Strength. Performance. Passion.

Concrete pipe reference manual

Issue 1

Contents

* Please note:

The information in this publication does not apply to pipes manufactured at our **Thornton NSW** or **Ipswich QLD** factories. For specific information on pipes manufactured at these two locations please speak to your Humes representative.

1. Introduction

Humes is the leading manufacturer of Steel Reinforced Concrete Pipes (SRCP) and associated precast products in Australia. Available in a wide range of diameters, lengths and with varying strengths. Humes concrete pipes have a proven track record and are custom designed for user applications including drainage, sewerage, water supply and irrigation.

This publication provides the information necessary to specify Humes concrete pipes for all of these applications.

Manufacturing

Humes steel reinforced concrete pipes are made from coarse and fine aggregates, cement and hard drawn deformed steel reinforcement. They are manufactured and factory tested for quality to AS/NZS 4058: Precast Concrete Pipes (Pressure and Non-Pressure). Pipes can also be custom made and tested to meet specific customer requirements.

High abrasion resistance and the impermeability of concrete makes SRCP the most appropriate selection for handling peak flows. A range of natural characteristics further enhance performance, including an indefinite increase in strength in the presence of moisture and autogenous healing of cracks.

Joint types

Humes concrete pipes are manufactured with two basic joint types - Flush Joint (FJ) and Rubber Ring Joint (RRJ).

FJ pipes provide an interlocking joint which allows for a small degree of flexibility in the pipeline alignment. RRJ pipes, either belled-socket or in-wall joint depending on the diameter of the pipe and its application, are designed to accommodate change in pipeline alignment and settlement in a pipeline whilst still maintaining a watertight joint.

Further information on the joints specific to the pipe application types are provided in the relevant sections of this manual.

Durability

For most common installations, the service life of concrete pipes is virtually unlimited. The longevity of steel reinforced concrete pipe provides asset managers with a resource requiring low in-service maintenance and the ability to be recycled into other projects if exhumed. Some of the Roman aqueducts are still in use after 2,000 years and samples from the first known concrete pipes in the US, laid in 1842, were in excellent condition after more than 140 years service.

Of the 350 million kilometres plus of reinforced concrete pipe that has been laid in Australia, the number of pipelines which have suffered from durability problems has been extremely small and confined mainly to unprotected pipe in highly aggressive conditions.

Advances in concrete, process and product technologies such as the use of HDPE linings for sewer pipelines together with our stringent quality control and assurance programs ensures that our pipes and associated products will be fit for their purpose.

Hydraulics

To establish the flow rates for the various types of concrete pipes the Manning's formula should be used for short run culvert and drainage applications, while the Colebrook-White formula should be used for long run drainage, gravity sewer lines and all pressure pipe applications.

The Concrete Pipe Association of Australasia (CPAA) publication "Hydraulics of Precast Concrete Conduits" is recommended as a reference. Comprehensive details on the hydraulics for the different pipe types are provided in each section.

Size class (DN)

Humes standard range of concrete pipes are available in sizes DN300 - DN2100 (DN = nominal diameter). Diameters outside the standard range and up to DN3600 are also available. Special project pipes are also available for all sizes when required or specified.

Humes concrete pipes are typically manufactured in nominal 2.44 m lengths to optimise transport and handling. Other lengths, longer or shorter can be manufactured on request. Comprehensive tables listing the availability of size classes (DN) are provided in each section.

Load class

Humes steel reinforced concrete pipes are available in standard-strength (class 2-4) and super-strength (class 6-10) load classes.

The numeric classification system adopted to identify the load carrying capacity of concrete pipes is based on the rationale that any particular pipe class is able to carry approximately the same proportionate height of fill. For example, a class 10 pipe can carry five times the height of fill of a class 2 pipe, under the same installation conditions. See Section 2 – Test load data, for further information on test loads for each size class.

The required strength of a concrete pipe depends on both the load to be carried by the installed pipe, and the supporting ground installation conditions.

The load transmitted onto the pipe depends on the height and the type of fill material. Also, when installed in a trench, the width of the trench at the top of the pipe is important. Generally the wider the trench, the greater the load for any height of fill over the pipe.

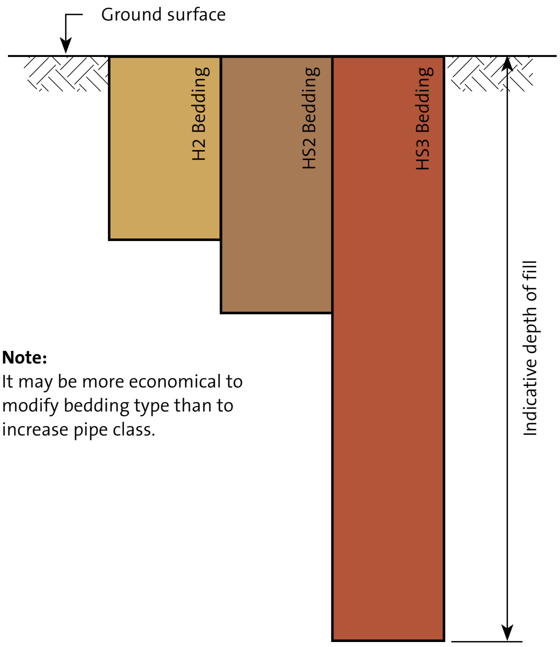
The load class for concrete pipes can be determined by consulting AS/NZS 3725: Design for Installation of Buried Concrete Pipes which provides methods for determining the installed load on concrete pipes from the earth fill over the pipes as well as any induced live (vehicle) load effects.

The standard also provides a range of recommended bedding support type options. The range varies from no support, to haunch support, to haunch and side support. For the majority of pipe installations, Humes standard-strength (class 2-4) concrete pipes, used in conjunction with type H2 or type HS2 bedding support, are suitable (see Figure 1.2 on the following page).

The letter H in the terminology indicates Haunch support only. HS indicates both Haunch and Side support. The numerals after H and HS indicate the level of support in the material used.

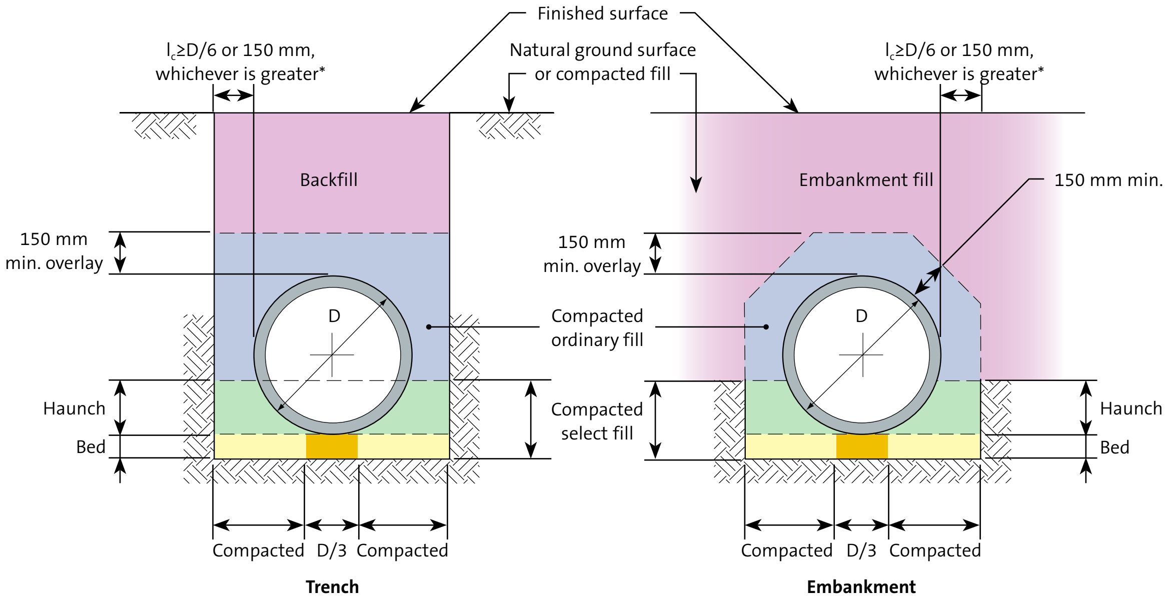
Tables 1.1 (page 6) and 1.2 (page 7) for bedding type H2 and HS2 are provided for ease of specifying concrete pipes within a limited range of stated conditions. Figure 1.1 below compares the results for a sample pipe installation using both type H and type HS bedding supports. Similarly, for embankment installation, Table 1.5 (page 9) is provided.

Figure 1.1 – Indicative depth of fill for various bedding installation types



Note:
It may be more economical to modify bedding type than to increase pipe class.

Figure 1.2 – Type H1 and type H2 supports



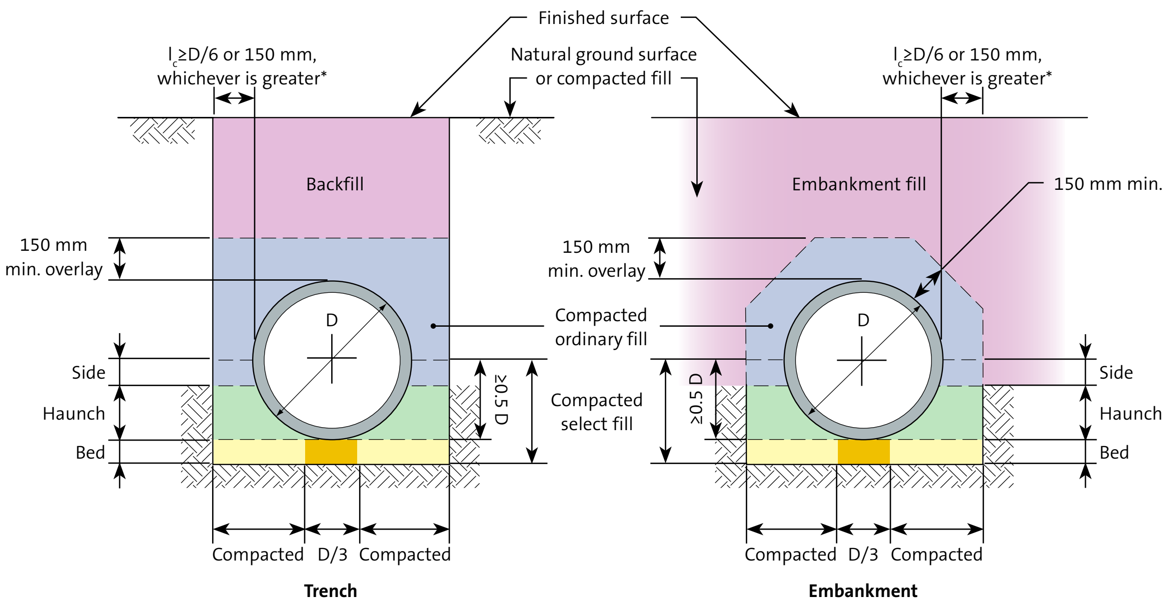
* Refer AS/NZS 3725 for cement stabilised soil

Table 1.1 – Material quantities - H1 and HS1 support types

Size class (DN)	Min trench width (m)	Material quantities (m³/lin.m)						
		Bedding zone	Haunch zone	H1 Overlay zone		HS1 side zone	HS1 Overlay zone	
				Trench	Embank		Trench	Embank
225	600	0.066	0.015	0.201	0.161	0.044	0.157	0.117
300	650	0.072	0.020	0.234	0.197	0.053	0.181	0.144
375	750	0.083	0.028	0.292	0.237	0.070	0.222	0.167
450	850	0.094	0.037	0.356	0.281	0.089	0.267	0.192
525	900	0.099	0.044	0.386	0.316	0.097	0.289	0.219
600	1,000	0.110	0.055	0.457	0.362	0.118	0.338	0.243
675	1,100	0.121	0.067	0.532	0.408	0.142	0.390	0.267
750	1,150	0.127	0.076	0.562	0.444	0.148	0.414	0.296
825	1,250	0.138	0.090	0.644	0.503	0.174	0.470	0.329
900	1,400	0.154	0.112	0.786	0.594	0.221	0.564	0.372
1,050	1,650	0.182	0.155	1.046	0.771	0.309	0.736	0.461
1,200	1,850	0.204	0.195	1.276	0.935	0.388	0.888	0.547
1,350	2,050	0.338	0.239	1.528	1.080	0.475	1.053	0.605
1,500	2,300	0.380	0.302	1.875	1.296	0.597	1.278	0.699
1,650	2,500	0.413	0.357	2.178	1.482	0.704	1.474	0.778
1,800	2,700	0.446	0.418	2.494	1.658	0.815	1.679	0.843
1,950	2,900	0.479	0.483	2.836	1.856	0.973	1.959	0.949
2,100	3,200	0.528	0.584	3.421	2.242	1.154	2.267	1.088

Note: Volume quantities are approximate and based on an assumed 10% bulking.

Figure 1.3 – Type HS support



* Refer AS/NZS 3725 for cement stabilised soil

Table 1.2 – Material quantities - H2, HS2 and HS# support types

Size class (DN)	Min trench width (mm)	Material quantities (m³/lin.m)						
		Bedding zone	Haunch zone	H2 and HS3 Overlay zone		HS2 and HS3 side zone	HS2 and HS3 Overlay zone	
				Trench	Embank		Trench	Embank
225	600	0.066	0.042	0.174	0.134	0.017	0.157	0.117
300	650	0.072	0.053	0.200	0.164	0.020	0.181	0.144
375	750	0.083	0.072	0.247	0.192	0.026	0.222	0.167
450	850	0.094	0.095	0.299	0.224	0.032	0.267	0.192
525	900	0.099	0.108	0.323	0.253	0.033	0.289	0.219
600	1,000	0.110	0.133	0.379	0.283	0.040	0.338	0.243
675	1,100	0.121	0.161	0.438	0.314	0.048	0.390	0.267
750	1,150	0.127	0.176	0.461	0.344	0.048	0.414	0.296
825	1,250	0.138	0.208	0.526	0.384	0.056	0.470	0.329
900	1,400	0.154	0.261	0.636	0.444	0.072	0.564	0.372
1,050	1,650	0.182	0.363	0.837	0.563	0.101	0.736	0.461
1,200	1,850	0.204	0.456	1.014	0.674	0.126	0.888	0.547
1,350	2,050	0.338	0.560	1.207	0.759	0.155	1.053	0.605
1,500	2,300	0.380	0.705	1.472	0.893	0.194	1.278	0.699
1,650	2,500	0.413	0.833	1.702	1.006	0.228	1.474	0.778
1,800	2,700	0.446	0.971	1.941	1.105	0.262	1.679	0.843
1,950	2,900	0.479	1.120	2.200	1.219	0.313	1.959	0.949
2,100	3,200	0.528	1.364	2.641	1.462	0.374	2.267	1.088

Note: Volume quantities are approximate and based on an assumed 10% bulking.

Table 1.3 – Max. fill heights - Trench installation, H2 bedding

Size class (DN)	Maximum fill height (m) Pipe load class 2	3	4	6	8	10
225	>25 metre height					
300						
375	5.8					
450	4.9					
525	4.8					
600	4.4					
675	4.5					
750	4.2	12.1				
825	4.4	12.7				
900	3.9	8.7				
1,050	3.7	7.3	19.7			
1,200	3.5	6.1	10.7			
1,350	3.4	6.1	10.7			
1,500	3.1	5.4	8.7			
1,650	3	5.2	8	21.9		
1,800	2.9	4.8	7.2	15.7		
1,950	2.3	3.9	5.9	11.7		
2,100	2.2	3.7	5.6	10.9	21.7	

Notes:
1. Assumed minimum trench width and clayey sand.
2. Soil internal weight of water is considered for > DN1800.
3. In onerous fill situations, a combination of standard strength concrete pipes and type HS3 bedding support* can provide the most appropriate solution. Table 1.6 provides details for such an installation.
4. *Type HS3 bedding support is similar to that required for a flexible pipe installation.

Table 1.4 – Max. fill heights - Trench installation, HS2 Bedding

Size class (DN)	Maximum fill height (m) Pipe load class 2	3	4	6	8
225	>25 metre height				
300					
375					
450					
525	10.7				
600	7.5				
675	7.7				
750	6.6				
825	6.8				
900	5.7				
1,050	5.2	13.5			
1,200	4.8	10			
1,350	4.6	9.3			
1,500	4.2	7.7	14.5		
1,650	4	7	12.3		
1,800	3.8	6.5	10.5		
1,950	3	5.3	8.4	20.8	
2,100	2.9	5.1	7.9	17.8	

Notes:
1. Assumed minimum trench width and clayey sand soil.
2. Internal weight of water is considered for > DN1800.

Table 1.5 – Max . fill heights - Embankment installation, H2 (and HS2)

Size class (DN)	Maximum fill height (m) — Pipe load class											
	2		3		4		6		8		10	
	H2	HS2	H2	HS2	H2	HS2	H2	HS2	H2	HS2	H2	HS2
225	3.2	4.6	4.9	6.8	6.5	9.2						
300	2.7	3.9	4.2	5.9	5.5	7.7	8.1	11.6	10.9	15.4	13.6	19.3
375	2.5	3.5	3.8	5.4	5.0	7.0	7.5	10.6	10.0	14.0	12.5	17.5
450	2.4	3.4	3.7	5.2	4.9	6.9	7.3	10.3	9.7	13.8	12.2	17.2
525	2.5	3.5	3.8	5.4	5.0	7.1	7.5	10.6	10.1	14.2	12.6	17.7
600	2.5	3.5	3.7	5.3	5.0	7.0	7.5	10.5	9.9	14.0	12.4	17.4
675	2.6	3.6	3.9	5.5	5.2	7.3	7.7	10.9	10.3	14.5	12.9	18.2
750	2.6	3.6	3.8	5.4	5.1	7.2	7.7	10.8	10.2	14.4	12.8	18.0
825	2.6	3.6	3.9	5.5	5.2	7.2	7.7	10.9	10.3	14.5	12.9	18.2
900	2.5	3.5	3.8	5.3	5.0	7.0	7.4	10.6	9.9	13.9	12.3	17.3
1,050	2.6	3.5	3.7	5.2	5.0	7.0	7.4	10.0	9.9	13.9	12.3	17.3
1,200	2.6	3.4	3.6	5.0	4.8	6.7	7.1	10.4	9.5	13.6	11.8	16.7
1,350	2.7	3.4	3.7	5.1	4.8	6.8	7.2	10.1	9.6	13.5	12.0	16.9
1,500	2.7	3.3	3.7	4.9	4.7	6.5	7.0	9.7	9.2	13.0	11.5	16.5
1,650	2.7	3.2	3.7	4.8	4.6	6.4	6.9	9.6	9.1	12.8	11.4	16.0
1,800	2.7	3.2	3.7	4.8	4.6	6.3	6.8	9.5	9.0	12.6	11.2	15.7
1,950	2.3	2.9	3.4	4.2	4.4	5.8	6.3	8.8	8.4	11.9	10.6	14.9
2,100	2.2	2.8	3.4	4.2	4.4	5.6	6.2	8.7	8.3	11.7	10.4	14.7

Notes:
1. Assumed clayey sand soil (p = 0.7 for H2 and p = 0.3 for HS2).
2. Internal weight of water is considered for > DN1800.
3. - Not typically supplied.

Table 1.6 – Max. fill heights - Embankment installation, Hs3

Size class (DN)	Maximum fill height (m) — Pipe load class			
	2	3	4	6
225	7.4	11.0	14.7	
300	6.2	9.4	12.3	18.5
375	5.6	8.6	11.3	16.9
450	5.5	8.3	11.0	16.5
525	5.6	8.6	11.4	17.1
600	5.6	8.4	11.2	16.9
675	5.8	8.7	11.6	17.4
750	5.8	8.6	11.5	17.3
825	5.8	8.7	11.6	17.4
900	5.6	8.4	11.2	16.7
1,050	5.6	8.3	11.1	16.7
1,200	5.3	8.0	10.7	16.0
1,350	5.4	8.1	10.8	16.2
1,500	5.2	7.8	10.4	15.6
1,650	5.2	7.7	10.3	15.4
1,800	5.1	7.6	10.1	15.1
1,950	4.5	7.0	9.4	14.3
2,100	4.4	6.8	9.3	14.1

Notes:
1. Assumed clayey sand soil with p = 0.3.
2. Internal weight of water is considered for > DN1800.
3. - Not typically supplied.

2. Test load data

Steel reinforced concrete pipes are manufactured and proof tested to Australian Standards requirements. AS/NZS 4058: Precast Concrete Pipes (Pressure and Non-Pressure) provides levels of proof test loads for concrete pipes and sample pipes taken for routine quality assurance during normal production which ensures the pipes' strength. Test load requirements for all Humes concrete pipes are provided below.

Note: Intermediate strength classes are specified by linear interpolation between values, Humes can advise on individual applications.

