Storm Sewer Design

RATIONAL METHOD

Q = CIA / 360 (metric units) or Q = CIA (English units)

where:

- Q = Peak flow, m3/s (ft3/s)
- C = Runoff Coefficient
- I = Rainfall Intensity, mm/hr (in/hr)
- A = Drainage area, hectares (acres)

Now we can start sizing our pipes!

Sample Runoff Coefficients

- The runoff coefficient (C), also called the “coefficient of imperviousness,” is the ratio of runoff to rainfall.

• Commercial areas	0.7 - 0.8
• Heavily developed areas	0.7
• Industrial areas	0.7 - 0.75
• Schools, churches, institutions	0.5 - 0.7
• Apartments	0.5
• Townhouses	0.65
• Semi detached residential	0.55
• Single family residential	0.45

IDF Curves (TORONTO)

Equation of IDF curves [5] is:

$$I = AT^C$$

Where:

I = Rainfall Intensity (mm/hr)
T = Time of Concentration (hour) - use 10 minutes inlet time (or initial time of concentration)

Parameters of A and C are shown as follows:

Return Period (Year)	A	C
2	21.8	-0.78
5	32	-0.79
10	38.7	-0.80
25	45.2	-0.80
50	53.5	-0.80
100	59.7	-0.80

2-Year IDF Curve (Toronto) = $I = \frac{21.8}{(T)^{0.780}}$ 100-Year IDF Curve (Toronto) = $I = \frac{59.7}{(T)^{0.80}}$

- Assuming an initial Tc of 10 minutes, calculate the 2 and 100 year Rainfall Intensities
- DON'T FORGET TO CONVERT FROM MINUTES TO HOURS AS RAINFALL INTENSITY IS mm/hr!

2-Year IDF = 88.19 mm/hr 100-Year IDF = 250.32 mm/hr

Pipe Sizing Methods

Mannings Equation

Use for sewers flowing freely under gravity (storm and sewer)

Hazen-Williams

Use for sewers under pressure – to be covered later (use for water mains and force main sewers)

Recall: Manning's Equation

$$\mathbf{Q = AR^{2/3} S^{1/2} n^{-1}}$$

Where:

Q = flow (m^3/s)

A = area of pipe (m^2)

R = hydraulic radius (m)

Note R = A/P (Area / Wetted Perimeter)

S = slope (unitless)

n = Manning's or "roughness" coefficient (unitless)

Roughness Coefficients

The roughness coefficients to be used for storm sewer pipes will be:

a) concrete pipe	n=0.013	
b) PVC pipe	n=0.013	
c) corrugated metal	n=0.024	(culvert use only)

Minimum Depths

- The depth should (IDEALLY) be sufficient to provide a suitable outlet for the building foundation weeping tile. Why???

- The minimum cover to the pipe obvert will be 1.5m. Why???
- Or to provide 1.0m clearance between the 25 year hydraulic grade line (H.G.L.) and foundation drains whichever is greater.

Typical Velocities

Minimum Velocities = 0.75 m/s

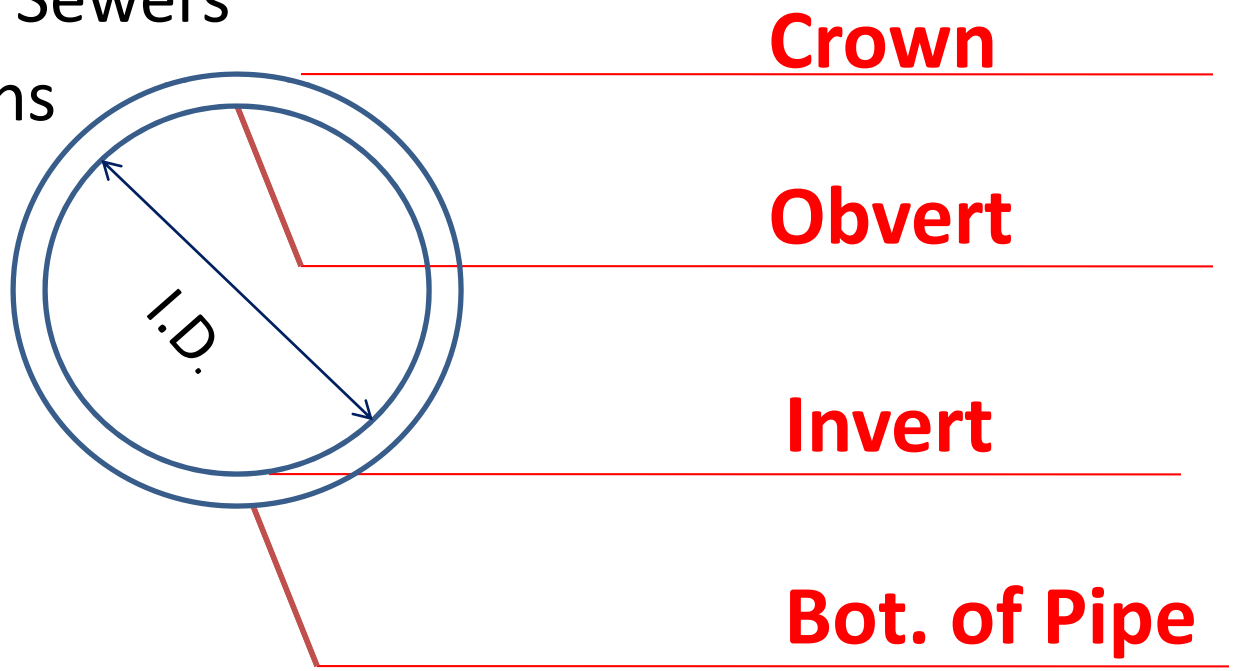
- to avoid siltation build up
- to minimize the sulfate production

Maximum Velocities

- 3.0 to 4.5 m/s – sanitary
- 5.0 m/s – storm

Sewer Pipes (Nomenclature)

