

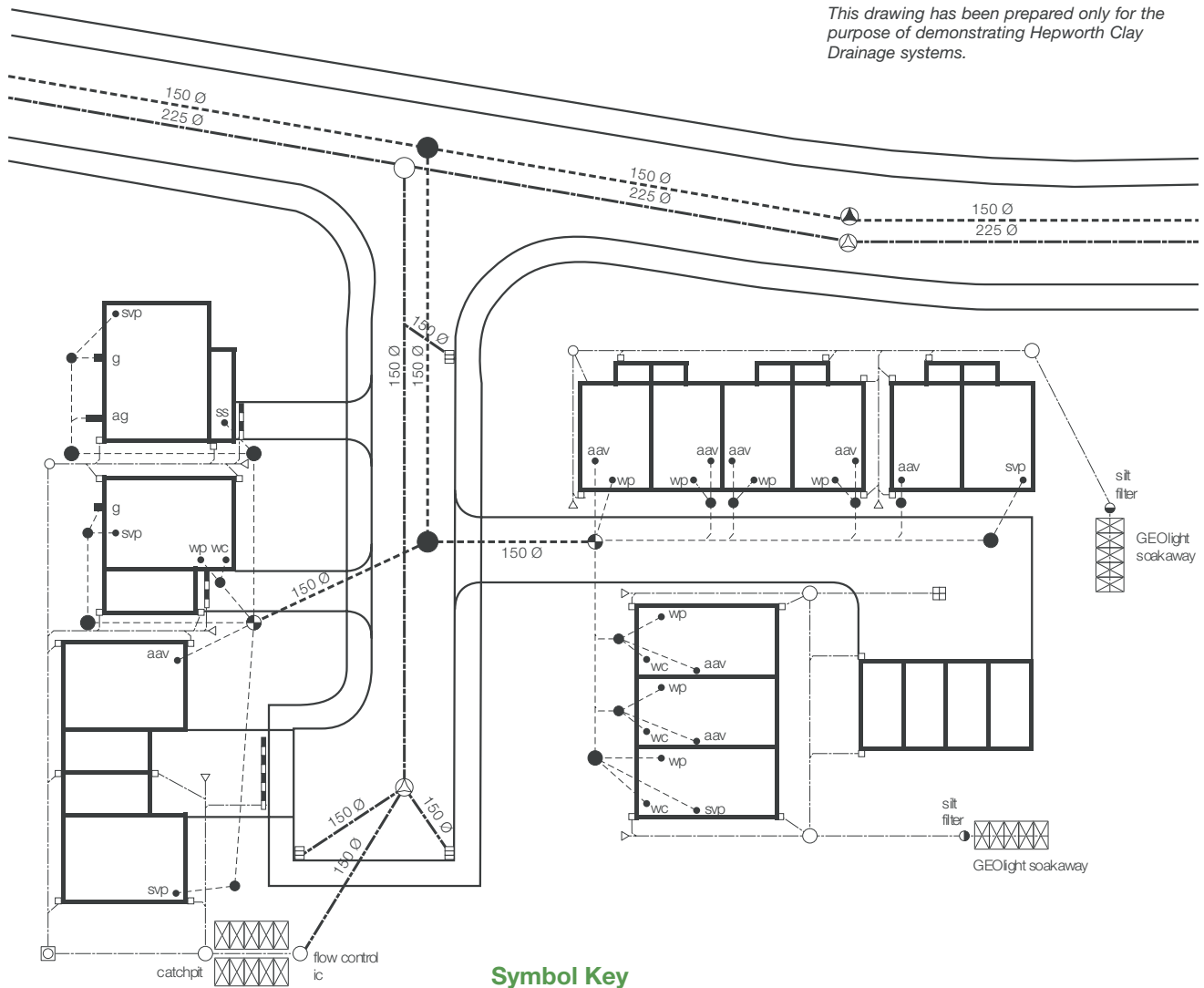
Introduction

Our Commitment to Specifiers



Layout

This drawing has been prepared only for the purpose of demonstrating Hepworth Clay Drainage systems.



Typical Site Layout

An efficient and well designed drainage system should collect, convey and discharge its contents without causing nuisance or danger to health and safety from leakage, blockage or surcharge, and provide an efficient service for the anticipated lifetime.

The design should take into account proposed flows, topography, pipeline environment, applied structural loads and the effects of chemicals in and around the pipeline. Design and construction should comply with Codes of Practice and mandatory requirements.

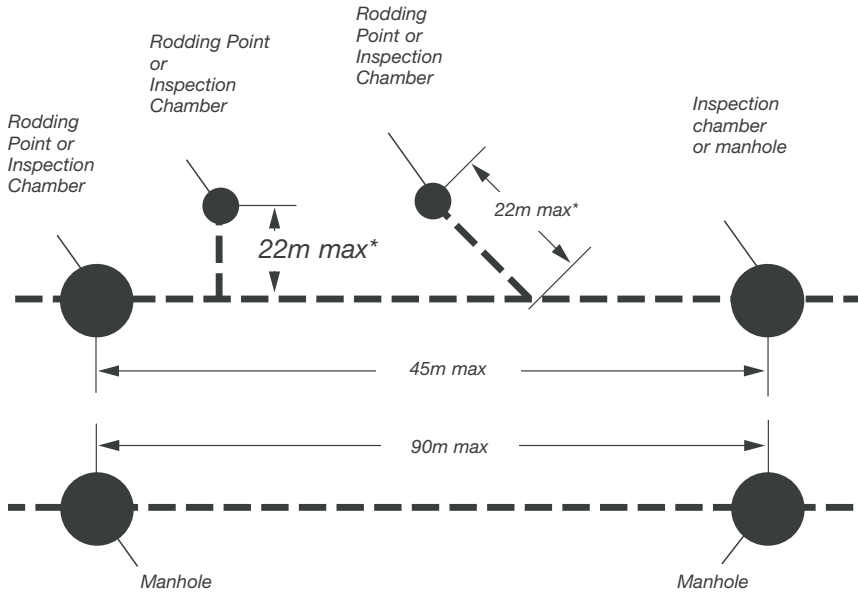
Symbol Key

Pipes			
Foul sewer and PCC ring manhole		-----●-----	
Surface water sewer and PCC ring manhole		-----○-----	
Foul drain		-----	
Surface water drain		-----	
Connection points		Foul Water	Surface Water
Rainwater pipe			□
Waste pipe	● wp		
WC	● wc		
Soil & Vent pipe	● svp		
Stub stack	● ss		
Soil pipe with air admittance valve	● aav		
Waste gully	■ g		
Access gully	■ ag		
Yard Gully			⊞
Road Gully			⊞
HepFlow™ channel drain			▬▬▬
Access points			
Rodding point			▷
Mini Access Chamber	●		○
PPIC (5 x 100 mm inlets)	●		○
PPIC (3 x 150, 2 x 100 mm inlets)	●		⊕
Tele-PPIC	■		⊕
RASS	▲		▲

Layout

Access Requirements

Maximum spacing of access points



* Note: In the interests of good drainage practice this distance should not exceed 12m.

Recommended maximum spacing of access provision (in metres) for manual cleaning (Table Note:1 in BS EN 752-3: 1996)

Distance from:	To access fitting:		To junction or branch	To inspection chamber shallow	To manhole and inspection chamber deep
	type 1	type 2			
Start of external drain*	12	12	–	22	45
Rodding eye	22	22	22	45	45
Access fitting (type 1) minimum 150 x 100	–	–	12	22	22
Access fitting (type 2) minimum 225 x 100	–	–	22	45	45
Inspection chamber shallow	22	45	22	45	45
Manhole and inspection chamber deep	–	–	–	45	90

* Stack or ground floor appliance.

Layout

Minimum dimensions for rodding eyes, access fittings and inspection chambers (non-personnel entry) (Table Note: 2 from BS EN 752-2: 1996)

Type of access	Depth to invert from cover level (m)	Minimum nominal internal dimensions ^a		Clear opening size		Remarks
		Rectangular length and width (mm)	Circular diameter (mm)	Rectangular length and width (mm)	Circular diameter (mm)	
Rodding eye	–	–	Preferably same size as drain but not less than DN 100	–	Same size as pipework ^d	
Access fitting ^b Type (1) See Table Note:1	0.6 or less, except where situated in chamber	150 x 100	150	Same size as access fitting ^d	Same size as access fitting ^d	The depth restriction is imposed because of the limited access afforded and is based on the ability to manipulate a stopper at arm's length from the surface.
Access fitting ^b Type (2) See Table Note:1	0.6 or less, except where situated in chamber	225 x 100	150	Same size as access fitting ^d	Same size as access fitting ^d	
Inspection chamber ^c – shallow	0.6 or less	225 x 100	190mm for drains up to DN 150	–	Min 190	
	1.2 or less	450 x 450	450	Min 430 x 430	Min 430	Restricted to inspection and remotely operated equipment – no personnel entry
Inspection chamber ^d – deep	Greater than 1.2	450 x 450 ^e	450 ^e	Access restricted to maximum 300 x 300 ^f	Access restricted maximum 350 ^f	Restricted to inspection and remotely operated equipment – no personnel entry Maximum size imposed to prevent personnel entry

a These sizes apply to straight-through pipes; larger sizes may be required for turning chambers or chambers with several side branches.

b Fitting with a removable cover that permits access into the pipe, either from surface level or from within a chamber.

c Chamber with a removable cover constructed on a drain or sewer that provides access from surface level only, but does not permit entry of a person (BS EN 752-1)

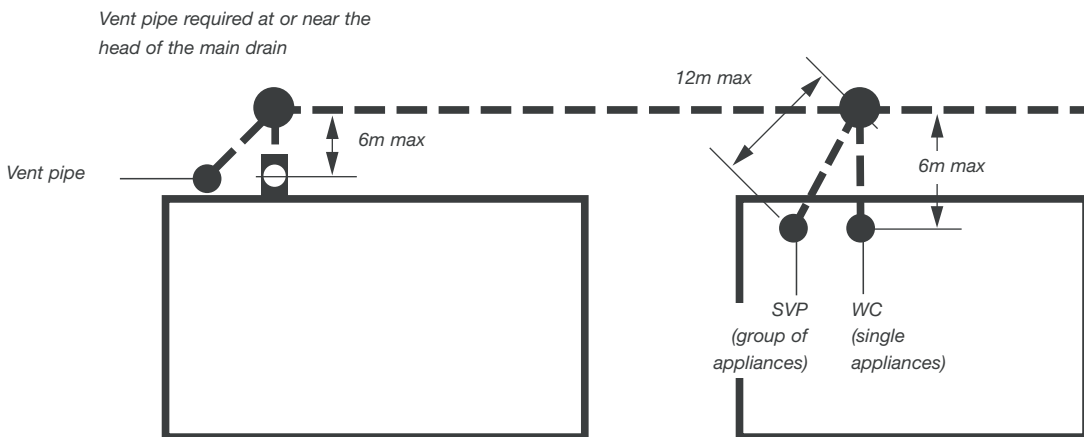
d The clear opening may be reduced by 20mm in order to provide proper support for the cover and frame.

e It may not be possible to gain access to side branches. The upper part of the chamber may be reduced to a minimum 300 x 300 or 350 dia. for a neck entry.

f A larger clear opening cover may be used in conjunction with a restricted access.

