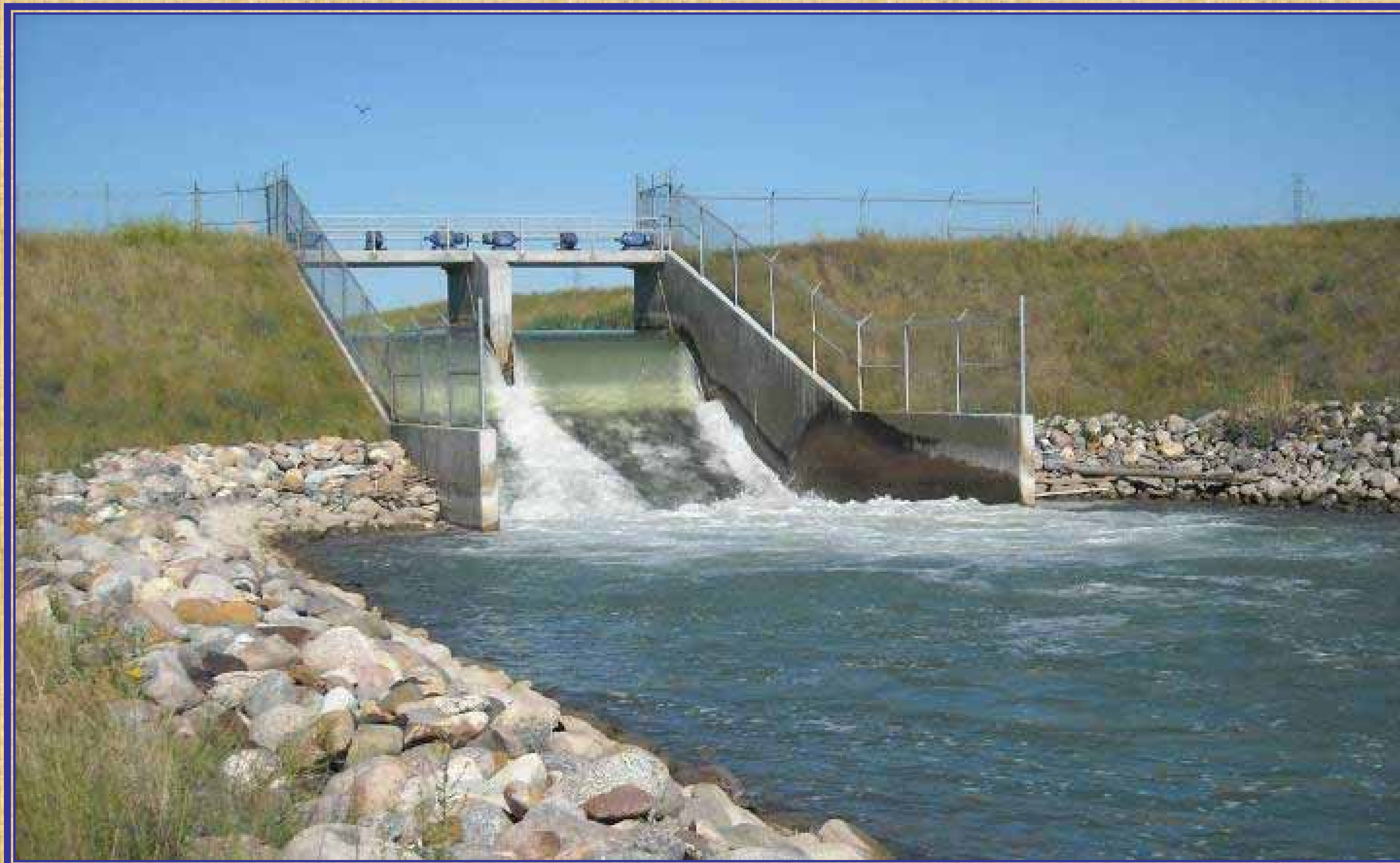
Irrigation Rehabilitation Program
Design and Construction Standards



Prepared by the IRP Standards Review Committee
For Alberta Agriculture and Rural Development, Irrigation Secretariat
April 26, 2010
Adopted by Irrigation Council - May 27, 2010

Variances from 1991 Standards

- There are not major technical changes, but there are differences in how the standards address specific issues.
- The standards are written so that they can be used as a single reference for anyone involved with the design of irrigation water distribution systems, especially new people to the industry.
- As much as possible, rather than referencing other documents, the applicable sections of those other documents are included.
- Graphs and curves are used but, where possible, an equation is also included to be incorporated into spreadsheet or other computer design processes.