- Storm Sewers
- Sanitary Sewers
- Combined Sewers
- Force Mains



Pipe Sizes are always referenced to their INSIDE DIAMETER

Types of Sewer Pipes

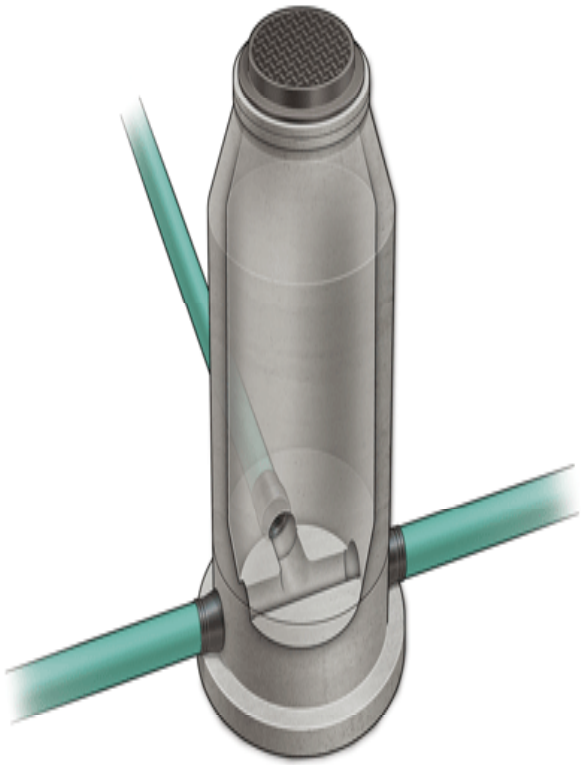
- Rigid
  - concrete and reinforced concrete 150 mm to 3600 mm diameter (very heavy, very durable (circular, elliptical, arch, etc.)
  - vitrified clay pipe - inert - remains stable with chemicals good for industrial applications
  - cast iron - must be coated for corrosion prevention still used today
  - Brick sewers still used

- Flexible
  - plastics - (PVC, HDPE, ABS) require special installation procedures - diameter 100 to 900 mm - over 600 usually concrete

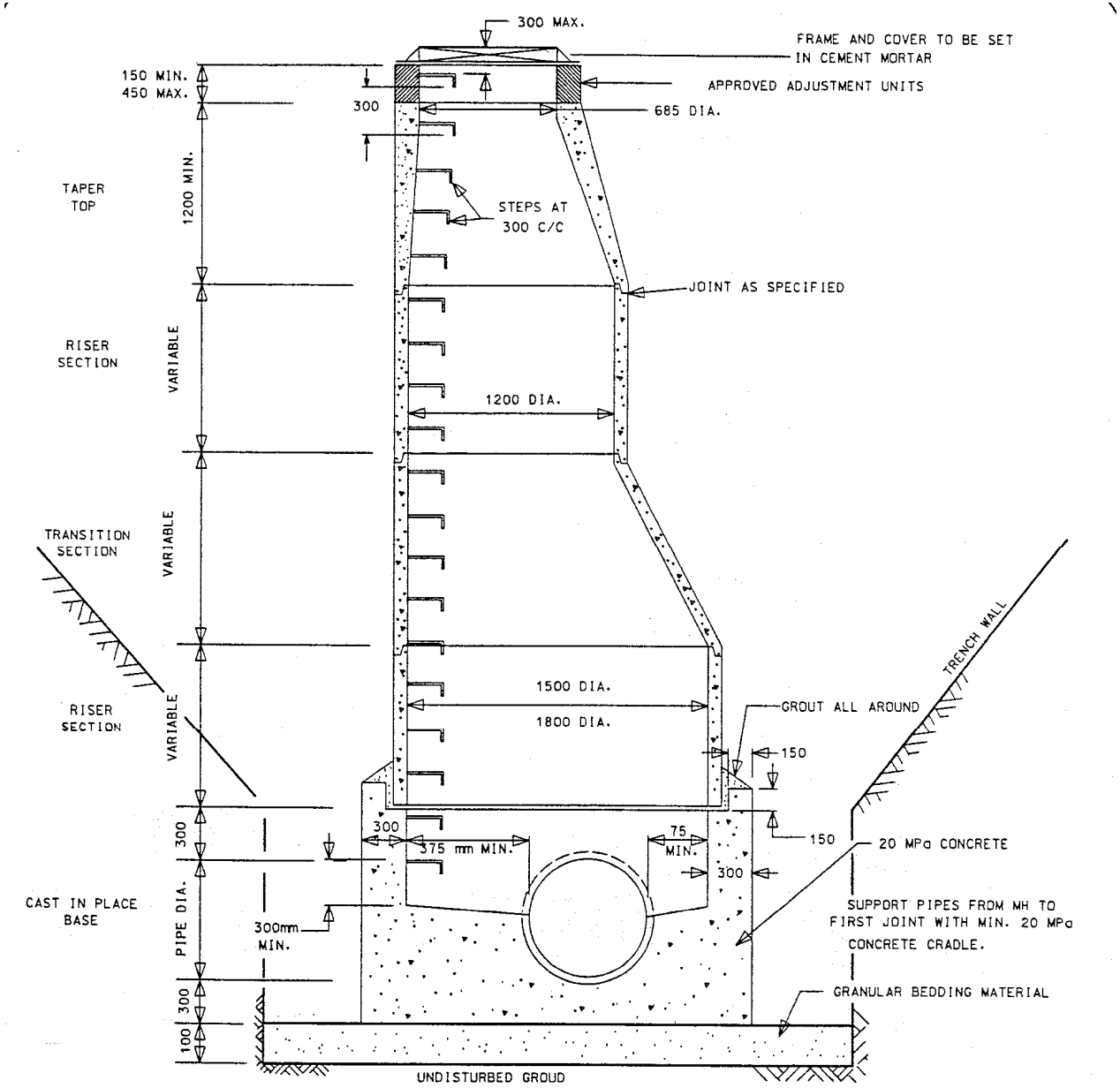
- CMP (corrugated metal pipe) - 100 mm to 15 m (Culverts and dams)
  - Come in multiple shapes - circular, elliptical, pipe arch - galvanized for protection - larger diameter are multi plate (series of sections are bolted together) - can be coated for extra protection - requires some care during installation

Maintenance Holes

- Maintenance holes shall be provided at each change in alignment, grade, material and at all junctions, except where radius pipe is used in sizes 1050 mm diameter and over.
- Maintenance holes shall be spaced at a maximum of:
  - 110m for 300 mm diameter to 750 mm diameter
  - 120m for 825 mm diameter to 1200 mm diameter
  - 150m for pipe sizes over 1200 mm diameter
- Type and size of maintenance holes shall be specified on the profiles
- All maintenance hole openings shall be located on the upstream side of the manhole.
- The change in direction of flow in any maintenance hole shall not be more than 90 degrees.
- The minimum drop across a maintenance hole shall be:
  - 30mm for straight runs
  - 75 mm between 5° and 45 °
  - 150 mm. Between 45 ° and 90°
- Obvert elevations shall be matched at locations where pipe sizes change.
- All maintenance holes shall be benched to the crown from the spring line.
- Shall NOT be located closer than 1.5m from any curb face or other utility.



