



WATER SERVICES
ASSOCIATION OF AUSTRALIA

GRAVITY SEWERAGE CODE OF AUSTRALIA

Version 3.2

(Incorporating Amendment No. 1)

WSA 02-2014

1.1 SCOPE.....	59
1.2 PLANNING AND DESIGN.....	59
1.2.1 Objectives.....	59
1.2.2 Scope and requirements.....	59
1.2.3 Servicing strategies.....	60
1.2.4 Functional design requirements.....	60
1.2.5 Concept plan format.....	61
1.2.6 Critical infrastructure protection.....	62
1.2.6.1 General.....	62
1.2.6.2 Asset categorisation.....	62
1.2.6.3 All hazards – Infrastructure protection.....	63
1.2.7 Detailed design.....	63
1.2.7.1 Designer's needs and responsibilities.....	63
1.2.7.2 Requirements to be addressed.....	63
1.2.7.3 Design outputs.....	64
1.2.7.4 Safety in design.....	65
1.3 CONSULTATION WITH OTHER PARTIES.....	65
1.3.1 Design life.....	65
1.3.2 Instrumentation and control systems.....	65
2 SYSTEM PLANNING.....	69
2.1 GENERAL.....	69
2.2 SEWER SYSTEM PHILOSOPHY AND DEFINITION.....	69
2.2.1 Disaggregation.....	69
2.2.2 Level 1 Total system.....	70
2.2.3 Level 2 Transportation subsystems.....	70
2.2.4 Level 3 operating units.....	70
2.2.4.1 Sewers.....	70
2.2.4.2 Sewage pumping stations (SPSs).....	71
2.2.4.3 Storage.....	71
2.3 PLANNING PRINCIPLES.....	71
2.3.1 Planning horizon.....	71
2.3.2 Concept plan.....	71
2.3.3 Catchment analysis.....	71
2.3.4 Provision for future gauging needs.....	72
2.4 PLANNING PARAMETERS.....	72
2.4.1 Loading per serviced lot.....	72
2.4.2 Estimating future catchment loads.....	73
2.4.3 Estimating existing system loads.....	73
2.4.4 Climate change impacts.....	73
2.4.5 Environmental, cultural and heritage impacts.....	74
2.4.6 Geotechnical investigations.....	74
2.4.7 Contaminated sites.....	74
2.4.8 Operations and maintenance considerations.....	75
2.4.9 Sewer mining.....	75
2.5 SEWAGE QUALITY.....	75
2.5.1 Septicity.....	75

2.5.2 Australian sewage quality management guidelines.....	77
2.6 PLANNING REVIEW.....	77
3 FLOW ESTIMATION.....	78
3.1 GENERAL.....	78
3.2 DESIGN FLOW ESTIMATION.....	78
3.3 DESIGN FLOW ESTIMATION METHOD.....	78
3.3.1 General.....	78
3.3.2 Traditional design flow estimation method.....	79
3.3.3 Design flow estimation incorporating existing systems.....	79
3.3.4 Design flow estimation—Partially pumped systems.....	79
3.3.5 Flow schedule.....	79
4 PRODUCTS AND MATERIALS.....	80
4.1 GENERAL.....	80
4.2 IDENTIFICATION OF SEWER SYSTEMS.....	80
4.3 SERVICABILITY OF SEWER SYSTEMS.....	83
4.4 PROTECTION AGAINST DEGRADATION.....	83
4.5 DUCTILE IRON GRAVITY SEWERS.....	83
4.5.1 Product Specifications.....	83
4.5.2 Sizes and configurations.....	84
4.5.3 Cement mortar lining.....	84
4.5.4 Sleeving.....	85
4.5.5 Screw-on flanges for DI pipes.....	85
4.5.6 Flanged joints.....	85
4.5.7 Coatings.....	86
4.6 PVC GRAVITY SEWERS.....	87
4.6.1 Product Specifications.....	87
4.6.2 Sizes and configurations.....	87
4.7 POLYETHYLENE GRAVITY SEWERS.....	87
4.7.1 Product Specifications.....	87
4.7.2 Sizes and configurations.....	88
4.8 POLYPROPYLENE GRAVITY SEWERS.....	88
4.8.1 Product Specifications.....	88
4.8.2 Sizes and configurations.....	89
4.9 GRP GRAVITY SEWERS.....	89
4.9.1 Product Specifications.....	89
4.9.2 Sizes and configurations.....	89
4.10 PLASTICS-LINED CONCRETE GRAVITY SEWERS.....	89
4.10.1 Product Specifications.....	89
4.10.2 Sizes and configurations.....	90
4.11 VITRIFIED CLAY SEWERS.....	90
4.11.1 Product Specifications.....	90
4.11.2 Sizes and configurations.....	90
4.12 STEEL GRAVITY SEWERS.....	90
4.12.1 Product Specifications.....	90
4.12.2 Sizes and configurations.....	91
4.12.3 Joints.....	91

4.12.4	Field welding.....	91
4.12.5	Flanged joints.....	91
4.13	MAINTENANCE STRUCTURES.....	91
4.13.1	Product Specifications.....	91
4.13.2	Classification and application.....	92
4.13.3	Sizes and configurations.....	93
4.14	MARKING TAPES.....	93
4.14.1	Product Specifications.....	93
4.14.2	Application.....	94
4.15	ACCESS COVERS AND FRAMES.....	94
4.15.1	Product Specifications.....	94
4.15.2	Application.....	94
4.15.3	Cast duction iron access covers and frames.....	94
4.15.4	Polymeric access covers and frames.....	95
4.15.5	Not Used.....	95
4.15.6	Size and configuration.....	95
4.15.7	Marking of access covers and frames.....	96
4.16	VENT SHAFTS.....	96
4.16.1	Product Specifications.....	96
4.16.2	Application.....	96
5	DETAIL DESIGN.....	97
5.1	DETAIL DESIGN PROCESS.....	97
5.2	DETAIL DESIGN CONSIDERATIONS.....	98
5.2.1	Catchment design.....	98
5.2.2	Design accuracy.....	98
5.2.3	Sewer layout.....	98
5.2.4	Location of sewers.....	99
5.2.4.1	General.....	99
5.2.4.2	Sewers located along side boundaries.....	100
5.2.4.3	Sewers located along rear boundaries.....	100
5.2.4.4	Sewers located in small lots (lot area $\leq 450 \text{ m}^2$).....	100
5.2.4.5	Sewers servicing industrial /commercial lots.....	101
5.2.4.6	Branch and trunk sewers.....	101
5.2.5	Trenchless techniques for pipe installation.....	101
5.2.6	Near-horizontal boreholes and tunnels.....	102
5.2.6.1	General.....	102
5.2.6.2	Design requirements.....	102
5.2.6.3	Silt traps.....	103
5.2.7	Environmental, cultural and heritage considerations.....	104
5.2.7.1	General.....	104
5.2.7.2	Urban salinity.....	105
5.2.7.3	Acid sulphate soils.....	105
5.2.7.4	Vegetation.....	105
5.2.7.5	Coastal zones.....	106
5.2.8	Easements.....	106
5.2.9	Disused sewers.....	107