Table 2.1 – Test loads in kilonewtons/metre length

Test loads (KN/m)												
	Standard strength						Super strength					
Load class	Class 2		Class 3		Class 4		Class 6		Class 8		Class 10	
Size class (DN)	Crack	Ultimate	Crack	Ultimate	Crack	Ultimate	Crack	Ultimate	Crack	Ultimate	Crack	Ultimate
225	14	21	21	32	28	42	-	-	-	-	-	-
300	15	23	23	34	30	45	45	56	60	75	75	94
375	17	26	26	39	34	51	51	64	68	85	85	106
450	20	30	30	45	40	60	60	75	80	100	100	125
525	23	35	35	52	46	69	69	86	92	115	115	144
600	26	39	39	59	52	78	78	98	104	130	130	163
675	29	44	44	66	58	87	87	109	116	145	145	182
750	32	48	48	72	64	96	96	120	128	160	160	200
825	35	52	52	78	69	104	104	130	138	173	173	217
900	37	56	56	84	74	111	111	139	148	185	185	231
1,050	42	63	63	95	84	126	126	158	168	210	210	263
1,200	46	69	69	104	92	138	138	173	184	230	230	288
1,350	50	75	75	113	100	150	150	188	200	250	250	313
1,500	54	81	81	122	108	162	162	203	216	270	270	338
1,650	58	87	87	131	116	174	174	218	232	290	290	363
1,800	62	93	93	139	124	186	186	233	248	310	310	388
1,950	66	99	99	149	132	198	198	248	264	330	330	413
2,100	70	105	105	158	140	210	210	263	280	350	350	438
2,250	74	111	111	167	148	222	222	278	296	370	370	463
2,400	78	117	117	176	156	234	234	293	312	390	390	488
2,700	86	129	129	194	172	258	258	323	344	430	430	538
3,000	94	141	141	212	188	282	282	353	376	470	470	588
3,300	102	153	153	230	204	306	-	-	-	-	-	-
3,600	110	165	165	248	220	330	-	-	-	-	-	-

3. Pipes for culvert applications

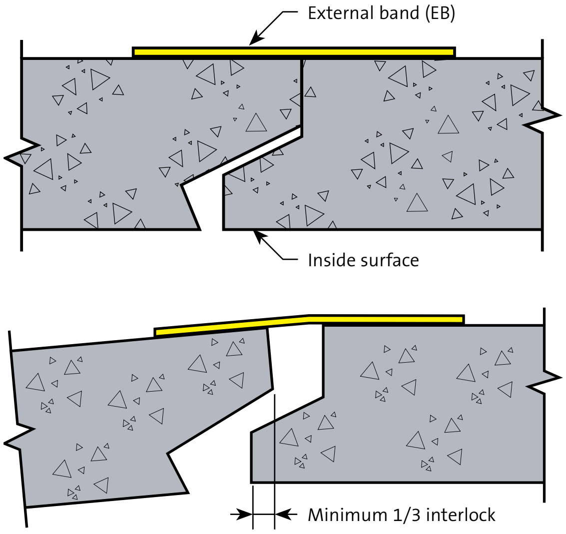
Humes can provide a comprehensive range of steel reinforced concrete culvert pipes in sizes DN225 to DN3600 (commonly supplied DN300 to DN2100). They are available with two basic joint types, Flush Joint (FJ) and Rubber Ring Joint (RRJ).

Flush Joint (FJ) pipes

FJ pipes with external bands (EB) are recommended for normal culvert conditions. They provide an interlocking joint between pipes, as shown in Figure 3.0, and give a true and positive alignment along the length of the pipeline.

When EB are used in conjunction with FJ culvert pipes, they provide a soil-tight joint along the pipeline and prevent loss of bedding material into the pipe. Groundwater infiltration may occur however, when the groundwater level is significantly above the pipeline obvert (approx. 3 m). FJ pipes fitted with EB allow a small degree of flexibility for the bedding-in/movement of the pipeline during natural processes of consolidation.

Figure 3.0 – Flush joint profile



Rubber Ring Joint (RRJ) pipes

RRJ pipes are also suitable for culvert applications and are most effective when differential ground settlement is anticipated or if a pipeline is expected to flow full under outlet control conditions with a significant hydraulic pressure head. See Section 4 – Pipes for drainage applications, for further details.

Figure 3.1 – Flush Joint pipe

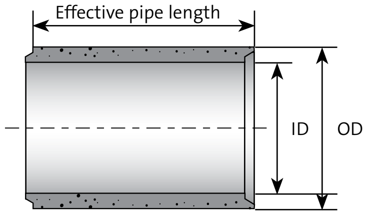


Table 3.1 – Flush Joint pipes – Internal Diameter (ID), Outside Diameter (OD), and mass

Size class (DN)	Standard strength load classes						Super strength load classes						OD (mm)
	Class 2		Class 3		Class 4		Class 6		Class 8		Class 10		
	ID (mm)	Mass (kg)	ID (mm)	Mass (kg)	ID (mm)	Mass (kg)	ID (mm)	Mass (kg)	ID (mm)	Mass (kg)	ID (mm)	Mass (kg)	
225	229	125	229	125	229	130							279
300	300	205	300	205	300	210	290	235	280	260	268	295	362
375	375	280	375	285	375	290	363	330	355	360	343	395	445
450	450	400	450	405	450	415	444	445	438	465	418	545	534
525	534	465	518	545	502	625	502	625	502	630	486	705	616
600	610	565	600	625	586	705	586	710	570	800	554	885	698
675	685	690	679	735	661	850	661	860	637	1,005	615	1,135	781
750	762	815	756	865	730	1,045	730	1,055	714	1,170	682	1,385	864
825	838	945	832	1,000	806	1,205	806	1,215	782	1,400	754	1,605	946
900	915	1,090	903	1,200	883	1,370	883	1,390	851	1,655	795	2,085	1,029
1,050	1,066	1,420	1,054	1,550	1,026	1,830	1,026	1,855	966	2,430	926	2,775	1,194
1,200	1,219	1,775	1,207	1,925	1,179	2,245	1,171	2,355	1,109	3,045	1,059	3,580	1,359
1,350	1,372	2,165	1,360	2,340	1,332	2,700	1,292	3,230	1,242	3,830	1,202	4,335	1,524
1,500	1,524	2,405	1,504	2,710	1,468	3,245	1,424	3,860	1,374	4,590	1,324	5,230	1,676
1,650	1,676	2,885	1,656	3,220	1,620	3,820	1,576	4,495	1,516	5,450	1,476	6,065	1,842
1,800	1,828	3,375	1,808	3,745	1,772	4,400	1,718	5,295	1,668	6,200	1,628	6,855	2,006
1,950	1,994	4,200	1,982	4,515	1,944	5,225	1,904	5,980	1,834	7,340	1,794	8,040	2,198
2,100	2,160	5,215	2,136	5,655	2,110	6,205	2,050	7,535	1,990	8,715	1,960	9,335	2,388
2,250*	2,250	8,140					Project specific production only						2,530
			2,250	8,775	2,250	9,165							2,550
							2,250	14,195					2,718
									2,250	15,050			2,742
											2,250	18,640	2,850
2,400*	2,438	8,795											2,718
			2,438	9,640									2,742
					2,438	10,850							2,768
							2,438	20,620	2,438	20,715	2,438	20,855	3,060
2,700*	2,700	11,460	2,700	11,585									3,030
					2,700	13,115							3,060
							2,700	21,250	2,700	21,340	2,700	21,490	3,410
3,000*	3,060	13,750											3,410
			3,060	15,835	3,060	16,510							3,460
							3,060	32,700	3,060	32,800	3,060	32,950	4,010
3,300	3,300	21,110	3,300	21,240	3,300	21,350							3,900
3,600	3,600	24,535	3,600	24,700	3,600	24,820							4,240

Notes:
1. Internal Diameters (ID) subject to change without notice.
2. Pipes are nominally 2.44 m in length. Other lengths may be available on request.
3. Mass is based on density of 2,600 kg/m³ for spun pipe and 2,500 kg/m³ for vertically cast pipe.
4. Indicates not typically supplied.

Load class

Humes concrete culvert pipes are available in standard-strength (class 2 - 4) and super-strength (class 6 - 10) load classes.

The most appropriate culvert installation can be obtained by matching both pipe load class and the bedding support type. For the majority of installations, standard-strength concrete culvert pipes used in conjunction with type H2 or type HS2 bedding support, is suitable.

For large fill situations, a combination of super-strength pipes and type HS3 bedding support can provide the most appropriate and economical solution.

Further information on the load class of concrete pipes can be obtained by referring to Section 1 – Introduction.

Hydraulics

The maximum flow to be considered in stormwater culverts and pipes is a function of:

- the hydrological data pertaining to tributary overland flows, as experienced throughout the service life of the drainage system.

The most commonly used formula to determine the quantity of water generated by a storm event is known as the rational formula:

$Q = 0.278\ C\ I\ A$ where Q = discharge (m^3/s)
C = coefficient of runoff (dimensionless)
I = intensity (mm/hour)
A = catchment area (km^2).

'C' will most commonly vary between 0.7 and 0.9 for grassed surfaces and paved (sealed) areas. The magnitude of 'I', the intensity is a function of geographical area. By example a Brisbane storm may have an intensity of two times that of a Melbourne storm.

Australian Rainfall and Runoff (ARR) is a guide to flood estimation produced by (and the subject of continuing review by) the Institution of Engineers, Australia.
In addition to ARR, local and state authorities may have specific or alternative data/design requirements, such the Queensland Urban Drainage manual (QUDM).

Inlet control

Inlet control conditions shown in Figure 3.2 exist in a pipeline where the capacity of the pipeline is limited by the ability of upstream flow to easily enter the pipeline, a common situation in coastal Australia where short culvert lengths on steep grades are used. The flow under inlet control conditions can be either inlet submerged or un-submerged.

Outlet control

Where culverts are laid on flat grades and empty below the downstream water level, the culvert typically operates with outlet control conditions as shown in Figure 3.3.

When operating under outlet control conditions, the culvert pipe may flow full or part-full depending on the tailwater depth.

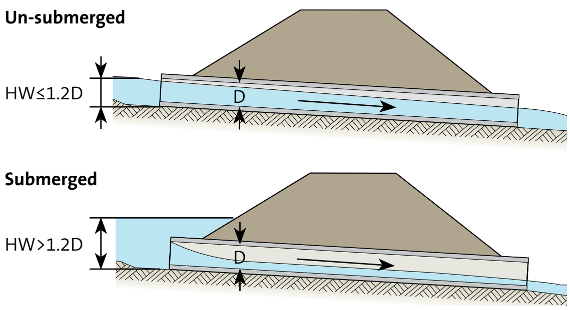
Where the tailwater depth is greater than the pipe diameter, the pipe will typically flow full. Where the tailwater depth is less than the pipe diameter, the design tailwater depth should be taken as the greater of the actual tailwater depth or (dc + D)/2, where dc is the critical depth for the actual flow discharge (see Figure 3.4 on the following page).

The design charts Figures 10.3 and 10.4 (pages 56 and 57) for pipe culvert inlet and outlet conditions allow the designer to evaluate maximum discharge conditions at maximum headwater. For a lesser discharge, Figure 3.4 can be used to determine flow characteristics.

Where inlet flow conditions exist in a culvert, the flow capacity of the pipeline is independent of the pipe surface roughness (Manning's 'n'). The pipeline flow capacity for inlet control conditions is dependent on the ratio of headwater depth to culvert diameter and the inlet geometry type.

Outlet control conditions operating in a culvert determine the pipeline flow capacity by the effects of pipe surface roughness (Manning's ‘n'), pipeline length and slope, and inlet geometry type.

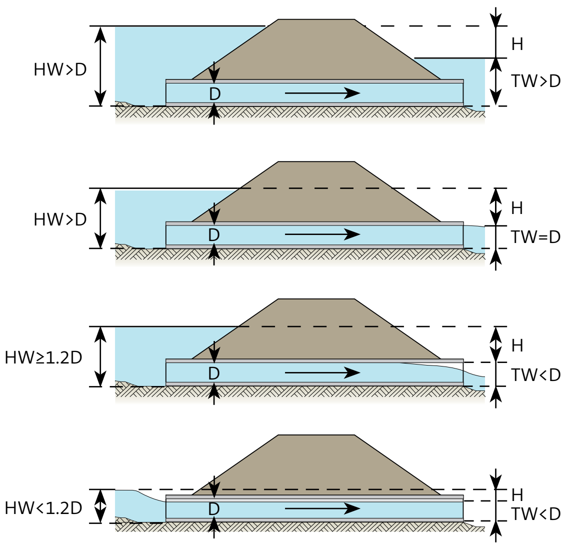
Figure 3.2 – Inlet control



Legend

HW	Headwater
TW	Tailwater
D	Diameter

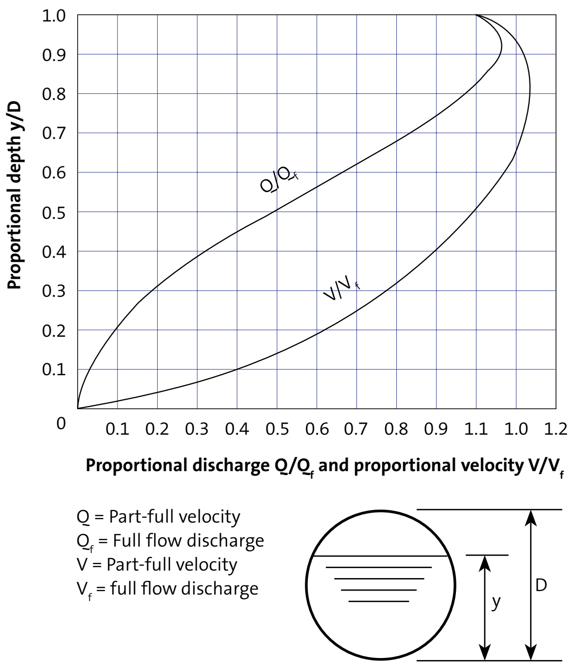
Figure 3.3 – Outlet control



Where inlet flow conditions exist in a culvert, the flow capacity of the pipeline is independent of the pipe surface roughness (Manning's 'n'). The pipeline flow capacity for inlet control conditions is dependent on the ratio of headwater depth to culvert diameter and the inlet geometry type.

Outlet control conditions operating in a culvert determine the pipeline flow capacity by the effects of pipe surface roughness (Manning's 'n'), pipeline length and slope, and inlet geometry type.

Figure 3.4 – Relative discharge and velocity in part-full pipe flow



Installation

Humes culvert pipes above DN525 are normally supplied with elliptical grid reinforcement, unless a circular grid is specifically requested. Elliptical grid reinforced pipes must be laid with the word TOP at the crown and within 10° each side of the vertical centreline. To simplify handling, lifting holes are generally provided in the top of all FJ pipes and FJ splays above DN525.

See Section 9 – Handling and installation, for further details.

Other culvert products

Humes manufactures a wide range of associated components to provide the complete culvert pipeline solution. These include:

- Headwalls - These are used where the hydraulic design requires improved inlet and outlet flow conditions.
- FJ splay pipes - These permit curves in pipeline alignment without the usual problems of hydraulic head loss (turbulence) that can result from a rapid change in the direction of the flow at a sharp bend. Details are given for the minimum radius of curved alignment. See Table 3.2 and Figure 3.5 for minimum radius using double ended splays and recommended radius using single ended splays. External bands can also be used with FJ splays. For lesser radii, FJ bend pipes may be supplied.

Notes:

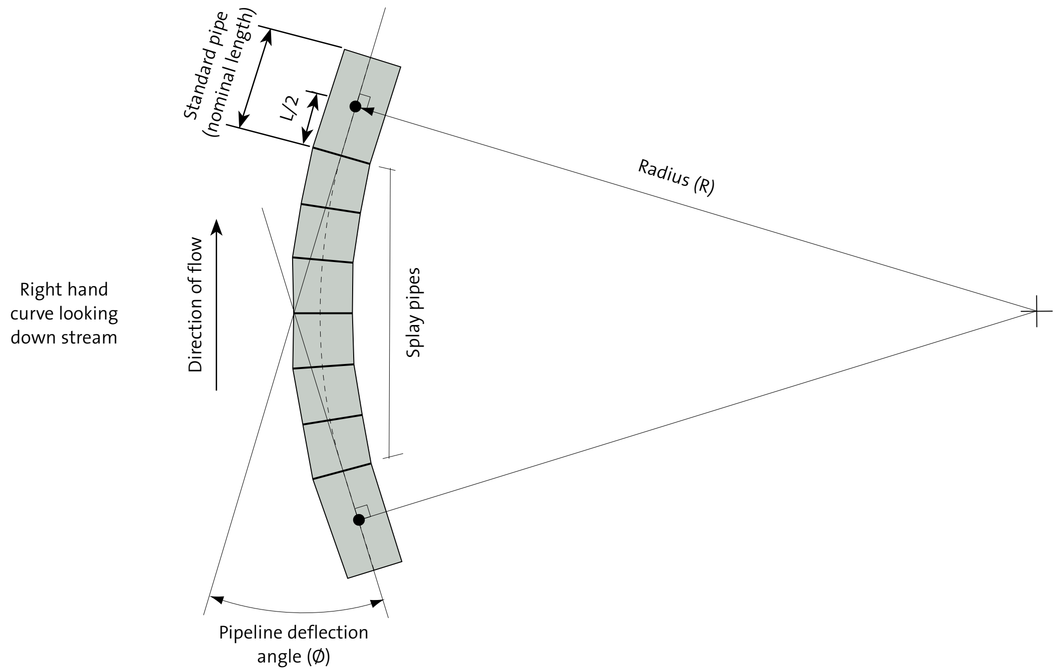
- The number of splay pipes required is determined from the deflection angle and the centreline radius. This information should be given when ordering splay pipes. Humes engineers will calculate the optimum number of splay pipes required.
- The curve "hand" is described as when looking downstream in the direction of the flow.

Table 3.2 – Minimum radius for curved pipe alignment: Flush joint splays

	Min CL radius* (m)	
Size class (DN)	Economical (single ended)	Absolute min. (double ended)
600	11.5	4
675	11.8	4.3
750	12.2	4.6
825	12.4	4.9
900	12.6	5.2
1,050	13	5.8
1,200	13.4	6.4
1,350	13.7	7
1,500	14	7.7
1,650	14.4	-
1,800	15	-
1,950	15.9	-
2,100	16.7	-

Notes:
1. *Minimum radius is measured to the pipe centre line at joint.
2. - Not typically supplied.

Figure 3.5 – Minimum single-ended splay radius achieved with flush joint splays in curved pipeline alignment



4. Pipes for drainage applications

Humes provide a comprehensive range of steel reinforced concrete stormwater pipes from DN225 to DN3600 (Commonly supplied DN300 to DN2100).

Rubber Ring Joint (RRJ) pipes

Rubber Ring Joint (RRJ) pipes are recommended for stormwater drainage systems, although Flush Joint (FJ) pipes can also be used dependant on requirements of the client/asset owner.

RRJ pipes up to DN1800 are supplied with a belled-socket joint, while those larger than DN1800 are supplied with an in-wall joint (see Figures 4.1 and 4.2).

RRJs provide concrete pipes with a high degree of flexibility to accommodate ground settlement or alignment adjustments.

Figure 4.1 – RRJ pipe with belled socket joint

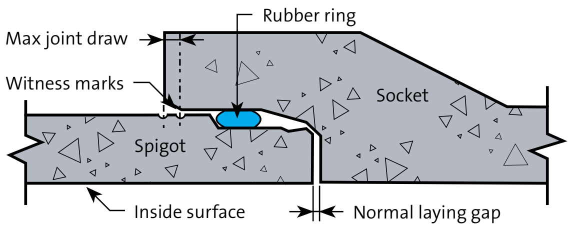
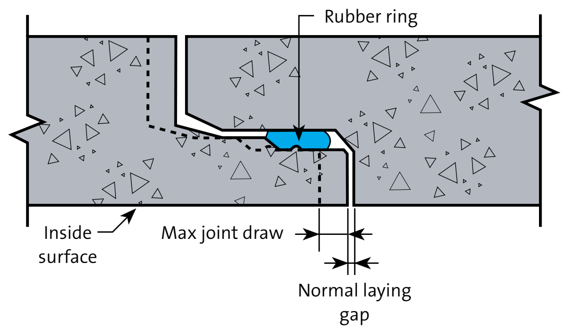


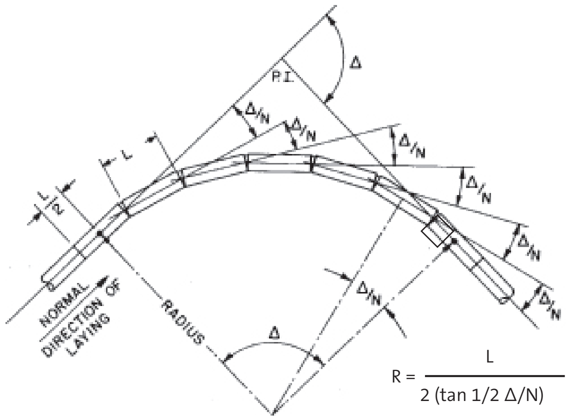
Figure 4.2 – RRJ pipe with in-wall (skid) joint



The RRJ profile is designed for ease of installation, and allows curved alignment adjustments while maintaining a watertight joint capable of withstanding the common levels of hydraulic head occurring in a stormwater pipeline (refer to Figure 4.3 below).

Table 4.1 presents the minimum radius for curves in the pipeline for the standard range of pipes. Details on other sizes can be obtained by contacting Humes.

Figure 4.3 – Curved alignment using deflected straight pipe



Where:

R = Radius of curvature, feet.
L = Average laid length of pipe sections measured along the centerline, feet.
Δ = Total deflection angle of curve, degrees.
N = Number of pipes with pulled joints.
Δ/N = Total deflection of each pipe, degrees.

Table 4.1 – Maximum joint deflection: RRJ – Drainage applications

Size class (DN)	Max CL deviation per pipe (mm)	Max deflection angle at joint Δ/N (degrees)	Min CL radius* (m)
300	81	1.9	70
375	81	1.9	70
450	55	1.3	105
525	43	1.0	135
600	38	0.9	155
675	34	0.8	170
750	26	0.6	230
825	21	0.5	275
900	34	0.8	170
1,050	26	0.6	230
1,200	21	0.5	275
1,350	21	0.5	275
1,500	26	0.6	230
1,650	21	0.5	275
1,800	68	1.6	85
1,950	26	0.6	230
2,100	34	0.8	170

Note:
* Minimum radius is measured to the pipe mid point.

