CITY OF SWIFT CURRENT

where life makes sense

PART A4

STORM DRAINAGE SYSTEM

OCTOBER 2020

1 GENERAL

Designing and accommodating storm drainage is essential to minimize property damage, flooding, safety in roadways, and impacts on other infrastructure. The majority of drainage in Swift Current makes its way to the Swift Current Creek through overland and underground infrastructure.

The design of the storm drainage system shall conform to "Stormwater Guidelines", latest edition, as published by the Saskatchewan Ministry of Environment and used as a companion to the applicable Acts, regulations, and other provincial publications and as amended by these Guidelines and Standard Details.

These Development and Design Standards shall be used in conjunction with the related City Construction Specifications.

2 DEFINITIONS

The following definitions are intended to be specific to the Storm Water Distribution System Standards. For additional general definitions refer to Part A1 – General Requirements.

Hydraulic Analysis: An Engineering analysis determining the water systems minimums to meet provincial or federal requirements.

Minor System: A network of sewer pipes, inlets, and street gutters, which are designed to rapidly convey storm water runoff from minor rainfall events. For purposes of these standards, a minor rainfall event is defined as a storm having a 1 in 5 year return period.

Major System: A major system consists of overland flow routes, swales, watercourses, outfalls, and storage facilities that are planned as part of the urban infrastructure to convey runoff from major rainfall events. For the purposes of these standards, a major rainfall event is defined as a storm having a 1 in 100 year return period.

Manning's Equation: Is a common equation that applies to flow in open channels, taking into account velocity, flow area and slope.

Rational Method: Method of estimating the peak runoff rates for the design of urban drainage systems.

Return Period: The return period of a rainfall event is the inverse of the statistical probability that a storm of a given size will occur in any given year based on historical data (i.e. 1 in 5yr return period = 20% chance of occurrence in any given year).

3 SUBMISSIONS AND APPROVALS

3.1 MASTER DRAINAGE PLAN

Where required by the City for larger scale developments, a Master Drainage Plan shall be prepared and used in developing and comparing alternatives, and to select the optimum storage and drainage solution for a development area. This Plan should provide, as a minimum, the following information:

- Detailed description of the development area, including proposed street layout, locations of parks, direction of overland flow, natural storage and drainage sub-catchment boundaries, etc.
- Identify and quantify the amount of upstream drainage entering onto the proposed development lands, including all points of entry.
- Identify the impact of the proposed development on the watershed.
- Identify all existing flow channels, drainage patterns or routes, and containment areas.
- Identify the point(s) of discharge from the lands, as well as the type and calculated capacity of the receiving drainage facility(s), whether natural, man-made, or a combination of both.
- Provide details of water quality enhancement facilities.
- Identify all licensing requirements as may be required by Saskatchewan Environment.
- Post-development hydrographs for the 5-year and 100-year events to be determined at key points in the system.
- Delineation of flood lines for the 100-year design storm for creeks or watercourses.
- Description and discussion of storage alternatives. All alternative storage and runoff control methods shall be reviewed and shall include, but not be limited to:
    - retention storage;
    - detention storage;
    - off-line stream storage;
    - channel storage;
    - on-line storage; and
    - wet ponds (retention storage) or dry ponds (detention storage).

  In reviewing the alternatives, the optimum number and location of the stormwater facilities shall be determined, bearing in mind the total system.
- Detailed description of the selected alternatives.

3.2 SITE DRAINAGE PLAN

3.2.1 Drainage from a single residential site, up to six units may be directed off site and into the adjacent public right of way where there is an existing storm drainage system.

3.2.2 For development on a commercial, industrial, multi-family residential (over 6 units) property, or a subdivision, a detailed Site Drainage Plan shall be prepared, submitted, and approved prior to a development permit being issued by the City.

3.2.3 Site Drainage Plans shall be in accordance with any approved Master Drainage Plans for the applicable area.

3.2.4 Site Drainage Plans shall be designed in accordance with Section 4 - Design Requirements of these standards.

3.2.5 For development where there is not a current Master Drainage Plan a sub-basin storm drainage evaluation will be required at the discretion of the City. This evaluation may be completed by the City, or for larger developments will be required by the developer. All Site Drainage Plans shall conform to the sub-basin storm drainage evaluation.

3.2.6 The Rational Method may be used to calculate the Minor (1 in 5yr) and Major (1 in 100yr) rainfall events. All site plans will be checked based on the Rational Method of Design.

3.2.7 With the exception of residential development up to 6 units, a development site can discharge up to a 1 in 5 year rainfall event unless otherwise specified in a Master Drainage Plan, or sub-basin storm drainage evaluation.