Ventilation Requirements

Maximum spacing of ventilation points



Reduced Access

Introduction

Over the last few years there have been several major changes to the legislation covering private and public drainage. One of these changes was the introduction of reduced access.

Concept of reduced access

The increased availability of a wide range of remotely operated equipment such as compact CCTV systems, specialised jetting machines and remote testing equipment means there is no longer the need for man entry at every access point. Using reduced access systems in a drain or sewer layout dictates that inspection and maintenance are performed safely from the surface.

That is not to say that man access can be completely replaced as it may be required to remove debris, jetted down from other units. The location of a man entry access point should be considered in relation to the position of the access point, ease of task maintained at major junctions and at the last access point before connection to the main sewer as a precaution.

Location of reduced access units in a drainage or sewer layout

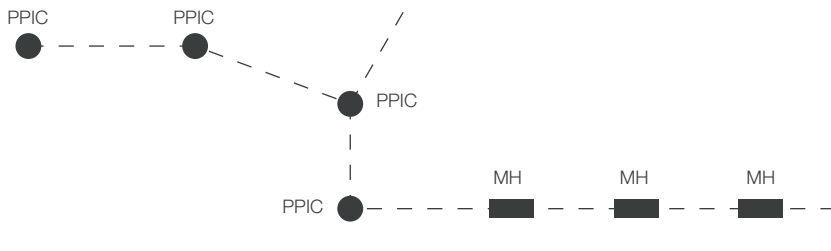
Acceptable location for reduced access unit use

- Location: Head of a run
Why: Access at the head of a run is generally for inspection, rodding or jetting which can be carried from a reduced access unit without problem
- Location: Slight change in direction, defined as 45° or less
Why: Less chance of blockage and rods or jetter introduced at previous access point will pass through without problem
- Location: Intermediate points on a straight main run of drainage (between manholes)
Why: Rods or jetter introduced at previous access point will pass through without problem

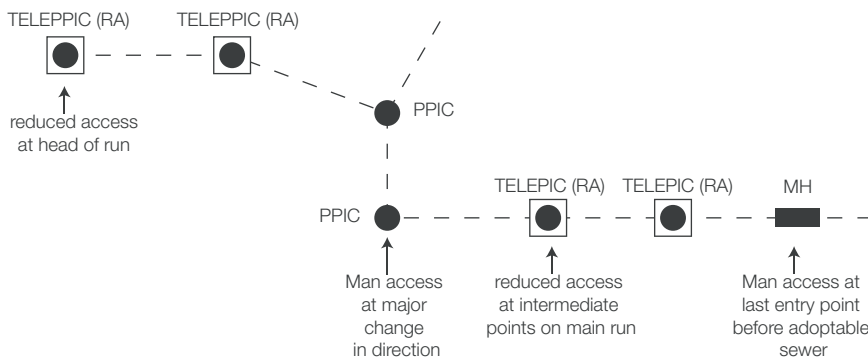
Unacceptable locations for reduced access unit use

- Location: Major junction
Why: Possibility of blockage, prudent to retain man access for removal of problem
- Location: Major change in direction
Why: Slight possibility of blockage, prudent to retain man access for removal of problem
- Location: Last access point before adoptable sewer
Why: Man access required for removal of debris prior to connection to main sewer. The DEFRA protocol on design, construction and adoption of sewers states that the last access point before connection to a main sewer must be man-entry.

Typical layout showing conventional access



Typical layout showing reduced access



Hydraulic – Introduction

Minimum Gradients

Foul Drainage

Gradients should be such as to maintain self-cleansing velocity. Minimum gradients are recommended below.

- 1 'For flows of less than 1 litre/sec, pipes not exceeding DN 100 at gradients not flatter than 1:40 have proved satisfactory.'
- 2 'Where the peak flow is more than 1 litre/sec, a DN 100 pipe may be laid at a gradient not flatter than 1:80, provided that at least one WC is connected.'
- 3 'DN 150 pipe may be laid at a gradient not flatter than 1:150, provided that at least five WCs are connected.'
- 4 'Experience has shown that for gradients flatter than those given in items (a) to (c), a high standard of design and workmanship is necessary if blockages are to be minimised. Where this has been achieved, gradients of 1:130 for DN 100 pipes and 1:200 for DN 150 pipes have been used successfully.' 'Recent research has shown that steep gradients do not cause increased erosion of pipes or deposition of solids.'

Surface Water Drainage

100mm pipes – 1:100

150mm pipes – 1:150

For pipe runs of 225mm and above the minimum gradient is usually determined by the capacity of the pipe being sufficient when running full bore, to accommodate the calculated flow rate.

Soakaways

Wherever possible surface water should be disposed of by use of a soakaway. A storage capacity equal to 20mm rainfall from the impervious area drained should be provided where the ground is of low permeability.

BRE Digest 365 'Soakaways' describes a simple test for measurement of rate of percolation into the ground, which is then used to determine the size of the soakaway for the area to be drained by a series of calculations.

Hydraulic – Design Equations

Design Equations

The most generally accepted equation currently in use is that attributed to Colebrook and White. In this equation, the velocity of flow is related to the pipe bore, the kinematic viscosity of the liquid, the gradient and the hydraulic roughness of the pipeline.

When a pipe is conveying sewage or a combination of sewage and surface water, slime, mostly micro-biological, adheres to and grows on the interior surface. This layer of slime is the major influence on the hydraulic roughness of pipelines and modifies the effect of various surface textures.

The Colebrook-White equation

The tables on the following pages are based on the Colebrook-White equation for transitional flow, the general form of which is:

$$\frac{1}{\lambda} = -2 \log \left[\frac{K_s}{3.75D} + \frac{2.5}{Re \sqrt{\lambda}} \right]$$

the equation, when expressed in engineering terms, becomes:

$$V = -2 \sqrt{2gDi} \log \left[\frac{K_s}{3.75D} + \frac{2.5v}{D \sqrt{2gDi}} \right]$$

where

λ = Friction coefficient, $\frac{2g Di}{V^2}$

V = Discharge velocity (m/s)

g = Gravitational acceleration (9.81 m/sec²)

i = Hydraulic gradient

v = Kinematic viscosity of fluid (m²/sec) at 10°C (1.31 X 10⁻⁶m²/sec)

K_s = Linear measure of effective roughness (0.6 or 1.5mm)

D = Nominal internal diameter of pipe (100 to 600mm)

Re = Reynolds number, $\frac{VD}{\nu}$

The tables developed from this equation may be used to determine the average velocity of flow and the discharge for pipes with an effective roughness (ks) of 0.6mm for surface

water sewers and 1.5mm for foul sewers and combined sewers. These values are specified for use in the Water Services Association's publication 'Sewers for Adoption' 4th Edition.

Table 4: Roughness (Ks) 1.50 – Pipe flowing full

Table 5: Roughness (Ks) 1.50 – Pipe flowing ³/₄

Table 6: Roughness (Ks) 0.60 – Pipe flowing full

Pipe Sizing

Foul drainage

For foul drains serving individual or small groups of buildings the peak flow rate can be calculated using the discharge unit method shown in BS EN 752-4 and BS EN 12056-2.

The peak flow is derived from the number and type of appliances connected and the frequency at which they discharge. Table 1 shows the appropriate discharge units allocated to a range of sanitary appliances. The table refers to system III values shown in BS EN 12056-2.

Table 1

Appliance	Discharge Units
Wash hand basin, bidet	0.3
Shower (without plug)	0.4
Shower (with plug)	1.3
Single urinal with cistern	0.4
Slab urinal	0.2*
Bath	1.3
Kitchen sink	1.3
Dishwater (domestic)	0.2
Washing machine (<6kg)	0.6
Washing machine (<12kg)	1.2
WC with 6 litres cistern	1.2-1.7**
WC with 7.5 litres cistern	1.4-1.8**
WC with 9 litres cistern	1.6-2.0**

*Per person- ** Depending on type

The flow rate in a foul drain is calculated using the following formula:

$$Q = k \sqrt{\sum DU}$$

Where Q = Flow rate

k = Frequency factor

$\sum DU$ = Sum of Discharge Units

The frequency factor for various types of building usage is shown in table 2.

Table 2

Type of building	k
Intermittent use, eg dwelling, guesthouse, office	0.5
Frequent use, eg hospital, school, restaurant, hotel	0.7
Congested use, eg toilets and showers open to the public	1.0
Special use, eg laboratory	1.2

BS EN 752 section NC2.2 also states that a value of 3.0 discharge units per dwelling can be used where several dwellings are connected to a drain, subject to a minimum flow of 1.6 l/sec.

Example calculation

Calculate the peak flow rate and size the outfall drain from a medical centre containing 10WCs, 15 WHBs, 3 sinks, 1 dishwasher, 2 showers.

Total number of discharge units:

- 10 X 1.7 (WCs) = 17.0
- 15 X 0.3 (WHBs) = 4.5
- 3 X 1.3 (Sinks) = 3.9
- 1 X 0.2 (Dishwasher) = 0.2
- 2 X 0.4 (Showers) = 0.8
- Total = 26.4**

Using frequency factor of 0.7:

$$Q = 0.7 \sqrt{26.5} = 3.6 \text{ l/sec}$$

Hydraulic – Worked Examples

Pipe size and gradient selection

Using table 5, which gives pipe capacities when flowing at $\frac{3}{4}$ full, select a pipe size and gradient which will accommodate the peak flow rate. Do not exceed minimum gradient values set by BS EN 752-4 and Building Regulations.

For a peak flow 3.6 l/sec a 100 mm diameter pipe laid at 1:80 (capacity at $\frac{3}{4}$ depth = 5.3 l/sec) should be adequate.

The following calculations are then used to check that the velocity of the flow is greater than 0.7 l/sec (self-cleansing velocity).

