Part 6: Wastewater Drainage

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6.1 Referenced Documents

Planning and Policy

- The *Christchurch District Plan*
  www.ccc.govt.nz/the-council/plans-strategies-policies-and-bylaws/plans/christchurch-district-plan
- Christchurch City Council *Development Contributions Policy 2021*
  www.ccc.govt.nz/the-council/plans-strategies-policies-and-bylaws/policies/building-and-planning-policies/development-contributions-policy
- Christchurch City Council *Water Supply and Wastewater Bylaw* (2022)
  www.ccc.govt.nz/the-council/plans-strategies-policies-and-bylaws/bylaws/water-supply-and-wastewater-bylaw-2022

Design

- *Christchurch City Council Odour and Corrosion Management Design Guide*
- Christchurch City Council *Sewage Pumping Station Design Specification*
  www.ccc.govt.nz/consents-and-licences/construction-requirements/infrastructure-design-standards/sewage-pumping-station-design-specification
- Christchurch City Council *Subdivision Bulletin 27 - Wastewater Capacity Certificates*
  www.ccc.govt.nz/consents-and-licences/news-and-information/
- New Zealand Building Code *Compliance Document G13 Foul Water*
  www.building.govt.nz/building-code-compliance/g-services-and-facilities/g13-foul-water
- New Zealand Transport Agency *Bridge Manual* (2013)
  www.nzta.govt.nz/resources/bridge-manual/bridge-manual.html
- Water Services Association of Australia *Pressure Sewerage Code of Australia* WSA 07-2007
- Water Services Association of Australia *Vacuum Sewerage Code of Australia* WSA 06-2008
- AS/NZS 2566.1:1998 *Buried flexible pipelines - Structural design*
- AS/NZS 3725:2007 *Design for installation of buried concrete* pipes
- AS/NZS 5065:2005 *Polyethylene and polypropylene pipes and fittings for drainage and sewerage applications*
- AS/NZS 4131:2010 *Polyethylene (PE) compounds for pressure pipes and fittings*
- AS 3996:2006 *Access covers and grates*
- PIPA POP010A *Polyethylene Pressure Pipes Design for Dynamic Stresses* May 2010
  www.pipa.com.au/index.php/technical/pop-guidelines
- PIPA POP101 *PVC Pressure Pipes Design for Dynamic Stresses* Feb 2009
  www.pipa.com.au/index.php/technical/pop-guidelines

> Australasian Society for Trenchless Technology *Guidelines for Horizontal Directional Drilling, Pipe Bursting, Microtunnelling and Pipe Jacking* www.astt.com.au/guidelines

> Lauchlan, C., Forty, J. and May, R., *Flow resistance of wastewater pumping mains,* Proceedings of the Institution of Civil Engineers 158 (WM2), (2005)

> Water Industry Specification 4-34-04 *Specification for renovation of gravity sewers by lining with cured-in-place pipe* March 1995 www.water.org.uk/technical-guidance/water-standards/wiss-and-igns/

Construction

> Christchurch City Council *Civil Engineering Construction Standard Specifications Parts 1-7 (CSS)* www.ccc.govt.nz/consents-and-licences/construction-requirements/construction-standard-specifications/download-the-css

> Christchurch City Council *Level 2 functional description template* (TRIM 09/367127)

> Christchurch City Council *Pumping Station O&M Manual Template Draft* www.ccc.govt.nz/consents-and-licences/construction-requirements/infrastructure-design-standards/pumping-station-design-specification

> Christchurch City Council *CWW Tagging Convention* www.ccc.govt.nz/consents-and-licences/construction-requirements/infrastructure-design-standards/pumping-station-design-specification

Where a conflict exists between any Standard and the specific requirements outlined in the Infrastructure Design Standard (IDS), the IDS takes preference (at the discretion of the Council).

Contact Council for access to those Council reference documents available only through TRIM.

6.2 Introduction

6.2.1 History of the city's wastewater system

Christchurch City's wastewater system differs from most other cities in New Zealand in that, due to the terrain, the early design decisions made extensive use of flatter than normal sewer grades. Further decisions to limit sewer depths in the rapidly expanding network, in the 1920's, resulted in a large number of pumping stations in the system.

The standard of specification and supervision of construction has always had a high priority, meaning that, on average, the system is in good condition despite its age.

Because of the flat grades, traditional maintenance methods involved regular flushing and cleaning of pipelines with water supplied from shallow wells. Mains-supplied water is now used for flushing and consequently the cost and conservation of water is important.

Banks Peninsula presently has seven public sewerage schemes, to which approximately 3,600 properties are connected - Akaroa, Diamond Harbour, Duvauchelle, Governors Bay, Lyttelton, Tikao Bay and Wainui. There are also approximately 600 properties that have connections but are currently unconnected.

The remaining properties on Banks Peninsula dispose of their wastewater by other means - generally from their own on-site wastewater treatment systems.

6.2.2 Changes in design philosophy

Since the Christchurch Drainage Board Design Manual was last revised in 1986, there has been a move towards self-flushing methods.

The application of the 'simplified sewerage design' method, which is based on 'tractive force' theory, provides a more robust method of ensuring self-cleansing velocities are achieved. Tractive force theory is modelled on the migration of sediment in small increments along a pipeline as pulses of turbulent flow pass.

Although the series of earthquakes from September 2010 highlighted the potential for longitudinal settlement under seismic loading, no additional grade allowance is being required as tractive force theory provides steeper grades than those that were previously constructed and found to be workable, albeit with more frequent cleaning.

Clauses 4.4.9 – Liquefaction and 4.6.2 – Seismic considerations (Geotechnical Requirements) provide further detail of Liquefaction Vulnerability Areas and their application when designing piped infrastructure. Use engineering judgement where proposed infrastructure traverses the boundaries of areas or where it is located in areas where liquefaction damage is possible or undefined. The Liquefaction Vulnerability is shown on the Vulnerability Map tab of apps.canterburymaps.govt.nz/ChristchurchLiquefactionViewer.

The IDS does not eliminate provision for flushing but encourages greater use of self-flushing grades, particularly at the head of catchments. Some relaxation of the degree of flushing elsewhere in the system is offered in return.

Pumping station designs now use submersible type pumps and are generally standardised, particularly for subdivisions.

6.2.3 Water Supply and Wastewater Bylaw

The *Water Supply and Wastewater Bylaw* defines the Council's requirements and protection for the drainage works.

6.2.4 New developments

Gravity reticulation, with conventional pumped systems where necessary, remains the preferred method of reticulation for most developments but consider alternative technologies for new developments on the perimeter of the older system. Council will also consider pressure sewer systems (PSS) where there are downstream capacity constraints or the site has significant construction issues.

In areas where gravity reticulation systems are not achievable due to grades or long distances, common pressure main or PSS systems, including small privately operated and municipal systems, are an option subject to the Council's approval. Each lot must have an individual wastewater pump connected to a common pressure main system.

Standard plans (subject to charge) and specifications for submersible pumping stations are available from the Council.

Odour treatment design is included in this Part of the IDS. Odour treatment are required at the terminal of all rising mains likely to generate.

6.2.5 Design lifetime

All wastewater reticulation systems are expected to last for an asset life of at least 100 years with appropriate maintenance. Design the systems accordingly, to minimise life cycle costs for the whole period. Maintenance in design and future serviceability must be considered to ensure future feasibility of repair and maintenance methodology and costs. Unlined concrete manholes and pipes should only be used where the average airflow concentration of H_2S is less than <0.1ppm and the peak airflow concentration is less than 1ppm.

6.2.6 Alternative technology

Consider alternative technologies in areas of high liquefaction vulnerability as defined on the Vulnerability Map tab of apps.canterburymaps.govt.nz/ChristchurchLiquefactionViewer. Examples of such technologies are PSS and vacuum systems. In addition to Table 1, areas suitable for implementing PSS are defined in the Outline Development Plan (ODP) in the District Plan. These technologies may also be appropriate in particular circumstances in other areas of the city and Banks Peninsula.

The Council will only consider vacuum technologies complying with clause 6.10 – Vacuum sewers on a case-by-case basis, where other methods are inappropriate.

Table 1 LR zone versus reticulation system

System	High liquefaction vulnerability areas	Very low, low and medium liquefaction vulnerability areas
Gravity	Possible option but need to discuss with Council	yes
PSS	Possible option but need to discuss with Council	no
Vacuum	Possible option but need to discuss with Council	no
Max depth for gravity	3.5m	Lesser of 5.0m or 3.0m below WT
Wrap plastic pipe haunching	yes	not required

6.3 Quality Assurance Requirements and Records

Provide quality assurance records that comply with the requirements in Part 3: Quality Assurance, during design and throughout construction.

6.3.1 The designer

The designer of all wastewater systems that are to be taken over by Christchurch City Council must be suitably experienced. Their experience must be to a level to permit membership in the relevant professional body. Refer to clause 2.7.1 – Investigation and design (General Requirements) for further information.

The design peer reviewer must have at least equivalent experience to the designer.

6.3.2 Design records

Provide the following information to support the Design Report:

- all options considered and the reason for choosing the submitted design;
- hydraulic calculations, preferably presented in an electronic form;
- all assumptions used as a basis for calculations, including pipe friction factors;
- a valid wastewater capacity certificate as described in *Subdivision Bulletin 27 - Wastewater Capacity Certificates;*
- design checklists or process records;
- design flow rates;
- system review documentation as detailed in clause 6.4.9 – System review;
- thrust block design calculations, including soil bearing capacity;

- trenchless technology details, where appropriate;
- calculations carried out for the surge analysis of pressure pipes where appropriate.

6.3.3 Construction records

Provide the information detailed in Part 3: Quality Assurance and the *Construction Standard Specifications (CSS)* through the Contract Quality Plan (CQP), including:

- performance test results;
- material specification compliance test results;
- compaction test results;
- subgrade test results;
- confirmation of thrust block ground conditions and design;
- CCTV records;
- site photographs.

Provide the Council with a certificate for each pipeline tested including the date, time and pressure of the test. Provide details of the pipes in a form complying with the requirements of Part 12: As-Builts including manufacturer, diameter, type, class, jointing and contractor who laid the pipe.

6.3.4 Approved materials

All materials must comply with those listed on the Council's web page for approved materials at www.ccc.govt.nz/consents-and-licences/construction-requirements/approved-materials-list and with the material specifications in the *Sewage Pumping Station Design Specification*..

6.3.5 Acceptance criteria

All pipelines must be tested before acceptance by Council. Provide confirmation in accordance with the Contract Quality Plan that they have been tested, inspected and signed off by the engineer. Perform testing in accordance with *CSS: Part 3* clause 14.0 – Performance Testing.

All pump stations must be commissioned before acceptance by Council. Provide the following pre-commissioning documentation before requesting Council witness commissioning:

- confirmation that HAZOP items are closed out
- completed Health and Safety audit of constructed works
- construction and safety audit defect record using Appendix XIX – Pump Station Outstanding Work/Defect List (Quality Assurance)
- draft Operations and Maintenance Manuals
- draft of Final Management Plan (if required)

Further information is available in the *Sewage Pumping Station Design Specification*.

6.4 Sanitary Sewer Design Flows

Sanitary sewer flows vary with the time of day, the weather and the extent and type of development within the catchment. Design systems to carry maximum flows without surcharging.

The maximum wastewater flow is given by:

Equation 1 Maximum flow

MF = P/A x SPF x ASF

where MF = Maximum flow occurring during wet weather (l/s)

P/A = Dry weather diurnal peak to average ratio (clause 6.4.1)

SPF = Storm Peak Factor including infiltration (clause 6.4.2)

ASF = Average Sewage Flow (clause 6.4.3 or 6.4.5)

Design pipelines with sufficient capacity to cater for all existing and predicted development within the area to be served. Make allowance for all areas of subdivided or unsubdivided land that are capable of future development.

When calculating the unit ASF, the net area used includes roads but excludes reserves.

All diameters are nominal bore, unless otherwise noted. PE only is specified by a nominal outside diameter (OD).

6.4.1 Peak to average ratios

Use a peak/average ratio (P/A) of 1.8 for wastewater reticulation design.

6.4.2 Dilution from infiltration and inflow

Infiltration is the entry of subsurface water into the pipeline through cracks and leaks in the pipeline. Inflow is the direct entry of surface water to the pipeline from low gully traps, downpipe discharges and illegal stormwater connections. Infiltration and inflow together account for approximately one third of Christchurch's annual wastewater flow.

For new developments, apply a storm peak factor (SPF) of 2.78 to the peak wastewater flow to allow for infiltration and storm inflow. When determining the minimum (self-cleansing) flow for the tractive force calculation, use a SPF of 1.0.

Infiltration and Inflow (I & I) can be reduced when designing greenfield pressure sewer systems. Nominate a SPF for pressure sewer system design in (both greenfield and) developed areas and explain the supporting rationale in the design report.

