

**THE DISTRICT OF HOPE**

**SUBDIVISION AND DEVELOPMENT SERVICING  
DESIGN CRITERIA MANUAL**

**SECTION D - DRAINAGE**

## SECTION D – DRAINAGE

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### **D1 INTRODUCTION**

All drainage works shall be designed with considerations for public safety, regulatory requirements, economic benefits and the natural environment.

Designers shall consult with the Engineering Department to determine what existing information may be of assistance to them.

The presence of an existing municipal drainage system does not mean, or imply, that the system has adequate capacity to receive the proposed design flows, nor does it indicate that the existing system pattern is acceptable to the Municipality. Existing facilities which are undersized or inadequate to accept additional drainage must be upgraded at the Developer's expense to accommodate the appropriate flows. Alternative drainage proposals may be considered.

It must be shown that all downstream drainage facilities within a distance of 1.5 km are capable of handling the projected increase in runoff created by the proposed development.

Proper erosion and sediment control is required for all developments or works discharging runoff into the municipal drainage system and/or natural watercourses.

### **D2 STORMWATER MANAGEMENT**

#### **D2.1 General**

Stormwater Management is the planning, analysis and control of storm runoff in consideration of the entire watershed. The design of the drainage system shall incorporate techniques such as minor-major systems, lot grading, surface infiltration, subsurface disposal, storage, erosion control and other acceptable methods to mitigate the runoff impacts due to changes in land use.

A comprehensive Stormwater Management Plan is required for all developments except in rural or agricultural areas where lots are 0.405 ha and over, unless otherwise noted. The plan shall include all drainage facilities, lot grading (showing pre and post-development ground elevations), major flood path routing, and all other appropriate information pertinent to the design. The plan shall address the impacts of both pre- and post-development upstream flows entering the development site, and

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identify all downstream improvements to accommodate the predicted post-development flow.

### D2.2 Minor and Major Systems

The *Minor System* comprises storm sewers, culverts, channels and flow control facilities designed to collect and carry the runoffs from frequent storm events. Flow control facilities include detention/retention ponds, exfiltration trenches or facilities, dry wells, and other acceptable methods suitable for reducing the rate of runoff into the downstream drainage system.

The minor system shall be designed to prevent flooding and property damage and minimize public inconvenience caused by storm events with a 1 in 10 year return frequency. The runoff from the minor storm is referred to as the minor flow.

The *Major System* comprises surface flood paths, swales, roadways, watercourses and flow control facilities designed to accommodate the runoff from rare and intense storms.

The major system shall be designed to protect the public and prevent significant property damage due to floodings caused by storm events with the return frequency of 1 in 100 years. The runoff from the major storm is referred to as the major flow.

Roadways, overland flow paths, channels and watercourses shall be designed to ensure that the maximum hydraulic grade line is below the lowest existing or proposed Minimum Building Elevation of adjacent buildings. Surcharging at the inlet under the major flow is acceptable provided the headwater profile does not rise above the Minimum Building Elevation. Adequate erosion protection shall be required where surcharging is proposed.

In the event that surface flow is not feasible or that the inlet facility is likely to be blocked or restricted, consideration shall be given to the sizing the storm sewer system to accommodate the major flow.

Under special circumstances, drainage facilities in major watercourses may be required to accommodate flows with return requirements greater than 1 in 200 year. The designer must confirm the required return frequency with the Administrator.

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### D3 RUNOFF ANALYSIS

Storm drainage systems shall be designed to accommodate the post-development flows using the Rational Method or the Runoff Hydrograph Method. All calculations pertinent to the design of the drainage system shall be signed and sealed by the Design Engineer and submitted to the Municipality.

For developments where the total tributary area is 10 hectares or less, the Rational Method shall be used to compute the peak runoffs.

For developments where the total tributary area is greater than 10 hectares, the Runoff Hydrograph Method shall be used to compute the peak runoffs. The Runoff Hydrograph Method shall also be used for the design of storage facilities with tributary areas greater than 10 hectares.

### D4 RATIONAL METHOD

The Rational Method calculates the peak flow using the formula:

$$Q = RAIN$$

Where

R	=	Runoff Coefficient x Soil Adjustment Factor (SAF)
A	=	drainage area in ha
I	=	rainfall intensity in mm/h
N	=	0.00278

#### D4.1 Runoff Coefficients

The following runoff coefficients shall be used for the Rational Formula:

<u>Land Use</u>	Percent <u>Imperv.</u>	10 Yr. <u>Runoff Coeff.</u>	100 Yr. <u>Runoff Coeff.</u>
Suburban Residential*	20	0.35	0.40
Low Density Residential	40	0.50	0.55
Medium Density Residential	65	0.60	0.65
High Density Residential	78	0.70	0.75
Commercial	90	0.80	0.85
Industrial	90	0.80	0.85
Institutional (i.e. Schools)	80	0.75	0.80
Parks/Grasslands	20	0.20	0.30
Cultivated Fields	30	0.30	0.40
Woodlands	5	0.10	0.30

\* Average lot 0.5 ha or greater

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### D4.2 Soil Adjustment Factor

A soil adjustment factor (SAF) shall be applied to the runoff coefficient to reflect the local ground conditions.

<u>Surface Type</u>	<u>SAF</u>
Sandy soil with flat slope (up to 5%)	0.9
Sandy soil with steep slope (over 5%)	1.0
Clayey soil with flat slope (up to 5%)	1.0
Clayey soil with steep slope (over 5%)	1.1

The runoff coefficients and soil adjustment factors listed above are for general application. The Designer shall verify that the coefficient is appropriate for the design area. The Administrator will be the final authority on the coefficient to be used.

### D4.3 Catchment Area

The tributary area used for the design of the storm drainage system shall be consistent with the actual contours of the land. Although minor changes in the catchment boundaries may be necessary for development, the total developed tributary area should not deviate from the total natural drainage area.

The Design Engineer shall be responsible for obtaining true and accurate surface elevations for the analysis.

