

City of Brandon

Municipal Servicing Standards

Section 5

Land Drainage

Rev 00 (2025)



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LAND DRAINAGE SERVICING STANDARDS REVISION HISTORY

Municipal Servicing Standards (MSS) Sections may be reviewed, updated or otherwise modified at any time. The Proponent's Engineer shall ensure that the current version of the MSS Section is applied.

Where such alternative solutions, systems, or approaches are being considered, a written proposal outlining the benefits, limitations, and total cost of ownership of the proposed solution shall be submitted to the City of Brandon Engineering Department for formal approval.

The following table summarizes the revision history:

Table 1-1 – Revisions to MSS

Date	Modification or Adjustment
July 2025	Municipal Service Standards – Section 5 – Land Drainage

1.0 OBJECTIVE

This standard describes the design of stormwater collection, conveyance, storage and quality mitigation systems. These systems must be designed to provide safe, cost-effective handling of drainage from rainfall and snowmelt and reduce the potential for flooding damage to infrastructure and property and creating unsafe conditions for people and road traffic.

This standard is a living document that will evolve as design standards develop. Older standards were concerned mainly with stormwater conveyance, but newer and evolving standards will place a greater emphasis on on-site retention to reduce the size of receiving infrastructure and extend the design life of existing infrastructure, the use of natural processes to reduce maintenance requirements, improve stormwater quality and integration of stormwater facilities with parkland to improve quality of life and provide wildlife benefits.

This standard is presented with the following main subject areas:

- Design Parameters and Methods for drainage infrastructure
- Lot Grading and Surface Drainage, including roadway surface drainage and subdrainage
- Design of Major System Components, including channels, culverts and ponds and other storage infrastructure
- Design of Minor System Components, including pipes, catch basins, manholes, outfalls and related works
- Building Services
- *(future addition)* Low Impact Development

A separate guidance document entitled “City of Brandon Naturalized Stormwater Pond Guidelines” dated April 9, 2018, for the design of naturalized stormwater basins is available from the City of Brandon website at:

<https://brandon.ca/what-is-happening-in-your-neighbourhood/completed-projects/naturalized-stormwater-retention-basin-s>

1.1 Engineering Submissions

For all submissions and approvals required as part of a Proponent’s project refer to Section 2 – Engineering Submission Standards.

2.0 DESIGN PARAMETERS AND METHODS

Stormwater systems shall be designed to convey runoff from a design rainfall event through both minor and major system components to an appropriate stormwater outlet. Both major and minor systems may be active during a rainfall event, however each is designed to protect the development for different volumes and intensities of rainfall.

The minor system is designed to convey runoff from lower magnitude, frequent rainfall events, and consists of sewers, catch basins, manholes, culverts, outlet structures and oil and grit separators. These common, or 'minor' rainfall events are expected to occur multiple times a year and the minor system is to convey runoff without impacting the functionality of the service area or development (no major overland flow or ponding).

The major system is designed to attenuate and convey runoff from larger magnitude, less frequent rainfall events that exceed the conveyance capacity of the minor system, and consists of storm drains, ditches, overflow channels, roadway gutters, retention ponds, detention ponds and naturalized stormwater ponds.

- During minor rainfall events (less than or equal to 20% annual probability of occurrence or 5-year return frequency), major system components will function as simple conveyance elements.
- During larger magnitude or 'major' rainfall events (greater than 20% annual probability of occurrence or 5-year year return frequency), major system components are expected to accommodate runoff by allowing water to attenuate in major system components, reducing the amount of conveyance required by minor system components.

2.1 Minor System

The minor system shall be designed to:

- Accommodate the 20% probability (1-in-5 year) design rainfall event.
- The peak hydraulic grade line (HGL) should be at least 300 mm below low ground elevation throughout the system.

2.2 Major System

The major system shall be designed to:

- Accommodate the 1% probability (1-in-100 year) design rainfall event.
- Attenuate runoff in major system elements on site, with ponding depth not exceeding:
 - Surface Storage: refer to Subsection 3.3 for parking lots and Subsection 3.4 for roadways.
 - Open channel systems: Top of sideslope for ditches or swales.
 - Ponds: refer to Subsections 4.3 for wet ponds, 4.4 for dry ponds and 4.5 for naturalized ponds.

- Convey runoff with flow depths not exceeding:
 - Top of curb for roadway gutters, or specified roadway encroachment limits (refer to Table 3-1)
 - Top of sideslope for ditches or swales, or ideally top of subgrade (bottom of granular road structure) for roadside ditches.
 - Public easements are required for major storm drainage overflow routes located on private property. A minimum easement width of 6.0 m is required.

2.3 Stormwater System Discharge Rates

Stormwater systems shall discharge to an appropriate downstream system at a rate:

- Not exceeding pre-development runoff rate for:
 - New closed conduit or open channel systems within City rights-of-way.
 - Existing closed conduit or open channel systems within City rights-of-way, where it can be shown that the existing drainage system has adequate capacity.
- Not exceeding Province of Manitoba requirements for:
 - Existing open channel systems (culverts, drains, coulees, highway and provincial road ditches) within or draining to Provincial rights-of-way. Designer should confirm Province of Manitoba requirements prior to commencing design.

2.4 Design Rainfall

Intensity-Duration-Frequency (IDF) curves based on Environment Canada's published IDF data for Brandon CDA station (Environment Canada Station 5010486, in service from 1960 to 1985) fit to a Gumbel Extreme Value Type 1 probability distribution are shown in Table 2-1 – IDF Equation Parameters. This family of IDF curves has historically been used in Brandon for the design of stormwater infrastructure and was developed as part of the 2003 Southeast Drainage Basin study. The City may consider adjustments to account for future climate change scenarios.

2.4.1 Intensity-Duration-Frequency (IDF)

Intensity-Duration-Frequency (IDF) curves are mathematical functions which represent the probability that a given rainfall intensity will occur within a given time duration based on historical extreme weather data.