6.4.3 Average residential wastewater flows

Residential flows are derived from a water use of 220 litres per person per day. The unit average wastewater flow is given by:

Equation 2 Unit ASF

Unit ASF = persons/hectare x litres/person/day

And

Equation 3 ASF

ASF = unit ASF x area

Further examples of unit ASF values for different residential zones, and corresponding maximum flows per hectare, are shown in Table 2.

Table 2 Unit ASF values

Zoning	Minimum net density (households/ ha)	Unit ASF (l/s/ha)	MF (l/s/ha)
Residential New Neighbourhood (RNN)	15	0.10	0.51
Residential Suburban (RS)	15	0.10	0.51
Residential Suburban Density Transition (RSDT)	22.5	0.15	0.77
Residential Medium Density (RMD)	30	0.21	1.03
Central City Residential (CCR)	300	2.00	10.0
Central City Mixed Use (CCMU)		2.00	10.0
Residential Hills (RH)	9	0.062	0.31
Residential Large Lot (RLL) (flat land)	6	0.041	0.21
Residential Large Lot (RLL) (Port Hills)	4	0.027	0.14
Residential Small Settlement (RSS)	8	0.055	0.28
Residential Banks Peninsula (RBP)	15	0.10	0.51

Note:

1) If there is any scope for further infill development, increase the net density to allow for this.

2) For mixed density developments or zonings not covered by Table 2, detail in the Design Report how the design flows, based on Table 2 values, were determined.

6.4.4 Maximum flows for new developments

Calculate the maximum flow for new developments using Equation 1.

For example, at an assumed residential population density (RNN) of 15 households per hectare, with a corresponding unit ASF of 0.10 l/s/ha (from Table 2) and a development area of 1 hectare, calculate the maximum flow as follows:

Equation 4 Maximum flow calculation example based on area

$$
\begin{aligned}
MF &= \textit{P/A ratio} \times \textit{SPF} \times \textit{ASF} \\
&= 1.8 \times 2.78 \times (0.10\ \ell/s/ha \times 1\ ha) \\
&= 0.451\ \ell/s
\end{aligned}
$$

Where the actual number of lots is known, use Equation 5. If there is any scope for further infill development, increase the number of lots to allow for this.

E.g. For a residential subdivision of 200 lots:

Equation 5 Maximum flow calculation example based on number of lots

$$
\begin{aligned}
ASF &= \text{number of lots} \times 220\ \ell/\text{person/day} \times 2.7\ \text{persons/lot} \\
&= 200\ \text{lots} \times 220\ \ell/\text{person/day} \times 2.7\ \text{persons/lot} \\
&= 118{,}800\ \ell/\text{day} \\
&= 1.38\ \ell/s
\end{aligned}
$$

$$
\begin{aligned}
MF &= 1.8 \times 2.78 \times 1.38\ \ell/s \\
&= 6.88\ \ell/s
\end{aligned}
$$

6.4.5 Average commercial and industrial wastewater flows

Wastewater flow from commercial developments is derived from a water use of 1 litre per second per 1,000 of population (where this is known). Unless other figures are available, use the values in Table 3.

Table 3 Commercial and industrial unit ASF values

Zoning	Unit ASF (l/s/ha)	Unit MF (l/s/ha)
Commercial Local (CL)	0.09	0.45
Commercial Core (COR)	0.15	0.75
Central City Business (CCB)	2.00	10.0
Central City Mixed Use (CCMU)	2.00	10.0
Industrial General (IG) - suburban	0.15	0.75
Industrial General (IG) - inner city	0.38	1.90
Industrial Heavy (IH)	0.38	1.90
Industrial Park (IP)	0.09	0.45

Note:

1) Where the type of commercial or industrial zoning is not known, assume IH.

2) For zonings not covered by Table 3, detail in the Design Report how the design flows, based on the Table 3 values, were determined.

3) The gross area of malls was used in calculating ASF values.

For known industries, base design flows on available water supply and known peak flows. Ensure that the design flow allows for potential wet industries, using Table 3.

Use Equation 1 for industrial areas greater than 15 hectares.

When assessing whether a wet industry can be reasonably accommodated in an area that is reticulated but not fully developed, leave sufficient flow capacity in the pipeline to serve remaining developing areas at a unit ASF of 0.15 l/s/ha (provided that no other wet industries are being planned).

6.4.6 Total design flows for existing developments

Base the design of major renewal and relief sewers (greater than 375 ID) serving older catchments on actual catchment performance. As the performance, which is derived from flow monitoring, is not always available, discuss larger reticulation requirements with Council.

6.4.7 Size of private sewer drains

The minimum size of private gravity sewer drains must be 100mm diameter.

For major industrial users, determine the size of the lateral using the maximum flow requirements and the available grade.

6.4.8 PSS design flows

For residential designs, MF is not used as the storage chamber and pump dampen the peak flows. Determine the design flow and either a probability assessment of the maximum number of pumps operating at any time or through dynamic modelling, using the ASF defined in clause 6.4.3 - Average residential wastewater flows or clause 6.4.5 - Average commercial or industrial wastewater flows.

6.4.9 System review

When the pipe selection and layout have been completed, perform a system review, to ensure that the design complies with both the parameters specified by the Council and detailed in the IDS. The documentation of this review must include a full hydraulic system analysis. Compliance records must cover at least the following requirements:

- pipe and fittings materials are suitable for the particular application and environment;
- pipe and fittings materials are approved materials;
- pipe class is suitable for the pipeline application (including operating temperature, surge and fatigue where applicable);
- seismic design - all infrastructure is designed with adequate flexibility and special provisions to minimise the risk of damage during an earthquake, and with consideration for the cost and time to repair any potential damage. Provide specially designed flexible joints at all junctions between rigid structures (e.g. pump stations, bridges, buildings, manholes) and natural or made ground;
- layout and alignment meets the Council's requirements;
- maximum operating pressure will not be exceeded anywhere in the pressure pipe system;
- capacity is provided for future adjacent development.

6.5 Gravity Pipelines

Design pipes to withstand all loads, including hydrostatic and earth pressure and traffic, in accordance with *Buried flexible pipelines - Structural design and Design for installation of buried concrete pipes*. Design pipes exposed to traffic to HN-HO-72 axle loading only, as described in clause 3.2.2 of the *Bridge Manual*.

6.5.1 Alignment

Lay gravity pipelines in straight lines and at a constant gradient between access points such as manholes and inspection chambers. Discuss major reticulation and its potential for significant traffic disruption at an early stage with Council.

Lay wastewater pipes in the centre of the road in general, with a minimum vertical cover of 1.2m. This makes the sewer equidistant from the properties it serves, and, being at a relatively high point on the road surface, vented manholes are less subject to surface floodwater entry. Refer to clause 6.14 – Haunching and Backfill for further information regarding depths of pipes.

In curved roads, straight lengths of wastewater pipelines must clear kerbs by 2.0m and manholes should be on the centreline. To minimise manhole numbers, they may be sited between the quarter point and the centreline.

The preferred solution for wastewater reticulation is to avoid easements over private property.

Equation 6 Easement width

The easement width is the greater of:

- 2 x (depth to invert) + OD
- 3.0m

where OD = outside diameter of pipe laid in easement

The easement registration must provide the Council with rights of occupation and access and ensure suitable conditions for operation and maintenance.

6.5.2 Temporary ends

Extend wastewater sewers to the upstream boundary of new developments, to allow for connection of any future upstream catchments. Terminate the main at an access point.

6.5.3 Minimum gradients

Design minimum gradients to maintain self cleansing flows, using the 'simplified sewerage design' method, which is based on 'tractive force' theory and uses the following parameters:

Minimum tractive force, τ	1 N/m^2
Minimum proportional depth of flow, d/D	0.2
Maximum proportional depth of flow, d/D (84% pipe–full capacity)	0.7
Manning's roughness (n)	0.013

Calculate the minimum (self cleansing) flow using Equation 7 but the minimum flow value should not be less than 1.5 l/s. It is important not to overestimate this value as the smaller the flow, the steeper the necessary gradient. If the flow is overestimated, the gradient chosen could be too flat to self-cleanse. 1.5 l/s has been chosen to represent the discharge from a single water closet or similar fitting.

Equation 7 Minimum self cleansing flow

$$SCF = P/A \times ASF$$

where SCF = minimum self cleansing flow (l/s)

P/A = Dry weather diurnal peak to average ratio (clause 6.4.2)

and ASF = Average sewage flow (clause 6.4.3 or 6.4.5)

Determine the minimum pipe gradient that meets the tractive force and proportional depth requirements for the minimum self cleansing flow from either Equation 8 or by using Appendix I – Tractive Force Design Charts. Use hydraulic models for pipes over 300mm diameter as the charts are not applicable at these larger diameters.

Equation 8 Minimum pipe gradient

$$i_{min} = 5.64 \times 10^{-3} \times SCF^{-0.461}$$

where i_{min} = minimum gradient in m/m and SCF = minimum self cleansing flow (l/s)

An example calculation is illustrated in Appendix II – Determination of Minimum Gradient and Hydraulic Design Example.

Consider detailing flush tanks where their use may reduce the need for a pump station. Present a non-conformance report in this instance.

6.5.4 Hydraulic design

Gravity pipelines maintained by the Council must have a minimum diameter of 150mm for residential and 175mm for industrial or commercial applications. 175mm diameter incorporates an allowance for future 'wet' industries, normally 8 l/s.

Determine the minimum pipe diameter that meets the tractive force and proportional depth requirements for the maximum flow using either Equation 9 or Appendix I – Tractive Force Design Charts. An example calculation is illustrated in Appendix II – Determination of Minimum Gradient and Hydraulic Design Example.

Equation 9 Minimum pipe diameter

$$D_{min} = 24.35 \times \left[\frac{MF}{i_{min}^{1/2}}\right]^{3/8}$$

D_{min} = minimum pipe diameter in mm

Size pipelines to cater for future flows from the upstream catchment, when fully developed.

6.5.5 Deep pipelines

Limit the maximum pipe depth in High Liquefaction Vulnerability areas to 3.5m to invert. Limit the maximum depth in Very Low, Low or Medium Liquefaction Vulnerability areas to the shallower of 5.0m to invert or 3.0m below the watertable. Liquefaction Vulnerability is shown on the Vulnerability Map tab of apps.canterburymaps.govt.nz/ChristchurchLiquefactionViewer. Pipelines with cover exceeding 4.0m in depth require structural design.

6.5.6 Inverted siphons on sanitary sewers

Inverted siphons are sometimes necessary when passing major obstacles such as rivers and large drains. Problems associated with inverted siphons derive primarily from an accumulation of solids when velocities are reduced during low flow. Accumulated solids can give rise to odour problems, make the wastewater more septic, and restrict peak flows. Remember that the water seal blocks airflows and can affect the ventilation pattern.

Size the pipes to give peak daily velocities as per Section 6.5.3 Hydraulic design and Section 6.8.2 Velocity. If flows are expected to increase significantly with time or there are significant differences in dry and wet weather flow scenarios, install two different sized pipes, giving three possible modes of operation. These modes of operation may be used progressively in steps, as flows build up over time, by the removal of plugs or via weirs. Design the plugs to be easily removable and provide details in the Design Report. Also, consider network redundancy, maintenance in design and future serviceability. This may trigger the requirement for duplicate pipelines.

Provide an O&M manual for all siphons.

To improve the transmission of solids, the maximum pipeline slopes must be 45° and 22.5° on the downward and upward legs respectively, with manholes placed to make cleaning easier. Because bedding conditions are often difficult, concrete-lined steel pipes and bends of cast iron are commonly used. Differential settlements are likely to occur between the manhole and the siphon piping so give special attention to the joints in these areas.

It may be necessary to surround piping with concrete under waterways that are dredged from time to time. It may also be necessary to provide isolation valves to help flush siphons.

Do not install siphons on any lateral.

6.5.7 Collector sewers

Design collector sewers where the sewer main is deeper than 2.5m and laterals would discharge to the sewer main. Detail the collector sewers to collect from individual property laterals and discharge into the sewer main at manholes. The sewer main then effectively acts as a trunk sewer.

Design collector sewers parallel to the sewer main and preferably directly over and falling in the same direction as the sewer main. Design grades as detailed in clause 6.5.3 – Minimum gradients, but ensure depths provide service to all properties. Where levels will constrain constructing a single grade, it is acceptable to fall the collector sewer against the sewer main grade as shown in Figure 1.