### D4.4 Time of Concentration

The time of concentration is the time required for water to flow from the most remote part of the catchment area under consideration to the design node. For both urban and rural areas, the time of concentration consists of the following formula:

$$T_c = T_i + T_t$$

Where

$T_c$	=	time of concentration (minutes)
$T_i$	=	inlet or overland flow time (minutes)
$T_t$	=	travel time in sewers, ditches, channels or watercourses (minutes)

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### Inlet or Overland Flow Time (Ti)

1. Typical inlet times for urban areas are as follow:

Single Family Lot	15 minutes
Multi-Family Lot	8 to 10 minutes
Commercial/Industrial/Institutional	5 to 8 minutes

2. The inlet time in rural areas shall be calculated using the Airport Method:

$$T_i = \frac{3.26 (1.1 - C) L^{0.5}}{S^{0.33}}$$

Where	Ti	=	inlet time (minutes)
	C	=	runoff coefficient (Section D4.1)
	L	=	travel distance (m), maximum length = 300 m
	S	=	slope of travel path (%)

### Travel Time (Tt)

The travel time in sewers, ditches, channels or watercourses can be estimated using the following formula:

$$T_t = \frac{C_t L n}{12 s^{0.5}}$$

Where	Tt	=	travel time (minutes)
	Ct	=	flow travel coefficient (0.5)
	L	=	length of flow (m)
	n	=	roughness coefficient
			0.050 Natural channels
			0.030 Excavated ditches
			0.013 Concrete lined channels
			0.013 Concrete or PVC pipe
			0.024 corrugated metal pipe (CMP)
	s	=	slope in m/m

The above equation provides an approximate travel time which shall be corrected with the actual time of flow calculated from the hydraulic properties of the selected pipe/channel. A composite value for Tt shall be calculated in cases where the type of flow along the longest path varies or the slope changes.

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### **D4.5 Rainfall Intensity**

The rainfall intensity for the Rational Formula shall be determined from the rainfall Intensity-Duration-Frequency (IDF) curve based on the calculated time of concentration.

The Atmosphere Environmental Service (AES) has produced IDF curves for the tipping bucket rainfall gauge at the Hope Airport, but not for the daily recording gauges at Kawkawa Lake or Little Mountain.

### **D4.6 Presentation of Rational Calculations**

The Designer will be required to tabulate the rational calculations on Table D4.6.1 for submission along with the appropriate plans and other relevant information.

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Insert Table D4.6.1

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### D5 RUNOFF HYDROGRAPH METHOD

#### D5.1 Selection of Modeling Program

For basins larger than 10 hectares, hydrologic programs shall be used for runoff analyses. Standard runoff simulations shall be modeled with either the OTTHYMO.89 or MIDUSS programs. The EPA-Stormwater Management Model (SWMM), the Illinois Urban Drainage Area Simulator (ILLUDAS) and other hydrologic programs may be considered if their uses are deemed necessary and approved by the Municipal Engineer.

#### D5.2 Design Storms

The AES has produced probability curves for rainfall distribution from short (1 hour) and long (12 hour) storms.

#### D5.3 Watershed Data

Watershed data includes catchment areas, percent of imperviousness, lengths of flow, surface slopes, soil types (CN value), etc.

The tributary area used for the design of the storm drainage system shall be consistent with the actual contours of the land. Although minor changes in the catchment boundaries may be necessary for development, the total developed tributary area should not deviate from the total natural drainage area.

The Designer is responsible for obtaining true and accurate surface elevations for the analysis.

The imperviousness of common land uses are tabulated in Section D4.1.

For design purposes, the drainage model shall be based on the post-development conditions using the most current planning information. Conservative parameters shall be selected if calibration data is not available.

For assessment of existing systems, the drainage model may be based on the existing conditions if no future land use changes are anticipated. Some parameters may be adjusted in order to calibrate the drainage model.

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### D5.4 Presentation of Modeling Results

The Designer will be required to submit a drainage report including the following:

- (1) name and version of modeling program
- (2) design storms and default parameters
- (3) schematic diagram of the model
- (4) drainage map showing the catchment and sub-catchment boundaries, slopes, land uses, soil conditions, etc.
- (5) input and output printouts and computer files

### D6 STORMWATER STORAGE FACILITIES

Stormwater storage facilities shall be located off the road right-of-way on land dedicated to the municipality by the Developer. The Developer shall provide a right-of-way for access to the site by municipal crews.

Storage facilities shall be designed according to requirements of the Master Drainage Plan (if available) in consideration of the minor and major systems. The construction of a community storage facility servicing a large catchment area is preferred over small ponds servicing localized areas. The common storage facilities are:

- Detention (Dry) Storage
- Retention (Wet) Storage
- On-site Storage

The Designer shall consider the site and downstream conditions and consult the Engineering Department to determine the most suitable type of storage facility.

#### D6.1 Release Rates

The design release rate will be based on the predominant role of the facility in the overall drainage plan. The design release rates are determined as follows:

- (1) For the exclusive purpose of mitigating environmental impacts, the storage facility shall be sized to limit the peak flow from the post-development 1:2 year storm to the pre-development levels.
- (2) For the purpose of drainage and flood control, the storage facility shall be sized to limit the post-development 1:10 year and 1:100 year flow to

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the pre-development level. Where justified on the basis of a risk analysis, or in consideration of adequate downstream capacities for the major runoff, the 1:100 year flow may be permitted to discharge without flow control subject to the approval of the Administrator.

- (3) For the multi-purpose role of mitigating both environmental impacts and flooding, the storage facility may be required to control the post development 1:2 year, 1:10 year and the 1:100 year storms. Where justified on the basis of a risk analysis, or in consideration of adequate downstream capacities for the major runoff, the 1:100 year flow may be permitted to discharge without flow control subject to the approval of the Administrator.

### D6.2 Design Volume (Small Catchments)

For small catchments (10 ha or less), the design storage volume is to be calculated using the Modified Rational Method Analysis.

The Modified Rational Method Analysis creates a number of symmetrical triangular and trapezoidal hydrographs for storms of different durations using the rational formula  $Q = I A$  where  $I$  is the average rainfall intensity for the specified storm duration ( $T_r$ ). The peak discharge coincides with the time of concentration ( $T_c$ ) from the most distant point of the basin. The time of the rising limb and the time of the falling limb of each hydrograph are both equal to  $T_c$ . The area below the triangular or trapezoidal hydrograph is the volume of runoff.

