Vacuum Wastewater Systems Standard

Draft

Amendments					
Revision No.	Details	Originator	Reviewed by	Approved by	Date
0.1	Issued for Client Review	Cristian Jara	Dragan Jovanovic	Dragan Jovanovic	16/10/2018
0.2	Issued for Client Review	Cristian Jara	Dragan Jovanovic	Dragan Jovanovic	02/11/2018
0.3	Issued as final draft	Cristian Jara	Simon Wang	Dragan Jovanovic	14/11/2018
0.4	Issued as final, final draft	Cristian Jara	Simon Wang	Dragan Jovanovic	16/11/2018
0.5	Working draft	J de Villiers		J de Villiers	27/11/2018

Table of Contents

Table of Figures

Glossary

ADWF	Average dry weather flow
Collection chamber	Sealed pit separated in sump, storing gravitational discharge from properties prior to entering the vacuum mains and valve chamber.
DN	Nominal metric diameter conforming to the International Standards Organization
HDD	Horizontal directional drilling
l/s	Litres per second
NPSH	Net positive suction head
PWWF	Peak wet weather flow
SS	Stainless Steel
Static lift	Elevation difference in pipeline at sections where pipe is raised to maintain an acceptable depth and profile
Static lift losses	Sum of all static lifts in a path from end of line or individual collection chamber to the vacuum vessel
Vacuum interface valve	Device that allows collected liquid to enter the vacuum wastewater pipeline once certain volume has been reached. Operates automatically
Vacuum vessel	Collects all wastewater from the network for pumping to the treatment plant. Also provides vacuum storage to the system

1 General

1.1 Introduction

This standard is set out to provide the general principles, minimum criteria and best practices for delivering vacuum wastewater systems to Watercare. This standard also shows where detailed studies are required to supplement the design requirements.

The Vacuum Sewerage Code of Australia (WSA 06) is used as the basis for this document.

Whenever a design varies from the requirements specified in this document, the designer shall discuss the variation with Watercare in the first instance. Significant variations from these standards require Watercare approval, and may be rejected at Watercare's discretion.

Vacuum wastewater systems will only be allowed by Watercare when gravity systems prove impractical, clearly show higher operation and life-cycle costs or where special circumstances can be demonstrated that require alternative systems (e.g. environmental risk management). Approval from Watercare must be obtained in advance of submission of engineering plans.

The design of vacuum wastewater systems needs to be completed by suitably qualified and experienced designers and to the minimum requirements as set out in this standard.

This standard covers the planning and design of vacuum wastewater network, collection chambers, vacuum vessel, vacuum pumps and other associated elements not referred in other Watercare standards.

This standard shall be read in conjunction with the latest version of the Watercare electrical standards and control drawings. Watercare's telemetry requirements are location based and require input from Watercare to identify the applicable standards and/or site requirement for the proposed site location.

Note – Any additional controls and telemetry not specified in the Watercare electrical standards must be specifically designed and reviewed with Watercare.

1.2 General requirements

Vacuum wastewater systems developed by Watercare or a developer shall follow the same process of review and implementation.

This design standard shall be read in conjunction with at least the following Watercare standards and documents:

- COP-02 – Water and wastewater Code of Practice for land development and subdivision, Chapter 5
- DP-06 – Local network wastewater pumping stations
- DP-07 – Design principles for transmission water and wastewater pipeline systems
- CG – General civil construction standard
- ME – General mechanical construction standard
- MS – Material supply standard
- EC – General electrical construction standards
- DP-09 – Electrical design standard
- DP-12 – Architectural design guidelines

- COP-03 – Code of Practice for commissioning.

Other standards referenced in this document:

- AS 3996-2006 Access covers and grates
- AS 4310-2004 DN 80 piston type vacuum interface valves for municipal sewer systems
- AS/NZS 1200:2015 Pressure equipment
- AS/NZS 4087 Metallic flanges for waterworks purposes
- AS/NZS 4130:2009 Polyethylene Pipes (PE) For Pressure Applications.

1.3 Vacuum wastewater systems

1.3.1 Vacuum system philosophy and description

Vacuum systems are suitable for domestic and industrial wastewater collection. This system uses a slug flow mixture of air and liquid to collect and transport wastewater to a central collection point. Vacuum wastewater systems, depending upon terrain and development layout, can provide an economical and practical solution over long distances and varying elevations.

This wastewater system operates with a constant level of vacuum maintained by vacuum pumps and a vacuum vessel. Wastewater flows gravitationally from each property to a collection chamber located in the vicinity, where once a certain volume of liquid is reached, an automatically operated vacuum interface valve opens. The difference in pressure between atmosphere and the vacuum wastewater pipeline forces the wastewater into the system and the valve closes after a set period of time, allowing for additional air to enter the system.

On each interface valve operation, the air and wastewater mixture is forced along the pipeline until friction losses cause the liquid to be brought to rest in the lower sections of the sawtooth profile. This process is repeated until the wastewater eventually discharges in the vacuum vessel located inside the vacuum pump station. From there, wastewater accumulates and discharge pumps forward the liquid through a rising main to the point of discharge. Vacuum pumps located in the station, evacuate air from the top of the vessel to maintain a constant level of vacuum in the system.