3.2.8 The site drainage plan shall clearly identify the following items:

- 1 in 5 year peak flow rate
- 1 in 100 year peak flow rate
- Computation of site area
- Finished grade elevations
- Paved and unpaved areas (indicated by hatching or text)
- Surface drainage patterns (arrows indicating direction of flow)
- Catch basins with both top and invert elevations
- Stormwater retention areas with calculations
- The stormwater retention calculations may be represented in a chart and shall include the following:
    - 1 in 5yr and 1 in 100yr return period peak flow rates
    - Allowable discharge to main (1 in 5yr shown as Q1) and actual discharge to main from retention area (shown as Qa)
    - List of runoff coefficients used
    - Area breakdown (paved, gravel, landscaped, roof, etc)

- Roughness coefficient used (PVC = 0.011, concrete = 0.013)
- Storage volume required and actual volume provided on site, including top and bottom elevations of retention feature
- Intensity (mm/hr)
- Size/type of ICD used, if necessary.

3.2.9 Sanitary sewer manholes and cleanouts that may be required on Commercial/Industrial properties are not to be located within the trapped low or detention/retention areas in order to prevent infiltration into the sanitary sewerage system.

3.2.10 All Drawing plans and Engineering documents will need to be submitted to the City for approval. All design drawings will follow the requirements stated in the drawings section of the General Requirements.

4 DESIGN REQUIREMENTS

4.1 CAPACITY ANALYSIS

For areas less than 65 ha,

4.1.1 The *Rational Method* shall be used to design minor storm systems and the *Modified Rational Method* shall be used to design major storm systems.

4.1.2 The formula to be used for the Rational Method is as follows:

$$Q = 2.78\,CIA$$

Where: Q = the design peak flow rate in litres per second
I = the intensity of rainfall in millimetres per hour, corresponding to the time of concentration (*Figure 4.1*)
A = the contributing area in hectares
C = the runoff coefficient

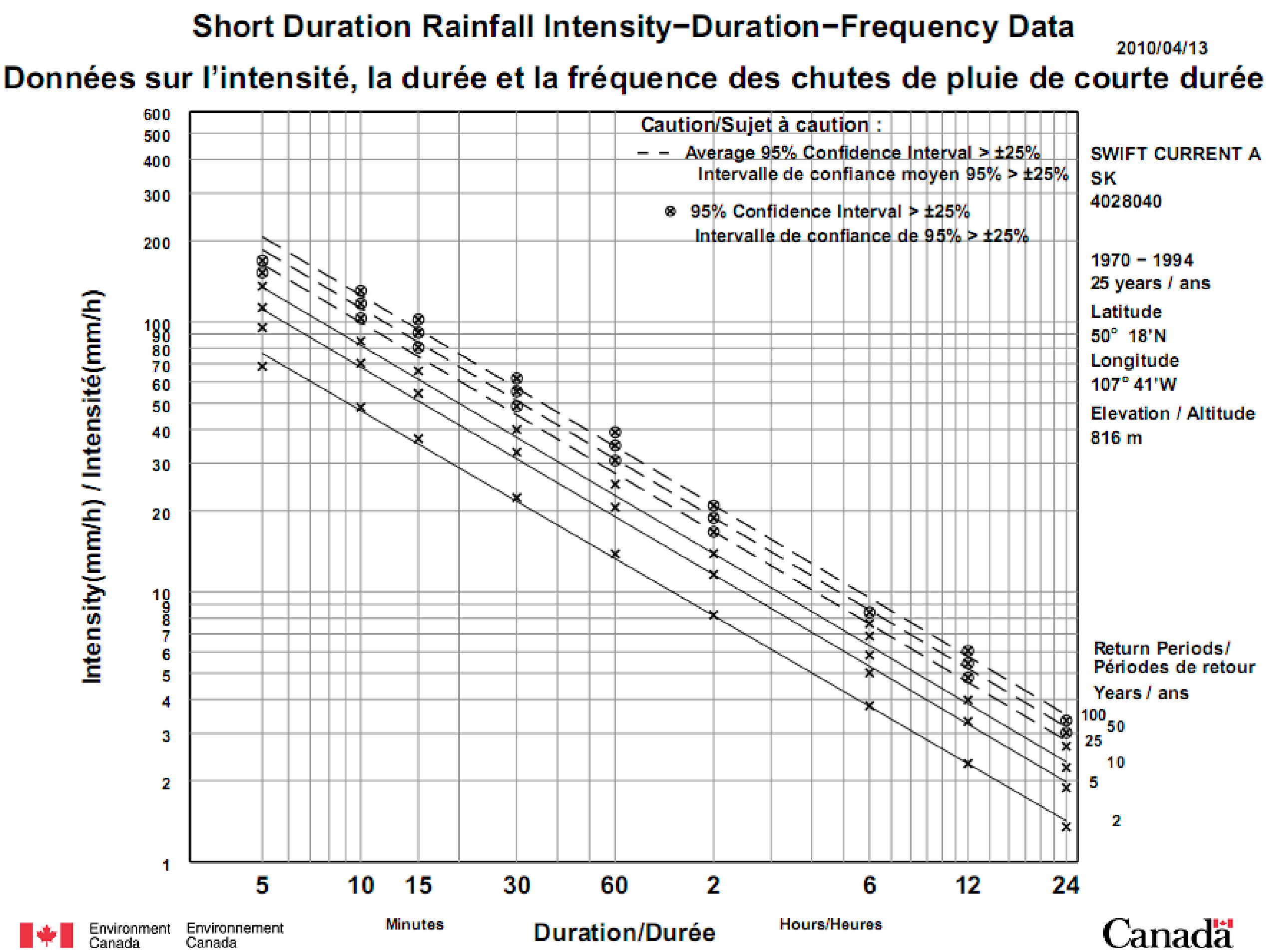
4.1.3 The Modified Rational Method will be used for the design of systems when the specified design has a return period greater than ten (10) years. This shall include the design over overland systems as well as on-site storage for site developments. The Modified Rational Method introduces a modifier which increases the runoff coefficient for larger events to accommodate for inaccuracy of the Rational Method when completing calculations on these events. The runoff coefficient in the formula shall be increased by the following factors to a maximum runoff coefficient of 1.0:

25 year add 10%
50 year add 20%
100 year add 25%

Intensity

4.1.4 *Figure 4.1* (or the current version) can be used to determine the intensity of rainfall ("I" value) in the Rational Method formula.

Figure 4.1



Note: Based on the Intensity-Duration-Frequency data for the Swift Current Airport.

4.1.5 For Minor Systems the 5 year return period in *Figure 4.1* shall be used.

4.1.6 For Major Systems the 100 year return period in *Figure 4.1* shall be used.

4.1.7 Alternatively, the intensity of rainfall ("I" value) may be manually calculated instead of using *Figure 4.1* (Intensity-Duration-Frequency chart). The formula to be used when calculating rainfall intensity is:

$$I = A/(T_c + B)^c$$

Where: I = intensity (mm/hr)
T_c = Time of Concentration in hours
A,B,C = Parameters for the selected return period

The data in *Table 4.1* (from IDF curve data) shall be used for the A, B, C parameters when using the manual calculation method for rainfall intensity.

Table 4.1

Return Period	A	B	C
2	14.3	0.033	0.739
5	21.0	0.048	0.762
10	25.4	0.054	0.771
25	30.9	0.059	0.779
50	35.1	0.062	0.784
100	39.2	0.064	0.787

For example, the intensity of a 1 hour storm, using a 5 year return period for a minor system component, would be calculated as:

$$I = 21.0 / (1 + 0.048)^{0.762} = 20.3 \text{ mm/hr}$$

Time of Concentration

4.1.8 When completing rainfall intensity calculations for the purposes of the Master Drainage Plan, an event of twenty-four (24) hours shall be considered.

4.1.9 For Site Drainage design the duration of rainfall used to determine the intensity shall be equal to the time of concentration. The time of concentration is the time of the overland flow to the minor system inlet as well as the travel time in the minor system. The overland flow time in residential and commercial areas shall not exceed 10 minutes in duration. In industrial areas specific overland flow times shall be computed separately using an approved method. The time of travel within the minor system shall be computed based on the pipe velocity.

4.1.10 Inlet times for overland flow from a catchment area to entry points of the minor systems or overland conveyances shall be computed using the Kerby/Hathaway formula as follows:

$$t_i = 1.444 (L \times n / S^{0.5})^{0.467}$$

Where: t_i = Inlet time in minutes
L = Distance of travel in meters
n = Manning's roughness coefficient for sheet flow (dimensionless)
S = Slope in m/m

4.1.11 Velocity calculations for the design of minor systems shall be completed using the Manning's equation as follows:

$$V = (1/n) S^{1/2} R^{2/3}$$

Where: V – Velocity in meters per second
n – Manning's roughness coefficient (dimensionless)
S – Slope in m/m
R – The channel flow area divided by the wetted perimeter in meters

The travel time, in seconds, is then equal to the length of pipe in the minor system, in meters, divided by V.