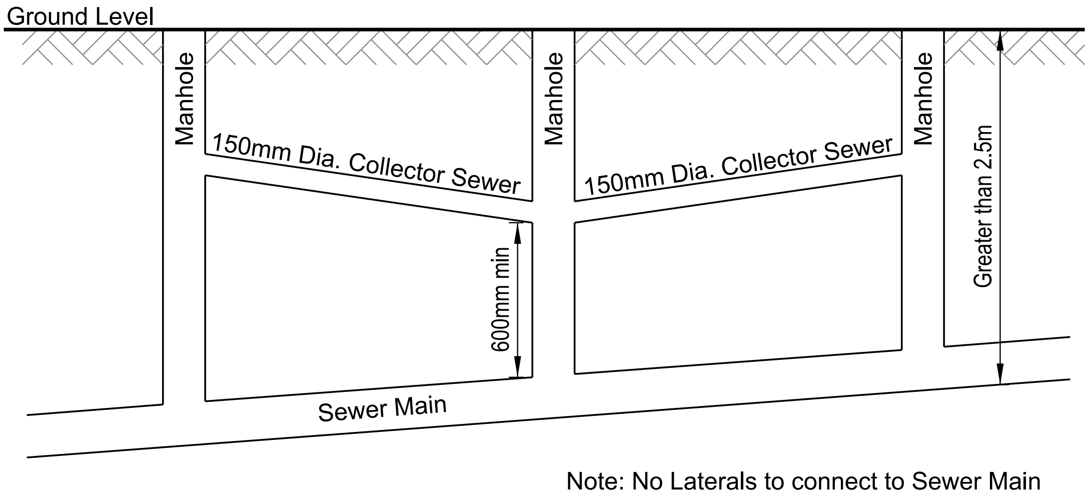


Figure 1 Collector sewer

Detail drop manholes on the collector sewer outlet only when the invert is 1.0m or more above the sewer main soffit. Detail flexible joints, to clause 6.6.3 – Structural design, on the collector sewer.

6.6 Manholes

Check the effects of turbulence or hydraulic grade on pressure within manholes. Where pressures may expel manhole covers, assess options to maintain public safety e.g. by installing safety grates or fixing down the manhole cover.

Consider plastic manholes where concrete manhole corrosion due to the presence of H_2S is likely e.g. immediately downstream from pressure sewer outfalls. Design manholes to clause 6.6.3 - Structural Design including mitigation of flotation or liquefaction related movement. Design the manhole cover's support structure to disperse traffic loads as required by the manhole's load bearing capacity and provide a producer statement confirming this design. Detail robust flexible connections that provide the equivalent design life to the adjacent infrastructure. Similarly, consider plastic inspection chambers where corrosion is an issue and provide equivalent details to those discussed above. Constraints on depth within the *CSS: Part 3* will also apply.

6.6.1 Location and spacing

Manholes should, preferably, be positioned on roadways or where there is vehicle access. The flow deviation angle between the inlet and outlet pipes must not be greater than 90 degrees, as shown in Figure 2. Ensure the distance between incoming pipes in the manhole complies with *CSS: Part 3* SD 303.

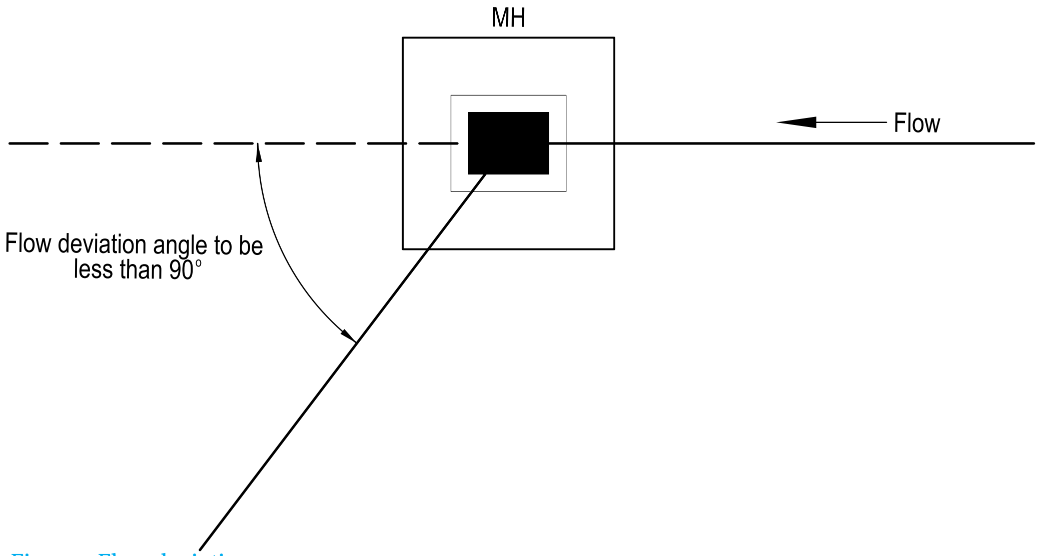


Figure 2 Flow deviation

Table 4 specifies the range of maximum spacings.

Table 4 Spacing for manholes

Diameter in mm	Maximum spacing (m)
150 – 225	100
300 – 900	120
1050 – 1500	150
1600 and above	180

6.6.2 Vented manholes

Vented manholes are designed to serve as intakes for fresh air, which passes through the sewers and laterals to the main vents on individual houses, disposing of corrosive and foul air in a way that causes minimal offence. However, occasional temperature inversions cause the air to flow in reverse and inlet vents should also be located so that any foul air coming from them causes minimal offence.

Use vented manholes on each alternate manhole cover and place them where there is minimal turbulence, to avoid undue odours. Avoid features such as angles, junctions and summit manholes, and rising main outlets.

To avoid surface water entry and the associated gorging of pipelines, site vented manholes away from areas where ponding of stormwater is likely to occur. If this is not possible, install vent stacks on the road boundary. Show on the wastewater engineering drawings the extent of flooding at which secondary flow paths are activated, to verify that vented manholes will not be affected. Likewise, avoid road intersections because gravel and grit entry is greater at these locations.

Special consideration must be given to large trunk sewers (larger than 450 mm ID) as these may be inadequately vented by house connections. To ensure that air movement adequately serves all parts of a sewer, it may be necessary to use special air inlets, special vent stacks and/or a forced draught with designed circulation, possibly in conjunction with odour control (Refer to clause 6.11 –Odour Treatment). Note that siphons cut off all airflow, unless special air ducting is incorporated.

6.6.3 Structural design

Design structures to withstand all loads, including hydrostatic and earth pressure and traffic, in accordance with the *Bridge Manual*. Design structures exposed to traffic to HN-HO-72 loading.

Manholes must comply with *CSS: Part 3* SD 302, 303 or 304, or with other Council approved designs. Provide yield joints between manholes and pipes in accordance with *CSS: Part 3* SD 341. Where the structure is likely to experience differing movement from the pipeline under seismic loading, replace the yield joints with flexible joints e.g. *CSS: Part 3* SD 341/4. These may mitigate against the potential for damage by allowing some longitudinal movement at the structure.

A specific design is required for larger pipes, especially where changes of direction are involved. The design must incorporate a standard manhole opening and be able to withstand a heavy traffic loading HN-HO-72.

Check all chambers for flotation, including under seismic conditions. The factor of safety against floating should be at least 1.2 excluding skin friction in the completed condition, with an empty camber and saturated ground. Counter increased forces resulting from greater depths and spans by thicker walls, counterweighting or reinforcing.

Unreinforced vertical concrete panels, provided for future connections in manholes or other underground structures, which are subject to soil and traffic loading should be specifically designed. Alternatively, in the case of a square panel, ensure that the length of the side does not exceed seven times the panel thickness.

Consider the foundation conditions as part of the design. If there is a possibility of soft ground, carry out ground investigations and a full foundation design.

6.6.4 Drop structures in manholes

Drop manholes are a potential source of blockages. Lay pipelines as steeply as possible to avoid any need for a drop.

When a wastewater pipe must enter a manhole with its invert level more than 200mm higher than the soffit of the outlet pipe, provide a drop manhole as detailed in *CSS: Part 3* SD 305. Clause 6.5.7 - Collector sewers modifies these requirements on collector sewers.

6.6.5 Fall through manholes

The minimum fall in the invert of angled wastewater manholes is set out in Table 5.

Table 5 Minimum fall in manhole

Angle of deviation	Minimum fall (mm)
60° - 90°	20
30° - 60°	10
0° - 30°	5

When there is an increase in the pipe size at a wastewater manhole, the soffit of an inlet pipe must not be lower than the soffit of the outlet pipe.

6.7 Wastewater Pumping Stations

Refer to the *Sewage Pumping Station Design Specification* for all details relating to public pumping stations. All Council pump stations or pump stations to be vested to Council require odour treatment in accordance with Christchurch City Council Odour and Corrosion Management Design Guideline to remove odours and corrosive gases. Acceptable odour treatment units typically include bark or mixed media biofilters, two-stage bioscrubber / activated carbon treatment unit or single-stage activated carbon treatment units. All activated carbon units are required to contain a fan and heater. It is up to Council's discretion to determine acceptance of a proposed odour treatment unit for a specific site upon receipt of a design and options evaluation report showing life-cycle costs.

The "Vulnerability Map" tab at apps.canterburymaps.govt.nz/ChristchurchLiquefactionViewer indicates the vulnerability of land to liquefaction-induced damage. Pump stations and reservoirs in areas identified as medium or high liquefaction vulnerability require seismic specific designs as per IDS Part 4. Areas where the liquefaction category is undetermined or liquefaction damage is possible require geotechnical investigation to define the liquefaction vulnerability level.

Provide operations and maintenance manuals using the *Pumping Station O&M Manual Template*. Include SCADA functional descriptions and code. For standard pumping stations, level 1 process description only is required. For pumping stations or processing plants that differ from standard, submit full level 2 functional descriptions before coding, using the *Level 2 functional description template*.

6.8 Pressure Pipelines

Rising main design is affected by the performance of the downstream pumping station. Carry out the design of these components together to provide an integrated and efficient system.

Minimise the time fluids spend in a rising main. Design rising mains to prevent wastewater from becoming septic. Maintain velocities high enough to transport solids and prevent solids accumulation. These objectives can be achieved by minimising the length and diameter of the pipe.

Rising mains and PSS pipelines will also need to withstand static and friction heads of long duration, together with short duration water hammer pressures. Once pipe diameters are selected, match pipe class selection to pump, flow and surge characteristics. Allow for fatigue (cyclic dynamic stresses) from a large number of stress cycles over a 100-year lifecycle when selecting the pipe pressure class.

Water hammer and surges can arise from a number of different operations, e.g. the sudden starting or stopping of a pump or closure of a non-return valve. Water hammer can be critical in pumping systems, especially in large diameter rising mains and high static head systems. For details on designing for surge and fatigue see the *Sewage Pump Station Design Specification*, *Polyethylene Pressure Pipes Design for Dynamic Stresses* and *PVC Pressure Pipes Design for Dynamic Stresses*.

Consider soft closing, non-return valves for installations in high head situations.

Submit the design for rising mains, including levels and layout, with the Design Report. Submit a detailed hydraulic surge and fatigue analysis report, including all assumptions and all calculations. Where the rising main is over 100m long or greater than 150mm diameter, model the main's performance.

Consider seismic effects, temperature differentials and the Poisson's effect in flexible pipes. Design end restraints to compensate for this where necessary. Design for lateral spread in high liquefaction vulnerability areas e.g. by drilling pipelines under rivers or designing flexibility at connections to bridges. Design for traffic loads, where the minimum covers in clause 7.9.5 – Cover over pipes are not achieved.

Implement maintenance in design to mitigate operational and maintenance issues and to improve resilience during the design life of the pipeline system. Maintenance in design considerations include:

> Failure of any mechanical surge protection measures, and protection of assets from damage during these situations;

> Future serviceability for example by including adequate drain points;

> Provision of network redundancy, especially for pipelines with difficult access, pipelines installed under rivers or pipelines where maintenance access will result in public disruption including heavily trafficked roads, motorways and expressways. This may trigger the requirement for installation of duplicate pipelines or an emergency backup pipeline; and

> Material selection, joint restraint and/or flexible expansion joints to increase the resilience of critical assets.

Rising mains are normally constructed from polyethylene pipe.

6.8.1 Maximum operating pressure

Design the components of a pressure pipeline to withstand a maximum operating pressure that is no less than any of the following:

Equation 10 Maximum operating pressure

Maximum operating pressure is greater of:

- 400 kPa
- $1.5(H_s + H_f)$
- pump shut off head
- positive surge pressures

where H_s = static head
H_f = friction head

Ensure that external loads on the pipeline are included in all load cases, especially when pressure testing large diameter pipes. Provide a factor of safety of at least 2.0 against buckling under negative or external pressures.

For flexible pipes, such as glass reinforced plastic (GRP), PVC or polyethylene, the fatigue effects may define the pressure rating, which must be the greater of the maximum operating pressure calculated above, the minimum pressure rating in Table 6 or the equivalent operating pressure. To calculate the equivalent operating pressure (P_{eo}) for polyethylene use the methodology described in *Polyethylene Pressure Pipes Design for Dynamic Stresses*. For PVC, use the methodology described in *PVC Pressure Pipes Design for Dynamic Stresses* to confirm the pipe class.

