storm Sewer System.
        i. It is the responsibility of the Applicant to obtain all necessary offsite easements to allow connection of proposed basin outlets to the Public Storm Sewer System at the Point of Discharge identified in the Mandatory Stormwater Scoping Sheet approval process.
        ii. Direct Connection can include pipe or open channel conveyance.
5. **Outlet Protection**: Design of outlet culverts shall include:
    a. Culverts shall have flared end sections.
    b. Energy dissipation and armoring shall be provided that is appropriate for the calculated shear stress and velocities from the 100-year 24-hour event.
    c. Rip-rap sizing shall meet the recommendations of ***Table 6-12.***
6. **Easements Required**: Basins shall include drainage easements or be platted as an undevelopable lot to fully contain the detention basin maximum pool, embankment, outlet protection and other elements as required by the City Engineer.
    a. Easements shall be noted as “Public” (maintained by the City of Dickinson or other approved public entity) or “Private” (maintained by the Applicant).
    b. Public Easements must be approved by the City.
    c. Private Easements must have a provision to allow access by the City to allow for maintenance of derelict BMPs.

d. Post-Construction BMPs constructed on undevelopable lots will only be allowed when platted as Common Interest Lots that are attached to benefiting parcels. Use of Common Interest Lots must be approved by the City.

4.4 ANALYSIS METHODOLOGIES

The goal of this section is to provide detailed requirements for the analysis of Peak Discharge Control Compliance. This section is not intended to provide instruction on how to use the various methodologies or software packages as it is assumed that a sufficient understanding of hydrologic and hydraulic analyses as they apply to urban stormwater management and drainage is a prerequisite to the use of this SWDM.

4.4.1 HYDROLOGY (COMPUTING RUNOFF)

Requirements necessary for computing runoff within the City of Dickinson's jurisdiction are listed below:

Acceptable Methods:

1. NRCS (SCS) Curve Number (CN) Method, NRCS Unit Hydrograph Methods & Time of Concentration Methods.
2. The Rational Method is not an accepted methodology for Peak Discharge Control Compliance.

Separation of Impervious/Pervious:

1. Impervious and pervious cover must be separated in the analysis on a per sub-catchment basis. Use of composite CN numbers that include the impervious area will not be allowed.
2. If the hydrology modeling software selected by the Design Engineer does not allow for direct entry of the sub-catchment percent impervious, the sub-catchment will need to be modeled as two individual sub-catchments, each having the same time of concentration but with the areas of each appropriately reflecting the pervious and impervious cover. This method is demonstrated in ***Example 4-1***.
3. Pervious and Impervious area within the project site must be manually measured to reflect the actual site design.
4. Modeling of offsite watersheds that are routed through a project site may utilize typical impervious percentages as provided in ***Table 4-2***.

Example 4-1 *Separation of Impervious and Pervious Areas*

If a 10-acre site is 25 percent impervious with the pervious portion having a CN of 74, the site:

1. Shall not be assumed to have a single, composite CN of 80; and
2. The runoff shall be computed using:
    a. A 2.5-acre sub-catchment with a CN of 98 for the impervious area;
    b. A 7.5-acre sub-catchment with a CN of 74 for the pervious area; and
    c. Both sub-catchments shall be assigned the same Tc, calculated based on the longest flow path within the 10-acre site.

Table 4-2 *– Typical Impervious Coverage for Offsite Drainage*

Land Use Type		***Impervious Cover***
Residential Developments	1/8 Acre Lots	65%
	1/4 Acre Lots	38%
	1/3 Acre Lots	30%
	1/2 Acre Lots	25%
	1 Acre Lots	20%
	2 Acre Lots	12%
Commercial		85%
Industrial		90%
Street ROW(1)		85%

(1) Street ROW includes the street, landscape boulevard, sidewalk and driveway aprons included in the public street right-of-way. Highway and/or arterial street sections may require higher impervious percentage.

Minimum Impervious Coverage:

The minimum impervious coverage values provided in *Error! Reference source not found.* are intended to guide the planning of stormwater facilities in the platting phase by providing a minimum impervious cover to be used for each zoning type. Impervious coverages exceeding the values in *Error! Reference source not found.* may be used when planning stormwater facilities. Site plans shall use the actual measured impervious cover. Additional explanation is provided below:

1. **Plats**:

   a. Development in the platting phase shall not assume a minimum impervious coverage value less than those provided in *Error! Reference source not found.***.**
   b. Higher assumed impervious amounts may be recommended or used by the Design Engineer.
   c. The approved plat SWMP will set the maximum impervious coverage for the development.
   d. Development of parcels inside of an approved plat SWPPP\SWMP to higher than planned impervious percentages will require a modification to existing facilities or construction of new facilities.
2. **Site Plans**:
   a. Shall use the actual impervious cover for the proposed project not to exceed the Municipal Code Section 62-162 – Development Regulations for the maximum impervious coverage.

<u>Hydrologic Soil Group (HSG):</u>

1. Shall be obtained from the NRCS Web Soil Survey;
2. Complex soil groups shall be set to the Aggregation Method of “Dominant Condition” within the Advanced Options of the NRCS Web Soil Survey (See *Error! Reference source not found.*);
3. “Urban Land” shall be assigned a HSG of “C”; and
4. Dual HSG classifications shall be assigned the HSG with the higher runoff potential (i.e. HSG B/D shall be assumed to be HSG D).

<u>CN Values</u>

CN values shall be obtained from ***Table 4-3***. Values different from those provided in ***Table 4-3*** must be approved by the City Engineer.

***Table 4-3** – Runoff Curve Numbers*

Cover Type	***Curve Numbers for HSG Soil Groups***			
	HSG A	***HSG B***	***HSG C***	***HSG D***
Impervious	98	98	98	98
Gravel Surface	96	96	96	96
Grass (Lawn)	39	61	74	80
Brush	30	48	65	73
Pasture/Rangeland	39	61	74	80
Cropland	62	73	80	84
Meadow (not grazed)	30	58	71	78

(1) The CN values are the maximum allowable for existing conditions analyses.

(2) The CN values Table 4-3are the minimum allowable for post-construction conditions analyses.

Time of Concentration (Tc):

1. **Minimum Tc:** 5 minutes
2. **Sheet Flow:** Maximum length of 100 feet.
3. Refer to Part 630 Chapter 15 of the National Engineering Handbook for additional guidance and information.

Rainfall Depths: See *Error! Reference source not found.*

1. **Rainfall Distribution**: SCS Unit Hydrograph Type II
2. **Rainfall Event**: 24-Hour Storm, unless otherwise master planned or platted.

Maximum Rainfall Hyetograph Time Increment:

10 minutes

Gravel Roadways and Gravel Parking Lots:

Shall be considered as part of the impervious area when separating and analyzing pervious and impervious area within a catchment.

4.4.2 HYDRAULIC ROUTING

The following list is intended to provide the Design Engineer with City of Dickinson requirements for Hydraulic Routing.