4.1.12 The time of concentration shall be computed by the addition of the inlet time to the computed travel times in the minor system.

For example, if runoff flows over 80 m of grass (n = 0.030) on a 1% slope before entering a minor system, and then travels through 12 m of 300 mm diameter concrete pipe (n = 0.013) flowing half full (R = 0.075) on a 0.44% slope, the time of concentration would be the inlet time plus the travel time, calculated as follows:

$t_i = 1.444\ (80 \times 0.030 / 0.01^{0.5})^{0.467} = 6.4$ minutes
$V = (1 / 0.013) \times 0.0044^{1/2} \times 0.075^{2/3} = 0.9$ m/s
$t_t = 12 / 0.9 = 13.2$ minutes
$T_c = 6.4$ minutes + 13.2 minutes = 19.6 minutes

This value would then be used to calculate the rainfall intensity as shown above.

Runoff Coefficient

4.1.13 The following runoff coefficients shall be used for the 1-in-5 year analysis:

Pavement	=	0.90
Parks	=	0.15
Residential	=	0.30
Industrial	=	0.70
Commercial	=	0.70
Multiple Family	=	0.70

Other coefficients generally used by the City may include:

Pervious surfaces	=	0.15
Impervious Surfaces	=	0.90
Landscaped Areas	=	0.30
Gravel Areas	=	0.70

4.1.14 The weighted average of runoff coefficients for a composite area shall be estimated from the following equation:

$$C = \sum (C_i \times A_i) / \sum A_i$$

Where the subscript "i" refers to individual areas and their respective runoff coefficients.

For example, for a 100 ha area which is 25% Residential, 15% Parks, and 60% Commercial, the runoff coefficient would be calculated as:

$$C = (0.30 \times 25 + 0.15 \times 15 + 0.70 \times 60) / 100 = 0.52$$

For areas greater than 65 ha:

4.1.15 Computer models shall be used to determine design flows and the sizing of systems that contain non-pipe stormwater management facilities (e.g. detention ponds) or systems that include a significant amount of undeveloped land.

4.1.16 The selection of an appropriate computer model shall be based on an understanding of the principles, assumptions, and limitations in relation to the system being designed.

4.1.17 Wherever possible, the computer model shall be calibrated. In all analyses, the parameters used, the drainage boundaries, the pipe network, and its connectivity shall be clearly identified on an overall drawing, computer printouts, and a design summary report.

4.1.18 The critical design rainfall hydrograph shall be selected. Both the AES Distribution (for long duration) and the Chicago Distribution (for short duration) will be evaluated.

4.1.19 The storm duration of an event is critical for the system being designed and shall be used to determine pipe sizes. The 5 year 4-hour Chicago Distribution event shall be selected. For systems involving storage design, both short duration and longer duration events such as the AES 24 hour event should be evaluated.

4.2 STORM MAINS

4.2.1 The minimum size of storm sewer mains shall be 300 mm diameter.

4.2.2 Pipe classes shall be determined to withstand subsequent superimposed loadings.

4.2.3 Various factors affecting the pipe class shall be taken into account, and pipe class shall be evaluated as per standard engineering practice.

4.2.4 The minimum velocity within a piped system shall be 0.70 m/s. Where greater velocities in excess of 3 m/s are attained, special provisions shall be made to protect against displacement by erosion or impact. Designs containing velocities in excess of 3 m/s shall require special provisions for invert scouring and pipe anchoring.

4.2.5 Pipe sizing shall be determined by utilizing the Manning's Formula, using an "N" value of 0.013. The minimum inside diameter for storm sewer pipe shall be 300 mm.

4.2.6 Storm sewer pipe shall be designed to convey the design flow when flowing full, with the hydraulic grade line at the pipe crown. All pipe crown elevations shall match at manhole junctions.

4.2.7 Surface water shall be intercepted with a sufficient number of catch basins such that the inlet capacity is sufficient to receive the design storm water flow. Catch basin capacity shall be considered, as shown on Table 5.3, where values are given for sag conditions and on slope conditions based upon inlet grate type.

4.2.8 Roadway ditches and swales will efficiently convey run-off through the storm drainage system. Roadway ditches and swales will not be used for stormwater detention or retention.