Table 6 Minimum pressure ratings for flexible pipes

Material type	Pressure rating (kPa)
PVC-U	900
PE 80	800
PE 100	800
GRP	800
Concrete lined steel	800
DI	800

6.8.2 Velocity

The rising main velocity should be no less than 0.6m/s. Where lower velocities are unavoidable or where sediment or slime build-up may be an issue, introduce a daily scouring cycle. Maintain this cycle at a velocity that achieves the below target tractive shear stress for a duration sufficient to clear the line:

> For scouring of sediment the minimum tractive shear stress shall be 3 Pa.

> For the stripping of slime growth the minimum tractive shear stress shall be greater than 4 Pa.

Calculate the tractive shear stress using Equation 11.

Equation 11 Tractive shear stress

$$\textit{Tractive shear stress} = (Pa)\ \tau = \frac{f \gamma V^2}{8g}$$

where f = friction factor

γ = fluid density (N/m^3)

V = flow velocity (m/s)

The friction factor ‘f’ should be determined from the Colebrook-White Equation 12.

Equation 12 Colebrook-White equation

$$\frac{1}{\sqrt{f}} = -2\log_{10}\left\{\frac{k_s}{3.71D} + \frac{2.51}{Re\sqrt{f}}\right\}$$

where k_s = hydraulic roughness (m)

D = pipe diameter (m)

Re = Reynolds number (VD/v)

v = kinematic viscosity 1.11×10^{-6} m^2/s at 15°C

The hydraulic roughness ‘ks’ may be calculated directly from Equation 13, as detailed in *Flow resistance of wastewater pumping mains*.

Equation 13 Hydraulic roughness

$$k_s\,(mm) = \alpha\, V^{-2.34}$$

where α = scaling coefficient

V = flow velocity (m/s)

Table 7 α values correspond to typical pipe sliming states which cover the range in Wallingford (2006) but with sliming state descriptions adapted to suit Christchurch design conditions. If a rising main is well managed with regular flushing, during normal operation the value α will typically fall into the range between good and poor and the hydraulic roughness k_s will vary accordingly.

Table 7 Values of the coefficient α for various sliming states

New	Good	Average	Poor	Neglected
0.06	0.15	0.6	1.5	6.0

Alternatively, the roughness value k_s is available in Table 8.

Table 8 Hydraulic Roughness (k_s) for various sliming states

Mean velocity	Sliming state versus k_s (mm)				
	New	Good	Average	Poor	Neglected
0.5m/s	0.30	0.60	3.0	6.0	30.0
0.75m/s	0.15	0.30	1.5	3.0	15.0
1.0m/s	0.06	0.15	0.6	1.5	6.0
1.5m/s	0.03	0.06	0.3	0.6	3.0
2.0m/s	0.015	0.03	0.15	0.3	1.5

Note: These k_s values are 'standardised' and so vary slightly from values calculated using Equation 13.

6.8.3 Gradients

Consider air movement through the system. Ideally rising mains should rise from the pumping station to termination. Surcharge all lengths sufficiently to keep the pipe full and prevent sudden discharges of foul air at pump start. Avoid creating summits since they trap air, reducing capacity, and allow the build up of sulphides, which convert to droplets of sulphuric acid and may cause pipe corrosion.

If a summit is unavoidable, provide automatic air release valves with drains to a sanitary sewer. Design the air valves specifically for wastewater operation. Mount air valves vertically above the pipeline to which the air valve is connected. (Fat or solids will block the connecting pipe if the valves are mounted to one side of the vented pipeline.) Fit an isolating gate valve between the air valve and the vented pipeline and mount the valves in a concrete valve chamber. The chamber must be large enough to allow easy access for maintenance staff to operate the isolating valves or remove all valves from the chamber. Specify that air valves on mains of 300mm diameter and less be installed on branches with the same diameter as the main.

Gradients are less important for temporary rising mains but consider creating vertical sections to provide pump starting head and pipeline charging. Wherever there are undulations in the line, consider installing air release valves.

6.8.4 Location and depth

Locate pressure sewer systems as recommended in clause 9.5.3 – Typical services layout and clearances.

Specify cover to pressure sewer system pipes complying with the requirements in clause 7.9.5 – Cover over pipes.

6.8.5 Valves

Consider detailing sluice and scour valves, particularly at troughs in the gradient. Consider isolation valves on long lengths of pressure pipe, particularly where there is insufficient capacity to store flows.

Sluice valves are defined in clause 7.10.1 – Sluice valves.

Label air valves with 10mm Helvetica text as specified in *CWW Tagging Convention* using a 200 x 70mm label on W/B/W traffolyte.

6.8.6 Thrust blocks

Specify thrust blocks to withstand the maximum operating pressure and the test pressure. Confirm the bearing capacity of the in-situ soil and the thrust block design and record as detailed in the Contract Quality Plan prior to installation.

Design and detail thrust blocks individually for any of the following situations, as the thrust block detailed in *CSS: Part 3* SD 346 is not appropriate:

- The test pressure or maximum operating pressure is greater than 390 kPa.
- The allowable ground bearing capacity is less than 50 kPa.

6.9 Pressure Sewer Systems

Generally use the *Pressure Sewerage Code of Australia* for the detailed design of pressure sewerage systems except as amended as follows.

Design the pressure sewer system (PSS) with sufficient capacity to cater for all existing and predicted development within the area to be served. Make allowance for all areas of subdivided or unsubdivided land that are capable of future development. In brownfield areas, the capacity of the existing downstream pressure sewer main may constraint the ability to add extra connections. Discuss reticulation requirements with Council.

Design PSS to allow for individual pumps and storage chambers located within each property and to these criteria:

> Total dynamic head of 45 - 55 metres
> Maximum in-network retention time of 4 hours (based on the weighted average of the accumulated retention time in each zone against the total number of connections)
> Provide emergency storage equivalent to 24 hours of average sewage flow (ASF) in the pump unit and storage chamber
> The minimal pipe length and diameter appropriate, to reduce detention times.

Construct PSS pipelines from polyethylene pipe.

6.9.1 Cleansing velocity

Verify that the design velocity in Table 9 is achieved in all PSS pipelines.

Table 9 Minimum cleansing velocity

Pipe size (DN)	Velocity (m/s)	Full pipe flow (l/s)
40	1.00	0.80
50	1.03	1.29
63	1.06	2.17
75	1.08	3.16
90	1.11	4.65
110	1.13	7.03
140	1.16	11.84

Note: Pipe assumed to be in a 'good' state, with a scaling coefficient $\alpha = 0.15$.

6.9.2 Air valves

For PSS, design out the need for air valves except at significant high points.

Design the PSS air valve to include the minimum head required to seal the air valve and so remove the requirement for drainage. Detail any air valves as specified in clause 6.8.3 - Gradients.

6.9.3 Location and Depth

Locate PSS as recommended in clause 9.5.3 – Typical services layout and clearances. Minimise road crossings through designing PSS submains where practical.

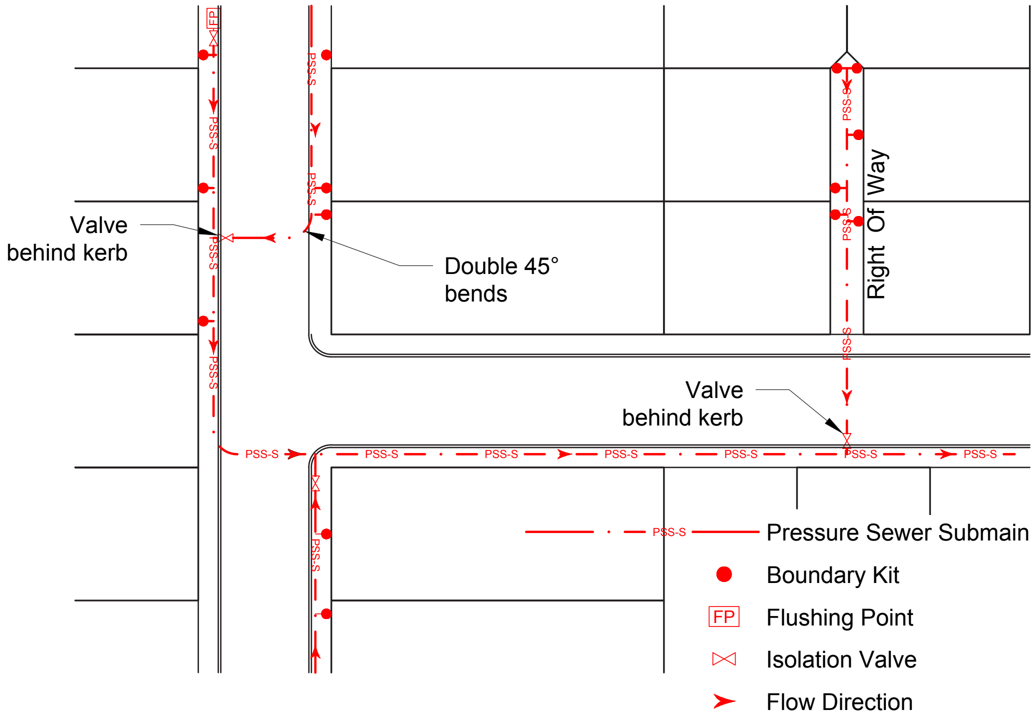


Figure 3 Typical PSS Layout - Submains only

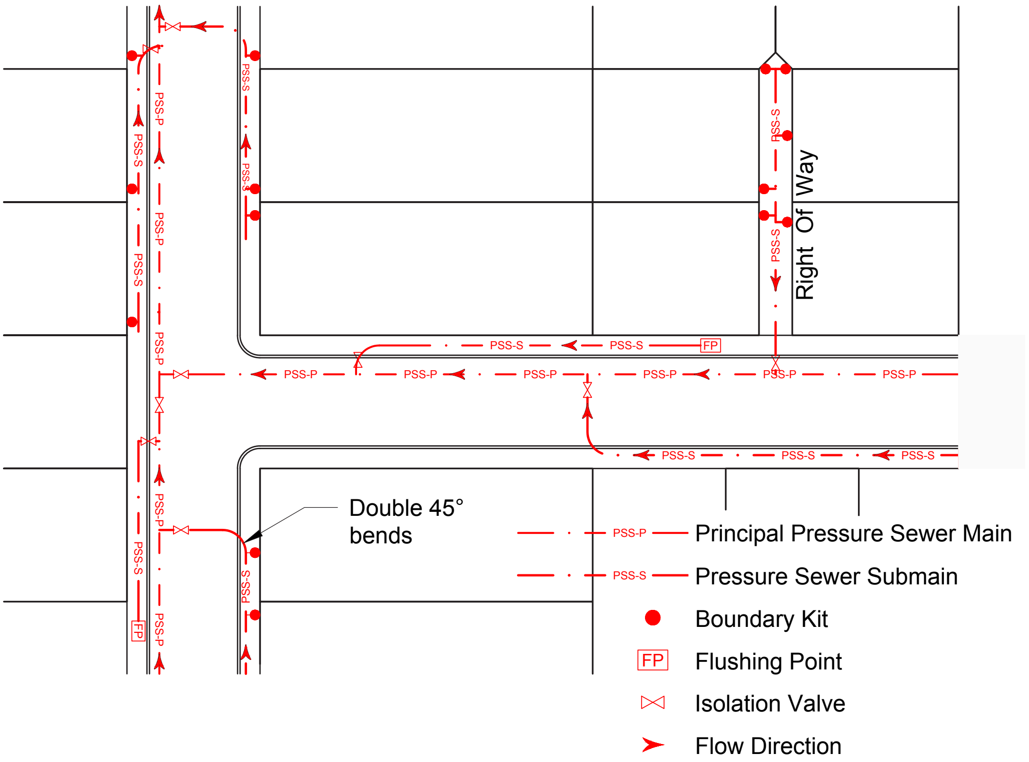


Figure 4 Typical PSS Layout - Mains and Submains

Pressure sewer mains 90mm OD and above are classed as principal mains. Lay principal mains within the carriageway, offset between 1.2 – 1.5m from the kerb face. Locate principal sewer mains on the opposite side of the carriageway from the watermain.

Show the PSS profile including the pressure sewer main depth on the design drawings. Provide a longsection of any main on the hill where the outfall is below the rest of the designed reticulation, showing air egress or ingress. Also provide a longsection where any grade deflection exceeds 250mm in total. Show the flow direction on the design plans.

Pressure sewer mains 90mm OD and above and crossovers in legal road should have a minimum cover of 750mm and a maximum cover of 1.1m. Pressure sewer submains and laterals shall have a minimum cover of 600mm where likely to be crossed by vehicles and 450mm elsewhere.

