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S E C T I O N 6A

STORM DRAIN - DESIGN

6A.l SCOPE

This section covers design standards and material specifications for municipal storm drainage works. This section does not cover requirements that may be imposed by the Ministry of Environment and/or Federal Fisheries for storm drainage works in or about natural watercourses, creeks, rivers, lakes or oceans. It shall be the Consultant's responsibility to ensure that the design requirements of the Ministry of Environment and/or Federal Fisheries are met.

6A.2 STORM WATER QUANTITY

6A.2.1 General

Storm drain design calculations shall be submitted with design drawings and must be approved by the Engineer. Adjacent contributory areas must be determined and included in the design and where required, design systems shall be proven capable of handling additional future upstream flows. The existing systems downstream of the design shall be proven capable of handling the additional flows.

A drainage area plan showing the proposed storm drainage system the contributory drainage areas and the l00 year storm flood routing shall be submitted conforming to the requirements of Section 2.4

6A.2.2 Design Return Period

Generally systems shall be designed for a l0-year return period, however large trunk systems (600 mm diameter and larger) shall be designed for a 25-year return period or as required by the Engineer.

Provision shall be made to accommodate flows in excess of the design return period in a manner that will minimize damage and danger. Overland flood routing for the l00 year storm shall be considered when designing the drainage system.

6A.2.3 Catchment Area

The contributory catchment areas shall be governed by the natural contours of the land and accommodating the overall drainage areas.

6A.2.4 Rate of Flow

Unless otherwise required by the Engineer, the rate of flow of storm water shall be determined using the Rational Method as follows:

$$Q = \frac{CIA}{360}$$

Where: Q = flow (m;/s)
C = runoff co-efficient (dimensionless)
I = rainfall intensity mm/hr
A = contributing area (ha)

6A.2.5 Rainfall Intensity

Rainfall intensity is determined by comparing the time of concentration (Tc) with the Rainfall Curves for the appropriate return period.

The rainfall intensity duration curve for the Town of Ladysmith is shown on Standard Drawing D17.

Time of Concentration (Tc):

Tc = The total time, from the onset of precipitation, until all areas, or the furthest areas, of the contributing runoff to the point of concentration.

The total time of concentration is comprised of two segments. Each is determined independently and the values are combined into the total time of concentration.

Tc = Te + Tr

Where: Te = Entry time or Inlet time
Tr = Running or system flow time

Entry times (Te) will vary but are usually ten (l0) minutes at the most distant point upstream.

Running times (Tr) are determined using the Upland Method. The Upland Method Time of Concentration Table is shown on Standard Drawing D18.

6A.2.6 Runoff Coefficient (C)

The choice of the runoff coefficient (C) shall be based on ground slope, type of ground or surface cover, size of drainage area and the expected ultimate land use of the properties within the drainage area. The choice of the coefficient shall be guided by the following ranges:

TYPE OF DEVELOPMENT	RUNOFF COEFFICIENT

Industrial	0.80 to l.00
Commercial Business Areas Multi Family	0.65 to 0.90
Single Family Residential Low Density Multi Family	0.50 - 0.80
Rural Area, Parks, Golf Courses	0.25 to 0.55

6A.3 STORM DRAIN HYDRAULICS

6A.3.1 Storm water facilities shall be designed to carry peak flows. Flows shall be calculated in accordance with the methods noted above.

6A.3.2 System capacity for an enclosed storm drain or open channel flow shall be designed using Mannings formula.

$$Q = \frac{(l)}{n} AR\ \beta\ S2$$

Where Q = volume flow rate (m;/s)
N = resistance factor (Manning's N)
= 0.0ll for PVC pipe
= 0.0l3 for Concrete pipe
= 0.024 for CMP
A = cross sectional area (m sq.)
R = hydraulic radius (m)
S = slope (m/m)

6A.3.3 No storm drain shall be less than 200 mm in diameter and no connection to a catchbasin shall be less than 200 mm in diameter.

6A.3.4 No service connections shall be less than l00 mm in diameter. Service connections serving more than duplex family dwellings shall be minimum 200 mm in diameter and sized in accordance with design flows and available grades.