Figure 4.4 – Rubber Ring Joint (belled socket) pipe

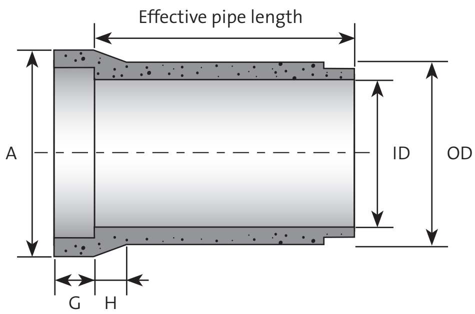


Table 4.2 – Rubber Ring Joint (belled socket) pipes – ID, socket dimensions A,G and H (refer Figure 4.4), OD and mass

	Standard strength load classes						Super strength load classes						Socket dimensions			
	Class 2		Class 3		Class 4		Class 6		Class 8		Class 10					
Size class (DN)	ID (mm)	Mass (kg)	ID (mm)	Mass (kg)	ID (mm)	Mass (kg)	ID (mm)	Mass (kg)	ID (mm)	Mass (kg)	ID (mm)	Mass (kg)	A (mm)	G (mm)	H (mm)	Pipe OD (mm)
225	**229**	**110**	**229**	**110**	**229**	**110**	Not typically supplied						**362**	**89**	**83**	**279**
	229	135	229	140	229	140							368	108	95	293
225	**229**	**220**	**229**	**220**	**229**	**220**							**394**	**114**	**114**	**305**
	229	240	229	240	229	240							406	114	114	311
300	**300**	**220**	**300**	**220**	**300**	**240**	**288**	**250**	**280**	**280**	**268**	**310**	**451**	**76**	**89**	**362**
	304	280	304	280	304	280	304	285	298	305	284	340	470	114	114	381
	300	370	300	375	300	375	300	375	300	380	300	380	508	114	114	400
375	**375**	**305**	**375**	**310**	**375**	**315**	**355**	**345**	**351**	**395**	**343**	**420**	**540**	**80**	**95**	**445**
	381	340	381	345	381	345	375	370	361	425	357	430	546	114	114	457
	380	545	380	545	380	545	308	545	380	545	380	550	622	121	133	496
450	**450**	**435**	**50**	**440**	**450**	**450**	**438**	**480**	**438**	**500**	**418**	**580**	**622**	**114**	**114**	**534**
	450	605	450	610	450	615	450	615	450	615	444	640	694	147	116	560
	457	800	457	805	457	805	457	805	457	810	457	810	749	133	190	597
525	**534**	**515**	**518**	**595**	**518**	**675**	**502**	**680**	**502**	**685**	**486**	**755**	**711**	**133**	**133**	**616**
	534	650	534	650	534	655	534	655	524	715	510	785	762	133	133	636
	530	880	530	880	530	880	530	890	530	895	530	895	822	140	133	666
600	**610**	**625**	**598**	**685**	**598**	**765**	**586**	**770**	**570**	**860**	**554**	**945**	**797**	**133**	**133**	**698**
	610	815	610	820	610	820	610	830	600	895	578	1,015	851	133	133	724
	610	1,130	610	1,135	610	1,135	610	1,140	610	1,145	610	1,150	932	143	152	762
675	**685**	**760**	**673**	**805**	**673**	**920**	**653**	**930**	**645**	**1,030**	**615**	**1,205**	**886**	**133**	**133**	**781**
	680	845	680	855	680	860	670	930	648	1,070	616	1,255	915	176	133	784
	680	1,175	680	1,180	6,800	1,185	680	1,190	680	1,200	656	1,350	988	196	146	820
750	**760**	**940**	**744**	**985**	**744**	**1,170**	**728**	**1,125**	**712**	**1,290**	**680**	**1,500**	**997**	**143**	**152**	**864**
	750	955	750	1,000	750	1,010	734	1,125	710	1,295	680	1,485	996	196	118	860
	762	1,145	762	1,150	762	1,160	762	1,170	738	1,340	706	1,560	1,033	143	152	890
	762	1,380	762	1,385	762	1,390	762	1,395	762	1,405	762	1,630	1,084	143	152	914
825	**838**	**1,050**	**818**	**1,105**	**818**	**1,305**	**798**	**1,320**	**782**	**1,500**	**748**	**1,745**	**1,064**	**146**	**146**	**946**
	830	1,200	830	1,210	830	1,215	814	1,350	782	1,590	750	1,825	1,098	196	128	950
	838	1,410	838	1,420	838	1,425	838	1,445	814	1635	785	1,875	1,149	171	149	978
900	**910**	**1,415**	**910**	**1,425**	**910**	**1,535**	**878**	**1,555**	**862**	**1,850**	**800**	**2,335**	**1,197**	**152**	**152**	**1,042**
	900	1,425	900	1,435	900	1,445	884	1,595	852	1,855	790	2,335	1,190	215	138	1,040
	915	2,030	915	2035	915	2,040	915	2,055	915	2,075	851	2,600	1,302	178	259	1,093
1,050	**1,070**	**1,895**	**1,070**	**1,910**	**1,058**	**2,115**	**1,022**	**2,250**	**990**	**2,725**	**950**	**3,075**	**1,391**	**171**	**149**	**1,220**
	1,050	1,790	1,050	1,800	1,050	1,820	1,018	2,140	960	2,695	920	3,035	1,364	215	151	1,190
	1,066	2,335	1,066	2,345	1,066	2,355	1,066	2,380	1,010	2,930	966	3,340	1,454	178	259	1,244
1,200	**1,220**	**2,175**	**1,220**	**2,195**	**1,200**	**2,555**	**1,156**	**2,695**	**1,120**	**3,360**	**1,070**	**3,905**	**1,543**	**171**	**149**	**1,372**
	1,200	2,190	1,200	2,210	1,194	2,300	1,160	2,685	1,090	3,435	1,040	3,970	1,540	215	165	1,350
	1,200	3,275	1,200	3,290	1,200	3,300	1,200	3,325	1,160	3,775	1,110	4,345	1,670	210	215	1,420
1,350	**1,370**	**2,460**	**1,370**	**2,610**	**1,330**	**2,995**	**1,294**	**3,400**	**1,240**	**4,115**	**1,200**	**4,630**	**1,695**	**171**	**149**	**1,524**
	1,350	2,690	1,350	2,715	1,344	2,810	1,268	3,555	1,230	4,210	1,190	4,720	1,710	230	170	1,514
1,500	**1,524**	**3,550**	**1,524**	**3,575**	**1,504**	**3,905**	**1,460**	**4,515**	**1,404**	**5,335**	**1,354**	**5,990**	**1,937**	**194**	**292**	**1,714**
1,650	**1,676**	**3,890**	**1,676**	**3,925**	**1,636**	**4,470**	**1,596**	**5,065**	**1,546**	**6,045**	**1,486**	**6,915**	**2,089**	**194**	**292**	**1,866**
1,800	**1,828**	**4,450**	**1,828**	**4,495**	**1,788**	**5,085**	**1,744**	**5,900**	**1,668**	**7,285**	**1,608**	**8,220**	**2,267**	**194**	**203**	**2,032**

Notes:
1. Internal Diameters (ID) subject to change without notice.
2. Pipes available in most areas are indicated by bold type. Other sizes have restricted availability, contact Humes to confirm availability.
3. Pipes are nominally 2.44 m in length. Other lengths may be available on request.

Rubber ring joint (in-wall) pipes

For culvert, drainage and sewerage applications

Commonly supplied size classes: DN1200 - DN3600.
Nominal pipe length: 3.0 m (*denotes 2.44 m).
Other lengths are available.

Figure 4.5 – Rubber ring in-wall joint pipe

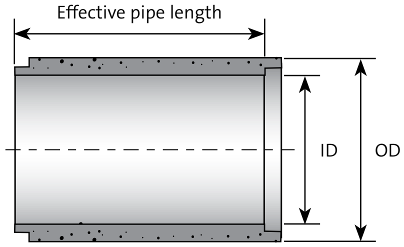


Table 4.3 – Rubber ring joints (In-wall) – Internal Diameter (ID), Outside Diameter (OD), and mass

Size class (DN)	Standard strength load classes						Super strength load classes						OD (mm)
	Class 2		Class 3		Class 4		Class 6		Class 8		Class 10		
	ID (mm)	Mass (kg)	ID (mm)	Mass (kg)	ID (mm)	Mass (kg)	ID (mm)	Mass (kg)	ID (mm)	Mass (kg)	ID (mm)	Mass (kg)	
1,200*	1,280	2,985	1,280	3,005	1,280	3,025	1,260	3,285	1,240	3,545	1,200	4,015	1,500
1,950*	1,950	5,515	1,950	5,540	1,950	5,580	1,894	6,715	1,830	7,850	1,780	8,760	2,220
2,100*	2,100	6,340	2,100	6,370	2,100	6,415	2,068	7,265	2,000	8,585	1,920	10,055	2,388
2,250	2,250	8,795	2,250	8,880			2,250	12,120					2,550
					2,250	11,925							2,650
									2,250	15,050			2,742
											2,250	18,640	2,850
2,400	2,438	9,575	2,438	9,660									2,742
					2,438	10,895							2,768
							2,438	20,620	2,438	20,715	2,438	20,855	3,060
2,700	2,700	11,505	2,700	11,590									3,030
					2,700	13,175							3,060
							2,700	21,250	2,700	21,340	2,700	21,490	3,410
3,000	3,060	13,795	3,060	15,875									3,410
					3,060	16,585							3,460
							3,060	32,700	3,060	32,800	3,060	32,950	4,010
3,300*	3,300	21,110	3,300	21,240	3,300	21,350							3,900
3,600*	3,600	20,165	3,600	20,220	3,600	20,320							4,130

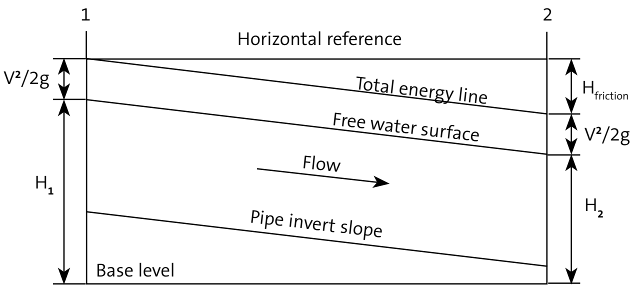
Notes:
1. Internal Diameters (ID) subject to change without notice.
2. Pipes are nominally 3.0 m in length. * Indicates nominal length of 2.44 m.
3. Mass is based on density of 2,600 kg/m³ for spun pipe and 2,500 kg/m³ for vertically cast pipe.
4. Indicates not typically supplied.

Load class

Humes concrete stormwater pipes are available in standard-strength (class 2-4) and super-strength (class 6-10) load classes. The most appropriate stormwater pipe installation can be obtained by matching both load class and the bedding support type. For the majority of installations, standard-strength concrete stormwater pipes used in conjunction with type H2 or type HS2 bedding support, is suitable.

For large fill situations, a combination of super-strength pipes and type HS3 bedding support can provide the most appropriate and economical solution. Further information on the load class of concrete pipes can be obtained by referring to Section 1 – Introduction.

Figure 4.6 – Uniform flow conditions



$$H_1 + V^2/2g = H_2\ v^2/2g + H_{friction}$$

Hydraulics

Generally, a stormwater pipeline system is designed so that the hydraulic gradeline is at or below the level of the line joining the upstream and downstream manhole surface levels as shown in Figure 4.3 (page 18).

The loss of energy head in the pipeline is the aggregate of elevation, exit velocity and friction head losses. Of these, normally only elevation and friction head losses are major considerations.

The flow of water in a stormwater pipeline operating full or with minor energy head is determined from the hydraulic grade of the pipeline. For determining head loss in a stormwater pipeline, the Colebrook-White formula is recommended as is a roughness value (k_s) of 0.6 mm.

Figure 4.6 gives the capacity and flow velocity of a pipeline flowing with an established hydraulic grade. Alternatively, available energy head can be used to determine the required pipe size for a given flow discharge. Figure 3.4 - Relative discharge and velocity in part-full pipe flow (page 15), can be used to determine part-flow depth, velocity and discharge in a pipeline.

Although a value of k_s = 0.6 mm is recommended, where the stormwater system is located in a fully developed urban environment, this reasonably conservative value, which is determined from the combined effects of pipe surface and solid material carried in the flow, may be reduced to 0.15 mm, considerably increasing the flow capacity where appropriate (see Figure 10.6, page 59).

Installation

All Humes RRJ belled socket pipes are supplied with laying witness marks indicated in the RRJ profile for easy control of the deflected joint. See Figure 9.8 on page 48.

Humes concrete stormwater pipes are normally supplied with elliptical grid reinforcement, unless a circular grid is specifically requested. Elliptical grid reinforced pipes must be laid with the word TOP at the crown and within 10° each side of the vertical centreline.

To simplify handling, lifting anchors can be cast-in as requested. For RRJ pipes DN1800 and over, Humes provides a special rubber ring lubricant to assist jointing. See section 9 – Handling and installation, for further details.

Left:
Large diameter Rubber Ring Joint (in-wall) pipe installation

Other stormwater products

Humes supplies a wide range of associated components to provide the complete stormwater drainage system. These include access chambers and maintenance shafts, kerb inlet systems, bends, tees, junctions, as well as stormwater pits. With the ever increasing need to responsibly manage a healthy environment, Humes have developed a technically advanced portfolio of stormwater treatment, detention and harvesting products.

Primary treatment – HumeGard® GPT is a pollution control device that is specifically designed to remove gross pollutants and coarse sediments ≥ 150 micron from stormwater runoff. This system is designed for residential and commercial developments where litter and sediment are the main pollutants. It is particularly useful in retrofit applications or drainage systems on flat grades where low head loss requirements are critical.

Secondary treatment – The HumeCeptor® system is an underground, precast concrete stormwater treatment solution that uses hydrodynamic and gravitational separation to remove entrained hydrocarbons and total suspended solids (≥ 10 microns) from stormwater runoff. It can contain spills and minimise non-point source pollution entering downstream waterways.

Tertiary treatment – JellyFish® filter uses gravity, flow rotation, and up-flow membrane filtration to provide tertiary treatment to stormwater in an underground structure. Using unique filtration cartridges, each JellyFish® filter provides a large membrane surface area, resulting in high flow rates and pollutant removal capacity.

Detention – The StormTrap® system is a purpose-built stormwater detention and infiltration solution that meets regulatory requirements while minimising the impact on land usability. It is the most cost effective, fully trafficable, below ground detention system on the Australian market today.

Harvesting and re-use – The RainVault® system is specifically designed to capture, treat, store and supply rainwater as an alternative to potable water for non-potable applications. The underground system consists of treatment devices, water quality measures, storage components and a pumping system. It can be customised to suit each project's requirements.

5. Pipes for sewerage applications

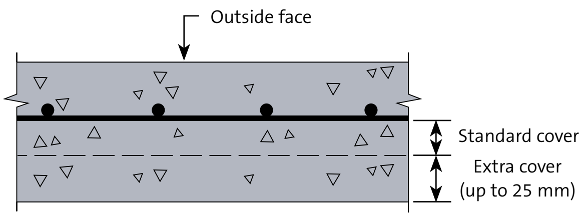
Humes provide a comprehensive range of steel reinforced concrete sewerage pipes in diameters from DN225 to DN3600 (Commonly supplied DN300 to DN2100).

Corrosion protection options

While Humes' sewerage pipes and products are designed to serve over 100 years in accordance with AS/NZS 4058, we offer the following variations to increase durability and manage corrosion.

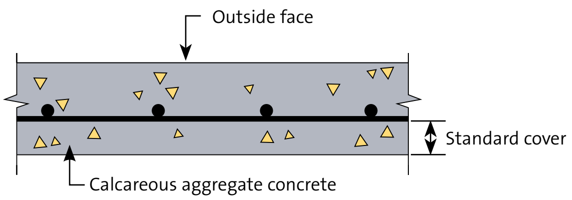
Extra cover to reinforcement

Adding extra cover increases protection when the system's designer has little or no information to carry out a detailed pipe system analysis. The cover can be increased from a nominal standard to lengthen the life of the pipe by up to two times.



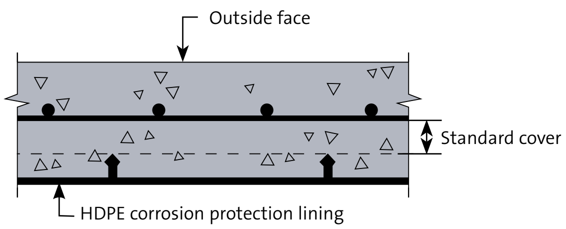
Calcareous aggregate

Manufacturing concrete pipes from calcium rich aggregate such as limestone, increases resistance to acidic corrosion, by inhibiting the progress of the chemical attack. It is most effective when incorporated as a sacrificial layer and can lengthen the pipe life by up to two times.



HDPE lining

High density polyethylene (HDPE) lining is firmly anchored to the pipe, forming a superior protective layer able to withstand both abrasion and harsh chemical environments. HDPE lining is available in 2 mm to 5 mm thicknesses in sheets up to 3 m wide.



Rubber Ring Joint (RRJ) pipes

Humes RRJ pipes are designed to provide a watertight seal against infiltration into the system and exfiltration of sewerage into groundwater.

The joint seal is designed against a minimum 9 m head (90 KPa), internal and external, and the joint configuration allows for watertightness to be maintained even when normal settlements cause joint deflections in the pipeline. Pipeline installers can also use this joint flexibility to maintain line and level of the pipeline. See Table 4.1 (page 18) for details of the minimum radius for RRJ pipelines.

Humes RRJ pipes used in sewerage pipelines are supplied with natural rubber rings with root inhibitor, which prevents vegetation roots from entering the system.

Size class (DN)

Where corrosion protection is added to the pipe in the form of extra cover, the internal bore of the pipe is reduced and designers need to include this reduction in the waterway area in their hydraulic design.

Pipes with HDPE lining are readily available in sizes of DN750 and above. The diameter reduction is generally 20 mm to 40 mm, depending on the system and its design life requirements. See Tables 4.2 and 4.3 (pages 19 and 20) for details of size class (DN) availability.

Load class

Humes concrete sewerage pipes are available in standard-strength (class 2-4) and super-strength (class 6-10) load classes. The most appropriate/ economical pipeline installation can be obtained by matching both load class and bedding support type.

For the majority of installations, standard-strength concrete sewerage pipes used in conjunction with type H2 or type HS2 bedding support are suitable. For large fill situations, a combination of super-strength pipes and type HS3 bedding support can provide the most appropriate and economical solution. Further information on the load class of concrete pipes can be obtained by referring to Section 1 - Introduction.

Hydraulics

The hydraulic design for each section of the sewage pipeline system requires investigation of both peak and minimum flows. Peak flows in the system determine the pipe size class which should then be checked to ensure that at minimum flows the sewage flow velocity does not fall below the self-cleansing velocity.

Gravity flows in a sewage pipeline between manholes are designed hydraulically by considering pipe friction losses and any flow disturbance losses at inlets, outlets, bends and junctions in the pipeline. Losses due to flow disturbances should be minimal since the designer should minimise these to reduce hydrogen sulphide generation.

Frictional losses along the pipeline are based on the Colebrook-White formula, using a recommended roughness height k_s value of 1.5 mm (see Figure 10.8 on page 61). This chart also indicates minimum velocities for slime control and the self-cleansing velocities. The flow discharge and velocity given is for the pipeline running full. The values can be adjusted for a pipeline running part-full by referring to Figure 3.4 (page 15) for part-full flow conditions.

Other sewerage products

Humes manufacture the following range of products associated with reticulation and trunk sewer systems.

Access chambers

Access chambers or manholes are vertical shafts that connect sewer transfer pipes to the surface to allow worker entry. Humes manufacture complete access chamber structures to satisfy various local codes, practices and physical site conditions.

The Humes range of precast concrete sewer access chambers is suitable for a depth up to 9 m, in accordance with AS 4198-1994 Precast Concrete Access Chambers for Sewerage Applications.

Humes' componentry includes precast bases, shafts, taper/squat tops, converter slabs, make up rings, covers and surrounds. Various joint types are also available to meet local requirements and conditions. Cored holes and precast benching can be placed at any angle, making the system capable of accommodating all inlet configurations.

QuickTee® maintenance shaft

The QuickTee® maintenance shaft is a DN600 vertical shaft for non-worker entry to the sewerage system to introduce inspection (CCTV) and maintenance equipment. The shaft is a complete system offering:

- effective heights from 1 m to 5.5 m
- a robust design for fast installation using ordinary backfill material and techniques
- the ability to accommodate traffic loadings and construction in roadways
- inline storage in the event of system surcharge
- high quality, high strength precast concrete for maximum service life
- an innovative base design to ensure efficient hydraulic performance
- a small site footprint for installation in areas congested with other services
- HumeSeal® joints for UPVC pipes which will accommodate a 90 kPa pressure differential and remain watertight with up to 7° of angular deflection.

Top:
Access chamber base

Middle:
Cover and surround completing a QuickTee® system installation

Bottom:
QuickTee® base

Storage tanks

Humes can design sewagestorage tanks using our range of steel reinforced concrete pipes, which is an ideal solution where unique footprints or depths are required. These storage tanks are available from DN1200 to DN3600 in a variety of storage capacities (See Table 5.1 below), and are configured with end walls and fittings to meet project specific needs. The entire precast concrete solution can be provided with corrosion protection lining to meet specific durability requirements.

Pump stations

Pump stations are used for a variety of infrastructure systems including the transfer of sewage to treatment plants. Humes supplies precast concrete chambers up to DN3600, which can be designed to meet customer requirements.

