Section 7

Storm Drain System Theory

Storm Drain Design Considerations

1. 10-yr design storm for laterals
2. 25-yr design storm for trunks
3. For pipe capacity, Q = VA, where V is velocity by Manning's equation & A is area of pipe
4. Maximum Junction Spacing
   ~300' for diameter<48"
   ~500' for diameter>48"
5. Minimum Pipe Diameter = 12" (8" for single laterals of 50' or less)
6. Full Flow Minimum Velocity = 3 ft/sec
7. Match Crowns at Junctions
8. Compute HGL if velocity > 6 ft/sec or when cover is shallow

Hydraulic Grade Line

- Computing HGL
  1. Calculate friction losses for the most downstream run of pipe.
  2. Calculate minor losses for the first junction upstream of outfall.
  3. Add all losses to water surface elevation at the outfall to get water surface elevation at the first upstream junction.
  4. Repeat Steps 1-3.
- MINOR LOSSES
  - Friction Loss
  - Entrance/Exit Loss
  - Bend Loss
  - Multiple Flow Loss

Friction Loss

$$H_f = L\left[\frac{2.15Qn}{D^{2.667}}\right]^2$$

where:

H_f	=	head loss due to friction in feet
L	=	length of pipe run in feet
Q	=	flow in pipe in cubic feet per second
n	=	Manning's roughness coefficient
D	=	diameter of pipe in feet

Entrance/Exit Loss

$$H_e = \frac{V^2}{2g}$$

$$H_{ex} = 0.5\frac{V^2}{2g} = \frac{V^2}{4g}$$

where:

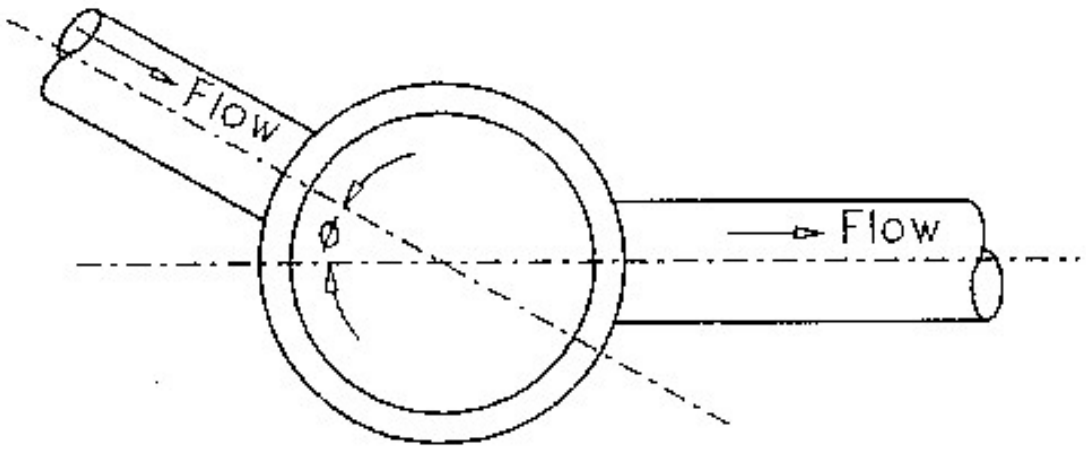
H_e	=	head loss from junction entrance in feet
H_{ex}	=	head loss from junction exit in feet
V	=	flow velocity in pipe in feet per second
g	=	gravitational acceleration constant

Bend Loss

$$H_b = K_b \frac{V^2}{2g}$$

where: H_b = head loss from change in direction in feet
K_b = head loss coefficient for change in direction, see below:

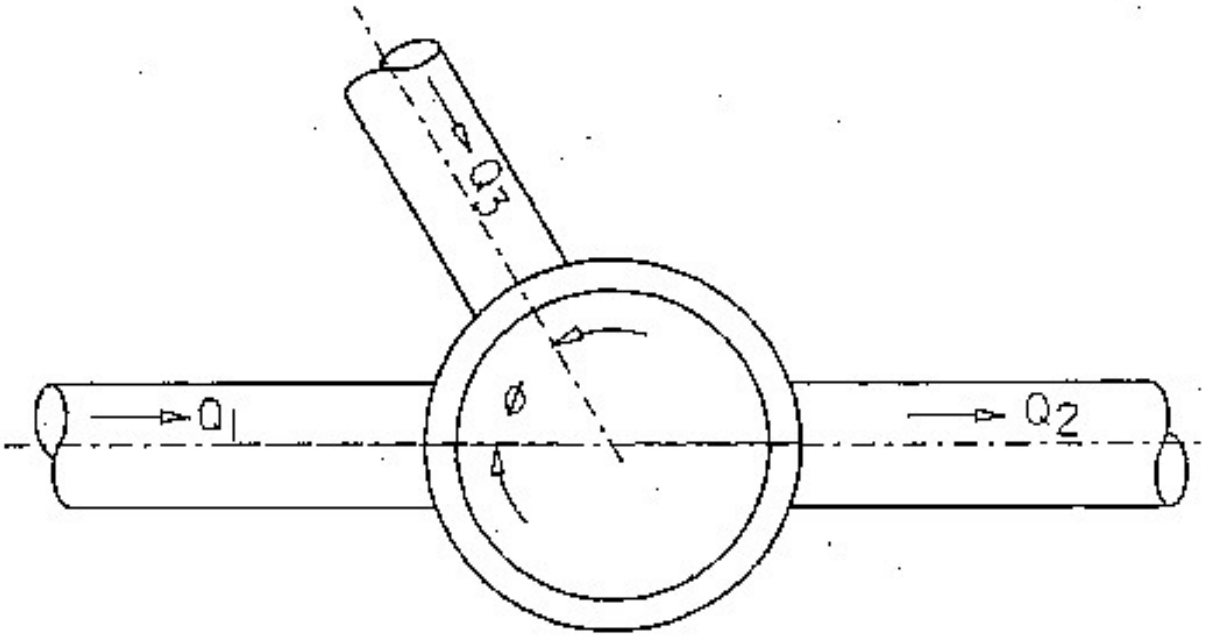
K_b	Angle of Change in Degrees
0.00	0
0.19	15
0.35	30
0.47	45
0.56	60
0.64	75
0.70	90 and greater



Multiple Flow Loss

$$H_m = \frac{Q_2 V_2^2 - Q_3 V_3^2 - Q_1 V_1^2 + K_b Q_3 V_3^2}{2gQ_2}$$

where: H_m = head loss from multiple flows in feet
K_b = head loss coefficient for change in direction



Washington State Department of Transportation

Storm Drain Design Calculations

Calculated By		Date	Checked By		Date	SR	Project		Sheet #	Of	Sheets

Location			Discharge										Drain Design				Drain Profile						
Drain Located On	From Station	To Station	Source Of Drainage	Drainage Area (A)	Runoff Coeff. (C)	CA	ΣCA	T_c To Col. 2 Station	Rainfall Intensity	Runoff	Con. Inflow	Total Flow	Pipe Diameter	Pipe Slope	Flow Velocity	Pipe Capacity	Length	Elev. Change	Upstr. Ground Elev.	Downstr. Ground Elev	Upstr. Invert Elev.	Downstr. Invert Elev.	Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

Hydraulics Manual Pages 6-4 to 6-8

Storm Drain Design Calculations

Calculated By			Date	Checked By								Date	SR	Project				Sheet #		or	Sheets
Location			Discharge										Drain Design				Drain Profile					
Ditch Located On	From Station	To Station	Source Of Drainage	Drainage Area (A)	Runoff Coeff. (C)	CA	ΣCA	Tc/To Col. 2 Station	Rainfall Intensity	Runoff	Con. Inflow	Total Flow	Pipe Diameter	Pipe Slope	Flow Velocity	Pipe Capacity	Length	Elev. Change	Upstr. Ground Elev	Downstr. Ground Elev.	Upstr. Invert Elev.	Downstr. Invert Elev.	Remarks
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

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Calculated By				Date				Checked By				Date
Location			Discharge									
Ditch Located On	From Station	To Station	Source Of Drainage	Drainage Area (A)	Runoff Coeff. (C)	CA	ICA	T_cTo Col. 2 Station	Rainfall Intensity	Runoff	Con. Inflow	Total Flow
1	2	3	4	5	6	7	8	9	10	11	12	13

Storm Drain Design Calculations

SR	Project							Sheet #	or	Sheets
Drain Design				Drain Profile						
Pipe Diameter	Pipe Slope	Flow Velocity	Pipe Capacity	Length	Elev. Change	Upstr. Ground Elev	Downstr. Ground Elev.	Upstr. Invert Elev.	Downstr. Invert Elev.	Remarks
14	15	16	17	18	19	20	21	22	23	24