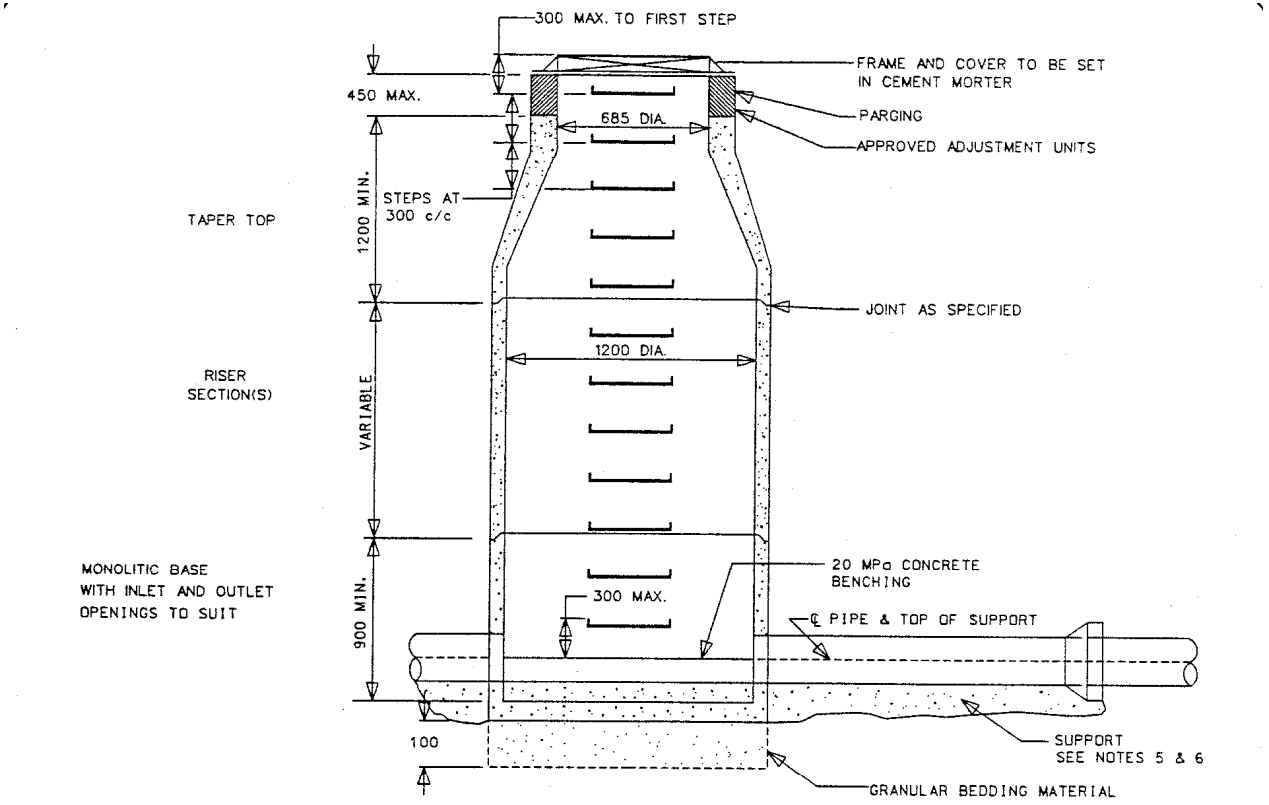
Precast Manhole



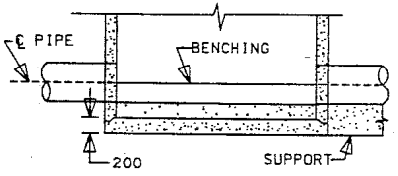
ALTERNATIVES

TYPE A –PRECAST SLAB BASE, 200 mm THICK SET IN 20 MPa CONCRETE AND PRECAST BOTTOM RISER SECTION.
TYPE B –PRECAST TRANSITION SLAB, 300 mm THICK, 1800 TO 1200 mm DIA.
TYPE C –PRECAST FLAT TOP, 200 mm THICK 1500 OR 1800 mm DIA TO 685mm DIA.
TYPE D –FLEXIBLE PIPE JOINT, 300 mm MAXIMUM FROM MANHOLE WALL, IN LIEU OF CONCRETE CRADLE.

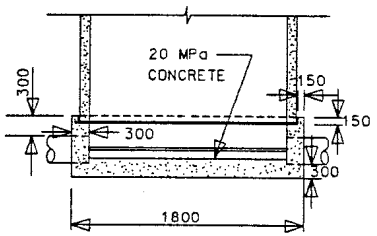
Precast Manhole



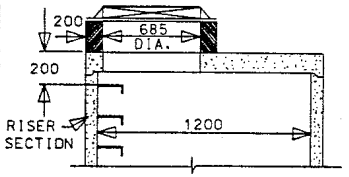
ALTERNATIVES



TYPE A
PRECAST SLAB BASE



TYPE B
CAST IN PLACE BASE



TYPE C
PRECAST FLAT TOP

FLEXIBLE JOINT 300 mm MAX. FROM MANHOLE WALL. IN LIEU OF CONCRETE CRADLE.