Provide mechanical protection, in the form of a 1m x 1m concrete protection slab compliant with SD342 Type E, where pressure sewer reticulation crosses under principal water mains (150mm diameter and above). This is to mitigate cross contamination of the water supply network in the event the services are damaged.

Specify bending radii greater than 100 x OD of the pipe where the pipe may be tapped on the bend or radii greater than 75 x OD otherwise.

6.9.4 Isolation valves

Detail isolation valves:

> on both upstream legs of any three way branch.

> on the pressure main just downstream of the last house serviced by the pressure sewer system.

> sufficient to allow isolation of any section of the network containing a maximum of 20 properties.

6.9.5 Detailing

The supply, installation and commissioning, by an authorised installer, of an approved PSS will be at the expense of the property owner under a building consent. Where the subdivision or building consent requires the installation of a PSS, all components of the residential PSS will vest with Council except the lateral between the house and the storage chamber. Where the subdivision or building consent requires the installation of a PSS in commercial or industrial areas, Council will only own the network up to and including the boundary kit.

Connections between new houses and pump chambers must be carried out by an authorised drainlayer.

Locate all PSS boundary kits within the service strip. For reticulation in a right of way, install a pressure sewer submain and locate the boundary kits within the right of way adjacent to each property. Detail an isolation valve behind the kerb. An easement shall be provided over the submain.

To minimise head losses on the pressure sewer lateral, detail multiple 45° bends or shallower instead of 90° deflections.

Detail a 50mm diameter flushing point on mains under DN160mm. Detail 75mm diameter flushing points on all mains DN160 and above. Locate flushing points offset from the main i.e. in the berm.

Laterals shall only connect to submains. Submains are defined as pipes below DN 90mm. Pipes DN90 and greater shall be classed as principal mains; and located in the carriageway on the opposite side to the principal watermains, on an alignment of 1.0m off the kerb.

6.10 Vacuum Sewers

The Council will only consider vacuum technologies on a case-by-case basis where other methods are inappropriate. Design vacuum sewerage systems using the *Vacuum Sewerage Code (WSA 06)*, amended as follows.

Use the following guidelines for the detailed design of vacuum systems:

> Water Environment Federation *Alternative Sewer Systems*, MOP FD-12 (2008)

> BS EN 1091:1997 *Vacuum sewerage systems outside buildings*

> *Airvac Design Manual 2012*.

Contact Council to determine whether existing vacuum sewer systems have the capacity to service additional connections. Specify hardware and fittings consistent with adjacent vacuum system infrastructure, to minimise operational requirements.

6.10.1 Location and depth

Locate vacuum collection chambers in non-trafficable areas of the legal road, and provide clearances between vacuum mains and other utility services, as specified in clause 9.5.3 – Typical services layout and clearances.

6.10.2 Hydraulic design

Ignore the requirement for vacuum generation rates *in WSA 06* clause 5.1 – General. Design sewer discharge pump starts that conform to the *Sewage Pump Station Design Specification*.

Design flows in accordance with clause 6.4 – Sanitary sewer design flows. The definitions and abbreviations in table 9 of *WSA 06* equate to the following:

Table 10 Definitions WSA to IDS

WSA 06 definition	IDS definition
'Design Flow'	Maximum Flow (MF) to IDS clause 6.4
Q_{max} or Maximum Sewage Flow	Maximum Flow (MF) to IDS clause 6.4
Q_a or Average Daily Flow	Average Sewage Flow (ASF) to IDS clause 6.4.3

In addition to the requirements of clause 6.4 - Sanitary Sewer Design Flows, allow for potential future connections from infill. Provide the flow estimations at every node and branch in tabular form in the Design Report, to permit design review and asset recording and to inform the design of future connections.

Consider larger mains up to 315mm diameter where large zones necessitate a single main. The recommended maximum liquid flow for a 315mm PE main is 29.3 l/s.

WSA-06 Table 5.3 gives maximum allowable design flows for different diameter PE80 polyethylene pipes. Note that the 90mm bore given is incorrect - this should be 76.7mm, not 93.3mm. The recommended maximum liquid flow given is correct. This table may be applied to PE100 flows as the SDR remains at 13.6 and the internal bore is the same.

6.10.3 Controls and telemetry system

Provide wireless telemetry monitoring of each vacuum collection chamber. Ensure that infrastructure is located to facilitate monitoring.

6.10.4 Vacuum sewer design

Detail minimum covers for vacuum mains of 750mm and a maximum depth to invert of 1800mm. Detail a minimum cover for vacuum laterals of 600mm. Consider special cover requirements when renewing or laying new pipes in streets with a high crown and dish channels (refer to IDS clause 7.9.5 – Cover over pipes).

Specify polyethylene pipe and materials complying with clause 6.13.1 – Approved materials including post-formed polyethylene bends that don't exceed 45°. Detail jointing of PE pipes and fittings with diameters less than 125mm OD using only electrofusion couplers.

Locate division valves upstream of every branch connection on both the trunk and the branch main. Consider operational issues when locating division valves. Couple valves with a thrust restrained dismantling joint to allow straightforward removal and replacement. Provide at least one maintenance riser for each vacuum main connecting to the vacuum station.

Specify gravity lateral sewers from the collection chamber to each property boundary complying with *CSS: Part 3*, with a minimum diameter of 150mm. Where detailing bends of up to 90 degrees, ensure materials and installation comply with clause 6.13.1 – Approved materials and *CSS: Part 3*.

Design systems to negate the requirement for air admittance devices. Install air admittance devices only where specified by the interface valve supplier.

6.10.5 Collection chambers

Design economical layouts that limit the number of properties connected to each collection chamber to four. Provide confirmation of the valve supplier's approval to support the non-conformance in the Design Report when proposing connecting more than four properties to a chamber.

Ensure that the MF to a standard collection chamber containing a single vacuum interface valve doesn't exceed 0.19 l/s. Where single point flows with MF in excess of 0.19 l/s are to be intercepted with a vacuum system e.g. from schools or other public or commercial facilities, use an interceptor chamber (also known as a buffer tank) containing one or more interface valves.

Allow no more than 25% of the total MF to the entire vacuum system and no more than 50% of the total MF to any single vacuum sewer to enter via interceptor chambers. The MF limits for interceptor chambers are 0.95 l/s for a single valve chamber and 1.9 l/s for a dual valve chamber. The use of three or more valves is possible in single or multiple interceptor chambers; however approval must be sought from the interface valve supplier and be recorded as a non-conformance in the Design Report.

Avoid detailing an interceptor chamber to intercept flows from existing gravity reticulation and pump station discharges as this reduces system reliability. Where a pumped flow is to be intercepted, take the MF to the collection chamber as the maximum capacity of the pump rather than the calculated gravity flow from the connections to the pumping station. The allowable MF to the collection chamber must still be within the limits specified above.

Specify an internal breather for the vacuum collection chamber sump and valve controllers that is capable of supplying air to the controller should the chamber be inundated with liquid. If there is no internal breather, install the breather pipe intake in a vent stack, located against the boundary to minimise the likelihood of vehicular or malicious damage. Locate the vent intake a minimum of 500mm above ground level.

Provide 400 litres storage volume in the collection chamber sump. Provide a storage volume equal to 12 hours of the total ASF from all connections, using the volume in each collection chamber sump and the gravity lateral sewers. Ensure that the storage at every chamber complies with the storage time requirement by providing additional volume if necessary or seek Council acceptance through a non-conformance report for a reduction in the storage time where it is not feasible.

Locate valves within 400mm of the surface. Specify watertight collection chamber access covers complying with clause 6.13.1 – Approved materials.

6.10.6 Commissioning, operation and maintenance

Provide a commissioning plan and a draft Operation and Maintenance Manual (OMM) with the Design Report. Include in the draft OMM a list of compatible replacement parts to be held by the Council's maintenance contractor.

6.11 Odour Treatment

All Council pump stations or pump stations to be vested to Christchurch City require odour treatment to remove odourous and corrosive gases.

Situations where odourous gases are most prevalent include anaerobic conditions, increasing hydraulic residence times, discharges from rising mains, discharges from pressure sewer systems, air valves, industrial and certain commercial discharges and turbulent flow conditions.

Refer to the *Odour and Corrosion Management Design Guide*.

6.12 Laterals

Limit the use of manholes on the public sewer main by installing direct connections that comply with *CSS: Part 3* SD 363. Where a manhole is not installed, specify an inspection point at the road boundary. On laterals over 50m in length, provide a trafficable inspection chamber over the junction of the last two laterals.

6.12.1 Sanitary junctions and laterals

Gradients are subject to BIA Regulations but the minimum gradient for a 100mm diameter pipe in roads is 1 in 80. Do not install siphons on any lateral without Council approval.

Each front lot must be provided with a separate lateral connection. Lay laterals at least 0.6m clear from property side boundaries, to terminate 0.6m inside the net site area of the lot. Haunch laterals, laid as part of a development, in accordance with this Part of the IDS. All materials used must be Council-approved.

Wherever possible, position each junction opposite the centre of each lot frontage, unless the position of the sanitary fittings is known and indicated otherwise.

Do not lay junctions on sewer mains deeper than 2.5m. Where junctions could be deeper than 2.5m, or where they are shallower and in areas with difficult ground conditions, design collector sewers parallel to the sewer main as detailed in clause 6.5.7 – Collector sewers. Where collector sewers are not detailed and the depth to soffit of the main sewer is more than 2.5m, risers may be used, subject to the requirements of other services and land levels. All other junctions must be side junctions.

Form all junctions with a Y or riser junction so that the side flow enters the main at 45°, to reduce deposition of solids.

Avoid lateral connections to manholes at the top of a line where minimum gradients are involved.

In accordance with the Water Supply & Wastewater Bylaw 2022, all existing private drainage to be re-used for infill development, including laterals serving existing dwellings, must be CCTV'd to confirm that they are free from defects.

6.12.2 Cover

Design the lateral grade and invert level to serve the lot adequately. If there could be conflict with other services, it may be necessary to lower the lateral.

The minimum level for a gully trap is calculated by starting from the soffit level of the main at the connection point. Add the minimum cover to the lateral and the elevation increase of the lateral to this soffit level. The minimum cover is set in the BIA regulations. The elevation increase over the lateral length is calculated assuming the lateral is laid at a gradient of 1 in 80 from the main to the gully trap.

Gully traps must be at least 1.0m above the soffit level of the sewer main. If the gully is lower than the crown of the road, ensure that the gully does not become an overflow for the sewer main in the event of a system blockage. Consider installing backflow prevention devices in places where this cannot be achieved.

On sewer renewal work, when a lateral is identified for renewal and runs close to trees as defined in *CSS: Part 1* clause 19.4 – Protection of Existing Trees, either reroute the lateral around the tree by repositioning the junction on the main, or use pipe bursting or similar techniques to relay the lateral in its present position. Specify jointing in accordance with *CSS: Part 3*, clause 11.1 – Laterals in Close Proximity to Trees.

6.12.3 Common drains

Read the following notes in addition to the BIA regulations.

New sewer mains installed in private property as part of a development and that serve only that development will be private common drains, unless Council specifies through a consent condition that they must be vested. If the developer considers a sewer main in private property should be vested, request this at the time of applying for subdivision consent.

Size the private common main using discharge units as specified in *Compliance Document G13 Foul Water*.

In developments serviced by sewer mains located at the rear of the lots (typically hill developments) extend the sewer main to the boundary of the last lot.

Haunch and backfill laterals laid at the time of development, including those in rights of way, in accordance with *CSS: Part 3* SD 344.

Provide Y junctions and laterals extending clear of the right of way for all lots. All laterals must finish 0.6m inside the net site area of the lot.

6.13 Material Selection

Use Appendix III - Wastewater Material Selection as a guide when specifying materials. Specify polyethylene materials for all wastewater mains where they cross waterways or which may experience lateral spread under seismic loading. Consider specifying polyethylene materials for wastewater mains installed adjacent to waterways, only where the grade is sufficient and constructability to comply with CSS tolerances is deemed acceptable.

6.13.1 Approved materials

A schedule of materials approved for use on the Council's infrastructure is on the Christchurch City Council web page at: www.ccc.govt.nz/consents-and-licences/construction-requirements/approved-materials-list.

6.13.2 Reducing waste

When designing the development, renewal or new asset, consider ways in which waste can be reduced.

> Plan to reduce waste during demolition e.g. minimise earthworks, reuse excavated material elsewhere.

> Design to reduce waste during construction e.g. prescribe waste reduction as a condition of contract.

> Select materials and products that reduce waste by selecting materials with minimal installation wastage.

> Use materials with a high recycled content e.g. recycled concrete subbase.

See the Resource Efficiency in the Building and Related Industries (REBRI) website for guidelines on incorporating waste reduction in your project www.rebri.org.nz/.