Left:
Precast storage tank

Table 5.1 – Indicative storage capacity (litres) based on flush joint pipe, load class 2

DN (mm)	Length of pipe (metres)														
	0.2	0.4	0.6	0.8	1.0	1.2	1.22	1.4	1.6	1.8	1.83	2.0	2.2	2.4	2.44
300	15	29	44	58	73	87	89	102	116	131	133	145	160	174	177
375	23	47	68	91	114	137	139	160	182	205	209	228	251	274	278
450	33	66	98	131	164	197	200	230	262	295	300	328	361	394	400
525	45	90	134	179	224	269	273	314	358	403	410	448	493	538	547
600	59	117	175	234	292	351	357	409	468	526	535	585	643	701	713
675	74	147	221	295	369	442	450	516	590	663	676	737	811	885	899
750	91	182	274	365	456	547	556	639	730	821	835	912	1,003	1,095	1,113
825	110	221	331	441	552	662	673	772	883	993	1,009	1,103	1,213	1,324	1,346
900	131	263	394	525	657	788	801	919	1,050	1,182	1,202	1,313	1,445	1,576	1,602
1,050	179	358	536	715	894	1,073	1,090	1,251	1,430	1,608	1,636	1,788	1,966	2,145	2,180
1,200	234	467	701	934	1,168	1,401	1,425	1,635	1,869	2,102	2,137	2,336	2,569	2,802	2,849
1,350	295	591	887	1,182	1,478	1,773	1,803	2,069	2,364	2,660	2,704	2,955	3,251	3,546	3,605
1,500	365	730	1,094	1,459	1,824	2,189	2,225	2,554	2,919	3,283	3,338	3,648	4,013	4,378	4,451
1,650	441	883	1,324	1,766	2,207	2,649	2,693	3,090	3,532	3,973	4,039	4,414	4,856	5,297	5,386
1,800	525	1,051	1,576	2,101	2,627	3,152	3,205	3,677	4,203	4,728	4,807	5,254	5,779	6,304	6,409
1,950	617	1,233	1,850	2,466	3,083	3,699	3,761	4,317	4,933	5,549	5,632	6,166	6,782	7,399	7,522
2,100	715	1,430	2,145	2,860	3,575	4,290	4,362	5,005	5,721	6,436	6,543	7,151	7,866	8,581	8,724

Notes:
1. Internal Diameters (ID) and hence, volume storage, is subject to change without notice.
2. This table is included to assist designers with determining volumes of pipes when they are used in other than conduit applications such as holding or storage tanks and pump wells.

6. Pipes for pressure applications

Humes provide a comprehensive range of steel reinforced concrete pressure pipes in diameters from DN225 to DN3600 (standard range DN300 to DN1800).

Rubber Ring Joint (RRJ) pipes

Rubber Ring Joint (RRJ) pipes are recommended for all concrete pressure pipe applications. RRJ pipes up to DN1800 are supplied with a belled socket joint, while those larger than DN1800 are supplied with an in-wall joint (see Figures 4.1 and 4.2 , page 17).

RRJs provide concrete pipes with a high degree of flexibility to accommodate ground settlement or deflections. The RRJ profile is designed for ease of installation, and allows curved alignments or alignment adjustments while maintaining a pressure tight joint seal. Table 6.1 on the following page presents the maximum joint deflections possible for the standard range of pressure pipes. See also Figure 6.1 below.

Witness marks are provided to indicate both nominal laying gap and maximum joint deflection. Where fittings are included in the pipe system, thrust blocks should be provided to prevent lateral or longitudinal movement and separation in the adjacent pipe joint. The magnitude of the thrust force is dependent on the pressure in the pipeline and the deflected angle or restriction to flow.

The design of reinforced concrete pressure pipe systems as described in the Concrete Pipe Association of Australasia publication, "Hydraulics of Precast Concrete Conduits", is recommended to specifiers and designers.

Figure 6.1 – Deflected joint details

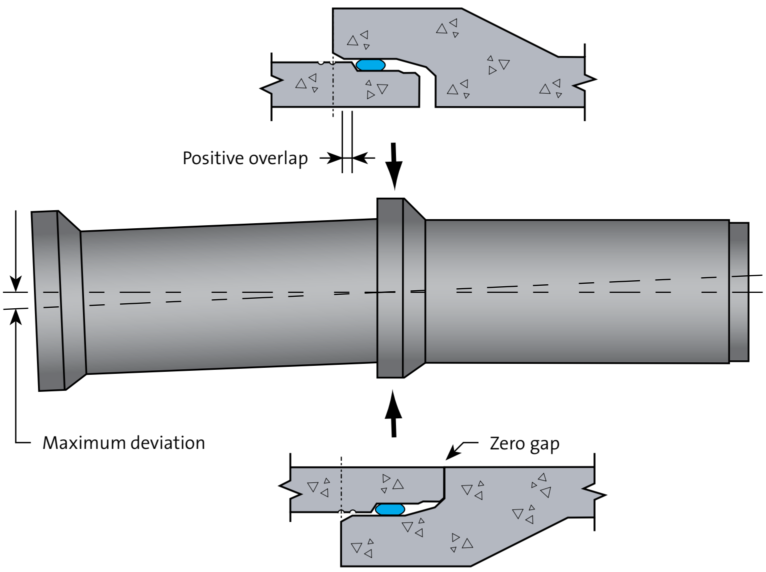


Table 6.1 – Maximum joint deflection: RRJ – Pressure pipe (and sewerage) applications

Size class (DN)	Internal Diameter (ID)	Wall thickness (mm)	Max CL deviation per pipe (mm)	Max deflection angle at joint (degrees)	Min CL radius* (m)
300	**304**	**38**	**72**	**1.7**	**83**
	300	50	68	1.6	88
375	**367**	**34**	**72**	**1.7**	**83**
	381	38	64	1.5	94
	380	58	55	1.3	108
450	**446**	**36**	**51**	**1.2**	**117**
	450	42	55	1.3	108
	450	55	68	1.6	88
	457	70	60	1.4	100
525	**534**	**41**	**43**	**1**	**140**
	534	51	34	0.8	175
	530	68	55	1.3	108
600	**610**	**44**	**38**	**0.9**	**156**
	610	57	34	0.8	175
	610	76	34	0.8	175
675	**685**	**48**	**34**	**0.8**	**175**
	680	52	51	1.2	117
	680	70	51	1.2	117
750	**760**	**52**	**26**	**0.6**	**234**
	750	55	51	1.2	117
	762	64	30	0.7	200
	762	76	30	0.7	200
825	**838**	**54**	**21**	**0.5**	**280**
	830	60	51	1.2	117
	838	70	30	0.7	200
900	**910**	**66**	**34**	**0.8**	**175**
	900	65	51	1.2	117
	915	89	30	0.7	200
1,050	**1,050**	**70**	**47**	**1.1**	**128**
	1,070	75	26	0.6	234
	1,066	89	26	0.6	234
1,200	**1,200**	**75**	**43**	**1**	**140**
	1,200	110	43	1	140
1,350	**1,370**	**77**	**21**	**0.5**	**280**
	1,350	82	38	0.9	156
1,500	**1,524**	**95**	**26**	**0.6**	**234**
1,650	**1,676**	**95**	**21**	**0.5**	**280**
1,800	**1,828**	**102**	**68**	**1.6**	**88**

Notes:
1. Commonly available sizes indicated in bold.
2. ID and walls thickness subject to change without notice.
3. * Minimum radius is measured to the mid point of the centre line (as opposed to centreline intersection at joint).

Size class (DN)

The size class for reinforced concrete pressure pipes will depend on hydraulic calculations for pressure and discharge. Commonly supplied size classes for reinforced concrete pressure pipes are from DN300 to DN1800 diameter (see Table 6.2 on the following page).

Pipes can also be supplied below DN300 and, for these diameters, reduced lengths of 1.22 m are normally provided. Pipe diameters above DN1800 can be supplied where required for special projects.

Load/pressure class

Reinforced concrete pressure pipes are designed for the combined effects of external load and internal (in-service) pressure. Australian/New Zealand Standard, AS/NZS 4058: Precast concrete pipes (pressure and non-pressure) gives a minimum requirement for factory test pressure of 120% of working pressure in the pipeline. Working pressure when specified should include all effects as well as any dynamic surge pressures in the pipeline.

To simulate the combined effects of load and pressure, the corresponding test load for a pressure pipe, with a minimum factory test pressure of 120% working pressure, is increased above the normal calculated non-pressure value by as much as 182% by the application of the formula:

$$T = \frac{W}{F}\left(\frac{P_t}{P_t - P_w}\right)^{1/3}$$

T = test load
W/F = calculated test load
P_t = test pressure
P_w = working pressure

The combination of test pressure and test load can be most economically achieved when a balanced condition of their effects is considered in the design.

For the majority of installations, concrete pressure pipes can be installed using type H2 bedding support.

Table 6.2 – Pressure pipe class range

Size class (DN)	Pressure class (kPa) 200	300	400	500	700	Pipe mass 2.44 m long (kg)
	Internal Diameter x wall thickness (mm)					
300	**304 x 38**	**304 x 38**	**304 x 38**	**304 x 38**		285
					300 x 50	390
375	**367 x 34**	**367 x 34**	**367 x 34**	**367 x 34**		300
450	**446 x 36**	**446 x 36**	**446 x 36**			385
			450 x 42			450
				450 x 55		625
					457 x 70	840
525	**534 x 41**	**534 x 41**	**534 x 41**			530
				534 x 51		680
					530 x 68	930
600	**610 x 44**	**610 x 44**	**610 x 44**			645
				610 x 57		915
					600 x 81	1,250
675	**685 x 48**	**685 x 48**				780
			680 x 52			880
				680 x 70		1,225
750	**760 x 52**	**760 x 52**				960
			762 x 64			1,195
				762 x 76		1,290
825	**838 x 54**	**838 x 54**				1,075
			830 x 60			1,295
				826 x 76		1,580
900	**910 x 66**	**910 x 66**	**910 x 66**			1,470
				899 x 97		2,255
1,050	**1,050 x 70**	**1,050 x 70**				1,840
			1,050 x 85			2,180
				1,050 x 97		2,610
1,200	**1,200 x 75**	**1,200 x 75**				2,260
			1,200 x 110	1,200 x 110		3,435
1,350	**1,370 x 77**	**1,370 x 77**				2,540
			1,326 x 94			3,130
1,500	**1,524 x 95**	**1,524 x 95**				3,655
			1,500 x 107			4,070
1,650	**1,676 x 95**	**1,676 x 95**				4,020
1,800	**1,828 x 102**	**1,828 x 102**				4,600

Notes:

1. Size commonly available indicated by bold type. Other pressure classes may also be available.
2. Pipe mass based on product density of 2,600 kg/m³ for spun pipe and 2,500 kg/m³ for vertically cast pipe.
3. Internal Diameters (ID) subject to change without notice.

= Not typically supplied

Table 6.3 – Pressure pipe actual size and maximum test pressures

Pressure pipes		
Size class (DN)	Actual size ID x wall (mm)	Maximum test pressure (kPa)
300	**304 x 38**	**650**
	298 x 41	**700**
	300 x 50	975
	294 x 53	1,050
375	**367 x 34**	**550**
	357 x 39	**575**
	381 x 38	525
	375 x 41	550
	380 x 58	900
	370 x 63	975
450	**446 x 36**	**450**
	436 x 41	**475**
	450 x 42	450
	450 x 55	700
	430 x 65	875
	457 x 70	900
525	**534 x 41**	**450**
	518 x 49	**550**
	534 x 51	525
	514 x 61	700
	530 x 68	750
	514 x 76	800
600	**610 x 44**	**425**
	594 x 52	**475**
	610 x 57	550
	598 x 63	625
	610 x 76	725
	598 x 82	800
675	**685 x 48**	**400**
	673 x 54	**475**
	680 x 52	425
	656 x 64	575
	680 x 70	600
	660 x 80	700
750	**760 x 52**	**350**
	736 x 64	**500**
	750 x 55	400

Pressure pipes		
Size class (DN)	Actual size ID x wall (mm)	Maximum test pressure (kPa)
750 (cont.)	730 x 65	525
	726 x 64	475
	750 x 70	550
	762 x 76	575
	750 x 82	625
825	**838 x 54**	**350**
	832 x 57	**400**
	830 x 60	425
	806 x 72	525
	838 x 70	475
	814 x 82	600
900	**910 x 66**	**425**
	898 x 72	**475**
	900 x 65	425
	880 x 75	500
	915 x 89	575
1,050	**1,050 x 70**	**375**
	1,018 x 86	**500**
	1,070 x 75	400
	1,058 x 81	450
	1,066 x 89	475
	1,050 x 97	525
1,200	**1,200 x 75**	**350**
	1,168 x 91	**450**
	1,200 x 110	525
	1,180 x 120	600
1,350	**1,370 x 77**	**325**
	1,360 x 82	**350**
	1,350 x 82	350
	1,326 x 94	400
1,500	**1,524 x 95**	**350**
	1,508 x 103	**400**
1,650	**1,676 x 95**	**325**
	1,652 x 107	**375**
1,800	**1,828 x 102**	**325**
	1,812 x 110	**350**

Notes:
1. Commonly available sizes indicated in bold.
2. Hydrostatic test pressure = 1.2 working pressure.
3. Internal Diameters (ID) subject to change without notice.

Hydraulics

Reinforced concrete pressure pipes are designed for the maximum operating discharge rate in the pipeline. There are two design types of pressure pipelines, the gravity pressure pipeline and the pumped pressure pipeline.

Gravity pressure pipelines utilise the static head over the length of the pipeline to provide discharge and the pipes used are designed to a minimum factory test pressure of 120% working pressure, or working pressure plus 15 metres head, whichever is greater. Gravity pressure mains are an hydraulically 'soft' system, rarely incurring the effects of water-hammer.

Pumped pressure pipelines are susceptible to water-hammer effects if the system is not designed and operated to eliminate its occurrence, possibly leading to an hydraulically 'hard' system. Water-hammer effects and their analysis require a detailed knowledge of the operating conditions within the system and its geometry.

Water-hammer in a pressure pipe system, which can be as high as 100 times the flow velocity head at shutdown in the pipeline, is typically caused by either rapid valve closure or uncontrolled pump operation, either at start-up or breakdown.

AS/NZS 4058 Clause 4.5 nominates minimum test requirements for pressure pipes:

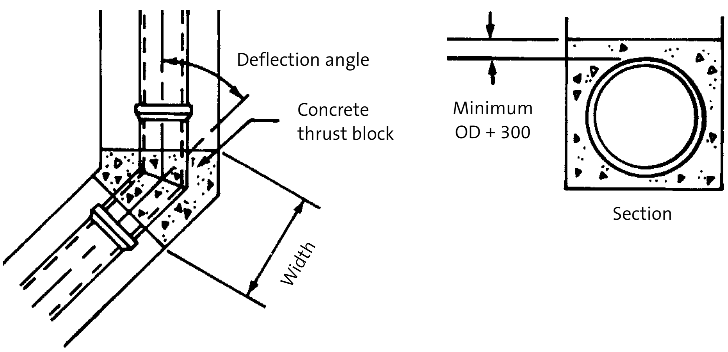
- performance test pressure of pipe and joint (P_t) = Min. 1.2 times the working pressure of pipe and joint
- ultimate test pressure (P_u) being the lesser of:
  (i) 1.5 times the allowable working pressure (P_w).
  (ii) 1.2 times the allowable working pressure (P_w) plus 75 kPa.

However, in a reinforced concrete pipeline subjected to unforeseen operations, the pipes are ductile in nature and any surges in the line which could result in cracked pipes will not cause the system to become unserviceable.

A reinforced concrete pipe, overloaded with passing pressure surges, will expand and some minor cracks may result.

So long as the concrete is not fractured or blown out, the pipe will likely return to its original state of serviceability after the pressure surge passes, with visible cracking reducing over time. The cracks will re-seal under the natural action of the concrete's autogenous healing process. During this time it may be necessary to reduce the pipeline working pressure.

Figure 6.2 – Thrust block detail



Note: Minimum concrete strength 25 MPa

The working pressure in a pipe to provide the specified discharge is determined from the sum of the elevation (static lift) between pipeline inlet and outlet and head (pressure) losses along the pipeline caused by pipe and fluid friction effects and exit velocity head loss.

The Concrete Pipe Association of Australasia document "Hydraulics of Precast Conduits" (available for download at www.concpipe.asn.au) is an excellent reference for quantifying the magnitude of these losses where considered appropriate.

Establishing the magnitude of friction head losses along the pipeline is carried out by using the Colebrook-White equation, adopting recommended values for pipe surface roughness height (k_s) depending on the fluid type.

For clean water in a water supply pipeline, a value of pipe surface roughness (k_s) 0.06 mm is appropriate. However, where in doubt, or where a significant number of fittings are in the pipeline, a more conservative value of (k_s) 0.15 mm is recommended.

Design charts based on the surface roughness values of 0.06 mm and 0.15 mm are provided on pages 58 and 59.

The Colebrook-White charts provide the slope of the hydraulic gradient for a required discharge flow rate in the pipeline, and friction head losses in the pipeline can then be determined by applying this value over the line's entire length.

Where a pressure pipeline has a change in horizontal or vertical alignment, or where bends, reducers, tees or valves are fitted within the pipe system, unbalanced forces at the change in flow direction need to be resisted by fitting thrust blocks along the pipeline.

The magnitude of the thrust force is determined by geometric's and the size of the thrust block is found by adopting a value for the passive resistance of the soil in the trench walls. (A minimum soil bearing capacity of 100 kPa is often adopted). Table 6.4 provides typical values of thrust block sizes based on stated conditions.

Table 6.4 - Pressure pipe thrust block size for horizontal bends

Size class (DN)	Width per 10 m head 15° deflection (mm)	
	Soil bearing pressure	
	100 kPa	200 kPa
300	100	50
375	100	50
450	125	75
525	150	75
600	175	100
675	185	100
750	200	100
825	200	100
900	250	125
1,050	275	150
1,200	300	150
1,350	325	150
1,500	350	175
1,650	375	175
1,800	425	200

Other pressure pipe products

Reinforced concrete pressure pipes can be manufactured with bends, reducers and cast-in mild steel, cast iron or plastic fittings, where required by the system designer. Typical arrangements are shown below.

Clockwise from top: Socket to spigot reducer; Single mitre bend; Mild steel adaptor for DN2100 skid ring joint pipe; Air valve on DN2700 skid ring joint pipe; Concrete lined mild steel off-take

Field hydrostatic testing

Before delivery to site, every Humes pressure pipe is hydrostatically tested to the specified test pressure. Consequently, field pressure testing should not be specified for the purpose of reassessing individual pipe performance.

However, the manner in which the pipes have been handled on site, and the conditions to which they have been subjected prior to and during laying, may require that the test be applied to "prove" the pipeline installation. The purpose of specifying a field hydrostatic test is solely to reveal the existence of inadequate laying procedures.

It is strongly recommended that the specified site test pressure be no greater than the sustained working pressure to which the pipeline will be subjected in service.

When a field test is to be applied, preconditioning of the pipeline is essential to give meaningful results. The pipeline should be allowed to stand under 50 kPa hydrostatic pressure at the highest point in the line for such time as is necessary to allow natural absorption of water into the concrete. The time taken for this to occur will depend on the moisture condition of the pipes, as well as the ambient site conditions.

Some lines will need no more than 24 hours, others may need weeks. Subsequently, pressurisation should be carried out slowly, initially at 50 kPa increments per hour. Once the test pressure has been reached, and providing no major faults have appeared, the loss of water should be measured at hourly intervals over a period of three hours.

If measurements show a steadily decreasing loss rate, equilibrium has not been achieved and it may be necessary to allow a further period of preconditioning before attempting further measurements. A test result is considered satisfactory when the amount of water lost in one hour does not exceed the amount defined by the equation:

$Q_L = N.D.(TP)^{1/2}/70$

Q_L: Leakage in litres per hour.

N: Number of joints in the section of line under test.

D: Diameter of pipe in metres.

TP: Specified site test pressure in kiloPascals.

Remember, correct laying procedures and proper supervision during installation are a better solution to providing evidence of good installation. See Section 9 – Handling and installation.

The Concrete Pipe Association of Australasia, CPAA, publication, “Field Testing of Concrete Pipelines and Joints", comprehensively details all aspects of this procedure. This document is available for download at www.concpipe.asn.au.

7. Pipes for irrigation applications

Humes provide a range of steel reinforced concrete irrigation pipes in diameters from DN300 to DN750. Rubber Ring Joint (RRJ) pipes are recommended for irrigation applications where a pressure tight joint seal is required.

Humes range of small diameter reinforced concrete irrigation pipes are easily transported and laid using farm machinery equipment and can be relocated around the property to meet changing irrigation requirements without the need for special pipe laying skills.

Rubber Ring Joint (RRJ) pipes

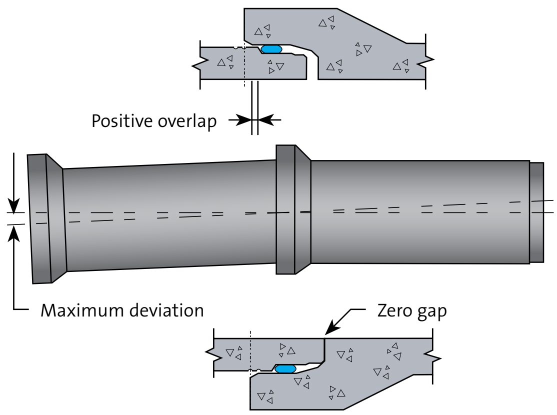
Rubber Ring Joints (RRJ) are designed to provide a joint seal capable of resisting pressures far in excess of those normally operating in most irrigation systems. Maximum deviations in alignment are given in Table 7.1 (refer also to Figure 7.1). Deflections may be the result of pipeline settlements or included during laying to provide a change in pipeline alignment. Witness marks are provided to indicate both nominal laying gap and maximum joint deflection (see Figure 9.8 on page 48).

DN375 and DN450 pipe joints may be compatible with some cast iron fittings. Check applicable dimensions with relevant suppliers to confirm. Custom fittings are normally specified for larger diameters.