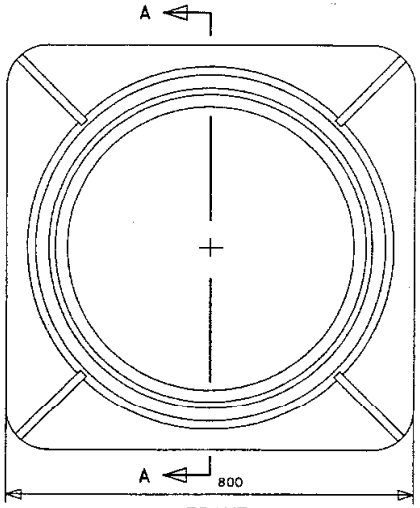
TYPE D

APPROVED FLEXIBLE WATERTIGHT PIPE CONNECTOR IN MANHOLE OPENING IN LIEU OF CONCRETE CRADLE.

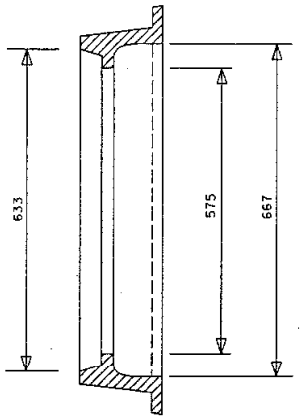
TYPE E

PIPE SUPPORT AT MANHOLE

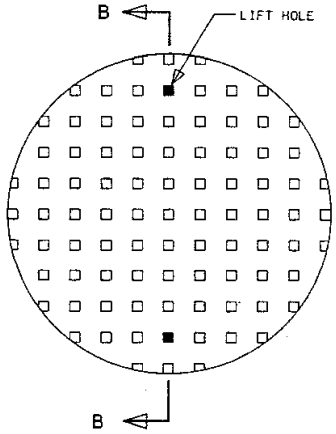
MH Cover



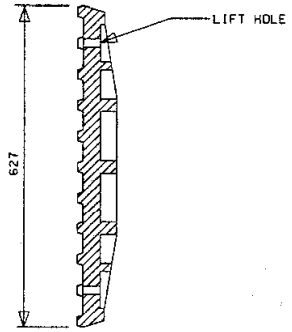
FRAME



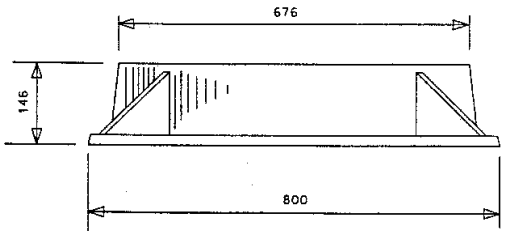
SECTION A–A



COVER



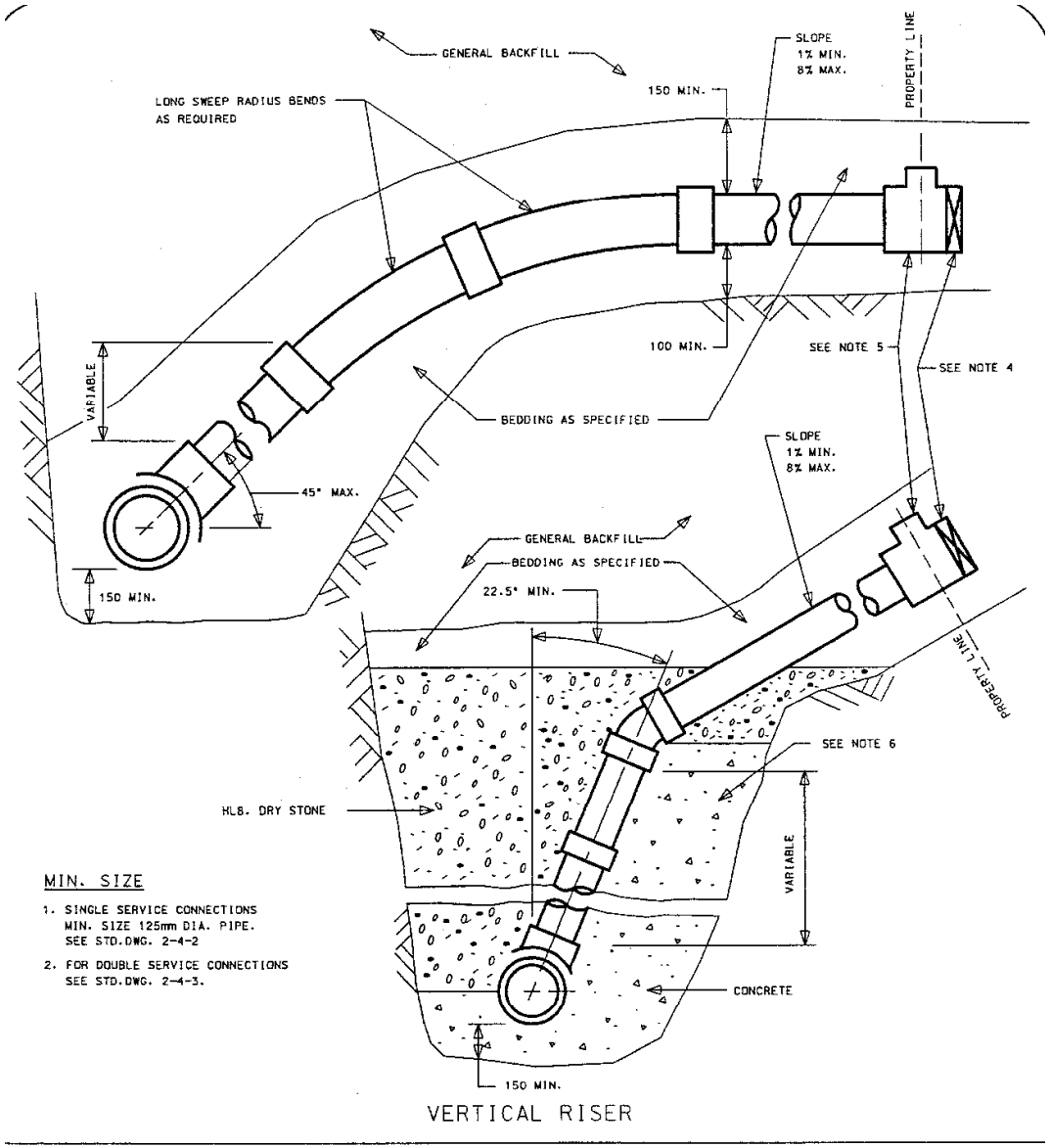
SECTION B–B



NOTES

1. THE WORD 'WATER' TO BE CAST INTO COVER WITH 50mm LETTERS.
2. COVER PATTERN AS PER CANRON 579 UNPERFORATED OR SIMILAR.
3. 25 X 25mm LIFT HOLES ALL THE WAY THROUGH COVER.