5.2.10 Special design considerations.....	107
5.3 HORIZONTAL ALIGNMENT OF SEWERS.....	107
5.3.1 General.....	107
5.3.2 Roads, reserves and open space.....	107
5.3.3 Railway reserves.....	108
5.3.4 Waterways.....	108
5.3.5 Maintenance structures and vent shafts.....	109
5.3.6 Changes in direction using an MH.....	109
5.3.7 Changes in direction using an MS or MC.....	110
5.3.8 Horizontal curves in sewers.....	110
5.3.8.1 General.....	110
5.3.8.2 Use of manufactured and variable bends in reticulation sewers.....	111
5.3.8.3 Cumulative deflection using pipe joints.....	112
5.4 OBSTRUCTIONS AND CLEARANCES.....	112
5.4.1 General.....	112
5.4.2 Surface obstructions.....	112
5.4.3 Clearance from transmission towers and power lines.....	112
5.4.4 Clearance from structures.....	113
5.4.5 Underground obstructions and services.....	113
5.4.5.1 General.....	113
5.4.5.2 Clearance requirements.....	113
5.4.6 Marker posts.....	115
5.5 PIPE SIZING AND GRADING.....	115
5.5.1 General.....	115
5.5.2 Environmental protection requirements.....	115
5.5.3 Minimum air space.....	115
5.5.4 Minimum pipe sizes for maintenance purposes.....	115
5.5.5 Maximum ET for reticulation sewers.....	116
5.5.5.1 General.....	116
5.5.5.2 Design assumptions.....	117
5.5.6 Limitation on sewer size reduction.....	118
5.5.7 Minimum grades for self-cleansing.....	118
5.5.7.1 General.....	118
5.5.7.2 Reticulation sewers.....	119
5.5.7.3 Property connection sewers and end-of-line sewers.....	120
5.5.8 Minimum grades for slime control.....	120
5.5.9 Maximum grades.....	121
5.5.9.1 Branch and trunk sewers.....	121
5.5.9.2 Reticulation sewers.....	121
5.6 VERTICAL ALIGNMENT OF SEWERS.....	121
5.6.1 General.....	121
5.6.2 Long section design plan.....	121
5.6.3 Minimum cover over sewers.....	122
5.6.4 Lot servicing requirements.....	123
5.6.4.1 General.....	123
5.6.4.2 Serviced area requirements for residential lots.....	123

5.6.4.3	5.6.4.3 Serviced area requirements for industrial and commercial lots.....	123
5.6.4.4	5.6.4.4 Partial lot service.....	123
5.6.4.5	5.6.4.5 Servicing of basements.....	124
5.6.4.6	5.6.4.6 Servicing of developed lots.....	124
5.6.5	5.6.5 Minimum depth of sewer connection point.....	124
5.6.5.1	5.6.5.1 General.....	124
5.6.5.2	5.6.5.2 Soffit requirement.....	124
5.6.5.3	5.6.5.3 Physical losses in customer sanitary drains.....	125
5.6.5.4	5.6.5.4 Depth of connection point.....	126
5.6.6	5.6.6 Grading through MHs.....	126
5.6.6.1	5.6.6.1 General.....	126
5.6.6.2	5.6.6.2 Internal fall through MHs joining sewers of same diameter.....	127
5.6.6.3	5.6.6.3 Internal falls through MHs joining sewers of different diameters.....	127
5.6.6.4	5.6.6.4 Major sewer junctions.....	127
5.6.6.5	5.6.6.5 Large falls at MHs.....	128
5.6.6.6	5.6.6.6 Avoiding hydraulic jumps due to steep grades.....	128
5.6.6.6.1	5.6.6.6.1 GENERAL.....	128
5.6.6.6.2	5.6.6.6.2 BRANCH AND TRUNK SEWERS.....	129
5.6.6.6.3	5.6.6.6.3 RETICULATION SEWERS.....	129
5.6.6.7	5.6.6.7 Avoiding deep channels in MHs due to steep grades.....	130
5.6.7	5.6.7 Vertical curves in sewers.....	131
5.6.8	5.6.8 Compound curves.....	131
6	6 PROPERTY CONNECTION.....	132
6.1	6.1 GENERAL.....	132
6.2	6.2 LIMITATIONS OF CONNECTION TO SEWERS.....	132
6.3	6.3 METHODS OF THE PROPERTY CONNECTION.....	132
6.3.1	6.3.1 General.....	132
6.3.2	6.3.2 IO interface method.....	132
6.3.3	6.3.3 Buried interface method.....	133
6.3.4	6.3.4 Typical layouts of sewers and general arrangements for property connection sewers.....	135
6.3.5	6.3.5 Maximum depth of property connection point.....	137
6.4	6.4 NUMBER OF PROPERTY CONNECTION POINTS.....	138
6.4.1	6.4.1 Single occupancy lots.....	138
6.4.2	6.4.2 Multiple occupancy lots.....	138
6.5	6.5 LOCATION OF PROPERTY CONNECTION POINTS.....	139
6.5.1	6.5.1 General.....	139
6.5.2	6.5.2 Vacant lots.....	139
6.5.3	6.5.3 Lots with existing buildings.....	139
6.6	6.6 PROPERTY CONNECTION SEWERS.....	139
6.6.1	6.6.1 General.....	139
6.6.2	6.6.2 'Type 7 spur' or 'Y' property sewer connections.....	140
6.7	6.7 LENGTH OF PROPERTY CONNECTION SEWERS.....	141
7	7 MAINTENANCE STRUCTURES.....	142
7.1	7.1 TYPES OF MAINTENANCE STRUCTURES.....	142
7.2	7.2 LOCATIONS OF MAINTENANCE STRUCTURES.....	142
7.3	7.3 SPACING OF MAINTENANCE STRUCTURES.....	143

7.3.1 General.....	143
7.3.2 Maintenance structure spacing—Reticulation sewers.....	145
7.3.3 Maintenance structure spacing—Branch and trunk sewers.....	146
7.4 SPECIAL CONSIDERATIONS FOR LOCATION OF MAINTENANCE STRUCTURES.....	146
7.5 SPECIAL CONSIDERATIONS FOR CONNECTION OF NEW SEWERS TO EXISTING SEWERS.....	147
7.6 MAINTENANCE HOLES (MHs).....	148
7.6.1 General.....	148
7.6.2 Types of MH construction.....	148
7.6.3 Design parameters for MHs.....	148
7.6.4 Design requirements for connection of sewers to MHs.....	148
7.6.4.1 Pre-cast concrete MH base units.....	149
7.6.4.2 Cast in-situ concrete MH base units.....	150
7.6.4.3 Rocker pipes.....	153
7.6.5 Connection of property connection sewers into MHs.....	154
7.6.6 MH drops.....	154
7.6.7 Diameters of MHs.....	158
7.6.8 MH base layout.....	158
7.6.9 Ladders, step irons and landings.....	158
7.7 MAINTENANCE SHAFTS (MSs) / MAINTENANCE CHAMBERS (MCs).....	159
7.7.1 General.....	159
7.7.2 Design parameters for MCs, MSs and TMSs.....	159
7.7.3 Connections to MCs, MSs and TMSs.....	160
7.7.3.1 Connections to PE MSs and TMSs.....	161
7.7.3.2 Connections to pre-cast concrete MC base units.....	162
7.7.3.3 Connections to PP MCs and MSs.....	163
7.7.4 High-level connections to MCs, MSs and TMSs.....	163
7.7.4.1 High-level connections into a pre-cast concrete MC.....	165
7.7.4.2 High-level connections into a PE MC and MS.....	166
7.7.4.3 High-level connections into a PVC-U MS.....	167
7.7.4.4 High-level connections into a PP MC and MS.....	168
7.8 INSPECTION SHAFTS (ISs).....	171
7.8.1 General.....	171
7.8.2 Terminal inspection shaft (Type A).....	172
7.8.3 Vertical drop inspection shaft (Type B).....	172
7.8.4 Intermediate inspection shaft (Type C).....	172
7.8.5 Ends of pipe.....	173
7.8.5.1 Temporary ends of pipe.....	173
7.8.5.2 Permanent ends of pipe.....	173
7.9 MAINTENANCE STRUCTURE COVERS.....	173
7.9.1 General.....	173
7.9.2 Cross-fall on MH covers.....	176
7.9.3 Modifications to existing maintenance holes.....	176
7.10 SEWERS FROM JUNCTIONS.....	176
7.11 OTHER MAINTENANCE STRUCTURES AT INTERFACE OF PROPERTY CONNECTION SEWERS AND SANITARY DRAINS.....	177