- 1 Read the pipe full velocity and capacity for the selected pipe and gradient in table 1. For a 100 mm pipe at 1:80 these are 0.75 m/sec and 5.6 l/sec
- 2 Calculate the proportional discharge by dividing the peak flow rate by the pipe capacity flowing full ie $3.6/5.6 = 0.643$
- 3 From table 3 read off the proportional velocity value when the proportional discharge is 0.643 ie 1.06
- 4 Multiply the pipe full velocity by the proportional velocity to calculate the actual velocity in the pipe ie $0.75 \times 1.06 = 0.8$ m/sec
Actual velocity exceeds 0.7 m/sec, therefore pipe is adequately sized.

Surface Water Drainage

For surface water drains serving impermeable areas no greater than 2000 m², or not exceeding 200 m in length, a rainfall intensity of 50 mm/hr is recommended. Where drains serve areas which are sensitive to surface flooding, a value of 75 mm/hr should be used. For the design of drainage serving larger areas site-specific rainfall data should be calculated based upon the storm frequency and duration.

A 50 mm/hr intensity generates 0.014 l/sec per square metre of impermeable area (assuming the surface to be drained has 100% impermeability). The flow rate in a surface water drain can be calculated by multiplying this value by the drained area in m² (the equivalent value is 0.021 for 75 mm/hr rainfall).

Example calculation

The same medical centre has a roof area of 350 m² and a car park of 500 m². Calculate the size of drain required at the outfall to the main sewer.

- 1 Calculate the total contributing impermeable area
ie $350 + 500 = 850$ m².
- 2 Multiply the total area by 0.014
ie $850 \times 0.014 = 11.9$ l/sec
- 3 From table 4 select a pipe diameter and gradient to accommodate the flow. For 100 mm diameter pipes BS EN 752 sets a minimum gradient of 1:100. For larger diameters the gradient at which the pipe full velocity is at least 1 m/sec should be used as a minimum. In this example a 100 mm pipe at 1:25 would accept the flow but this is probably too steep to be practical therefore a 150 mm pipe at 1:100 should be used.

Proportional velocity and discharge in pipes running part full

Table 3

Proportional Depth	Proportion of full-bore values	
	Velocity	Discharge
0.02	0.128	0.001
0.04	0.213	0.003
0.06	0.283	0.007
0.08	0.345	0.013
0.10	0.400	0.021
0.12	0.450	0.031
0.14	0.496	0.042
0.16	0.539	0.056
0.18	0.580	0.071
0.20	0.618	0.088
0.22	0.654	0.107
0.24	0.688	0.127
0.26	0.720	0.149
0.28	0.750	0.172
0.30	0.779	0.197
0.35	0.846	0.264
0.40	0.904	0.338
0.45	0.955	0.417
0.50	1.000	0.500
0.55	1.038	0.585
0.60	1.071	0.671
0.65	1.097	0.755
0.70	1.117	0.835
0.75	1.130	0.909
0.80	1.136	0.974
0.85	1.134	1.027
0.90	1.121	1.063
0.95	1.092	1.072

Hydraulic – Pipe Flow Capacity Table

Table 4 – Pipe flowing full – Roughness $K_s=1.50$

		Nominal Diameter (mm)															
		100		150		225		300		400		450		500		600	
Hydraulic	Gradient	velocity	discharge	velocity	discharge	velocity	discharge	velocity	discharge	velocity	discharge	velocity	discharge	velocity	discharge	velocity	discharge
	1 in	m/s	l/s	m/s	l/s	m/s	l/s	m/s	l/s	m/s	l/s	m/s	l/s	m/s	l/s	m/s	l/s
0.0010	1000.0	0.21	1.62	0.27	4.82	0.36	14.27	0.43	30.70	0.52	65.91	0.57	90.06	0.61	119.04	0.68	192.80
0.0011	909.1	0.22	1.70	0.29	5.06	0.38	14.97	0.46	32.22	0.55	69.16	0.59	94.50	0.64	124.91	0.72	202.29
0.0012	833.3	0.23	1.78	0.30	5.29	0.39	15.65	0.48	33.67	0.58	72.27	0.62	98.75	0.66	130.51	0.75	211.35
0.0013	769.2	0.24	1.85	0.31	5.51	0.41	16.30	0.50	35.06	0.60	75.25	0.65	102.82	0.69	135.89	0.78	220.05
0.0014	714.3	0.24	1.92	0.32	5.72	0.43	16.92	0.51	36.40	0.62	78.12	0.67	106.73	0.72	141.06	0.81	228.42
0.0015	666.7	0.25	1.99	0.34	5.93	0.44	17.52	0.53	37.69	0.64	80.89	0.69	110.51	0.74	146.05	0.84	236.49
0.0016	625.0	0.26	2.06	0.35	6.12	0.46	18.10	0.55	38.94	0.66	83.56	0.72	114.16	0.77	150.88	0.86	244.30
0.0017	588.2	0.27	2.12	0.36	6.32	0.47	18.67	0.57	40.15	0.69	86.16	0.74	117.71	0.79	155.56	0.89	251.87
0.0018	555.6	0.28	2.19	0.37	6.50	0.48	19.22	0.58	41.33	0.71	88.68	0.76	121.14	0.82	160.10	0.92	259.22
0.0019	526.3	0.29	2.25	0.38	6.68	0.50	19.75	0.60	42.47	0.73	91.13	0.78	124.49	0.84	164.52	0.94	266.37
0.0020	500.0	0.29	2.31	0.39	6.86	0.51	20.27	0.62	43.58	0.74	93.51	0.80	127.75	0.86	168.82	0.97	273.34
0.0022	454.5	0.31	2.42	0.41	7.20	0.53	21.27	0.65	45.73	0.78	98.11	0.84	134.03	0.90	177.12	1.01	286.76
0.0024	416.7	0.32	2.53	0.43	7.52	0.56	22.22	0.68	47.78	0.82	102.51	0.88	140.03	0.94	185.05	1.06	299.58
0.0026	384.6	0.34	2.64	0.44	7.83	0.58	23.14	0.70	49.75	0.85	106.72	0.92	145.79	0.98	192.65	1.10	311.88
0.0028	357.1	0.35	2.74	0.46	8.13	0.60	24.02	0.73	51.64	0.88	110.78	0.95	151.32	1.02	199.97	1.14	323.72
0.0030	333.3	0.36	2.84	0.48	8.42	0.63	24.87	0.76	53.47	0.91	114.69	0.99	156.67	1.05	207.02	1.19	335.14
0.0032	312.5	0.37	2.93	0.49	8.70	0.65	25.70	0.78	55.24	0.94	118.48	1.02	161.84	1.09	213.85	1.22	346.19
0.0034	294.1	0.38	3.02	0.51	8.97	0.67	26.49	0.81	56.95	0.97	122.15	1.05	166.85	1.12	220.47	1.26	356.89
