SECTION 5

Storm Drainage System

5.0 STORM DRAINAGE SYSTEM

5.1 General

The policy framework guiding the City's drainage servicing practice is an evolving Best Management Practice (BMP) format. The Design Engineer is to contact the City Engineer to ensure the current BMPs are used. Stormwater quality and quantity control measures must be a consideration in all stormwater designs to protect downstream areas and receiving water bodies. All drainage servicing designs must conform to the applicable federal, provincial, and City statutes, by-laws, and guidelines. These include, amongst others, statutes and guidelines such as:

- *Local Government Act*;
- *Fisheries Act*;
- *Water Act*;
- *Dyking Act*;
- Riparian Area Regulations;
- Subdivision and Development Control By-law;
- Watercourse By-law No. 17-6; and
- Master Drainage Plans

5.2 Existing System

The Design Engineer shall review and discuss downstream system capacity requirements with the City Engineer. Adequacy of the existing system, downstream of the proposed catchment area, shall be determined using the analytical methods given in the following sections.

5.3 Plans and Objectives

5.3.1 Drainage Planning

Master Drainage Plans (MDP) have been prepared for some drainage basins and these will be added to or updated over time. The MDP provides a review of drainage opportunities and constraints on a watershed and presents a conceptual drainage servicing plan. All development related servicing proposals should satisfy the servicing framework given in the appropriate MDP if completed or as amended. The Design Engineer is to review the MDP to ensure it conforms to current criteria. Where concerns are addressed the Design Engineer is to provide a summary report to the City Engineer for consideration.

Where no MDP exists or where new development is proposed before the completion of the required works recommended in a MDP, the Applicant may be required to complete those works necessary to service the specific development in accordance with Section 2.0.

Interim stormwater management measures may be considered providing that they can be practically achieved and protect the downstream drainage system from surcharge and erosion.

5.3.2 Servicing Objectives

The planning for drainage systems must meet the following basic criteria:

a) A piped minor system conveyance capacity up to the 1:5-year return period storm to minimize inconvenience of frequent surface runoff.

b) A piped or overland major system conveyance capacity up to the 1:100-year return period storm to provide safe conveyance of flows to minimize damage to City infrastructure and property.

c) Capture and retain all small storms (less than 10mm in 24 hours) on site for re-use, infiltration, evaporation, and/or transpiration. In areas where infiltration is not feasible detention in lieu of retention may be acceptable.

d) BMPs designed to attenuate peak flows and remove TSS must be implemented on large parking areas (>1,000m^2).

e) Design engineers should highlight any stormwater BMPs incorporated in their designs.

f) Protection from erosion and sedimentation recognizing the importance of environmental concerns.

5.3.3 Development Design Requirements

The Design Engineer is required to submit the following plans for review and approval:

Stormwater Control Plan

Stormwater Control Plans (SCP) describe in detail how the proposed development will impact the existing drainage system and how the proposed major and minor drainage infrastructure meets the City's drainage policies and design criteria. Unless otherwise required by the City Engineer a SCP is to be provided for all developments larger than 3.0 ha, except those in rural areas where lots larger than 0.4 ha are proposed or as directed by the City Engineer.

The Stormwater Control Plan must be provided for all developments that alter the existing drainage characteristics. It is the Design Engineer's responsibility to confirm the extent of the drainage catchments with the City Engineer prior to detailed design.

The Stormwater Control Plan and supporting documentation should include the following:

- Consideration of impact on the total watershed and recommendations in the MDP, Official Community Plan (OCP), or Neighbourhood Plan (NP) if applicable;
- Tributary areas to the development including existing and ultimate land use in accordance with the OCP;

- The development area within the drainage catchment including all features such as roads, natural watercourses, watercourse crossing structures, and low or poorly drained areas;
- Contour plan with 1.0 m elevation interval (1:2500 scale). Five metre contours may be considered for areas of steep terrain outside the developing lands to depict general drainage patterns. All contours must be labeled and easily discernable;
- Plan view of existing and proposed drainage systems;
- Major and minor conveyance capacity;
- Impervious or runoff coefficient values for each catchment area based on future OCP land use;
- Hydrologic calculations summarized in table form and supporting parameters to a point 200 m downstream of the discharge into an existing trunk storm sewer or as identified in the subdivision Preliminary Letter of Approval or by the City Engineer;
- 1:100 year flow routing internal and external to the development.
- General lot grading patterns.
- Control of discharges to meet downstream conditions such as prevention of erosion and flooding;
- Capacity constraints of downstream storm sewers and natural watercourses;
- Location and sizes of detention facilities including summary of design flows, volumes, and control orifice sizing;
- Hydraulic considerations - surcharged system impact, water flow on road surface;
- The Geotechnical Engineer is to address the impact of surcharging sewers on perimeter drains as there is no backflow provided within the City infrastructure; and
- Recommendations for works required to address the above including any interim facilities.