Table 7.1 – Maximum joint deflection: RRJ – Irrigation pipe applications

Size class (DN)	Max CL deviation per pipe (mm)	Max deflection angle at joint (degrees)	Min CL radius* (m)
300	63	1.4	100
375	72	1.6	88
450	51	1.1	128
525	46	1.0	140
600	40	0.9	156
675	36	0.8	175
750	29	0.6	234

Figure 7.1 – Deflected joint details



Size class (DN)

Reinforced concrete irrigation pipes are manufactured in diameters from DN300 to DN750 as shown in Table 7.2 below. Beyond this range, Humes reinforced pressure pipes as detailed in Section 6 (page 27) can be used to give an increased choice to the pipeline designer. The size class of pipe required is determined from the irrigation supply requirements of the planned farm crop yield.

Figure 7.2 – Pipe dimensions

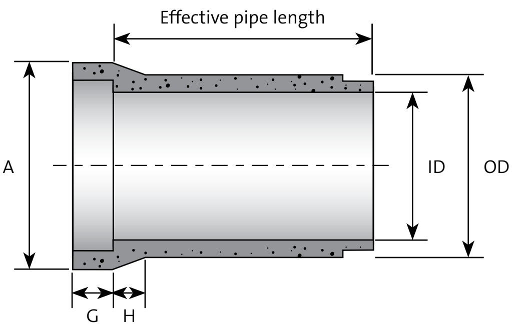


Table 7.2 – Pipe dimensions and masses

Size class (DN)	Internal Diameter (ID)	Outside Diameter (OD)	Socket dimensions			Mass per 2.44 m length (kg)
			*A	*G	*H	
300	300	362	451	107	89	220
375	367	435	516	106	70	300
450	446	518	603	127	74	385
525	534	616	711	147	133	530
600	610	698	797	147	133	645
675	685	781	886	147	133	780
750	760	864	997	143	152	960

Notes:
1. Pipe mass based on product density of 2,600 kg/m³.
2. *Refer to Figure 7.2.

Load/pressure class

The load class of a reinforced concrete irrigation pipe is normally class 2, since most pressure pipelines follow the ground's natural surface and are laid at a maximum depth of around 1 metre. The pressure class of irrigation pipes is determined from the irrigation requirements and is usually up to a maximum of 500 kPa pressure class (415 kPa working). Most commonly, a reinforced concrete irrigation pipe pressure class 200 kPa is required. Table 7.3 presents standard pressure classes as a guide. Other intermediate pressure classes are also available when required.

Table 7.3 – Standard pressure classes

Size class (DN)	Pressure class (kPa)		
	200	300	500
	Internal Diameter x wall thickness (mm)		
300	300 x 31		
375	367 x 34	367 x 34	367 x 34
450	446 x 36	446 x 36	440 x 39
525	534 x 41	534 x 41	534 x 41
600	610 x 44	610 x 44	
675	685 x 48	685 x 48	
750	760 x 52	760 x 52	

Note:
- Not typically supplied.

Hydraulics

The hydraulic flow requirements of the reinforced concrete irrigation system is used to determine the size class required. The hydraulic pressure to provide the required flow discharge in the pipeline is determined from the sum of the elevation difference between the supply point and receiving discharge point, and frictional losses along the pipeline caused by flows along the pipe's surface. Table 7.4 below presents head loss based on the surface texture common to concrete pipe for irrigation water (k_s = 0.15 mm).

Table 7.4 – Head loss in metres per 10 m length of pipeline

Size class (DN)	Discharge litres/second						
	10	50	100	250	500	750	1,000
300		0.016	0.055	0.36			
375		0.0053	0.019	0.15	0.5		
450		0.0022	0.0077	0.047	0.2	0.45	0.8
525		0.001	0.0035	0.025	0.065	0.15	0.25
600			0.0015	0.010	0.035	0.075	0.13
675			0.001	0.0055	0.020	0.045	0.075
750				0.0030	0.012	0.025	0.045

Notes:
1. Values are for clean water (ks = 0.15 mm).
2. Values to right of red line have pumped velocity > 3.0 m/sec and scour may occur in the channel at the outlet.
3. - Not typically supplied.

Table 7.5 – Cylindrical capacity (litres) based on flush joint pipe, load class 2

DN (mm)	Length of pipe (metres)														
	0.2	0.4	0.6	0.8	1.0	1.2	1.22	1.4	1.6	1.8	1.83	2.0	2.2	2.4	2.6
300	15	29	44	58	73	87	89	102	116	131	133	145	160	174	177
375	23	47	68	91	114	137	139	160	182	205	209	228	251	274	278
450	33	66	98	131	164	197	200	230	262	295	300	328	361	394	400
525	45	90	134	179	224	269	273	314	358	403	410	448	493	538	547
600	59	117	175	234	292	351	357	409	468	526	535	585	643	701	713
675	74	147	221	295	369	442	450	516	590	663	676	737	811	885	899
750	91	182	274	365	456	547	556	639	730	821	835	912	1,003	1,095	1,113

8. Jacking pipes

Humes provide a comprehensive range of steel reinforced concrete jacking pipes in diameters from DN300 to DN3600 (standard range DN300 to DN2100).

Butt joint jacking pipes

Butt joint jacking pipes are available in the size range DN300 to DN3000 (standard range DN300 to DN2100). Butt joint jacking pipes are manufactured as a modification to the standard flush joint drainage pipe. Butt joint jacking pipes incorporate a single wide jacking face. External recesses at each end of the pipe allow for a rolled steel band to be located between adjacent pipes, providing the necessary shear connection (see Figure 8.2 below).

Butt joint jacking pipes can provide a cost effective solution for typically short length applications where only limited flexibility is required and a soil or watertight joint is not required. This pipe is most suited to sleeve pipe applications for road and rail crossings where the annulus between the utility pipeline or conduit is to be filled with grout after installation.

Figure 8.2 – Butt joint profile

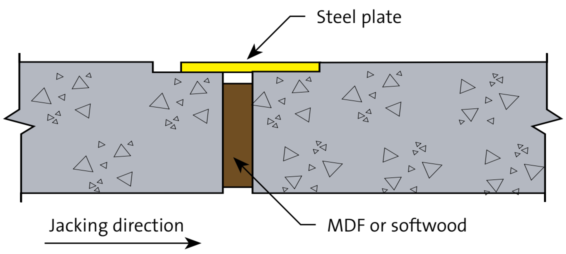


Table 8.1 – Butt joint jacking pipe details

Size class (DN)	ID (mm)	OD (mm)	Mass (kg)
300	280	362	263
375	363	445	333
450	438	534	467
525	518	616	560
600	586	698	718
675	653	781	919
750	730	864	1,067
825	790	946	1,348
900	875	1029	1,471
975	951	1,111	1,657
1,050	1,026	1,194	1,873
1,200	1,163	1,359	2,461
1,350	1,324	1,524	2,850
1,500	1,452	1,676	3,493
1,650	1,596	1,842	4,186
1,800	1,756	2,006	4,680
1,950	1,930	2,198	5,507
2,100	2,096	2,388	6,445

Note: Standard range is manufactured to load class 4.

S series jacking pipes

These are available in the size range DN300 to DN700 inclusive and are a custom designed jacking pipe incorporating a single wide jacking face including timber packers, a stainless steel corrugated collar cast onto the pipe, an elastomeric seal located within the steel collar and an accurately formed spigot (see Figure 8.4 below).

In this unique design the seal is retained between the corrugations in the steel collar ensuring that it remains in place and in compression in deflected joints subject to either internal or external hydrostatic pressure.

This pipe provides a pipe with high axial load transfer capacity and a flexible joint watertight tight joint. This is the ideal choice for jacking pipes for stormwater, culverts and sleeve pipe applications. Available diameters of these pipes are listed in Table 8.2 (page 42).

J series jacking pipes

These pipes are available in the size range DN800 to DN2000 inclusive and are a custom designed jacking pipe incorporating a single wide jacking face including timber packers, a steel collar cast onto the pipe, an elastomeric seal and muck ring located on the pipe spigot (see Figure 8.5 below). In this design the elastomeric seal is retained within the accurately formed recess on the pipe spigot that will remain in place and in compression in deflected joints subject to either internal or external hydrostatic pressure. The muck ring limits the ingress of soil into the joint during jacking.

The J series is a complete jacking pipe system incorporating standard jacking pipes, pipes with specially designed threaded fittings for injection of lubricants and grout and intermediate jacking station (interjack) pipes. The J series range of pipes all provide high axial load transfer capacity and a flexible water tight joint including the interjack pipes. This is the ideal jacking pipe for all stormwater, sewerage (including an inert thermoplastic lining if required), culvert, sleeve pipe and jacked low pressure pipeline applications. Available diameters of these pipes are listed in Table 8.2 (page 42).

Figure 8.4 – S series joint profile

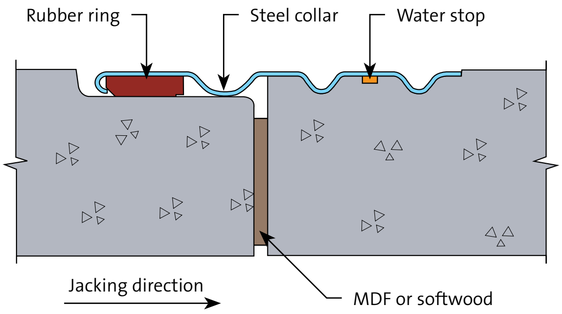


Figure 8.5 – J series joint profile

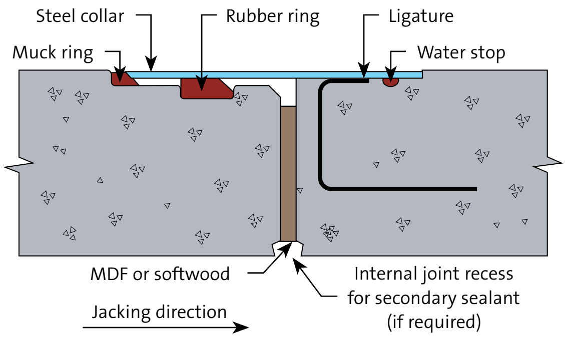


Table 8.2 – S and J series jacking pipe details

Size class (DN)	S series ID (mm)	S series OD (mm)	S series Mass (kg)	J series ID (mm)	J series OD (mm)	J series Mass (kg)
300	300	430	500			
350	350	480	550			
400	400	540	660			
450	450	606	725			
500	500	672	1,000			
600	600	774	1,190			
700	700	876	1,380			
800				800	1,000	1,800
900				900	1,110	2,100
1,000				1,000	1,220	2,400
1,100				1,100	1,332	2,800
1,200				1,200	1,450	3,300
1,350				1,350	1,626	4,000
1,500				1,500	1,800	4,800
1,650				1,650	1,974	5,700
1,800				1,800	2,150	6,700
2,100				2,100	2,500	12,050
2,400				2,374	2,783	12,950
2,500				2,500	3,000	16,650
2,700				2,636	3,096	16,150
3,000				2,972	3,472	19,700

Note: Standard range is manufactured to load class 4.

Table 8.3 – Jacking pipe type selection guide

	Capability/suitability of Humes jacking pipes			
	Jacking pipe requirements or application	**Butt joint**	**S series**	**J series**
Assest owner	Standard size class	DN300 - D2100	DN300 - DN700	DN800 - DN2000
	Extended diameter range[1]	DN2250 - DN3000	DN800	> DN2000
	Incorporation of inert thermoplastic lining	N/A	N/A	Available
	Suitability in different soil conditions	Not recommended in soft silts/clays or sandy soils[2]	All soil types	All soil types
	External grouting	Not suitable	Suitable for short lengths	Ideally suited
	Internal pressure test capability (kPa)[3]	N/A	90	150[4]
	Application of internal secondary sealants	Not suitable	N/A	Suitable
	Sewerage pipelines	Not suitable	Limited suitability[5]	Ideally suited
	Stormwater pipelines	Limited suitability	Ideally suited	Ideally suited
	Road and rail culverts	Limited suitability	Ideally suited	Ideally suited
	Sleeve pipe applications	Limited suitability[6]	Ideally suited	Ideally suited
Assets owner and contractor	Length of jacked pipeline (m)	0 - 50[7]	0 - 150[8]	< DN1000: 0 - 150 DN1000 - DN2000: no limit[9]
	External pressure test capability[10]	N/A	90	250[4]
	Jacking force transfer	Good	Excellent	Excellent
	Intermediate jacking stations pipes	To be provided by contractor	N/A	Available DN900 - DN2000
Contractor	Open face shields	Suitable	Suitable	Suitable
	Closed face pressure shields	Not Suitable	Ideally suited	Ideally suited
	Lubrication along length of pipeline	Not Suitable[11]	N/A	Ideally suited

Notes:

1. Refer to Humes for availability.
2. The joint is not water or soil tight, this could lead to ingress of soil surrounding the pipe and ultimately collapse of the ground above the pipeline. Attempts to seal the butt joint with internally applied joint sealants are generally not effective in the long term life of the pipeline.
3. Test to AS/NZS 4058: 2007.
4. Higher pressures are possible with certain diameters – refer to Humes for advice if higher pressures are required.
5. If corrosive sewage gases are expected consider using vitrified clay jacking pipes distributed by Humes.
6. The butt joint jacking pipe is suitable for short length drives in certain soil conditions if the annulus between the concrete sleeve pipe and the product pipe is grouted. This grout should also flow into the annulus between the sleeve pipe and the excavated ground.
7. Lack of joint flexibility largely controls max. length. This could be extended in certain soil conditions and if some damage to joints is acceptable.
8. Intermediate jacking stations not available and length is mainly limited by installation equipment. Some pipe jacking contractors may be able to achieve longer lengths of individual drives in certain soil conditions. Refer to jacking pipe contractor for advice for longer drives.
9. The maximum length will be controlled by installation equipment rather than pipe capability.
10. There is no published test method for external joint testing of reinforced concrete pipes. External pressures due to lubrication or grouting can be well in excess of ground water pressures.
11. For lubrication to be effective, the annulus between the external diameter of the pipe and the excavated soil needs to be filled. The butt joint pipe will not provide an effective sealed joint.

Size class (DN)

The Internal Diameter (ID) of the jacking pipe will be determined by the in-service requirements of the pipeline. The external diameter (OD) in turn must be compatible with the shield machine used by the pipe jacking contractor. Table 8.1 and 8.2 (Pages 39 and 40) contains details of internal and external diameters for Humes standard range of class 4 jacking pipes.

The external diameters of the S and J series are typically compatible with overseas pipe jacking equipment. The nominal diameters of some S and J series pipes correspond to nominal diameters adopted in European standards and differ to current Australian standards.

Load class

Jacking pipes are subject to substantial installation loads and permanent soil and live loads as for any buried pipe. These permanent loads are usually much less than those which may act on the pipe during installation. As such a minimum class 4 pipe is usually recommended although in some short length drives a class 3 may be suitable. The class 4 pipe to Australian Standard AS/NZS 4058 has very similar strength requirements to load classes specified for jacking pipes in European and Japanese standards.

AS/NZS 4058 gives the method for determining the permanent vertical loads acting on pipes installed using pipe jacking. The jacking pipe is installed underground into undisturbed natural ground where the soil's natural cohesion contributes to arching over the pipe. Where the calculation includes the effects of arching due to soil cohesion extensive soil investigations should be carried out to determine the appropriate design soil properties.

The jacking installation results in a recommended bedding factor between 2 and 3 that is used to determine the minimum suitable pipe class required due to permanent loads. The higher value is recommended when the annulus between the pipe and ground is grouted.

Grouting of this annulus with a suitable cementitious grout is recommended in most installations as any voids could create a drainage path external to the pipeline which in turn could lead to soil erosion, lowering of ground water tables and, in aggressive soil conditions, an increased risk of corrosion of pipe materials.

The axial loading from the pipe jacking is not directly included in the selection of the pipe load class. Timber packers are placed between the jacking faces of the concrete pipes to avoid high stresses that could result from direct concrete to concrete contact. The axial load capacity of the concrete pipe is determined based on the minimum pipe wall thickness, concrete strength, properties of the timber packers and the deflections that can be expected at pipe joints during installation.

The allowable jacking forces and associated maximum joint deflections are calculated in accordance with the Concrete Pipe Association of Australasia's publication Jacking Design Guidelines.

Hydraulics

Whether the jacking pipes are used in culvert, stormwater, sewerage or pressure applications, the same hydraulic design methods used for trenched pipes apply. The relevant information is provided in each of these respective sections:

- Section 3 - Pipes for culvert applications
- Section 4 - Pipes for stormwater applications
- Section 5 - Pipes for sewerage applications
- Section 6 - Pipes for pressure applications.

Installation

Humes S and J series jacking pipes are provided with cast in lifting anchors as standard. These anchors can also be provided in some sizes in butt joint jacking pipes.

Threaded steel fittings can be included in all man-entry sized jacking pipes for injection of both lubricating fluid and cementitious grout into the annulus external to the pipe. These fittings are usually located midway along the pipe length at the four quarter points of the pipe circumference starting at 45° from the top of the pipe. The actual details of the fittings and the number of pipes with these fittings are usually advised by the pipe jacking contractor prior to manufacture.

Timber packers are attached to one end of the jacking pipe using a suitable adhesive well in advance of jacking. It is essential that the correct sized packers are placed in the correct position to ensure satisfactory load transfer between pipes.

Jacking forces and joint deflections must be monitored during installation to ensure that the pipe is not overstressed. If maximum jacking forces and associated joint deflections are exceeded spalling of the concrete in the pipe joint may occur. This spalling often occurs on the external surfaces of the joint that may not be visible from inside the pipeline.

Top:
Launch shaft showing exit opening and jacking station

Bottom:
A typical jacking pipe installation, note air ducting and rail transport of spoil material

9. Handling and installation

Placing your order

Top:
Concrete pipe delivery

When ordering Humes pipe products, the following basic information helps us quickly meet your requirements.

Give the details of the delivery address and unloading requirements, the specific pipe details, diameter, type, class, quantities and delivery schedules. Any other particular pipe or delivery requirements. List any other requirements i.e. fittings or associated products. If necessary specification type or application type details if you require verification of product suitability. Also include any testing or special inspection requirements.

Arriving on site

The Concrete Pipe Association of Australasia (CPAA) publication,"Concrete Pipes - Foreman's Laying Guide" is available as a PDF from www.cpaa.asn.au or in hard copy for site use. The content covers a broad range of the issues which may be encountered on site. In addition, the CPAA has a DVD covering the installation practices for SRCP.

When stacking on site, pipes should always be placed with the TOP mark facing upwards. Take extra care when pipes are double stacked.

If pipes are to be stored on the job for a period of months, orientating them east to west, when possible, will reduce the sun's effects on the barrel of the pipes. This, although not essential, will help to ensure integrity until installed below ground level.

Handling on site

When installing Rubber Ring Joint (RRJ) pipes, minimise the rubber rings' exposure to direct sunlight. Rubber rings are best stored inside the pipe barrel and left in plastic or hessian bags when supplied. EB bands as available for Flush Joint (FJ) pipes should also be stored inside the pipe.

Rolling rubber rings do not need lubrication as they rely on the natural effects of rubber on concrete to roll. Ensure the spigot end (male end) of the pipe is clean and dry. Rubber rings and EB bands should be fitted to the pipe's spigot at the ground surface before lowering the pipe into the trench. The rubber ring is fitted into the groove on the spigot as shown in Figure 9.1 and should be checked to ensure that the ring has no twists around its circumference. This guarantees uniform rolling when jointing.

If the pipes are joined and excessive "springback" is experienced in the joint, then the joint should be pulled open and the rubber ring again fitted onto the spigot, ensuring that no twists occur around its circumference.

It's a good idea to stack pipes on timber bearers at one-third points along the barrel for easy access when fitting lifting equipment. All pipes should be chocked to prevent movement when stacked.

RRJ pipes can be supplied with lifting devices if requested for handling and laying, however, more commonly suitable lifting straps or chains are used for handling the pipes. Where chains are used, take care to minimise damage to the pipe and bedding when removing the chains after placing the pipe.

Humes rubber ring lubricant is supplied with all skid ring joint pipes (see Figure 9.2). The lubricant is a special mix of soft soap solution. Never use petroleum products, (e.g. grease) as a substitute lubricant.

Flush Joint (FJ) pipes are generally supplied with lifting holes and plugs are provided which should be secured after laying. Lifting equipment (certified for the pipe load) should be sized so as not to damage the pipe (see Figure 9.3).

Figure 9.1 – Fitting rubber ring

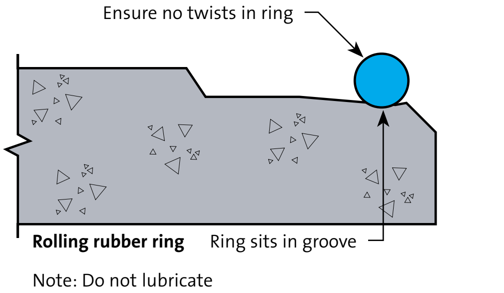


Figure 9.2 – Skid joint lubrication

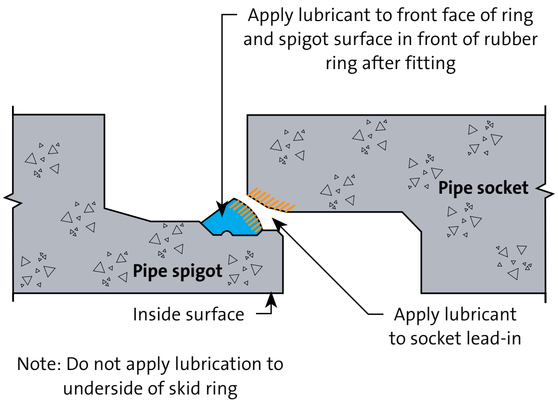
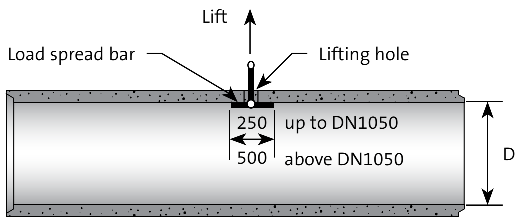


Figure 9.3 – Lifting equipment



Note: Lifting equipment to suit pipe mass as stencilled on pipe

Digging trenches

Remember, all trenches, deep or shallow, can be dangerous environments. Excavated material should be placed far enough from the top of the trench to allow sufficient clearance for installation operations, and to minimise the danger of rocks or lumps rolling back into the trench.