8 ANCILLIARY STRUCTURES.....	178
8.1 GENERAL.....	178
8.2 WATER SEALS, BOUNDARY TRAPS, WATER-SEALED MHs AND GAS CHECK MHs.....	178
8.2.1 Boundary traps on sanitary drains.....	179
8.2.1.1 General.....	179
8.2.1.2 Responsibility for installation of boundary traps.....	179
8.2.2 Water seals, water-sealed MHs and gas check MHs.....	180
8.2.2.1 General.....	180
8.2.2.2 Water seals on reticulation sewers entering branch or trunk sewers.....	180
8.2.2.3 Water seals on branch sewers entering trunk sewers.....	180
8.2.3 Water-sealed MHs and gas check MHs.....	181
8.2.3.1 General.....	181
8.2.3.2 Water-sealed MHs.....	181
8.2.3.3 Gas check MHs.....	183
8.3 VERTICAL AND NEAR VERTICAL SEWERS.....	185
8.3.1 General.....	185
8.3.2 Design parameters for bored, exposed and encased vertical and near vertical sewers.....	185
8.4 VENTILATION.....	186
8.4.1 General.....	186
8.4.2 Design parameters for ventilation and location of vent shafts.....	186
8.4.3 Design details for ventilation lines, vent shafts and cowls.....	187
8.5 VORTEX INLETS AND WATER CUSHIONS.....	187
8.6 INVERTED SYPHONS.....	188
8.6.1 General.....	188
8.6.2 Design parameters for inverted syphons.....	188
8.7 EMERGENCY RELIEF STRUCTURES.....	190
8.7.1 General.....	190
8.7.2 Design parameters for ERSs.....	191
8.7.2.1 General.....	191
8.7.2.2 Configuration.....	191
8.7.2.3 Overflow pipe.....	192
8.7.2.4 Overflow level.....	192
8.8 FLOW MEASURING DEVICES.....	194
8.8.1 General.....	194
8.8.2 Within the sewer system.....	194
8.8.3 At a sewage pumping station.....	195
8.9 WET WEATHER STORAGE.....	195
8.9.1 General.....	195
8.9.2 Design considerations.....	196
9 STRUCTURAL DESIGN.....	197
9.1 GENERAL.....	197
9.2 PRODUCTS AND MATERIALS.....	197
9.3 STRUCTURAL CONSIDERATIONS.....	197
9.3.1 Pipes.....	197
9.3.2 Design factors affecting buried flexible and rigid pipes.....	198
9.3.3 Maintenance structures.....	198

9.4	LOADINGS.....	198
9.4.1	External forces.....	198
9.4.2	Native soil strength.....	199
9.4.3	Embedment zone dimensions.....	200
9.4.4	Pipe embedment.....	200
9.4.5	Buoyancy.....	201
9.4.6	Flotation.....	202
9.5	FOUNDATION DESIGN AND GROUNDWATER CONTROL.....	202
9.5.1	Migration of fines.....	203
9.6	GEOTECHNICAL CONSIDERATIONS.....	203
9.6.1	General.....	203
9.6.2	Pipelines in engineered or controlled fill.....	206
9.6.3	Pipelines in non-engineered fill.....	207
9.6.4	Filling along route of pipeline.....	207
9.6.5	Mine subsidence.....	207
9.6.6	Slip areas.....	208
9.6.7	Water-charged ground.....	208
9.7	SPECIAL EMBEDMENT CONCRETE AND STABILISED SUPPORTS.....	208
9.7.1	General.....	208
9.7.2	Requirements.....	209
9.8	ABOVE GROUND CROSSINGS.....	210
9.9	PIPE COVER.....	211
9.10	BULKHEADS AND TRENCHSTOPS.....	211
9.11	TRENCH DRAINAGE.....	212
10	DESIGN REVIEW AND DRAWINGS.....	219
10.1	DESIGN REVIEW.....	219
10.2	DESIGN DRAWINGS.....	219
10.2.1	General.....	219
10.2.2	Composition of Design Drawings.....	219
10.2.3	Scale.....	220
10.2.4	Real property information.....	220
10.2.5	Sewers.....	220
10.2.6	Structures.....	221
10.2.7	Longitudinal sections (profiles).....	221
10.2.8	Title block notation and standard notes.....	222
10.2.9	Other.....	222
10.3	SEWER SYSTEM ACRONYMS.....	223
10.4	SPECIFICATIONS.....	223
10.5	RECORDING OF WORK AS CONSTRUCTED INFORMATION.....	224
PART 2: CONSTRUCTION.....		226
11	GENERAL.....	226
11.1	SCOPE.....	226
11.1.1	Resolution of complaints.....	226
11.2	INTERPRETATION.....	226
12	GENERAL CONSTRUCTION.....	228
12.1	GENERAL.....	228

12.2 ORDER OF CONSTRUCTION, TESTING AND COMMISSIONING.....	228
12.3 CONTRACT INTERFACES.....	228
12.4 CUSTOMER FOCUS.....	228
12.4.1 General.....	228
12.4.2 Resolution of complaints.....	229
12.5 PROTECTION OF PROPERTY AND ENVIRONMENT.....	229
12.5.1 Protection of other services.....	229
12.5.2 Road reserves or other thoroughfares.....	230
12.5.2.1 Road opening permits.....	230
12.5.2.2 Treatment of pavements and other surfaces.....	230
12.5.2.3 Cleanliness of roads, paths, accesses and drainage paths.....	230
12.5.2.4 Storage of products, materials, equipment and excavated material.....	230
12.5.2.5 Obstruction of street drainage.....	230
12.5.3 Private and public lands.....	230
12.5.4 Protection of the environment and heritage areas.....	231
12.5.4.1 General.....	231
12.5.4.2 Collection and disposal of wastes.....	231
12.5.4.3 Protection of adjacent lands and vegetation.....	231
12.5.4.4 Control of water pollution.....	232
12.5.4.5 Contaminated soils.....	234
12.5.4.6 Control of noise and atmospheric pollution.....	234
12.5.4.7 Equipment and machinery use in bush fire prone areas.....	234
12.6 DISUSED SEWERS.....	234
12.7 OPERATION OF WATER SUPPLY NETWORK.....	234
12.8 ALTERATION OF EXISTING SERVICES.....	235
12.9 SURVEY MARKS.....	235
12.10 CONSTRUCTION TOLERANCES.....	235
12.11 LATENT CONDITIONS.....	235
13 PRODUCTS AND MATERIALS.....	236
13.1 APPROVED PRODUCTS AND MATERIALS.....	236
13.2 DELIVERY INSPECTION OF PRODUCTS AND MATERIALS.....	236
13.3 TRANSPORTATION, HANDLING AND STORAGE OF PRODUCTS AND MATERIALS.....	236
13.3.1 General.....	236
13.3.2 Transportation.....	237
13.3.3 Unloading and handling.....	237
13.3.4 On-site storage.....	237
13.3.5 Plastics-lined concrete products.....	238
13.3.6 Coiled plastics pipe.....	238
13.4 CONCRETE WORKS.....	238
13.5 SUPPLY OF WATER TO THE WORKS.....	239
14 EXCAVATION.....	240
14.1 PRECAUTIONS.....	240
14.2 LIMITS OF CLEARING AND EXCAVATION.....	240
14.3 PROTECTION OF TREES.....	240
14.3.1 General precautions.....	240
14.3.2 Protection of roots.....	240