Lot Grading Plan

A comprehensive lot grading plan prepared by the Design Engineer is required. This requirement may be waived by the City Engineer if fewer than three new lots are created and there is no apparent impact on adjacent properties. Regardless of the size of development the City Engineer may require a report or grading plan prepared by the Design Engineer analyzing the existing development and impact on adjacent properties. This plan must illustrate a strategy that addresses both the compatibility of the grading on all lots within the development area and the impact of these strategies on the existing adjacent development area. Items to be addressed are:

- Pre- and post-development contours;
- Identification of cut and fill areas. Areas of greater than 1 m of fill are to be identified and the Geotechnical Engineer is to provide comments on these areas pertaining to suitability for building construction;
- Building envelopes within the proposed lots;
- Grade elevations at property corners and any other change in grade.
- A typical grading detail identifying general conditions and any special conditions for construction;
- Minimum and maximum main floor elevations for buildings.

- Directional arrows showing proposed drainage flow routes on each lot. Cumulative drainage of two or more properties is to be avoided and where necessary the Design Engineer is to provide rationale for this condition as well as propose a means of directing the flows to prevent impact on adjacent lots. This condition may require installation of special works by the Applicant and encumbrances registered on the lands;
- Existing drainage patterns adjacent to the site;
- Legend identifying all notations; and
- Lot numbering as per the final registered plan.

Confirmation of final elevations will be required prior to acceptance of works. The final grading plan submitted to provide guidance for the development of buildings on the lots may omit pre-development contours and cut/fill notations. Covenants may be registered on lots to ensure compliance with the approved plan.

Sediment Control Plan

A Sediment Control Plan is a requirement of all development projects and must clearly outline the measures to be taken to reduce sediment discharges from the site during the full construction period (City works and building construction). It is the Design Engineer's responsibility to give consideration to the impact of sediment on existing infrastructure as well as watercourses. Some forms of sediment control may include:

- Siltation ponds;
- Bioswale filtration;
- Point source control; and
- Prefabricated sediment control systems.

Groundwater

Where groundwater emergence can reasonably be expected, the Design Engineer (or Geotechnical Engineer) must ensure this is addressed. Control of groundwater emergence and protection of City and private infrastructure from the negative impacts of groundwater must become part of the overall servicing strategy for a development. Groundwater management must be accounted for in a site's infrastructure design. The use of cut-off drains or connecting servicing trenches to the storm sewer system are two possible solutions to this problem.

Detention Control

Private detention systems may be utilized to reduce the impact of new development on existing infrastructure at the discretion of the City Engineer. These systems may include individual single and two family residential detention systems or detention of flows for other forms of development such as multi-family, commercial, etc. Generally residential detention systems are incorporated due to collection of hard surface areas as may be recommended by the Geotechnical Engineer associated with special geotechnical concerns. In all cases a report must be submitted and approval is at the discretion of the City Engineer. Covenants will generally be required to ensure enforcement of these conditions.

5.4 Stormwater Runoff Generation (Hydrology)

This section describes the rationale, methodology and parameters for determining the hydrologic variables such as rate and amount of stormwater runoff in the design of storm drainage conveyance and storage facilities.

5.4.1 Floodproofing

Protection of habitable floor space from flooding is to be provided up to the 200-year flood level (inclusive of 0.6 m freeboard) for areas in the flood plains of the Thompson River systems. As indentified on City Flood Mappings, all other areas will be protected from the100-year flood level (plus 0.6 m freeboard).

5.4.2 Snowmelt

In all cases the Design Engineer (in determining the critical design conditions) is to consider the impact of snowmelt on the drainage system.

5.4.3. Rational Method

(a) Application

The use of the Rational Method for final design calculations is to be limited to the design of minor or major storm drainage system components proposed to accommodate flows from catchments with an area of approximately 20 ha or smaller.