The design engineer has specified the pipe strength class based on a maximum trench width at the top of the pipe. The width of the trench nominated by the specifier should not be exceeded without first checking with the pipeline designer.

Trench walls may be battered or benched above the top of pipe without affecting the pipe design strength class (see Figure 9.4).

Where a pipe is to be laid at natural surface level, the more severe loading from an embankment condition results in a higher pipe class requirement. A trench load condition can be simulated by placing and compacting fill material to 95% modified maximum dry density up to the level of the top of pipe, and then excavating the trench into the placed fill as shown in Figure 9.5.

Preparing the foundation

The foundation for a pipeline at the trench invert under the pipes, provides stability and uniformity along the pipeline. Hard or soft spots in the foundation under the pipeline should be removed and replaced with compacted granular material to give uniform support to the pipe (see Figure 9.6).

Figure 9.4 – Trench profile

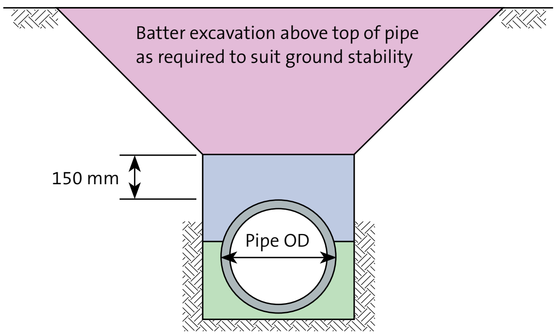
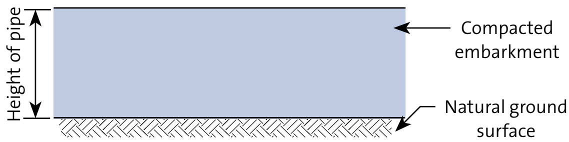
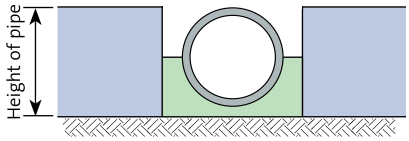


Figure 9.5 – Creating trench conditions at embarkment installations

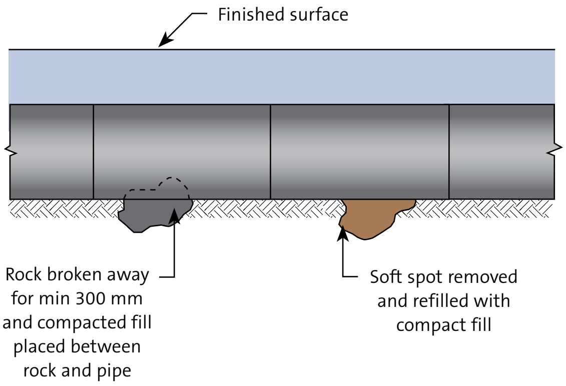


Step 1 – Place embarkment fill to level of top of pipe



Step 2 – Excavate trench into the placed fill, lay pipe

Figure 9.6 – Trench foundation conditions



Placing bedding

Concrete pipes are placed on a prepared flat bedding. Shaped bedding is not necessary for concrete pipe. Bed material is spread across the full trench width to the depth required, and compacted to prevent settlement of the pipeline. Bed material should be granular and fall within the specified size limits given in Table 9.1.

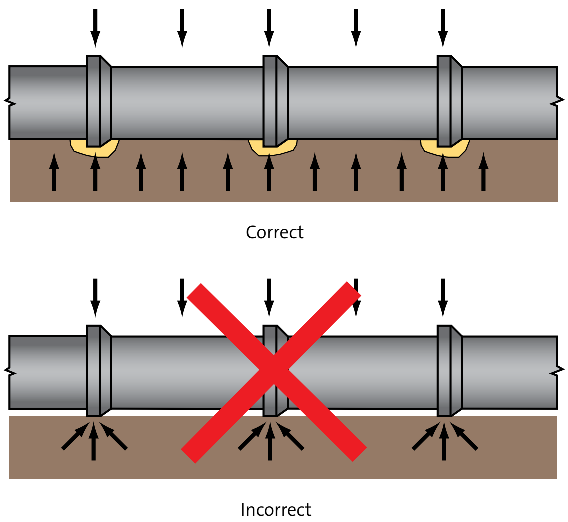
In many instances, the pipe mass is sufficient to compact the bed under the pipe after an allowance of extra depth of loose bed material is made to accommodate settlement during natural compaction. Bed material each side of the pipe should be compacted to give a good stable support to the embedment soil profile higher up in the installation. Chases must be dug-out for belled-socket joints as shown in Figure 9.7.

Table 9.1 – Recommended grading limits for select fill in bed and haunch zones

Sieve size (mm)	Weight passing (%)
19.00	100
2.36	100 to 50
0.60	90 to 20
0.30	60 to 10
0.15	25 to 0
0.075*	10 to 0

Note:
*Low plasticity required.

Figure 9.7 – Trench foundation preparation



Laying pipes

EB bands when fitted to flush joint pipes are "flipped" into position across the joint after settling the pipe in place on the prepared bed.

For RRJ pipes less than DN1800, a laying gap is indicated on the outside of the pipe by a series of witness marks (see Figure 9.8) which show that the joint has been pushed fully home (zero laying gap), thus ensuring proper jointing.

RRJ pipes laid around a curve where the joint is to be deflected, should firstly be pushed fully home and then the pipe levered at the opposite end to produce the required deflection as shown in Figure 9.9.

The recommended procedure for laying pipe is to fit the spigot into the socket. In this orientation, joints are restrained from opening as a result of pipe movement during pipeline settling. Laying in this manner protects surfaces inside the pipe socket from the entry of bed material which may occur if jointed socket onto spigot. Even so, if adequate precautions are taken, there is no reason why concrete pipes cannot be jointed and laid in the reverse manner.

Figure 9.8 – Rubber Ring Joint (RRJ) witness marks

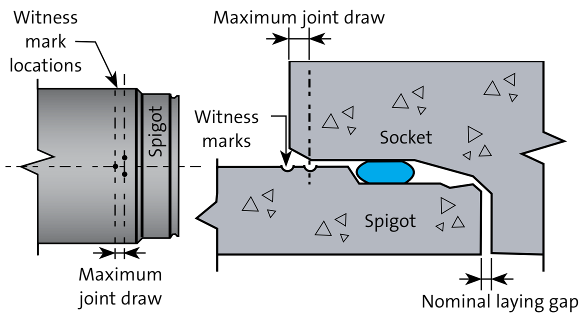
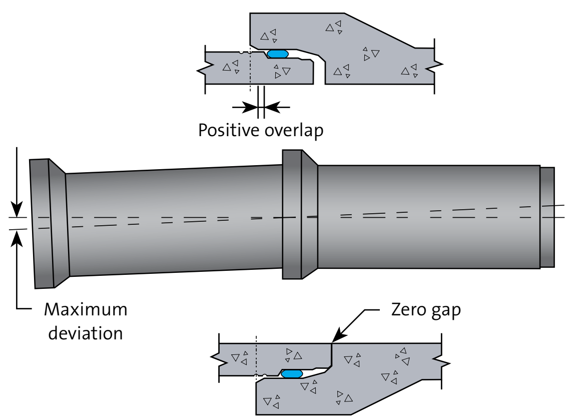


Figure 9.9 – Deflected joint details



Jointing pipes

When jointing RRJ pipes there is a nominal recommended joint laying gap and a maximum laying gap, as shown in Figure 9.10 and Table 9.2 (following page). The force required to joint RRJ pipes increases as the pipe diameter increases. Generally speaking, pipes less than DN450 can readily be pushed home without using leverage tools.

Pipes larger than DN450 and up to DN1200 can be pushed home using simple leverage tools combined with the slung pipe mass.

Pipes larger than DN1200 require jointing by use of a come-along, or by a winch and rope to the slung pipe from the laid pipeline. The jointing load is resisted by a "dead man" timber located upstream in the pipeline as shown in Figure 9.11.

Approximate jointing loads are given in Table 9.3 on the following page for standard RRJ pipes. Where lifting devices are fitted for handling, these are used to make the jointing operation quick and easy. FJ pipes are easily jointed without effort, but always ensure that the joint interlock is properly made.

Figure 9.10 – Rubber ring joint laying gaps

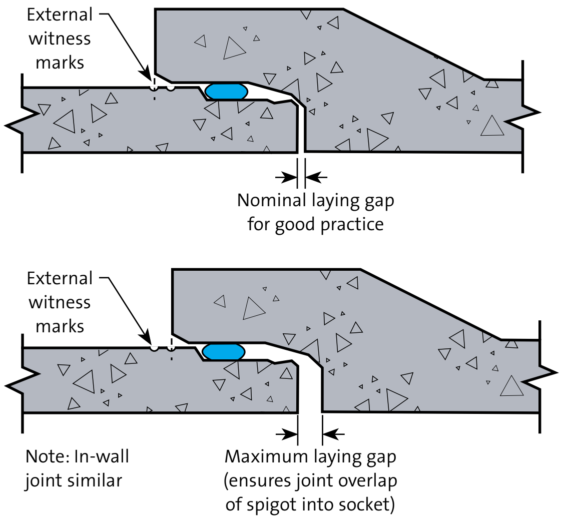


Figure 9.11 – Jointing large diameter pipes

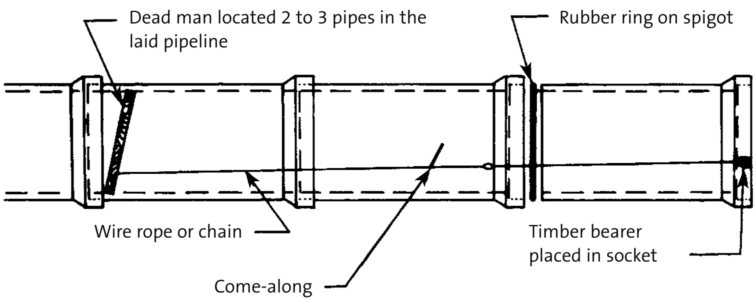


Table 9.2 – Laying gaps

	Size class (DN)	Laying gaps* Nominal (mm)	Laying gaps* Maximum (mm)
Belled socket joint	100	3	5
	150	3	5
	225	3	5
	300	3	10
	375	5	12
	450	5	12
	525	5	12
	600	5	12
	675	5	12
	750	8	12
	825	8	10
	900	8	15
	1,050	10	15
	1,200	10	20
	1,350	10	15
	1,500	10	18
	1,650	10	18
	1,800	10	55
In-wall joint	1,950	10	25
	2,100	10	33
	2,250	10	36
	2,400	10	37
	2,700	15	44
	3,000	15	48

Note:
*Laying gaps as viewed from pipe bore.

Table 9.3 – Table of indicative joint loads - standard range

SIze class (DN)	Indicative joint load (kg)*
300	110-140
375	150-170
450	180-250
525	250-290
600	300-380
675	320-400
750	420-470
825	500-590
900	570-660
1,050	700-770
1,200	810-850
1,350	900-980
1,500	1,000-1,200
1,650	1,200-1,350
1,800	1,600-1,700
1,950	1,600-1,800
2,100	1,700-1,850

Note:
*The lower figure is the most commonly achieved in practice.

Bedding and backfilling

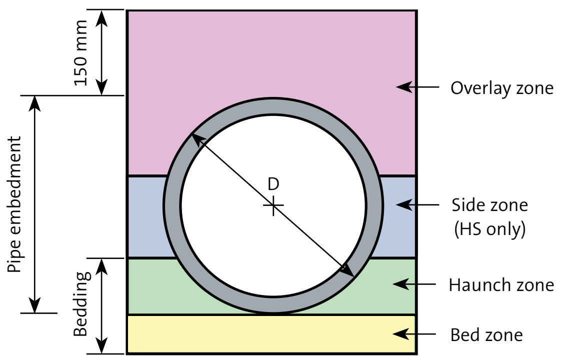
Pipe embedment is the general name given to the soil profile around the installed pipe and includes the bed zone, where required, and overlay zone as shown in Figure 9.12. Pipe bedding refers to the bed and haunch zones which provide the underlying support to the pipe.

The four most important points when bedding and backfilling around reinforced concrete pipes are:

- Avoid damaging the pipes by excessive impact from heavy compaction equipment. Keep large rocks (greater than 300 mm) and other such hard objects out of the fill adjacent to the pipes.
- Bring up the haunch and side zones on both sides of the pipe, so that the difference between the level of the material never exceeds two compaction layer thicknesses. This ensures that the pipes will not be eased slightly out of alignment.
- Avoid running heavy construction equipment over the pipes until a sufficient cushion of material has been placed, approximately 300 mm for normal equipment.
- When using vibrating compaction equipment, allow a 500 mm cushion of material over the pipe or alternatively turn off the vibration until this level is reached.

Large vibrating rollers should always be checked for their effects. Humes engineers can provide guidance.

Figure 9.12 – Pipe embedment profile



The haunch zone in both "H" and "HS" type installations is essential to support the lower portion of the pipe. Voids in the haunch zone under the pipe should not exist as they may cause instability in the embedment compaction.

The side zone compaction in HS type installations is important in supplying side support to laterally resist the load on the pipe.

When installing pipes in HS type installations, it is a requirement that the trench side walls also have sufficient strength to carry the load shed from the pipe and through the side zone material.

Visual inspection of the physical nature of the exposed surface is usually sufficient to determine if this condition is achievable, however, when in doubt, Humes engineers can provide guidelines and recommendations.

The range of recommended concrete pipe installations varies from that which requires the least amount of work, Type U, through to the installation containing the greatest amount of preparation and supervision, the Type HS3 installation.

Type U support shown in Figure 9.13 is an uncontrolled pipe installation and only requires that there should be no unevenness in support under the pipe. In many instances, the in-built strength of reinforced concrete pipe allows this very inexpensive method to be used. Where the pipeline is to be subjected to vehicle loads, this type of installation is not recommended.

Type H support involves the selection and compaction, not only of the bed material, but also the haunch material as illustrated in Figure 9.14.

Selection of the bed and haunch material to be used should be made to suit the grading limits described in Table 9.1 (page 47). These grading limits have been derived from experience, of both stability of the compaction after installation and ease of compaction during placement. The depth of the haunch zone and the degree of compaction is dependent on the type of support specified, either H1 or H2.

Figure 9.13 – Type U support

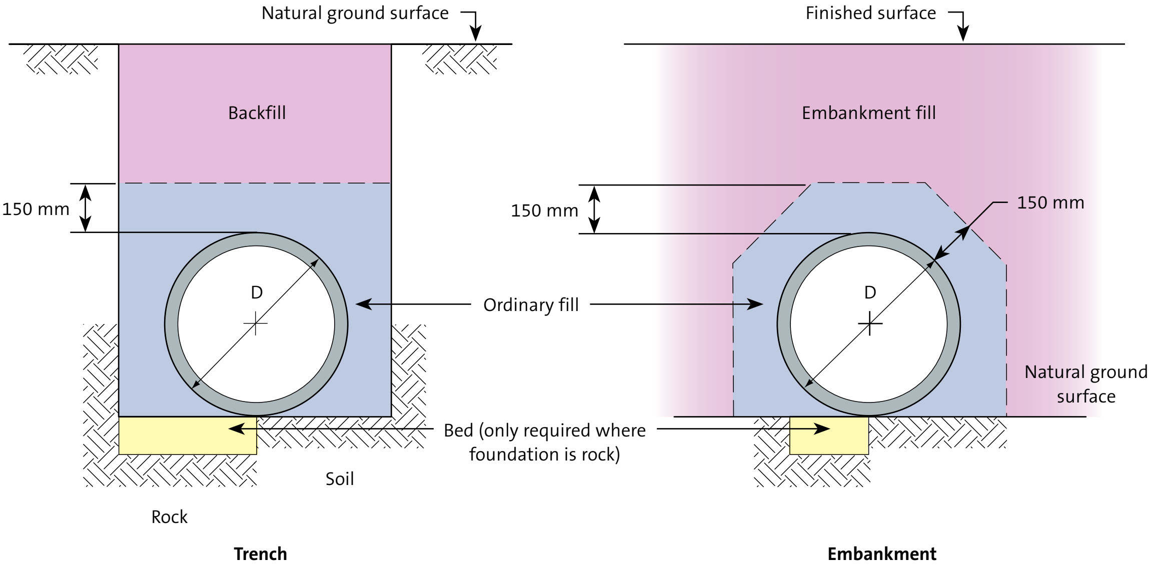
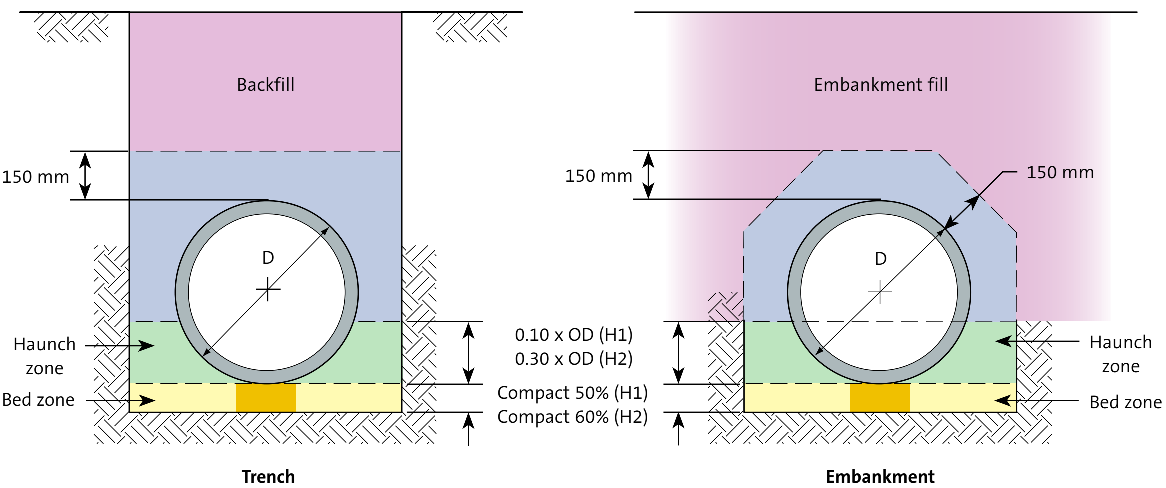


Figure 9.14 – Type H support



The measurement of compaction given "Density index", relates to the non-cohesive material specified. If a cohesive material outside the grading limits and containing significant amounts of clay and silt is to be used, then "Maximum dry density" for standard compaction is used to describe the degree of compaction.

Table 9.4 presents a table of equivalent support stiffness. After placement of the haunch material, ordinary fill material can be used in the overlay zone around the pipe. This material only requires that no stones be greater than 150 mm and no specific compaction level is needed.

The third type of bedding support available is the "HS type", which specifies both haunch and side support, as indicated in Figure 9.15. This type of installation is an extension of the haunch type support and includes a side zone with material meeting the requirements given in Table 9.5.

Table 9.4 – Equivalent compaction stiffness

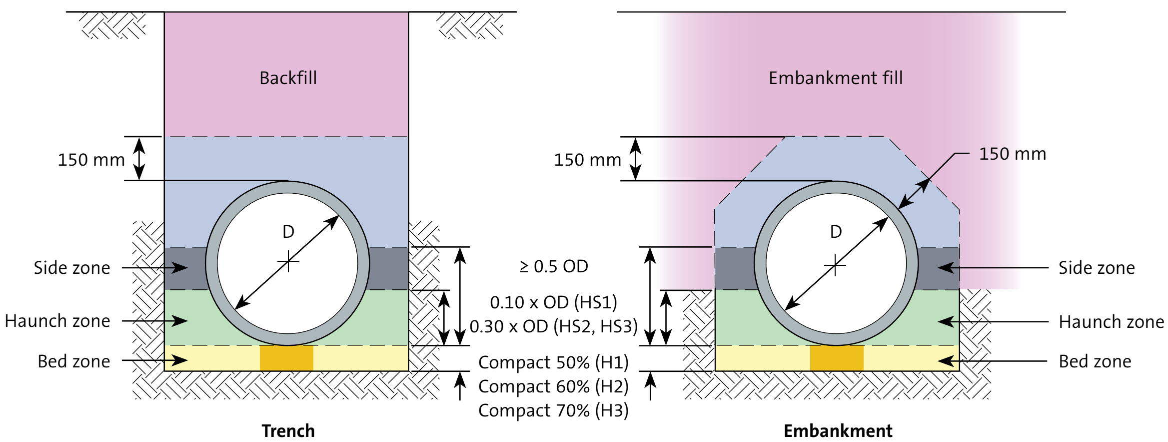
Standard compaction* Max. dry density	Density index
95%	70%
90%	60%
85%	50%

Note:
*Compactive effort shall be applied at 90-100% of optimum moisture content.

Table 9.5 – Grading limits for select fill in side zones

Sieve size (mm)	Weight passing (%)
75.0	100
9.5	100 to 50
2.36	100 to 30
0.60	50 to 15
0.075	25 to 0

Figure 9.15 – Type HS support

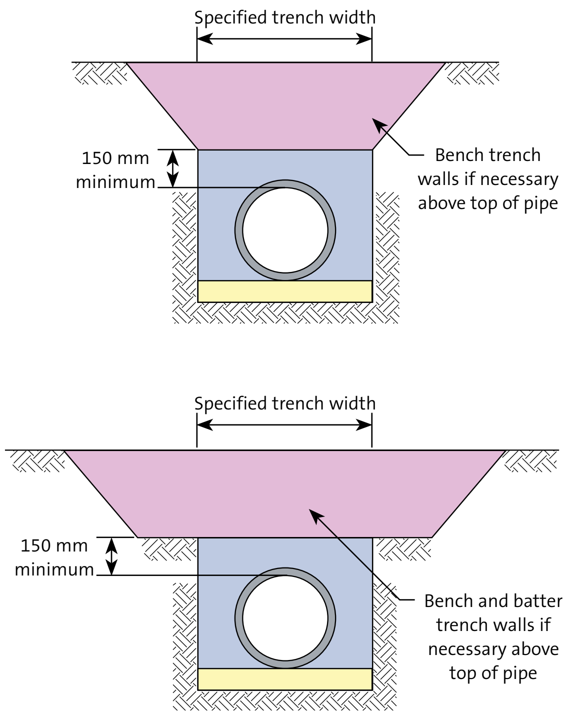


Depth of placement and compaction of both this side zone material and the haunch zone material lower down in the soil profile, is dependent on the type of support specified, HS1, HS2 or HS3.