Routing Method:

1. Storage Indication Method (also known as hydrologic routing) may be utilized for projects with unconnected basins and free discharges.
2. Dynamic Routing Methods (also known as hydraulic routing) shall be incorporated for all projects that include interconnected basins, pump stations, tail water or backwater conditions, and other complex conditions that require a dynamic routing method.
3. Rational routing methods shall not be allowed.
4. Routing method requirements will generally be noted in the Mandatory Stormwater Scoping Sheet.

Starting Water Surface Elevation:

1. For proposed basins the starting Water Surface Elevation (WSE) in a detention facility shall be assumed to be equal to the invert of the lowest engineered outlet.
2. Known tail water or backwater conditions may require that the starting WSE be higher.

Outlet Protection:

1. **Shear Stress:** Shall be calculated using the following equation:

$$\tau = \gamma D S$$

Where:

τ = Shear Stress (lb/ft^2)

γ = Weight of Water (lb/ft^3)

D = Average Depth of Water (ft)

S = Surface Water Slope (Energy Grade Line)

4.4.3 ACCEPTABLE SOFTWARE

Acceptable software for the analysis of peak discharge is provided by *Error! Reference source not found.*.

5.0 POST-CONSTRUCTION WATER QUALITY COMPLIANCE

The goal of this section is to provide guidance on the design, performance, and analysis for Post-Construction Water Quality BMPs to meet the requirements as outlined in the City's MS4 permit (*Error! Reference source not found.*).

5.1 POST-CONSTRUCTION BMP PERFORMANCE REQUIREMENTS

Projects that require a SWPPP are subject to Post-Construction Water Quality requirements and shall propose permanent structural or non-structure BMPs that conform to the requirements of ***Table 5-1.*** Note that these are underlying basic requirements and additional analysis and design requirements for specific components of the City's Public Storm Sewer System are provided within the following sections of this SWDM.

Table 5-1 *– Water Quality Performance Requirement*

Situation	***Water Quality Requirement***
New Development & Impervious Areas	Prescriptive BMP sizing requirements per *Error! Reference source not found.*.
Redevelopment & Retrofit	Design BMPs to treat the first 0.5 inches of runoff from impervious areas.
Alternative BMP Method[1]	80% Total Suspended Solids (TSS) removal on an average annual basis shall be achieved.

(1) Requires approval from the City Engineer during the Mandatory Scoping Sheet process.

5.2 POST-CONSTRUCTION BMP ANALYSIS & REPORTING REQUIREMENTS

5.2.1 ALTERNATIVE BMP METHOD ANALYSIS AND REPORTING

Post-Construction water quality BMPs, other than the Prescriptive BMPs included in *Error! Reference source not found.**,*** may be utilized when the analysis and sizing has been documented in the required SWPPP. The following minimum information shall be provided:

1. Citation and reference to an accepted BMP Manual for the analysis requirements and design standards for the Alternative BMP;
2. Demonstration that the requirements of ***Table 5-1*** have been met; or
3. Demonstration that alternative performance requirements approved by the City Engineer have been met; and
4. The alternative performance requirements have been approved as a deviation prior to the submittal of the SWPPP application.

5.3 POST-CONSTRUCTION WATER QUALITY BMP DESIGN STANDARDS

The following sections include minimum standards that stormwater structures and BMPs shall meet in the City of Dickinson.

5.3.1 DETENTION BASINS

In addition to the minimum design standards presented in ***Section 4.3.1***, detention basins proposed for post-construction water quality BMPs shall meet the following minimum design standards:

Engineered Outlets:

All water quality basins shall have an engineered outlet that conforms to the following minimum standards:

1. Minimum orifice size of 2 inches.
2. The distance between inlets and the outlet shall be maximized to facilitate sedimentation and limit short-circuiting of the water quality BMP:
    a. Minimum length to width ratio is 3:1 as measured along the flow path from inlet to outlet; or
    b. If project area constraints make this ratio unobtainable, the Design Engineer shall incorporate baffles, islands or peninsulas to increase the flow path and limit short-circuiting.

Required Forebay:

All water quality basins shall include a forebay to aid in routine maintenance, limit the potential for short-circuiting, and reduce resuspension of accumulated sediments.

1. Dry Detention Basins shall be divided into a minimum of two cells.
    a. The first cell (forebay) shall contain, at a minimum, 10-percent of the design surface area as measured at the required water quality volume surface elevation; and
    b. The forebay shall provide a minimum of 1 foot of dead storage for sediment accumulation.
2. Wet Detention Basins shall be divided into a minimum of two cells with the forebay containing no less than 10-percent of the design surface area as measured at the required water quality volume surface elevation.

Embankment and Basin Protection:

All exposed soils shall be stabilized by an appropriate method. Stabilization of the active storage area will need to consider the type of protection, including vegetation species selection, given the anticipated frequency and depth of inundation.

1. Dry Detention Basins shall be stabilized with native vegetation suitable for frequent inundation or other vegetative plantings that will allow for 100% coverage of the basin area;
2. Wet Basins shall include:
   a. Appropriate stabilization at and below the normal pool elevation;
   b. Suitable native grass or other vegetative plantings above the normal pool elevation;
   c. Vegetation shall provide 100% coverage to the basin area over the normal pool elevation; and
   d. Vegetative stabilization shall be selected from species suitable to grow and survive during periods of inundation.

5.3.2 INFILTRATION BMPS

Use of infiltration and filtration BMPs requires approval by the City Engineer during the Mandatory Stormwater Scoping Sheet process.

When approved for use, infiltration and filtration BMPs shall meet the Geotechnical Report requirements and design standards:

5.4 ANALYSIS METHODOLOGIES

The goal of this section is to provide detailed requirements for the analysis of Water Quality performance.

5.4.1 WATER QUALITY VOLUME (V_{WQ})

The water quality volume shall be determined using the methods described in *Error! Reference source not found.*.

5.4.2 STANDARD METHODOLOGY

Standard Methodology analysis will be for the prescribed drawdown time of the selected BMP. For the purposes of determining compliance with the drawdown time requirements, the method presented in *Error! Reference source not found.* shall be used.

Drawdown time refers to the amount of time it takes for the V_{wq} to drain down to within 3 inches of the lowest engineered outlet. Depths under 0.25 feet (3 inches) may take an extensive amount of time to drawdown to the point of zero volume due to minimal head.

6.0 POST-CONSTRUCTION DRAINAGE AND CONVEYANCE COMPLIANCE

The goal of this section is to provide guidance on the design, performance, and analysis requirements for Drainage and Conveyance within the City of Dickinson. Examples of drainage and conveyance facilities include storm sewer, drainage ditches, streets, open channels, culverts and other engineered systems intended to carry stormwater to a Point of Discharge.