(b) Rational Formula Q=RAIN

Where	Q	=	Flow in cubic m per second
	R	=	Runoff coefficient (see table 5.1)
	A	=	Drainage area in hectares
	I	=	Rainfall intensity in mm/hr (see Table 5.3)
	N	=	0.00278

Table 5.1 Runoff Coefficients

Description of Area	% Imperviousness Ratio	Runoff Coefficient
Commercial	90	0.80
Industrial	90	0.80
Suburban Residential (lots>0.4 ha)	20	0.35
Low Density Residential	40	0.50
Medium Density Residential	65	0.60
High Density Residential	80	0.75
Woodlands	5	0.10
Parks, Playgrounds, Cemeteries; Agricultural Land	20	0.25
Institution; School; Church	80	0.75

Note:

- The above table assumes conventional site drainage of directing all surface drainage overland into streets and catch basins. The runoff coefficients account for antecedent wet conditions.
- In the case of mixed land use, a composite runoff coefficient is to be determined.
- The Design Engineer is to verify the above values meet site specific conditions and if higher values are required.

(c) Time of Concentration (Tc)

Time of Concentration is the time required for stormwater runoff to travel from the most remote point of the drainage basin to the point of interest and having the greatest impact on downstream flows. In developments where substantial undeveloped areas remain, the contributing drainage area flows and corresponding time of concentration should be checked by trial and error to determine the maximum peak outflow rate. It is the cumulative sum of all flow times Overland, Channel (swale or stream); and/or Storm Drain.

Overland Flow Time:

Several equations for overland flow time may be used such as; the kinematic wave equation, the airport method etc. It may be appropriate in fully developed basins as determined by the Design Engineer, to use the minimum inlet times in the following table:

Development Type	Minimum (minutes)	Maximum (minutes)
Single Family	10	15
Multi-family	10	15
Commercial/Industrial	10	10

The minimum inlet times reflect roof leaders and parking lot drainage (hard surface) being discharged directly into a piped storm system. The maximum inlet times reflect roof leaders and parking lot drainage being discharged onto ground (grass, gravel, swales) and accounting for travel distances and other variables. It is the Design Engineer's responsibility to verify the above values are appropriate and provide recommendations to the City Engineer for approval where variations are appropriate.

Channel Flow Time:

When the channel characteristics and geometry are known, the preferred method of estimating channel flow time is to divide the channel length by the channel velocity obtained by using the Manning equation, assuming bank full conditions.

Storm Drain Flow Time:

When it is appropriate to separate flow time calculations, such as for urban storm drains, Manning's equation may be used to obtain flow velocities within pipes.

(d) Drainage Area

The extent of the tributary drainage areas for the storm drainage system being designed shall be determined using the natural and/or the proposed contours of the land taking into account future land use in accordance with the OCP.

It is stressed that it is the Design Engineer's responsibility to confirm the extent of the drainage areas with the City Engineer prior to final design, and to incorporate the designs for the minor and major flows into the overall system.

(e) Presentation of Rational Method Computations

The Design Engineer shall tabulate the design calculations based on Manning's formula using Table 5.2 (or similar) for submission with the Stormwater Control Plan.

5.4.4 Rainfall Data

Data from the Kamloops Airport or other approved rainfall gauges will be used in designing drainage infrastructure in the City of Kamloops. This data is compiled in the rainfall Intensity Duration Frequency (IDF) curves for 5 minutes to 24-hour durations in Table 5.3.

Other data which may become available is to be used or considered by the Design Engineer.

5.4.5. Hydrograph Method

Computer simulation programs based on hydrograph techniques are required for catchments greater than 20 ha.