Narrow trenches can cause difficulty in working and compacting the bedding to the required levels which must be achieved to give the assumed support for the pipe. This is particularly important for type HS3 Support where significant levels of side support are assumed.

Remember, if the width of the trench is increased during installation, this will cause an increase in the load on the pipe. The trench width however, may be increased by benching or battering above the level of the top of the pipe as shown in Figure 9.16.

Figure 9.16 – Trench profile above pipe installation



10. Reference material

The following is a compilation of informative reference material, useful for the hydraulic design and installation of steel reinforced concrete pipe.

Figure 10.1 – Approximate critical depth relationships for circular pipe

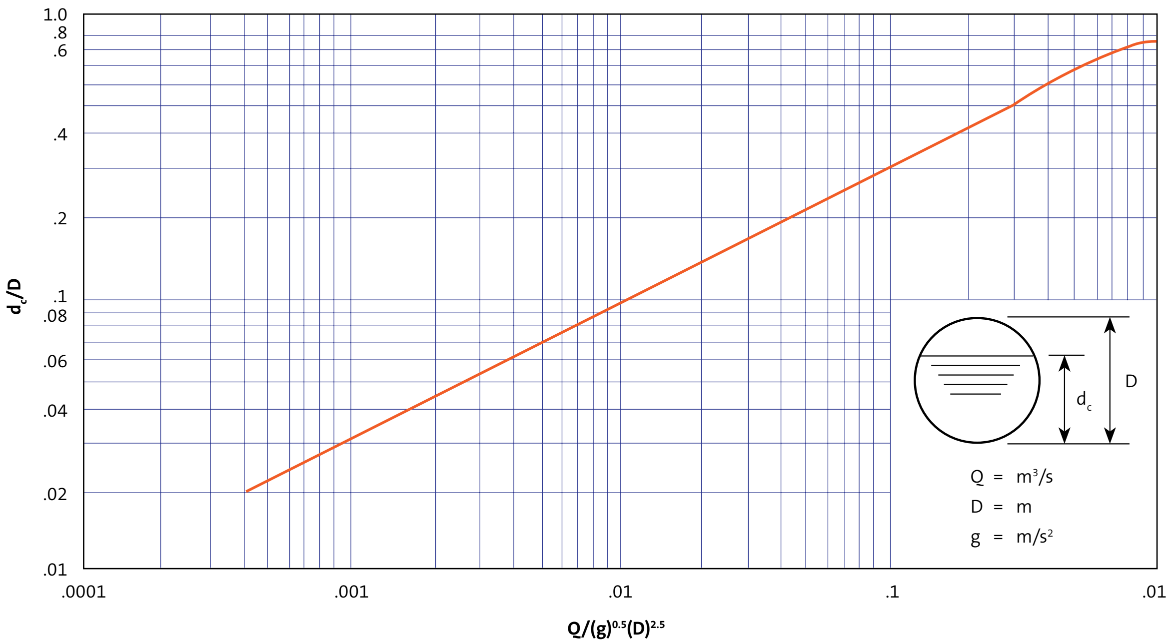


Figure 10.2 – Relative discharge and velocity in part-full pipe flow

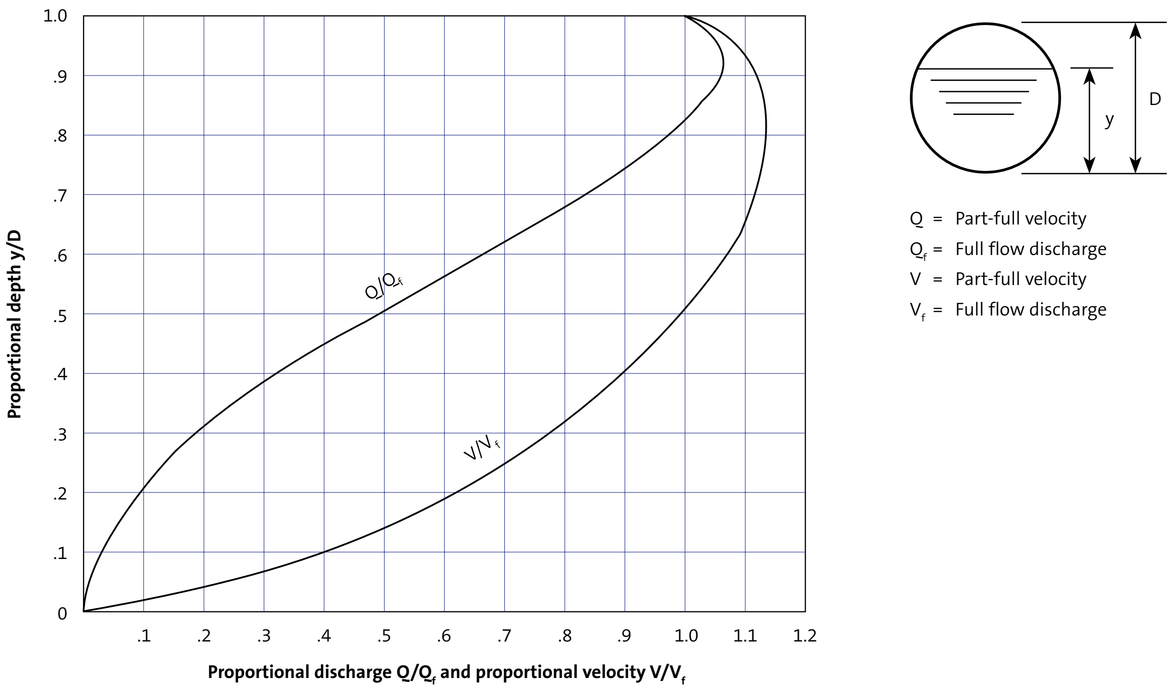


Figure 10.3 – Flow relationships for inlet control in culverts

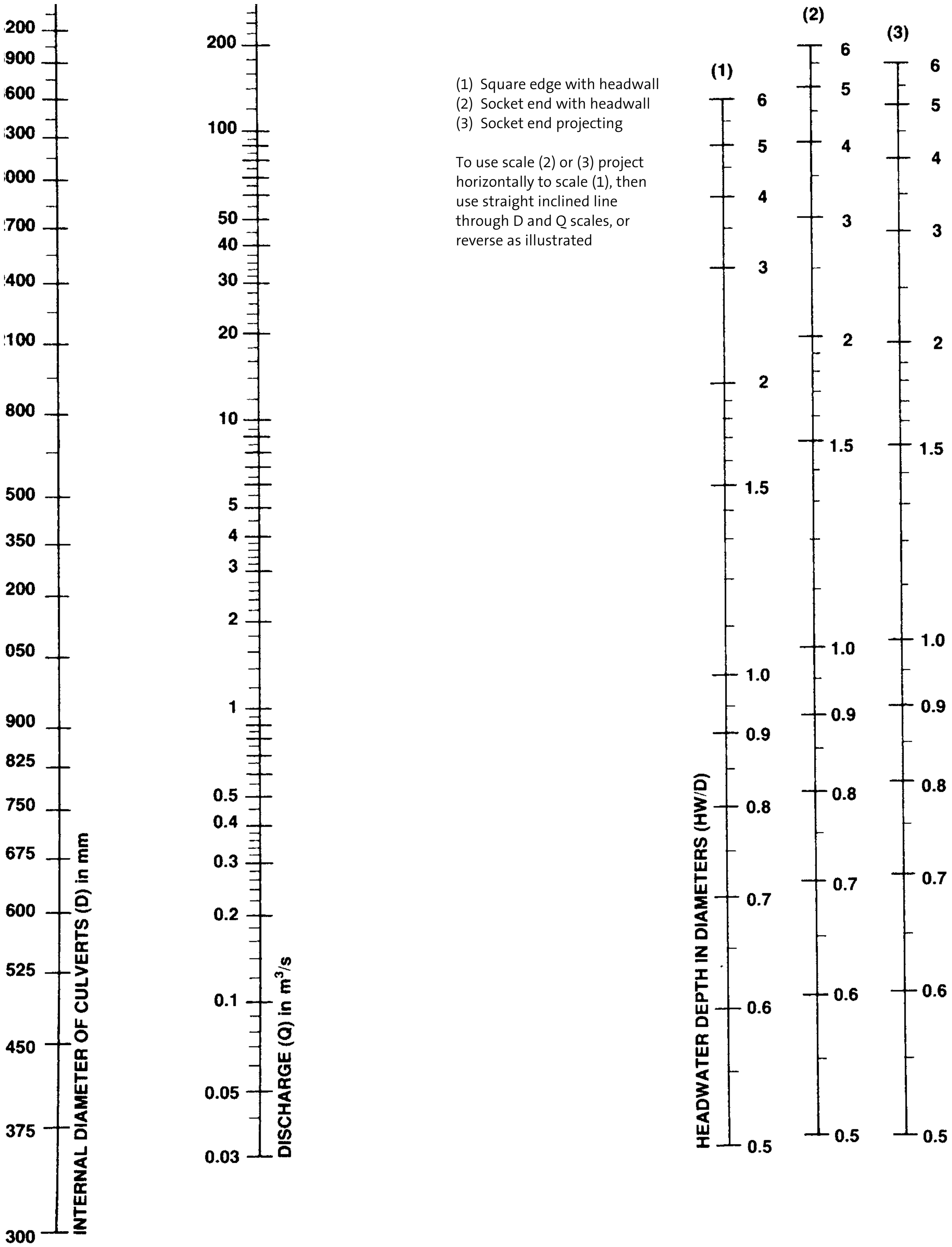


Figure 10.4 – Energy head relationships for pipes flowing full (n = 0.011)

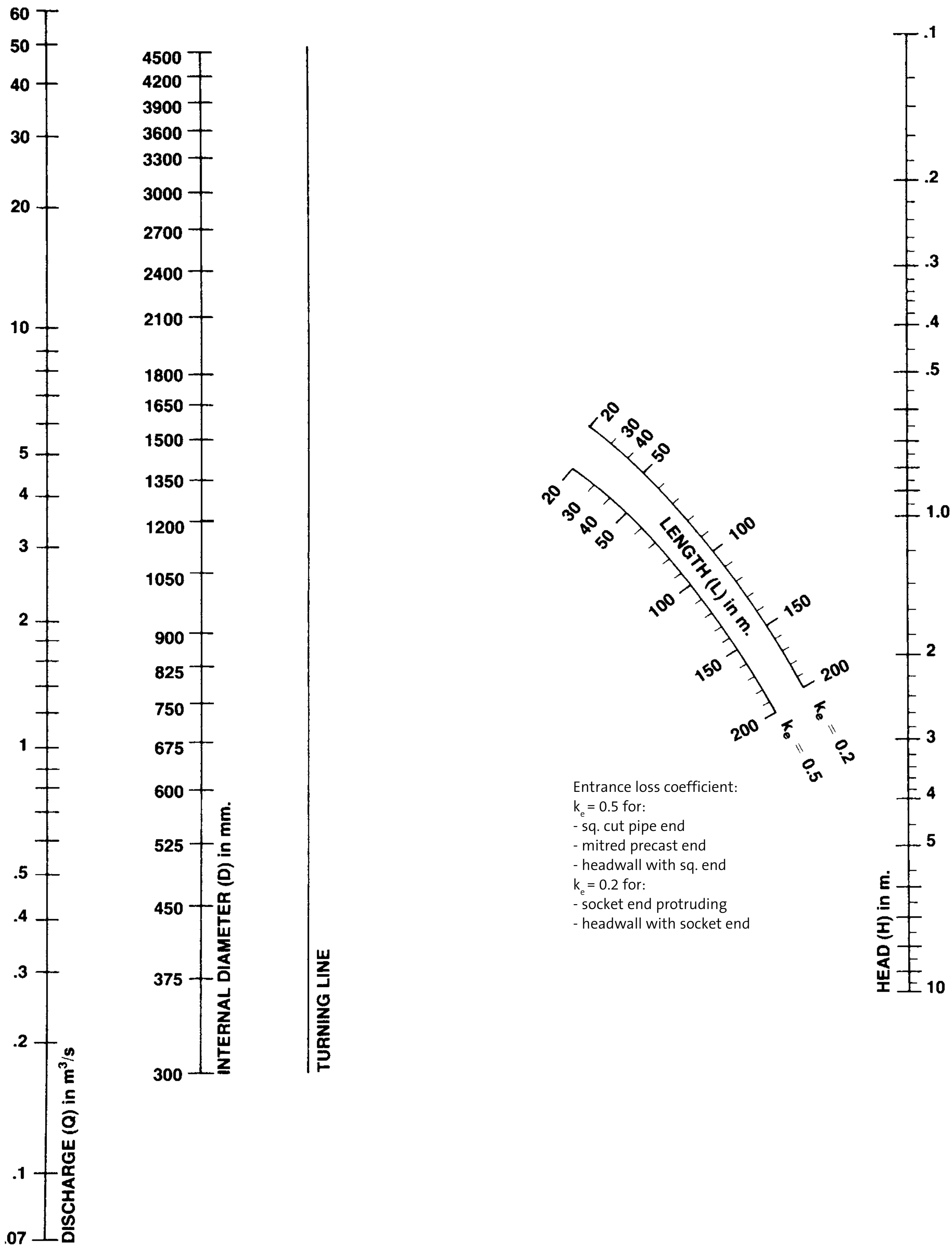


Figure 10.5 – Full flow conditions Colebrook-White formula k_s = 0.06 mm
(applicable to concrete culverts carrying stormwater)

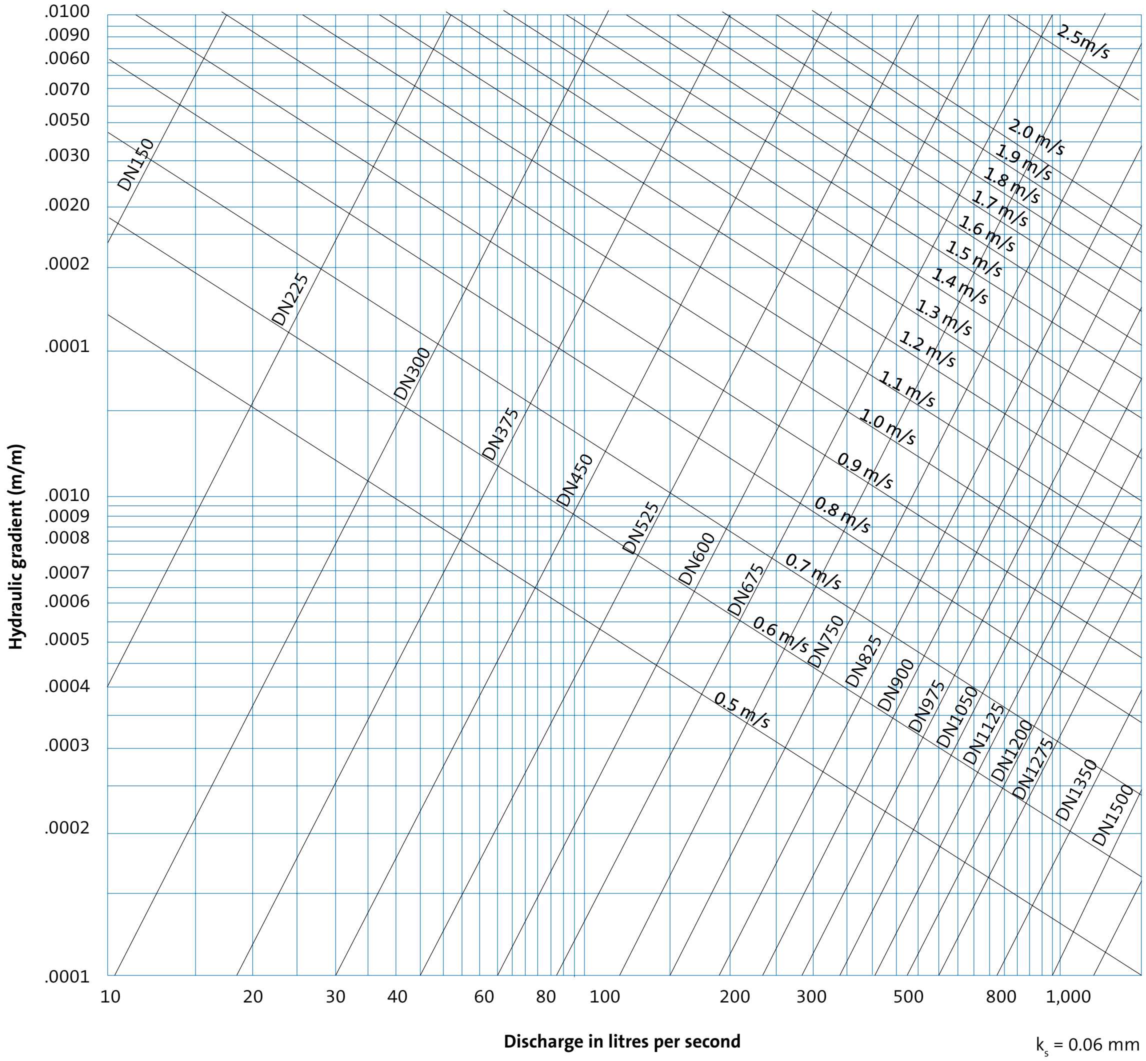


Figure 10.6 – Full flow conditions Colebrook-White formula k_s = 0.15 mm
(applicable to concrete rising mains carrying clean water)

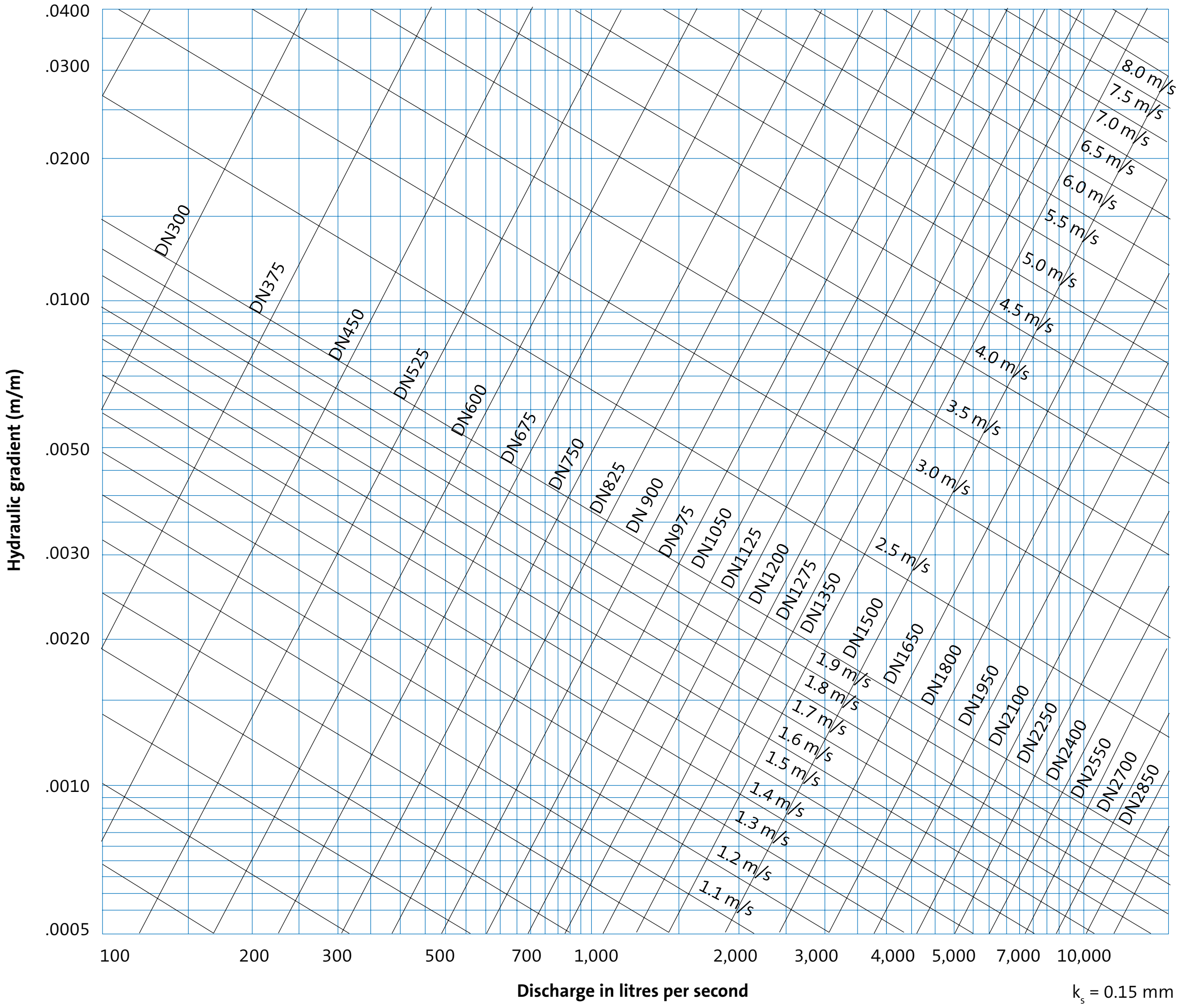


Figure 10.7 – Full flow conditions Colebrook-White formula k_s = 0.06 mm
(applicable to concrete culverts carrying stormwater)