6.13.3 Corrosion prevention

Corrosion can be caused by hydrogen sulphide, aggressive groundwater, saltwater attack, carbon dioxide or oxygen rich environments.

Design to minimise corrosion through:

> selecting materials which will resist corrosion;

> designing in an allowance for corrosion over the 100-year life-cycle of the asset;

> providing protective coatings;

> using the measures suggested in clause 6.13.4 - Aggressive groundwater.

Bolts and fittings must be hot dip galvanised and incorporate zinc anodic protection. All metal components must be protected from corrosion with a petrolatum impregnated tape system, applied in strict accordance with the manufacturer's specifications. Do not use stainless steel where it may fail as a result of crevice corrosion caused by cyclic stress in the presence of sulphides and chlorides.

6.13.4 Aggressive groundwater

Appendix IV - Aggressive Groundwater Map shows the areas that the Council have found to be subject to aggressive groundwater. Before specifying concrete pipes within 1km of these known areas, test the groundwater to check whether concrete piping is appropriate.

Regard groundwater as aggressive to ordinary Portland cement if any of the following criteria are met:

> over 35ppm calcium carbonate ($CaCO_3$) alkalinity and over 90ppm aggressive carbon dioxide (CO_2).

- under 35ppm calcium carbonate ($CaCO_3$) alkalinity and over 40ppm aggressive carbon dioxide (CO_2).
- pH less than six.
- sulphate greater than 1,000mg/l.

Measures to counter aggressive groundwater include:

- laying concrete pipes in concrete haunching.
- wrapping pipes with polyethylene film.
- providing a sacrificial layer of concrete.
- increasing cover to reinforcing.
- using special cements.
- coating pipes with bitumen, epoxy, or similar, before installation.
- use of alternative highly resistant pipe materials.

6.13.5 Sewers in commercial or industrial zones

Concrete pipes may be used only with approval from the Council and may require an internal sacrificial layers up to 25mm thick. This layer should not be taken into account in strength calculations. Using additives that promote chemical resistance, installing internal linings or specifying a pipe supplied with an internal lining system may be an alternative.

6.13.6 Gravity sewers immediately downstream of pressure pipelines

PVC, PE and concrete pipes are suitable for use in gravity sewer pipelines. Do not specify concrete pipes where it is likely that, in the future, a rising main will discharge to the top end of a gravity system because of the risk of attack from hydrogen sulphide.

Where a new rising main or PSS will discharge to an existing gravity system, mitigate against H2S corrosion and odorous gases by:

- detailing corrosion protection treatment or plastic structures for the receiving manhole and all additional manholes or structures within 400m.
- designing for velocities below 1.5 ml/s at the discharge point.
- reducing turbulence through detailing a minimum four metres length of gravity flow between the discharge chamber and the existing gravity sewer system and ensuring the flow enters the existing system at its invert.

Provide odour control at the receiving manhole where the fully developed system's maximum retention time exceeds 4 hours.

6.13.7 Steep gradients

Where gradients are steeper than 1 in 3 over lengths greater than 3.0m or where velocities are higher than 4.0m/s, and when flows are continuous or frequent, site-specific enigneering design specifying wear-resistant pipe is required (see Appendix III-Wastewater Material Selection Table). This requirement may extend past the termination of the steep grade. Sacrificial layers can be used in special concrete pipes, or in in-situ structures.

Avoid lateral junctions on these sections of pipeline. Take care to provide adequate anchorage for the pipes, through designing thrust or anchor blocks or by utilising restrained pipe systems.

6.14 Haunching And Backfill

Consider the whole trench, including the pipe, the in-situ material, the haunching and the backfill as a structural element. Design it to withstand all internal and external loads.

Specify wrapping of the joints in all rubber ringed jointed concrete pipes with a geotextile that complies with TNZ F/7 strength class C. Select a geotextile that will prevent the infiltration of backfill or natural material into the wastewater system where pipes break under seismic loading. Wrapping of joints is not required for pipes laid on 'hillsides', as defined in clause 6.14.3 – Scour.

Haunching for plastic pipes shall be wrapped with a geotextile that complies with TNZ F/7 strength class C when the pipe is in a location with high liquefaction vulnerability. Consider wrapping where the proposed pipeline extends into a medium liquefaction vulnerability area. Use engineering judgment where the site is in a location where liquefaction damage is possible or where the liquefaction category is undetermined. Wrapping may improve the longitudinal strength of the pipeline, reducing the likelihood of a earthquake causing potential alterations in grade. Liquefaction vulnerability categories are shown on the Vulnerability Map tab of apps.canterburymaps.govt.nz/ChristchurchLiquefactionViewer.

Use the manufacturer's material specifications, design charts or computer models to design bedding and haunching, unless these provide a lesser standard than would be achieved through applying the requirements of *CSS: Part 3*. Provide details in the Design Report.

Specify backfill materials individually. The material used must be capable of achieving the backfill compaction requirements set out in *CSS: Part 1* clause 32 - Backfilling.

Earth loads on deep pipelines can significantly increase when pipes are not laid in narrow trenches e.g. embankments. However, where there is a danger of the surrounding soils or backfill migrating into the haunching or foundation metal, protect the haunching and foundation metals with an approved geotextile.

6.14.1 Pressure pipes

Haunch pressure pipelines as detailed in *CSS: Part 3* and design thrust blocks as detailed in clause 6.8.5 - Thrust blocks. In the case of upward thrust, reliance must be placed on the dead weight of the thrust block. Special design may be warranted where there are high heads, large pipes or unusual ground conditions.

6.14.2 Difficult ground conditions

Consider the ground conditions as part of the design. If there is a possibility of soft ground, carry out ground investigations.

Replacing highly compressible soils (such as peat) with imported granular fill material can cause settlement of both the pipeline and trench surface, because of the substantial increase in weight of the imported material. Refer to clause 4.6.3 – Peat (Geotechnical Requirements) for further information.

Haunching and backfill in these areas may need to be wrapped in filter cloth to stop the sides of the trench pushing out into the softer ground. Wherever the allowable ground bearing strength is less than 50 kPa, design structural support of the pipe and any structures.

Consider using a soft beam under the pipe haunching for support or using a flexible foundation raft. Retain joint flexibility. Difficult bedding conditions may warrant the use of piling, in which case smaller pipes may require some form of reinforced concrete strengthening to take bending between piles.

6.14.3 Scour

'Hillsides' are defined as any location where either the pipe gradient or surface slope directly upstream or downstream is steeper than 1 in 20. 'Hillsides' may have large variations in groundwater levels. These variations can cause sufficient water movement within the trench for bedding scour to develop.

Fill any under-runner voids encountered during the work with either 'foam concrete' or 'stiff flowable mix' as defined in *CSS: Part 1*. This treatment must be carried out under the direction of the engineer.

Haunching and backfill materials for hillside areas include lime stabilised backfill (CCC Stabilised AP40 + 40kg/m3 Hydrated Lime) or 'firm mix' (CCC Stabilised AP20 + 60kg/m3 Hydrated Lime) as defined in *CSS: Part 1*.

Use lime stabilised SAP40 for backfilling all carriageways, and lime stabilised SAP20 in all areas outside carriageways where loess is not suitable. Wrapping of joints is not required in 'hillside' trenches backfilled with lime stabilised material.

Specify water stops at 5m spacing on all pipelines with gradients steeper than 1 in 3. Where 'firm mix' is used for haunching, water stops are not required. Construction must comply with *CSS: Part 3* SD 347.

6.14.4 Abandoned Infrastructure

Where work will produce abandoned in-ground piping, treat the potential void by either removing or by filling the pipe as detailed below:

> Treat abandoned pipes below new pipes where the new pipe is within the zone of influence of the abandoned pipe, as illustrated in Figure 5.

> Treat all pipes on the hillside.

> Where treating abandoned AC pipes, fill them and leave them in the ground to avoid contamination issues. Ownership of the in-ground abandoned pipe located on private property shall be transferred into private ownership in terms of a mutual agreement or alternatively abandoned AC pipes shall be removed and disposed as hazardous waste.

> For all other pipes that are outside the zone of influence illustrated in Figure 5, only detail sealing of the ends of the abandoned pipes with concrete or grout, including the lateral junctions.

CSS: Part 3 clause 5.3 – Abandoned Infrastructure, specifies treatment methods for abandoned manholes.

Flowable fill with a minimum strength of 1.5 MPa is the suggested material for filling abandoned pipes. Require confirmation through the Contract Quality Plan that the void has been filled. This may be through the provision of a methodology or other means.

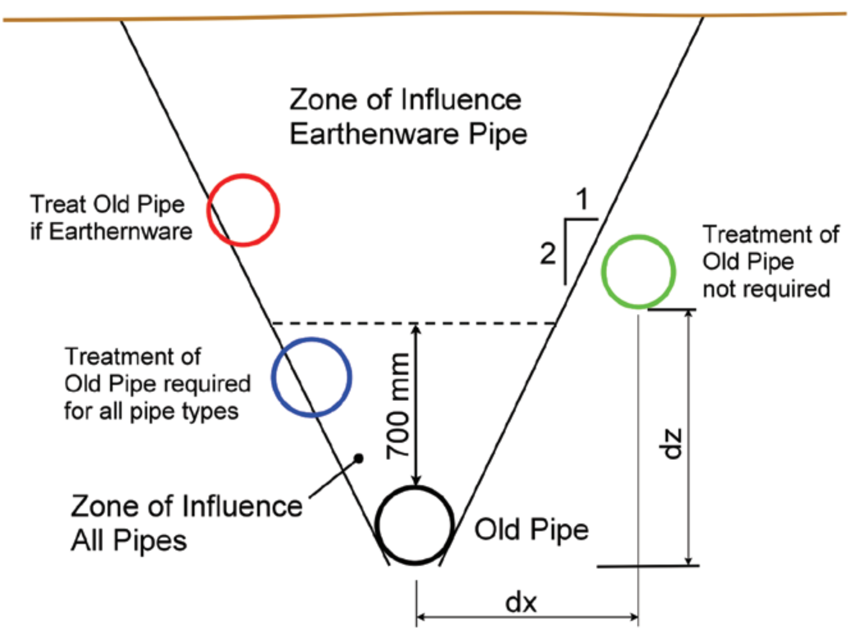


Figure 5 Pipe zone of influence

The zone of influence extends to the ground surface for obsolete earthenware pipes but is limited to 700mm above the soffit of the obsolete pipe otherwise.

A pipe is within the zone of influence if the centreline separation distance (d_x) is less than the minimum given by:

Equation 14 Separation distance

$$d_{xmin} = 0.5d_z + 0.3\,dia_{old} + 0.8\,dia_{new}$$

where d_z is the difference in invert level between the new and obsolete pipes.

CSS: Part 3 clause 5.3 – Redundant and Abandoned Infrastructure specifies treatment methods for redundant manholes.

Where the design manhole invert is being adjusted to a higher pipe level, detail that the manhole invert be filled and re-benched to the requirements of *CSS: Part 3* clause 12.11.6 – New pipe invert in existing manhole.

6.15 Clearances and Asset Protection

Part 9: Utilities summarises clearances for utility services. Confirm these clearances with the network utility operators before deciding on any utility layout or trench detail. Maintain the clearances unless the utility operator grants approval otherwise.

No structures or trees shall be placed within the Maintenance Access Corridor of wastewater assets. Structures include temporary or relocatable buildings (such as sheds), shipping containers, storage tanks, decks, hard landscaping, etc. Tree pits and root barriers are required for all trees at the clearances specified below where the drip line will overhang the Maintenance Access Corridor.

For pipes, the Maintenance Access Corridor width will be the greater of:

a) twice the buried depth of pipe (surface to trench base), plus the outside diameter of the pipe; or

b) 1.5 metres from either side of the centre of the pipe.

Where the infrastructure or asset is not a pipe (example a manhole), the Maintenance Access Corridor is one metre off the asset's border in all directions.

6.16 Trenchless Technology

When working in high volume roads, public areas, adjacent to trees or through private property, consider using trenchless technologies.

Thorough surveys and site investigations, which minimise the risk of encountering unforeseen problems during the work, are essential for the success of trenchless construction. Ensure that the method used complies with the pipe manufacturer's specifications.

Options available include the following:

> Pipe bursting;
> Pipe or manhole relining;
> Horizontal directional drilling (HDD);
> Auger boring/Guided boring;
> Pipe ramming;
> Slip lining;
> Microtunnelling;
> On-line replacement (pipe reaming or pipe eating).

The Council may approve other technologies on a case-by-case basis as they are considered or developed. When proposing a new trenchless technology, submit a full specification to the Council that covers the design and installation process.