The 2010 IRP Design and Construction Standards must be followed for all projects funded under the IRP.

- **Where the terms *"shall", "must"* or *"will"* are used, it indicates components of the standards that must be met in all situations where IRP funds are used.**
- **Where the terms *"should"* or *"it is recommended"* are used, it indicates components of the standards that should be met whenever possible.**
- **Where the terms *"may"* or *"can"* are used it indicates components of the standards that are optional.**

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The determination of the design flow rate for a particular project is a separate chapter. The calculation of that value for smaller blocks, or for projects with a number of small parcels is more detailed (and more accurate).

The pipeline chapter has been expanded and the installation section included in this chapter.

The structures chapter has been expanded significantly with all of the necessary design formulae incorporated into the standards.

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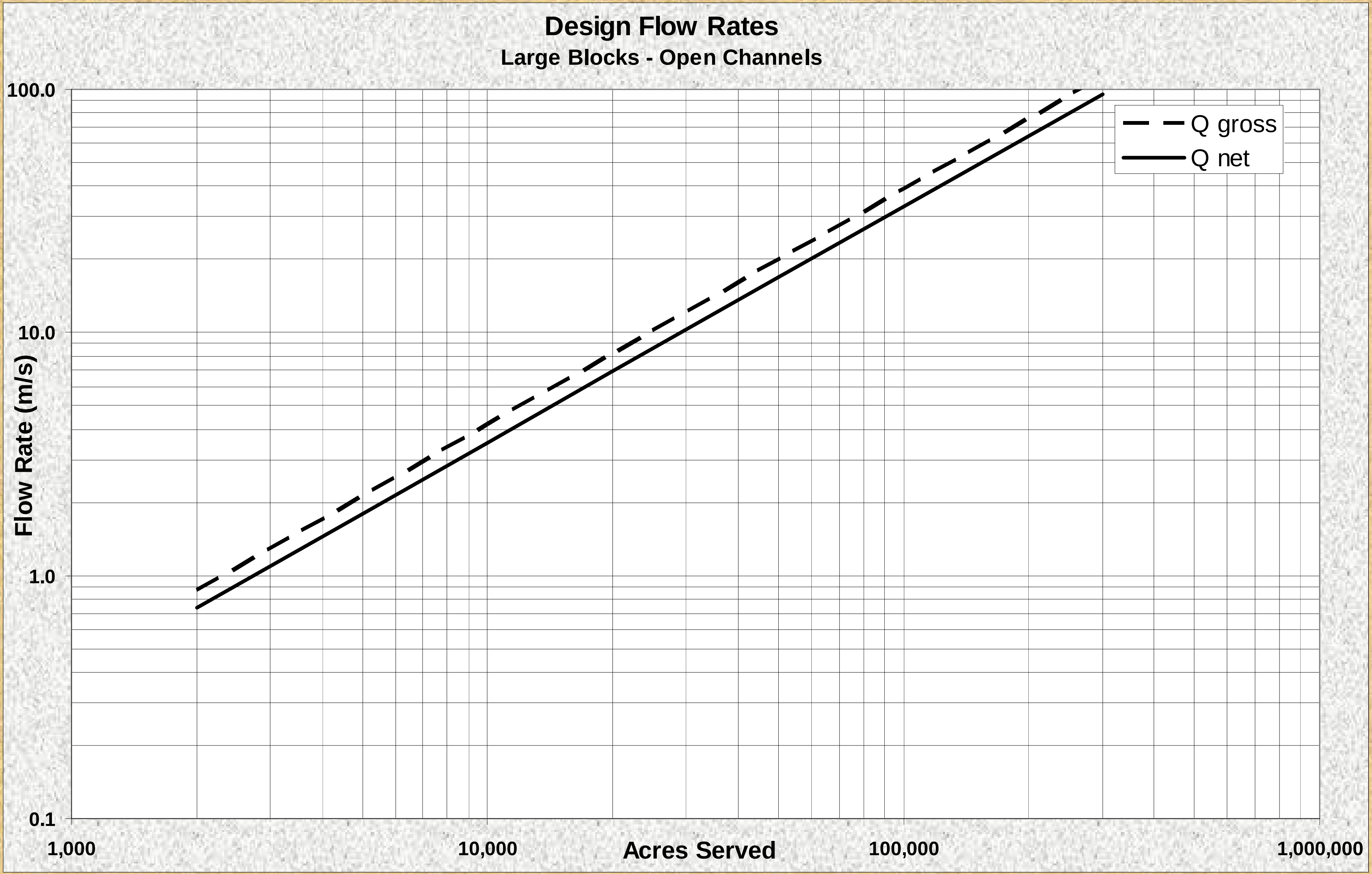
Determining Qn for Large Blocks