6A.3.5 The following shall be the minimum grades for each size of pipe:

SIZE	GRADE
l00	2.0%
l50	l.0%
200 & greater	0.5%

6A.3.6 The minimum velocity for maximum flow shall be l metre per second in a pipe.

6A.3.7 Where the pipe discharge velocity of the design flow exceeds l.5 metres per second, into an open ditch or water course, provision shall be made for the installation of an energy dissipator to reduce flow velocity to the acceptable rate.

6A.3.8 There are no maximum allowable velocities, however, where grades exceed l0%, the need for scour protection shall be examined and anchor blocks will be required as per Standard Drawing T4.

6A.4 DEPTHS

6A.4.1 Minimum cover on lateral sewers shall be l.5 meters in road right-of-ways and l.0 meters in untravelled areas.

6A.4.2 Where minimum cover cannot be provided, an explanation of the reasons and pipe loading calculations shall be submitted with the proposed method of pipe protection to the Engineer for approval.

6A.4.3 Service connections shall be deep enough to accommodate by gravity the lowest elevation of each lot serviced. In addition, all existing foundation drains shall be accommodated. For vacant lots, service connections shall also be deep enough to accommodate by gravity foundation drains for future building(s) constructed to the minimum basement floor elevation as determined by the Consulting Engineer.

6A.4.4 Storm sewer mains shall be deep enough so that all service connections accommodating surface and foundation drainage from all lots in the upstream drainage basin can be drained to the storm sewer system by gravity.

6A.4.5 Where the minimum depths of mains and service connections cannot be met, an explanation of the reasons shall be submitted to the Engineer for approval.

6A.5 LOCATIONS

6A.5.1 (a) Unless otherwise approved by the Engineer, storm drains shall be located in the road right-of-way in accordance with Section 7 Standard Drawings.

(b) Storm drains may be installed in a common trench with gravity sanitary sewers provided the maximum invert elevation difference is 300 mm and the minimum lateral clearance between the walls of adjacent pipes is 300 mm. Where deflections are required to accommodate manholes and other works, only the storm drain shall be deflected from the design alignment.

(c) In accordance with the Ministry of Health requirements, no storm or sanitary sewer is to be constructed within 3.0 m of a watermain, nor within 0.50 m vertical clear separation at sewer cross-unders without the written permission of the Public health Engineer.

6A.5.2 Where topography makes placement of storm drains in the road right-of-way unfeasible, storm drains may be located in a statutory right-of-way (SRW) over private property, subject to the following conditions:

(a) Municipal service location and SRW widths shall conform to Standard Drawing R6

(b) In general, manholes and cleanouts shall not be located in SRW's, however, where this cannot be avoided, only one manhole or cleanout should be located in a SRW without making provision for direct vehicular access.

(c) Where vehicular access to manholes or cleanouts in SRW's is required an approved access lane shall be provided.

6A.6 CURVED STORM DRAINS

6A.6.1 Horizontal curves will be permitted where the right-of-way requires curvature for a constant offset and where the design velocity exceeds l.0 metres per second. Vertical curves will be permitted under special circumstances where excessive cuts are to be avoided and where energy dissipation is required. Horizontal and vertical curves may not be used in combination on the same section.

6A.6.2 Radius of horizontal curvatures shall be uniform throughout the curves and shall be not less than 60 meters; in no case shall the deflection required to achieve the design curvature exceed the manufacturer's recommended deflection for the particular material being installed.

6A.7. MANHOLES

6A.7.1 Distances between manholes shall not exceed l20 metres unless otherwise approved by the Engineer. For pipes larger than 600 mm in diameter, manhole spacing may be increased to l80 metres.

6A.7.2 Manholes shall be located at grade and alignment changes, at lateral size changes, at the upstream end of all lateral sewers, and at the junctions of all lateral sewers.

6A.7.3 Cleanouts may be substituted for manholes at the upstream end of lateral sewers where no future extension of the lateral sewer will occur and where otherwise approved by the Engineer.

6A.7.4 Where the difference in elevation between incoming and outgoing sewers exceeds 600 mm, standard drops for pipe sizes 375 mm or less shall be used as shown in the standard drawings. Inside drops between 250 mm and 600 mm shall be avoided.