6.1 PERFORMANCE REQUIREMENTS

6.1.1 STREET DRAINAGE PERFORMANCE REQUIREMENTS

The criteria and procedures found in this section establish the performance requirements for street drainage conveyance infrastructure including gutters, inlets, manholes, and storm sewers.

Hydrologic Requirements

The street drainage system shall be designed as an integral part of the Public Storm Sewer System. Performance standards for stormwater flows on City streets are separated into requirements for the 5-year 24-hour event and the 100-year 24-hour event:

1. The 5-year 24-hour event has been selected to minimize nuisance flooding, protect against recurring minor damages, and reduce maintenance costs for streets by removing frequent flows in an orderly and economic manner.
2. The 100-year 24-hour event has been selected to minimize the potential for substantial property damage and loss of life by providing a defined drainage pathway for large rainfall events.

Allowable Street Spread

Street spread performance requirements are applicable to runoff being conveyed longitudinal to (i.e. parallel to) the right-of-way.

In situations where runoff is conveyed perpendicular to the right-of-way, the stream crossing and culvert crossing performance standards described in ***Section 6.1.3*** are applicable.

For the 5-year 24-hour storm, the performance requirements are to limit the spread (encroachment into the travel lanes) and the depth (inundation) of stormwater conveyed longitudinally in the right-of-way to below acceptable limits during the design event.

For the 100-year 24-hour storm, the performance requirement is to contain the runoff inside of the public right-of-way.

The street spread performance requirements for the 5-year 24-hour and 100-year 24-hour storm events are provided in ***Table 6-1*** and

Table 6-2**.**

Table 6-1 *– 5-year 24-hour Storm Street Performance Requirements*

Street Classification[(1)]	***Max Depth***	***Max Encroachment***[(2)]
Local Residential	No curb overtopping.	Flow may spread to crown of the street.
Local Commercial	No curb overtopping.	Flow may spread to crown of the street.
Collector – (All Sections)	No curb overtopping.	Leave 12 feet on each side of centerline clear of encroachment.
Arterial (Principal & Minor) & Parkways [(3)]	No curb overtopping.	Flow spread shall be limited to 7.5 feet or less from the face of curb.
State Highways	Shall meet the requirements of the NDDOT.	

(1) Typical City urban street classification and geometry as defined by Title 14-09-05(1)(k) of the Zoning Ordinance.

(2) Where no curb exists, flow spread shall not extend past street right-of-ways.

(3) Maximum encroachment from interior raised median shall be less than 4-feet from the median curb.

(4) Performance Requirements for non-standard street sections and geometry shall be determined by the City Engineer during the Mandatory Stormwater Scoping Sheet.

Table 6-2 *– 100-year 24-hour Storm Street Performance Requirements*

Street Classification[(1)]	***Max Depth***	***Max Encroachment***
Local Residential	6 inches at the crown	The inundated area shall not exceed the street right-of-way.
Local Commercial	6 inches at the crown	The inundated area shall not exceed the street right-of-way.
Collector – (All Sections)	6 inches at the crown	The inundated area shall not exceed the street right-of-way.
Arterial (Principal & Minor) & Parkways	3 inches at the highest point of the driving lane.	The inundated area shall not exceed the street right-of-way.
State Highways	Shall meet the requirements of the NDDOT.	

(1) Typical City urban street classification and geometry as defined by Title 14-09-05(1)(k) of the Zoning Ordinance.

(2) Performance Requirements for non-standard street sections and geometry shall be determined by the City Engineer during the Mandatory Stormwater Scoping Sheet.

Allowable Cross-Street Flow

Cross-street flow occurs when runoff flowing longitudinally in a gutter is allowed to cross the travel lane due to a lowered crown in the street section or a valley gutter in an intersection. Cross-street flow is applicable to runoff contained in the street right-of-way and is not the same as allowable street overtopping for culverts crossing perpendicular to a street right-of-way.

Allowable cross-street flows for the 5-year 24-hour and 100-year 24-hour storm events are shown in ***Table 6-3***.

Table 6-3 *– Allowable Cross-Street Flow Requirements*

Street Classification *(1)*	***5-year 24-hour Criteria*** *(1)*	***100-year 24-hour Criteria*** *(1)*
Local	6 inch Depth at Crown or in Valley Gutter	9 inch Depth at Crown or in Valley Gutter
Collector	3 inch Depth in Valley Gutter	6 inch Depth at Crown or in Valley Gutter
Arterial	None	3 inch Depth or Less at Crown no allowable Valley Gutter Flow

(1) Typical City urban street classification and geometry as defined by Title 14-09-05(1)(k) of the Zoning Ordinance.

6.1.2 STORM SEWER SYSTEM PERFORMANCE REQUIREMENTS

The Storm Sewer System is a series of underground pipes designed to convey runoff to an outfall. This system includes inlets, pipes, manholes and other appurtenances necessary to efficiently collect and covey drainage from streets and surrounding properties. Design of the Storm Sewer System components shall be determined by a thorough analysis of the drainage area involved in accordance with the provisions of this SWDM.

The following section generally describes the performance standards for the analysis and design of a Storm Sewer System associated with a transportation system. These standards also can be applied to Storm Sewer trunk mains or other drainage pipes not located under a road or street. Based on drainage area, the Design Engineer or City Engineer may determine that more stringent performance requirements may be necessary for specific projects.

Storm Sewer Inlets and Catch Basins

Inlet Capacity and Spacing

Storm sewer inlets are a structure that intercept and capture surface runoff and direct the flow into the mainline pipe. All storm sewer inlets shall meet the following minimum performance requirements:

1. Storm sewer inlets installed in public streets shall be designed with capacity and spacing such that the maximum street spread widths and cross flow requirements of ***Table 6-1***,
2. ***Table*** 6-2 and ***Table 6-3*** are not exceeded.
3. Storm sewer inlets shall be designed to intercept the 5-year 24-hour design flow with the allowable bypass as defined in ***Table 6-4.*** Storm sewer inlets located in sag locations shall include the consideration of conveying flows greater than the design event in a manner that limits the potential for damage to adjacent property or structures.
4. The theoretical capacity of inlets and grates in sags or on grade shall be determined from manufacturers' or industry design charts or procedures utilizing the 5-year 24-hour event street spread criteria.
5. The capacity of the inlet lateral pipe shall exceed that of the theoretical capacity of the inlet for the 5-year 24-hour event.

Table 6-4 *– Storm Sewer Inlet Bypass Flow Design Requirement*

Condition	***Allowable Bypass***
Sag Location	No bypass flows are allowed during the 5-year 24-hour event. Provide a 100-year 24-hour event overflow path that minimizes the potential for damage to adjacent property or structures.
Streets on Continuous Grade	The final downstream inlet or inlets shall be designed to intercept no less than 50% of the 5-year 24-hour storm.
Temporary Dead End Streets on Down Grade	Unless otherwise approved by the City Engineer, final downstream Storm Sewer Inlets shall not allow bypass flows during the 5-year 24-hour event.
Tee-Intersections on Down Grades and Low Points	No bypass flows are allowed during the 5-year 24-hour event design flow. Depending on downstream conditions, the City Engineer may require oversizing inlets at low points.
Sag or Low Point with a Storm Sewer Outfall	Storm Sewer Inlets and Outfall Pipe shall be designed to allow no bypass flows during the 25-year 24-hour event design flow.