After the maximum release rate (i.e. pre-development flow) is selected, an outflow hydrograph is determined to compute the storage volume. For simple outlet controls, the outflow hydrograph can be approximated by assuming that it will increase linearly and reach the maximum release rate where it intersects the receding limb of the inflow hydrograph where the storm duration is equal to the time of concentration of the basin (see Figure D6.2.1). The release rate is assumed to remain at the maximum rate thereafter. For more complex outlet controls, a reservoir routing procedure as documented in standard engineering manuals is required.

The required storage is represented by the area between the inflow hydrograph and the outflow hydrograph (Figure D6.2.1).

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The storage volume (m<sup>3</sup>) can be calculated by:

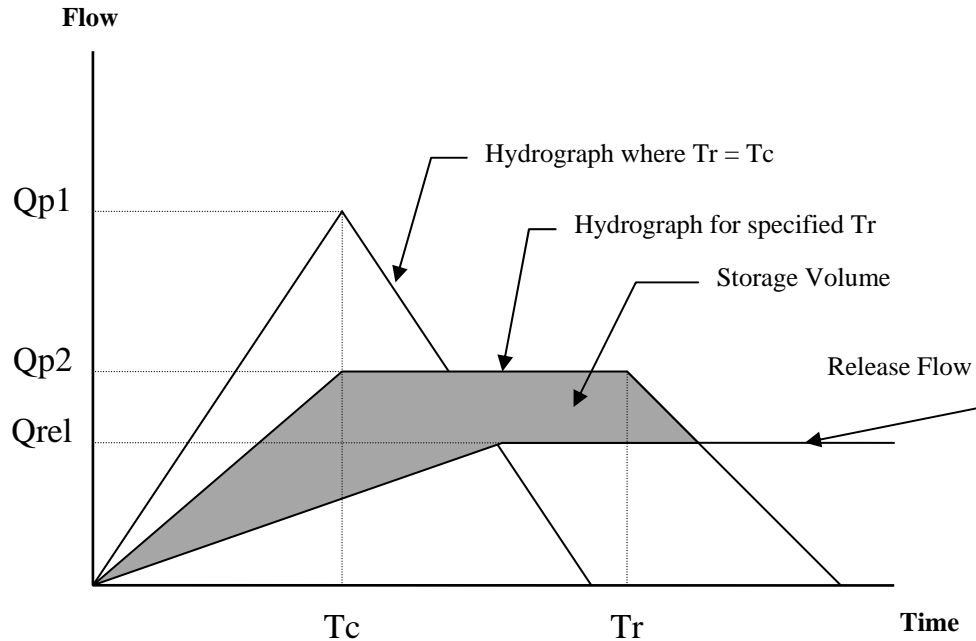
$$\text{Storage Volume} = T_r(Q_{p2} - Q_{rel}) + 0.5 T_c Q_{rel}^2 \left( \frac{1}{Q_{p2}} - \frac{1}{Q_{p1}} \right)$$

Where	$T_r$	=	duration of specified storm (seconds)
	$T_c$	=	time of concentration (seconds)
	$Q_{p1}$	=	peak flow for storm duration $T_r = T_c$ (m <sup>3</sup> /s)
	$Q_{p2}$	=	peak flow for specified storm duration (m <sup>3</sup> /s)
	$Q_{rel}$	=	maximum release rate (m <sup>3</sup> /s)

Storms with durations greater than the normal time of concentration ( $T_r > T_c$ ) will result in peak flow rates less than storms where  $T_r = T_c$  but may produce more runoff volume. Therefore several storms with varying durations must be analyzed to determine the critical design volume. Figure D6.2.2 shows an illustrative example of a storage volume calculation using the Modified Rational Method.

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### MODIFIED RATIONAL METHOD FOR COMPUTING STORAGE FOR SMALL CATCHMENTS (10 HA OR LESS) FIGURE D6.2.1



- Step 1** Determine maximum release rate ( $Q_{rel}$  = pre-development flow).
- Step 2** Calculate the time of concentration ( $T_c$ ) of the basin
- Step 3** Determine the peak flow ( $Q_{p1}$ ) for the hydrograph resulting from a storm where the duration equal to the  $T_c$  of the basin (use Rational Formula).
- Step 4** Select a range of storm durations ( $T_r > T_c$ ) and compute the peak flow ( $Q_{p2}$ ) using the Rational Formula  $Q = RAIN$  where  $I$  correlates with  $T_r$ .
- Step 5** Calculate the Inflow Runoff Volume = Peak Flow  $Q_{p2} \times T_r$ .
- Step 6** Compute the required storage volume for each hydrograph using Storage Volume =  $T_r (Q_{p2} - Q_{rel}) + 0.5 T_c (1/Q_{p2} - 1/Q_{p1}) Q_{rel}^2$ .
- Step 7** Select maximum storage from the range of storms for sizing pond.



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### D6.3 Design Volume (Large Catchments)

For large catchment areas over 10 ha in size, storage requirement shall be computed by the OTTHYMO-89 or MIDUSS program. Once the allowable release rate is established, the designer shall run the model for storms of various durations and selected the critical storage requirement.

### D6.4 Outlet Control

The outlet control for storage facilities may be designed using the standard orifice and weir equations:

Orifice Equation:  $Q = C A (2 g h)^{0.5}$

Where

Q	=	release rate (m <sup>3</sup> /s)
C	=	orifice coefficient (0.62 for sharp or square edge)
A	=	area of orifice (m <sup>2</sup> )
g	=	gravitational acceleration (9.81 m/s <sup>2</sup> )
h	=	net head on orifice (m)

Weir Equation:  $Q = C L H^{1.5}$

Where

Q	=	release rate (m <sup>3</sup> /s)
C	=	weir coefficient (from published references)
L	=	effective length of weir crest (m)
H	=	net head on weir crest (m)

Large storage facilities shall include provisions for discharging water above the design release rate. The rapid drawdown of the facility may be necessary for emergency purposes or to restore the available storage to accommodate subsequent storm events.