0.0036	277.8	0.40	3.11	0.52	9.24	0.69	27.27	0.83	58.61	1.00	125.71	1.08	171.71	1.16	226.89	1.30	367.29
0.0038	263.2	0.41	3.20	0.54	9.49	0.70	28.02	0.85	60.23	1.03	129.18	1.11	176.44	1.19	233.14	1.33	377.40
0.0040	250.0	0.42	3.28	0.55	9.74	0.72	28.76	0.87	61.81	1.05	132.55	1.14	181.05	1.22	239.23	1.37	387.25
0.0042	238.1	0.43	3.36	0.57	9.98	0.74	29.47	0.90	63.34	1.08	135.84	1.17	185.54	1.25	245.17	1.40	396.85
0.0044	227.3	0.44	3.44	0.58	10.22	0.76	30.17	0.92	64.84	1.11	139.06	1.19	189.93	1.28	250.96	1.44	406.23
0.0046	217.4	0.45	3.52	0.59	10.45	0.78	30.85	0.94	66.31	1.13	142.20	1.22	194.22	1.31	256.63	1.47	415.40
0.0048	208.3	0.46	3.60	0.60	10.68	0.79	31.52	0.96	67.74	1.16	145.27	1.25	198.42	1.34	262.18	1.50	424.37
0.0050	200.0	0.47	3.67	0.62	10.90	0.81	32.18	0.98	69.15	1.18	148.28	1.27	202.53	1.36	267.61	1.53	433.15
0.0055	181.8	0.49	3.86	0.65	11.44	0.85	33.76	1.03	72.54	1.24	155.56	1.34	212.46	1.43	280.72	1.61	454.38
0.0060	166.7	0.51	4.03	0.68	11.95	0.89	35.27	1.07	75.79	1.29	162.51	1.40	221.95	1.49	293.26	1.68	474.66
0.0065	153.8	0.53	4.20	0.70	12.45	0.92	36.72	1.12	78.90	1.35	169.17	1.45	231.05	1.55	305.28	1.75	494.11
0.0070	142.9	0.55	4.36	0.73	12.92	0.96	38.12	1.16	81.90	1.40	175.59	1.51	239.81	1.61	316.85	1.81	512.82
0.0075	133.3	0.57	4.51	0.76	13.38	0.99	39.46	1.20	84.78	1.45	181.78	1.56	248.26	1.67	328.01	1.88	530.88
0.0080	125.0	0.59	4.66	0.78	13.82	1.03	40.76	1.24	87.58	1.49	187.76	1.61	256.43	1.73	338.81	1.94	548.35
0.0085	117.6	0.61	4.80	0.81	14.25	1.06	42.03	1.28	90.29	1.54	193.57	1.66	264.36	1.78	349.27	2.00	565.28
0.0090	111.1	0.63	4.95	0.83	14.66	1.09	43.25	1.31	92.92	1.59	199.20	1.71	272.05	1.83	359.43	2.06	581.72
0.0095	105.3	0.65	5.08	0.85	15.07	1.12	44.44	1.35	95.47	1.63	204.68	1.76	279.53	1.88	369.31	2.11	597.70
0.0100	100.0	0.66	5.22	0.87	15.46	1.15	45.60	1.39	97.97	1.67	210.01	1.80	286.82	1.93	378.94	2.17	613.27
0.0110	90.9	0.70	5.47	0.92	16.22	1.20	47.84	1.45	102.77	1.75	220.30	1.89	300.86	2.02	397.49	2.28	643.29
0.0120	83.3	0.73	5.72	0.96	16.95	1.26	49.98	1.52	107.36	1.83	230.13	1.98	314.28	2.11	415.22	2.38	671.97
0.0130	76.9	0.76	5.95	1.00	17.64	1.31	52.03	1.58	111.76	1.91	239.56	2.06	327.15	2.20	432.22	2.47	699.48
0.0140	71.4	0.79	6.18	1.04	18.31	1.36	54.00	1.64	115.99	1.98	248.63	2.13	339.54	2.28	448.58	2.57	725.95
0.0150	66.7	0.81	6.40	1.07	18.96	1.41	55.91	1.70	120.08	2.05	257.38	2.21	351.49	2.37	464.37	2.66	751.49
0.0160	62.5	0.84	6.61	1.11	19.59	1.45	57.75	1.75	124.03	2.12	265.85	2.28	363.05	2.44	479.63	2.75	776.19
0.0170	58.8	0.87	6.81	1.14	20.19	1.50	59.53	1.81	127.86	2.18	274.05	2.35	374.25	2.52	494.43	2.83	800.13
0.0180	55.6	0.89	7.01	1.18	20.78	1.54	61.27	1.86	131.58	2.24	282.02	2.42	385.13	2.59	509.80	2.91	823.37
0.0190	52.6	0.92	7.21	1.21	21.35	1.58	62.95	1.91	135.20	2.31	289.77	2.49	395.71	2.66	522.78	2.99	845.98
0.0200	50.0	0.94	7.39	1.24	21.91	1.62	64.59	1.96	138.72	2.37	297.32	2.55	406.01	2.73	536.39	3.07	868.01
0.0220	45.5	0.99	7.76	1.30	22.99	1.70	67.76	2.06	145.51	2.48	311.87	2.68	425.88	2.87	562.63	3.22	910.46
0.0240	41.7	1.03	8.10	1.36	24.01	1.78	70.78	2.15	152.00	2.59	325.77	2.80	444.86	2.99	587.70	3.36	951.02
0.0260	38.5	1.07	8.44	1.41	25.00	1.85	73.68	2.24	158.22	2.70	339.10	2.91	463.06	3.12	611.74	3.50	989.92
0.0280	35.7	1.12	8.76	1.47	25.94	1.92	76.47	2.32	164.21	2.80	351.93	3.02	480.58	3.23	634.88	3.63	1027.35
0.0300	33.3	1.15	9.07	1.52	26.86	1.99	79.16	2.40	169.99	2.90	364.31	3.13	497.48	3.35	657.21	3.76	1063.47
0.0320	31.2	1.19	9.37	1.57	27.74	2.06	81.77	2.48	175.58	2.99	376.28	3.23	513.83	3.46	678.80	3.88	1098.40
0.0340	29.4	1.23	9.66	1.62	28.60	2.12	84.29	2.56	181.00	3.09	387.89	3.33	529.67	3.56	699.72	4.00	1132.26
0.0360	27.8	1.27	9.94	1.67	29.43	2.18	86.74	2.63	186.26	3.18	399.15	3.43	545.05	3.67	720.05	4.12	1165.14
0.0380	26.3	1.30	10.21	1.71	30.24	2.24	89.12	2.71	191.37	3.26	410.11	3.52	560.02	3.77	739.81	4.23	1197.11
0.0400	25.0	1.33	10.48	1.76	31.03	2.30	91.45	2.78	196.36	3.35	420.79	3.61	574.59	3.87	759.06	4.34	1228.26
0.0420	23.8	1.37	10.74	1.80	31.80	2.36	93.71	2.85	201.21	3.43	431.20	3.70	588.80	3.96	777.83	4.45	1258.63
0.0440	22.7	1.40	10.99	1.84	32.55	2.41	95.92	2.91	205.96	3.51	441.36	3.79	602.68	4.05	796.17	4.56	1288.29
0.0460	21.7	1.43	11.24	1.88	33.28	2.47	98.08	2.98	210.60	3.59	451.30	3.87	616.25	4.15	814.09	4.66	1317.28
0.0480	20.8	1.46	11.48	1.92	34.00	2.52	100.20	3.04	215.14	3.67	461.02	3.96	629.52	4.24	831.62	4.76	1345.65
0.0500	20.0	1.49	11.72	1.96	34.71	2.57	102.27	3.11	219.58	3.74	470.54	4.04	642.52	4.32	848.79	4.86	1373.43
0.0550	18.2	1.57	12.29	2.06	36.40	2.70	107.27	3.26	230.32	3.93	493.55	4.24	673.93	4.53	890.28	5.09	1440.55
0.0600	16.7	1.64	12.84	2.15	38.03	2.82	112.05	3.40	240.58	4.10	515.53	4.43	703.94	4.74	929.92	5.32	1504.69
0.0650	15.4	1.70	13.37	2.24	39.59	2.93	116.64	3.54	250.42	4.27	536.61	4.61	732.73	4.93	967.94	5.54	1566.20
0.0700	14.3	1.77	13.88	2.32	41.08	3.04	121.05	3.68	259.89	4.43	556.89	4.78	760.42	5.12	1004.53	5.75	1625.38
0.07																	