The three parameter IDF equation is as follows:

Equation 2-1 – Intensity-Duration-Frequency (IDF) Equation

$$i = \frac{a}{(t + b)^c}$$

Where:

- i is rainfall intensity (mm/hr).
- t is time of concentration (minutes)
- a is a magnitude parameter estimated by curve fit (mm/hr).
- b is a time constant estimated by curve fit (minutes).
- c is an exponent estimated by curve fit (dimensionless).

IDF parameters based on historical Brandon CDA data for various design storms are found in Table 2-1, a summary of rainfall intensities and rainfall amounts for various times of concentration found in Table 2-2 and Table 2-3.

Table 2-1 – IDF Equation Parameters

IDF Parameter	Units	Probability of Event					
		50% (1-in-2 year)	20% (1-in-5 year)	10% (1-in-10 year)	4% (1-in-25 year)	2% (1-in-50 year)	1% (1-in-100 year)
'a'	(mm/hr)	575.9	837.3	1009.6	1236.3	1406.1	1569.5
'b'	(min)	5.6	4.7	4.4	4.2	4.1	4.0
'c'		0.774	0.767	0.764	0.763	0.763	0.762

Table 2-2 – Summary of Design Rainfall Intensities (mm/hr)

Time		Probability of Event					
Mins	Hrs	50% (1-in-2 year)	20% (1-in-5 year)	10% (1-in-10 year)	4% (1-in-25 year)	2% (1-in-50 year)	1% (1-in-100 year)
5	0.083	92.6	146.6	182.3	227.4	260.8	294.2
10	0.167	68.7	106.5	131.6	163.3	186.7	210.1
15	0.25	55.4	85.1	104.8	129.7	148.1	166.5
30	0.50	36.3	55.1	67.6	83.5	95.2	106.8
60	1	22.6	34.2	41.9	51.6	58.8	66.0
120	2	13.7	20.7	25.3	31.2	35.5	39.9
180	3	10.1	15.3	18.8	23.1	26.3	29.5
360	6	6.0	9.1	11.1	13.7	15.6	17.5
720	12	3.5	5.4	6.6	8.1	9.2	10.4
1440	24	2.1	3.2	3.9	4.8	5.5	6.1

Table 2-3 – Summary of Design Rainfall Depths (mm)

Time		Probability of Event					
Mins	Hrs	50% (1-in-2 year)	20% (1-in-5 year)	10% (1-in-10 year)	4% (1-in-25 year)	2% (1-in-50 year)	1% (1-in-100 year)
5	0.083	7.7	12.2	15.2	18.9	21.7	24.5
10	0.167	11.4	17.8	21.9	27.2	31.1	35.0
15	0.25	13.8	21.3	26.2	32.4	37.0	41.6
30	0.50	18.1	27.6	33.8	41.7	47.6	53.4
60	1	22.6	34.2	41.9	51.6	58.8	66.0
120	2	27.3	41.3	50.7	62.4	71.0	79.7
180	3	30.3	45.9	56.3	69.3	78.9	88.5
360	6	35.9	54.5	66.9	82.4	93.7	105.3
720	12	42.2	64.3	79.1	97.6	111.0	124.7
1440	24	49.5	75.8	93.4	115.2	131.1	147.4

2.4.2 Design Rainstorms

Artificial rainfall hyetographs for use in storage design and computer modelling shall use the “Chicago” design rainstorm. Design rainstorms are discretized to a 10-minute timestep and a using an assumed 33% storm advancement factor (meaning that the storm peak occurs at 33% of the storm duration). Design storms are truncated when the intensity drops below a threshold of 2.4 mm per hour. This lower threshold represents a single 0.2 mm tip from a metric rain gauge within a 5-minute duration (e.g. the smallest amount of rain that can be recorded within the smallest duration that is investigated).

10-minute discretized design rainstorms for Brandon are shown in Appendix 5A.

2.5 Calculation Methodology

The calculation methodology to be used by the designer will depend on the overall catchment size, complexity of the proposed drainage system, and the criticality of the downstream system:

Rational Method shall be used for:

- Developments with an overall catchment area of 20 ha or less.
- Developments with an overall catchment area of 20 ha or greater, in the conceptual or feasibility stages of design only.

Dynamic Stormwater Modelling shall be used for:

- Developments with an overall catchment area of 20 ha or greater.
- Developments with a catchment area of 20 ha or less and discharging to a critical existing LDS system as determined by the City.

- Critical existing LDS system refers to an existing LDS system that is known by the City to be at or near capacity and additional verification with a dynamic model is required to demonstrate the proposed development will not negatively impact the receiving system.
- Development that includes storage, including stormwater ponds, underground storage chambers or surface storage (parking lots, roofs).

The duration of the analysis should be sufficient to fully capture the entire rainstorm event and return of the system hydraulic grade line elevation to within 100 mm of the normal water level in retention ponds or detention pond bottom elevation.

2.5.1 Rational Method

The Rational Method calculates instantaneous peak flow for a given average rainfall intensity based on an estimated time of concentration and for a given catchment area and runoff coefficient.

Equation 2-2 - Rational Method Equation

$$Q = K_u C i A$$

Where:

- Q is the estimated flow (m^3/s)
- C is the Runoff Coefficient (dimensionless)
- i is Rainfall Intensity (mm/hr), estimated with the IDF equation
- A is Drainage Area (ha)
- K_u is a Unit Conversion Factor equal to $1 / 360 = 0.00278$ (or 1.0 for Imperial units),

2.5.1.1 Runoff Coefficient

- Feasibility or Conceptual design stages may use typical Runoff Coefficients for common area types.
- Preliminary and Detailed design stages shall use composite runoff coefficients. Composite runoff coefficients shall:
 - be calculated for at least one representative subcatchment per area type, or for each subcatchment where the subcatchments do not follow a standard configuration.
 - be calculated using an area-weighted method:

Equation 2-3 – Composite Runoff Coefficient Area-Weighted Method Equation

$$C = \frac{\sum((C_1 A_1) + (C_2 A_2) \cdots (C_n A_n))}{\sum(A_1 + A_2 \cdots A_n)}$$

Where:

- C is the Composite Runoff Coefficient (dimensionless)
- $C_1, C_2 \dots C_n$ are the Runoff Coefficients for each surface type (dimensionless)
- $A_1, A_2 \dots A_n$ are the Areas for each surface type (square meters or hectares)

Table 2-4 – Runoff Coefficients for Rational Formula

Area Type	Runoff Coefficient, C
Single Detached Residential Dwelling	0.50
Low Density Multi-Unit Dwellings (Duplex/Semi-detached)	0.60
Low Density Multi-Unit Dwellings (Row-house, townhouse, walk-up apartments)	0.70
Medium Density Multi-Unit Dwellings (Mixed Use Development)	0.75
High Density Multi-Unit Dwellings (Medium to High Rise Apartments)	0.85
Low / Medium Density Commercial (Service Stations, Convenience Stores, Motels, Medium Sized Hotels, Highway Commercial, etc.)	0.90
High Density Commercial (Shopping malls, Retail Centre's)	0.90
Industrial (Large Graveled lots)	0.70
Industrial (Large Paved Lots)	0.90
Institutional (Schools)	0.50
Parks, Cemeteries	0.20
Playgrounds	0.30
Unimproved Areas	0.20
Farmland	0.20
Surface Type	Runoff Coefficient, C
Roofs	0.95
Pavement (concrete or asphalt)	0.95
Pavement (paving stones)	0.85
Gravel	0.65
Grass (boulevards, lawns)	0.15
Grass (lawns, steep >7%)	0.20
Grass (side slopes, >15%)	0.25
Farmland (cultivated)	0.30
Natural prairie (grass)	0.20
Forested and brush areas	0.15

2.5.1.2 Time of Concentration

Time of Concentration is the time it takes runoff to travel from the hydraulically furthest point within the contributing catchment area to reach the design location. Determination of Time of Concentration requires estimation of two components, "Inlet Time" and "System Travel Time".

2.5.1.3 Inlet Time

Inlet Time is the time required for flow from the farthest point of a subcatchment to reach the point of inflow into a defined conveyance system (flow channel or LDS inlet). Inlet time should be calculated as the sum of continuous flow segments, including sheet flow and shallow concentrated flow.

- Sheet flow time of concentration shall be calculated using the Kinematic Wave Equation. This equation is iterative with the Rainfall IDF equation.
- Sheet flow length shall not exceed 100 m, beyond this surface runoff tends to concentrate and form small rills and gullies
- Beyond flow lengths of 100 m, the shallow concentrated flow equation shall be used.
- Minimum inlet time shall be 5 minutes. Computed times of concentration less than 5 minutes shall be set to 5 minutes.

Equation 2-4 – Kinematic Wave Equation

$$T_s = \frac{K_s n^{0.6} L^{0.6}}{i^{0.4} S^{0.3}}$$

Where:

- T_s is the sheet flow travel time (minutes)
- n is the Manning roughness coefficient for overland sheet flow (dimensionless) see Table 2-5
- i is the estimated rainfall intensity (mm/hr) computed using the Rainfall IDF equation
- L is the surface flow length (m) typically 100 m maximum before becoming shallow concentrated flow
- S is the ground surface Slope (as a fraction in m/m)
- K_s is a constant equal to 6.988 (or 0.939 for Imperial units)

* Note: This equation is iterative as rainfall intensity depends on time of concentration which is not known. An initial estimate of time of concentration is used and the calculation is repeated until the solution reaches equilibrium within a tolerance of 0.1 minutes or less.

Equation 2-5 – Shallow Concentrated Flow Equation (HEC-22)

$$T_{sc} = \frac{L}{K_{sc} k S^{0.5}}$$

Where:

- T_{SC} is the shallow concentrated flow travel time (minutes)
- k is an intercept coefficient (dimensionless) see
- Table 2-5
- L is the flow path length for concentrated flow (m)
- S is the ground surface Slope (as a fraction in m/m)
- K_{SC} is a constant equal to 1.0 (or 3.28 for Imperial units)

Table 2-5 – Shallow Concentrated Flow Intercept Coefficient

Surface Cover Type	Manning's Roughness Coefficient (n) for Sheet Flow	Intercept Coefficient (k) for Shallow Concentrated Flow
Pavement (concrete or asphalt)	0.015	0.619
Unpaved (gravel)	0.020	0.491
Grass (lawns)	0.250	0.457
Farmland (cultivated)	0.170	0.274
Natural prairie (grass)	0.150	0.213
Natural prairie (brush)	0.400	0.152
Forested areas	0.800	0.076

2.5.1.4 System Travel Time

Travel Time is the time required for flow to travel from the most upstream point of a conveyance to the downstream end or outlet of the conveyance.

- Manning's Equation shall be used to estimate average flow velocities in pipes and open channels.
- Travel time in closed conduits shall be based on full flow velocity for simplicity.

Equation 2-6 – Manning's Equation (Velocity form)

$$V = \left(\frac{k}{n}\right) R^{2/3} S^{1/2}$$

Where:

- V is the Velocity of flow (m/s)
- n is the Manning's roughness coefficient (dimensionless)
- $R = A/W_p$ or the Hydraulic Radius (m)

- A is the Flow area (m^2)
- W_p is the Wetted Perimeter (m)
- S is the Slope of the hydraulic grade line (as a fraction in m/m)
- k is a Unit Conversion Factor equal to 1.0 (or 1.486 for Imperial units)

2.5.2 Computer Modelling

Large or complex drainage systems shall be modeled using EPA SWMM 5, Computational Hydraulics Inc. PCSWMM and/or Autodesk Storm and Sanitary Analysis (SSA) software. All the drainage components including surface runoff, inlets, outlets, conduits, ditches, culverts, storage systems and outfalls shall be modelled for both the minor and major systems. The model input files and the simulation results including background files shall be electronically submitted to the City for review and approval in a .zip archive format along with sketches, system maps, technical memos and other associated files.

2.6 Design Parameters

2.6.1 Gravity Flow: Minor System

Piped systems shall be designed using the Manning Equation, and assuming full pipe flow for all design conditions.