4.2.9 Mains shall be installed to provide a minimum depth to pipe obvert of 1.2 m below final finished grade.

4.2.10 Mains shall be installed in accordance with cross sectional drawings located in Standard Drawings.

4.2.11 Pipe bedding shall be provided for all mains in accordance with the Standard Drawings. A sample of the proposed bedding sand shall be submitted to the City for approval prior to the commencement of construction. All storm sewermains shall have a minimum of 150 mm bedding under the pipe and 300 mm above the pipe.

4.2.12 *Table 4.2* lists the minimum slopes that must be used for various pipe sizes:

Table 4.2

Storm Sewer Size	Minimum Slope (%)	
	Concrete Pipe n = 0.013	PVC, PE Pipe n = 0.011
300mm	0.44	0.32
375mm	0.32	0.24
450mm	0.26	0.18
525mm	0.22	0.16
600mm	0.18	0.12
675mm	0.15	0.11
750mm	0.13	0.10
≥900mm	0.10	0.10

4.2.13 The design engineer should always keep in mind that fulfilling the requirements of minimum slope can ensure the minimum velocity, but the capacity of the sewermain will be reduced and may not carry the estimated quantity of run-off. Therefore the provision of high percentage of slope is always recommended to obtain maximum capacity (viable) for each size of sewermain.

4.2.14 The minimum slope for curved pipes and dead-end pipes shall be 50% greater than the minimum slopes required for straight runs.

4.3 MANHOLES

4.3.1 Transitions in size, grade, or direction of sewer pipes are to be accomplished by means of manholes except in the case of curved sewer. Manholes are also to be installed at the beginning and end of the curve for curved sewers and at the intersection of storm sewer mains.

4.3.2 The maximum distance between manholes for pipe sizes 200 mm – 375 mm is 120 m and for pipes 450 mm and larger is 150 m. In all cases, a manhole is required at the upper end of a sewer for maintenance purposes. Manhole spacing on storm sewers greater than 750 mm in diameter may exceed 150 m if approved by the City.

4.3.3 Benching in manholes shall be provided to minimize hydraulic losses. The downstream invert in a manhole shall be a minimum of 30 mm lower than the lowest upstream invert. At a change in direction, the drop shall be at least 60 mm. If an influent pipe diameter is greater than 525 mm and the bend is greater than 45 degrees, or if the outflow pipe velocity exceeds 1.5 m/s, then minor losses shall be considered (see AISI, 1980).

4.3.4 If the difference in elevation in the inverts of an inlet pipe and the outlet pipe is greater than 600 mm then a drop structure shall be installed. Internal drop structures are permitted as long as a minimum 900 mm clear space is maintained from the inside wall to the tee of the drop structure and the vertical drop pipe may be sized one pipe size smaller than the influent pipe. Where a drop structure is required for 600 mm diameter and larger inlet pipe or flow velocities greater than 3.0 m/s are proposed, the drop structure shall be an exterior drop with energy dissipation devices in the manhole.

4.3.5 Every storm sewer shall have a manhole or manhole/catch basin at the upper end of the system for maintenance purposes.

4.3.6 Types of manholes, along with frames and covers to be used, shall conform to the storm sewer specifications which accompany these documents.

4.4 CATCH BASINS

4.4.1 Catch basin barrels along with frames and covers shall conform to storm sewer specifications outlined in these documents.

4.4.2 Catch basin manholes shall be used in place of a catch basin when the lead exceeds 30 m in length or where one catch basin discharges into another.

4.4.3 Catch basin leads:

- The minimum size of catch basin leads shall be 250 mm diameter with a minimum grade of 2.0%.
- The minimum grade on a 300 mm catch basin lead shall be 1.0%.
- Two catch basins may be connected in series. The catch basin lead connecting to the storm sewer manhole shall be 300 mm at a minimum slope of 1.0%.
- The maximum length of a catch basin lead shall be 30 m.
- If a lead of over 30 m in length is required, a catch basin manhole shall be installed at the upper end.
- Catch basin leads shall have a minimum cover of 1.2 m to obvert.
- All leads shall be connected to a main line manhole or a catch basin manhole.

4.4.4 Catch basins shall be “twinned” (two basins built side by side) and interconnected at points where there is a large trapped drainage catchment area, accumulation, or where a large amount of water after bypassing upstream catch basin which are situated on a very long steep street.

4.4.5 Inlet control devices (where required) must be shown on all drawings.

4.4.6 Catch basin spacing shall range from 90 m to 150 m depending on road slopes and configuration.

4.4.7 Closer spacing may be required for flat grades and at all corners where storm sewers exist, except in the case of a high corner (i.e. Drainage away from corner in both directions.)