a) Application

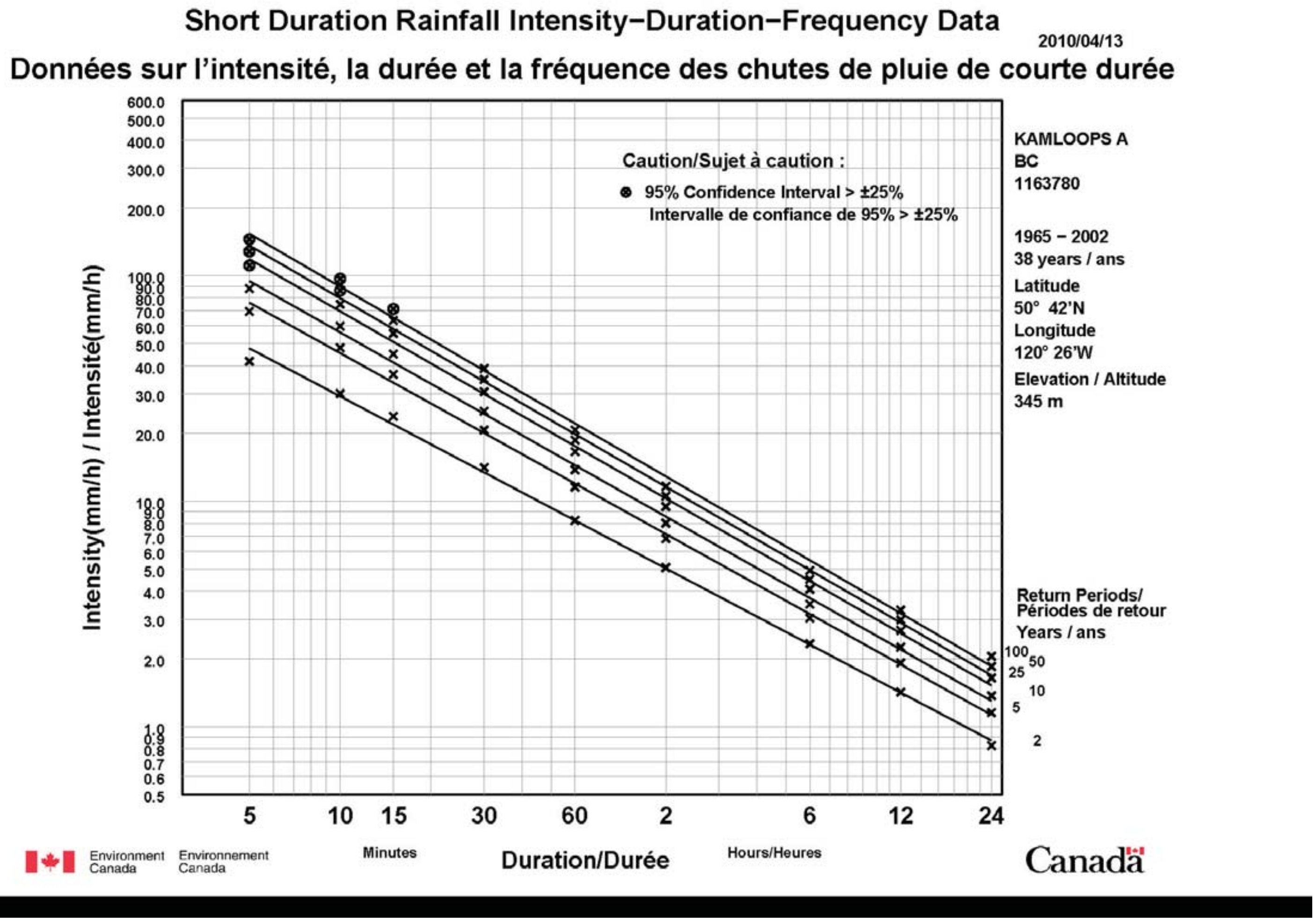
For the design of conveyance sewer systems servicing areas greater than 20 hectares, hydrologic computer programs using hydrograph generation methodology shall be applied. The City of Kamloops supports PCSWMM and EPA SWMM models and the Design Engineer is to seek clarification prior to analysis.

Table 5.2

Consultant:	Storm Sewer Design Criteria	Sheet of
Project No.:	Rainfall Intensity (5-year storm)	File Name:
Project Description:	Rainfall Intensity (100-year storm)	Completed by:
	Q = RAIN	Date:
Location:		Checked by:
	MANNINGS "n" =	Date :

Manhole		Drainage Area Description	Area (ha)	Runoff Coefficient	R *A	Total R *A	Time of Concentration	Total Time	Intensity		Flow		Sewer Design						Inc. Travel Time to Downstream Manhole	Ratio		Comments
									I(5)	I(100)	Q(5)	Q(100)	Slope	Pipe Dia.	Manning's "n"	Q Cap.	V Cap.	Length		Q(5)/ Q Cap.	Q(100)/ Q Cap.	
From	To		A	R	(ha)	(ha)	(min)	(min)	(mm/hr)	(mm/hr)	(L/s)	(L/s)	%	(mm)		(L/s)	(m/s)	(m)	(min)	%	%	Major Flow Routes

Table 5.3


Short Duration Rainfall Intensity−Duration−Frequency Data
2010/04/13
Données sur l'intensité, la durée et la fréquence des chutes de pluie de courte durée
Caution/Sujet à caution :
95% Confidence Interval > ±25%
Intervalle de confiance de 95% > ±25%
KAMLOOPS A
BC
1163780
1965 − 2002
38 years / ans
Latitude
50° 42'N
Longitude
120° 26'W
Elevation / Altitude
345 m
Return Periods/
Périodes de retour
Years / ans
100
50
25
10
5
2
Intensity(mm/h) / Intensité(mm/h)
600.0
500.0
400.0
300.0
200.0
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
5
10
15
30
60
2
6
12
24
Minutes
Duration/Durée
Hours/Heures
Environment Canada
Environnement Canada
Canada

5.5 Methodology of Analysis for Minor Conveyance System

5.5.1 Scope

The emphasis of this section is on those criteria which determine the size and grade profiles of minor conveyance storm sewers and certain elements of the system arrangements, such as inlet requirements. Major system design requirements are addressed in Subsection 5.6.