14.4	BLASTING.....	240
14.5	SUPPORT OF EXCAVATIONS.....	241
14.6	DRAINAGE AND DEWATERING.....	241
14.7	EXCAVATION ACROSS IMPROVED SURFACES.....	241
14.8	TRENCH EXCAVATION.....	242
14.8.1	General.....	242
14.8.2	Construction of embankment.....	242
14.8.3	Clearances for on-site works.....	242
14.9	REFILL OF EXCESSIVE EXCAVATION.....	242
14.10	FOUNDATIONS AND FOUNDATION STABILISATION.....	243
14.11	SURPLUS EXCAVATED MATERIAL.....	243
14.12	EXCAVATION AND PIPELAYING USING TRENCHLESS TECHNIQUES.....	244
15	BEDDING FOR PIPES AND MAINTENANCE STRUCTURES.....	245
15.1	TRENCH FLOOR PREPARATION.....	245
15.2	BEDDING MATERIALS.....	245
15.2.1	Placement of bedding.....	245
15.3	SPECIAL PIPE SUPPORT FOR NON-SUPPORTIVE SOILS.....	245
15.4	BEDDING FOR MAINTENANCE CHAMBERS, MAINTENANCE SHAFTS, INSPECTION SHAFTS AND BENDS.....	245
15.5	BEDDING FOR MAINTENANCE HOLES.....	246
16	PIPE LAYING AND JOINTING.....	247
16.1	INSTALLATION OF PIPES.....	247
16.1.1	General.....	247
16.1.2	Cleaning, inspection and joint preparation.....	247
16.1.3	Coiled plastics pipes.....	247
16.1.4	Laying.....	247
16.2	HORIZONTAL AND VERTICAL DEFLECTION OF SEWERS.....	248
16.2.1	General.....	248
16.2.2	Methods of deflection.....	248
16.2.3	Horizontal curves.....	249
16.2.4	Vertical curves.....	249
16.2.5	Compound curves.....	250
16.3	HORIZONTAL AND VERTICAL SEPARATION OF CROSSING PIPELINES.....	250
16.4	FLOTATION CONTROL.....	250
16.5	TRENCH STOPS.....	250
16.6	BULKHEADS.....	250
16.7	PROPERTY CONNECTION SEWERS.....	250
16.8	DEAD ENDS.....	251
16.9	MARKING OF PROPERTY CONNECTION SEWERS AND DEAD ENDS.....	251
16.10	CORROSION PROTECTION OF CAST IRON.....	251
16.11	MARKERS.....	251
16.11.1	Non-detectable marking tape.....	251
16.11.2	Detectable marking tape.....	251
16.12	BORED PIPES UNDER ROADS, DRIVEWAYS AND ELSEWHERE.....	252
16.13	AQUEDUCTS.....	252
16.14	BRIDGE CROSSINGS.....	252

16.15 PLASTICS-LINED RC PIPE JOINTING.....	252
16.15.1 General.....	252
16.15.2 Plastics lining work protection.....	252
16.15.3 Field jointing.....	253
16.15.4 Plastics lining ancillary work.....	253
16.15.4.1 Alignment of lining keys.....	253
16.15.4.2 Provision of seepage channels.....	253
16.15.4.3 Use of jointing accessories and adhesives.....	253
16.16 WELDING OF STEEL PIPELINES.....	253
16.16.1 General.....	253
16.16.2 Field welding of flanges.....	253
16.16.3 Reinstatement of cement mortar lining.....	254
16.16.4 Reinstatement of external corrosion protection at joints using a tape system.....	254
16.16.4.1 General.....	254
16.16.4.2 Surface preparation.....	254
16.16.4.3 Priming surfaces.....	254
16.16.4.4 Mastic filler.....	255
16.16.4.5 Tape application.....	255
16.16.5 Reinstatement of external corrosion protection at joints using a heat-shrinkable sleeve system.....	256
16.16.5.1 Surface preparation.....	256
16.16.5.2 Preheat pipe.....	257
16.16.5.3 Priming surfaces.....	257
16.16.5.4 Mastic filler.....	257
16.16.5.5 Heat-shrinkable sleeve preparation.....	257
16.16.5.6 Heat-shrinkable sleeve application.....	257
16.17 WELDING OF PE PIPELINES.....	257
16.17.1 General.....	257
16.17.2 Welder qualifications.....	258
16.17.3 Connections to pipes of other materials.....	258
16.18 FLANGED JOINTS.....	258
17 MAINTENANCE HOLES (MHs).....	259
17.1 GENERAL.....	259
17.2 CONCRETE MHs.....	259
17.2.1 Concrete MH base.....	259
17.2.2 Pre-cast concrete MH systems.....	259
17.2.3 Cast in-situ concrete MH.....	259
17.2.4 Benching and channels.....	260
17.2.5 Concreting for thermoplastics-lined works.....	260
17.2.5.1 Concrete work planning.....	260
17.2.5.2 Fixing of thermoplastics lining for concrete work.....	260
17.2.5.3 Concrete placement and formwork removal.....	260
17.2.6 Internal coating of concrete MHs.....	261
17.3 GLASS REINFORCED PLASTICS (GRP) MHs.....	261
17.4 POLYETHYLENE (PE) MHs.....	261
17.5 POLYPROPYLENE (PP) MHs.....	261

17.6 TRENCH DRAINAGE AROUND MHs.....	261
17.7 COVERS.....	261
17.8 CONNECTIONS TO MHs.....	261
17.9 MH DROPS.....	261
17.10 LADDERS, STEP IRONS AND LANDINGS.....	262
18 MAINTENANCE CHAMBERS (MC), MAINTENANCE SHAFTS (MS AND TMS) AND INSPECTION OPENINGS (IO) OR INSPECTION SHAFTS (IS).....	263
18.1 GENERAL.....	263
18.2 SEALING CAPS.....	263
18.3 COVERS.....	263
18.4 CONNECTIONS TO MCs, MSs AND TMSs.....	263
19 PIPE EMBEDMENT AND SUPPORT.....	264
19.1 GENERAL.....	264
19.2 EMBEDMENT MATERIALS.....	264
19.3 COMPACTION OF EMBEDMENT.....	264
19.3.1 Methods.....	264
19.3.2 Compaction trials / Pre-qualification of embedment compaction method.....	265
19.3.2.1 General.....	265
19.3.2.2 Test method.....	265
19.3.2.3 Interpretation and applicability.....	265
19.3.3 Compaction control.....	265
19.4 SPECIAL BEDDING AND EMBEDMENTS / GEOTEXTILE SURROUND AND PILLOW.....	265
19.5 REMOVAL OF TRENCH SUPPORTS.....	265
19.6 CONCRETE EMBEDMENT AND ENCASEMENT.....	266
20 FILL.....	267
20.1 TRENCH FILL.....	267
20.1.1 General.....	267
20.1.2 Material requirements.....	267
20.1.2.1 Trafficable areas.....	267
20.1.2.2 Non-trafficable areas.....	267
20.1.3 Placement.....	268
20.1.4 Compaction of trench fill.....	268
20.2 EMBANKMENT FILL.....	269
20.3 DRIVES AND TUNNEL FILL.....	269
21 ACCEPTANCE TESTING.....	270
21.1 GENERAL.....	270
21.2 VISUAL INSPECTION—ABOVE-GROUND.....	270
21.3 COMPACTION TESTING.....	271
21.3.1 General.....	271
21.3.2 Compaction testing requirements.....	272
21.3.2.1 General.....	272
21.3.3 Embedment compaction testing.....	273
21.3.3.1 Applicable pipe sizes.....	273
21.3.3.2 Frequency and location of embedment tests.....	273
21.3.3.3 Retesting.....	273
21.3.4 Trench fill compaction testing.....	273