INLETS LOCATED ON SAGS WITH A STORM SEWER OUTFALL

In situations where a street drainage inlet and storm sewer system intercepts street runoff and discharges perpendicular to the right-of-way, the final sag inlets shall be sized to allow no bypass flows during a **25-year 24-hour event** and a pipe shall convey this design flow to the Point of Discharge. Additionally, an open channel overflow path shall be provided to convey the 100-year 24-hour event from the street sump location to the Point of Discharge consistent with the requirements of ***Section 6.1.4 Open Channels***.

Storm Sewer Pipe

All storm sewer pipe shall meet the minimum performance requirements for the 5-year 24-hour and 100-year 24-hour design events as shown in ***Table 6-5***.

***Table 6-5** – Storm Sewer Pipe Capacity Requirements*

Storm Classification	***Requirement***
5-year 24-hour Storm	HGL less than 0.5 foot above the crown of pipe as measured at the structure inlet point.
100-year 24-hour Storm	Storm sewer may be designed to surcharge during the 100-year 24-hour events; however, surcharging shall not result in a HGL elevation higher than the criteria listed in ***Table 6-1*** or ***Table*** 6-2.

All storm sewer pipe shall meet the velocity performance requirements listed in ***Table 6-6.***

***Table 6-6** – Storm Sewer Pipe Velocity Requirements for 5-year 24-hour Storm*

Parameter	***Requirement***
Minimum Velocity	2 feet per second
Maximum Velocity	15 feet per second

Storm Sewer Reporting Requirements

Inlets & Catch Basins

When storm sewer inlets are proposed for a project that requires a SWPPP application, the Basis of Design Report shall include the following information documenting the performance of the storm sewer system:

1. Location, type, size, rim elevation and depth of the proposed inlet;
2. 5-year 24-hour design flow to the inlet;
3. Theoretical inlet capacity;
4. Depth of water in the gutter at the inlet;
5. Flow intercepted and flow bypassed; and
6. Street drainage spread width.

Storm Sewer Pipe

When storm sewer is proposed for a project that requires a SWPPP application, the Basis of Design Report shall include the following information documenting the performance of the storm sewer system:

1. Pipe calculations that state the design peak flow rates and design information for each pipe run, such as size, slope, length, material type, and Manning's coefficient;
2. Velocities at design flow for each segment of proposed pipe;
3. HGL at each inlet, manhole, angle point, and outlet;

4. Depth from finish grade to pipe invert for each segment of proposed pipe; and
5. When there is a significant change in slope of the pipe through a manhole or other structure, the EGL at the structure assuming the velocity approaches zero.

6.1.3 CULVERT PERFORMANCE REQUIREMENTS

Requirements presented in this section shall be used in the analysis and reporting for design of culverts for public streets, roads and highways. Culverts are defined as a closed conduit for the passage of water under an embankment, such as a road or street. Water enters the culvert directly through the upstream opening in the conduit.

Calculations relating to design of culverts shall be submitted for approval with the SWPPP application, with criteria sections of this SWDM being referenced. The following tables define the minimum performance requirements for the analysis and design of culverts.

Hydrologic analysis and capacity of culverts shall be determined using a combination of the design storm, the allowable headwater depth and allowable street overtopping. The headwater depth is measured from the invert of the culvert to the resulting inlet headwater elevation.

The proposed culvert size and/or slope shall be increased until the requirements of ***Table 6-7***, ***Table 6-8*** and ***Table 6-9*** have been met.

The allowable headwater requirements in ***Table 6-7*** are intended to apply to the majority of situations encountered in the City of Dickinson. All culvert crossing of the State Highway System shall also conform to the North Dakota Public Highway Stream Crossings as defined by NDAC 89-14.

Table 6-7 *– Culvert Headwater Requirements*

Storm	***Allowable Headwater***
25-year 24-hour Event	1.5 times the culvert diameter or culvert rise(1)
100-year 24-hour Event	***Table 6-8*** Overtopping Criteria shall not be exceeded

(1) Culvert Rise is the height of the culvert for shapes other than round.

Allowable street overtopping for culverts installed perpendicular to road right-of-ways shall meet the criteria shown in ***Table 6-8.*** The street overtopping criteria is applicable to situations where the culvert headwater rises to a level where the flow in the channel overtops the street embankment and flows over the street to the downstream outlet of the culvert. Culvert street overtopping is not the same as allowable cross-street flow.

Table 6-8 *– Culvert Allowable Street Overtopping Requirements*

Street Classification	***Storm***	***Requirement***
All Streets	25-year 24-hour Event	No Overtopping
Local	100-year 24-hour Event	6 inches measured to the highest point on the street section (1)
Collector & Arterial	100-year 24-hour Event	No Overtopping

(1) For local urban streets, the highest point is typically the ROW line and for local rural road the highest point is the centerline of the ROW.

Analysis of the culvert shall consider the minimum velocity for cleansing and the maximum velocity for outlet protection. ***Table 6-9*** presents the minimum required cleaning velocity and allowable outlet velocities for typical types of protection. Outlet velocities in excess of 11 feet per second require an engineered energy dissipation feature or outlet armor design and supporting calculations.

Table 6-9 *– Culvert Velocity Requirements*

Parameter	***Requirement***
Minimum Velocity	2.5 feet per second during the 5-year 24-hour Storm
Outlet Protection	Per ***Table 6-12***

Culvert Reporting Requirements

When culverts are proposed for a project that requires a SWPPP application, the Basis of Design Report shall include the following information documenting the performance of the culvert:

1. Complete culvert calculations that state the design peak flow rates, culvert size, slope, inverts, length, material type, wall thickness, and Manning’s coefficient.
2. Type of end treatment.
3. Headwater depths and water surface elevations for the design storm events.
4. Velocities at the inlet and outlet for the design storm events.
5. Flow control type (inlet or outlet).
6. Roadway cross-section and roadway profile.

6.1.4 OPEN CHANNELS PERFORMANCE REQUIREMENTS

Open channels in the City of Dickinson consist of two types; engineered channels and natural channels. Engineered channels are generally constructed to uniform lines and grades with lining materials or established vegetation to protect the channel from erosive forces. Natural channels include all watercourses that have been established by nature. State, local, and federal laws shall be adhered to if modifications are proposed to natural channels.

Requirements presented in this section shall be used in the analysis and reporting for design of engineered open channels that convey runoff through and from developed areas. Analysis and impact to natural channels shall conform to FEMA floodplain management requirements and other applicable local, state and federal regulations. Channels should be located such that they will not adversely affect existing infrastructure.