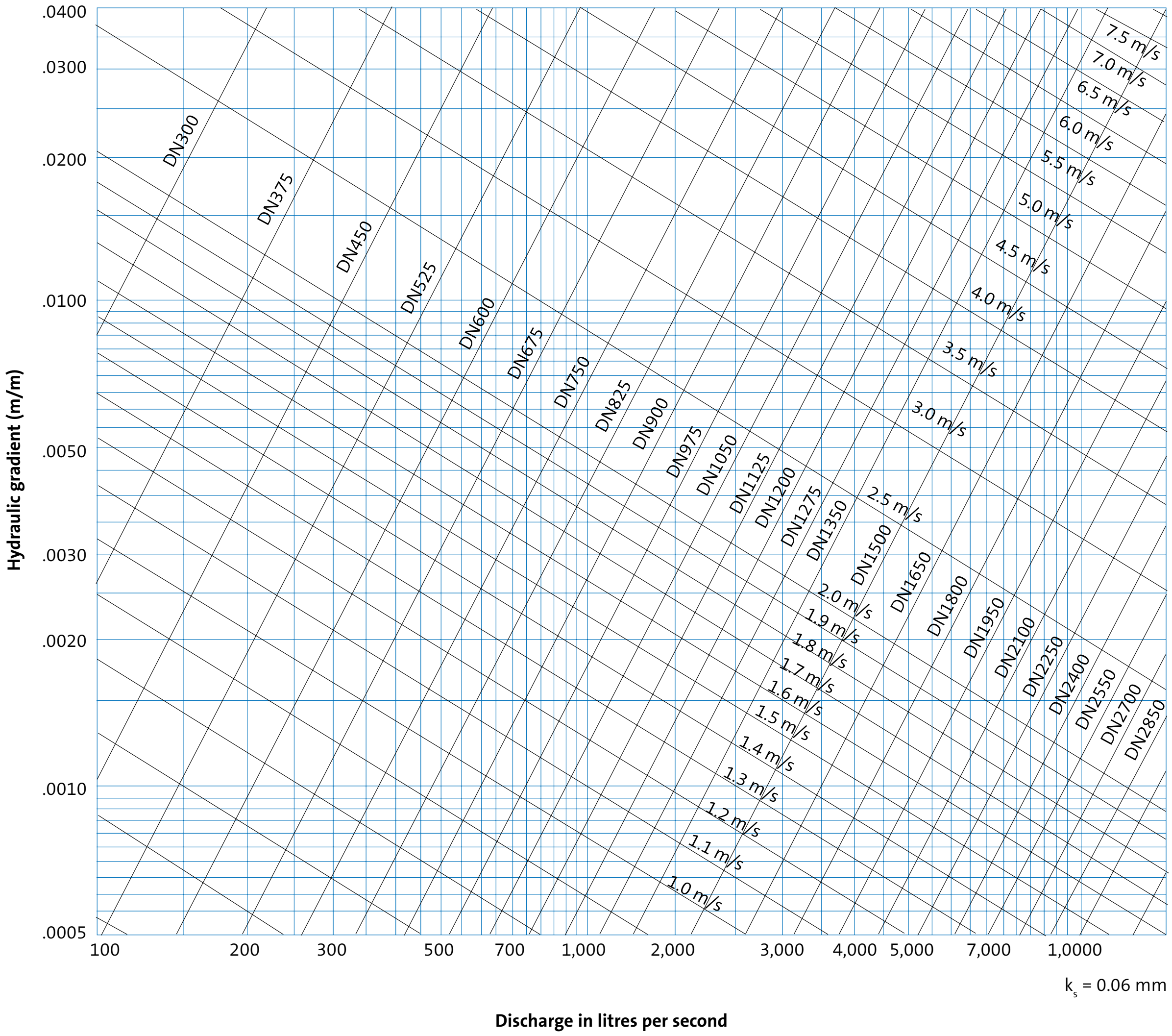


Figure 10.8 – Full flow conditions Colebrook-White formula k_s = 1.5 mm
(applicable to concrete carrying sewerage)

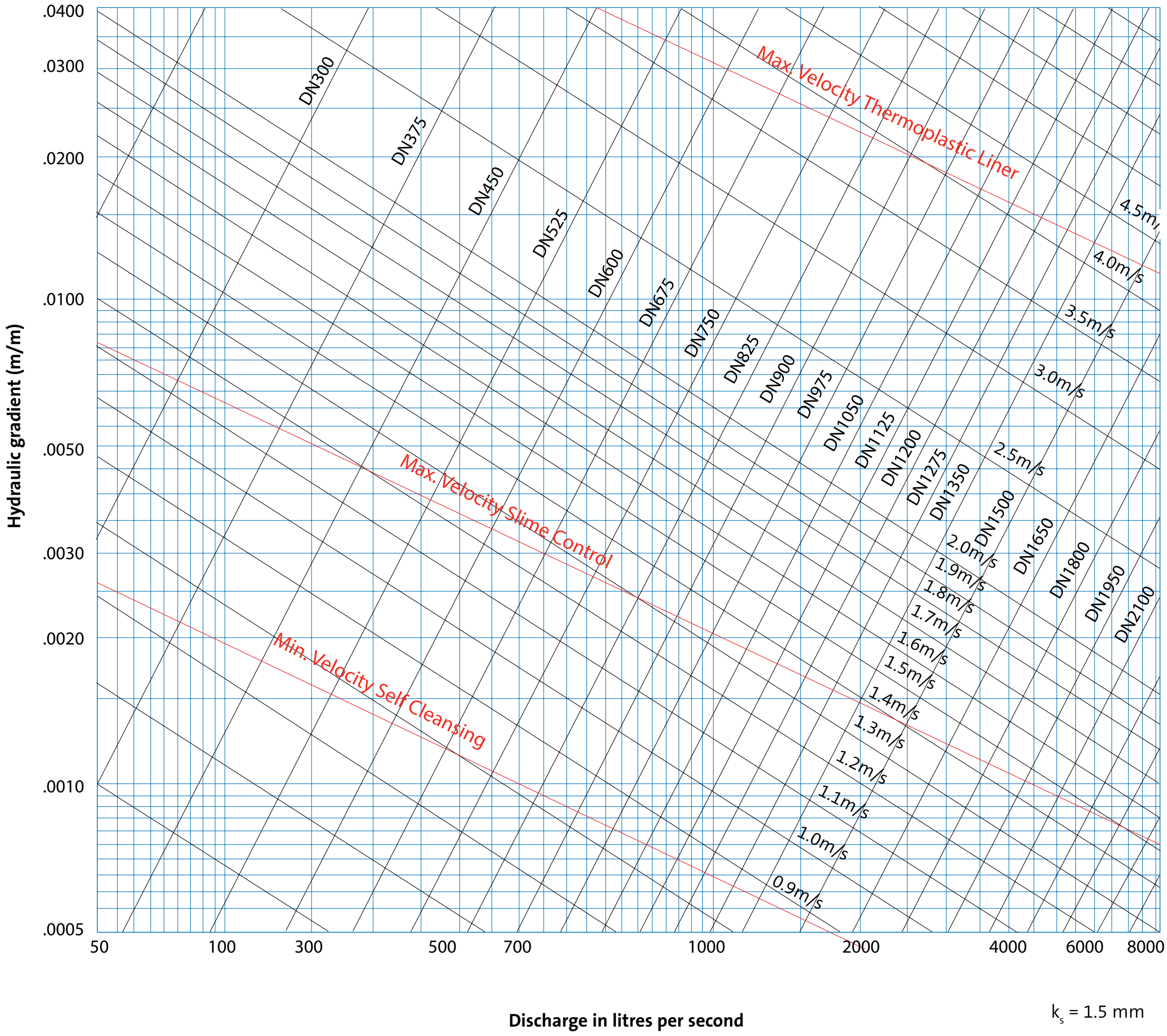
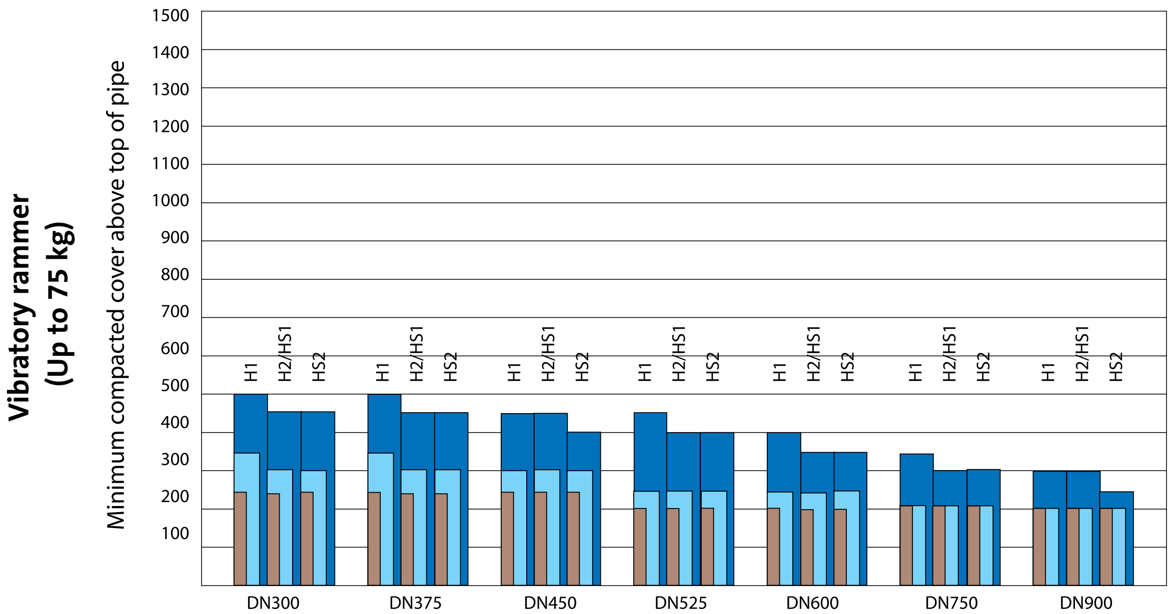
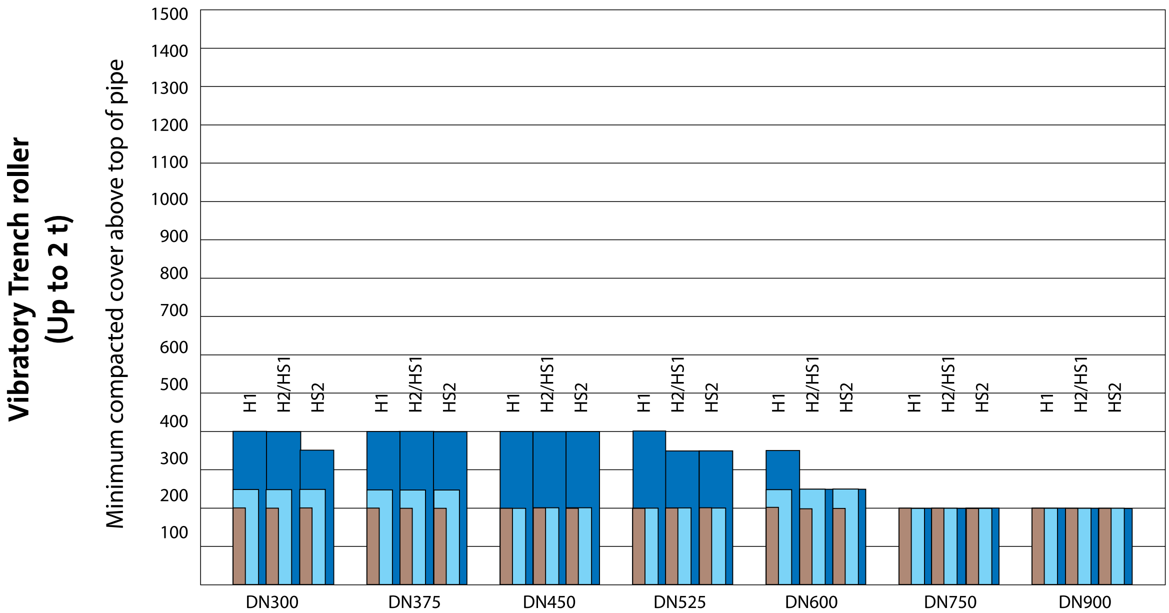


Figure 10.9 – CPPA compaction charts





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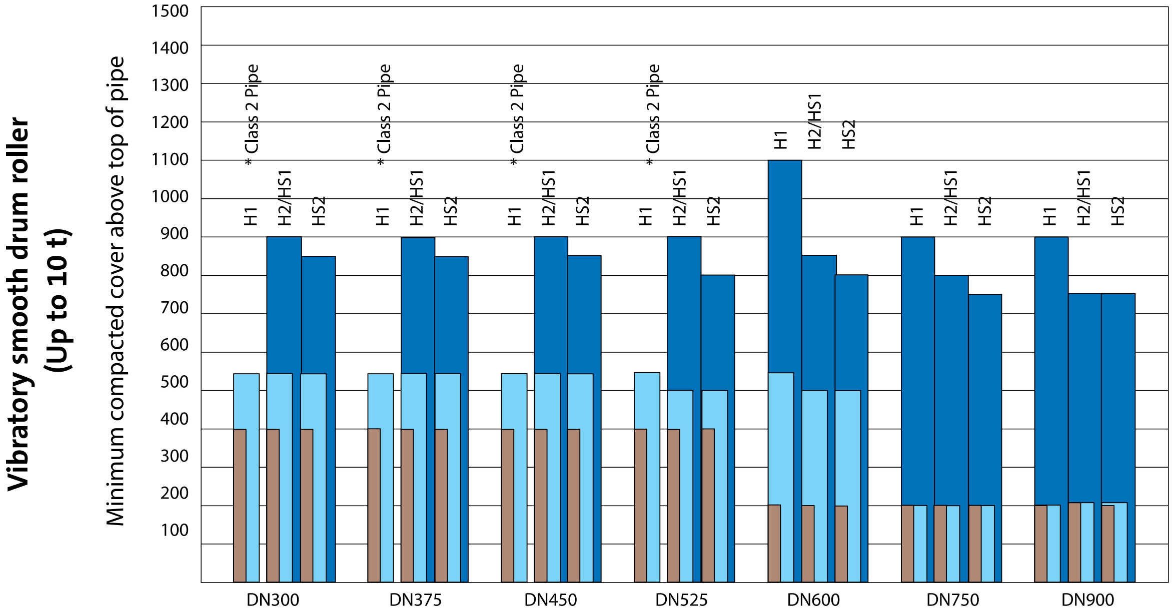
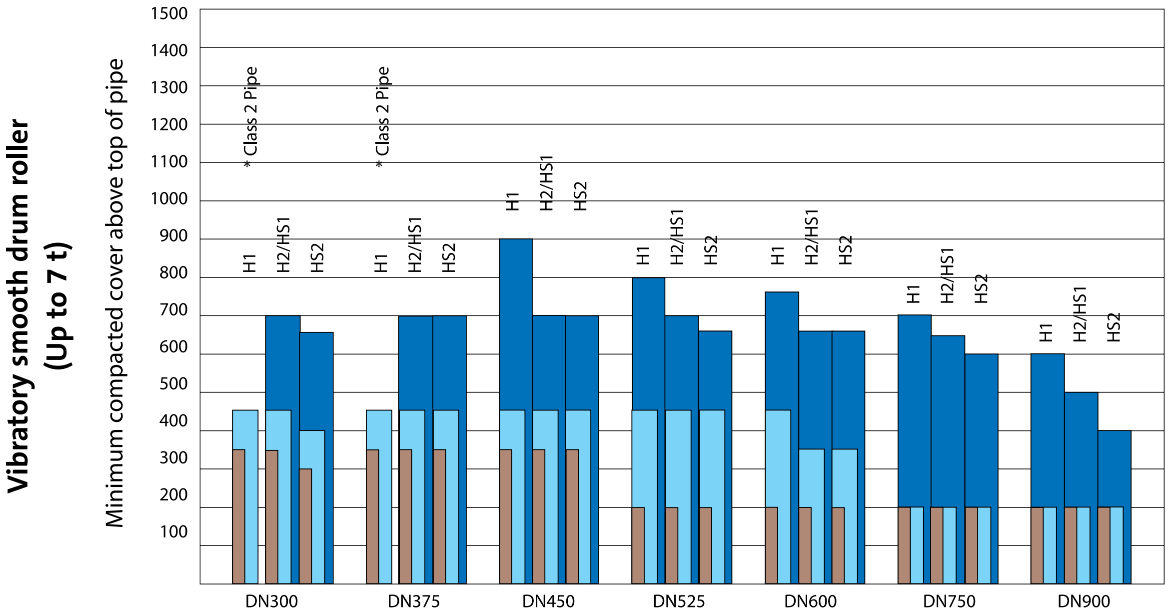
Notes:

1. When using a pedestrian vibrating plate the minimum compacted fill is 125 mm for all pipe classes and trench types.
2. The graphs and diagrams shown are for guidance only. For special applications or for applications not shown on the drawing refer to AS/NZS 3725: 2007 or use the CPAA software, Pipe class v1.2.
3. Widening of the trench beyond the minimum specified in AS/NZS 3725: 2007 will increase the load carried by the pipe and will require a review of the pipe class and trench compaction method.
4. The pipe cover shown on the graphs refers to compacted depth of fill above the pipe crown
5. To obtain sufficient compaction you may have to use shallower fills and possibly a lighter roller.

	Class 2 Pipe
	Class 3 Pipe
	Class 4 Pipe

* Exceeds allowable limits. Do not use.





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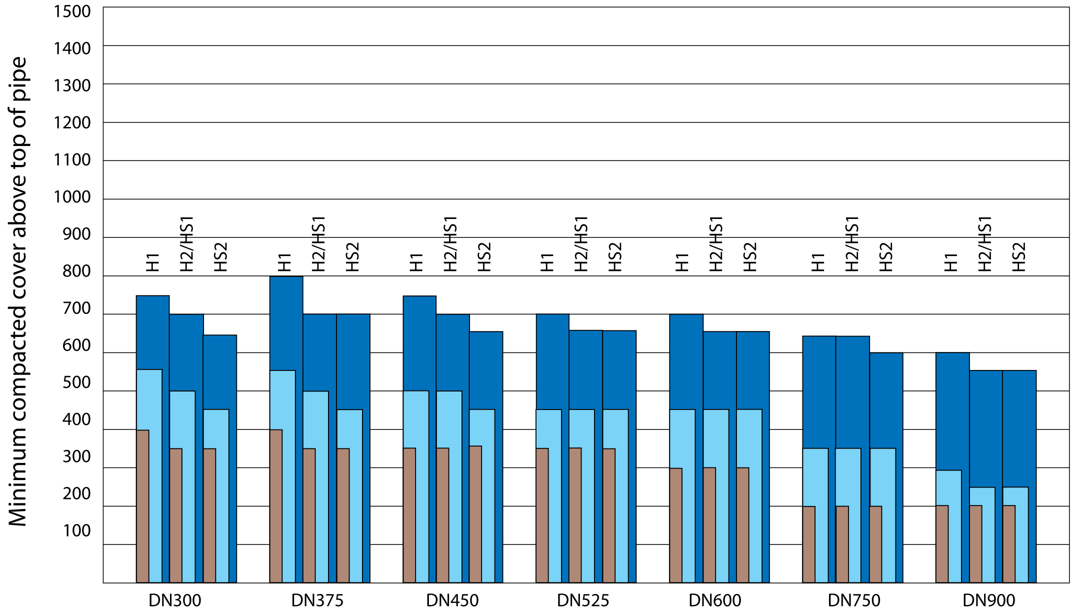
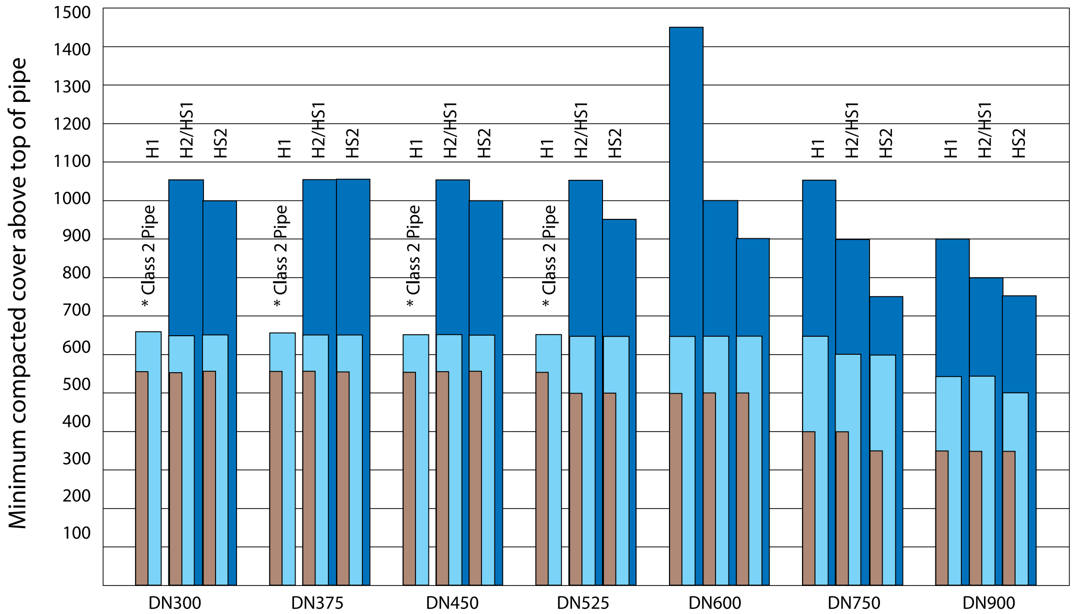
15 t Excavator and compaction wheel



25 t Excavator and compaction wheel



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