21.3.4.1	Trafficable test zone.....	273
21.3.4.2	Non-trafficable test zone.....	273
21.3.4.3	Test method.....	273
21.3.4.4	Frequency and location of tests.....	274
21.3.4.5	Retesting.....	274
21.3.5	Other fill compaction testing.....	274
21.3.5.1	General.....	274
21.3.5.2	Trafficable test zone.....	274
21.3.5.3	Non-trafficable test zone.....	274
21.3.5.4	Frequency and location of tests.....	274
21.3.5.5	Retesting.....	275
21.4	AIR PRESSURE AND VACUUM TESTING OF SEWERS.....	275
21.4.1	General.....	275
21.4.2	Air testing methods for sewers.....	275
21.4.2.1	Vacuum testing.....	275
21.4.2.2	Low pressure air testing.....	276
21.4.3	Testing of sewers >DN 1500.....	277
21.4.3.1	General.....	277
21.4.3.2	Method of test.....	277
21.4.4	Testing of non-pressure PE sewers.....	277
21.4.5	Testing of concrete MHs.....	277
21.4.5.1	General.....	277
21.4.5.2	Test method.....	278
21.5	INFILTRATION TESTING.....	279
21.6	DEFLECTION (OVALITY) TESTING OF FLEXIBLE SEWERS.....	279
21.6.1	General.....	279
21.6.2	Ovality proving tools.....	280
21.6.3	Flexible sewers ≤DN 300.....	280
21.6.4	Flexible sewers >DN 300.....	280
21.6.4.1	General.....	280
21.6.4.2	Flexible sewers >DN 300 and <DN 750.....	281
21.6.4.3	Flexible sewers ≥DN 750.....	282
21.7	MEASUREMENT OF SEWER GRADE.....	282
21.8	INTERNAL INSPECTION.....	282
21.9	INSPECTION AND TESTING OF THERMOPLASTICS LINED CONCRETE SEWERS AND MHs.....	282
21.9.1	Visual inspection.....	282
21.9.2	Spark testing.....	283
21.9.3	Locking key pull-out tests.....	283
21.10	PRESSURE TESTING OF INVERTED SYPHONS.....	283
21.10.1	General.....	283
21.10.2	Hydrostatic system test pressure.....	284
21.10.3	Satisfactory pressure test.....	284
22	TOLERANCES ON AS-CONSTRUCTED WORK.....	285
22.1	HORIZONTAL TOLERANCES.....	285
22.1.1	Sewers and on-line structures.....	285

22.1.2 Property connection sewers.....	285
22.2 VERTICAL TOLERANCES.....	285
22.2.1 Sewers and structures.....	285
22.2.2 Property connection risers and inspection openings.....	285
22.2.3 Grade.....	286
22.2.4 Verticality ("plumb").....	286
22.3 TOLERANCES ON FINISHED SURFACE STRUCTURES AND FITTINGS.....	286
22.4 TOLERANCES ON CAST IN-SITU CONCRETE STRUCTURES AND SLABS.....	286
23 CONNECTION TO EXISTING SEWERS.....	288
24 RESTORATION.....	289
24.1 GENERAL.....	289
24.2 PAVEMENTS.....	289
24.3 LAWNS.....	289
24.4 GRASSED AREAS.....	290
24.5 BUSHLAND.....	290
24.6 PROVISION FOR AND RECTIFICATION OF SETTLEMENT.....	290
24.7 MAINTENANCE OF RESTORED SURFACES.....	290
25 WORK AS CONSTRUCTED DETAILS.....	291
APPENDICES.....	292
APPENDIX A — GENERIC INFRASTRUCTURE PROTECTION GUIDANCE.....	292
A1 INFRASTRUCTURE PROTECTION TREATMENTS - SELECTION AND DEFINITION.....	292
A2 RISK MANAGEMENT - INFRASTRUCTURE PROTECTION RISK ASSESSMENTS.....	292
A3 INFRASTRUCTURE PROTECTION DESIGN CONSIDERATIONS.....	292
A4 INFRASTRUCTURE PROTECTION TREATMENTS.....	293
A5 SECURITY DESIGN CONCEPTS.....	293
A6 ENVIROMENTAL DESIGN CONSIDERATIONS.....	294
A7 SEWER FAILURE IMPACT ASSESSMENT.....	295
A8 WATER AGENCY'S ENVIRONMENTAL AESTHETICS GUIDANCE.....	296
APPENDIX B — ESTIMATION OF EQUIVALENT POPULATION (EP).....	304
B1 GENERAL.....	304
B2 ESTIMATION METHOD.....	304
B2.1 Residential component.....	304
B2.1.1 Single occupancy lots.....	304
B2.1.2 Multiple occupancy lots—Medium density residential.....	304
B2.1.3 Multiple occupancy lots—High-density / multi-storey residential.....	305
B2.2 Commercial and special use components.....	305
B2.3 Industrial component.....	305
B2.3.1 General.....	305
APPENDIX C — FLOW ESTIMATION FOR DEVELOPMENT AREAS.....	307
C1 GENERAL.....	307
C2 PEAK DRY WEATHER (SANITARY) FLOW.....	307
C3 GWI CALCULATION.....	309
C4 RDI CALCULATION.....	309
C5 WORKED EXAMPLE FOR A RESIDENTIAL DEVELOPMENT.....	312
C5.1 <i>Description</i>	312
C5.2 <i>Peak dry weather flow (PDWF)</i>	312

C5.3 Ground water infiltration (GWI).....	313
C5.4 Rainwater dependent inflow and infiltration (RDI).....	313
C5.5 Design flow.....	314
APPENDIX D — PROTECTION AGAINST DEGRADATION.....	315
D1 GENERAL.....	315
D2 PROTECTION AGAINST INTERNAL CORROSION.....	315
D3 PROTECTION AGAINST EXTERNAL AGGRESSIVE ENVIRONMENT.....	315
D4 PROTECTION AGAINST EXTERNAL CONTAMINATED GROUND.....	316
APPENDIX E — GUIDELINES FOR VENTILATION OF RETICULATION SEWERS.....	318
E1 INTRODUCTION.....	318
E2 VENTING OF RETICULATION SEWERS.....	319
E2.1 Consideration at the Planning Stage.....	319
E2.2 Location and spacing of educt and induct vents.....	319
E3 EDUCT VENT SHAFTS.....	320
E3.1 Types.....	320
E3.2 Design requirements.....	320
E3.2.1 Material selection.....	320
E3.2.2 General.....	320
E3.3 Educt vent cowls.....	321
E3.4 Installation limitations.....	321
E3.4.1 Guy-wire vents.....	321
E3.4.2 Post type vents.....	321
E3.4.3 Wall vents.....	321
E4 INDUCT VENT SHAFTS.....	321
E5 STANDARD DRAWINGS.....	322
APPENDIX F — TRENCHLESS TECHNOLOGIES.....	323
F1 GENERAL.....	323
F2 HORIZONTAL DIRECTIONAL DRILLING (HDD).....	323
F3 MICRO-TUNNELLING.....	323
F4 UNGUIDED BORING/THRUST BORING/AUGER BORING.....	324
F5 PIPE JACKING.....	324
F6 MINI-TUNNELLING.....	324
APPENDIX G — USE OF BENDS, FITTINGS AND MAINTENANCE SHAFTS/CHAMBERS.....	328
G1 GENERAL.....	328
G2 MAINTENANCE SHAFT AND MAINTENANCE CHAMBER BASE CONFIGURATIONS.....	329
G2.1 STANDARD MAINTENANCE SHAFT CONFIGURATIONS.....	330
G2.2 STANDARD MAINTENANCE CHAMBER CONFIGURATIONS.....	332
G3 NOTATION AND SYMBOLS FOR MAINTENANCE SHAFTS/CHAMBERS AND VARIABLE BENDS.....	335
G4 USE OF BENDS IN RETICULATION SEWERS.....	335
G4.1 VARIABLE-BEND USAGE.....	336
G4.1.1 General.....	336
G4.1.2 Variable bends - DWV PVC-U Pipes.....	336
G4.1.3 Minimum bend radii – DWV PVC-U bends.....	337
G4.1.4 Variable bend deflection limits – DWV PVC-U variable bends.....	337
G4.1.5 Polyethylene (PE) sweep bends.....	339