Calculations relating to design of engineered channels shall be submitted with the SWPPP application for approval, with criteria sections of this SWDM being referenced. The following tables define the minimum performance requirements for the analysis and design of engineered open channels.

Engineered channels shall meet the minimum freeboard requirements listed in ***Table 6-10*** for the 100-year 24-hour event. Excavated or incised channels are constructed below the existing grade and do not require berms to contain the 100-year 24-hour design flows and freeboard requirements.

When berms are used to contain the 100-year 24-hour design flows, a greater amount of freeboard is required to account for the increased risk of uncontrolled flows if the berms are breached.

Table 6-10 *– Engineered Channel Freeboard Requirement*

Channel Type	***100-year 24-hour Storm Minimum Freeboard***
Fully Excavated or Incised	1 foot below the easement or right-of way boundary.
Berms or Built-Up Channels[1]	2 feet below the easement or right-of way boundary

(1) City Engineer may require more stringent requirements for channels constructed with berms that could overtop and result in an uncontrolled discharge.

(2) Minimum top width of channel berms shall be 6-feet

Engineered open channels shall be designed to resist the erosive forces of both the 5-year 24-hour and 100-year 24-hour events. Each case will require the Design Engineer to select channel geometry and lining materials that meet the performance requirements of this section. Channel lining design requires analysis of both the design velocity and predicted shear stress to select the proper lining material for individual channels.

Channels should be designed to avoid flows near critical depth or supercritical flows.

Table 6-11 and *Error! Reference source not found.* provide minimum performance requirements for the allowable velocity and shear stress for engineered channels.

***Table 6-11** – Engineered Channel Lining Requirements*

Condition	***Minimum Requirement***
5-year 24-hour Event V < 5 FPS	Grass Lined Channels
5-year 24-hour Event V > 5 FPS	Lining to Resist Calculated Shear Forces
100-year 24-hour Event V < 5 FPS	Grass Lined Channel
100-year 24-hour Event V > 5 FPS	Lining to Resist Calculated Shear Forces

V = Velocity

FPS = Feet per Second

Open Channel Reporting Requirements

When engineered open channels are proposed for a project, the submitted SWMP shall include the information outlined on the SWPPP Checklist (SM-05) available in *Error! Reference source not found.*.

6.1.5 OUTLET AND OUTFALL PROTECTION PERFORMANCE REQUIREMENTS

Outlet and\or outfall protection of culverts shall be designed to resist the erosive forces of events up to the 25-year 24-hour storm. For critical infrastructure, the City Engineer may require that culvert outfalls be designed for the 100-year 24-hour event.

Culvert outfalls shall be designed to resist the scour at the outlet and dissipate velocities to values that are appropriate for the downstream channel. For the majority of installations, utilization of properly sized rip-rap at the outlet will provide suitable protection against scour and sufficient energy dissipation.

***Table 6-12** – Maximum Allowable Design Velocities for Outlet Protection*

Parameter		***Velocity of Design Event***
Vegetation and/or Permanent Turf Reinforcement Mat		< 5 feet per second
Riprap Size Classification	VL	6.5 feet per second
	L	8.0 feet per second
	M	9.5 feet per second
	H	10.5 feet per second
	VH	11.0 feet per second
Energy Dissipater Required		> 11 feet per second

When velocities exceed 11 feet per second for the 25-year 24-hour event, or the City Engineer requires a higher design standard for critical infrastructure, the Design Engineer shall include an engineered energy dissipation structure. Accepted structures include:

1. Short Stilling Basin (USBR Type II).
2. Baffled Apron Stilling Basin (USBR Type IX).
3. Impact Stilling Basin (USBR Type VI).

Energy dissipation structures shall meet the design requirements of the current United States Bureau of Reclamation technical circular.

Other proprietary outlet protection measures may be proposed by the Design Engineer and approved at the City's discretion. **Articulated Concrete Block is not allowed as culvert outlet protection**.

6.2 MINIMUM DESIGN STANDARDS

All design and construction for the extension of the City's Public Storm Sewer System shall conform to the requirements of the current edition of the Standard Specifications. Requirements of the Standard Specifications are not reproduced or repeated in this SWDM. It is the responsibility of the Design Engineer to cross-reference the requirements for this SWDM and the Standard Specifications.

6.2.1 STREET DRAINAGE DESIGN STANDARDS

Street Layout

Street layout and design shall meet the requirements of Title 14-09-05 Municipal Code.

Curb & Gutter

Curb & Gutter shall be included on all new public and private streets proposed for development activities in the City of Dickinson.

Curb and gutter grades shall meet the minimum design requirements of Title 14-09-05 Municipal Code.

Public Streets shall have curb and gutter that conforms to Section 603 of the Standard Specifications.

Valley Gutters

Where storm sewer is not required by street spread requirements or otherwise not justified, valley gutters may be installed to convey runoff through Local Street intersections only. No valley gutters are allowed on Arterial or Collector streets unless approved by the City Engineer.

Design considerations for valley gutters include:

1. The minimum grade of the valley gutter shall be 0.5 percent at the flow line.
2. When valley gutters are used to redirect surface flow greater than 90-degrees (change direction), the Design Engineer shall include an analysis of the HGL and EGL to determine if a significant change in water surface elevation occurs due to a reduction in velocity.

6.2.2 STORM SEWER SYSTEM DESIGN STANDARDS

Storm Sewer Inlets

The primary purpose of storm sewer inlets is to intercept surface runoff and deposit it in a Public Storm Sewer System, thus reducing the potential for surface flooding. Storm sewer inlets can be located along street and\or in landscaped areas. The following design requirements generally apply to storm sewer inlets located within public streets and right-of-ways. These general concepts can be applied to private collection systems located in parking lots, parks, athletic fields and other areas that have storm sewer inlets and pipes to collect runoff.

The inlet capacity governs both the rate of water removed from the gutter and the amount of water that can enter the storm drain system. Inadequate inlet capacity or poor inlet location may cause flooding which creates a safety hazard and may interrupt traffic or damage adjacent property.

Storm sewer inlets located within public streets are classified into two major groups: Sag inlets and On-Grade inlets. In addition, inlet types vary as well. A brief description of the inlet types follows:

1. Curb-opening inlets: These inlets consist of a vertical opening in the curb through which the gutter flow passes.

2. Grate inlets: These inlets consist of an opening in the gutter covered by one or more grates.
3. Combination inlets: These units consist of both a curb-opening and a grate inlet acting as a single unit.
4. Catch Basin Inlets: These inlets consist of a flat grate opening intended to be installed in a parking lot or landscaped area.

Storm sewer inlets shall conform with the requirements of Section 1205 of the Standard Specifications and applicable current details.