Service Connection



VERTICAL RISER

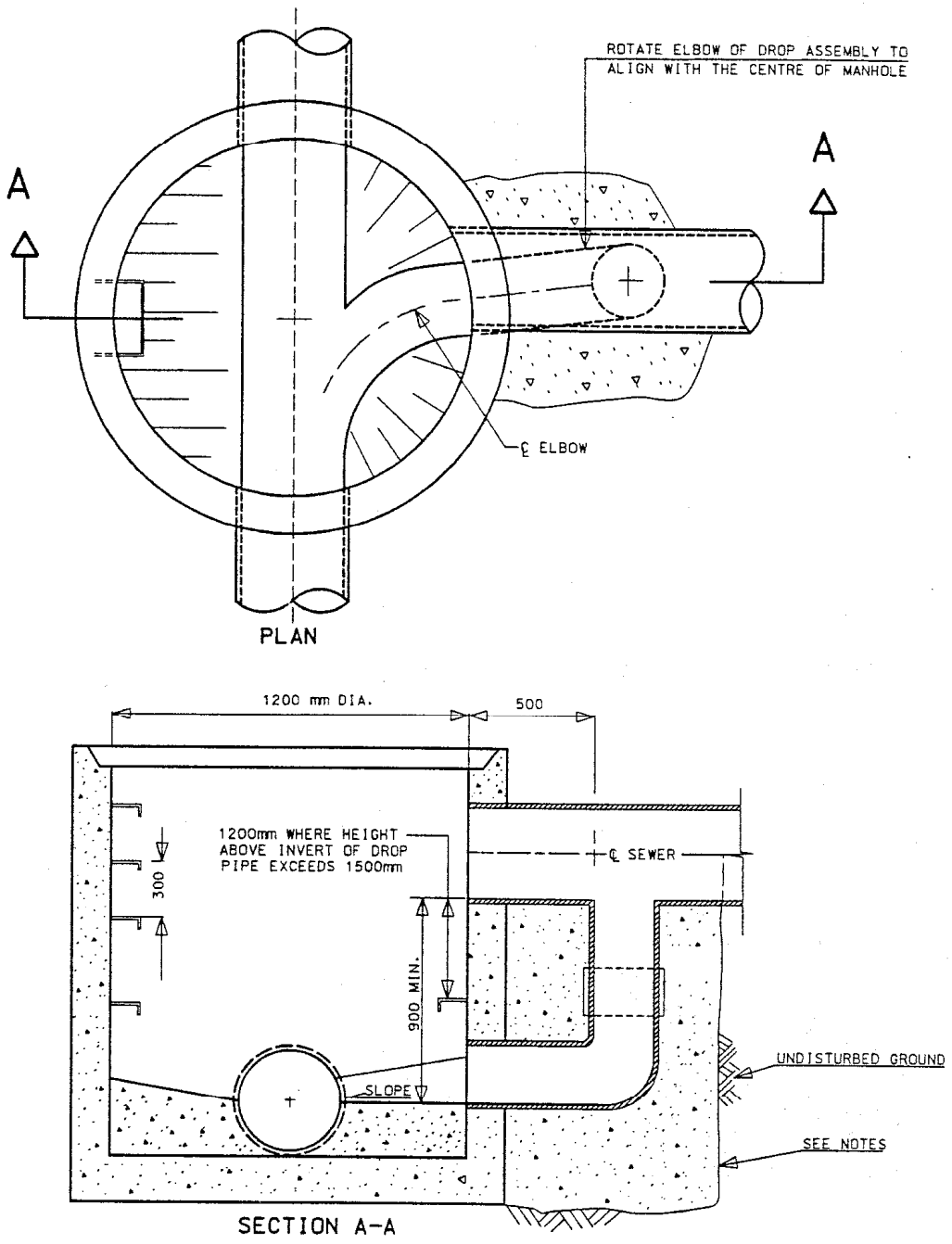
MIN. SIZE

1. SINGLE SERVICE CONNECTIONS MIN. SIZE 125mm DIA. PIPE. SEE STD.DWG. 2-4-2
2. FOR DOUBLE SERVICE CONNECTIONS SEE STD.DWG. 2-4-3.

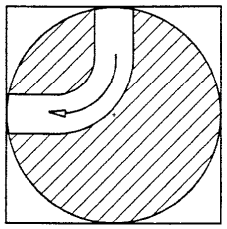
NOTES

1. FOR SEWERS 375mm AND SMALLER, CONNECTIONS MUST BE MADE USING FACTORY MADE TEES; FOR ALL OTHER SIZES, EITHER FACTORY MADE TEES OR APPROVED STRAP-ON SADDLE MAY BE USED.
2. STRAP-ON SADDLES MUST BE INSTALLED ON THE MAIN PIPE BEFORE THAT PIPE IS LAID.
3. APPROVED CUT-IN TOOL MUST BE USED FOR THE FIELD MADE TEES.
4. SERVICE CONNECTION MUST BE SECURELY PLUGGED AT PROPERTY LINE WITH AN APPROVED PLUG.
5. AN APPROVED TEST FTTING TO BE INSTALLED AT PROPERTY LINE.
6. FOR RISER DETAIL, CONCRETE BEDDING TO HAVE A MINIMUM WIDTH OF 600mm.
7. ALTERNATE, TO VERTICAL RISER SHOWN, IS ON STD. 2-4-2.