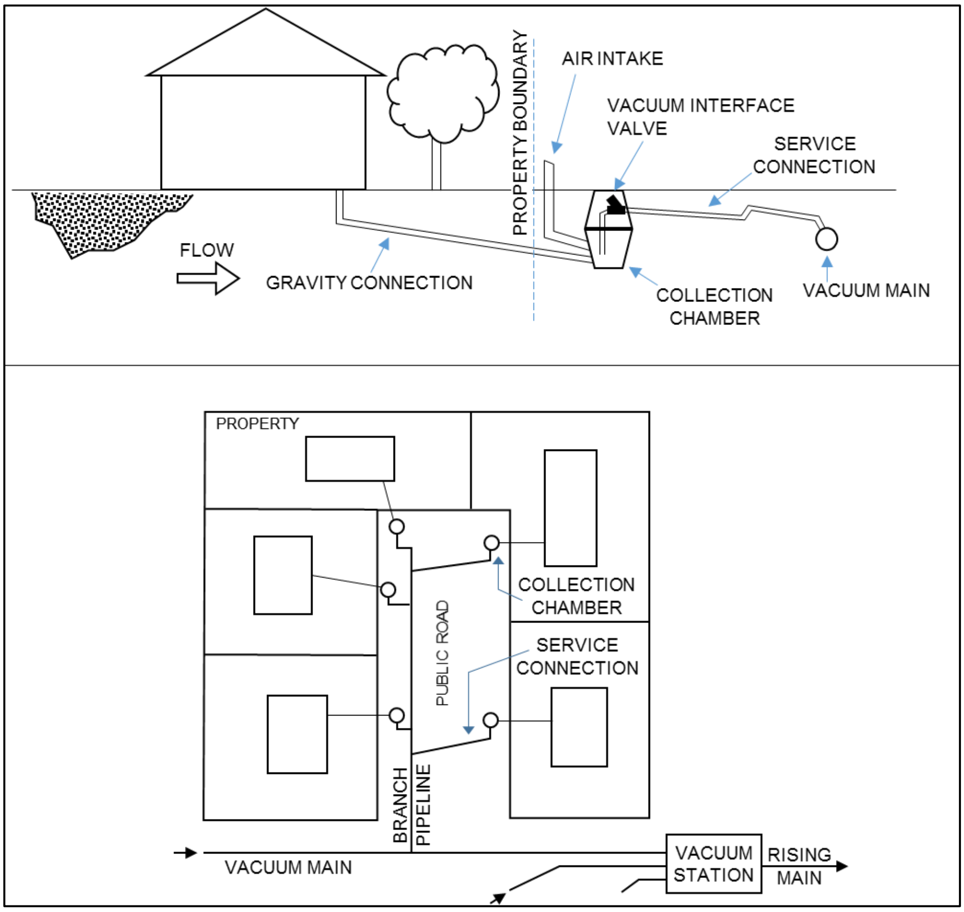


Figure 1-1 Examples of property connection and branch layout

1.3.2 Application of vacuum wastewater systems

Some of the circumstances in which vacuum wastewater systems offer an advantage against other systems are:

- Insufficient terrain slope (i.e. flat or slightly uphill terrain)
- Poor subsoil (i.e. shallow rock or high water table)
- Obstacles in the pipeline route
- Communities with only seasonal flows
- Network in aquifer protection zones
- Reduced maintenance requirement (lower maintenance cost).

1.4 Design output and responsibilities

The design shall be delivered by a person with evaluated competency. Refer to the Watercare compliance statement policy for acceptable levels of qualification and competency registration. The following comprehensive documents shall be provided to Watercare for evaluation of the design:

a) Geotechnical report on the suitability of the land for subdivision

b) Basis of design report describing options and selection of design

c) Final design report that includes:

- Site information such as location, layout, contours, soil contamination test results
- Impact assessment on adjacent properties and services
- Value engineering that includes material selection, constructability analysis, simplification, innovation and life-cycle costing
- Assumptions and non-compliance - identifying alternative options to meet performance requirements
- Detailed calculations
- Drawings showing location, detailed long sections, pipe grades and sectional details
- Site specific specification for construction
- Nominated minimum levels of construction supervision

d) Risk analysis

e) Functional descriptions (process and pump stations)

f) O&M manual

g) New assets register

h) Project execution plan that includes the engineering construction plan/approach and Watercare's connection requirements

i) Design compliance statement – See Watercare compliance statement policy.

The design engineer shall provide evidence that a vacuum wastewater system is the most appropriate solution, including but not limited to technical, financial, economic and environmental evaluation against other alternatives.

The design of vacuum wastewater systems shall be reviewed with the selected system supplier, however, the design engineer shall be responsible for to ensure that the final aspects of vacuum system design meets Watercare's requirements.

1.5 Wastewater system design approach

1.5.1 System design life

All wastewater systems shall be designed and constructed for a service life of at least 100 years without rehabilitation. The design flows are to ensure that the system has sufficient capacity over its 100 year design life to adequately transport expected high spikes in flow due to changing conditions of the system.

Some components such as pumps, valves, and control equipment may require earlier renovation or replacement. The designer should specify suitable materials for the system, based on Watercare's materials standard. The use of components not listed on the material supply standards requires specific approval from Watercare.

Table 1.1 Typical assed design life

Item	*Minimum design life (years)*
Vacuum vessel and storage tanks	*40* (1)
Pipework (gravity, vacuum and pressure)	*100*
Power systems	*25*
Vacuum interface, division and other valves	*30*
Meters	*30*
Vacuum pumps	*25*
Wastewater discharge pumps	*25*
SCADA and control	*15*
Civil structures	*100*

(1) For coated carbon steel. Other more resilient materials consider 90 years.

1.5.2 Objectives of the system design

The objectives of the design are to ensure that the wastewater system is functional and complies with the requirements of Watercare's wastewater systems.

In principle the wastewater system shall provide:

a) A single gravity connection for each property
b) A level of service to Watercare's customers in accordance with the Watercare's customer contract
c) Minimum practicable adverse environmental and community effects
d) Compliance with all relevant resource consent and other environmental requirements
e) Compliance with statutory Health and Safety requirements
f) Adequate hydraulic capacity to service the full catchment
g) Long service life with minimal maintenance and least life-cycle cost
h) Zero level of infiltration into pipelines, ancillary structures and manholes on commissioning of pipes
i) Low level of infiltration/exfiltration into pipelines, ancillary structures and manholes over the life of the system
j) Resistance to entry of tree roots and avoidance of build-up of fats, oils and grease
k) Resistance to internal and external corrosion and chemical degradation
l) Structural strength to resist applied loads
m) 'Whole of life' costs that are acceptable to Watercare
n) Compatibility with Watercare's site specific requirements for service delivery and maintenance
o) Consider any environmental changes through the life of the asset in terms of sustainability, asset renewal, future access and levels of service
p) Control of septicity.

2 Concept Design

The pump station plan and design shall optimise construction, operation and maintenance cost to ensure a low life-cycle cost.

For concept design considerations of pumping stations, pressure mains and associated works, in addition to this document, refer to Watercare's Local Network Wastewater Pumping Stations standard DP-06 and current legislation.

This includes material design, vacuum station staging, infrastructure, support systems, noise control and health and safety.

Deliverables for concept design shall consider at least:

- Layout plan of vacuum lines (mains and branches)
- Vacuum station location
- Vacuum site station layout (including access road, odour bed, main building, etc.)
- Vacuum station equipment layout (discharge pumps, vacuum pumps, vessel, control panels, workstation, etc.)
- Vacuum station P&ID
- Level 1 functional description
- Estimated capital and operational costs to a minimum Class 3 level as per AACE Cost Estimate Classification System.

3 General Design

For the following topics, refer to Watercare's standards and code of practice:

a) Design tolerances and levels

b) Ground conditions

c) Environmental considerations

d) Easements

e) Crossings

f) Mechanical protection of pipelines

g) Clearances from structures and underground services

h) Disused or redundant pipelines

i) Septicity.

4 Materials Design

Materials shall comply with Watercare's material supply standards. For corrosion protection of metallic materials (pipes, fittings and vessels), concrete surfaces and other items refer to Watercare's standards.