6A.7.5 Precast manhole barrels shall be sized according to inside pipe diameter and depth as detailed below:

Pipe Size (Nominal)	Depth of Manhole (Top of Cover to Inv.)	Barrel Size (Inside Dia.)
150 - 375 mm	0.0 - 5.9 m	l050 mm
l50 - 375 mm	6.0 - 9.0 m	l200 mm
l50 - 600 mm	9.0 m or greater	l500 mm
400 - 600 mm	0.0 - 8.9 m	l200 mm
675 - 750 mm	All Depths	l350 mm
900 - 1050 mm	All Depths approved Engineer	l500 mm or riser Manhole as by City

6A.7.6 Where cast-in-place manholes are proposed, design and construction details shall be submitted to the Engineer for approval.

6A.7.7 Manholes shall be located to avoid any conflict with curb and gutter or sidewalks.

6A.8 CATCHBASINS

6A.8.1 Catchbasins shall be provided at regular intervals along streets, at street intersections, and at all low points in street.

6A.8.2 Catchbasins located in streets shall be spaced to collect a maximum of 450 square meters of pavement drainage where grades do not exceed 5 percent. On grades over 5 percent the maximum area collected shall be reduced to 300 square meters.

6A.8.3 Double catchbasins shall be installed at all low points in roads and downhill cul-de-sacs.

6A.8.4 Location requirements for the different catchbasins types shall conform to the following:

- Typical Catchbasin Type 1 - Standard Drawing D11 & D12:
  For location along curbed roads where road grades are 5% or less.

- Typical Catchbasin Type 2 - Standard Drawing D11 & D12A:
  For location along curbed roads where road grades exceed 5%.

- Side Inlet Catchbasin Type 3 – Standard Drawing D13 & D13A:
  At low spots and at such other places as damage by flooding might occur if the flat grating were to become blocked.

- Ditch Inlet Type Catchbasin Type 4 - Standard Drawing Dl4 & D14A:
  For location in boulevards and easements outside of the paved road.

6A.8.5 Catchbasin leads shall have a minimum diameter of 200 mm for single basins and 250 mm diameter for double basins. The maximum length of 200 mm diameter leads shall be 30 meters. Leads over 30 meters length shall be 250 mm in diameter.

6A.8.6 Unless otherwise approved by the Engineer, single side inlet Catchbasin leads shall be 250 mm in diameter.

6A.8.7 Double catch basins shall not be connected directly together but rather one basin will be wyed into the lead of the other.

6A.8.8 Leads shall have a minimum grade of two percent (2%).

6A.9 STORM DRAIN SERVICE CONNECTIONS

6A.9.1 Connections shall be installed in accordance with Standard Drawing D5.

6A.9.2 Minimum grade for a l00 mm service shall be two percent.
Minimum grade for a l50 mm service shall be one percent.

6A.9.3 Minimum cover on services shall be l.0 m unless otherwise approved by the Engineer.

6A.9.4 Services shall be extended 2.0 m into the lot in order to prevent undermining of the boulevard and to protect cleanout when connection to service.

6A.9.5 Where horizontal bends are required in the service pipe these shall be made with long radius bends.

6A.9.6 Where a horizontal bend greater than 45 degrees is required, a cleanout shall be constructed.

6A.l0 OPEN CHANNELS

6A.l0.1 The design of open channels to carry minor or major flows shall be restricted to the following maximum velocities:

(a)	Unlined channel:	l.5 metres per second
(b)	Suitably lined channel:	3.0 meters per second

6A.l0.2 If the mean velocity exceeds that permissible for the particular kind of soil or is greater than l.5 metres per second the channel shall be suitably lined to protect it from erosion.

6A.l0.3 The maximum depth of flow shall not exceed 300 mm with a freeboard of l50 mm.

6A.l0.4 Channel cross section shall have a minimum of 1.5 horizontal to 1.0 vertical banking and a channel depth of no less than 600 mm. The channel bottom shall be a minimum of 300mm wide.

6A.ll INLET AND OUTLET STRUCTURES

6A.ll.l Headwalls shall be provided at the inlet and outlets of all storm drains and culverts in accordance with Standard Drawings.

6A.ll.2 The inlet and outlet of storm drains are to be protected from debris by suitable grates. All grates are to be at least the same diameter of the storm drain and be sized to handle the design flow of the storm drain as shown on Standard Drawings.