- For canals serving large blocks, a graph or the corresponding equation is used to determine the net design flow rate (Qn). The curve assumes sprinkler irrigation methods.
- Where there is a significant gravity irrigation, the parcel by parcel method is used rather than the figures or equation. Using the figures/equation will result in a flow less than what is required.
- For open or closed pipeline projects the parcel by parcel method is used to determine Qn.



$$Qn = 0.000465\ A^{0.970}$$

Parcel by Parcel Method
Design Flow Rates per Parcel

Table 1.1: Design Flow Rates per Parcel (Qp)					
Size of parcel Irrigated acres	**Flow required (Gravity irrigation)**		**Flow required (Sprinkler irrigation)**		
(Current & Potential)	ft^3/s	m^3/s	ft^3/s	m^3/s	USgpm
< 20 acres	**1.0**	0.028	(Estimated on a case-by-case basis)		
20 to < 40 acres	**2.0**	0.057	1.0	0.028	**450**
40 to < 80 acres	**3.0**	0.085	1.5	0.043	**675**
80 to < 120 acres	**4.5**	0.13	2.0	0.057	**900**
120 to 160 acres	**6.0**	0.17	2.5	0.069	**1,100**
> 160 acres	(Determined on a case-by-case basis.)				

Determining Qn for Small Blocks and Pipelines
(Parcel by Parcel Method)

- The maximum flow rate for the block is the sum of the flow rates required for each individual parcel: $Qm = \sum Qp$

- The net design flow rate (Qn) is then determined by reducing the maximum flow rate (Qm), when all parcels will not be irrigated at the same time period.

- The amount that Qm is reduced is a factor of the number of parcels in the block.

Utilization Reduction Factors

If there are more than seven (7) parcels, it is likely that during the peak demand period, not all parcels will be irrigated at once and Qn shall be calculated according to <u>one of two methods</u>:

1) <u>By multiplying by a utilization reduction factor (F)</u> calculated as:

$$F = 0.8 + \frac{0.8}{N}$$

where: N = the number of parcels being served.

Qn is then calculated as: $Qn = Qm * F$

2) <u>By reducing Qm according to the number of parcels not being irrigated</u>. Qn then equals the sum of the individual flows for the remaining parcels that are being irrigated.

Table 1.2: Design Flow Rate Reduction Factors

Total Number of Parcels Served	Assumed Number of Parcels NOT Being Irrigated
1 to 7	0
8 to 11	1
12 to 16	2
17 to 21	3
22 to 26	4
27 to 31	5
32 to 36	6
37 to 41	7
42 to 46	8
47 to 51	9
52 to 56	10
57 to 60	11

Gross Required Flow Rate

- Qn is the flow rate required at the farm turnouts to serve the area being irrigated.
- Conveyance losses (seepage and/or evaporation) and operational spill water (return flow) need to be included.
- The gross design flow rate (Qg) is the total flow diverted into the system. Qg equals Qn plus any conveyance losses.

Table 1.3: Water Conveyance Efficiencies (Ec)

Type of Distribution System	Ec
Closed Pipeline	1.00
Open Pipeline	0.90
Open Earth Channel	0.85

$$Qg = \frac{Qn}{Ec}$$

Qg is also shown in Figures 1.1a and 1.1b

$$Qg = 0.000547\,A^{0.970}$$

Climatic Reduction

- A change from the previous two regions only (1.00 and 0.80). Now on a district basis, not a line on a map.
- For certain climatic areas Qg **may** be reduced due to the different climatic conditions and cropping patterns in areas where the crop evapotranspiration (ET) rates and the corresponding utilization demand factors are lower.

Table 1.4: Climatic Design Flow Rate Adjustment

Irrigation District	Climatic Reduction Factor
SMRID, BRID, TID, RCID, LNID, RID, EID	1.00
WID, MID	0.90
UID, AID, LID, MVID	0.80

- This adjusted flow rate will be the revised gross design flow rate (Qg) for irrigation purposes for the block.

FLOW RATES FOR OTHER USERS

- Where there are significant non-irrigation users who require water at the same time as the peak irrigation demand, the flow rate required by the other users is added to the gross design flow rate calculated for irrigation.
- If they take water at off-peak times, the flow rate does not need to be increased.
- The flow rates required for the other users is estimated on a case-by-case basis.