5 Hydraulic Design

5.1 General

The pressure (rising main) system and vacuum system shall be considered together for their hydraulic design.

For pumping system and discharge pipe work, the design shall be in accordance with section 11.

Pressure mains design shall be in accordance with Watercare's Local Network Wastewater Pumping Stations standard DP-06.

The design of gravity wastewater sections of the system shall be in accordance with Watercare's Design principles for transmission water and wastewater pipeline systems, standard DP-07.

The design drawings must be viewed by Watercare. Where there is a conflict between this document and drawings, an interpretation should be sought from Watercare.

5.2 Vacuum station design flows

Wastewater flows into the vacuum stations shall be estimated according to the procedures in the Water and Wastewater Code of Practice COP-02, chapter 5, with the following considerations:

a) Design flow for vacuum wastewater systems shall be the peak wet weather flow (PWWF)
b) Peak wet weather flow factor shall be as stated in COP-02 less 25% unless otherwise approved by Watercare.

5.3 Vacuum wastewater system design flows

5.3.1 General

Recommended maximum flows for wastewater are based on conservative assumptions and hydraulic testing. These flows limits, shown in Table 5.1, consider reduced frictional losses along the wastewater pipes as detailed in Section 9.3.2.

These flow limits may be increased with the recommendation of the vacuum system supplier and approval by Watercare.

Pipe selection should consider ultimate flows of the network. The ultimate flows shall be discussed and agreed with Watercare.

Table 5.1 Maximum flow for pipes

Pipe Nominal Diameter DN	*PE 100 SDR 17*			*PE 100 SDR 11 (for HDD)*	
	Internal Diameter (mm)	*Recommended Liquid Flow (L/s)*		*Internal Diameter (mm)*	*Recommended Liquid Flow (L/s)*
90	*79.0*	*1.2*		*73.0*	*1.0*
125	*109.9*	*2.9*		*101.5*	*2.4*
160	*140.7*	*5.5*		*130.0*	*4.5*
180	*158.3*	*7.5*		*146.3*	*6.1*
200	*175.8*	*9.8*		*162.5*	*8.1*
225	*197.8*	*13.4*		*182.9*	*11.1*
250	*220.0*	*17.7*		*203.4*	*14.6*
280	*246.3*	*23.9*		*227.8*	*19.4*
315	*276.6*	*32.4*		*256.3*	*26.5*

Notes: DN 125 pipe sections should be limited to no more than 600 m in length for adequate vacuum recovery.
DN 90 for service connections only.
DN 280 and greater with recommendation from system supplier only.

5.3.2 Air-to-liquid ratios

The air-to-liquid ratio used for vacuum systems design is related to the length of the longest vacuum pipeline in the system, as detailed in Table 5.2.

These ratios are used in vacuum station design as well as in hydraulic design, where the interface valve requires to be set for the specified air-to-liquid ratio.

In case the system supplier requests higher ratios, an application shall be submitted to Watercare stating the reason for the higher ratio and its effects on efficiency, flow and power consumption.

Table 5.2 Default design air-to-liquid ratios

Longest vacuum pipeline length m	*Design air-to-liquid ratio* AL_R
0 – 1500	*6*
>1500 – 2100	*7*
>2100 – 3000	*8*
>3000 – 4000	*9*
>4000	*11*

6 Vacuum Station Design

6.1 Site selection, location and layout

Site selection, location and general layout requirements shall be assessed in accordance to Watercare's standard DP-06 unless otherwise specified and agreed with Watercare.

Vacuum stations location shall be selected in a site that minimises the length of vacuum mains and pressure main. The location is dependent on the capabilities of the system and particular topographical and operational characteristics of each project.

The pump station shall be located 500mm above the 100 year flood level or suitably designed to ensure that the pump station can be operated and maintained during flood events.

6.2 Vacuum station layout

A typical vacuum station layout is shown in the standard drawings. Alternative layouts for vacuum stations designed for specific sites and equipment shall be submitted to Watercare for approval.

- The vacuum station shall be divided into three main areas, a below ground dry well, an above ground plant room, and a control room. Skid-mounted vacuum stations shall be considered for small temporary stations (see Section 6.10)
- The dry well floor level shall be designed according to the required invert levels of the incoming pipelines and the size of the vacuum vessel and discharge pumps
- The vacuum vessel, discharge pumps, valves, pipe work and sump shall be located in the dry well
- The vacuum pumps and moisture removal vessel (if required) shall be located in the plant floor above ground. Control cubicles and equipment shall also be located above ground, but isolated from the rest of the station equipment.
- The sump in the dry well shall be drained by a DN 50 PVC PN 12 suction line from the vacuum vessel through a vacuum interface valve. Valve shall be automatically operated but also be capable of being manually operated from the plant floor
- A stairway shall be installed to provide access to the dry well and main wastewater isolation valves
- Isolation valves shall be fitted on each incoming vacuum main, immediately upstream of the vessel and inside the building. These shall be manually operated with a pedestal and handles at waist level
- Station shall be fitted with a workbench and a water service connection unless otherwise specified by Watercare
- Odour control systems shall be part of the station design unless otherwise specified by Watercare
- Vacuum station shall include emergency pumping arrangements for wastewater collection directly from the vacuum mains and from the vessel
- Vacuum station design shall not restrict future expansion of the system. Sufficient room shall be allowed for addition of a new vacuum pump, a new vacuum line or larger vacuum vessel.

For Vacuum station infrastructure and support systems refer to Watercare's pump station design standard DP-06.

6.3 Vacuum vessel

6.3.1 Operating volume

The operating volume, or volume between discharge pump start and stop, shall be determined by pump capacity and shall be set to limit the frequency of pump starts. This limit shall not exceed more than 6 start/stop cycles per hour for ADWF, as per Watercare's standard for wastewater pumping station.

Pump duty standby to alternate on each successive pumping cycle.

Duty Wastewater Pump Capacity (Q_{dp}) shall not be less than 2 times ADWF.

$$Operating\ \mathrm{Volume}\ (\mathrm{V_o}) = \frac{3600}{\mathrm{max\ starts/hr}}\ x\ \frac{\mathrm{ADWF}\ \left(\mathrm{Q_{dp}} - \mathrm{ADWF}\right)}{\mathrm{Q_{dp}}}$$

Where:

V_o = Vacuum vessel operating volume (L)

ADWF = Average dry weather flow (L/s)

Q_{dp} = Wastewater pump capacity (L/s)

max starts/hr = Maximum allowed pumps start/stop cycles per hour

6.3.2 Capacity

Total capacity of the vacuum vessel shall consider the following:

- Adequate length required for accommodation of incoming pipelines
- The height above alarm levels to ensure no blockage of the incoming pipelines with wastewater inside the tank
- Minimum liquid level above pumps to prevent cavitation, maintain prime and prevent the formation of vortices. Minimum liquid level shall be advised by pump suppliers.
- Minimum separation between operating and alarm levels as shown in Figure 6-1.