Equation 2-7 - Manning Equation (Flow Form)

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

Where:

- Q is the estimated Flow (m^3/s)
- n is the Manning roughness coefficient, dimensionless
- A is the Cross sectional area of flow (m^2)
- R is the Hydraulic radius (m)
- S is the Slope of hydraulic grade line (as a fraction in m/m)
- k is a Unit Conversion Factor equal to 1.0 (or 1.486 for Imperial units)

2.6.1.1 Sewer Velocity

Flow velocities within piped systems are limited to:

- Minimum Velocity:

- 0.9 m/s for mainline sewer at full pipe flow, to allow for the resuspension and transport of settled solids
- **Maximum Velocity:**
 - 4.5 m/s for mainline sewer at full pipe flow for rainfall events up to the minor system design probability of event.
 - If velocities are higher during larger design rainfall events, designers shall provide design rationale and consider mitigation methods for pipe invert erosion and erosion of manhole interior walls.

2.6.1.2 Pipe Roughness

Manning's roughness coefficient for all sewer design and pipe material types shall be 0.013.

2.6.1.3 Sewer Slope

Minimum and maximum sewer slope shall be based on the minimum and maximum full flow velocity limits specified above.

Table 2-6 – Minimum and Maximum Sewer Slopes ($n=0.013$)

Pipe Diameter (mm)	Minimum Slope (%)	Maximum Slope (%)
300*	1.00	10.90
375	0.32	8.10
450	0.26	6.36
525	0.22	5.18
600	0.18	4.33
750	0.13	3.22
900 and larger	0.10	2.50

* Catch basin leads only, minimum size for mainline sewers is 375 mm.

Gravity flow for major system components (ditches, swales, channels, culvert groups) shall use the Manning equation.

2.6.1.4 Channel Velocity and Flow Depth

Maximum channel velocities shall be limited based on channel type, and channel material type:

Table 2-7 – Maximum Channel Velocities

Channel Lining Type	Maximum allowable velocity (m/s)	Maximum Flow Depth (m)	Governing Criteria
Culverts	Varies	85% of Diameter	Fish Passage, Channel bed erosion
Gravel surface	1.0	0.30	Surface erosion
Minor swales (lawns, grade breaks)	1.0	0.30	Channel bed erosion
Larger ditches and channels	1.5	Top of slope	Channel bed erosion

Channel Roughness

Table 2-8 – Channel Roughness

Channel Material	Manning's roughness coefficient
Culvert (concrete)	0.013
Culvert (corrugated metal)	0.024
Pavements, gutters	0.015
Bare soil	0.020
Vegetated (grass)	0.035
Vegetated (natural channel)	0.040
Vegetated (natural channel, irregular, pools)	0.095
Riprap	0.035

Hydrologic Modelling Parameters

Hydrologic modelling parameters are recommended as follows:

Table 2-9 – Computer Modelling Parameters

Subcatchment Parameters	Value
Catchment Width (m)	Typically based on area divided by flow path length
Flow Path Length (m)	Based on longest of governing hydraulic flow path length
Slope (Residential), (%)	2.0%, or based on lot grading
Slope (commercial, industrial)	1.0%, or based on lot grading
Slope (parks, cemeteries)	1.0%, or based on lot grading
Imperviousness	0 – 100%
Manning's Roughness for Impervious Areas	0.015
Manning's Roughness for Pervious Areas	0.250
Depression Storage for Impervious Areas	2.0 mm
Depression Storage for Pervious Areas	5.0 mm
Percent of Impervious Area with No Depression Storage	25.0%
Infiltration Parameters	
Infiltration Calculation Method	Horton
Maximum Infiltration Rate	100 mm/hr
Minimum Infiltration Rate	13 mm/hr
Decay Constant	4.1 hr ⁻¹
Drying Time	7 days

Runoff Coefficient may be derived from imperviousness, or vice versa, using the following conversion:

Equation 2-8 – Runoff Coefficient from Imperviousness

$$C = (IMP \times C_i) + ((1 - IMP) \times C_p)$$

Where:

- C is the Equivalent Runoff Coefficient (dimensionless, typically expressed as a fraction)
- C_i is the Runoff Coefficient of Impervious Areas, typically 0.95
- C_p is the Runoff Coefficient of Pervious Areas, typically 0.20
- Imp is the Imperviousness (dimensionless, typically expressed as a fraction)

Equation 2-9 – Impervious from Runoff Coefficient

$$IMP = \frac{1}{(C_i - C_p)} C - \left(\frac{C_p}{C_i - C_p} \right)$$

3.0 LOT GRADING AND SURFACE DRAINAGE

3.1 Single Detached Dwelling Residential Lot Grading

Refer to City of Brandon By-Law No. 6626 and the– MSS - Lot Grading Guidelines for lot grading requirements.

3.2 Gratings in Pedestrian Pavements

Gratings in sidewalks or pedestrian pavements should comply with industry standards or good practice guides (e.g. US “Americans with Disabilities Act” Accessibility Standards, Clause 302), namely:

- Gratings should have a maximum opening size of 13 mm. High heel friendly openings of not more than 6 mm may be appropriate in certain situations.
- Elongated openings should be placed so that the long dimension is perpendicular to the direction of travel.

3.3 Parking Lot Grading (Multi-Unit Residential, Commercial, Industrial, Institutional)

Parking lots shall be graded to provide adequate drainage. The following are recommended grading limits:

- Minimum Slope Asphalt surface = 1.0%
- Minimum Slope Concrete surface = 0.5%
- Maximum Slope = 5.0%
- Maximum Ponding Depth = 0.3 m
- All low points must include a spill over or overflow location such that the Maximum Ponding Depth is not exceeded. In the event a parking lot inlet grate is clogged, water ponding above the clogged inlet will spill over the overflow location and drain to another parking lot inlet.

3.4 Roadway Drainage

Pavement drainage design for urban cross-section roadways and bridges (to mitigate the encroachment of flow in gutters and ponding at sag low points into the roadway) must be designed to meet the following requirements.