Natural Runoff

- In addition to the flow rate required for irrigation and other demands, calculations must be done to ensure canals are capable of carrying flows created by storm water, surface drainage or snow melt.
- The flow rate expected from local runoff from the contributing drainage areas is determined using conventional hydrologic methods.

RETURN FLOW, SURGE CAPACITY

- For canals and open pipelines, additional capacity must be included.
- The design must be able to carry return flows, including normal operational spill water / return flow and:
  - Possible surge flows due to natural runoff / snowmelt, and
  - Increased flows due to upstream shut downs.
- Normal return flows must be carried within the FSL. Short term surges may be handled within the freeboard of the canal.
- Converting canals to pipelines has increased the need to design for surges. What used to be return flow in lateral canals now remains in the main canal.

Canals

- There were not a lot of changes in this chapter.

Table 2.1 Manning's Roughness Coefficients (n)	
Capacity Range	n
0 to 3 m3/s	0.040
3 to 20 m^3/s	0.035
20 to 30 m^3/s	0.030
30 to 75 m^3/s	0.028
Greater than 75 m^3/s	0.025

- The "n" values are for a canal with vegetative cover. A new canal may have a significantly lower "n" value.
- The "n" values may be modified in unique situations.
- Flow depth calculations also need to be done using a lower "n" value to ensure that the depth is adequate to provide sufficient head at all deliveries. If this is an issue, additional check structures may be required.

Buried Membrane Lined Canals

2.3.1 Side Slopes

2.3.2 Lining Cover

2.3.3 Gravel Armour Over Lined Earth Canals

2.3.4 Freeboard

2.3.5 Woven Fabric Polyethylene Liners

2.3.6 Polyvinyl Chloride Liners

2.3.7 Membrane Lining Installation

CONCRETE LINED CANALS

- Concrete slip-lined canals are not approved for IRP projects.
- In rare cases, a reinforced concrete, cast-in-place, canal may be used. In these instances, the canal shall be designed and installed as an individual reinforced concrete structure.

PIPELINES

Pipelines used in irrigation are classed as open or closed pipelines, depending on whether or not there is open channel flow at some point in the pipeline.

Water flows in the pipeline either because of gravity pressure (elevation changes), pumping units, or a combination.

PIPE MATERIALS

Accepted pipes are polyvinyl chloride (PVC), polyethylene (PE), pre-stressed or reinforced concrete pipe and certain types of steel pipe.

Standard corrugated steel pipe (CSP) is only allowed in culvert and turnout applications.

Specialized types of CSP may be used in low-pressure applications and heavier wall steel pipe may be used in high-pressure applications, if adequately protected from corrosion.

Pipeline Roughness Coefficients

Table 3.1 Hazen-Williams C_h for Closed Pipelines		
	Pipe I. D.	C_h
PVC Pipe	0 ≤ 500 mm	140
	≥ 500 mm	145
HDPE Pipe	0 ≤ 500 mm	140
	≥ 500 mm	145
Concrete Cylinder Pipe	All	135
Reinforced Concrete (C361) Pipe	All	130

Table 3.2 Manning's n for Open Pipelines	
	n
PVC Pipe	0.010
Smooth-Wall HDPE Pipe	0.010
PVC Ribbed Sewer Pipe (smooth inside)	0.010
Pre-stressed Concrete Cylinder Pipe	0.011
Reinforced Concrete (C361) Pipe	0.012
"Ultra Flo" Smooth Inside Wall Corrugated Steel Pipe	0.013

Entrance Losses

- The HGL at the start of the pipeline shall be:

$$HGL = FSL - 0.30 - \frac{V^2}{2g}$$

- This takes into account typical head loss across inlet screens and / or trash racks and the inlet to the pipeline and the energy converted to velocity head.

- The pipeline inlet shall be designed to ensure that inlet control does not govern / restrict the flow into the pipeline.

PVC Pipe Pressure Ratings

Table 3.3: PVC Pipe Pressure Ratings (PVC 1120 Resin)

OD to wall thickness ratio		Pressure Rating (psi)				IRP Project Pressure Limits	
SDR	DR	ASTM D-2241	CSA B-1373	AWWA C900 C905	SCS 430-DD	Maximum operating/ static pressure	Maximum total pressure (operating plus potential surge)
13.5		315	315			315	630
	14.0			305		305	610
17.0		250	250			250	500
	18.0			235		235	470
21.0		200	200	200		200	400
	25.0			165		165	330
26.0		160	160	160	160	160	320
32.5		125	125	125	125	125	250
41.0		100	100	100	100	100	200
51.0		80	80	80	80	80	160
PVC pipe with a SDR/DR > 51 is not approved for IRP projects.							