The total volume for the vacuum vessel should typically be 3 times the operating volume considering future expansion of the system.

The minimum recommended tank size is 3,700 litres. For smaller tank sizes, advice and endorsement from system supplier shall be sought and presented to Watercare for approval.

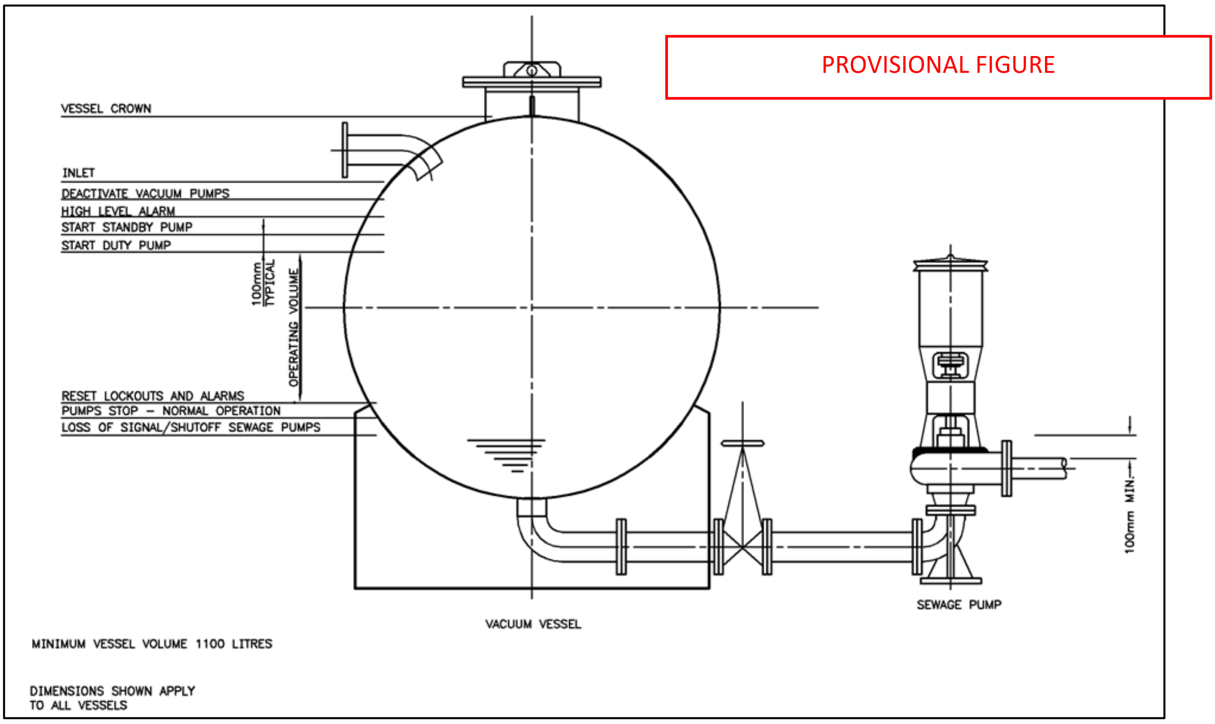


Figure 6-1 Schematic vacuum vessel operating levels

6.3.3 Design, construction and testing

For vacuum vessel design, construction and testing, the requirements of AS/NZS 1200 shall be followed.

Vessel shall be made minimum of carbon steel with a coating suitable for wastewater service.

Inlets and outlets connections to the vacuum vessel shall be correctly sized for the correct operation of the vessel.

Wastewater network inlets into the vessel shall be fitted with short radius elbows inside it in order to direct the liquid inflow away from the vacuum suction as well as from vessel walls and discharge pump suctions.

No network inlets shall be connected below the emergency stop level. All level control systems shall be suitable for operation in vacuum and easily removed for replacement or adjustment.

A spare inlet of the same diameter as the largest incoming main shall be provided in the vacuum vessel. This connection shall be externally sealed with a bolted flange and gasket. The minimum size for this inlet is DN 150.

Suction connections for discharge pumps shall be provided at the invert of the vacuum vessel.

A drain connection with a resilient seated gate valve shall be provided at the invert level of the vessel or on the pipe work previous to the discharge pump. The valve shall be as close as practicable to the vessel and selected according to Watercare's material supply list.

Access manhole and cover of minimum DN 600 with a lifting eye shall be provided on the top of or side of the vacuum vessel.

An external polycarbonate liquid level gauge with stainless steel tube guard shall be fitted on the vacuum vessel. Its design shall include isolation and drain valves to provide cleaning. It shall be located in a position that allows inspection from the top level of the pump station and shall include a calibration chart to identify volume of liquid inside the vessel.

6.4 Moisture removal vessel

Moisture removal vessels or traps are required for vacuum pumps. These shall be installed on the inlet piping of each vacuum pump and should include baffles or moisture removing material for additional reliability.

Moisture removal traps shall have a drain line fitted with a check valve, connecting back to the vacuum vessel.

6.5 Vacuum pumps and pipe work

6.5.1 Vacuum pump capacity

Capacity of the vacuum pump (Q_{vp}) shall be rated in m^3/hr. Its selection is based on air-to-liquid ratio (AL_R) (dependent on length of longest vacuum main installed, see section 5.3.2) and design evacuation rate for the vacuum station.

$$Q_{vp}\ (m^3/h) = 3.6 \text{ x } AL_R \text{ x } PWWF\ (L/s)$$

Each vacuum pump shall be capable of delivering 125% of the required flow under the specific operating conditions of the system. A minimum capacity of 260 m^3/h for vacuum pumps is required.

6.5.2 Evacuation time

Once the vacuum pumps, vessel and the rest of the system upstream of it have been sized, the evacuation time for the system can be calculated. Evacuation time is the time required for the vacuum pumps to evacuate the piping network and vessel from a pressure -55 kPa to a final pressure of -65 kPa (standard operating range), assuming 1/3 of the system is filled with liquid.

$$t\ (min) = \frac{\left(^2/_3\right) V_s + (V_v - V_o) + MRv}{Q_{vp}} \text{x} \frac{3}{50}$$

Where:

t =	System evacuation time (min)
V_s=	Vacuum pipelines total volume (L)
V_v =	Vacuum vessel total volume (L)
MRv=	Moisture removal vessel volume (if installed) (L)
Q_{vp} =	Vacuum pump capacity (m^3/h)

Evacuation time shall range between 1 and 3 minutes. If greater than 3 minutes, the capacity of the vacuum pumps shall be increased. If lower than 1 minute, the size of the vacuum vessel shall be increased.