Note that while freeways/expressways (such as the Trans-Canada Highway) do exist within the City, these roadways fall under Provincial jurisdiction and are not part of the design guidance of this document.

- Maximum gutter flow or ponding encroachment into roadway lanes under minor and major design rainfall shall not exceed the performance standards listed in Table 3-1.

- Gutter depth and flow shall not exceed the maximum values listed in Table 3-2.
- It is always preferable to grade roadways away from intersections than to situate inlets near or within intersections or permit cross-flow. This reduces the likelihood of ponding or icing at intersections and potential for splashing onto pedestrian crosswalks.
- Notwithstanding the above statement, it may be necessary especially in reconstruction situations to provide inlets near intersections to control localized ponding or cross-flow. Inlets should be placed no closer to the intersection than 6.0 m from the ends of curb returns to reduce the impacts of ponding or icing at the intersection
- Longitudinal gutter grading around intersection curb shall be a minimum 1.0% to reduce the potential for nuisance ponding.
- The first catch basin of any urban roadway to be located a maximum distance of 200 m from the nearest high point.
- For continuous grades longer than 200 m, on-grade catch basins must be used. The location and number of on-grade catch basins will depend on the spread limit for the roadway classification type.
- Sag low inlet points shall have a maximum spacing of 120 m.
- Catch Basin capacity for on-grade situations shall be computed using the methods outlined in Appendix 5B, based on HEC-22 Chapter 4 methodology.
- Catch Basin capacity for sag low inlet locations shall be computed based on rating curves for the standard City inlet grates. These rating curves are shown in Appendix 5B. Note that multiple inlets may be required to maintain ponding depth or flow encroachment to within the specified limits.
- The effectiveness of inlets in terms of increased depth over the grates may be improved by locating the inlets outside of the roadway travelway in small turnout pockets.

Table 3-1 – Roadway Drainage Requirements for Traffic Safety

Roadway Classification	Local	Collector	Arterial
Design (Minor) Storm	20% Probability (1-in-5 year)	20% Probability (1-in-5 year)	10% Probability (1-in-10 year) 4% Probability (1-in-25 year) for depressed roadways
Concept	Ponding and Street Storage permitted	Ponding permitted. Road must remain passable.	Ponding permitted. Road must remain passable.
Spread limit	Water may spread to crown	One travel lane open.	One travel lane open in each direction.
Maximum Depth at Crown	0.00	0.00	0.00
Maximum Depth at Gutter	Curb height	Curb height	Curb height
Cross-flow (through intersections)	Controlled cross- flow permitted.	Controlled cross- flow permitted.	Not permitted.
Design (Major) Storm	4% Probability (1-in-25 year) or greater	4% Probability (1-in-25 year) or greater	1% Probability (1-in-100 year)
Concept	Ponding permitted	Ponding permitted. Road must remain passable.	Ponding permitted. Road must remain passable.
Spread limit	Water may spread across crown.	Water may spread across crown.	Water may spread to crown.
Maximum Depth at Crown	0.15 m maximum	0.15 m maximum	0.00
Maximum Depth at Gutter	0.30 m maximum. Curb overtopping permitted, not to encroach on private property	0.30 m maximum. Curb overtopping permitted, not to encroach on private property	0.40 m maximum. Curb overtopping permitted, not to encroach on private property
Cross-flow through intersections	0.30 m maximum	0.30 m maximum	0.15 m maximum over crown or centreline.

Table 3-2 – Maximum Gutter Flow Depth and Velocity for Pedestrian Safety

Flow Velocity (m/s)	Maximum Permissible Depth (m)
1.00	0.32
2.00	0.21
3.00	0.09

4.0 DESIGN OF MAJOR SYSTEM COMPONENTS

4.1 Channels

Channels (ditches, swales, grade breaks) shall be designed for stormwater conveyance of smaller storms and stormwater attenuation during larger rainstorms.

- Channels should be vegetated with native or boulevard grasses, to be specified by the City depending upon the channel location.
- Where flow velocities exceed erosion resistance of vegetation (or maximum channel velocities noted in Table 2-7), riprap armouring shall be used. Erosion resistance of vegetation should be calculated using HEC-15 “Design of Roadside Channels with Flexible Linings”.
- Concrete lined channels may be considered in isolated cases instead of riprap.
- Private easements shall be provided for all swales serving more than two lots or where one or more lots may drain through adjacent private property. A minimum easement width of 3.0 m is required for private lot drainage.
- Channels shall be constructed with maximum 4:1 side slopes, and to the following dimensions:

Table 4-1 – Channel Dimensions

Channel Type	Channel Use	Minimum Bottom Width (m)
V-bottom Swale	Lot grading	N/A
Trapezoidal Channel (Ditch)	Lot grading	1.0
Trapezoidal Channel (Ditch)	Roadside ditch, local streets, collector	1.8
Trapezoidal Channel (Ditch)	Roadside ditch, arterial, highway	3.0

- Deep or wide channel side slopes should be flattened to improve slope stability and to facilitate mowing or haying with larger equipment. Deep channel side slopes shall require a geotechnical assessment for slope stability.
- Roadway gutters that could receive major flow shall be constructed to standard City pavement crossfall and curb or curb and gutter profiles.