- **The maximum operating or static pressure shall not exceed the values shown as Maximum operating / static pressure.**
- **The maximum operating pressure plus the maximum potential surge pressure in a pipeline shall not exceed the Maximum total pressure.**

PVC Pipe Dimensions
(Lack of consistency)

- Pipe with the same nominal diameter and SDR / DR may have significantly different OD's depending on whether it is manufactured to IPS, CIOD or PIP standards.
- e.g. 14" SDR 41 PVC pipe has these outside diameters:
  14" CIOD Pipe (AWWA C905)………………. OD = 15.30"
  14" IPS Pipe (ASTM D2241, CSA B-137.3).. OD = 14.00"
  14" PIP Pipe (SCS 430-DD)…………………. OD = 14.28"
- In some other nominal sizes (e.g. 12") IPS pipe has a larger OD than PIP pipe.
- 15" PIP pipe is available, but 15" IPS or CIOD pipe is not. However 15" PIP pipe has the same OD as 14" CIOD pipe.
- Because of these variances, care must be taken to ensure the fittings used are the correct dimensions.

Velocity Limits - Closed Pipelines

- The likelihood of surge pressures / hydraulic transients dictates the maximum velocity.
- Irrigation pipelines with multiple turnouts do not have large instantaneous flow changes.
- Where surge pressures can be excessive, surge protection shall be incorporated in the system.
- Maximum velocity in gravity-fed closed pipelines with multiple outlets is 2.5 m/s. Exceptions up to 3.0 m/s are acceptable for short reaches where the topography allows.
- Maximum velocity in pump-fed closed pipelines is 1.5 m/s, unless significant surge protection is included at the pump station design.
- The minimum velocity shall be 0.6 m/s to avoid silting in the pipeline.