If operation requires a different vacuum pressure range in the vessel, advice from the system supplier shall be sought and presented Watercare for approval.

6.5.3 Vacuum pump selection

Vacuum pump selection shall be according to Watercare's material supply list, considering the operating conditions of each project as well as life-cycle cost analysis. The following parameters shall be considered:

- Capital cost
- Sustainability and carbon footprint
- Operational cost (power consumption)
- Maintenance and spare parts
- Equipment reliability
- Equipment noise
- Water requirement (temperature and quality) (for liquid ring pumps)
- Moisture removal vessel (for oil lubricated rotating vane pumps)
- Temperature (ambient and cooling)
- Exhaust gasses quality
- Wastewater quality.

6.5.4 Vacuum pump operating vacuum

Operating vacuum pressure for the pumps is determined from the reticulation design. For a common system, where static losses in the vacuum pipelines are less than 4 m, then the normal operating range shall be set between -55 kPa to -65 kPa.

Higher static losses in the system and higher vacuum required can have effects on system efficiency and recovery time. For any pressure operating range different from the one specified above, advice from system supplier shall be sought and presented to Watercare for approval.

Duty and stand by vacuum pumps shall be of equal capacity.

6.5.5 Vacuum pump motors

Electric motors shall be continuously rated for the lesser of the following:

- 110% of the maximum power required by the pump anywhere on the head-quantity curve for the operating speed when fitted with the duty impeller; or
- 120% of the power required by the pump at the duty point when fitted with the duty impeller.

Electric motors shall have a minimum rating of three kilowatts shaft power. Four pole motors shall be used unless the pumps are pre-frontal screw type in which case two pole motors may be used with the approval of Watercare.

Electric motors shall be fitted with thermistors.

6.5.6 Vacuum pipe work and valves

Pipework for the vacuum pumps in the station shall be PVC PN 12, with the exception of vacuum pump exhaust which shall be 316L SS. All pipe and fittings should be flanged with EPDM gaskets.

Piping should be adequately supported to prevent vibration, as well as permit expansion and drainage.

Inlet pipe work to the vacuum pump shall be fitted with a manually actuated butterfly valve and sequentially downstream of it the moisture removal trap and a non-return valve. The butterfly valve shall be threaded lug type and non-return valve dual flap type as per Watercare’s material supply list.

6.6 Emergency pumping arrangements

Emergency bypass and/or pump-out shall be provided within or outside the vacuum station.

A branch with a gate valve, a non-return valve and a quick connector coupling hose adaptor shall be installed on the pipework between the vessel and discharge pump as well as on the pressure main downstream from the pump. The position shall allow for connecting hose to come from any direction.

Similar quick connectors shall be installed in each incoming main, upstream of the isolation valves and outside the building, to allow external wastewater collection during programmed downtime or vacuum station malfunction.

For vacuum stations with flows up to 25 L/s, emergency pumping pipe work shall be DN 100. For flows between 25 L/s and 60 L/s pipework shall be DN 150, with flanged valves and fittings. For larger flows, multiple DN 100 and DN 150 pipes shall be provided.

6.7 Wastewater discharge pumps and delivery pipe work

For details on pumping system see Section 11.

6.8 Gauges and recorders

6.8.1 Vacuum gauges

150 mm vacuum gauges designed for a measuring range of 0 to -100 kPa shall be located above each incoming vacuum main and on the vacuum switches above the station workbench. Accuracy of gauges shall be of ±2%.

Gauges shall have bleed valves to clear condensation in the feed line and be suitable for operation under wastewater gases. Each gauge shall be correlatively numbered for identification purposes.

6.8.2 Pressure gauges

A 150 mm pressure gauge designed for a measuring range of 0 to 150% of the delivery main pressure shall be fitted to the pressure main inside the vacuum station. Accuracy of the gauge shall be of ±2%.

Gauges shall be fitted with stainless steel pressure variation dampeners and be suitable for operation under wastewater gases.

6.8.3 Vacuum / pressure recorder

Pressure data shall be digitally recorded and stored (see Section 8).

6.9 Noise and odour control

Noise levels and odour control measures shall be implemented as specified in Watercare's standard for wastewater pump stations DP-06 and wastewater pipeline systems DP-07.

Unless otherwise specified, a soil bed biofilter complying with Watercare's standard (DP-07) shall be fitted at the pump station for odour control. Biofilters have a proven record of effectiveness and efficiency for this type of system. When oil lubricated vacuum pumps are used, oil discharge into the biofilter shall be addressed.

Other types of odour control can be considered, taking into account the high humidity of the discharged air. Activated carbon filters are not suitable for this operating environment.

6.10 Skid-mounted packaged stations

When skid-mounted packaged stations are proposed these shall be arranged with duty wastewater and vacuum pumps mounted on the vacuum vessel or on the base frames. All equipment shall be accessible by doorways.

Electrical and level controls shall be mounted on a cabinet. This cabinet shall be mounted on the base frames or on the vacuum vessel.

Package vacuum stations shall be factory assembled and comply with all current environment regulations. Tests performed shall be at their duty rating.

- The unit shall be lifted in one piece by lifting eyes provided and one positioned at site, installation shall be limited to the following connections:
    - Vacuum pipelines
    - Pressure main
    - Vacuum pump exhaust
    - Power supply
    - Water supply (if required)
    - Odour control measures.

7 Power System

This standard shall be read in conjunction with the latest version of the Watercare electrical standards and control drawings DP-09.

Electrical, control and telemetry design and installation shall comply with the Watercare electrical and control template drawing set DW18 for pumping stations.

Note – Any additional controls and telemetry not specified in the Watercare electrical standards must be specifically designed and reviewed with Watercare.

7.1 Electrical

Additional to the electrical standards the following requirements for establishing electrical power on site shall also be completed:

- Sites owned by Watercare shall be coordinated for connection through Watercare. Early engagement with the mains provider is required.
- Where mains electricity is not available at the site a new installation point (ICP) will be provided.
- Mains electricity shall be of sufficient capacity taking into account future expansion.
- Unless otherwise approved, substations on an electrical consumer’s premises shall be for the sole supply of the Watercare facility.
- Information required for the ICP include: supply phase; maximum demand load in amps; physical address of connection; name and contact of the electrical contractor undertaking the works.
- Any easement requirements for electrical mains and transformers must be referred to Watercare.