Submit the following, with the Design Report:

> plans and long sections showing the design vertical and horizontal alignment, how the required clearances from other services and obstructions will be achieved and the expected construction tolerances (including annulus dimensions);
> the location and site space requirements of launch and exit pits and their impacts on traffic and existing services;
> how the alignment and depth will be tracked and as-built records provided over the whole length, including joint locations;
> reticulation details including structural pipe design, jointing details, jointing methods, connections, inline structures and excavation treatments to prevent groundwater movement;
> geotechnical investigation results and how these have affected the choice of trenchless installation method;
> the method of spoil removal;
> a risk management and assessment study including environmental management, to mitigate potential constructed, installed and operational issues.

Refer to *Guidelines for Horizontal Directional Drilling, Pipe Bursting, Microtunnelling and Pipe Jacking.*

Specify hold points for acceptance and for inclusion in the Contract Quality Plan, and required material or performance tests to be included in the Contractors Inspection and Test Plan, including:

> Presentation of trenchless contractor's details, including experience with method, pipe diameter and expected ground conditions, to Council for acceptance.

> Presentation of installation methodology to Council for acceptance, including depth and location tracking.

> Determination of design tensile forces/stresses on the pipe and auditing against these values during pipe pull and compression stresses on pipe ram casings.

> Determination of design slurry pressure rates, methods to prevent fracking and auditing against these during directional drilling.

- Calculations and methodology to ensure installed allowable pipe buckling stress is not exceeded during grouting.
- Relaxation period for polyethylene pipe post installation.

6.16.1 Pipe bursting

Pipe bursting is suitable for replacing sewers that are constructed of brittle pipe material, such as unreinforced concrete and vitrified clay. Generally, this method is not suitable for replacing reinforced pipes. Pipe bursting is not permitted for replacement of asbestos cement (AC) pipes.

Pipe bursting should not be used unless the sewer being replaced has sufficient grade to comply with clause 6.5.3 – Minimum gradients, with an allowance for grade variations as the burst line will maintain the existing grade. Pipe bursting is not suitable when existing pipelines contain dip defects. Provide CCTV records of both the existing pipeline before bursting and the new pipeline after bursting, to confirm the adequacy of the final grades.

Obtain accurate information about the original construction material and the condition of the existing pipeline, including whether there have been any localised repairs, and whether sections of the pipeline have been surrounded or haunched in concrete. Take special care when the existing pipe has been concrete haunched, as this will tend to raise the invert level of the new pipeline and cause operational problems. Shallow pipes or firm foundations can also disturb the ground above the burst pipe.

Replace the entire pipe from manhole to manhole. The number and frequency of lateral connections may influence the economic viability of this technique.

Grouting of the annulus, especially on the hills, is an essential part of this technique. Where special techniques are required, ensure these are approved **before** the work commences.

6.16.2 Cured in Place Pipe (CIPP) Lining

Lining systems can be considered for renovating gravity wastewater mains when standard trenching installation is deemed unfeasible. Before undertaking lining, check the structural integrity of the host pipe and make good any infiltration points. Ensure that the hydraulic capacity, after lining, is sufficient for projected future peak flows. Council will not accept lining of 100 mm diameter wastewater mains or laterals.

The liner must produce a durable, close fit with a smooth internal surface. The liners must have a minimum design life of 50 years, and be resistant to all chemicals normally found in sewers in the catchment area. The manufacturer must submit guarantees to this effect to the Council.

The design of the liner, including the required wall thickness under different loading conditions, must comply with the manufacturer's recommendations and specifications. Submit a specification to the Council that details liner system design and installation methodology for Council acceptance.

As the host pipe is blocked during the liner installation process and any curing requirements, adequate flow diversion procedures and detailed methodology is required. Repair any structural, lateral junction or grade issues by open dig prior to liner installation.

The opening of connections must be carried out remotely from within the lined sewer. Prepare accurate location records by detailed surveys prior to liner installation. Additional grouting of junctions may be required after opening.

6.16.3 Horizontal directional drilling and auger or guided boring

Restrict sewer installation using boring or directional drilling to instances where their construction tolerances are acceptable. Installing gravity reticulation using directional drilling is not generally appropriate. Consider possible ground heave over shallow pipes.

Take into account the space requirements for the following:

- drill pits, including working space;
- drill rigs, including access paths for drill rigs;
- drill angle (the drill rig may need to be placed some distance away from the sewer starting point, depending on the angle);
- placement of an appropriate length of the joined sewer on the ground for pulling through the preformed hole;
- erosion and sediment control.

Surface-launched drilling machines require larger construction and manoeuvring spaces compared to pit-launched drilling machines. Consult specialist contractors before selecting this technique.

6.16.4 Slip lining

It is essential to carefully consider the effect that the work will have on the system operation **before** using a slip-lining technique, especially in relation to finished invert levels and capacity.

Carefully inspect and prepare the host pipe prior to the installation of the new pipe. Use a sizing pig at the investigation stage, to confirm clearances.

Replace the entire pipe from manhole to manhole. Reconnect lateral connections to the new sewer as set out in *CSS: Part 3*, clause 7.3 – Thermoplastic Jointing of Polyethylene Pipe by Electrofusion Welding. The number and frequency of lateral connections may influence the economic viability of this technique.

Carry out grouting of any annulus after installing the new pipeline and gain approval for the technique to be used **before** the pipe is installed. Ensure that grouting doesn't cause buckling or flotation of the internal pipe.

Slip lining of 150mm diameter sewers is not permitted.

6.17 Pipe Ducts

Pipe ducts are required for any pipes crossing the alignment of a newly constructed NZTA expressway or motorway. Pipe ducts shall be considered when a pipeline crosses an NZTA designated road, railway crossing, stream crossings or other instances where above-ground features obstruct or impede the ability to access a pipe for maintenance or renewal. Install duplicate or oversize ducts where growth modelling indicates a capacity increase with a 50 year timeframe.

Pipe ducts crossing a railway shall comply with Kiwi Rail ducting requirements. In all other instances, pipe ducts shall be constructed out of PE100, RCRR, DI or steel. Pipe ducts shall meet maximum anticipated loading and asset life of the greater of 100 years or the theoretical lifespan of the pipeline to be placed within the duct. Minimum class strengths allowed shall be SDR 11 for PE100, Class 4 (Z) for RCRR and PN35 for DI and steel. Steel ducting requires corrosion protection.

Duct design shall provide for removal and replacement of the pipeline within the duct with the duct remaining in place. Minimum duct design requirements include:

> Minimum duct diameter shall be the diameter of largest diameter flange, coupler or other fitting on the pipeline plus the greater of 50mm or 20% of diameter.

> Assume minimum duct internal diameter and maximum external diameter of pipe, flange, coupler or other fitting within the tolerances in the relevant manufacturing standards.

> Gravity pipelines through ducts shall maintain grade, either by duct installation on a matching grade or increasing the duct diameter to allow for the grade.

> Pipelines within ducts shall not have high points.

> High points at either end of a duct shall allow for air valves.

> At least one end of the duct shall provide a staging area sufficiently sized for removal of the entire flange-to-flange or coupler-to-coupler pipeline length.

> Duct end designs shall minimise forces on the pipeline from bending, shear and differential settlement. Mitigation measures shall include over excavation and compaction under duct ends and installation of compressible rubber at the duct ends as per AS/NZS 2566.2:2002 figure 5.6.

> Centraliser and casing separation systems shall support the pipe within the duct and be removable. Design drawings shall detail any and all such systems.

> Seals at duct ends shall prevent ground or surface water ingress and be removable. Design drawings shall detail any and all such seals.

Pipelines in ducts shall be SDR11 PE100 pipe material to allow for pipe de-rating and mitigate risk of scratching or gouging the pipe during installation. Detail flange connection and fitting details at each end.

Grouting or installation of any flowable fill within the annulus is prohibited.

6.18 On-Site Wastewater Treatment Systems

In rural residential areas, where ground conditions and terrain are suitable, wastewater disposal may be catered for using on-site septic tanks or wastewater treatment systems.

The *Natural Resources Regional Plan (NRRP)* contains policies and rules relating to the discharge of wastewater effluent.

If compliance with the *NRRP* rules is not achieved, a resource consent is required from Canterbury Regional Council (Environment Canterbury). Contact Canterbury Regional Council for information on their requirements.

In all instances, obtain a Building Consent from the Christchurch City Council to install, modify or renew an on-site wastewater treatment and distribution system.

6.19 Authorised Installers

Only Christchurch City Council Authorised Drainlayers are permitted to install pipework that will be vested into the Council and any pipework that is located within legal roads. A full list of authorised drainlayers and conditions of approval may be found on the Council webpage www.ccc.govt.nz/consents-and-licences/construction-requirements/approved-contractors/authorised-drainlayers.

Construction of the wastewater system must not start until acceptance in writing has been given by the Council.

Wherever works are installed within existing legal roads, obtain a Works Access Permit (WAP) for that work. Apply for a Corridor Access Request (CAR) at www.beforeudig.co.nz. The work must comply with requirements as set out in *CSS: Part 1* for this type of work.

6.20 As-Built Information

Present as-built information which complies with Part 12: As-Built Records and this Part.

APPENDIX I

Tractive Force Design Charts

Chart 1 Tractive force design chart (grade as %)

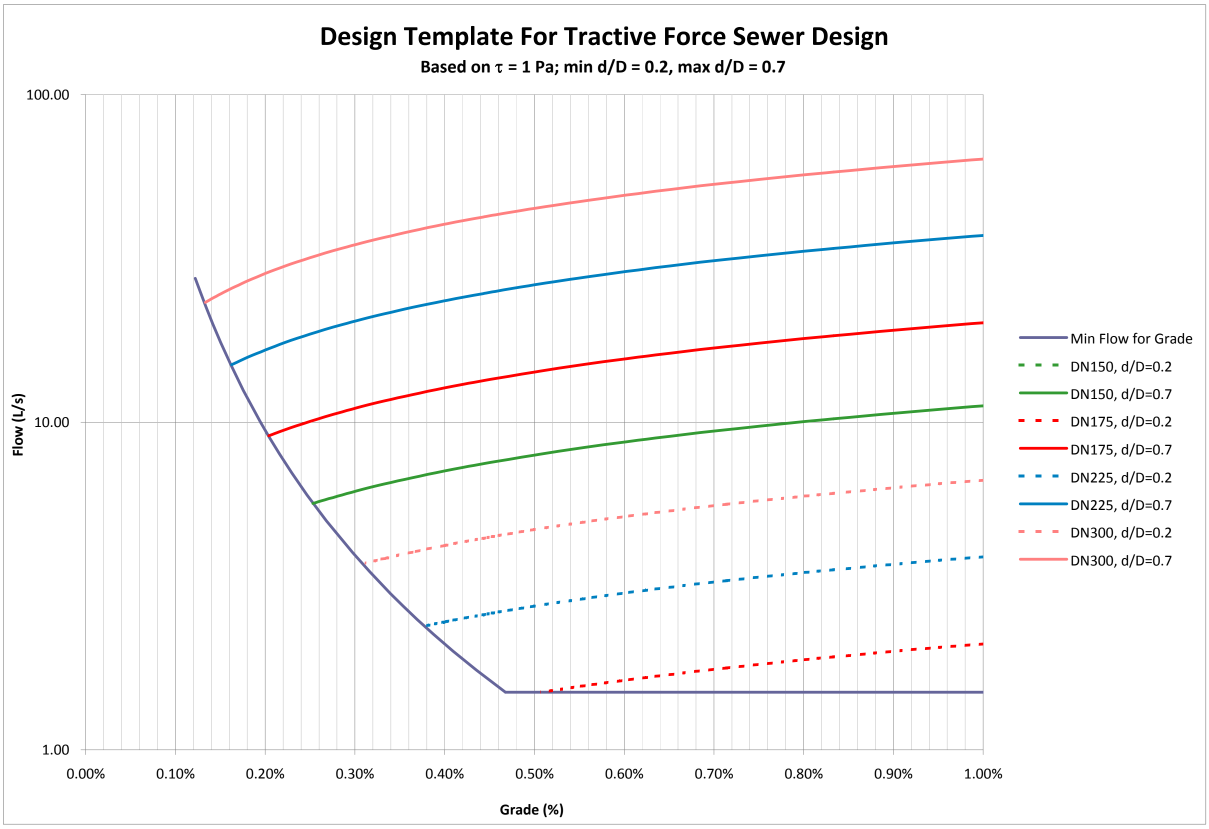
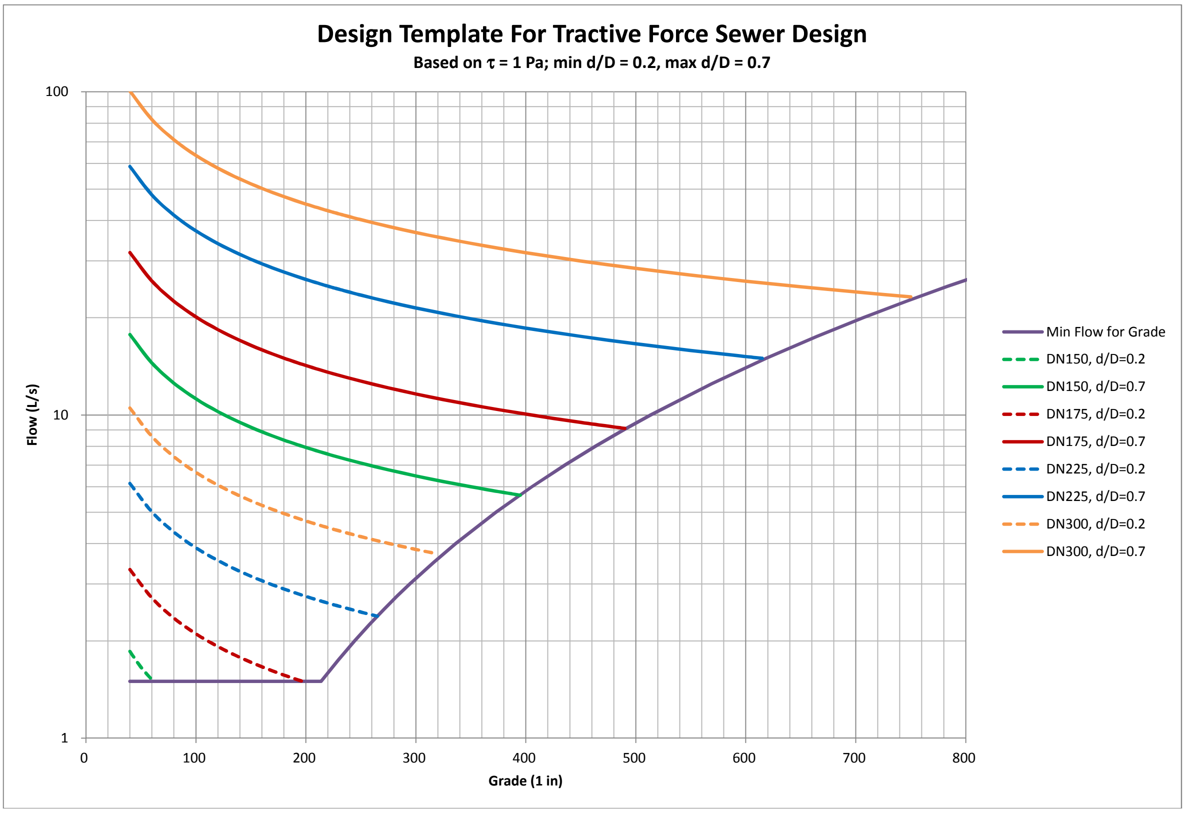