4.1.1.1 Channel Slope

Channels should be constructed with the following minimum longitudinal slopes:

Table 4-2 – Minimum Channel Slopes

Channel Type	Minimum Longitudinal Slope (%)
Hard Surfaces	
Roadway Gutters	0.5%
Roadway Gutters around curb return	0.7%
Vegetated Surfaces	
V-Bottom Swale	0.50%
Ditch – 1.0m or less bottom width	0.15%
Ditch – 2.0m or less bottom width	0.10%
Ditch – 3.0m or greater bottom width	0.05%

4.2 Culverts

Culverts may be used for short land crossings (roadway, rail, etc.) of overland flow channels and shall meet the following criteria:

- Minimum diameter of 300 mm, although the City may specify larger minimum sizes for higher capacity ditches.
- Minimum longitudinal slope of 0.5%, with steeper slope of 2.0% being preferable.
- Culverts shall be designed with adequate capacity as follows:
 - Maximum upstream headwater depth of 85% of pipe depth during culvert design flow.
 - Check performance during 1% probability (1-in-100 year) flow to avoid overtopping of the crossing roadway.
- Erosion control measures (e.g. riprap) should be considered at the inlet and outlet for all culverts. Riprap shall be required for all culverts with a diameter of 600 mm or larger.
- Minimum cover shall meet the pipe structure requirements and manufacturer's specifications for protection from live and impact loading and prevent floatation.
- Parallel culverts should be installed with a minimum of one nominal pipe diameter or 1.0 m between pipes, whichever is smaller, to facilitate compaction during construction,
- Culverts through dikes will require shut off valves and an external anti-seepage collar, baffling, high plasticity clay or bentonite cutoff trench or other measures to minimize seepage.
- Culverts should be designed and ballasted to mitigate uplift.
- Culverts larger than 600 mm shall have step bevel mitered or flared end sections to improve hydraulics, better blend to the slope and lessen the amount of exposed pipe in the clear zone or that may be damaged by maintenance equipment.
- Culverts larger than 300 mm entering a closed conduit land drainage system shall include a safety and debris grate. Inlet grates for culverts 600 mm and larger shall be inclined to aid in the floatation of trapped persons or debris.

- Culverts larger than 1050 mm, culverts in fish habitat or any culvert designated as a small animal crossing must include a naturalized stone embedment of 30% of the culvert height and designed to withstand 1% probability (1-in-100 year) flow velocity.
- Corrugated Steel Pipe culverts must be designed with a minimum 75-year service life.
- Acceptable pipe materials include Reinforced Concrete Pipe and Corrugated Steel Pipe.
- Culverts with a diameter of 900 mm or greater or located within major channels require special consideration and may require structural and geotechnical measures to ensure pipes stability. Design calculations including hydraulic performance, erosion protection, fish passage and factor of safety against uplift must be submitted to the City.

4.3 Retention Ponds (Wet Ponds)

Retention ponds, or wet ponds, are stormwater structures featuring a permanent wet basin, designed to attenuate runoff during and following a rainstorm and reduce peak flows to downstream systems. The ponds are designed to slowly drain based on the capacity available in the downstream system. Naturalized design and vegetation are preferred and encouraged as outlined in the City of Brandon Naturalized Stormwater Pond Guidelines (2018).

Retention pond design criteria are as follows:

- Storage volume to be based on the 1% probability (1-in-100 year) design rainstorm event.
- Consideration of the movement of local groundwater into and out of the pond. Impermeable soil liners with a hydraulic conductivity of 1×10^{-6} cm/s or less may be used reduce the potential groundwater infiltration or exfiltration.
- Minimum normal water surface area of 1.0 ha (2.47 ac)
- Preferred length to width ratio of 2:1 to 3:1.
- Avoid narrow or dead areas where floating debris may accumulate.
- Maximum allowable side slopes:
 - 4:1 from pond bottom to nominally 0.5 m below NWL.
 - 7:1 from 0.5 m below NWL to HWL. Side slopes of less than 7:1 may be used if geotechnical slope stability analysis demonstrates that the side slope will have a minimum factor of safety of 1.5 against all types of slope failure, if the pond is fenced above freeboard level, and if the pond is located in an industrial area. Flatter side slopes may be warranted due to soil and groundwater conditions. Steeper side slopes will not be permitted in residential areas.
 - 10:1 above HWL to freeboard level.
- Allowable NWL depths:
 - Minimum NWL depth of 2.0 m.
 - Maximum NWL depth of 3.5 m.

- Active storage depth between NWL and HWL of 1.2 m. Increasing the active depth to 1.5 m may be permitted in certain situations such as commercial or industrial park area and if the designer can provide a valid reason to do so.
 - Freeboard above HWL of 0.6 m. Reducing the freeboard to 0.3 m may be permitted in certain situations if the designer can provide a valid reason to do so.
 - All buildings within 30 m of the pond HWL extents must be constructed with main or basement floor level not less than the freeboard level.
 - Ponds in proximity to the Assiniboine River shall also consider the 100-year return river flood level as the HWL. Such ponds will have two HWLs, one from rainfall and another from river stage.
- Submerged inlet and outlet pipes:
 - Preferred versus unsubmerged inlets and outlets to minimize obstruction from floating debris and reduce ice damage.
 - Crown of inlet and outlet pipes must be a minimum of 0.6 m below NWL, to situate them below the depth where a person might wade onto the pipe.
 - Submerged inlets or outfalls do not require grates unless they are exposed during low flow periods. Shall be located to mitigate short circuiting of flow through the pond, to promote settling of sediment.
- Unsubmerged inlet and outlet pipes:
 - Must include headwalls and grates.
 - The outlet must be set at or nominally below NWL. Outlet pipe inverts will not be considered to be an elevation control structure, a control weir is required.
- Weir control structures are required for all retention ponds. These structures must be a closed manhole, and must be designed to provide minor adjustment for levelling of the weir (e.g. a weir plate with minimum 100 mm of vertical adjustment for levelling).
- Pond maximum drawdown time:
 - 48 hours (2 days) or less following the end of 20% probability (1-in-5 year) rainfall.
 - 120 hours (5 day) or less following 1% probability (1-in-100 year) rainfall.
- Minimum 3.0 m buffer strip required between pond HWL and property lines or park dedications.
- Shoreline erosion protection shall be provided for 1.5 horizontal metres below NWL and a minimum of 0.6m above HWL.
- Pond must include signage for public education and safety.

4.4 Detention Ponds (Dry Ponds)

Detention ponds, or dry ponds, function the same as wet bottom retention ponds, however instead of a permanent water body, a basin with a dry bottom is used. Retention ponds are preferred over detention ponds; however, detention ponds will be considered where construction of retention ponds is not feasible.