The provisions to accommodate higher discharges will involve oversizing the fixed openings and sewers connected to control structure. Adjustable mechanism such as slide gates or removable orifice plates can be used to regulate the design release rates. The extent of the oversizing will depend on the capacity of the downstream drainage system.

The design of inlet/outlet structures shall consider flow energy dissipation and erosion control. Safety gates are required over all inlet/outlet openings larger than 525 mm in diameter. Locks for access hatches are required to prevent unauthorized entrance to the structure.

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### D6.5 Emergency Overflow

An emergency overflow spillway with capacity to convey the 1:100 year flow and larger is required for all storage facilities. The spillway surface shall be finished with erosion resistant materials such as concrete, turf stone or other approved equal. The maximum spillway slope is 4 (horizontal) to 1 (vertical). The design of the spillway and/or overflow shall consider the possibility of blockages in the outlet structure and the consequences of extreme storm events.

### D6.6 Operation and Maintenance Requirements

A minimum 3 m wide all-weather vehicle access shall be constructed from a public road right-of-way to the control outlet and other works requiring maintenance. The maximum grade of the access is 20%. The surface shall be finished with gravel, concrete, or asphalt suitable for maintenance traffic. A sediment sump accessible to maintenance equipment shall be provided near the pond inlet.

For large detention facilities (over 2,000 m<sup>3</sup> of storage). The Designer shall submit two copies of the operation and maintenance manual at the time when the facility is completed and transferred to the Municipality. The manual shall include:

- (1) record drawings of the completed facility
- (2) brief description of the facility operation including design flows, design depths and schematic diagrams of the inlet and outlet structures, connections, controls, valves, bypass, overflows, etc.
- (3) list of manufacturer's operation, service and repair instructions and part lists
- (4) volume-stage-discharge relationships of all control structures
- (5) general maintenance requirements and emergency procedures
- (6) copies of approval from BC Environment (if applicable)

### D6.7 Safety Barrier and Signage

Storage facilities with open water greater than 1.0 m depth may be hazardous to the public. If the side slope is steeper than 7:1 and the design depth is greater than 1.0 m, fencing, or log rail barriers, with proper signage shall be erected along the perimeter of the storage pond.

The design, height and type of fencing will be to the approval of the Administrator and will take into consideration appearance and public safety.

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### D6.8 Detention (Dry) Storage

One of the most common forms of runoff control is detention (dry) storage. A detention pond is normally “dry” and only retains water during severe storm events. A control outlet permits the low flow to discharge downstream but limits the higher flows existing into the downstream system. The excess runoff is temporarily stored in the detention pond and gradually released back into the drainage system.

A detention pond can be constructed on-line or off-line from the drainage path, depending on the site conditions and the environmental constraints. The design standards are as follow:

maximum depth of storage (up to 1:10 Year)	1.5 m
maximum depth of storage (over 1:10 Year)	2.5 m
minimum bottom slope	1.0%
maximum pond side slopes	4 (H):1 (V)
preferred side slope	7 (H):1 (V)

The berm of the pond shall be constructed of stable impermeable material such as clay, compacted glacial till or an impermeable geo-membrane with permeability coefficient in the order of  $1 \times 10^{-8}$  m/s.

A landscaping plan detailing the reinstatement of grass cover or other approved surface finish is required for all dry detention ponds.

### D6.9 Retention (Wet) Storage

Retention storage provides temporary detention of severe storm runoff while maintaining a permanent pool of water throughout the year. A control outlet regulates the amount of flow released into the downstream system. During a storm event, the permanent pool of water is partially or completely replaced with stormwater. The design criteria is as follow:

min. land requirement (% of total catchment area)	0.5% to 2%
recommended minimum length to width ratio	2:1
minimum pond depth (normal water level)	1.0 m
maximum pond depth (high water level)	3.0 m
max side slopes from pond bottom to low water level	4 (H):1 (V)
max side slopes from low water to high water level	7 (H):1 (V)
maximum side slope above high water level	4 (H):1 (V)
minimum freeboard above high water level	0.5 m

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A retention pond requires a continuous base flow to maintain the permanent pool. A complete water budget analysis under post-development conditions is required to ensure that the base flow will exceed evaporation and seepage loss. Considerations shall be given for the circulation of water while narrow and/or dead bay areas are to be avoided. Provisions for draining the lake completely by gravity should be included if possible. Otherwise, provisions for a mobile pumping unit shall be included. A forebay shall be provided at the pond inlet for sedimentation control.

The pond berm shall be constructed of stable impermeable material such as clay, compacted glacial till or an impermeable geo-membrane with permeability coefficient in the order of  $1 \times 10^{-8}$  m/s.

A landscaping plan detailing the reinstatement of grass cover or other approved surface finishes on the side slopes and the surrounding berm is required. Special plant species may be required for environmental enhancement.

### D6.10 On-Site Detention Storage

On-site detention may consist of a number of methods such as parking lot storage, exfiltration trenches/drywells, rockpits, etc. Some common on-site storage methods are outlined below:

- (1) Parking Lot Storage
  - a. Requires detailed lot grading design to ensure proper drainage
  - b. Ponding shall be located in the remotest areas of the parking lot or along grass medians
  - c. Maximum ponding depth is 100 mm for 1:2 year storm, 150 mm for 1:5 year storm and 300 mm for 1:100 year storm
  - d. Emergency overflows are required for events exceeding the design frequency
  - e. Release rate shall be regulated by a standard flow control chamber (see Standard Drawings).
  
- (2) Exfiltration Trenches and Drywells
  - a. Only permitted where the native soils demonstrate high permeability and groundwater table is well below the invert of the trench (geotechnical investigation required)
  - b. Capacity of the system shall be determined from site-specific data

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- c. A positive drainage outlet is required
- d. Exfiltration trench shall consist of perforated storm sewer with a geotextile sleeve embedded in a geotextile wrapped drain rock filled trench. See Standard Drawings for a standard exfiltration trench cross-section.
- e. The 1:10 year hydraulic grade line shall be below all service connections at the property lines.
- f. The 1:100 year hydraulic grade line shall be at least 0.35 m below adjacent MBE's.
- g. Sediment traps are required at or before inlet to trenches
- h. Drywell (perforated) manholes shall be used in place of standard manholes.
- i. Shall be located in greenways, parks and open spaces wherever possible.
- j. Emergency overflows are required for storm events exceeding the design frequency.
- k. Release rate shall be regulated by a standard flow control chamber.