4.4.8 The maximum length of drainage in lanes shall be 200 m. The length of drainage in a lane is to be minimized where possible. Where catch basins are located in lanes, it is necessary to compact utility trenches and pave 6 m in all directions from the catch basin, up to the property lines. Trap lows in lanes should be avoided when possible.

4.4.9 Catch basins at intersections are to be positioned at the low side of the corner grade at the BC and EC of the curb return.

4.5 OIL AND GRIT SEPERATORS

Oil and grit separators are underground detention structures that are designed to capture hydrocarbons and sediment. They replace conventional manholes in the storm water drainage system and are typically used in areas that have potential for discharge of hydrocarbons and/or polluted sediments.

4.5.1 A high flow-rate bypass oil/grit separator or approved equivalent pre-treatment system may be required to remove sediments and other pollutants from runoff. The City will evaluate the need for such pre-treatment devices on a case-by-case basis.

4.5.2 Most oil/grit separators are proprietary products. The Designer should contact the Infrastructure and Operations Department of the city to determine if a specific oil/grit separator type system is acceptable for the specific conditions of a site. If on-site detention is also required, such detention storage shall be provided upstream of the oil/grit separator. Manufacturers' guidelines are to be followed for any specific oil/grit separator. All sizing and design information shall be provided with the detailed engineering plans.

4.6 CONNECTIONS TO STORM SEWERS

Only catch basins and approved private storm services shall be connected to the City's storm sewer.

4.7 CURVED SEWERS

Curved sewers will be permitted, with the following restrictions:

4.7.1 The sewer shall be laid as a simple curve, with a radius equal to or greater than 90 m or the manufacturer's minimum recommended radius, whichever is larger.

4.7.2 Manholes shall be located at the beginning and end of the curve.

4.7.3 Manholes shall be located at intervals not greater than 90 m along the curve.

4.7.4 The main shall run parallel to the curb or street centerline.

4.7.5 The minimum grade for sewers on curve shall be 50% greater than the minimum grade required for straight runs of sewers.

4.8 STORM WATER MANAGEMENT FACILITIES

Storm Water Management Facilities consist of lakes, wet ponds, and dry detention ponds. These facilities are typically a part of the Major Storm Water System. The following characteristics apply to Storm Water Management Facilities:

4.8.1 The design of Storm Water Management Facilities shall conform to Best Management Practices.

4.8.2 The approximate location and size must be identified at the time of the Development Concept Plan, or Master Drainage Plan, to avoid conflicts with adjacent land uses.

4.8.3 The effects of maximum pond water levels shall be considered in the design of the minor system and lot grading. If possible, the crown elevations of the pipes in the first manhole upstream of a pond shall be at or above the maximum pond level during the five-year storm event.

4.8.4 A sediment control plan is required as a part of the Storm Water Management Study to define measures that must be taken for the control of sediment into the pond and into the receiving stream.

4.9 DRY DETENTION PONDS

4.9.1 Dry pond (detention) storage is the storm water management method where the storm run-off is collected and the excess run-off is temporarily detained for a short period of time and released after the storm run-off from the contributing area has ended. Generally, low flows do not enter the pond.

4.9.2 The City should be contacted to provide input to the design of detention facilities from the concept stage through to detailed design and construction.

4.9.3 Dry ponds should have gentle side slopes and be aesthetically contoured and landscaped to provide an attractive feature for the subdivision.

4.9.4 Where possible, and as agreed by the City, they should be associated with municipal reserve areas to take advantage of the joint use ability of the facilities (e.g. extension of sport fields or passive park uses into the detention pond). Active park uses should not be located adjacent to the inlet/outlet facilities nor in areas that flood frequently (more than twice per year on average).

4.9.5 The following general design parameters should be considered for a dry pond in a residential subdivision:

- Storage capacity for up to the 100-year storm event.
- Detention time to be determined based on downstream capacity; recommended maximum detention time is twenty-four (24) hours.
- Maximum active retention storage depth of 1.5 m. The maximum water level should be below adjacent house basement footings (a greater freeboard may be required if an emergency overflow route cannot be provided).

- Maximum interior sideslopes of 5:1 (7:1 is recommended).
- Maximum exterior sideslopes of 3.5:1.
- Minimum freeboard of 0.6 m above 1:100 year high water level (a greater freeboard may be required if an emergency overflow route cannot be provided).
- Maximum 4:1 ratio of effective length to effective width measured at 1:100 year high water level.
- Dimensions must be acceptable to the City when the bottom of the pond is to be used for recreational facilities.
- Minimum lateral slope in the bottom of the pond of 1.0% (2.0% is preferred) and a minimum longitudinal slope of 0.5% (1.0% is preferred),
- Low flow bypass for flows from minor events to be provided.
- French drains are to be provided within pond bottom where water table is near pond bottom.
- Address all safety issues (particularly during operation).