Detention ponds design criteria are as follows:

- Storage volume to be based on the 1% probability (1-in-100 year) design rainstorm event.
- Detention ponds shall not be used to retain runoff for design rainstorms of 50% probability (1-in-2 year) or smaller.
- Preferred length to width ratio of 2:1 to 3:1.
- Maximum side slopes of 7:1.
 - Slopes steeper than 7:1 may be used if geotechnical slope stability analysis demonstrates that the side slope will have a minimum factor of safety of 1.5 against all types of slope failure, if the pond is fenced above freeboard level, and if the pond is located in an industrial area.
- If the detention pond also acts as a conveyance with flow-through, include a low flow channel designed to accommodate 50% probability (1-in-2-year) flow. This channel shall have a minimum depth of 0.3 m.
 - Where low flow channels are not included or not appropriate because the pond bottom will be used for sporting or recreation when dry, a subdrainage system should be used to improve drainage and aid in drying the pond bottom following a rainstorm.
- Pond bottom to include both longitudinal slope and crossfall of minimum 1.0% to promote drainage of the pond following rainstorms. Steeper 2% crossfall is preferred to aid in drying of the pond bottom and reducing the potential for nuisance ponding and mosquitoes.
- Active storage depth between pond bottom and HWL of 1.2 m maximum. Freeboard above HWL of 0.6 m. Reducing the freeboard to 0.3 m may be permitted in certain situations if the designer can provide a valid reason to do so.
 - All buildings within 30 m of the pond HWL extents must be constructed with main or basement floor level not less than the freeboard level.
- Increasing the active depth to 1.5 m may be permitted in certain situations if the designer can provide valid rationale to do so.
- Inlets, outlets or combined inlet / outlet pipes whether a culvert or connection to a closed conduit land drainage system must include inclined grates to force persons and floating debris up towards the water surface.
- The entire pond footprint to be vegetated with upland grass seed, or a combination of upland grass seed on the slopes and specialized wet meadow grass seed in the pond bottom area. The City may request the use of boulevard seed for specific park areas for compatibility with existing or proposed landscaping. Proposed seed mixes are to be submitted to the City for approval.

- Ponds must include signage for public education and safety.

4.5 Naturalized Stormwater Ponds (NSP)

Naturalized Stormwater Ponds shall meet criteria provided in the City of Brandon Naturalized Stormwater Pond Guidelines (2018).

4.6 Underground Stormwater Storage

- Underground stormwater storage (tanks, oversized pipes, grid structures) may be used on private sites to attenuate flow and manage discharge from the site but will not be acceptable for use in public property or rights-of-way where the City is expected to take ownership.

5.0 DESIGN OF MINOR SYSTEM COMPONENTS

5.1 Storm Water Pipes

5.1.1 Sizing

Storm sewer pipes shall be sized to accommodate design flows and shall have a minimum diameter of:

- 375 mm for mainline land drainage sewers.
- 300 mm for catch basin leads.

5.1.2 Depth of Cover

The minimum depth of cover to crown of pipe shall be:

- 1.8 m for mainline land drainage sewers mains.
- 1.2 m for catch basin leads and must be at least 0.1 m below bottom of granular road structure.

A maximum preferred depth of 6.0 m to pipe invert for all pipes, except under certain situations such as inverted siphons undercrossing other infrastructure. Local topography may require deeper sewers and these special locations should be reviewed with the City prior to finalizing design.

Pipes must be designed to prevent floatation. In high groundwater areas, a subdrain system may be installed within the mainline sewer trench to promote localized lowering of groundwater. These subdrains should be connected to both upstream and downstream manholes. The subdrains need not be placed near or below the mainline sewer invert, it is usually sufficient to situate them at an elevation matching mainline sewer crown.

5.1.3 Clearances

Table 5-1 – Minimum Storm Sewer Main Separations

Sewer Main in Proximity to:	Minimum Clearance (m)	
	Horizontal ¹	Vertical ²
Domestic Sewer Mains	3.0	0.5
Watermains	3.0	0.5
Water Services	3.0	0.3 ³
Existing or Proposed Shallow/Above Ground Utilities	3.0	
Domestic Sewer Manholes	3.0 ³	
Edge of Right of way and/or Easements	3.0	

¹ Separation is defined as centreline to centreline.

² Separation is defined as actual clearance from outside of pipe to outside of other pipe.

³ Where separation from domestic sewer manholes of water services cannot be met, manhole sidewall or pipe crossing shall be insulated.

5.1.4 Alignment

Land Drainage Sewer mains must be designed as follows:

- Straight alignment between manholes, at an offset parallel to the adjacent property line.
- Located within the street section of the road right of way. Where sewer mains are not located within a road right of way, manholes and other appurtenances shall be accessible by a route suitable for travel by a heavy maintenance vehicle.

5.1.5 Pipe Material

Refer to SCS for allowable pipe materials

5.1.6 Pipe Structure Design

Refer to Appendix 5B for pipe structure design.

5.2 Catch Basins

5.2.1 Catch Basin Locations

Catch basins shall be located:

- At all low points within pavement.
- As required on continuous roadway slopes to manage flow encroachment into travel lanes.
- Outside of:
 - Intersections, minimum 5m away from of stop lines or ends of intersection curb returns
 - Cross walks
 - Driveways
- Rear yard catch basins within residential neighbourhoods will not be permitted.

5.2.2 Catch Basin Capacity

Catch basin inlet capacity shall ensure that ponding limits in Subsection 0 are not exceeded, and multiple catch basins may be required.

5.2.3 Catch Basin Barrels

- Barrel diameter: 750 mm or 900 mm (see 5.3.4 for catch-basin manholes)
- Sump depth: 600 mm

5.2.4 Catch Basin Leads

All catch basin leads that discharge to LDS systems shall tie in at a manhole. Where catch basin leads discharge to an overland system, an outlet grate must be used on the downstream end.

- Maximum lead length shall be 30 m, if a longer catch basin lead is required then a catch basin-manhole should be substituted
- Minimum lead size shall be 300 mm, with a minimum slope of 1.0%.
- Minimum lead size shall be 375 mm when two or more catch basins are connected together. Hydraulic calculations shall be provided to confirm the sizing of catch basin leads serving more than two catch basins.