### (3) Other Storage Systems

Due to a variety of site-specific characteristics, it is not possible to list all the unique or typical storage alternatives. Designers shall review all proposals for on-site detention systems with the Engineering Department prior to detailed design.

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### D7 STORM SEWERS

#### D7.1 Sizing of Storm Sewers

The required storm sewer capacity shall be calculated using the Manning Formula under free flow (non-surcharged) condition. The Manning formula is:

$$Q = \frac{A R^{0.667} S^{0.5}}{n}$$

Where	Q	=	flow capacity (m <sup>3</sup> /s)
	A	=	cross sectional area (m <sup>2</sup> )
	R	=	hydraulic radius (m)
	S	=	slope of hydraulic grade line (m/m)
	n	=	roughness coefficient
			0.011 for PVC
			0.013 for asbestos cement, clay and concrete pipe
			0.024 for corrugated metal pipe (CMP)

NOTE: Asbestos cement pipes, clay pipes and corrugated pipes are not acceptable for new storm sewers.

Downsizing of storm sewers will not be accepted for sizes 600 mm diameter or less. A maximum downsizing of two pipe sizes for storm sewers larger than 600 mm diameter will be considered.

The minimum size of storm sewers shall be 250 mm diameter except at a terminal section of a short cul-de-sac with no catch basin connections where the size may be reduced to 200 mm diameter.

For the purpose of reference in this section, large diameter sewer refers to sizes 675 mm or larger, and small diameter sewer refers to sizes 600 mm and smaller.

#### D7.2 Minimum/Maximum Velocity

The minimum velocity for pipes flowing full or half full shall be 0.75 m/s.

There is no limit on the maximum velocity. However, if the design velocity exceeds 3.00 m/s and/or supercritical flow occurs, provisions for

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structural stability and durability of the pipe shall be included. Anchor blocks are required where the pipe grade is steeper than 15%.

Where drainage enters a natural watercourse, sediment control and energy dissipation will be provided and the maximum velocity shall be limited to 1 m/s.

### **D7.3 Minimum/Maximum Depth of Cover**

The minimum depth of cover shall be 1.0 m for storm sewer up to 600 mm diameter. For pipe sizes larger than 600 mm, for cover less than that specified above, an engineering design for cover will be required.

The depth of storm sewers shall be adequate to service all adjacent developments as well as all existing properties within practical limits. The invert of storm sewers at the upstream end must be of sufficient depth to service all of the tributary lands. In common trench installations, the sanitary service connections shall be permitted to cross over the top of the storm sewer.

Sewers shall not be constructed with more than 4.5 m of cover unless approved by the Administrator under special circumstances.

### **D7.4 Pipe Joints**

All storm sewer systems shall be designed of closed joint construction unless otherwise specified.

### **D7.5 Curvilinear Sewers**

Curvilinear sewers are not acceptable unless approved by the Administrator under special circumstances.

Where approved, horizontal curves will require a constant offset and/or shall be uniform throughout the curve. The minimum radius should not be less two times the minimum recommended by the pipe manufacturer. The maximum joint deflection shall not exceed one half of the pipe manufacturers' recommendations and all joints shall be deflected equally.

If straight tangent lengths with metered blinds are approved instead of curvilinear sewers each bend shall be located by survey.

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### D7.6 Sewer Location/Corridors

Storm sewers shall be located within the road right-of-way as noted in the typical road cross-sections in the Standard Drawings. Sewers and manholes should be offset from the vehicular wheel paths wherever possible to minimize the roughness of travel.

Where the storm sewer is required to cross private lands, the right-of-way shall have a minimum width of 5.0 m or two times the depth to the pipe invert, whichever is greater. Where both storm and sanitary sewers are located within a single right-of-way, the minimum width shall be 5.0 m or two times the depth to the invert of the deeper pipe, whichever is greater.

When a storm sewer and other appurtenances (i.e. manholes, valve chambers, etc.) are located within a right-of-way, the Developer may be required to construct and dedicate a road access for Municipal maintenance. The maintenance access shall be constructed to Municipal standards adequate to support the maintenance vehicles for which the access is intended. The surface shall normally be concrete or asphalt paving but, under special circumstances other hard surface materials may be used if approved by the Administrator.

### D7.7 Utility Separations

As per the Standard Drawings.

### D7.8 Manholes - Standard Requirements

Manholes shall be minimum 1200 mm diameter, and are required at:

- every intersecting sewer
- all changes in pipe size
- every 150 m for pipes less than 900 mm diameter
- every 200 m for pipes 900 mm diameter and larger
- all changes in direction and all changes in grade
- downstream end of curvilinear sewers (if permitted)

### D7.9 Hydraulic Losses Across Manholes

The following criteria shall be used:

1. The crown of the downstream pipe shall not be higher than that of the upstream pipe.

## SECTION D – DRAINAGE

2. An outside drop or ramp pipe shall be provided wherever the drop between the invert of the higher pipe is more than 0.25 m above the crown of the lower pipe.
3. Inside ramps will be permitted up to 250 mm from invert to crown.
4. Sudden and extreme changes in direction for large sewers should be avoided.
5. For large diameter sewers with 90E directional change, the ratio of the radius of bend (measured to the pipe centreline) to the pipe inside diameter should be greater than 2. Otherwise, the maximum bend deflection at one point shall be 45E (i.e. use two 45E bends to turn 90E).
6. 90E bends in large sewers shall not be located inside a junction with other sewer connections. Separate manholes are required.
7. To minimize the head loss in large sewers, high incoming flows from opposite direction should not impinge in the same manhole structure. Separate manholes are to be used.
8. Manhole anchorage may be required for 90E bends with large flows or high velocity flows.