8 Control and Telemetry System

8.1 General

a) Watercare will complete a connection suitability study for the location, to establish the telemetry requirements for the proposed pumping station site. A desk study will determine if there is an available connection for the location.

b) If a connection is possible, the desktop study is followed by a site check to establish the signal to noise level ratio to ensure a good quality signal is available.

c) Should there be no communications available or the signal strength is less than -90dB a specific design will be required.

d) The telemetry and radio system shall be from a Watercare standardised supplier, refer to Watercare's material supply standard. The installation shall be carried out by a Watercare approved contractor.

e) The designer shall obtain a facility code from Watercare that is used to provide the tag information used to configure the control system. The information required to obtain the facility code is:
   - GIS location of the site
   - The physical address associated with the site
   - Lot number or Land Registry identification
   - The SCADA software shall be developed and implemented by a Watercare approved developer.
   - Watercare has five different control systems that operate in various areas, they are:
   - Emerson DCS
   - In Touch SCADA
   - IFIX LNT SCADA
   - Citect SCADA
   - Abbey Systems Powerlink

f) In order for Watercare to complete the SCADA the following will be developed and supplied by the designer:
   i. A level one Functional Description (FD), to be reviewed and accepted by Watercare before software programming commences.
   ii. Liaise with Watercare point of contact in the production of the Electrical/ Control system design.
   iii. Process and instrumentation diagrams (P&IDs).
   iv. Bill of materials.
   v. Confirmed Input and Output lists (I/O).

g) Backup level/sensing control systems shall be required unless otherwise specified by Watercare.

h) Additional instrumentation and control systems for improved system monitoring and operation can be installed in the system with approval from Watercare.

8.2 Control systems

8.2.1 Vacuum pump control

The duty vacuum pump shall be initiated by a vacuum switch when vacuum pressure inside the vessel reaches the cut-in level (generally -55 kPa). It shall run until pressure reaches the cut-out level (generally -65 kPa) and then stop.

Vacuum pump operation shall cycle to equalise running time. The stand-by vacuum pump shall operate when duty pump fails and vacuum level reaches cut-in level.

On a two vacuum pump station, an interlock shall be installed to prevent duty and stand-by pumps running simultaneously on both automatic and manual control.

Vacuum pumps shall stop if liquid inside the vessel reaches a high level to prevent suction of wastewater by the pumps.

8.2.2 Vacuum vessel control

Vacuum levels shall be controlled by vacuum switches with an operating range between 0 and -100 kPa. Separate switches shall be used for operation of each duty and stand-by vacuum pump as well as for the low vacuum alarm.

Liquid level in vessel shall be controlled with level sensors.

All elements shall be suitable for vacuum service. Float switches of any kind shall not be permitted.

8.2.3 Discharge pump control

Discharge pumps shall be controlled by liquid level inside the vessel. Other controls and restrictions are as specified in Watercare's standards for wastewater pumping stations.

8.2.4 Others

When system pressure is other than the typical range or total static lift exceeds 4 m, electronic air admission control (EAAC) or equivalent systems shall be considered with endorsement from system supplier and approval by Watercare.

No remotely operated elements are required to be installed within the collection chamber.

8.3 Telemetry

Telemetry inside the vacuum station shall be reviewed with Watercare.

Telemetry in collection chambers shall include level inside chamber, valve status, valve cycle counter and if required by Watercare, pressure. See section 10 for more details on these instruments.

Pressure sensors shall also be installed at furthest collection chambers from the vacuum station on each main and on any additional location specified by Watercare for better operational assessment of the system, if required by Watercare.

8.4 Alarms

For alarm type and requirements in pump stations, refer to Watercare's standards DP-06 and DW-03.

Additional alarms to be included in a vacuum wastewater system are:

- Vacuum pump failure or fault
- Vacuum vessel extra low vacuum
- Vacuum pump excessive run time
- Collection chamber high level
- Interface valve failure
- Pressure loss at end of lines (if sensors installed).

9 Vacuum Pipeline Design

9.1 Staging

Civil aspects of the wastewater network (e.g. pipes, chambers, vessels, tanks, etc.) shall be designed and sized for the ultimate flows. Discharge pumps shall be sized according to requirement of each stage of a project.

9.2 Pipeline layout

9.2.1 General layout and zoning

A diagram of a typical vacuum network layout is shown in Figure 9-1, showing main and branch pipelines, isolation valves, properties connections and a centrally located vacuum pump station.

Usually vacuum networks have 3 to 4 mains directly connected to the vacuum vessel, but can have more as required provided there is adequate room in the vessel to accommodate them.

Each vacuum main shall enter the vacuum vessel individually and be installed with a valve for sectioning. The use of manifolds in the incoming mains is not allowed unless multiple vacuum vessels are installed.

The layout of the vacuum system shall consider a logical distribution that allows the served catchment to be divided into zones, each served by a separate vacuum main. When zoning, each vacuum pipeline shall take into consideration the minimisation of lift and total length, have similar flows or served catchment size as the other mains, have adequately spaced location of service connections, and have adequate access for operation and maintenance purposes.

Zoning enables reduced pipe diameter, length and system losses, as well as quick troubleshooting to locate and isolate faults within the system.

When zoning, care must be taken into the maximum allowed lift on each vacuum main as well as not having long stretches of main without service connections to provide energy to the transport system.

The main pipeline for each connection starting from the vacuum vessel will be defined as the route with the highest static losses, considering branches and service connections.

Metal detector identification tape or equivalent method for pipe protection shall be laid above vacuum mains.