4.10 WET RETENTION PONDS

4.10.1 Land that is adjacent to a lake that is subject to flooding, as per the design standard established, but is part of the development parcel, will carry easements to allow City forces right of access through the lands to the water's edge to carry out normal maintenance operations.

4.10.2 Public land that is permanently under water shall be designated Environmental Reserve, or as required by the City. Private land that is subject to flooding due to the operation of the lake shall carry a flooding easement up to the 1:100 year storm level.

4.10.3 The storage capacity shall be determined at the Master Drainage Plan stage along with the hydraulic performance criteria.

4.10.4 The annual volume exchange shall be twice per year.

4.10.5 Side slopes shall be designated as shown in the detail drawings.

4.10.6 The inlets and outlets are to be fully submerged at least one metre below normal water level to crown of pipe.

4.10.7 The lake bed is to be composed of impervious material.

4.10.8 No dead bay areas shall be permitted unless special circulatory provisions are made.

4.10.9 The first manhole in the minor system, the connecting or interconnecting pipe system, shall have an invert that is at or above the normal water level.

4.10.10 The lake design shall include an approved sedimentation removal process for control of heavy solids to the lake during the development of the basin.

4.10.11 A sedimentation measurement system may be required for control and recording of siltation during long term performance of the lake.

4.10.12 Soils investigation specific to the detention facility shall be undertaken to determine the soil's permeability and salinity (or other potential contaminants), and the height of the groundwater table. Where the facility is sited above a shallow aquifer the potential for groundwater contamination must be minimized. Where the pond bottom is below the water table, weeping tile systems may be required to keep the pond bottom dry enough to support grass growth and maintenance equipment traffic.

4.10.13 The edge treatment or shore protection required shall be compatible with adjacent land use. The standard used shall meet the criteria of low maintenance, safety, and ease of access to the water edge. The recommended guideline is approved rip-rap rock material varying in size from 50 to 100 mm, for a thickness of 0.3 m and extending in a vertical distance of 0.6 m below and above the normal water level, and encased in Gabion baskets.

4.10.14 Lake design must provide for vehicular access for maintenance and emergency purposes.

4.10.15 Approved lighting shall be provided at the interface between the lake high water levels and any adjacent public lands.

4.10.16 Approved fencing will be required where necessary for safety purposes.

4.10.17 Approved signage shall be installed to warn of anticipated water level fluctuations, with demarcation of maximum water levels to be expected for design conditions. Warning signs will be designed by the Developer and approved by the City.

4.10.18 An approved fresh water well system is required to maintain the lake water levels during extended dry hot periods.

4.10.19 If approved, the Developer will be responsible for all construction costs in excess of the cost to construct the original dry pond facility. The Developer will also be required to establish maintenance of the pond.

4.10.20 Design of a wet pond is to be in accordance with the Saskatchewan Ministry of Environment publication entitled "Stormwater Guidelines". Some general design parameters to consider are:

- 2.0 ha minimum water surface area.
- Maximum sideslopes of 7:1 between the high water level and 1.0 m below normal water level.
- Minimum permanent pool depth of 2.0 m
- Maximum 1:100 year storage depth of 1.5 m
- Maximum water fluctuation for a 1:5 year storm event should not exceed 1.0 m.
- Sediment forebays required at each inlet.
- Hard edge treatment required along lake perimeter.

- Minimum freeboard depth of 0.6 m. House footings must be above freeboard elevation.
- Water recirculation and make-up system required.
- Provide access for maintenance and emergency equipment.
- Design of outlet control structure to be capable of maintaining permanent pool depth and capable of draining the permanent pool for maintenance purposes.

4.11 EMERGENCY SPILL WAY PROVISIONS

4.11.1 The feasibility of an emergency overflow spillway is to be evaluated for each storage facility (wet or dry) design, and, where feasible, such provisions are to be incorporated in the pond design.

4.11.2 As part of the pond design process, the probable frequency of operation of the spillway should be determined. Where it is not possible to provide an emergency spillway route, the design is to include an analysis of the impact of over-topping the pond and a significant freeboard above the 100-year level.

4.11.3 The functional requirements of the spillway, and the impact analysis for the absence of one, are to consider the possible consequences of blockage of the system outlet or overloading due to the run-off events, such that the storage capacity of the facility may be partially or completely unavailable at the beginning of a run-off event.