The following are minimum design standards for inlet situations:

1. **Parking Lots and Private Property**: Catch basins installed in parking lots or private pervious areas shall meet the following minimum requirements:
    a. **Catch Basin Capacity**: Provide 150% of the 5-year 24-hour event at each catch basin assuming a 0.5 foot depth;
    b. **Max Ponding Depth**: 18 inches during the 100-year 24-hour event.
    c. **Minimum Freeboard**: 1 foot to finished floor elevations, or lowest openings, of adjacent buildings during the 100-year 24-hour event.
    d. **Overflows**: No uncontrolled (overflow) discharge to the public street right-of-way during the 100-year 24-hour event.
2. **Private Streets**: Meet the requirements of Public Streets.
3. **Public Street Right-of-Ways**: Inlets installed in public street right-of-ways shall meet the following minimum design standards:
    a. **On-Grade Inlets**:
        i. Inlet Capacity: Can use 100% of the computed inlet capacity (i.e. ignore clogging); and
        ii. Minimum Inlet Size: Type 36"
    b. **Sag Inlets**:
        i. Inlet Capacity:
            1. Sag without a Storm Sewer Outfall: Provide 150% of the 5-year 24-hour design flow at curb depth;
            2. Sag with a Storm Sewer Outfall: Provide 150% of the 25-year 24-hour design flow at a depth that does not allow overflow from right-of-way;
        ii. Minimum Inlet Size: Type 72"
        iii. See *Error! Reference source not found.* for theoretical capacity of standard inlets in a sag. Design Engineer shall confirm capacities for actual location and products specified.

<u>Storm Sewer Pipe Design Standards</u>

Storm Sewer Pipe design, material and construction shall conform to the requirements of Section 802 and current Standard Drawings of the Standard Specifications.

All storm sewer pipe sizes shall conform to the requirements of ***Table 6-13*** unless approved by the City Engineer.

Table 6-13 *– Storm Sewer Pipe Size Requirements*

Pipe Type	***Minimum Size Requirement***
Public Lateral	15-inch diameter
Public Mainline	18-inch diameter or not decreasing in flow direction
Private Storm Sewer	12-inch diameter
Private Foundation or Building Drain	4-inch diameter

All storm sewer pipes shall be located consistent with the requirements ***Table 6-14*** unless approved by the City Engineer.

Table 6-14 *– Storm Sewer Pipe Location Standards*

Situation	***Design Location***
Street Right-of-Way	Storm sewer parallel to the street and in the right-of-way should be placed beneath the traveled lanes, to fit specific manhole or inlet connections. Storm sewers should be located in streets with 10 feet of horizontal separation from sanitary sewers and water mains. Storm sewer pipe changes in grade or direction shall be made at manholes that are accessible through a standard manhole casting.
Public Easements	Pipe centered in a 30-foot minimum easement width. Easements located outside of street right-of-ways shall include a 20 foot wide all-weather access and maintenance path.
Private Easements	Pipe centered in a 20-foot minimum easement width.

Notes:

(1) Easements shall be noted as “Public” (maintained by the City of Dickinson or other approved public entity) or “Private” (maintained by the Applicant).

(2) Public Easements must be approved by the City.

(3) Private Easements must have a provision to allow access by the City to allow for maintenance of derelict storm sewer pipes.

Pipes shall be designed to withstand anticipated loads in accordance with standard industry design procedures. AASHTO HS-20 loading may be assumed during design unless unique conditions of the site warrant a higher load capacity.

The Design Engineer shall confirm the minimum pipe cover for materials specified for individual projects.

Manholes

Manholes or other maintenance access ports (tee manhole sections on large diameter pipe) are required whenever there is a change in direction, elevation, grade or the junction of two runs of storm sewer.

Manhole design, material and construction shall conform to the requirements of Section 1205 and current Standard Drawings of the Standard Specifications.

Manholes shall be located such that the maximum spacing requirements of ***Table 6-15*** are not exceeded.

Table 6-15 *– Storm Sewer Manhole Spacing Standards*

Situation	***Maximum Manhole Spacing***
18” to 21” Storm Sewer Pipe	450 feet
24” to 30” Storm Sewer Pipe	500 feet
Over 30” Storm Sewer Pipe	600 feet

(1) All pipe sizes are in round diameters.

Manhole size (diameter) shall be sufficient for the size of pipe entering and exiting the structure. ***Table 6-16*** lists the design standards for typical reinforced concrete pipe and precast concrete manholes. The Design Engineer shall confirm that the minimum manhole size listed in ***Table 6-16*** is appropriate for the materials specified for individual projects and angles of pipe entering/exiting the manhole.

***Table 6-16** – Storm Sewer Manhole Typical Minimum Sizes*

Situation	***Minimum Manhole Size***
18” to 24” Storm Sewer Pipe	48-inch Diameter Manhole
27” to 36” Storm Sewer Pipe	60-inch Diameter Manhole
42” Storm Sewer Pipe	72-inch Diameter Manhole
48” and larger Storm Sewer Pipe	Junction Box or Tee Manhole as approved by the City Engineer

(1) Sizing based on recommendations by Forterra. Design engineer to confirm manhole sizing from actual supplier.

(2) All pipe sizes are in round diameters. Design engineer to confirm minimum manhole size to other pipe shapes.

(3) Inlets shall not be utilized as manholes for mainline storm sewer pipe.

Elevation drop shall be provided in manholes per the requirements of ***Table 6-17***.

***Table 6-17** – Storm Sewer Manhole Drop Standards*

Situation (1)	***Minimum Manhole Drop***
Increase in Storm Sewer Pipe Size	Match Crowns of Pipes (2)
Same Size Pipe with less the 45-degree Change in Direction	Carry the Pipe Slope Through the Manhole Structure
Same Size Pipe with 45-degree or greater Change in Direction	Minimum of 0.2 foot Drop Through the Manhole

(1) All pipe sizes are in round diameters. Design engineer to confirm minimum manhole size to other pipe shapes.

(2) In areas of flat topography, City Engineer may waive the requirement to match crowns.

Easements

Storm sewer pipes constructed outside of the street right-of-way shall include drainage meeting the requirements of ***Table 6-14***.

Design Considerations

Factors to be taken into consideration in culvert design include design flows, the culvert’s hydraulic performance, the economy of alternative pipe materials and sizes, horizontal and vertical alignment, and environmental concerns. The following minimum design considerations shall be met when designing culverts:

1. The minimum size as listed by *Error! Reference source not found.*.

2. The size, shape, and type of culvert crossings shall be based on flow quantities calculated using the hydrologic methods set forth in ***Section 6.1.3***.
3. The structural design of culverts shall conform to those methods and criteria recommended by the manufacturer for that culvert type and for the conditions found at the installation site. However, the minimum standards set forth in the current AASHTO standards shall be adhered to.
4. All culvert inlet structures shall be designed to minimize entrance losses. All culverts shall be fitted with flared end sections, headwalls, wing-walls or other approved methods of entrance loss minimization. Projecting ends are not permitted.
5. Culvert outlets shall be designed to resist the erosive forces from the design storm. All culvert outlets shall be fitted with a flared end section, headwalls, wing-walls or other approved outlet structure. Projecting ends are not permitted.
6. For large structures or where groundwater is a problem, the design shall include necessary provisions to resist hydrostatic uplift forces that could result in failure of the structure.
7. All culvert designs shall include an analysis that determines whether inlet or outlet control conditions govern.
8. Ponding above culvert inlets will not be allowed if such ponding will cause property or roadway damage, culvert clogging, saturation of fills, detrimental upstream deposits of debris, or inundate any other structure.
9. All culvert designs shall meet AASHTO HS-20 loading criteria.