5.5.2 Level of Service

The minor drainage system will be designed to convey the 5-year return period rainfall event runoff.

5.5.3 Storm Sewers

a) Sizing of Storm Sewers

Storm sewers shall be designed as open channels sized to provide the required capacity in free flow (not surcharged) conditions using Manning's formula. Manning's n of 0.013 shall be used for smooth wall plastic and concrete pipe, and 0.024 for corrugated pipes.

The minimum storm sewer size will be 200 mm inside diameter. Where ditches discharge directly into a storm sewer, the minimum pipe diameter will be 300 mm subject to the approval of the City Engineer.

Downstream pipe sizes are not to be reduced unless the downstream pipe is 600 mm diameter or larger and increased grade provides adequate capacity. The maximum reduction is two pipe sizes and the system must be a closed pipe network or be protected with approved inlet structures. **The City Engineer must give approval to this condition**.

b) Surcharged Sewers

Surcharged sewers to convey the design flows are permitted only as exceptions and with completion of a report by the Design Engineer and approval of the City Engineer. In all such cases, it must be clearly demonstrated that the projected highest hydraulic grade line has no impact on downstream properties.

c) Storm Sewer Slope Requirements

All storm sewers shall be designed and constructed to give mean velocities, when flowing full, of 0.60 m/s or greater based on Manning's formula except that the minimum slope shall be 0.4% for the most upstream leg of any storm system (between the terminal manhole and the first manhole downstream there from) unless approved by the City Engineer.

On steeper slopes the Design Engineer is to consider if special provisions are required to protect against displacement of sewers by erosion or shock. No upper limit to flow velocities in storm sewers is defined, however, when supercritical flow does occur, (where steep grades are utilized), the Design Engineer shall provide appropriate analysis and justification and make provisions in the design to ensure that structural stability and durability concerns are addressed. Flow throttling or energy dissipation measures to prevent scour may be required to control the flow velocity or to accommodate the transition back to subcritical flow.

For pipes on steep grades an approved anchoring system shall be provided in accordance with the Standard Drawings and Specifications.

d) Location

Storm sewers are to be located as shown on the Standard Drawings within a City road or open lane. Where this is technically impractical and it is proposed to place storm sewers within private property the Design Engineer is to provide rationale and analysis for consideration by the City Engineer.

e) Depth

Where the catchment is on both sides of a roadway, storm sewers shall be installed at a depth capable of servicing properties on both sides by gravity where economically feasible. Elevation of storm sewers at upstream tributary points must be of sufficient depth to service all of the tributary lands.

Sewers shall not be designed with pipe cover less than 1.2 m above the crown of the pipe nor with depths in excess of 4.5 m, unless there is justification by the Design Engineer and approval is given by the City Engineer.

f) Groundwater

Storm sewer connections to other utility trenches shall be provided where there is a possibility of groundwater concentration. The Geotechnical Engineer-of-record is to provide a report and recommendations for review by the City Engineer.

5.5.4 Manholes

a) Location

Manholes are required at the following locations:

- every 150 m for pipes less than 900 mm diameter.
- every 300 m for pipes 900 mm diameter or larger.
- every change of pipe size.
- every change in grade or direction with the exception of curvilinear sewers.
- all sewer confluences (including future consideration) and junctions where anticipated service connections are 200 mm or larger.
- at the upstream end of all terminal sewers.

b) Drop Manhole Structures

Drop manholes shall <u>only</u> be used where approved by the City Engineer in accordance with Standard Drawings. Outside drops are not approved. The Design Engineer shall match crowns whenever possible or have a maximum drop in accordance with the inside ramp type standard drawing. The Design Engineer is to provide a report outlining the rationale for consideration by the City Engineer if drop manhole structures are proposed. On existing systems they shall only be used when a new incoming sewer cannot be steepened or where site conditions do not permit excavation to the base of an existing manhole at the sole discretion of the City Engineer.