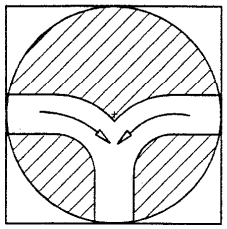
Drop Connection



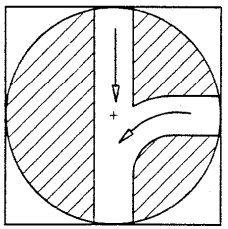
Benching



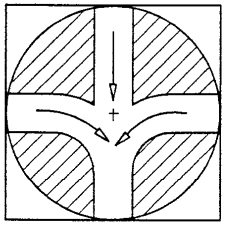
1. RIGHT ANGLE BEND



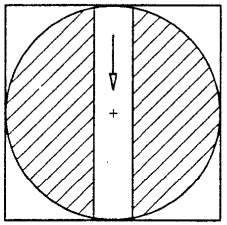
2. TEE CONNECTION



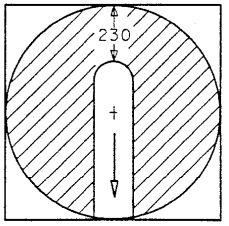
3. THREE WAY JUNCTION



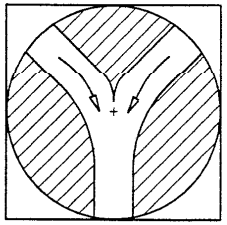
4. FOUR WAY JUNCTION



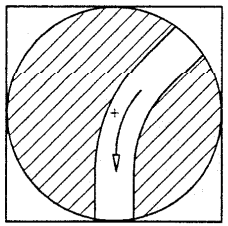
5. STRAIGHT THROUGH



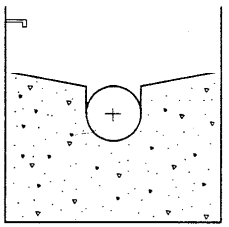
6. DEAD END



7. WYE CONNECTION



8. 45° BEND



9. PROFILE

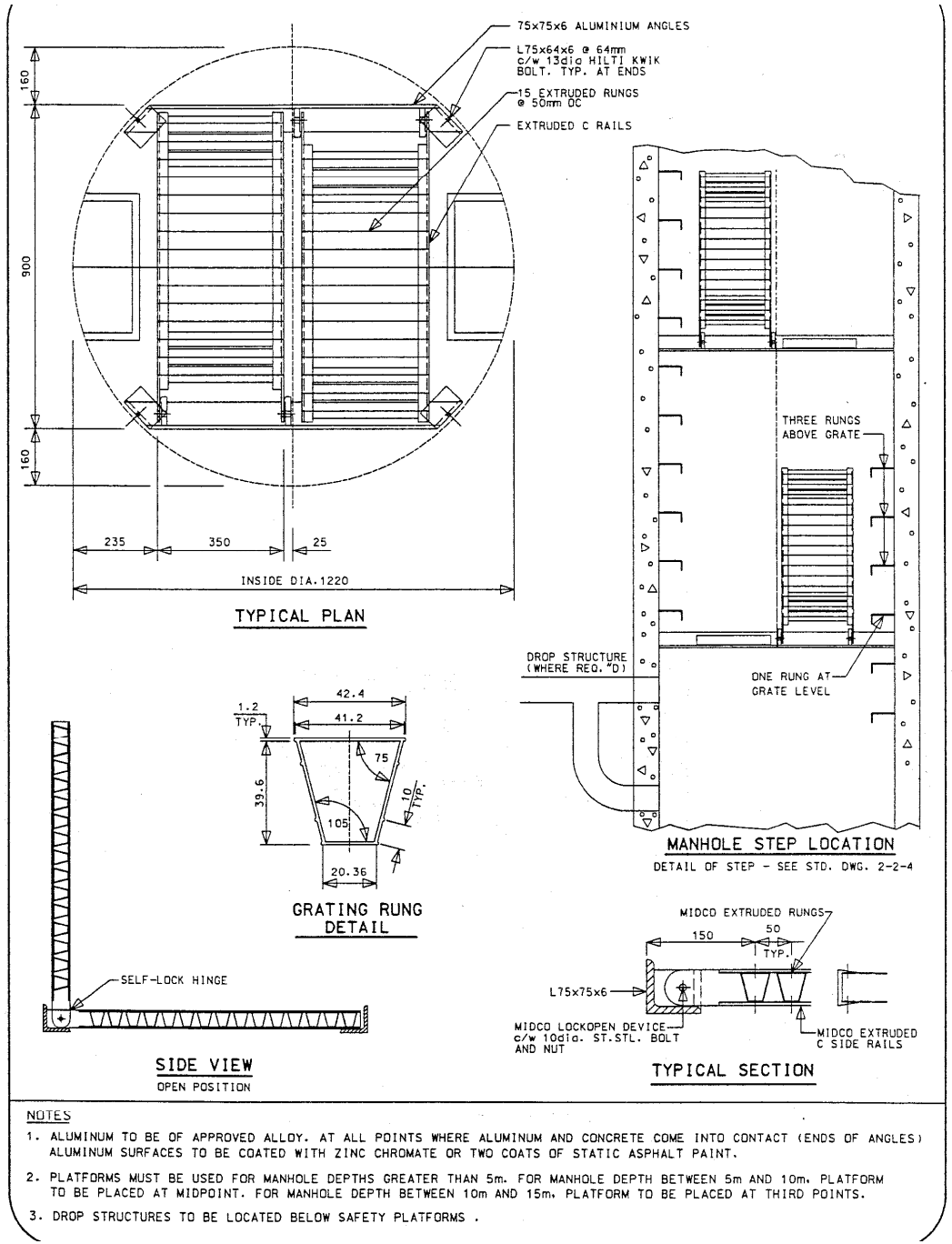
NOTES

1. CONCRETE TO BE 20 MPa COMPRESSIVE STRENGTH.
2. BENCHING TO BE GIVEN WOOD FLOAT FINISH. CHANNEL TO BE GIVEN STEEL TROWEL FINISH.
3. ALL CHANNEL MUST EXTEND 300 mm STRAIGHT OUT FROM MANHOLE WALL BEFORE CURVATURE BEGINS.
4. BENCHING TO BE CONSTRUCTED TO THE OBVERT OF THE PIPE ON ALL PIPE 600mm AND LARGER ON PIPE SMALLER THAN 600 mm, BENCHING TO BE TO SPRINGLINE.