Chart 2 Tractive force design chart (grade as ratio)



APPENDIX II

Determination Of Minimum Gradient And Hydraulic Design Example

An area of 5.0 hectare is zoned L3, with a corresponding unit ASF of 0.25 l/s/ha. The minimum SCF from Equation 14 is:

Equation 15 Self cleansing flow example

$$\begin{aligned} SCF &= P/A\ ratio \times SPF \times ASF \\ &= 1.8 \times 1.0 \times (0.25\ \ell/s/ha \times 5\ ha) \\ &= 2.25\ \ell//s \end{aligned}$$

Drawing the minimum SCF on the Tractive Force Design Chart, the horizontal line intersects the minimum grade line at an approximate grade of 0.39% or 1 in 260.

Chart 3 Tractive force design chart example (grade as %)

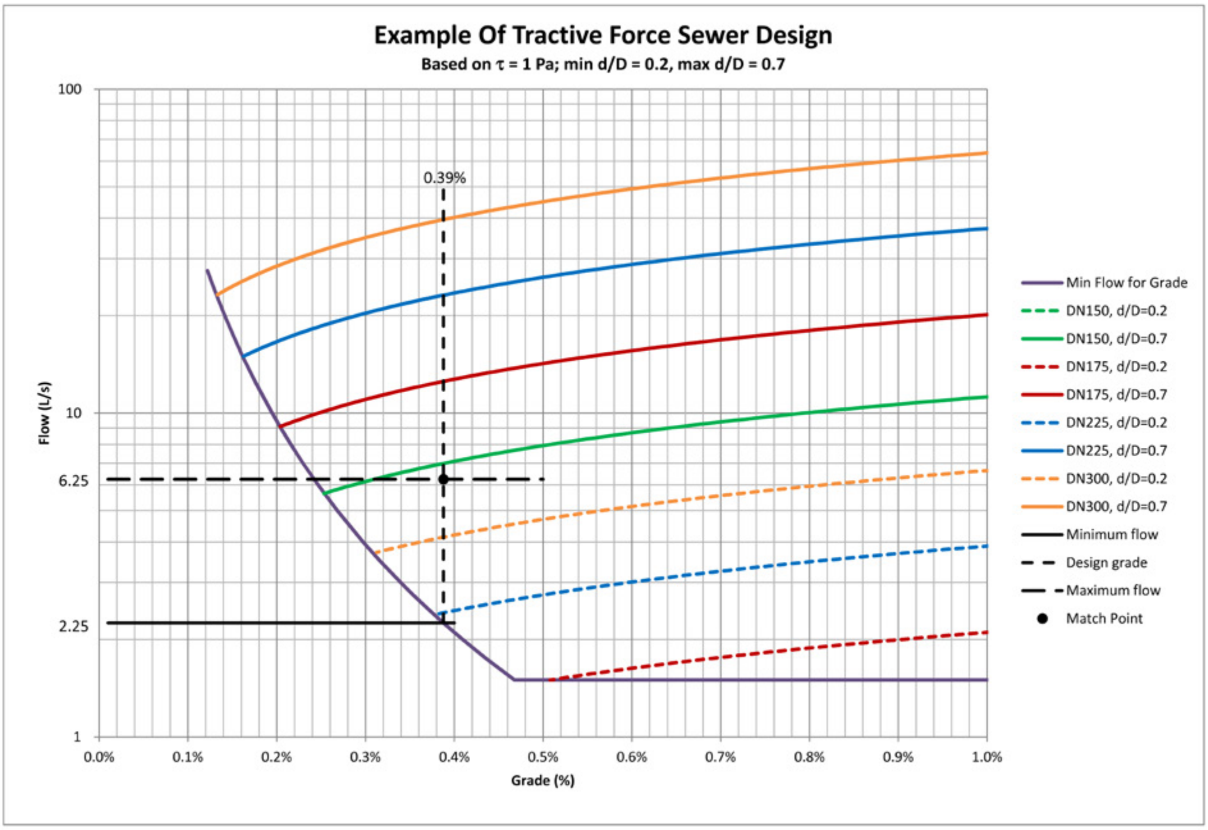
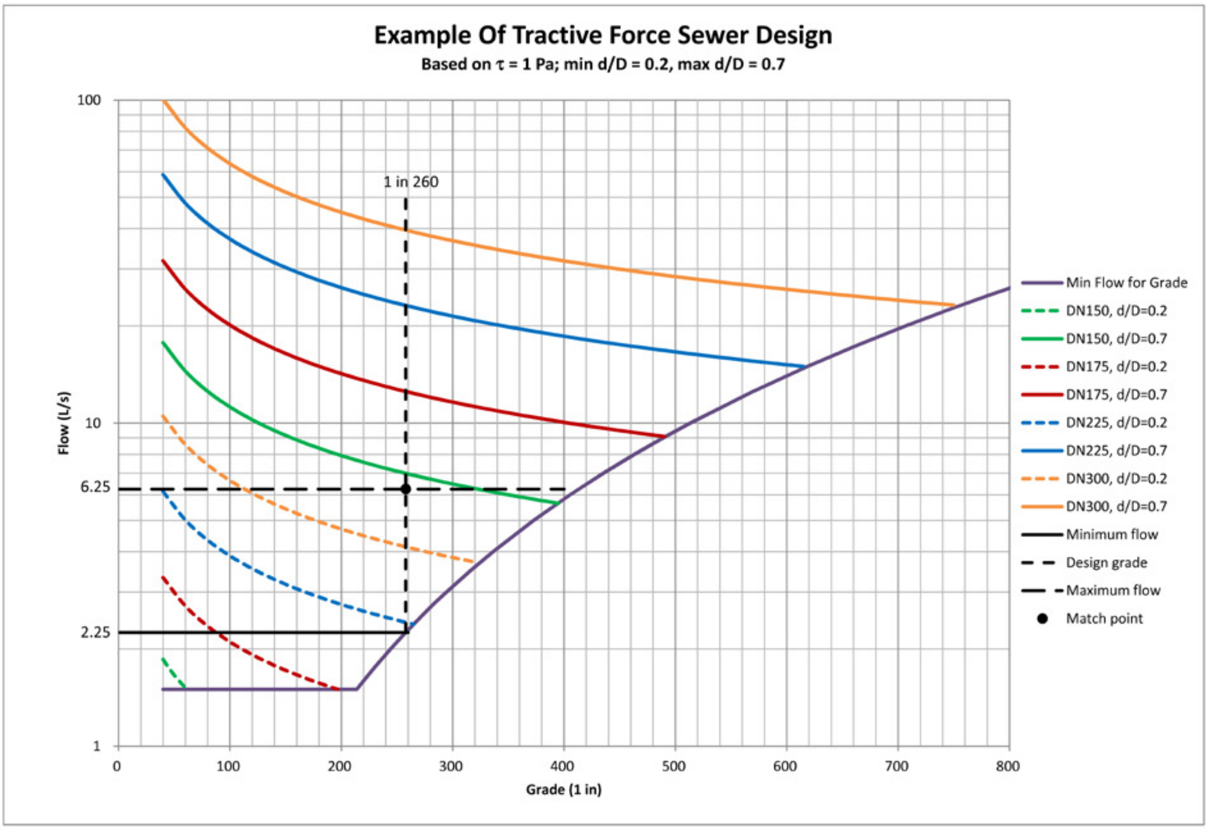


Chart 4 Tractive force design chart example (grade as ratio)



Calculate the maximum flow:

Equation 16 Maximum flow calculation example

$$
\begin{aligned}
MF &= P/A\ ratio \times SPF \times ASF \\
&= 1.8 \times 2.78 \times (0.25\ \ell/s/ha \times 5\ ha) \\
&= 6.25\ \ell//s
\end{aligned}
$$

Drawing a horizontal line at this value on the chart, the line intersects the vertical line representing the grade of 0.39% or 1 in 260 at a point just below the line representing the maximum capacity of a DN150 pipe.

The corresponding pipe size will be 150mm.

APPENDIX III

Wastewater Material Selection Table

Property	CLS	DI	GRP	Single Wall MDPE100	Single Wall PPRRJ	Twin Wall MDPE100/ PP	PVC-U	RCRRJ
Approved for Gravity Wastewater	Specials Only	Specials Only	Project Specific	Project Specific	Laterals Only	Project Specific	Yes	Yes
Approved for Pressure Wastewater	Specials Only	Yes	Project Specific	Yes	No	No	Yes	No
Approved for LPSS Wastewater	No	No	No	Yes	No	No	No	No
Approved for Vacuum Wastewater	No	No	No	Yes	No	No	No	No
Suitable for Trenchless Installation	No	No	No	Yes	No	No	No	Specific Design
Provides a Restrained System	Specific Design	Specific Design	No	Yes	No	No	No	No
Suitable for Aggressive Groundwater	No	Specific Design	Yes	Yes	Yes	Yes	Yes	No
Suitable for Anaerobic Conditions	No	Specific Design	Yes	Yes	Yes	Yes	Yes	No
Suitable for Tidal Zones	No	Specific Design	Yes	Yes	Yes	Yes	Yes	No
Suitable for Above Ground Applications	Specific Design	Specific Design	No	No	No	No	No	Yes
Suitable for High Liquefaction Vulnerability Areas	Specific Design	Specific Design	No	Yes	No	No	No	No
Fatigue Resistant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N/A
Approved for Internal Diameters > 600	Specific Design	Specific Design	Specific Design	Specific Design	No	Specific Design	Specific Design	Specific Design
Wear Resistant (scouring veolcities > 4 m/s)	No	Specific Design	Yes	Yes	Yes	Yes	Yes	Specific Design
Suitable for Industrial Zones	No	Specific Design	Yes	Yes	Yes	Yes	Yes	Specific Design
H2S Resistant	No	Specific Design	Yes	Yes	Yes	Yes	Yes	Specific Design

Pipe materials other than those listed are not approved for use on the wastewater network.

Project Specific means that project specific approval is required. An options assessment proving benefits of the material may be required.

Specific Design means the material requires a site specific design to meet the requirements for use in the application or installation method. Specific designs may focus on jointing methods, coating materials, lining materials and/or installation methods. Specific designs require Council review and approval.

Specials Only means the material is not approved for widespread use but may be used for short lengths to address site specific constraints.

APPENDIX IV

Aggressive Groundwater Map