G4.1.6 Minimum bend radii - polyethylene (PE) sweep bends.....	339
G4.1.7 Typical PE sweep bend assembly.....	340
G4.2 MANUFACTURED-BEND USAGE.....	340
APPENDIX H — PROPERTY CONNECTION TYPES.....	341
H1 SCOPE.....	341
H2 TYPE 1 - PROPERTY CONNECTION SEWERS.....	341
H3 TYPE 2 - RISER PROPERTY CONNECTION SEWERS.....	342
H4 TYPE 3 - SLOPING RISER PROPERTY CONNECTION SEWERS.....	344
H5 TYPE 4 - VERTICAL RISER FOR PROPERTY CONNECTION SEWERS.....	344
H6 TYPE 5 - SLOPING RISER FOR PROPERTY CONNECTION SEWERS.....	345
H7 TYPE 6 - VERTICAL JUNCTION FOR PROPERTY CONNECTION SEWERS.....	345
H8 TYPE 7 - SPUR PROPERTY CONNECTION SEWERS.....	347
APPENDIX I — MAXIMUM DEPTH TO INVERT FOR STANDARD SUPPORT TYPES.....	349
I1 GENERAL.....	349
I2 STRUCTURAL DESIGN.....	349
I2.1 Flexible buried pipelines.....	349
I2.2 Precast concrete pipes pipelines.....	349
I2.3 Trench width dimensions.....	350
I3 EMBEDMENT MATERIAL.....	350
I4 TRENCH FILL.....	350
I5 COMPACTION.....	351
I6 MAXIMUM DEPTH TO INVERT FOR STANDARD SUPPORT TYPE.....	351
APPENDIX J — PIPELINES IN SLIP AND POTENTIALLY UNSTABLE AREAS.....	356
J1 INTRODUCTION.....	356
J2 SLIP AND UNSTABLE AREAS.....	356
J2.1 FACTORS INFLUENCING STABILITY OF SLOPES.....	357
J2.1.1 Soil and rock condition.....	357
J2.1.2 Angle of slope.....	357
J2.1.3 Groundwater and surface water.....	357
J2.1.4 Domestic development.....	357
J2.1.5 Vegetation.....	357
J2.1.6 Road construction.....	357
J3 IDENTIFICATION OF POTENTIALLY UNSTABLE AREAS.....	357
J4 PRECAUTIONS.....	358
J4.1 GRAVITY SEWERS AND PRESSURE MAINS.....	358
J4.1.1 Gravity sewers.....	358
J4.1.2 Pressure mains	359
J4.2 ALTERNATIVE SEWERAGE SYSTEMS AND CONSTRUCTION TECHNIQUES.....	360
J4.3 SHALLOW TRENCH OR ABOVE-GROUND CONSTRUCTION.....	360
J4.4 DESIGN FOR POSSIBLE GROUND MOVEMENT.....	361
J4.5 CONSIDER GROUNDWATER AND DRAINAGE.....	361
J4.6 PRECAUTIONS DURING CONSTRUCTION.....	363
APPENDIX K — OVALITY TESTING OF PVC AND GRP GRAVITY SEWERS DEFAULT PROVING TOOL DIAMETERS.....	365
K1 GENERAL.....	365
K2 REQUIREMENTS.....	365

APPENDIX L — SPECIFICATION FOR INTERNAL INSPECTION OF NEWLY CONSTRUCTED OR REHABILITATED SEWERS.....	367
L1 INTRODUCTION.....	367
L2 INSPECTION REQUIREMENTS.....	367
L3 QUALIFICATIONS OF INSPECTORS AND ACCEPTANCE ASSESSORS.....	367
L4 WORK AS CONSTRUCTED.....	368
L5 REPORTING SUMMARIES.....	368
L6 ACCEPTANCE INSPECTION REPORTS.....	369
L7 MATERIALS.....	370
L8 STEEL REINFORCED CONCRETE PIPE.....	371
L9 DEFORMATION OF FLEXIBLE CONDUITS.....	371
L10 LATERAL INSPECTION.....	372
L11 INSPECTION AT THE END OF DEFECTS LIABILITY PERIOD.....	372
L12 MANUFACTURING DEFECTS.....	372
L13 RISK ASSESSMENT AND RECTIFICATION.....	372
L14 ACCEPTANCE PARAMETERS.....	373
Definitions.....	385

List of Figures

Figure 2.1 DISAGGREGATION MODEL FOR TRANSPORTATION SUBSYSTEMS.....	69
Figure 3.1 FLOW COMPONENTS IN A GRAVITY SYSTEM.....	78
Figure 4.1 FLANGE FASTENER TIGHTENING SEQUENCE.....	85
Figure 5.1 PHYSICAL LOSSES IN CUSTOMER SANITARY DRAINS.....	125
Figure 5.2 DEPTH OF POINT OF CONNECTION AND USE OF RISERS.....	126
Figure 5.3 EXCESSIVELY DEEP CHANNELS CAUSED BY STEEP GRADES.....	130
Figure 5.4 INCOMING LEVEL ADJUSTED TO PREVENT DEEP CHANNEL.....	130
Figure 6.1 TYPICAL RAISED INSPECTION OPENING INTERFACE METHOD.....	133
Figure 6.2 TYPICAL BURIED INTERFACE METHOD – VARIATION (A).....	134
Figure 6.3 TYPICAL BURIED INTERFACE METHOD – VARIATION (B).....	135
Figure 6.4 PROPERTY CONNECTION POINTS FOR SEWERS IN ROAD RESERVES – IO INTERFACE METHOD.....	136
Figure 6.5 PROPERTY CONNECTION POINTS FOR SEWERS IN EASEMENTS AND PRIVATE LOTS – BURIED INTERFACE METHOD.....	137
Figure 6.6 TYPICAL CONNECTION TO DEEP SEWERS IN PRIVATE PROPERTY.....	138
Figure 6.7 'TYPE 7 'SPUR' OR 'Y' PROPERTY SEWER CONNECTIONS - BURIED INTERFACE METHOD.....	140
Figure 7.1 SINGLE MS OR MC BETWEEN CONSECUTIVE MHS.....	145
Figure 7.2 MULTIPLE MS OR MC BETWEEN CONSECUTIVE MHS.....	145
Figure 7.3 NO MS OR MC BETWEEN LAST MH AND IS, TMS OR MCs.....	146
Figure 7.4 SINGLE MS/MC BETWEEN LAST MH AND IS, TMS OR MC.....	146
Figure 7.5 TYPICAL PRE-CAST MH BASE WITH PRE-FORMED BENCHING.....	150
Figure 7.6 TYPICAL PRE-CAST CONCRETE MH BASE WITH CONICAL BENCHING.....	150
Figure 7.7 TYPICAL CAST IN-SITU CONCRETE MH BASE FOR VC, RC AND DI RRJ SEWERS.....	151
Figure 7.8 TYPICAL CAST IN-SITU CONCRETE MH BASE FOR PVC RRJ SEWERS.....	151
Figure 7.9 TYPICAL CAST IN-SITU CONCRETE MH BASE FOR PVC-U SCJ.....	151
Figure 7.10 TYPICAL CAST IN-SITU CONCRETE MH BASE FOR VC AND GRP SLEEVED COUPLED SEWERS.....	152