Hydraulic – Pipe Flow Capacity Table

Table 5 – Pipe flowing 3/4 full – Roughness $K_s=1.50$

Hydraulic Gradient 1 in	Nominal Diameter (mm)																
	100		150		225		300		400		450		500		600		
	velocity m/s	discharge l/s	velocity m/s	discharge l/s	velocity m/s	discharge l/s	velocity m/s	discharge l/s	velocity m/s	discharge l/s	velocity m/s	discharge l/s	velocity m/s	discharge l/s	velocity m/s	discharge l/s	
0.0010	1000.0	0.23	1.47	0.31	4.38	0.41	12.97	0.49	27.91	0.59	59.91	0.64	81.87	0.69	108.21	0.77	175.25
0.0011	909.1	0.24	1.55	0.32	4.60	0.43	13.61	0.52	29.29	0.62	62.87	0.67	85.90	0.72	113.54	0.81	183.88
0.0012	833.3	0.26	1.62	0.34	4.81	0.44	14.22	0.54	30.60	0.65	65.69	0.70	89.76	0.75	118.64	0.84	192.12
0.0013	769.2	0.27	1.68	0.35	5.01	0.44	14.81	0.56	31.87	0.68	68.40	0.73	93.46	0.78	123.52	0.88	200.03
0.0014	714.3	0.28	1.75	0.37	5.20	0.46	15.38	0.58	33.09	0.70	71.01	0.76	97.02	0.81	128.22	0.91	207.63
0.0015	666.7	0.29	1.81	0.38	5.39	0.50	15.93	0.60	34.26	0.73	73.53	0.79	100.45	0.84	132.76	0.95	214.97
0.0016	625.0	0.30	1.87	0.39	5.57	0.51	16.46	0.62	35.40	0.75	75.96	0.81	103.77	0.87	137.15	0.98	222.07
0.0017	588.2	0.31	1.93	0.40	5.74	0.53	16.97	0.64	36.50	0.77	78.32	0.84	106.99	0.90	141.40	1.12	255.71
0.0018	555.6	0.31	1.99	0.42	5.91	0.55	17.47	0.66	37.56	0.80	80.61	0.86	110.12	0.92	145.53	1.16	263.22
0.0019	526.3	0.32	2.04	0.43	6.07	0.56	17.95	0.68	38.60	0.82	82.83	0.88	113.16	0.95	149.55	1.19	270.53
0.0020	500.0	0.33	2.10	0.44	6.23	0.58	18.42	0.70	39.62	0.84	85.00	0.91	116.12	0.97	153.46	1.22	277.65
0.0022	454.5	0.35	2.20	0.46	6.54	0.60	19.33	0.73	41.57	0.88	89.18	0.95	121.83	1.14	180.35	1.28	291.38
0.0024	416.7	0.36	2.30	0.48	6.84	0.63	20.20	0.76	43.43	0.92	93.18	0.99	127.29	1.19	188.48	1.34	304.49
0.0026	384.6	0.38	2.40	0.50	7.12	0.66	21.03	0.80	45.22	0.96	97.01	1.16	148.72	1.24	196.28	1.39	317.07
0.0028	357.1	0.39	2.49	0.52	7.39	0.68	21.84	0.83	46.94	1.00	100.70	1.21	154.41	1.29	203.78	1.45	329.18
0.0030	333.3	0.41	2.58	0.54	7.66	0.71	22.61	0.85	48.60	1.16	117.23	1.25	159.90	1.34	211.02	1.50	340.86
0.0032	312.5	0.42	2.66	0.56	7.91	0.73	23.36	0.88	50.21	1.20	121.13	1.29	165.21	1.38	218.02	1.67	378.71
0.0034	294.1	0.43	2.75	0.57	8.16	0.75	24.08	0.91	51.77	1.24	124.90	1.33	170.35	1.42	224.81	1.72	390.57
0.0036	277.8	0.45	2.83	0.59	8.40	0.77	24.79	0.94	53.28	1.27	128.57	1.37	175.35	1.47	231.40	1.77	402.09
0.0038	263.2	0.48	2.91	0.61	8.63	0.80	25.47	0.96	54.75	1.31	132.14	1.41	180.21	1.62	256.14	1.82	413.29
0.0040	250.0	0.47	2.98	0.62	8.85	0.82	26.14	0.99	56.18	1.34	135.61	1.45	184.94	1.66	262.91	1.87	424.21
0.0042	238.1	0.48	3.06	0.64	9.08	0.84	26.79	1.14	65.07	1.38	139.00	1.48	189.56	1.71	269.52	1.91	434.85
0.0044	227.3	0.50	3.13	0.65	9.29	0.86	27.43	1.17	66.62	1.41	142.31	1.64	209.27	1.75	275.97	1.96	445.24
0.0046	217.4	0.51	3.20	0.67	9.50	0.88	28.05	1.20	68.14	1.44	145.54	1.67	214.06	1.79	282.28	2.00	455.40
0.0048	208.3	0.52	3.27	0.68	9.71	0.90	28.65	1.22	69.62	1.47	148.71	1.71	218.74	1.83	288.45	2.05	465.35
0.0050	200.0	0.53	3.34	0.70	9.91	0.91	29.25	1.25	71.08	1.62	163.88	1.75	223.33	1.86	294.50	2.09	475.08
0.0055	181.8	0.55	3.51	0.73	10.40	0.96	30.69	1.31	74.59	1.70	172.02	1.83	234.42	1.96	309.11	2.19	498.61
0.0060	166.7	0.58	3.66	0.76	10.87	1.14	36.43	1.37	77.95	1.78	179.81	1.92	245.01	2.05	323.06	2.29	521.09
0.0065	153.8	0.60	3.81	0.80	11.31	1.19	37.94	1.43	81.17	1.85	187.27	1.99	255.17	2.13	336.45	2.39	542.65
0.0070	142.9	0.63	3.96	0.83	11.74	1.23	39.39	1.48	84.26	1.92	194.46	2.07	264.95	2.21	349.33	2.48	563.40
0.0075	133.3	0.65	4.10	0.86	12.16	1.28	40.79	1.68	94.50	1.99	201.39	2.14	274.39	2.29	361.76	2.57	583.42
0.0080	125.0	0.67	4.24	0.88	12.56	1.32	42.15	1.72	97.66	2.06	208.09	2.22	283.51	2.37	373.79	2.65	602.79
0.0085	117.6	0.69	4.37	0.91	12.95	1.36	43.46	1.77	100.72	2.12	214.59	2.29	292.36	2.44	385.44	2.73	621.56
0.0090	111.1	0.71	4.50	0.94	13.33	1.40	44.74	1.82	103.69	2.19	220.90	2.35	300.95	2.51	396.76	2.81	639.78
0.0095	105.3	0.73	4.62	0.96	13.70	1.44	45.97	1.87	106.57	2.25	227.04	2.42	309.30	2.58	407.76	2.89	657.51
0.0100	100.0	0.75	4.74	0.99	14.06	1.48	47.18	1.92	109.39	2.31	233.02	2.48	317.44	2.65	418.48	2.97	674.77
0.0110	90.9	0.79	4.97	1.19	16.91	1.68	53.81	2.02	114.81	2.42	244.55	2.60	333.13	2.78	439.15	3.11	708.06
0.0120	83.3	0.82	5.20	1.24	17.67	1.76	56.24	2.11	119.99	2.53	255.56	2.72	348.12	2.91	458.90	3.25	739.86
0.0130	76.9	0.86	5.41	1.29	18.40	1.83	58.58	2.20	124.96	2.63	266.13	2.83	362.50	3.03	477.84	3.39	770.37
0.0140	71.4	0.89	5.62	1.34	19.10	1.90	60.83	2.28	129.75	2.73	276.29	2.94	376.33	3.14	496.06	3.52	799.72
0.0150	66.7	0.92	5.82	1.39	19.78	1.97	63.00	2.36	134.36	2.83	286.10	3.05	389.68	3.25	513.65	3.64	828.05
0.0160	62.5	0.95	6.01	1.44	20.44	2.04	65.10	2.44	138.83	2.92	295.59	3.15	402.60	3.36	530.66	3.76	855.44
0.0170	58.8	0.98	6.19	1.48	21.07	2.10	67.13	2.52	143.15	3.02	304.78	3.24	415.11	3.46	547.15	3.88	881.99
0.0180	55.6	1.17	7.38	1.67	23.70	2.16	69.10	2.59	147.36	3.10	313.71	3.34	427.27	3.57	563.16	3.99	907.78
0.0190	52.6	1.20	7.59	1.71	24.36	2.22	71.03	2.66	151.44	3.19	322.39	3.43	439.09	3.66	578.73	4.10	932.85
0.0200	50.0	1.23	7.79	1.76	25.00	2.28	72.90	2.73	155.42	3.27	330.85	3.52	450.60	3.76	593.89	4.21	957.28
0.0220	45.5	1.29	8.17	1.85	26.24	2.39	76.50	2.87	163.10	3.43	347.16	3.70	472.79	3.95	623.13	4.42	1004.36
0.0240	41.7	1.35	8.54	1.93	27.43	2.50	79.95	3.00	170.43	3.59	362.74	3.86	494.00	4.12	651.06	4.61	1049.35
0.0260	38.5	1.41	8.89	2.01	28.57	2.60	83.25	3.12	177.46	3.74	377.68	4.02	514.34	4.29	677.86	4.80	1092.50
0.0280	35.7	1.46	9.20	2.09	29.66	2.70	86.43	3.24	184.23	3.88	392.06	4.17	533.91	4.45	703.54	4.99	1134.02
0.0300	33.3	1.66	10.50	2.16	30.72	2.80	89.50	3.35	190.76	4.02	405.94	4.32	552.79	4.61	728.52	5.16	1174.08
0.0320	31.2	1.72	10.85	2.23	31.74	2.89	92.47	3.47	197.07	4.15	419.36	4.46	571.06	4.76	752.58	5.33	1212.83
0.0340	29.4	1.77	11.19	2.30	32.73	2.98	95.35	3.57	203.20	4.28	432.37	4.60	588.76	4.91	775.90	5.50	1250.39
0.0360	27.8	1.82	11.52	2.37	33.69	3.07	98.14	3.68	209.14	4.40	445.00	4.74	605.95	5.06	798.54	5.66	1286.85
0.0380	26.3	1.87	11.84	2.44	34.63	3.15	100.86	3.78	214.92	4.52	457.28	4.87	622.67	5.20	820.56	5.81	1322.32
0.0400	25.0	1.92	12.16	2.50	35.54	3.24	103.51	3.88	220.55	4.64	469.25	4.99	638.96	5.33	842.02	5.97	1356.87
0.0420	23.8	1.97	12.46	2.56	36.43	3.32	106.09	3.98	226.04	4.76	480.92	5.12	654.84	5.46	862.94	6.11	1390.56
0.0440	22.7	2.02	12.76	2.62	37.29	3.40	108.61	4.07	231.41	4.87	492.31	5.24	670.35	5.59	883.37	6.26	1423.46
0.0460	21.7	2.07	13.05	2.68	38.14	3.47	111.07	4.16	236.65	4.98	503.45	5.36	685.51	5.72	903.34	6.40	1455.62
0.0480	20.8	2.11	13.33	2.74	38.97	3.55	113.48	4.25	241.78	5.09	514.35	5.47	700.34	5.84	922.88	6.54	1487.09
0.0500	20.0	2.15	13.61	2.80	39.79	3.62	115.85	4.34	246.80	5.19	525.02	5.59	714.87	5.96	942.02	6.67	1517.91
0.0550	18.2	2.26	14.29	2.94	41.75	3.80	121.55	4.55	258.94	5.45	550.81	5.86	749.97	6.26	988.25	7.00	1592.37
0.0600	16.7	2.36	14.93	3.07	43.63	3.97	127.00	4.76	270.54	5.69	575.45	6.12	783.50	6.54	1032.43	7.31	1663.51
0.0650	15.4	2.46	15.55	3.20	45.43	4.13	132.23	4.95	281.66	5.93	599.09	6.38	815.67	6.80	1074.80	7.61	1731.75
0.0700	14.3	2.56	16.14	3.32	47.16	4.29	137.26	5.14	292.36	6.15	621.83	6.62	846.62	7.06	1115.57	7.90	1797.40
0.0750	13.3	2.65	16.72	3.43	48.83	4.44	142.11	5.32									