MAXIMUM SIZE HOLE IN THE WALL IN PRECAST RISER SECTIONS

NOM. DIAMETER mm	No. 1-4 mm	No. 5 & 6 mm	No. 8 mm	No. 7	
				INLET PIPE mm	OUTLET PIPE mm
1200	700	860	780	700	860
1500	860	1220	960	860	1170
1800	1220	1485	1220	1220	1485

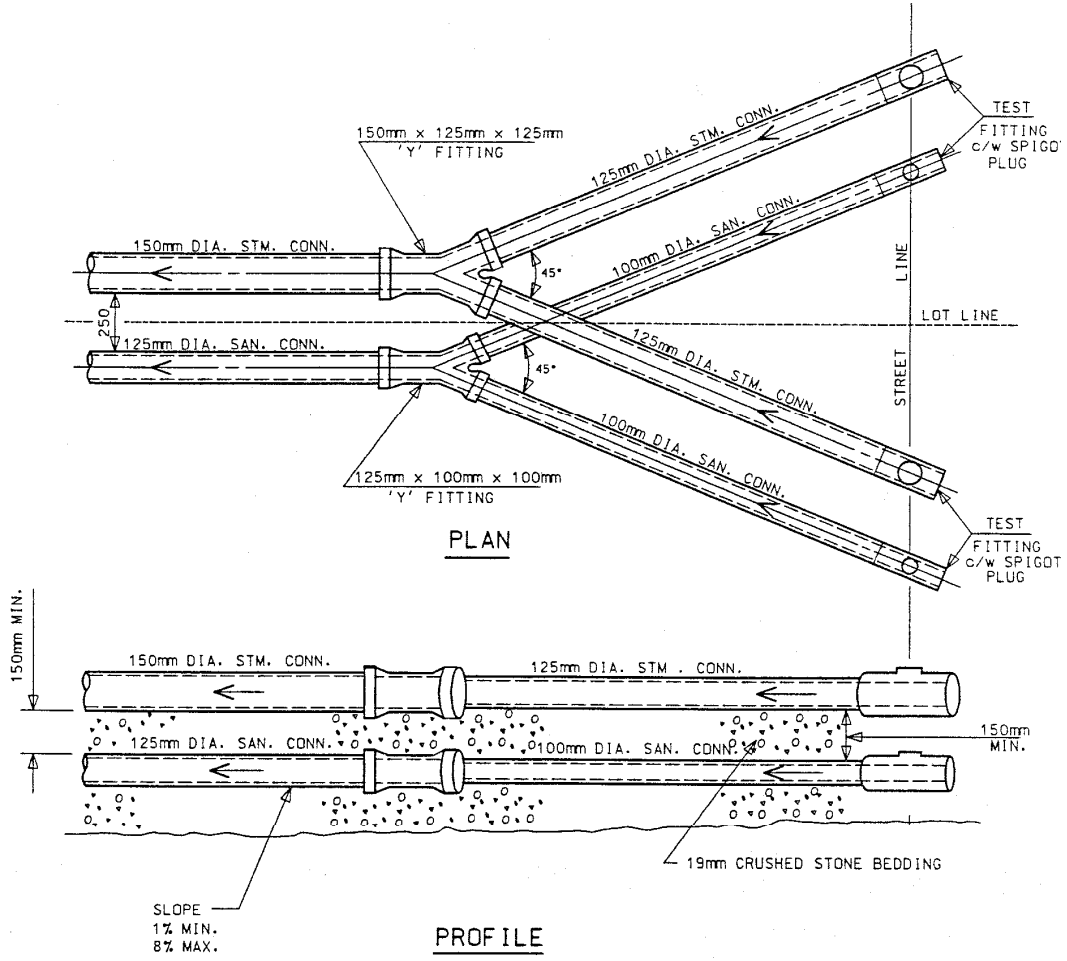
Safety Platform



NOTES

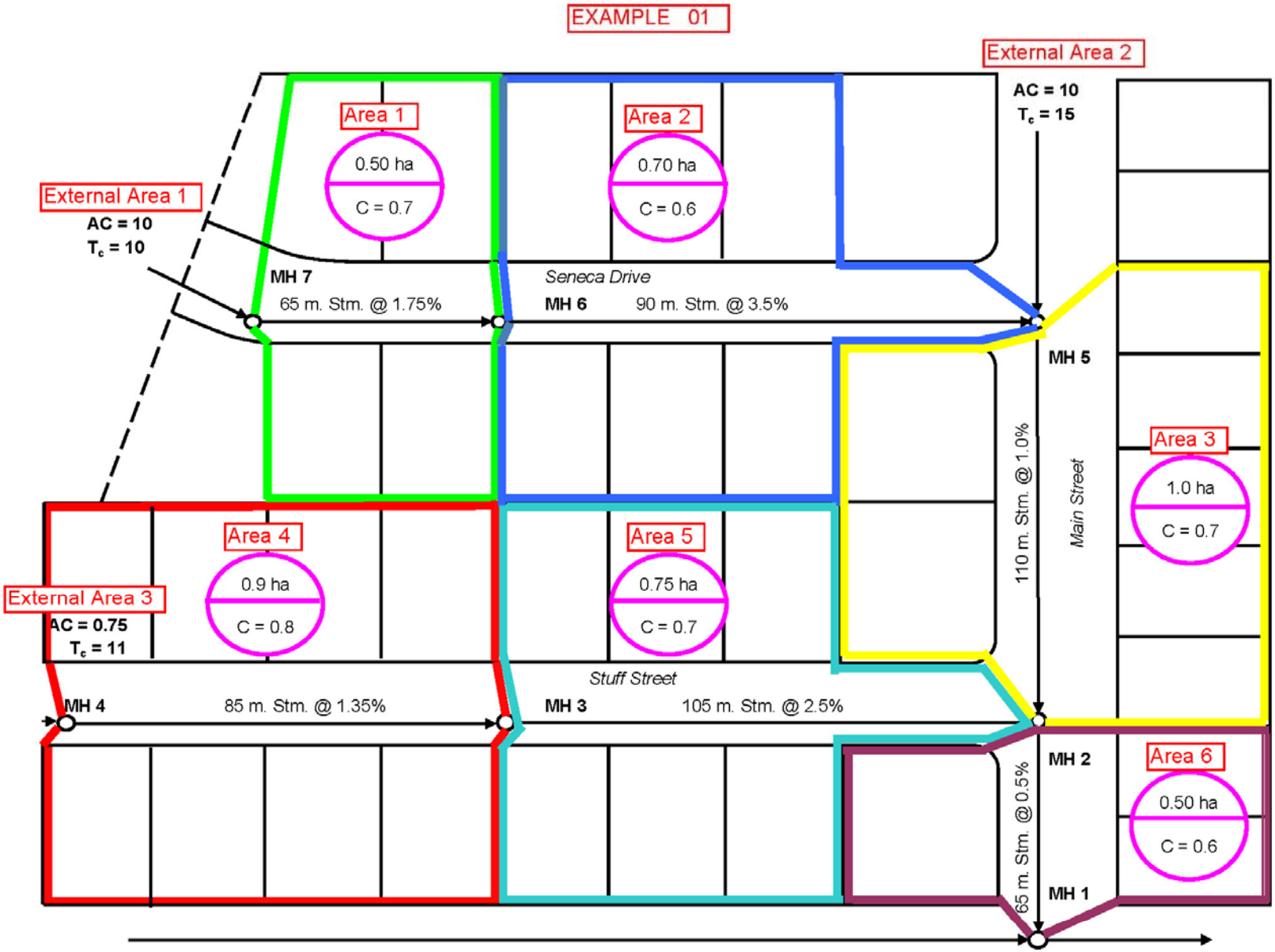
1. ALUMINUM TO BE OF APPROVED ALLOY. AT ALL POINTS WHERE ALUMINUM AND CONCRETE COME INTO CONTACT (ENDS OF ANGLES) ALUMINUM SURFACES TO BE COATED WITH ZINC CHROMATE OR TWO COATS OF STATIC ASPHALT PAINT.
2. PLATFORMS MUST BE USED FOR MANHOLE DEPTHS GREATER THAN 5m. FOR MANHOLE DEPTH BETWEEN 5m AND 10m, PLATFORM TO BE PLACED AT MIDPOINT. FOR MANHOLE DEPTH BETWEEN 10m AND 15m, PLATFORM TO BE PLACED AT THIRD POINTS.
3. DROP STRUCTURES TO BE LOCATED BELOW SAFETY PLATFORMS .