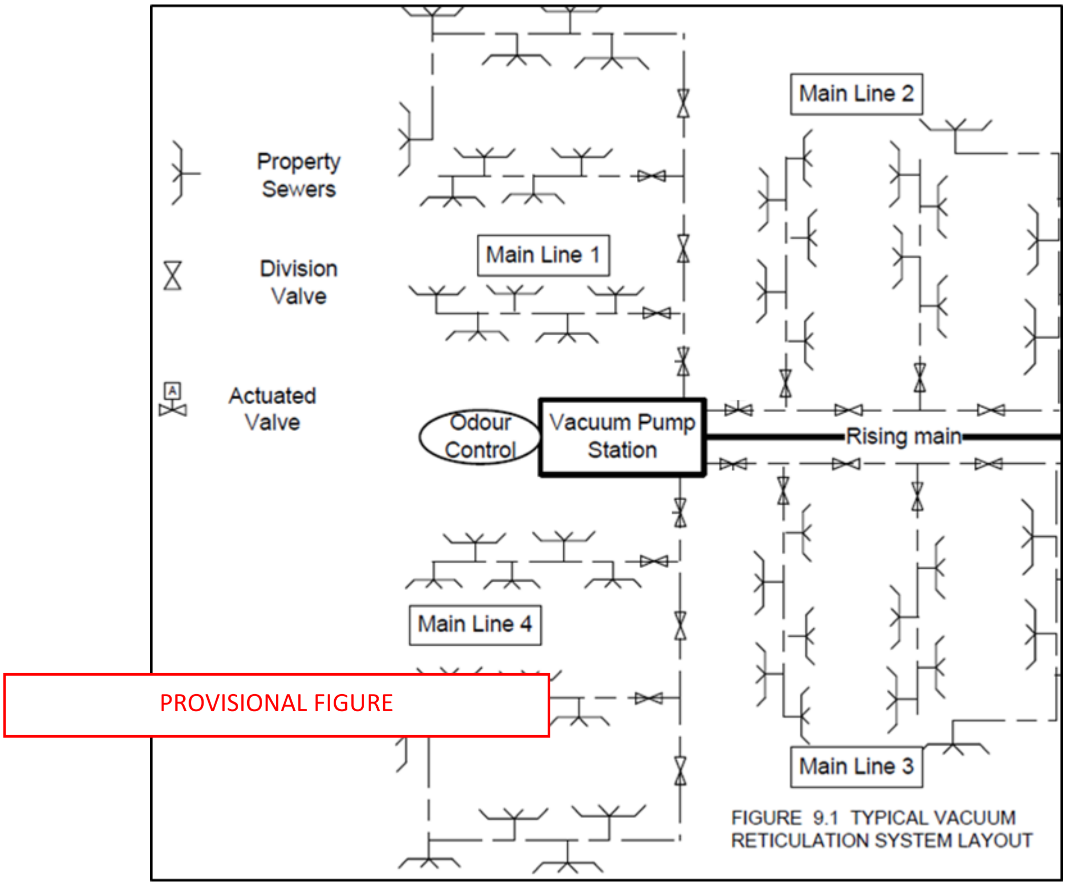


Figure 9-1 Typical vacuum reticulation system layout

9.2.2 Location

Pipeline location shall be according to Watercare's code of practice for wastewater networks COP-02.

9.2.3 Pipe cover

Vacuum pipelines, branches and connections from collection chambers shall be located at depth that provides protection from surface loads as specified in Watercare COP-02.

9.2.4 Service connections distribution

Service connections are sources of energy input for the system. Large stretches of pipe without energy inputs should be avoided as they affect the performance of the system. The recommended maximum distance between service connections is 150 m. If a larger distances are required, advice shall be sought from the system supplier and presented to Watercare for approval.

9.3 Headloss

9.3.1 Available vacuum

Operating vacuum range for the systems is usually in the range of -55 kPa to -65 kPa, as being the more practical in terms of operation and reliability.

With vacuum interface valves requiring typically -15 kPa to open, this leaves -40 kPa available for vacuum transport immediately after the valve opens, with the -15 kPa becoming available afterwards for transport as well.

Transport along the vacuum system is in pulses of a mixture of air and liquid. Due that not all vacuum valves are open at the same time, friction and static losses occur at different times and are calculated separately as well, with independent maximum allowable limits.

9.3.2 Friction loss

Friction losses are only calculated in downward slopes between 0.2% and 2% and are cumulative for each flow path from the furthest interface valve on the system to the vacuum station. Friction losses are ignored where pipeline slope is greater than 2%.

Friction losses are based on hydraulic testing and the Hazen-Williams formula.

$$F = 2.75 \text{ x } \frac{1206.3 \, x \, 10^9}{ID^{4.87}} \, x \left(\frac{Q}{C}\right)^{1.85}$$

Where:

F = Frictional losses (m/100 m)

ID= Internal diameter of pipeline (mm)

Q = Flow (l/s)

C= Friction coefficient (150 for PE)

The recommended maximum losses due to friction in the pipe are 0.25 m of head per 100 m of pipe. Corresponding flows for this losses are shown in Table 5.1.

Friction losses on a vacuum main shall not exceed 1.5 m.

9.3.3 Static lift loss

The total available lift for the wastewater system is normally 4 m in each vacuum main. This limit allows for automatic recovery of the system and efficient operation.

Losses due to static lift shall be calculated and written on the pipe long section for each main or branch pipeline. Losses are calculated between each vacuum interface valve and the pump station.

Static lift is determined as the lift height, from invert to invert, less the pipe diameter, as per Figure 9-2.

When concrete collection chamber or buffer tank valve pits have a suction lift (from the bottom of the sump to the valve centreline) in excess of 1.7 m, static lift losses shall be added to the losses for that main. Suction lift shall not exceed 2.4 m.

If total lift losses in the system exceed 4 m, advice shall be sought from the system supplier and their written design recommendation be submitted to Watercare for approval.

9.4 Pipeline profiles

9.4.1 General

The design requirements and recommendations for pipeline profiles provided in this section offer a great general design, but guarantee on the profiles shall be sought from the system designer/supplier before submitting them to Watercare.

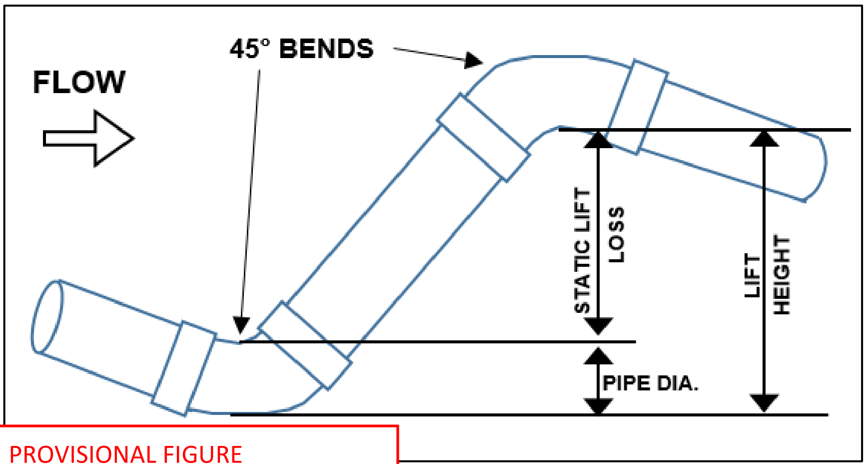
9.4.2 Profile design

Horizontal, uphill and downhill pipeline profiles shall follow the requirements shown on Figure 9-3.

The minimum slope allowed in vacuum pipelines profiles is 0.2%. For downhill transport, the pipe may follow the slope of the ground, provided that following it there is a 15 m section of pipe with slope 0.2% before the next lift.

Lift pitches and heights are indicated in Table 9.1. Minimum fall in in vacuum pipelines between consecutive invert lifts shall be defined by the slope of 0.2% or 75 mm, whichever is the greatest, to prevent liquid at rest sealing the pipe.

For uphill transport, design shall use a series of consecutive lifts numbering no more than 5, spaced at least 6 m apart and with a 75 mm minimum fall between lifts.