Figure 7.11 TYPICAL CAST IN-SITU CONCRETE MH BASE FOR PROFILE WALL PP SEWERS.....	152
Figure 7.12 TYPICAL CAST IN-SITU CONCRETE MH BASE FOR SOLID WALL PE SEWERS.....	153
Figure 7.13 TYPICAL CAST IN-SITU CONCRETE MH WITH EXTERNAL DROP PIPE (PVC-U DWV RRJ SEWER PIPE SHOWN).....	155
Figure 7.14 TYPICAL PRE-CAST CONCRETE MH WITH EXTERNAL DROP PIPE (PVC-U DWV RRJ SEWER PIPE SHOWN).....	156
Figure 7.15 TYPICAL CAST IN-SITU CONCRETE MH WITH INTERNAL DROP PIPE (PVC-U DWV SEWER PIPE SHOWN).....	157
Figure 7.16 TYPICAL MH BASE DESIGN.....	158
Figure 7.17 TYPICAL ARRANGEMENTS FOR THE CONNECTION OF PE SEWERS.....	161
Figure 7.18 TYPICAL ARRANGEMENTS FOR THE CONNECTION OF A PE MS TO PE SEWERS.....	162
Figure 7.19 TYPICAL PVC-U CAP ASSEMBLY AND FITTINGS.....	162
Figure 7.20 TYPICAL ARRANGEMENT FOR THE CONNECTION TO A PRE-CAST CONCRETE MC.....	163
Figure 7.21 TYPICAL PP MC AND MS CONNECTION DETAILS.....	163
Figure 7.22 TYPICAL TMS WITH PROPERTY CONNECTION AHEAD.....	165
Figure 7.23 TYPICAL PRE-CAST MC WITH HIGH-LEVEL CONNECTION.....	166
Figure 7.24 TYPICAL PE MC OR MS DROP DETAIL DIMENSIONS.....	167
Figure 7.25 TYPICAL PVC-U MS DROP DETAIL DIMENSIONS.....	168
Figure 7.26 TYPICAL PP MC/MS WITH HIGH-LEVEL CONNECTION.....	169
Figure 7.27 TYPICAL EXTERNAL SEWER DROP STRUCTURE TYPE A - 45° SLOPE JUNCTION.....	170
Figure 7.28 TYPICAL EXTERNAL SEWER DROP STRUCTURE TYPE B - 90° SLOPE JUNCTION.....	171
Figure 7.29 TERMINAL INSPECTION SHAFT – TYPE A.....	172
Figure 7.30 VERTICAL DROP INSPECTION SHAFT – TYPE B.....	172
Figure 7.31 INTERMEDIATE INSPECTION SHAFT – TYPE C.....	173
Figure 7.32 ACCESS REQUIREMENTS FOR SEWERS FROM JUNCTIONS.....	177
Figure 8.1 APPLICATION OF WATER SEAL ARRANGEMENTS.....	178
Figure 8.2 TYPICAL BOUNDARY TRAP AND SHAFT.....	180
Figure 8.3 TYPICAL WATER SEAL ON INLET SEWER.....	181
Figure 8.4 TYPICAL WATER-SEALED MH WITH EXTERNAL DROP – PLAN VIEW.....	182
Figure 8.5 TYPICAL WATER-SEALED MH WITH EXTERNAL DROP – ELEVATION.....	182
Figure 8.6 TYPICAL WATER-SEALED MH WITH MINIMUM DROP – PLAN VIEW.....	183
Figure 8.7 TYPICAL WATER-SEALED MH WITH MINIMUM DROP - ELEVATION.....	183
Figure 8.8 TYPICAL GAS CHECK MH – SECTIONAL PLAN.....	184
Figure 8.9 TYPICAL GAS CHECK MH – SECTION ELEVATION.....	184
Figure 8.10 TYPICAL GAS CHECK MH – INTERNAL DROP ARRANGEMENT SECTION ELEVATION.....	185
Figure 8.11 TYPICAL SYPHON CREEK CROSSING.....	190
Figure 8.12 TYPICAL PE PIPE SECTION.....	190
Figure 8.13 TYPICAL ERS ARRANGEMENT – PLAN.....	193
Figure 8.14 TYPICAL ERS ARRANGEMENT – ELEVATION.....	193
Figure 8.15 TYPICAL HEADWALL ARRANGEMENT - ELEVATION.....	194
Figure 9.1 TYPICAL ARRANGEMENT FOR BURIED FLEXIBLE PIPELINES.....	199
Figure 9.2 TYPE 1 SUPPORT FOR RIGID PIPES ONLY.....	200
Figure 9.3 TYPE 2 SUPPORT FOR RIGID PIPES ONLY.....	201
Figure 9.4 TYPE 3 SUPPORT FOR FLEXIBLE AND RIGID PIPES.....	201

Figure 9.5 TYPE 4 EMBEDMENT SUPPORT WITH GEOTEXTILE FILTER FABRIC FOR FLEXIBLE AND RIGID PIPES.....	203
Figure 9.6 TYPE 5 AND 6 SUPPORT UTILISING CONCRETE FOUNDATION.....	204
Figure 9.7 TYPE 7 SUPPORT UTILISING GEOTEXTILE PILLOW FOUNDATION FOR RIGID AND FLEXIBLE PIPES.....	204
Figure 9.8 TYPE 8 SUPPORT UTILISING CEMENT STABILISED FOUNDATION FOR RIGID AND FLEXIBLE PIPES.....	205
Figure 9.9 TYPE 9 EMBEDMENT SUPPORT.....	205
Figure 9.10 TYPE 10 EMBEDMENT SUPPORT.....	206
Figure 9.11 TYPE 11 EMBEDMENT SUPPORT.....	206
Figure 9.12 TYPE 12R SUPPORT CONCRETE EMBEDMENT.....	209
Figure 9.13 TYPE 12U SUPPORT CONCRETE ENCASEMENT.....	210
Figure 9.14 TYPE 13 SUPPORT UTILISING CEMENT STABILISED EMBEDMENT.....	210
Figure 9.15 TYPICAL CONCRETE BULKHEAD DETAIL.....	213
Figure 9.16 TYPICAL ROAD CROSSING BULKHEAD.....	214
Figure 9.17 TYPICAL TRENCHSTOP DETAIL.....	215
Figure 9.18 TYPICAL TRENCH DRAINAGE DETAIL AT BULKHEAD.....	216
Figure 9.19 TYPICAL TRENCH DRAINAGE DISCHARGE.....	216
Figure 9.20 TYPICAL TRENCH DRAINAGE DETAIL AT LOW POINT IN TRENCH.....	217
Figure 9.21 TYPICAL TRENCH DRAINAGE DETAIL AT CONCRETE ENCASED SECTIONS.....	217
Figure 9.22 TYPICAL TRENCH DRAINAGE AROUND MHs.....	218
Figure 16.1 BALL AND SOCKET JOINT.....	255
Figure 16.2 SLIP-IN WELDED JOINT.....	255
Figure 16.3 PLAIN END WELDED COLLAR JOINT.....	256
Figure 16.4 PLAIN END BUTT WELDED JOINT.....	256
Figure 16.5 CML/FBPE WELDED JOINT (CLPEWJ).....	256
Figure C.1 FLOW COMPONENTS IN A GRAVITY SYSTEM.....	307
Figure C.2 "d" FACTOR VERSUS EP – EP < 50000.....	308
Figure C.3 "d" FACTOR VERSUS AREA - AREAS < 1000 Ha.....	308
Figure G.1 TYPICAL VARIABLE BEND ADAPTORS.....	336
Figure G.2 TYPICAL VARIABLE BEND ASSEMBLY.....	336
Figure H.1 TYPE 1 RUN-IN PROPERTY CONNECTION SEWER.....	342
Figure H.2 TYPE 2 RISER PROPERTY CONNECTION SEWER.....	343
Figure H.3 TYPE 3 SLOPING RISER PROPERTY CONNECTION SEWER.....	344
Figure H.4 TYPE 4 VERTICAL JUMP-UP PROPERTY CONNECTION SEWER.....	344
Figure H.5 TYPE 5 SLOPING RISER FOR PROPERTY CONNECTION SEWER.....	345
Figure H.6 TYPE 6 VERTICAL JUNCTION FOR PROPERTY CONNECTION SEWER.....	346
Figure H.7 TYPE 7A SPUR RUN-IN PROPERTY CONNECTION SEWER.....	347
Figure H.8 TYPE 7B SPUR JUMP-UP PROPERTY CONNECTION SEWER.....	348
Figure H.9 TYPE 7C VERTICAL SPUR PROPERTY CONNECTION SEWER.....	348
Figure J.1 Example of Typical Talus Slopes.....	356
Figure J.2 CUT AND FILL SCENARIO.....	358
Figure J.3 POTENTIALLY UNSTABLE/LANDSLIP AREAS MONITORING PITS FOR DN 100 AND DN 150 RETICULATION MAINS IN ROAD RESERVES.....	359
Figure J.4 Examples of Shallow trench, above-ground construction.....	361
Figure J.5 Groundwater regime.....	362