Inside drop manholes shall be larger in diameter (minimum 1200 mm) and shall accommodate the incoming sewer and drop pipe, as well as ensuring sufficient access and working space for personnel and safety equipment within the manhole.

c) Through Manhole Structures

Where a small pipe joins a larger pipe the crown elevation of the smaller pipe shall be at or above the larger pipe. No drop in invert is required for a through manhole where the sewer mains are of the same size. A 30 mm drop in invert for alignment deflections up to 45 degrees and a 60 mm drop in invert for alignment deflections from 45 degrees to 90 degrees shall be provided. Deflections greater than 90 degrees shall only be permitted at the discretion of the City Engineer.

(d) Location of Manholes

Manholes for sewers located within road dedications shall be generally located within the travel lanes or centre median as appropriate, between the outside curb lines.
No Standard manhole shall be located such that its centre line is closer than 1.5 m from a roadway curb face. Manhole tops, (frames and covers) shall not be located within a sidewalk unless approved by the City Engineer. Manhole frames are to be rotated to be outside the wheel path where possible.

(e) Energy Loss Provisions at Manholes, Junctions and Bends

There is a loss of energy when flow passes through a bend, a manhole, or a point of confluence. These losses can be negligible as in the case of a small diameter sewer flowing partially full at minimum velocities, or substantial as in the case of a large diameter sewer flowing full and turning 90 degrees in a manhole. It is the Design Engineer's responsibility to analyze these losses and provide detailed hydraulic analysis for complex or unusual sewer junctions where excessive losses will exist or to provide analysis as directed by the City Engineer.

(f) Sump Manhole

Where ditches discharge into a storm sewer system, the initial connecting manhole shall be of a sump type as per Standard Drawings. Sump manholes may also be required under special conditions.

5.5.5 Catch Basins

Catch basins shall be provided at regular intervals along roadways, at upstream end of radii at intersections, in advance of wheelchair ramps and at low points (sags) where double side inlet (full curb or rollover curb) catch basins are required unless otherwise approved by the City Engineer. Where possible, low points are not to be located within curb returns. The Design Engineer must ensure that sufficient inlet capacity is available to collect the entire minor flow, or major flow if required, into the underground pipe system.

The maximum spacing shall be established to permit each catch basin to drain a maximum area of 500 m^2 (of roadway) on road grades up to 5% and 400 m^2 on steeper grades. If the major flow is to be conveyed in the pipe system, additional catch basins are required. Detailed calculations are to be provided by the Design Engineer.

The effect of roadway gradient and cross fall on the capture capacity of the catch basin grates is to be used to check the flow intercepted by standard grates. Side inlet grates (full curb or rollover curb) are to be used where road grades exceed 5%.

The catch basin lead size and slope shall be based upon hydraulic capacity requirements. Leads shall be 200 mm in diameter (minimum) for single basins and 250 mm (minimum) in diameter for double basins. Double catch basins shall be connected directly together. Catch basin leads should be taken into manholes wherever possible. Maximum length of lead shall be 30 m.

5.5.6 Ditches

No new ditches shall be created for servicing land development projects except as permitted under specific zones or as approved by the City Engineer.

(a) Depth

Ditches adjacent to travelled roadways shall not exceed 1 m in depth unless adequate safe slope and barriers can be provided. Additional road dedication may be required to accommodate cross-sectional elements.

(b) Shape and Erosion Control

Ditches shall be designed to convey the 1:5-year flow (or 1:100 year flow as determined for specific conditions) with a minimum freeboard and depth of 300 mm. Ditches shall be trapezoidal in shape having maximum side slopes of 2 H : 1 V, dependent on soil characteristics.

The minimum grade of a ditch shall be 0.5% where feasible with a maximum velocity in an unlined ditch of 0.5 m/s. Higher velocities may be permitted where soil conditions are suitable or where erosion protection has been provided. The Design Engineer is to provide analysis of velocities with recommendations for erosion protection for review by the City Engineer. On steep slopes, grade control structures may be used to reduce velocities. Interim erosion control is required until vegetation is established.

5.5.7 Culverts

(a) Minimum Diameter

The minimum culvert diameter shall be 300 mm for driveways.

Driveway culverts shall be designed to accommodate the minor flow unless otherwise indicated.

(b) Hydraulics

Culverts crossing all roads shall be designed to accommodate the major flows with either inlet or outlet control.

On collector and local roads, overtopping may be permitted only when the replacement of existing facilities or the installation of a secondary relief culvert is not economically feasible and the back water profile does not negatively encumber adjacent lands. Where road overtopping is anticipated, appropriate scour protection shall be provided. All roads shall be graded to provide the sag point at the watercourse culvert crossing to provide a fail-safe major system outlet with limited ponding on the road allowance. The Design Engineer is to provide analysis of all parameters for consideration by the City Engineer.