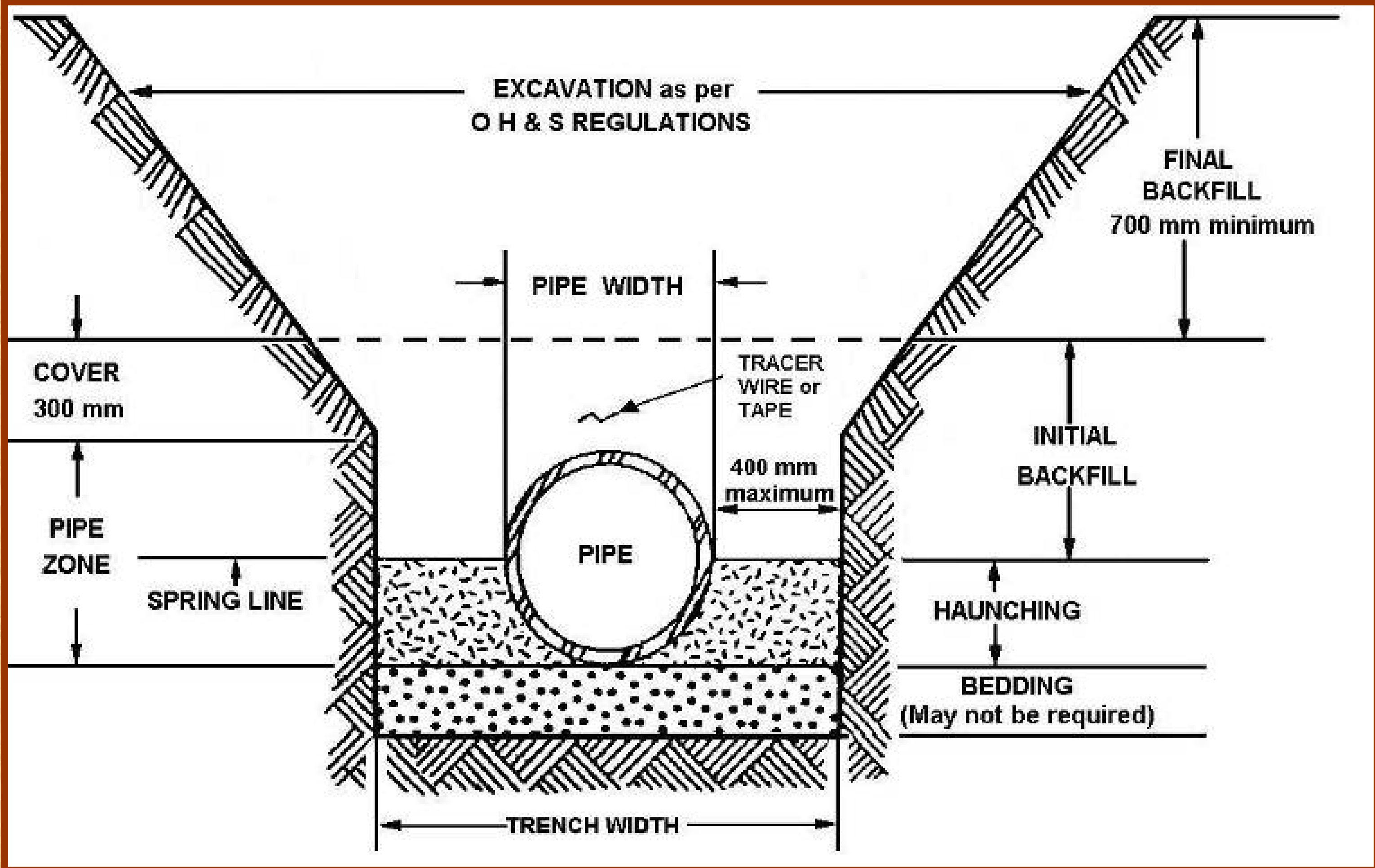
Turnout Sizing

- The design flow rate for turnouts to individual parcels or to a group of parcels shall be based on the flow rate per parcel (Qp).
- The turnout pipe and valve size shall be determined by using the minimum pressure in the pipeline at the point of the turnout.

Table 3.5: Minimum Turnout Sizes			
Design Flow Rate (calculated using ≈ 2.5 m/s maximum velocity)			Minimum Turnout Size
m^3/s	ft^3/s	USgpm	mm
< 0.02	<0.7	< 300	100
0.02 - 0.04	0.7 - 1.5	300 - 700	150
0.04 - 0.08	1.5 - 2.8	700 - 1,200	200
0.08 - 0.12	2.8 - 4.3	1,200 - 2,000	250
0.12 - 0.18	4.3 - 6.2	2,000 - 2,800	300

Pipeline Installation

Thermoplastic pipes fall under the category of flexible pipe. The pipe/soil interaction is critical to the load carrying capability of flexible pipe.



Alternate Procedures

Smaller, High Pressure PVC Pipe

Allowed for PVC pipe with a SDR <=41 (>=100 psi) and a diameter of 300 mm (12”) or less.

- **<u>Trench Construction</u>**
  - May use wheel or chain trenchers. Trench width shall allow backfill material to flow around the sides of the pipe. Excessive trench width should be avoided.
  - Backfill material can be native material, providing it is free from lumps, rocks and frozen material.
- **<u>Pipe Assembly</u>**
  - It is preferable to assemble the pipe in the trench. If this is not practical, pipe may be assembled above ground.
  - Pipe shall be inserted into each bell the correct depth before being lowered, not dropped, into the trench.
  - Each joint installation depth shall be checked after the pipe is lowered into the trench and prior to backfilling.

Special Installation Procedures

- 3.4.3 Special Considerations: HDPE Pipe
- 3.4.4 Special Considerations: Corrugated Steel Storm Sewer Pipe
- 3.4.5 Special Considerations: Rigid Concrete Pipe
- 3.4.6 Special Considerations: Semi-Rigid Concrete Pipe

HYDRAULIC STRUCTURES

This chapter is based on the principle that the document should be self-contained for design use.

It covers the general structural and hydraulic requirements for cast-in-place hydraulic structures where the flow is <= 100 m^3/s and the change in elevation <= 15 m.

Chapter 5: SEEPAGE CONTROL

- 5.1 Cut-Off Curtains
- 5.2 Clay Cut-Off (Core Trench)
- 5.3 Interceptor Drains
- 5.4 Grid Drainage
- 5.5 Drainage Materials
  - 5.5.1 Corrugated PE Drain Pipe
  - 5.5.2 Perforated PVC Pipe
  - 5.5.3 Gravel Chimney
  - 5.5.4 Gravel Bedding
  - 5.5.5 Filter Socks
  - 5.5.6 Manholes

Chapter 6:
SURFACE DRAINAGE WORKS

- 6.1 Required Capacities
- 6.2 Open Channel Drainage Design
- 6.3 Culvert Crossings

IRP Standards Committee "Teamwork"