5.2.5 Catch Basin Restriction

Where restriction is required to limit the amount of flow into the catch basin lead (to provide increased surface storage or ponding), restriction shall be achieved by a permanent device (such as grouting a smaller restriction pipe into the catch basin lead invert at the manhole). Orifice plates, or any removable restriction device will not be permitted as they may easily be removed intentionally or unintentionally by persons who do not understand their intended purpose.

Catch basin restriction undertaken as a retrofit on a public catch basin must consider the potential encroachment of ponding onto private property and mitigate the potential for private property damage.

5.3 Manholes

5.3.1 Manhole Locations

Manholes shall be located at:

- the upstream end of each land drainage sewer main.
- changes in pipe size.
- changes in alignment
- All junctions.

Manhole spacing shall not exceed 120 m.

5.3.2 Manhole Barrels

All manhole barrels shall:

- have a minimum diameter of 1200 mm when connected pipe diameters are 525 mm or less.
- have a minimum diameter of 1500 mm when pipe diameters exceed 525 mm.

- Manholes serving larger sewers shall maintain a minimum of 300 mm of intact barrel between pipe penetration breakouts.

Refer to the manufacturer's recommendations for minimum manhole diameters to suit various connecting pipe sizes and connection angles. Suggested minimum manhole sizes are shown in Table 5-2.

Table 5-2 – Suggested Minimum Manhole Diameters

Sewer Diameter (mm)	Manhole Diameter (mm) Straight Through Installation	Manhole Diameter (mm) Right Angle Installation
450 and smaller	1200	1200
525	1200	1350
600	1350	1500
750	1500	1800
900	1800	2100
1050	1800	2400
1200	2100	2700

Manholes shall be designed to resist floatation.

5.3.3 Hydraulic Losses

Hydraulic losses at manholes shall be managed by:

- Providing benching to the spring lines of connecting pipes.
- Dropping downstream inverts by 30 mm for deflection angles between inlet and outlet greater than 45° but not exceeding 95°.
- The preferred vertical alignment for pipes is to match pipe crowns at pipe diameter changes, however matching inverts may be permitted if it can be demonstrated that preserving pipe depth of cover is required.

5.3.4 Catch Basin Manholes

Catch basin manholes, or manholes located at low points with surface water inlet covers may be used at the discretion of the City. Catch basin manholes shall include:

- Minimum barrel diameter: 1200 mm.
- Sump depth: minimum 300 mm.
- Manholes on the upstream and downstream side of inverted siphons shall include a minimum 300 mm sump.

5.4 Outfalls

The following design criteria shall apply to stormwater outfalls to a receiving water body such as a pond or the Assiniboine River:

- Outfalls shall be submerged where possible, with a minimum depth of from NWL to invert of 1.5 m, or minimum water depth above the pipe crown of 1.0 m, whichever provides greater depth between pipe crown and NWL. This situates the pipe outside of the zone where it could be subject to damage from ice or floating debris
- Where submergence is not possible:
 - The outfall invert shall be located minimum 300 mm above NWL.
 - If discharging to a river or stream, the outfall shall be protected from ice or waterborne debris damage by inseting the end of the pipe into the riverbank by a minimum horizontal distance of 3.0 m.
 - Outlet erosion protection including riprap with separation geotextile underlay placed downstream of the outfall to the bottom of the receiving water body or extend a minimum of 3.0 m into the water body. The riprap shall be inset into the riverbank such that to top surface of the riprap matches the existing riverbank.
 - The outfall pipe trench shall include a 300 mm thick granular drainage layer below the granular pipe surround to aid in the equalization of local groundwater and receiving water level. This granular drainage layer shall extend 15 m upstream of the end of pipe or to the top of pond freeboard level or the top of natural riverbank, whichever is greater.
 - If the outfall pipe penetrates a dike, the granular drainage layer must terminate at the dike and an anti-seepage collar, diaphragm, or high plasticity clay or bentonite-enriched cutoff trench installed to minimize the potential for seepage.
 - Include an outlet safety grate to prevent access. The grate should be constructed of galvanized steel with nominal horizontal bar spacing of 150mm.

Stormwater outfalls to a receiving open channel:

- Include riprap, complete with geotextile placed downstream of the outfall to the opposite side of the receiving ditch and up the opposite ditch side slope to prevent erosion. The riprap shall be inset into the channel or riverbank such that to top surface of the riprap matches the channel or riverbank surface.
- Include a removable safety grate with nominal horizontal bar spacing of 150 mm to prevent access.

5.5 Oil and Grit Separators

Oil and grit separators (OGS) may be required at the City's discretion for locations where potential discharge of hydrocarbons or contaminated sediments may be present.

Oil and grit separators are required for:

- Industrial, Commercial, Institutional or Multi-Unit Residential sites with 1500 m² or greater paved areas.
- All commercial or industrial sites which handle hydrocarbons such as gas stations, lube and oil change facilities, vehicle maintenance and mechanical shops, and sites with on-site fuel storage.

Oil and grit separators design criteria is as follows:

- Sized to capture a 1-hour, 50% probability (1-in-2-year) post development flow.
- Remove at least 85% Total Suspended Solids (TSS) during 2-year flow, based on the target particle size greater than or equal to 75 microns. Assumed sediment composition for design is shown in Table 5-3.
- Include a high flow bypass for larger storms to avoid resuspension of settled solids.
- Located upstream of stormwater ponds, underground storage tanks, or pumping stations to prevent sediment and oil from entering these facilities.

The following sediment profile should be used for sediment capture estimates, based on water at 4° C:

Table 5-3 – Sediment Composition (based on City of Calgary 2011)

Size Range (µm)	Target Particle (µm)	Particle Density (kg/m ³)	Settling Velocity (m/s)	Fraction of Total Load (%)
<10	10	1500	1.738 E-05	23%
10 - 20	20	2000	1.389 E-04	9%
20 - 50	50	2500	1.304 E-03	13%
50 - 75	75	2650	3.221 E-03	11%
75 - 150	150	2650	1.240 E-02	12%
>150	300	2650	3.229 E-02	32%