5.5.8 Inlet and Outlet Structures

a) General

The Standard Drawings and Specifications shall be used as a guide for designing inlet and outlet structures for storm sewers and culverts. The Design Engineer is to determine inlet control elevations and protect embankments from potential sloughing. Outlets for culverts and storm sewers, having discharge velocities greater than 1.0 m/s (or less depending on soil conditions) require evaluation of the downstream channel and rip-rap or an approved energy dissipating structure may be required to control erosion.

b) Structural Design

The structural requirements for inlet and outlet structures, given on Standard Drawings are minimum requirements. Structures exceeding these standards should receive individual structural design by the Design Engineer.

c) Safety Grillage and Trash Screens

A safety grillage or trash screen is required as detailed in the Standard Drawings, at the entrance and outlet of every storm sewer or on culverts as identified. This requirement does not include driveway crossings unless identified by the City Engineer.

5.5.9 Flow Control Structures

The Design Engineer is to provide rationale for any proposed flow control structures for consideration by the City Engineer. Where flow control structures are permitted, the following orifice equation may be used:

$$q = Ca(2gh)^{0.5}$$

Where
q = Desired Release Rate (m^3/s)
a = Area of Orifice (m^2)
g = Acceleration due to Gravity (m/s^2)
h = Net Head on the Orifice Plate (m)
C = Coefficient of Discharge (0.62 for sharp edge)

The Design Engineer is to provide details for flow control structures for consideration by the City Engineer. Minimum orifice size shall be 100 mm in diameter. Where smaller orifices are required special provisions are required to prevent blockage. These special provisions will be clearly marked on the design drawings.

5.5.10 Storm Sewer Service Connections

(a) General Requirements for Storm Services to Properties

Storm sewer service connections are required for lots zoned for detached residential use for the purposes of draining the perimeter (foundation) drains unless otherwise recommended by the Geotechnical Engineer and approved by the City Engineer. All service connections require an inspection chamber (IC) in accordance with Standard Drawings except proposed or future services 200 mm or larger require a manhole on the City mainline.

(b) Single and Two Family Properties

In the case of potential duplex lots a service connection shall be provided for each half of the duplex. Where the Applicant does not wish to provide two services a covenant must be registered on the lands restricting the use to a single family home only.

Roof drains are to discharge into a drainage cistern (which acts as a detention system on private lands) unless otherwise recommended by the Design Engineer and approved by the City Engineer. The Design Engineer is to provide and/or verify storage, location and orifice sizing is appropriate for the anticipated conditions.

(c) Commercial/Institutional, Industrial, and Multiple Residential Properties

Storm sewer service connections for the connection of on-site storm drainage systems and/or roof drains are to be provided to properties zoned or proposed to be zoned for commercial, institutional, industrial and multiple residential land use. When required service locations are known, storm service connections should be installed concurrently with the general area servicing. Installation of such connections may be deferred until the specific property development is proposed at the sole discretion of the City Engineer.

(d) Priority Listing for Storm Sewer Service Connections

Each lot will have:

- a gravity connection to the frontage storm sewer; or
- a gravity connection to the storm sewer in an open lane, walkway or service corridor with an access road.

When a gravity service is not feasible and approved by the City Engineer, consideration will be given to a gravity connection through a private rear lot easement to a storm sewer, provided it does not traverse more than one lot, the easement is registered and a dedicated connection with an IC for the lot exists on the fronting storm sewer.

- Size and Grade

  Residential storm service connections will meet the following:

  150 mm minimum diameter
  2.0% minimum grade from property line to storm sewer

  For commercial/industrial sites and multi-family sites, the storm service size (minimum 150 mm) and grade is to be established by the Design Engineer with supporting calculations. Covenants may be required to support certain conditions.

- Location

  (a) Development Lots

  For undeveloped lots, service connections shall be located as shown on the Standard Drawings with a depth to provide sufficient grade and depth to a building structure which could be located at a front yard setback of 6 m. The service connection shall be extended 2.0 m into the property. Where service connections exceed 3.5 m in depth the service connection shall extend into the property by 4.0 m.

  (b) Existing Properties

  All proposed storm sewers shall be designed within practical limits with adequate depth to properly service foundation drains of all existing properties which it passes. All existing drains shall be connected to the storm sewer provided that the Design Engineer ensures there will be no negative impact on adjacent properties. Service connection locations shall be acceptable to the property owner.