Easements

Culverts extended outside of the street right-of-way shall include drainage easements of a width necessary to contain the 100-year 24-hour water surface elevation required freeboard and maintenance access.

1. Easements shall be noted as “Public” (maintained by the City of Dickinson or other approved public entity) or “Private” (maintained by the Applicant).
2. Public Easements must be approved by the City.
3. Private Easements must have a provision to allow access by the City to allow for maintenance of derelict open channels and culverts.
4. The minimum drainage easement width shall be 30 feet.

6.2.3 OPEN CHANNEL DESIGN STANDARDS

The use of open channels shall generally be limited to undeveloped areas that can conform to the requirements of the hydraulics, topography, and right-of-way limitations.

Minimum Geometry Requirements

***Table 6-18** – Engineered Channel Geometry Requirements*

Parameter	***Minimum Value***
Longitudinal Slope of Channel	0.25 Percent
Side-Slopes	3 Horizontal to 1 Vertical or flatter
Cross Section Shape	Trapezoidal
Minimum Bottom Width	4 feet

Restrictions on Inter-Lot Flow

Overland flow occurs when excess precipitation runs off in sheet fashion prior to accumulating in a drainage way. Overland flow generally occurs on private property and can also be described as inter-lot flows. Restrictions on inter-lot flows include:

1. Overland flow will only be permitted within individual private lots or land parcels, and in defined swales less than 2 feet deep.
2. Storm water runoff cannot be diverted, or channelized, from one private lot downstream though a separate lot unless appropriate easements are executed.
3. Private adjacent lots in common ownership are still required to dedicate easements.

Engineered Channels – Vegetated

In addition to the requirements stated in ***Section 6.1.4*** the following minimum design standards shall be met:

1. Drop structures may be used to control the grade in order to meet the velocity and shear stress requirements.
2. The design shall consider the channel material's ability to withstand projected channel velocities and shear stresses for the 100-year 24-hour event. Channel protection measures shall be designed where necessary.
3. Side slopes greater than 3H:1V may be permitted if approved stabilization is utilized.
4. All grass channels shall include the utilization of a biodegradable or photodegradable erosion control mat to resist the calculated shear stress until vegetation can be established.
5. The grass species selected for seeding shall conform to requirements set forth by the Standard Specifications.

Easements

Open channels shall include drainage easements of a width necessary to contain the 100-year 24-hour water surface elevation required freeboard and maintenance access.

1. Easements shall be noted as “Public” (maintained by the City of Dickinson or other approved public entity) or “Private” (maintained by the Applicant).
2. Public Easements must be approved by the City.
3. Private Easements must have a provision to allow access by the City to allow for maintenance of derelict open channels.
4. The minimum open channel drainage easement width shall be 30 feet regardless of the size of the channel.

6.3 ANALYSIS METHODOLOGIES

The goal of this section is to provide the detailed requirements for the analysis of drainage and conveyance facilities.

6.3.1 HYDROLOGIC ANALYSIS

1. **Unit Hydrograph:** NRCS (formerly SCS) Curve Number (CN) & Time of Concentration (Tc) Methods discussed in ***Section 4.0*** of this SWDM.
2. **Rational Method**
    a. Intensity-Duration-Frequency (IDF) curves shall be from NOAA Atlas 14 using the Dickinson Municipal Airport station (*Error! Reference source not found.**)***.
    b. Intensity (I) shall be based on the Time of Concentration (Tc) to the inlet(s). Note that multiple intensities may be needed for a single system.
    c. Runoff Coefficient (C) shall be determined based on the site cover and obtained from accepted literature. The source used to obtain the Runoff Coefficient(s) shall be stated in the SWMP.

6.3.2 HYDRAULIC ANALYSIS

1. **Inlet Analysis:** Shall use the following methods:
    a. On-Grade:
        i. HEC-22 methodology.
    b. Sag (Low Point):
        i. HEC-22 methodology; or
        ii. Orifice/Weir Equation.

2. **Manning's n Coefficients:**
    a. Manning's n coefficients for commonly used materials and surfaces are provided in ***Table 6-19***.
    b. For surfaces not covered by ***Table 6-19***, values shall be obtained from literature approved by the City Engineer.
    c. The source(s) used to determine any coefficient(s) not provided in ***Table 6-19*** shall be stated in the SWMP.

Table 6-19 *– Manning's Coefficients*

Material/Surface	***Manning's n Coefficient***
RCP	0.013 – 0.014
CMP	0.022 – 0.024
HDPE (smooth)	0.010 – 0.012
HDPE (corrugated)	0.021 – 0.023
PVC	0.010 – 0.012
Vegetated Channel (not mowed)	0.035 – 0.050
Maintained Ditch/Channel (mowed)	0.030 – 0.040
Concrete Channel	0.015
Street (Asphalt)	0.014 – 0.016
Street (Concrete)	0.013 – 0.015
Urban Street Boulevards	0.045

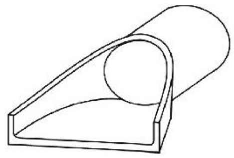
3. **Entrance and Exit Coefficients:**
    a. Entrance and Exit Coefficients for common configurations are provided in ***Table 6-20*** and ***Figure 6-1***.
    b. For situations not covered by ***Table 6-20***, values should be obtained from accepted literature approved by the City Engineer.
    c. The source(s) used to determine any coefficient(s) not provided in ***Table 6-20*** shall be stated in the SWMP.

***Table 6-20** – Entrance and Exit Coefficients*

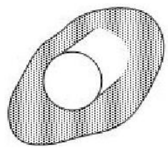
	Material	***Design Scenario***	***Entrance Coefficient***	***Exit Coefficient***
Pipe or Arch Culverts	RCP	Flared End Section	0.5	1.0
		Square Cut*	0.5	
		Socket or Rounded*	0.2	
	CMP or HDPE	Projecting	0.9	
		Mitered	0.7	
		Conforms to Fill	0.5	
Box Culverts	RCP	No Wingwalls	0.5	1.0
		Wingwalls (30° - 75°)	0.4	
		Wingwalls (10° - 25°)	0.5	
		Wingwalls (Straight)	0.7	

*Applies to Headwall or Projecting

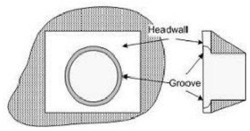
Figure 6-1 – *Entrance and Exit Configurations*



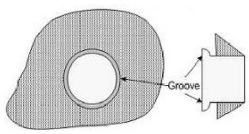
Flared-End Section
These are common end sections that function hydraulically equivalent in operation to a headwall in both inlet and outlet control.