6A.l2 SUB-SURFACE DRAINAGE

6A.l2.l Where sub-surface drainage is anticipated or encountered it may be intercepted using perforated drains (French drains) where approved by the Engineer. Proposed installations must be submitted for approval prior to construction.

6A.l2.2 When sub-surface drainage is encountered in utility trenches, trench dams and inlets to the storm drainage system shall be installed in accordance with Section 3.

6A.l2.3 Installation of perforated drains shall be in accordance with the following:

(a) Pipe shall be as specified under Section 6A.l3.5.

(b) Filter material (drain rock) shall be a clean, round rock ranging in size from 20 mm to 40 mm diameter.

(c) Geotextile fabric shall be used to ensure the drain rock does not become contaminated by surrounding soils.

(d) Drain rock shall be placed around pipe in accordance with bedding cross section shown on Standard Drawing Tl.

(e) Clean-outs and/or inspection points shall be provided in locations approved by the Engineer.

6A.l3 PIPE MATERIALS

6A.l3.l The following materials may be used for storm drain installations in the Municipality subject to the specifications and conditions listed below.

6A.l3.2 Storm Drain Mains

(a) Polyvinyl Chloride (PVC) Pipe (Smooth Profile)

- Pipe and fittings up to 675 mm diameter shall be SDR-35. Pipe and fittings shall have a minimum pipe stiffness of 320 kPa at 5.0% deflection when tested in accordance with ASTM D2412

- Pipe and fittings shall be manufactured to the following specifications:

  100 mm - 375 mm dia. to ASTM D3034 and CSA B182.2

  450 mm - 675 mm dia. to ASTM F679 and CSA B182.2

- Pipe and fittings shall include integral bell and spigot ends with stiffened wall section and formed groove for a rubber gasket conforming to ASTM F477.

(b) Concrete Pipe

- Non-reinforced concrete pipe and fittings shall conform to ASTM C14M Class 3 to a maximum diameter of 600 mm and shall be designed with flexible rubber gasket joints conforming to ASTM C443M.

- Reinforced circular concrete pipe and fittings shall conform to ASTM C76M Class 3 or higher for all pipe greater than 600 mm diameter and shall be designed with flexible rubber gasket joints conforming to ASTM C443M.

- Pipe with chips, cracks, porous concrete or any other defects which impair joint sealing or durability will not be accepted.

6A.l3.3 Storm Drain Services

Polyvinyl Chloride (PVC) Service Pipe

- All storm service connection pipe and fittings shall be green or white in color.
- Storm service connections of 100 mm diameter shall be SDR-28 and conform to CSA B182.1. Pipe and fittings shall have elastomeric seal joints, locked in gasket and integral bell joint features.
- Storm service connections greater than 100 mm diameter shall be as specified for PVC (smooth profile) mainline pipe.

6A.l3.4 Catchbasin Leads

(a) Polyvinyl Chloride (PVC) Leads

- Catchbasin leads shall be as specified for PVC (smooth profile) mainline pipe.

(b) Other

- Subject to the Engineer's approval, other materials may be used in areas where there is not sufficient cover to PVC pipe.

6A.l3.5 Perforated Drains

Polyvinyl Chloride (PVC) Drains

- Perforated drain pipe shall be as specified for PVC (smooth profile) mainline pipe.
- Minimum diameter shall be l50 mm.
- Perforations shall be l3 mm diameter, located in the bottom half of the pipe.

6A.l3.6 Alternate Materials

Alternate materials will be considered in special circumstances, such as inadequate cover, subject to the approval of the Engineer.

6A.l3.7 Pipe Selection

The class and type of pipe and fitting, together with required class of bedding and trench widths shall be so selected that the pipe will support the anticipated gravity earth and any surface dead and live loads with a safety factor of l.5.

6A.l3.8 Testing of Pipe Materials

All pipes are subject to testing and inspection at the discretion of the Engineer. The basis of acceptance shall be confirmation with the applicable ASTM and CSA specification. The cost of all testing shall be borne by the Developer.

6A.l3.9 Appurtenances

All appurtenances shall be of a type and standard compatible with the pipe on which it is being installed.