5.5.11 Alignment of Sewers

(a) Location of Sewers within Road or Lane/Walkway

The alignments of storm sewers within road or open lane are to conform to the Standard Drawings.

(b) General Alignment Requirements
Sewers shall generally be installed with straight alignment and uniform slope between manholes, and generally parallel with the centre line of the roadway. Curvilinear sewers are permitted in accordance with Specifications.

(c) Horizontal Separation

See Section 2.

(d) Sewers in Common Trench

See Section 2.

(e) Curvilinear Sewers

No vertical curves are permitted. Horizontal curves may be formed using pipe joint deflections as follows:

- Minimum radius and joint deflection in accordance with Standards and Specifications.
- Constant radius throughout curve.
- Only one horizontal defined curve is permitted between any two manholes.
- Minimum design velocity = 0.9 m/s.
- The centre line alignment of sewers installed on a curve shall run parallel to curb or street centre line.

  Sufficient data is to be provided for setting out of horizontal curves and detailing as-built construction record information.

(f) Utility Rights-of-Way for Drainage Facilities

See Section 2.

5.5.12 Subsurface Drains

Subsurface drains shall be used where supported by a soils report carried out by a qualified Geotechnical Engineer.

5.6 Methodology of Analysis for Major Conveyance System

5.6.1 Scope

This section outlines the requirements and considerations which apply to the detailed design of the conveyance elements of the major drainage system, and of surface grading plans that generally apply to residential development.

5.6.2 Representation of the Major Conveyance System

The nature and detail of the Major Conveyance System is to be shown on the Stormwater Control Plan. Information shown is to include the direction of surface flows on roadways, other rights-of-way, and all surface flow routes, areas subject to ponding and depths of ponding, elevations of overflow points from local depressions, and details of channel cross-sections. Where significant major system flows are expected to discharge or overflow to a watercourse, ravine, etc., the rate and projected frequency of such flows is to be noted on the Stormwater Control Plan.

5.6.3 Surface Drainage on Public Rights-of-Way - Major System

(a) Level of Service

Rights-of-way for utilities, walkways, and other public purposes shall be graded to provide a continuous surface drainage system to accommodate flows from rainfall events up to the 1 in 100-year events and convey these flows to appropriate safe points of escape or storage.

The service level for the major system includes protection against surface flooding and property damage for the 1 in 100-year return frequency design storm. Roadway and other surface features along the major flow path shall provide a minimum of 300 mm freeboard to the finished ground elevation of buildings on adjacent properties. Overflows will be provided from all sags or depressions such that there will be a minimum freeboard of 150 mm, and such that the maximum depth of ponding is limited to 150 mm.

(b) Flow Capacity of Street

The theoretical street carrying capacity can be calculated using modified Manning's formula with an "n" value applicable to the actual boundary conditions encountered. Minimum recommended values for n are:

0.018 for roadway; and
0.05 for grassed boulevards.

(c) Major Flow Routing

All overland flows shall have specifically designed flow routes that are protected and preserved by registered easements, restrictive covenants or rights-of-way. The major flow routing shall normally be provided along roads and in natural watercourses.

Where roadways, used for major flows, intersect, care shall be taken to lower the intersection to allow flows to pass over the cross street. Where major flow routes turn at intersections similar care in the road grading design is required.
Major flow routes on the surface are not be permitted between lot lines or on easements/rights-of-way where public access may be difficult unless approved by the City Engineer.

Major flow routing shall be shown on the stormwater control plans and sufficient design shall be carried out to provide assurance to the City Engineer that no serious property damage or endangering of public safety will occur under major flow conditions. The discharge point from the development for the major flow route shall be coordinated with the downstream routing to outfalls as determined by the City

Engineer. Where major flow outfalls to a receiving watercourse, an energy dissipater, or other such measure shall be provided to minimize erosion. Approval as applicable is required from Provincial or Federal agencies having jurisdiction.

5.6.4 Piped - Major System

In special circumstances the minor system may be enlarged or supplemented to accommodate the major flow. Provision for overland flood routing must still be provided although a somewhat reduced overland flow may be recommended for consideration by the City Engineer. A pipe system will be designed with adequate inlets to accommodate introduction of the major flow. Pipe systems to convey the major flows will follow the design criteria used for the minor system.

5.7 Stormwater Storage Facilities

The provision and location of stormwater storage facilities is at the sole discretion of the City Engineer and is discouraged if other alternatives are feasible. Individual private stormwater detention for all types of development shall be considered as a primary alternative.