Hydraulic – Pipe Flow Capacity Table

Table 6 – Pipe flowing full – Roughness $K_s=0.60$

		Nominal Diameter (mm)															
		100		150		225		300		400		450		500		600	
Hydraulic	Gradient	velocity	discharge	velocity	discharge	velocity	discharge	velocity	discharge	velocity	discharge	velocity	discharge	velocity	discharge	velocity	discharge
	1 in	m/s	l/s	ms	l/s	m/s	l/s	m/s	l/s	m/s	l/s	m/s	l/s	ms	l/s	m/s	l/s
0.0010	1000.0	0.23	1.84	0.31	5.45	0.40	16.06	0.49	34.45	0.59	73.75	0.63	100.66	0.68	132.91	0.76	214.87
0.0011	909.1	0.25	1.93	0.32	5.73	3.42	16.87	0.51	36.18	0.62	77.43	0.66	105.67	0.71	139.52	0.80	225.54
0.0012	833.3	0.26	2.02	0.34	5.99	0.44	17.64	0.54	37.83	0.64	80.95	0.69	110.48	0.74	145.84	0.83	235.74
0.0013	769.2	0.27	2.11	0.35	6.24	0.46	18.38	0.56	39.41	0.67	84.32	0.72	115.06	0.77	151.90	0.87	245.52
0.0014	714.3	0.28	2.19	0.37	6.49	0.48	19.09	0.58	40.93	0.70	87.57	0.75	119.48	0.80	157.74	0.90	254.93
0.0015	666.7	0.29	2.27	0.38	6.72	0.50	19.78	0.60	42.40	0.72	90.70	0.78	123.75	0.83	163.36	0.93	264.01
0.0016	625.0	0.30	2.35	0.39	6.95	0.51	20.44	0.62	43.82	0.75	93.73	0.80	127.88	0.86	168.81	0.96	272.79
0.0017	588.2	0.31	2.43	0.41	7.17	0.53	21.09	0.64	45.20	0.77	96.66	0.83	131.88	0.89	174.09	0.99	281.31
0.0018	555.6	0.32	2.50	0.42	7.39	0.55	21.71	0.66	46.53	0.79	99.51	0.85	135.77	0.91	179.21	1.02	289.58
0.0019	526.3	0.33	2.57	0.43	7.59	0.56	22.32	0.68	47.83	0.81	102.29	0.88	139.54	0.94	184.19	1.05	297.62
0.0020	500.0	0.34	2.64	0.44	7.80	0.58	22.92	0.69	49.10	0.84	104.99	0.90	143.23	0.96	189.05	1.08	305.45
0.0022	454.5	0.35	2.77	0.46	8.19	0.61	24.06	0.73	51.54	0.88	110.19	0.95	150.32	1.01	198.41	1.13	320.55
0.0024	416.7	0.37	2.90	0.44	8.56	0.63	25.15	0.76	53.88	0.92	115.17	0.99	157.10	1.06	207.35	1.18	334.98
0.0026	384.6	0.38	3.02	0.50	8.92	0.66	26.20	0.79	56.12	0.95	119.94	1.03	163.61	1.10	215.92	1.23	348.81
0.0028	357.1	0.40	3.14	0.52	9.27	0.68	27.21	0.82	58.27	0.99	124.53	1.07	169.87	1.14	224.18	1.28	362.13
0.0030	333.3	0.41	3.25	0.54	9.60	0.71	28.18	0.85	60.35	1.03	128.97	1.11	175.90	1.18	232.14	1.33	374.98
0.0032	312.5	0.43	3.36	0.56	9.92	0.73	29.13	0.88	62.36	1.06	133.25	1.14	181.75	1.22	239.85	1.37	387.41
0.0034	294.1	0.44	3.47	0.58	10.24	0.76	30.04	0.91	64.31	1.09	137.41	1.18	187.41	1.26	247.31	1.41	399.45
0.0036	277.8	0.45	3.57	0.60	10.54	0.78	30.92	0.94	66.20	1.13	141.44	1.21	192.90	1.30	254.56	1.45	411.15
0.0038	263.2	0.47	3.67	0.61	10.83	0.80	31.79	0.96	68.04	1.16	145.36	1.25	198.25	1.33	261.61	1.49	422.53
0.0040	250.0	0.48	3.77	0.63	11.12	0.82	32.63	0.99	69.83	1.19	149.19	1.28	203.46	1.37	268.48	1.53	433.61
0.0042	238.1	0.49	3.87	0.65	11.40	0.84	33.44	1.01	71.58	1.22	152.91	1.31	208.54	1.40	275.18	1.57	444.41
0.0044	227.3	0.50	3.96	0.66	11.68	0.86	34.24	1.04	73.29	1.25	156.55	1.34	213.50	1.43	281.72	1.61	454.97
0.0046	217.4	0.52	4.05	0.68	11.94	0.88	35.03	1.06	74.96	1.27	160.11	1.37	218.35	1.47	288.11	1.65	465.28
0.0048	208.3	0.53	4.14	0.69	12.20	0.90	35.79	1.08	76.59	1.30	163.59	1.40	223.09	1.50	294.37	1.68	475.38
0.0050	200.0	0.54	4.23	0.71	12.46	0.92	36.54	1.11	78.19	1.33	167.00	1.43	227.74	1.53	300.50	1.72	485.26
0.0055	181.8	0.57	4.44	0.74	13.08	0.96	38.35	1.16	82.06	1.39	175.24	1.50	238.96	1.61	315.30	1.80	509.15
0.0060	166.7	0.59	4.64	0.77	13.67	1.01	40.08	1.21	85.75	1.46	183.11	1.57	249.69	1.68	329.45	1.88	531.97
0.0065	153.8	0.62	4.84	0.81	14.24	1.05	41.74	1.26	89.29	1.52	190.66	1.63	259.98	1.75	343.01	1.96	553.85
0.0070	142.9	0.64	5.02	0.84	14.79	1.09	43.34	1.31	92.70	1.58	197.93	1.70	269.88	1.81	356.07	2.03	574.92
0.0075	133.3	0.66	5.20	0.87	15.32	1.13	44.88	1.36	95.99	1.63	204.94	1.76	279.43	1.88	368.66	2.11	595.24
0.0080	125.0	0.68	5.38	0.90	15.83	1.17	46.37	1.40	99.17	1.68	211.72	1.82	288.67	1.94	380.85	2.17	614.89
0.0085	117.6	0.71	5.55	0.92	16.32	1.20	47.81	1.45	102.25	1.74	218.29	1.87	297.63	2.00	392.66	2.24	633.94
0.0090	111.1	0.73	5.71	0.95	16.80	1.24	49.21	1.49	105.25	1.79	224.67	1.93	306.32	2.06	404.12	2.31	652.44
0.0095	105.3	0.75	5.87	0.98	17.27	1.27	50.58	1.53	108.16	1.84	230.88	1.98	314.78	2.11	415.27	2.37	670.43
0.0100	100.0	0.77	6.02	1.00	17.72	1.31	51.91	1.57	110.99	1.89	236.92	2.03	323.01	2.17	426.14	2.43	687.96
0.0110	90.9	0.81	6.32	1.05	18.60	1.37	54.47	1.65	116.46	1.98	248.57	2.13	338.89	2.28	447.07	2.55	721.74
0.0120	83.3	0.84	6.61	1.10	19.44	1.43	56.91	1.72	121.68	2.07	259.71	2.23	354.06	2.38	467.08	2.67	754.01
0.0130	76.9	0.88	6.88	1.15	20.24	1.49	59.26	1.79	126.69	2.15	270.39	2.32	368.62	2.48	486.27	2.78	764.97
0.0140	71.4	0.91	7.15	1.19	21.02	1.55	61.52	1.86	131.51	2.23	280.66	2.41	382.62	2.57	504.73	2.88	814.76
0.0150	66.7	0.94	7.40	1.23	21.76	1.60	63.70	1.93	136.17	2.31	290.58	2.49	396.13	2.66	522.55	2.98	843.50
0.0160	62.5	0.97	7.65	1.27	22.48	1.66	65.81	1.99	140.67	2.39	300.17	2.57	409.20	2.75	539.78	3.08	871.30
0.0170	58.8	1.00	7.89	1.31	23.18	1.71	67.85	2.05	145.03	2.46	309.46	2.65	421.86	2.83	556.48	3.18	898.25
0.0180	55.6	1.03	8.12	1.35	23.86	1.76	69.83	2.11	149.26	2.53	318.49	2.73	434.16	2.92	572.70	3.27	924.41
0.0190	52.6	1.06	8.34	1.39	24.52	1.80	71.76	2.17	153.38	2.60	327.26	2.81	446.12	3.00	588.47	3.36	949.85
0.0200	50.0	1.09	8.56	1.42	25.17	1.85	73.64	2.23	157.39	2.67	335.81	2.88	457.77	3.08	603.84	3.45	974.64
0.0220	45.5	1.14	8.99	1.49	26.41	1.94	77.26	2.34	165.12	2.80	352.29	3.02	480.23	3.23	633.45	3.62	1022.41
0.0240	41.7	1.20	9.39	1.56	27.59	2.03	80.73	2.44	172.51	2.93	368.04	3.15	501.69	3.37	661.75	3.78	1068.06
0.0260	38.5	1.25	9.78	1.63	28.73	2.11	84.05	2.54	179.60	3.05	383.15	3.28	522.27	3.51	688.89	3.93	1111.85
0.0280	35.7	1.29	10.15	1.69	29.83	2.19	87.24	2.64	186.42	3.16	397.68	3.41	542.07	3.64	715.00	4.08	1153.98
0.0300	33.3	1.34	10.51	1.75	30.88	2.27	90.32	2.73	193.00	3.28	411.70	3.53	561.18	3.77	740.20	4.23	1194.63
0.0320	31.2	1.38	10.86	1.81	31.90	2.35	93.30	2.82	199.36	3.38	425.27	3.64	579.67	3.89	764.57	4.36	1233.94
0.0340	29.4	1.43	11.20	1.86	32.89	2.42	96.19	2.91	205.53	3.49	438.41	3.76	597.58	4.01	788.19	4.50	1272.05
0.0360	27.8	1.47	11.53	1.92	33.85	2.49	99.00	2.99	211.52	3.59	451.17	3.87	614.97	4.13	811.13	4.63	1309.05
0.0380	26.3	1.51	11.85	1.97	34.79	2.56	101.73	3.07	217.34	3.69	463.59	3.97	631.89	4.24	833.43	4.76	1345.04
0.0400	25.0	1.55	12.16	2.02	35.70	2.63	104.39	3.15	223.01	3.79	475.68	4.08	648.36	4.36	855.16	4.88	1380.09
0.0420	23.8	1.59	12.46	2.07	36.59	2.69	106.98	3.23	228.55	3.88	487.47	4.18	664.43	4.46	876.35	5.00	1414.28
0.0440	22.7	1.62	12.76	2.12	37.45	2.75	109.51	3.31	233.95	3.97	498.99	4.28	680.13	4.57	897.04	5.12	1447.66
0.0460	21.7	1.66	13.05	2.17	38.30	2.82	111.98	3.38	239.23	4.06	510.25	4.37	695.47	4.67	917.27	5.24	1480.29
0.0480	20.8	1.70	13.33	2.21	39.13	2.88	114.40	3.46	244.40	4.15	521.26	4.47	710.47	4.77	937.06	5.35	1512.22
0.0500	20.0	1.73	13.61	2.26	39.94	2.94	116.78	3.53	249.46	4.23	532.05	4.56	725.17	4.87	956.45	5.46	1543.49
0.0550	18.2	1.82	14.28	2.37	41.90	3.08	122.50	3.70	261.69	4.44	558.11	4.78	760.68	5.11	1003.27	5.73	1619.03
0.0600	16.7	1.90	14.92	2.48	43.78	3.22	127.98	3.87	273.37	4.64	583.01	5.00	794.62	5.34	1048.01	5.98	1691.21
0.0650	15.4	1.98	15.53	2.58	45.58	3.35	133.23	4.03	284.58	4.83	606.89	5.20	827.16	5.56	1090.93	6.23	1760.44
0.0700	14.3	2.05	16.12	2.68	47.31	3.48	138.28	4.18	295.36	5.01	629.87	5.40	858.47	5.77	1132.22		

Structural

Cover

It is recommended that a minimum cover of 1.2m to the top of the pipe is maintained under roads and 0.9m elsewhere. If this cannot be achieved, consult the Technical Advisory Service for advice – see below for contact details.

Pipes laid under or adjacent to roads are likely to be subject to higher loads in construction than in service. In order to prevent damage, it may be necessary to provide stronger beddings, adjust the levels to increase cover, or provide temporary protection.

Use of Design Charts

1. Select chart for road or field loading as appropriate.
2. Identify the nominal diameter and pipe system to be used (e.g. DN 150 SuperSleve).
3. Establish maximum and minimum depths of cover from the surface to the crown of the pipe.
4. Read from table type of bedding required to satisfy the range of cover depths required.
5. If the pipe and bedding combinations shown in the charts cannot achieve the required supporting strength then a full calculation should be performed using actual trench widths and soil densities. Refer to Design Tables for Determining the Bedding Construction of Vitrified Clay Pipelines, published by the CPDA.

Revised Bedding Factors for Vitrified Clay Drains and Sewers

Information and Guidance Note No. 4-11-02, published by the Water Authorities Association’s Sewers and Water Mains Committee, sets out revised bedding factors for vitrified clay drains and sewers. It recommends that bedding factors of 1.9, 2.5 and 2.5 should be used with vitrified clay pipes for Classes F, B and S beddings respectively.

Relationship Between Class Number and Crushing Strength

In some instances pipe strengths may be specified by class number as an alternative to crushing strength. The two numbers are selected by the following formula.

$$\text{Crushing strength (measured in kN/m)} = \frac{\text{Class Number} \times \text{Nominal size}}{1000}$$

For further information on bedding see Section 11.

Crushing Strength Crushing Test Loads (WT)

System Diameter (mm)	SuperSleve	SuperSeal®	HepSeal	HepLine	HepDuct	Unjointed
100	40	–	–	28	40	22
150	40	40	–	28	40	22
225	45	45	–	36	28	28
300	72	72	–	48	34	34
400	–	–	64	48	–	–
450	–	–	54	54	–	–
500	–	–	60	48	–	–
600	–	–	57	57	–	–

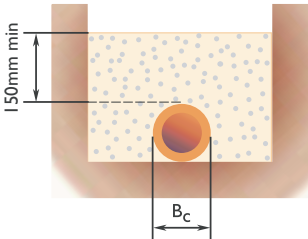
Note: Crushing test loads measured in kN/m.

Structural

Construction of Trench Beddings for Clay Pipes

Pipes Laid on Trench Bottom

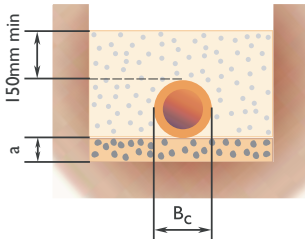
Class D Bedding Factor 1.1



Trimmed trench bottom.