4.12 SAFETY PROVISIONS AT INLETS AND OUTLETS

4.12.1 All inlet and outlet structures associated with dry ponds shall have grates provided over their openings to restrict access and prevent entry into the sewers by unauthorized persons. A maximum clear bar space of 150 mm shall be used for gratings.

4.12.2 Grated outlet structures are to be designed with a hydraulic capacity of at least twice the required capacity to allow for possible plugging. Further, the velocity of the flow passing through the grating should not exceed 1.0 m/sec. Appropriate fencing and guard rails are to be provided to restrict access and reduce the hazard presented by the structure head and wingwalls.

4.13 OUTFALLS

4.13.1 Outfall structures shall be placed at the end of all storm sewers discharging to an open channel, watercourse, river, or other receiving water body such as a lake. The purpose of the structure is to reduce velocities and prevent erosion. All outfall structures must be approved by Saskatchewan Ministry of Environment. It is the responsibility of the Developer to obtain the necessary approvals and permits from the above mentioned Authorities.

4.13.2 The outfall structure may be a chute, spillway drop structures and energy dissipaters, stilling basin, or plunge pool with head wall. A cut off wall is required at the end of the outfall apron to prevent undermining of the structure.

4.13.3 Obverts of outfall pipes shall be at least 150 mm above the 5-year flood level in the receiving stream. Inverts of outfall pipes shall be above winter ice level, otherwise outfall pipes shall be submerged below the bottom of ice level. In addition, outfalls shall be located to avoid damage from moving ice during breakup.

4.13.4 If the downstream channel is relatively flat, the apron shall be 150 mm to 225 mm above the channel invert to prevent collection of debris on the apron.

4.13.5 Rip-rap and a filter layer shall be placed downstream of the outfall structure, where required to prevent erosion. Where erosion control or bank stability work must be done, preservation of watercourse aesthetics and wildlife habitat must be considered.

4.13.6 Weeping tile shall be placed under the structure to reduce any water pressure behind the head wall.

4.13.7 Grills or trash bars shall be placed over all storm sewer outlets to prevent access.

4.13.8 Railings shall be placed along the head wall and wingwalls of the outfall structure.

4.13.9 Outfalls shall be landscaped designed with low maintenance, to aesthetically blend in with surrounding areas.

4.13.10 Measures, such as detention ponds, should be incorporated in new developments to prevent any increase in the amount of erosion and downstream flooding to existing receiving streams.

4.14 LOT DRAINAGE

4.14.1 The grading design shall complement the overall design of both the minor and major storm drainage system.

4.14.2 Where surface drainage swales direct run-off from one lot to the next, the necessary drainage easements shall be registered concurrently with the plan of subdivision.

4.14.3 A range of 2% to 4% slope shall be used for general property drainage.

4.14.4 The building grade should be in the range of 0.3 m to 1.0 m above curb.

4.14.5 Where extremes in elevation of adjoining lots require the construction of a retaining wall, it shall be indicated on the proposed grading plan.

4.14.6 In cases where the backyard slopes towards the building, provisions are required to keep the runoff at least 3.0 m away from the building, with the possibility of draining the surface water along the lot lines onto the streets.

4.15 DRAINAGE SWALES

4.15.1 Where drainage swales are provided on rear property lines in laneless subdivisions, the Developer shall provide an approved concrete drainage swale.

4.15.2 Where drainage from a group of lots is directed along one or more property lines an easement shall be registered on lots where the drainage is directed.

4.15.3 The slope for concrete swales shall be a minimum of 0.5% and a maximum of 6%.

4.15.4 The minimum slope for grassed swales or channels is 2%.

4.16 STORM CHANNELS

4.16.1 The Developer shall identify any proposed storm channels in the Concept Plan, or Master Drainage Plan. The routing and land requirements shall be identified on a plan and be designed to handle the 1:100 year return period.

5 LIST OF DRAWINGS

B-100 Typical Pre-Cast Manhole Detail
B-101 Exterior Drop Manhole Detail
B-102 Interior Drop Manhole Detail
B-103 Pre-Benched Manhole Base
B-104 Catch Basin Manhole
B-105 Catch Basin Typical – 900mm
B-106 Typical Perched Manhole for 600 – 1500mm diameter pipes
B-107 T-Riser Manhole for Pipe Diameter 1200mm and Larger
B-108 Manhole Safety Platform
B-109 Trash Grate Inlet
B-110 Outfall Structure
C-100 Pipe Bedding Details

END OF SECTION