Figure J.6 Groundwater Seepage path.....	363
Figure L.1 Summary Report Template (blue text is example only).....	369

List of Tables

Table 1.1 ASSET CATEGORIES.....	62
Table 1.2 TYPICAL ASSET DESIGN LIFE.....	65
Table 1.3 PLANNING AND DESIGN APPROACH.....	66
Table 4.1 COLOUR IDENTIFICATION OF COMPONENTS IN RETICULATION SEWER SYSTEMS.....	80
Table 4.2 LIMITATIONS OF SEWAGE CHEMISTRY CONSTITUENTS FOR USE OF DIFFERENT TYPES OF CEMENT.....	84
Table 5.1 MAXIMUM LIMIT OF DEVIATION IN LEVEL AND LINE OF BOREHOLES AND TUNNELS.....	103
Table 5.2 MAXIMUM ALLOWABLE DEFLECTIONS THROUGH A MH1.....	109
Table 5.3 METHODS OF ACHIEVING CURVED SEWERS.....	110
Table 5.4 CLEARANCES BETWEEN SEWERS AND OTHER UNDERGROUND SERVICES.....	114
Table 5.5 MINIMUM PIPE SIZES FOR RETICULATION AND PROPERTY CONNECTION SEWERS.....	115
Table 5.6 MAXIMUM CAPACITIES FOR GRAVITY SEWERS FOR VARIOUS LOCATIONS.....	116
Table 5.7 MANNING COEFFICIENT.....	119
Table 5.8 DESIGN MINIMUM GRADES.....	119
Table 5.9 MINIMUM GRADES FOR PROPERTY CONNECTION SEWERS.....	120
Table 5.10 MINIMUM GRADES FOR END-OF-LINE SEWERS.....	120
Table 5.11 MINIMUM COVER OVER SEWERS1.....	122
Table 5.12 MINIMUM INTERNAL FALL THROUGH AN MH JOINING RETICULATION SEWERS OF SAME DIAMETER.....	127
Table 5.13 LIMITATIONS ON LARGE FALLS AT MHs USING INTERNAL AND EXTERNAL DROPS.....	128
Table 5.14 STEEP SEWERS REQUIRING SPECIAL TREATMENT.....	129
Table 7.1 ACCEPTABLE MAINTENANCE STRUCTURE OPTIONS FOR RETICULATION AND PROPERTY CONNECTION SEWERS.....	143
Table 7.2 EXTERNAL MH DROP PIPE STRUCTURE.....	153
Table 7.3 ROCKER PIPE DIMENSIONS.....	154
Table 7.4 MINIMUM DROP HEIGHT DETAILS FOR PP.....	171
Table 7.5 GUIDE TO SELECTION OF MAINTENANCE STRUCTURE ACCESS COVERS, CLASS AND FINISHED SURFACE LEVELS.....	174
Table 8.1 REQUIREMENTS FOR VORTEX INLETS AND WATER CUSHIONS.....	187
Table 8.2 ERS STRUCTURE COMPONENTS.....	192
Table 9.1 REQUIREMENTS FOR BULKHEADS AND TRENCHSTOPS.....	211
Table 21.1 FLEXIBLE PIPES – MINIMUM COMPACTION EMBEDMENT, TRENCH FILL AND EMBANKMENT OF FLEXIBLE PIPES.....	271
Table 21.2 RIGID PIPES – MINIMUM COMPACTION EMBEDMENT, TRENCH FILL AND EMBANKMENT.....	272
Table 21.3 PRESSURE AND VACUUM AIR TESTING ACCEPTANCE TIMES FOR 7 kPa PRESSURE CHANGE.....	276
Table 21.4 CONCRETE MH TESTING FREQUENCY.....	278
Table 21.5 MINIMUM TEST TIMES FOR CONCRETE MHs.....	278
Table 21.6 MAXIMUM ALLOWABLE SHORT-TERM PIPE DEFLECTIONS.....	281
Table 22.1 SEWER GRADE TOLERANCES.....	286
Table 22.2 PROPERTY CONNECTION SEWER GRADE TOLERANCES.....	286

Table A.1 ASSET CATEGORISATION AND INDICATIVE PROTECTIVE TREATMENT SCHEDULE.....	297
Table B.1 EQUIVALENT POPULATIONS FOR SYNCHRONOUS* DISCHARGES *Peaks coinciding with normal residential occupancies.....	305
Table C.1 LEAKAGE SEVERITY COEFFICIENT (C).....	310
Table C.2 APPROXIMATE VALUES OF I(1,39.35%) FOR VARIOUS LOCATIONS.....	311
Table C.3 CONTAINMENT FACTOR VERSUS AEP.....	312
Table F.1 GENERAL PERFORMANCE CHARACTERISTICS OF BOREHOLE AND TUNNELLING TECHNOLOGIES.....	325
Table G.1 OPERATIONAL, MAINTENANCE AND TESTING LIMITATIONS OF MC, MS AND TMS.....	328
Table G.2 MAINTENANCE SHAFT BASE CONFIGURATION.....	330
Table G.3 MAINTENANCE CHAMBER BASE CONFIGURATION.....	333
Table G.4 MINIMUM BEND RADII OF DWV PVC-U VARIABLE BENDS.....	337
Table G.5 DEFLECTION LIMITS OF DN 150 DWV PVC-U VARIABLE BENDS.....	337
Table G.6 VARIABLE BEND CUTTING TABLE DN150 DWV PVC-U PIPE.....	337
Table G.7 MINIMUM WALL BEND RADII OF PE SWEEP BENDS.....	339
Table H.1 MINIMUM RETICULATION AND PROPERTY CONNECTION SEWER SIZES.....	341
Table H.2 MINIMUM RISE FOR TYPE 1 PROPERTY CONNECTION SEWERS.....	342
Table H.3 MINIMUM RISE FOR TYPE 2 PROPERTY CONNECTION SEWERS.....	343
Table H.4 MINIMUM RISE FOR TYPE 4 PROPERTY CONNECTION SEWERS.....	344
Table H.5 MINIMUM RISE FOR TYPE 6 VERTICAL JUNCTIONS.....	346
Table I.1 MAXIMUM DEPTH TO INVERT FOR PVC SEWERS.....	352
Table I.2 MAXIMUM DEPTH TO INVERT FOR PVC SEWERS (including W7 & T44 wheel loads).....	352
Table I.3 MAXIMUM DEPTH TO INVERT FOR PP SEWERS.....	352
Table I.4 MAXIMUM DEPTH TO INVERT FOR PP SEWERS (including W7 & T44 wheel loads).....	353
Table I.5 MAXIMUM DEPTH TO INVERT FOR FW-GRP SEWERS.....	353
Table I.6 MAXIMUM DEPTH TO INVERT FOR FW-GRP SEWERS (including W7 & T44 wheel loads).....	353
Table I.7 MAXIMUM DEPTH TO INVERT FOR PE100.....	354
Table I.8 MAXIMUM DEPTH TO INVERT FOR PE100 SEWERS (including W7 & T44 wheel loads).....	354
Table K.1 PROVER OUTSIDE DIAMETER FOR PVC AND GRP PIPES.....	365
Table L.1 General Comments GC.....	372
Table L.2 ACCEPTANCE PARAMETERS FOR RIGID SEWERS – VITRIFIED CLAY, STEEL REINFORCED CONCRETE.....	373
Table L.3 ACCEPTANCE PARAMETERS FOR FLEXIBLE SEWER PIPES – PLASTICS (PVC, PE, PP, GRP), DUCTILE IRON AND STEEL.....	378
Table L.4 ACCEPTANCE CRITERIA - CONFIGURATION OF PIPEWORK AND FITTINGS – ALL SEWERS.....	382