Double Service



NOTES

1. MINIMUM TRENCH WIDTH TO BE 900mm.
2. 19mm CRUSHED STONE BEDDING TO BE USED 350mm EITHER SIDE OF CROSS OVERS TO SPRING LINE OF UPPER PIPE
3. 125mm DIA. TEST FITTING TO BE MARKED "SAN".
4. SANITARY CONNECTION PIPE TO BE ANY COLOUR EXCEPT WHITE
5. STORM CONNECTION TO BE ON THE LEFT WHEN FACING THE HOUSE.
6. SANITARY CONNECTION MUST BE SECURELY PLUGGED AT PROPERTY LINE WITH AN APPROVED PLUG.
7. SINGLE SANITARY SERVICE CONNECTIONS SHALL BE 125mm.


EXAMPLE 01
External Area 2
AC = 10
T_c = 15
Area 1
0.50 ha
C = 0.7
Area 2
0.70 ha
C = 0.6
External Area 1
AC = 10
T_c = 10
MH 7
65 m. Stm. @ 1.75%
Seneca Drive
MH 6
90 m. Stm. @ 3.5%
MH 5
110 m. Stm. @ 1.0%
Main Street
Area 3
1.0 ha
C = 0.7
Area 4
0.9 ha
C = 0.8
Area 5
0.75 ha
C = 0.7
External Area 3
AC = 0.75
T_c = 11
Stuff Street
MH 4
85 m. Stm. @ 1.35%
MH 3
105 m. Stm. @ 2.5%
MH 2
Area 6
0.50 ha
C = 0.6
65 m. Stm. @ 0.5%
MH 1

Commercial Development

City of Toronto - Technical Services Division

2 / 100 -YEAR STORM SEWER DESIGN SHEET

2-Year IDF Curve = $I = \frac{21.8}{(T)^{0.780}}$

Street	From MH	To MH	A (ha)	R	A x R	Accum. A x R	T_c (min)	I (mm/hr)	Q_{act} (l/s)	Size of Pipe (mm)	Slope (%)	Nominal Capacity Q_{cap} (L/s)	Full Flow Velocity (m/s)	Actual Flow Velocity (m/s)	Length (m)	Time in Sect. (min)	Total Time (min)	Q_{act}/Q_{cap}	Contributing Sheds
Pipe 1					0.000	0.000	10.0	88.2	0.00			0.00	0.00	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!	
Pipe 2					0.000	0.000	10.0	88.2	0.00			0.00	0.00	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!	
Pipe 3					0.000	0.000	10.0	88.2	0.00			0.00	0.00	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!	
Pipe 4					0.000	0.000	10.0	88.2	0.00			0.00	0.00	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!	
Pipe 5					0.000	0.000	10.0	88.2	0.00			0.00	0.00	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!	
Pipe 6					0.000	0.000	10.0	88.2	0.00			0.00	0.00	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!	
Pipe 7					0.000	0.000	10.0	88.2	0.00			0.00	0.00	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!	
Pipe 8					0.000	0.000	10.0	88.2	0.00			0.00	0.00	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!	
Pipe 9					0.000	0.000	10.0	88.2	0.00			0.00	0.00	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!	
Pipe 10					0.000	0.000	10.0	88.2	0.00			0.00	0.00	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!	
Pipe 11					0.000	0.000	10.0	88.2	0.00			0.00	0.00	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!	
Pipe 12					0.000	0.000	10.0	88.2	0.00			0.00	0.00	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!	
Pipe 13					0.000	0.000	10.0	88.2	0.00			0.00	0.00	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!	
Pipe 14					0.000	0.000	10.0	88.2	0.00			0.00	0.00	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!	
Pipe 15a					0.000	0.000	10.0	88.2	0.00			0.00	0.00	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!	
Pipe 15					0.000	0.000	10.0	88.2	0.00			0.00	0.00	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!	
Pipe 16					0.000	0.000	10.0	88.2	0.00			0.00	0.00	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!	
Pipe 17					0.000	0.000	10.0	88.2	0.00			0.00	0.00	#DIV/0!		#DIV/0!	#DIV/0!	#DIV/0!	