For junctions involving large diameter sewers or high velocity flows, detailed engineering analyses may be required. For small diameter sewers (600 mm or smaller) and low velocity flows, the following equation can be used to calculate the head loss:

$$H_L = k \frac{V^2}{2g}$$

Where	HL	=	head loss (m)
	k	=	head loss coefficient
	V	=	outlet flow velocity (m/s)
	g	=	gravitational acceleration (9.81 m/s <sup>2</sup> )

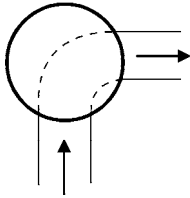
The minimum drops are:

- straight run - no drop required
- deflections up to 45E - 20 mm drop
- deflection 45E to 90E - 30 mm drop

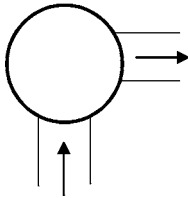
## SECTION D – DRAINAGE

Head loss coefficient  $k$  is related to the type of connections and the type of benching inside the manhole.

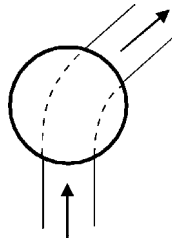
### Manhole Bends



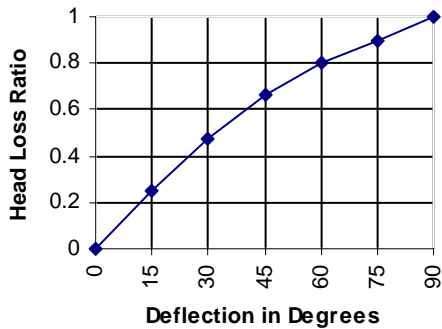
$k = 1.0$   
for 90 degree manhole bend with channelized benching up to the crown of pipe to deflect the full flow



$k = 1.5$   
for 90 degree manhole bend with no channelized benching (or only partial channelized benching up to springline)



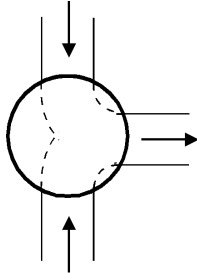
$k$  is determined by multiplying the head loss coefficient  $k$  for a 90 degree manhole bend and type of benching by the head loss ratio factor in Figure D7.9.1



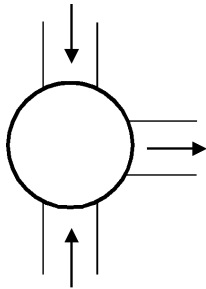
**HEAD LOSS COEFFICIENT FOR JUNCTIONS  
FIGURE D7.9.1**

## SECTION D – DRAINAGE

### Manhole Tees with Side Outlets

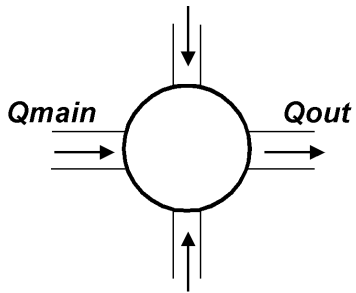


$k = 1.0$   
for tee manhole with deflector between incoming pipes for the full depth of flow.

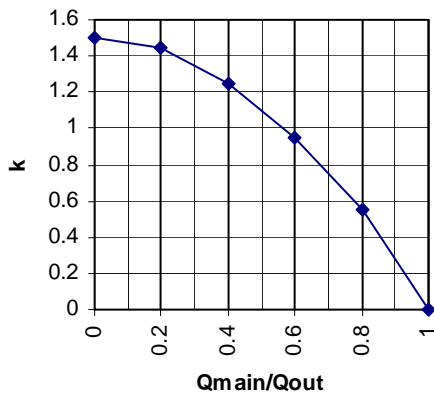


$k = 1.5$   
for tee manhole without deflector between the incoming flows.

### Manhole Crosses or Tees with Side Inlets



Use Figure D7.9.2 to determine the value for  $k$ . Proper channelized benching shall be incorporated in the design to maximize the flow velocity to the outlet direction. If opposite inflows impinge inside the manhole, separate manholes should be considered.



**HEAD LOSS COEFFICIENT FOR  
JUNCTIONS  
FIGURE D7.9.2**

## SECTION D – DRAINAGE

### D8 CATCH BASINS

Catch basins shall be provided at regular intervals along roadways, at upstream end of radius at intersection and at low points (sags). Low points are not to be located within curb returns at intersections. The Designer must ensure that sufficient inlet capacity is available to collect the entire minor flow into the underground pipe system. Grates shall have a “fish” symbol.

The spacing of the catch basins shall be based on hydraulic requirements. The capacity of a single catch basin can be calculated by the orifice equation:

$$Q = 0.67 C A (2gh)^{0.5}$$

Where	Q	=	inlet capacity (m <sup>3</sup> /s)
	0.67	=	clogging factor
	C	=	orifice coefficient (0.8)
	A	=	open area (0.068 m <sup>2</sup> for Dobney B-23 grate)
	g	=	gravitational acceleration (9.81 m/s <sup>2</sup> )
	h	=	depth of ponding (m)

The maximum spacing shall be established to permit each catch basin to drain a maximum area of 500 m<sup>2</sup> on road grades up to 5% and 350 m<sup>2</sup> on steeper grades. If the major flow is to be conveyed in the pipe system, additional catch basins are required.

The minimum diameter for catch basin leads is 200 mm for single catch basins and 250 mm for double catch basins. Catch basin leads should be taken directly into manholes if feasible. Double catch basins shall not be directly connected together; instead the lead from each catch basin shall be connected to a wye to a 250 mm lead and into the manhole. The minimum grade for leads is 2%, the maximum length is 30 m.

### D9 LAWN BASINS

Lawn Basin leads shall have a minimum diameter of 150 mm and a minimum slope of 2%. Lawn basin leads shall have a 200 mm diameter inspection chamber is at the property line. Grates shall have a “fish” symbol.

### D10 TEMPORARY CLEAN-OUTS

Temporary clean-outs may be provided at terminal sections of a main provided that all the following conditions are met:

## SECTION D – DRAINAGE

1. future extension of the main is proposed or anticipated
2. the length of sewer to the downstream manhole does not exceed 45 m
3. the depth of the pipe does not exceed 2 m at the terminal point

NOTE: Clean-outs shall not be considered a permanent structure.