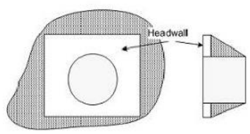
Projecting
This configuration results in the end of the culvert barrel projecting out of the embankment.



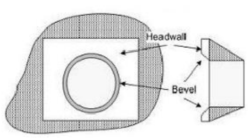
Grooved Pipe with Headwalls
The grooved pipe is for concrete culverts and decreases the loss through the culvert entrance.



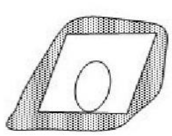
Grooved Pipe Projecting
This option is for concrete pipe culverts.



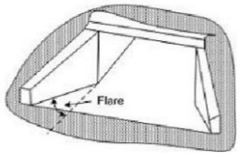
Square Edge with Headwalls
Square edge with headwalls is an entrance condition where the culvert entrance is flush with the headwall.



Beveled Edge with Headwalls
A beveled edge is a tapered inlet edge that decreases head loss as flow enters the culvert barrel.



Mitered
A mitered entrance is when the culvert barrel is cut so it is flush with the embankment slope.



Wingwall
Wingwalls are used when the culvert is shorter than the embankment and prevents embankment material from falling into the culvert.

Source: http://www.fhwa.dot.gov/

4. **Storm Sewer Junction Losses**
   a. Minimum storm sewer junction losses are provided in ***Table 6-21***.
   b. For situations not covered by ***Table 6-21*** values should be obtained from accepted literature approved by the City Engineer.
   c. The source(s) used to determine any coefficient(s) not provided in ***Table 6-21*** shall be stated in the SWMP.

Table 6-21 – *Storm Sewer Junction Losses*

Design Scenario	***Entrance Coefficient***	***Exit Coefficient***
Inlet Junction	0.2	0.5
Manhole Junction	0.1	0.3

5. **Inlet/Outlet Control:**
   a. Analysis method shall account for both the potential for inlet or outlet control conditions with the water surface based on the higher computed water surface elevation.
   b. Inlet/outlet control shall be computed at all surface entrances to storm sewer (e.g. ditch draining to a flared end section) and culverts.
6. **Inlet Analysis Clogging Factor:**
   a. Inlet clogging factors are not required.
   b. For situations that the Design Engineer determines inlet clogging factors are necessary or applicable, state the use of clogging factors in the SWMP.
7. **Shear Stress:** Shall be calculated using the following equation:

$$\tau = \gamma D S$$

Where:

τ = Shear Stress (lb/ft^2)

γ = Weight of Water (lb/ft^3)

D = Average Depth of Water (ft)

S = Surface Water Slope (Energy Grade Line)

7.0 CONSTRUCTION STORMWATER CONTROL

7.1 THE GOAL OF THIS SECTION IS TO PROVIDE GUIDANCE ON THE DESIGN, PERFORMANCE, AND ANALYSIS OF THE CONSTRUCTION STORMWATER CONTROL REQUIREMENTS OF THE CITY OF DICKINSON AS DEFINED IN THE SWPPP.ANALYSIS METHODOLOGIES

The goal of this section is to provide specific analysis methodologies for Construction Stormwater Control as required by the North Dakota Construction General Permit and the City's MS4 General Permit (*Error! Reference source not found.*). Note that Small Site SWPPP applications do not need a hydrologic or hydraulic analysis.

7.1.1 HYDROLOGY (COMPUTING RUNOFF)

1. **Computing Runoff:** Runoff calculation methods shall be consistent with those discussed in ***Section 4.4.1***.
2. **Newly Graded Ground:** A minimum CN of 90 shall be used for all newly graded ground regardless of Hydrologic Soil Group.

7.1.2 HYDRAULIC ANALYSIS

Hydraulic analyses shall be made using the methods described below unless otherwise approved by the City Engineer.

1. **Velocity:** Shall be obtained using one of the acceptable methods presented in *Error! Reference source not found.***.**
2. **Shear Stress:** Shall be calculated using the following equation:

   $\tau = \gamma D S$

   Where:

   τ = Shear Stress (lb/ft^2)

   γ = Weight of Water (lb/ft^3)

   D = Average Depth of Water (ft)

   S = Surface Water Slope (Energy Grade Line

3. **Capacity of Swales and Ditches:** Shall be analyzed using one of the methods presented in *Error! Reference source not found.*.

Error! Reference source not found.

NOAA Atlas 14 Rainfall Depths

Average Recurrence Frequency	*24-Hour Rainfall Event (inches)*
2-year (50% Chance Storm)	2.1
5-year (20% Chance Storm)	2.6
10-year (10% Chance Storm)	3.1
25-year (4% Chance Storm)	3.9
100-year (1% Chance Storm)	5.3
500-year (0.2% Chance Storm)	7.2

Source: http://www.noaa.gov/

Error! Reference source not found. ***– Allowable Velocity and Shear Stress for Selected Materials***

Material Category	*Material Type*	*Allowable Velocity (ft/s)*	*Allowable Shear Stress (lb/ft2)*
Temporary Rolled Erosion Control Product (RECP) (1)	Jute Net Straw w\ Net Coconut Fiber w\ Net Fiberglass roving	1-2.5 1-3 3-4 2.5-7	0.45 1.5-1.65 2.25 2
Nondegradable RECP (1)	Unvegetated Partially Established Fully Vegetated	5-7 7.5-15 8-21	3 4-6 8
Hard Surface (1)	Gabions Concrete	1-19 >18	10 12.5
Riprap (2)	D_{50} = 6-inches D_{50} = 12-inches		2.4 4.8

Source:

(1) *NRCS Part 654 Stream Restoration Design National Engineering Handbook*, Table 8-11.

(2) Kilgore, R. T. and Cotton, G. K. (2005). *Design of roadside channels with flexible linings. FHWA-NHI-05-114 Hydraulic Engineering Circular Number 15*, 3rd Edition, 153 pp.

The allowable velocity and shear stress presented in *Error! Reference source not found.* are provided as a guideline for the selection of a type, or class, of stabilization. The Design Engineer shall select materials and provide manufactures literature for allowable velocity and shear of the actual material to be installed.

Error! Reference source not found. ***– Theoretical Street Sag Inlet Capacities***

Sag Inlet Size	***Theoretical 6” Head Capacity (cfs)***
36-Inch	6.8
72-Inch	10.3
108-Inch	13.8
144-Inch	17.3

*Inlets were analyzed as Neenah Foundry R-3295 Type C

Error! Reference source not found.

<u>Precipitation-Intensity Graphical</u>

Need to update this

Source: http://www.noaa.gov/

<u>Precipitation-Intensity Tabular</u>

Need to update this

Source: http://www.noaa.gov/