Pipes Laid in a Bed of Single Size Granular Material Classes F, B and S

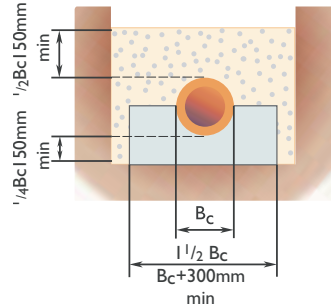
Class F Bedding Factor 1.9



Single size granular material bed.
Generally suitable for all conditions.

Pipes Laid with a Concrete Bedding Class A

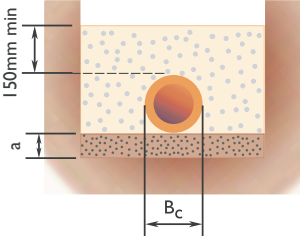
Class A Plain Concrete Bedding Factor 2.6



Plain concrete cradle.
Generally suitable for all conditions, but for rock in mining areas, use granular base course.

Pipes Laid on Continuous Bed of Granular Material Class N

Class N Bedding Factor 1.1



Dimension a

In machine-dug uniform soils:

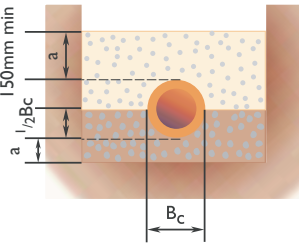
a = For sleeve jointed pipes, a minimum of 50mm or $1/6 B_c$ whichever is the greater; for socketed pipes a minimum of 100mm or $1/6 B_c$, whichever is the greater under barrels but not less than 50mm under sockets.

In rock or mixed soils containing rock bands, boulders, large flints or stones or other irregular hard spots:

a = For sleeve jointed pipes, a minimum of 150mm or $1/4 B_c$, whichever is the greater; for socketed pipes, a minimum of 200mm or $1/4 B_c$, whichever is the greater under barrels and 150mm minimum under sockets.

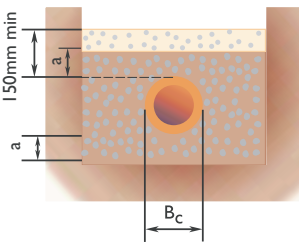
For a concrete surround the bedding factor is 4.5. For a reinforced concrete surround, an increased bedding factor of 4.8 can be used, provided that the area of transverse steel is at least 1.0% both above and below the pipe, and there is vertical steel jointing this main steel. This bedding factor has been derived from the 4.8 for a 1.0% reinforced concrete arch. A concrete arch is not a practicable construction.

Class B Bedding Factor 2.5



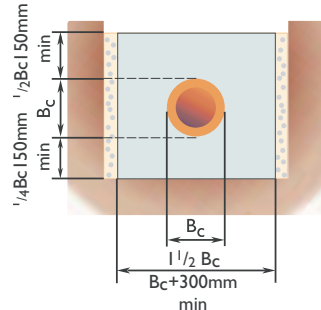
Machine-cut trench bottom.
Generally suitable for all soil conditions.

Class S Bedding Factor 2.5



Granular surround.
Generally suitable for all soils.

Bedding Factor 4.5



Plain concrete surround.
Generally suitable for all conditions, but for rock in mining areas, use granular base course.

key

Graded or all-in aggregate or compacted sand or suitable as-dug material.

Fill selected from excavated material and lightly compacted by hand.*

Undisturbed natural soil.

Concrete 28 days cube strength to be at least 20 MN/m².

Single-size granular material.

* Selected fill: Selected fill should be readily compactable, free from timber, frozen material, vegetable and foreign matter and exclude hard lumps of clay retained on a 100mm sieve and stones retained on a 40mm sieve.

Structural

Typical Pipe Bedding Specification for a clay pipe

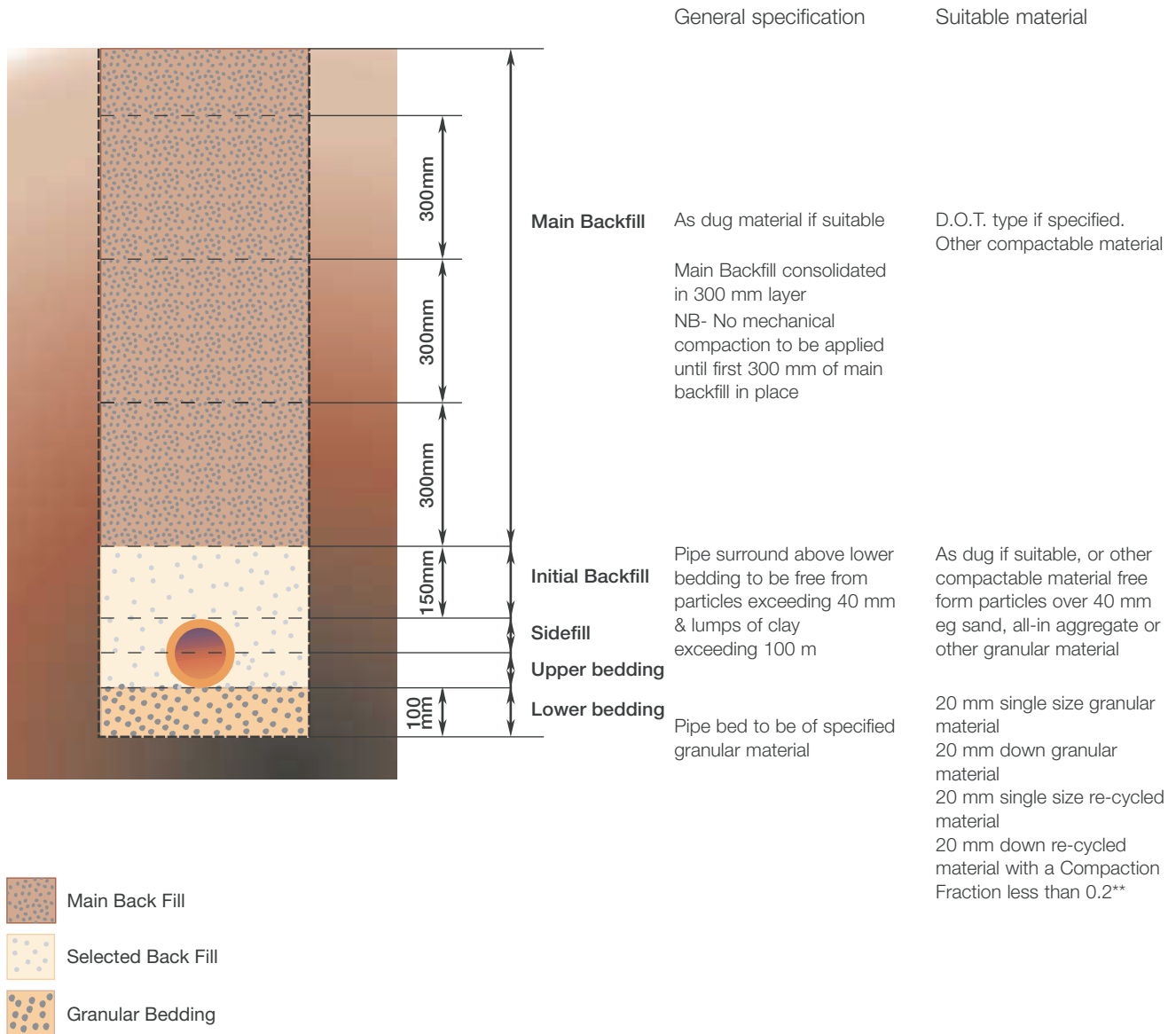
Design load – Main Road

Bedding Classification – Class F

Bedding Factor – 1.9

Suitable for all diameters of SuperSeal®

Pipes to a maximum cover depth of 7.5 metres. Normal ground conditions*



* Special bedding construction will be required where the trench formation has little bearing strength eg soft ground, running sand, etc.

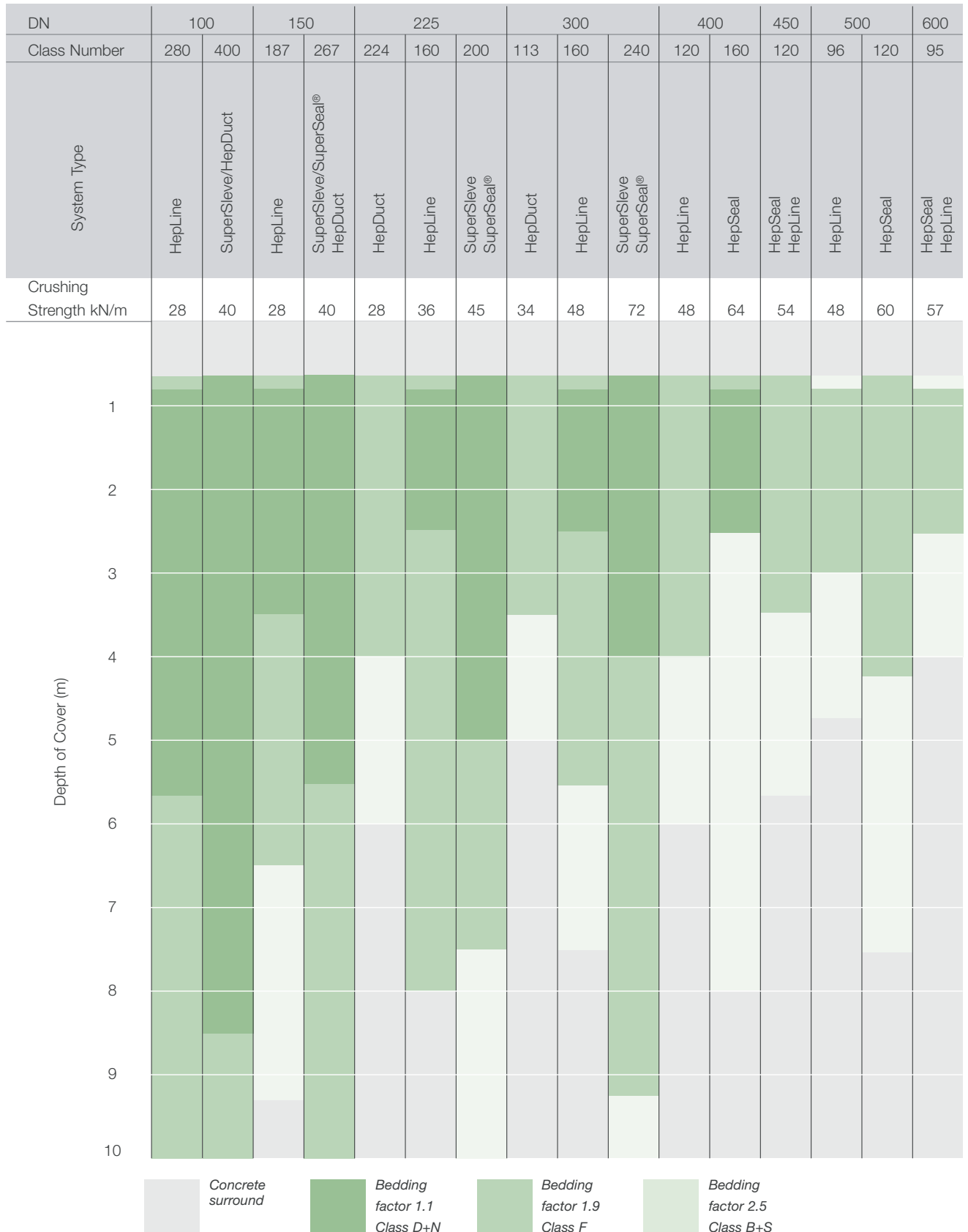
**A Compaction Fraction value greater than 0.2 but less than 0.3 will achieve a Bedding Factor of 1.5 which allow a maximum cover depth of 5.9 metres.