### **D11 SERVICE CONNECTIONS**

Service connections shall be installed to provide a “gravity-flow” connection to all buildings fronting the main, except where the land can drain to an acceptable alternate existing system. The design requirements are:

1. The minimum diameters are 100 mm for residential and 150 mm for industrial/commercial.
2. The minimum slope is 2.0%.
3. The connection shall be located at the lower (downstream) portion of a larger rural lot or land parcel. In urban developments, connections shall be as noted on the Standard Drawings unless an alternate location is approved by the Administrator.
4. The service connection at the property line shall be above the hydraulic grade line of the minor flow.
5. Each connection shall only service a single lot.
6. When the design is proposed to infill an existing ditch, all existing service connections are to be connected to the proposed main.
7. The maximum length is 30 meters.
8. Service connections shall have a 200 mm diameter inspection chamber at the property line. The factory installed plug shall be removed before the inspection chamber is installed.

### **D12 FRENCH DRAINS**

The use of French drains shall only be permitted where the topography and soil conditions are proven adequate to the acceptance of the Administrator. A soils report will be required to support the design.

### **D13 ROCKPIT/DRYWELL**

The use of rockpits or drywell drainage will only be permitted at the discretion of the Approving Officer. Rockpits or drywell drainage will only be considered in certain areas of the Municipality where it can be demonstrated that the subsoil conditions will provide a percolation rate equal to, or in excess of, twice the minor runoff flows. A soils report will be required to confirm the suitability of the soils.

## SECTION D – DRAINAGE

This does not preclude the requirement for Major Flood Path Routing and all designs shall incorporate a positive outlet for rainfall intensities in excess of the minor system design.

### D14 MAJOR FLOW ROUTING AND FLOOD CONTROL

#### D14.1 Major Flow Routing

Unless the storm sewer system is oversized to accommodate the major flow (i.e. 1:100 year return frequency storm), provision for surface flow is required wherever the overland flow in excess of 0.05 m<sup>3</sup>/s is anticipated. Major flow routing is generally accommodated along roadways, swales and watercourses. These designated flow paths shall be protected by restrictive covenants or rights-of-way and clearly identified in the stormwater management plan.

The quantity of flow to be conveyed by the surface flow path is the total major flow less the capacity of the minor system. The design of the major flow routing shall ensure to the satisfaction of the Administrator that no endangering of public safety nor substantial property damages will occur under the major flow conditions.

#### D14.2 Roadway Surface Drainage

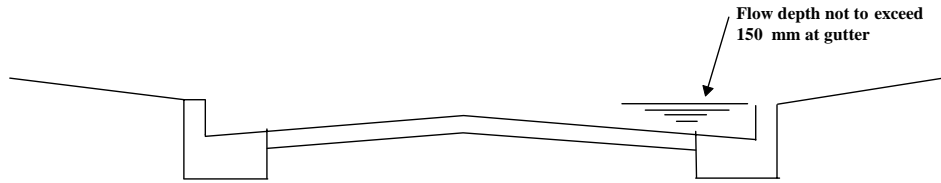
Urban roadways with curbs and gutters can be designed as wide shallow channels to convey major surface flow. The water elevation at maximum ponding/flow shall be at least 0.35 m below the lowest minimum building elevation of the adjacent buildings. The maximum depths of flow shall not exceed 150 mm above the gutter line. Refer to the following diagram when calculating the flow capacities.

The design of intersections shall ensure that the surface flow can continue along the designated path crossing over lateral streets. Similar considerations are required if a change of surface flow direction is required at an intersection.

**Pavement Width = W**

**2% Cross Fall**

## SECTION D – DRAINAGE



**ROAD SURFACE USED FOR MAJOR FLOOD ROUTING**  
**TABLE 2.3.6**

Flow Capacity	Q	=	A*V
Flow Velocity	V	=	(1/n)
*(A/P) <sup>0.667</sup> X(2/100) <sup>0.5</sup>			
Flow Area	A	=	0.15W - 0.005W <sup>2</sup>
Wetted Perimeter	P	=	0.3 + W
Roughness Coeff.	n	=	0.013

### D14.3 Ditches

Ditches adjacent to roadways shall conform to the following criteria:

- |                                     |               |
|-------------------------------------|---------------|
| 1. maximum depth                    | 1.0 m         |
| 2. minimum bottom width             | 0.3 m         |
| 3. Maximum inner side slope         | 2.0 (H):1 (V) |
| 4. maximum outer side slope         | 1.5 (H):1 (V) |
| 5. minimum grade                    | 0.5%          |
| 6. maximum velocity (Unlined ditch) | 1.0 m/s       |

Where soil conditions are suitable or where erosion protection is provided, higher velocities may be permitted. If grades are excessive, erosion control structures or ditch enclosure may be required.

The minimum right-of-way width for a ditch shall be 5 m where the ditch crosses private property. The ditch shall be offset in the right-of-way to permit a 3 m wide access for maintenance vehicles. Additional right-of-way may be required to facilitate the ditch construction and access. The top of the ditch adjacent to the property line shall be a minimum 0.5 m away from that property line.

### D14.4 Watercourses

Natural watercourses are integral components of the major drainage system and the ecological system. If the process of development or drainage design involves instream works, the Designer shall refer to the “Land Development Guidelines for the Protection of Aquatic Habitat” by Department of Fisheries and Oceans & BC Ministry of Environment, Lands and Parks.

## SECTION D – DRAINAGE

All proposals for works affecting natural watercourses must be forwarded (by the Designer) to the following Federal and Provincial Government Agencies for review:

1. Department of Fisheries and Oceans (DFO)  
Habitat Management Unit  
610 Derwent Way  
Annacis Island  
New Westminster, BC  
V3M 5P8  
Tel: 666-6627
2. Ministry of Environment, Lands and Parks (MOELP)  
Fish and Wildlife Branch  
10470 – 152 Street  
Surrey, BC  
V3R 7P8  
Tel: 582-5200
3. Ministry of Environment, Lands and Parks (MOELP)  
Water Management Branch  
10470 – 152 Street  
Surrey, BC  
V3R 7P8  
Tel: 582-5200

Care must be taken to ensure that no toxic materials are employed and that such materials as concrete and fine soils are not permitted to enter the watercourse. In no case will sand/cement bags be permitted as rip rap or wall structures on watercourses.