For more detailed information please contact Hepworth Technical Advisory Service, or the C.P.D.A. on 01494 791456

Structural

Recommended Bedding Requirements

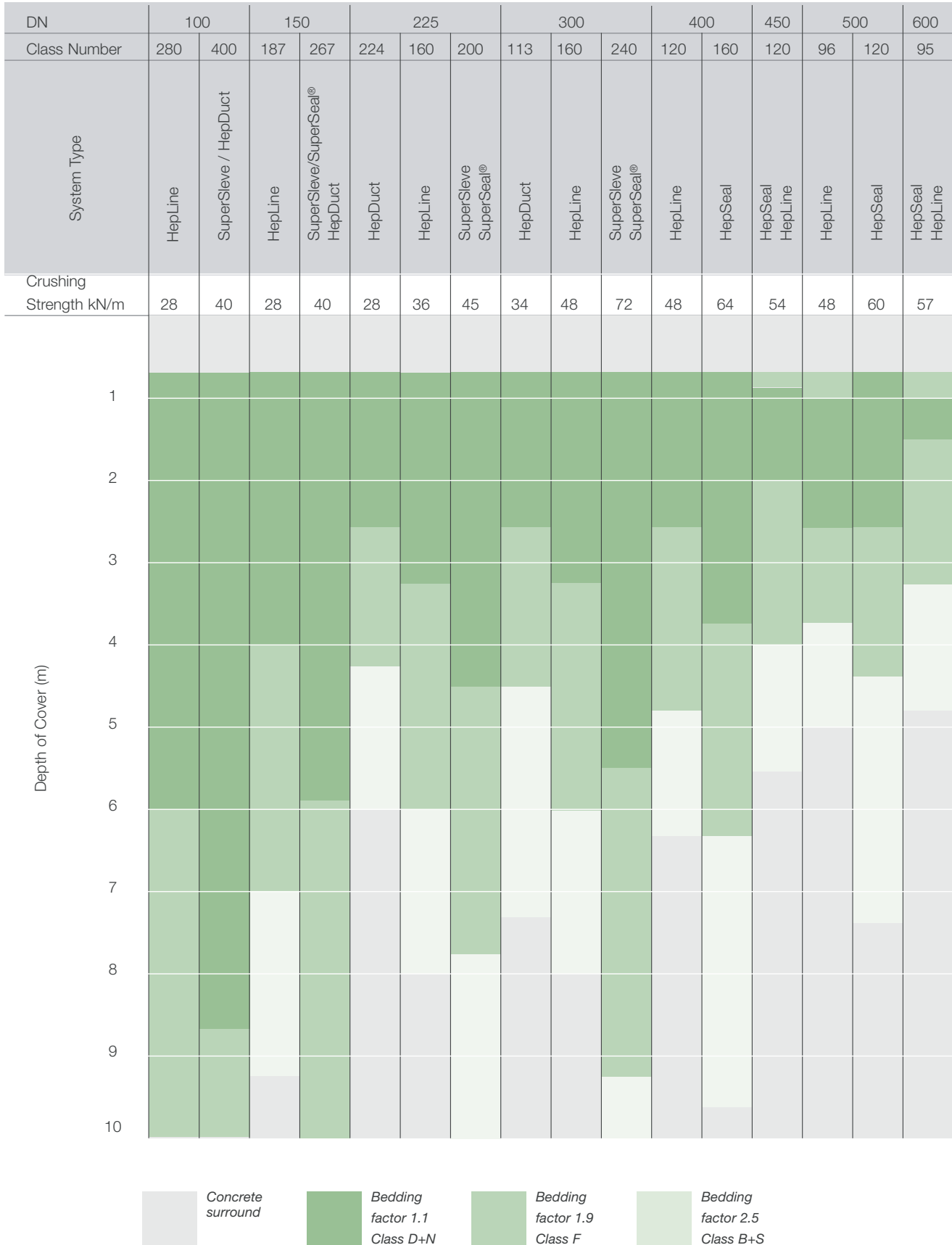
Recommended bedding requirements for main traffic roads



Structural

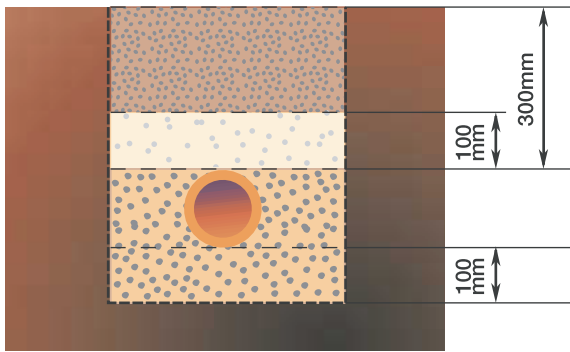
Recommended Bedding Requirements




Recommended bedding requirements for fields and gardens

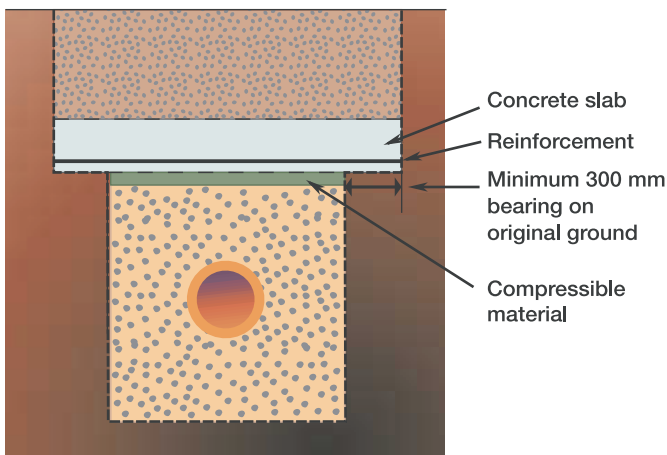





Structural

Typical Pipe Bedding Specification for a Plastic Pipe



-  Selected fill free from stones larger than 40 mm, lumps of clay over 100 mm, timber, frozen material, vegetable material
-  Selected Fill or granular material free from stones larger than 40 mm
-  Single-size granular material



-  Compressible material
-  Concrete slab
-  Single-size granular material

Chemical Resistance and Durability

Clay Pipes and Fittings

The standard SuperSleve, SuperSeal® and HepSeal systems fitted with SBR sealing rings are capable of carrying effluent within the pH range 3 to 11 at normal ambient temperatures. Surges of pH outside these limits can be accommodated so long as the line is subsequently flushed with water or aqueous waste within these limits. The chemical resistance of the system can be improved by using EPDM or Nitrile special purpose sealing rings.

It is difficult to give precise limits of acceptability that will cover all cases, since any variations of concentration, temperature and composition will affect the nature of the effluent. The alternative sealing rings have a higher inherent chemical resistance to a much wider range of chemicals. The nitrile ring are particularly suitable for applications involving oil and petrol type contamination whereas the EPDM is for the more general chemical condition and applications involving high temperatures. Regardless of which seal is used caution should be exercised if there is to be any discharge of organic solvents, since these will adversely affect the rubber.

In the SuperSleve and SuperSeal® systems the sealing ring is housed in a polypropylene coupling socket. This material has a very high order of chemical resistance. The HepSeal rubber ring is housed in a cast polyester material which gives the same order of resistance as the special purpose sealing rings.

The limitations imposed on the system with respect to chemical resistance are for the benefit of the flexible joint materials. The clay pipes themselves are resistant to most chemicals with the exception of hydrofluoric acid (HF). This resistance provides the option in extreme cases, of using unjointed spigot and socket pipes with a furane based chemically resistant jointing compound. The resulting joint has a high order of chemical resistance but has the usual limitations associated with rigid joints.

Clay pipes are ideally suited for applications involving contact with contaminated ground. The same considerations with respect to the joint apply but additional precautions sometimes need to be taken. This can be surrounding the line with imported uncontaminated fill and in extreme

cases wrapping the pipe joints with a suitable barrier material. In sulphate bearing ground clay pipes with standard joints are appropriate.

Clay pipes are also the ideal choice for systems prone to septicity and are unaffected by the effects of hydrogen sulphide built up.

The evaluation of effluents and selection of appropriate pipe materials can be complex and difficult. Guidance on the resistance of materials to various chemicals is available in CPDA Technical Notes Number 8 and in the table below. It is important that careful consideration is given not only to the constituents and their concentrations, but also to the temperature, rate of discharge and hydraulics of flow.

Further help and advice on the performance of clay pipe systems and their resistance to chemicals found in effluents and groundwaters can be obtained by contacting Hepworth Technical Advisory Service.

General Guidance for Resistance of Materials to Chemical Contamination

Material	No Chemical contamination	At normal temperature		Organic solvents	Containing oils and fats		At High temperature		Soil environment containing	
		Acids	Alkalis		Vegetable	Mineral	Acids	Alkalis	Sulphates	Acids
Clayware pipes and fittings	A	S	S	S	S	S	A	A	S	S
(SBR) Rubber	A	A	A	E	E	E	E	A	A	A
Nitrile Rubber	A	A	A	E	A	A	E	A	A	A
EPDM Rubber	A	A	A	E	A	E	A	A	A	A
Polyester resin	A	S	A	E	A	A	E	E	S	S
Polypropylene	A	S	S	A	S	A	A	A	S	S

A = normally suitable

E = need expert advice, each case to be considered on its own merits

S = specially suitable

Note: It is important to take account of quantities and concentrations of all types of chemical likely to be encountered