The *Developer* and the *Developer's Engineer* are required to be aware of the sections of the *Municipality's Zoning Bylaw* as amended from time to time, which pertain to flooding and floodproofing.

Prior to construction, verification of environmental agency approvals must be received by the Municipality.

Rights-of-way, as required by the Administrator for maintenance access are required.

## SECTION D – DRAINAGE

### D14.5 Culverts

Culverts located in natural watercourses or culverts crossing all roads shall be designed to convey the major flow or greater. The Designer shall determine whether the culvert will operate under inlet or outlet control at design conditions.

Concrete culverts are preferred for general uses. Corrugated steel culverts may be considered under special circumstances when their use can be justified.

The minimum diameter of culverts is 450 mm (300 mm for driveway culverts).

The average water velocity in culverts should not exceed:

1. 1.2 m/s for lengths up to 24.4 m
2. 0.9 m/s for lengths over 24.4 m
3. for culverts longer than 61 m within a fishery stream, special conditions from DFO and MOELP will apply

The minimum depth of cover for culvert is 0.3 m, subject to the correct pipe loading criteria.

No culvert shall exceed 30 meters in length unless approved by the Administrator.

Inlet and outlet structures are required for all culverts designed for the major flow. Considerations for the installation of energy dissipation and erosion control shall be included in the design.

Driveway culverts that form part of the minor system shall have capacity for the runoff from the 10 year storm with the design headwater not to exceed the top of the culvert.

### D14.6 Inlet and Outlet Structures

Refer to Standard Drawings for the design of inlet and outlet structures for pipes up to 1050 mm diameter. Pipes larger than 1050 mm diameter and non-circular culverts require specially designed inlet and outlet structures.

Outlets having discharge velocities in excess of 1 m/s require rip rap protection and/or energy dissipating structures for erosion control.

Grills are required at the inlets and outlets of all pipes over 300 mm in diameter and exceed 30 m in length (except large culverts in major watercourses). Trash racks are required at the inlet of the pipes over 600 mm in diameter. Grills may

## SECTION D – DRAINAGE

also be required on smaller diameter storm sewers at the discretion of the Administrator. See Standard Drawings for grill details.

### **D15 SITE AND LOT GRADING**

Developments shall incorporate site and lot grading techniques unless otherwise noted.

The following criteria shall be used:

1. Each lot shall be graded to drain into a Municipal Drainage System or a natural drainage path independent of adjacent lots where possible. Minimum lot grades to be 1%. Lot grading is to be uniform and consistent.
2. Areas around buildings (or proposed building sites) shall be graded away from the (proposed) foundations at a minimum of 1% grade to prevent flooding.
3. Lots lower than adjacent roadways should be avoided where possible or acceptable storm water management techniques must be incorporated to direct the runoff to an existing or proposed drainage system. Proper flood proofing is required at the low points of roadways.
4. Existing or proposed buildings must be sited above the hydraulic grade line of the Major System. The Designer shall note any existing Minimum Building Elevations (MBE).
5. Individual lots will not be permitted to direct storm runoff into any natural watercourse, park or green belt areas. Only sheet flow may be permitted.

NOTE: The submission and acceptance of the lot grading record drawings is required prior to issuance of the building permits.

### **D16 MINIMUM BUILDING ELEVATIONS (MBE)**

The MBE is defined as the elevation of the lowest floor slab in a building or the underside of the floor joists where the lowest floor is constructed over a crawlspace.

Crawlspace is a space between a floor and the underlying ground having a maximum height of 1.2 m to the underside of the joists and not used for the storage of goods or equipment damageable by floodwater.

## **SECTION D – DRAINAGE**

The MBE shall be established at least 0.6 m above the service connection invert and 0.2 m above the 100 year hydraulic grade line elevation. Accepted MBEs may not be revised without referral to the Administrator.

Unless otherwise required, rural and agricultural developments do not require MBEs for the proposed lots/parcels.

A gravity connection to the municipal storm drainage system may be made only where the habitable portion of a dwelling is above the Major System hydraulic grade line.

### **D17 ROOF DRAINAGE**

1. Roof drainage for all new dwellings shall be discharged to the ground and dispersed via splash pads at the downspouts.
2. If discharge of roof leaders to splash pads is not considered practical, roof drainage may be discharged into the Municipal drainage system, at the discretion of the Administrator, where the size of the proposed or existing storm sewer has been designed for, or can be shown to accommodate the anticipated flows. Roof leaders shall be connected to the storm drain connection at the property line. Roof leaders shall not be connected to foundation drains.

### **D18 SWALES**

Swales shall be a maximum 150 mm deep and shall conform to Standard Drawings. All swales are to be lined with turf on a minimum 100 mm of topsoil. Swales required for lot grading conformity shall be located on a 3 m easement for accepting drainage from adjacent lots. Swales designed for Major Flow Routing may exceed the 150 mm depth to accommodate the anticipated flows with the easement established accordingly. Swales shall have a minimum 1% grade.

### **D19 SILTATION CONTROLS**

Designers are required to demonstrate how work will be undertaken and completed so as to prevent the release of silt, raw concrete, leachate and other deleterious substances into any ditch, storm sewer, watercourse or ravine. Construction materials, excavation wastes, overburden soils, or other deleterious substances shall be disposed of or placed in such a manner as to prevent their entry into any watercourse, ravine, storm sewer system, or restrictive covenant area.

## **SECTION D – DRAINAGE**

The Designer shall refer to the “Land Development Guidelines for the Protection of Aquatic Habitat” by DFO and MOELP and consult these agencies with regards to the required siltation controls. Details of the proposed controls are to be included in the design drawings and shall be installed as part of the works.

All siltation control devices shall be situated to provide ready access for cleaning and maintenance. Proposed siltation control structures must be maintained throughout the course of construction and to the end of the maintenance period (final acceptance). Changes in the design of the structure will be required if the proposed structure is found to be inadequate.