PROVISIONAL FIGURE

Figure 9-2 Static and invert lift detail

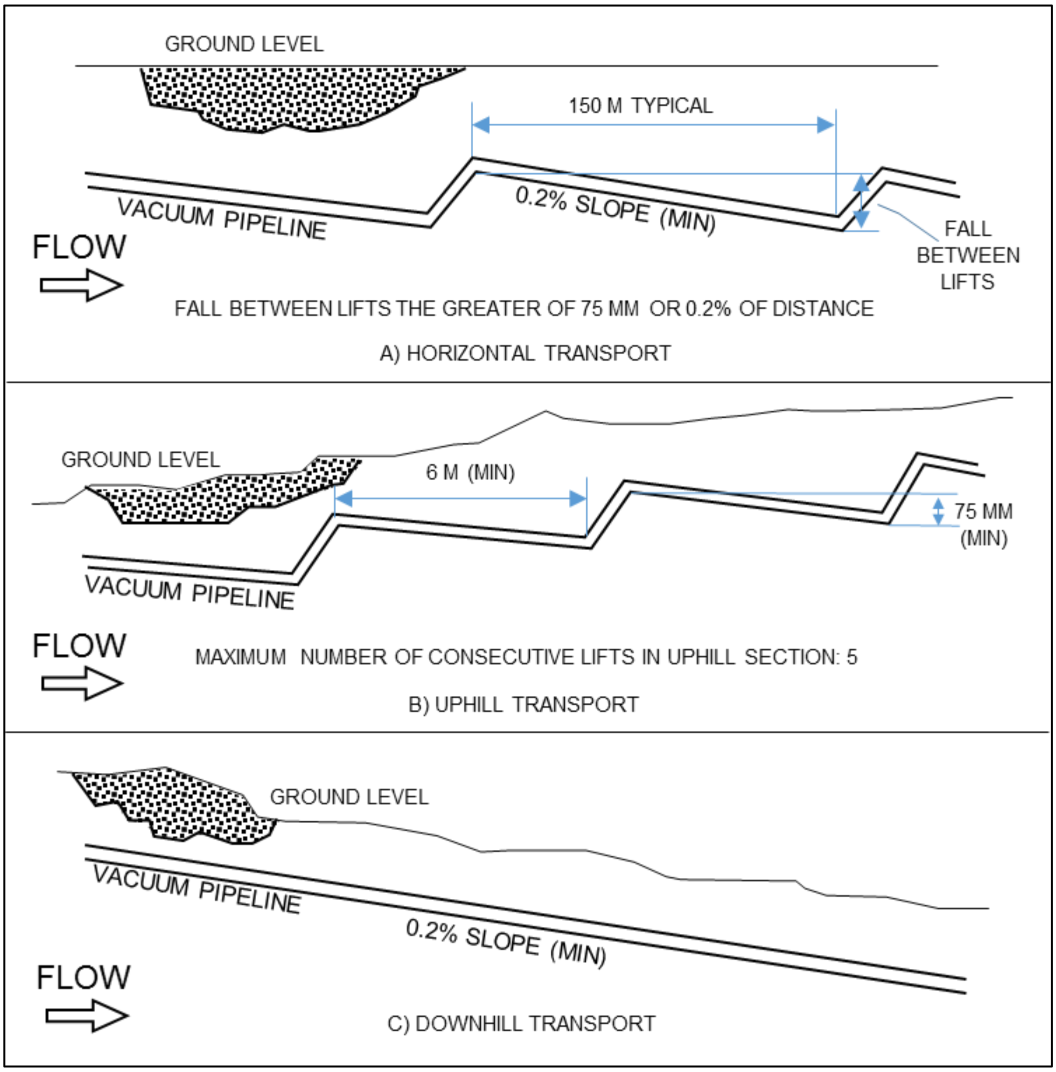


Figure 9-3 Pipeline profiles for horizontal, uphill and downhill transport

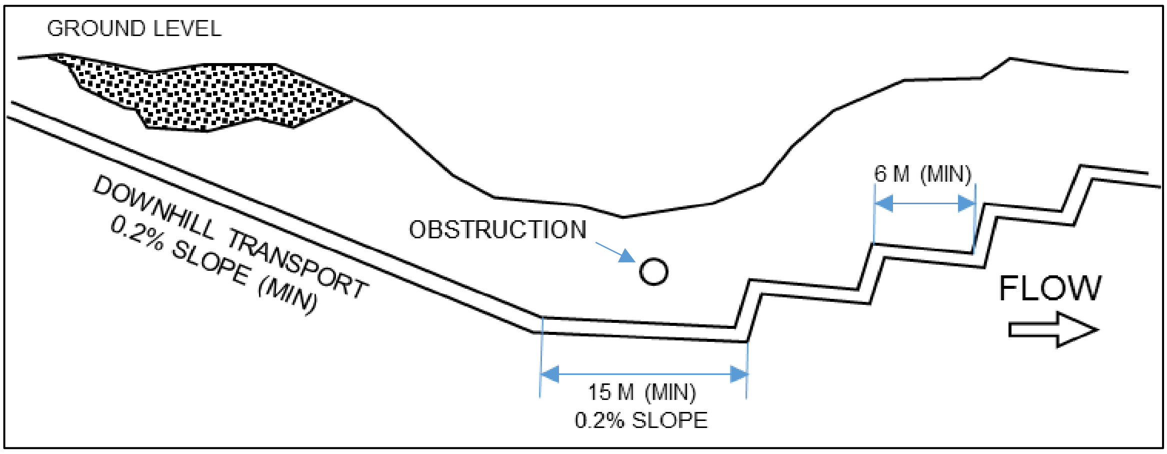


Figure 9-4 Example of pipeline profile for obstacle evading

9.4.3 Lift design

Recommended lift heights vary between 300 mm for smaller pipe and 450 mm for larger vacuum pipelines. These shall be designed in accordance to Figure 9-3 and Table 9.1. Any lift higher than the recommended height shall be verified and endorsed in writing by the system supplier and submitted to Watercare for approval. Lifts higher than 900 mm shall be avoided.

Lifts should be as small as possible, with numerous smaller lifts preferable to one large lift.

Table 9.1 Lift lengths, heights and falls for vacuum pipelines

Pipe Size DN	***Design Requirements PE pipelines***		
	Recommended lift height	***Minimum length between invert lifts***	***Minimum fall between lifts***
125	*300 mm nominal*	*6 m*	*The greater of 75 mm or a 0.2% grade*
160/250	*450 mm nominal*		
280/315	*Consult with system supplier*		

9.4.4 Connection to vacuum vessel

Connections of vacuum mains to the vacuum vessel shall be in accordance with Figure 9-5.

PROVISIONAL FIGURE

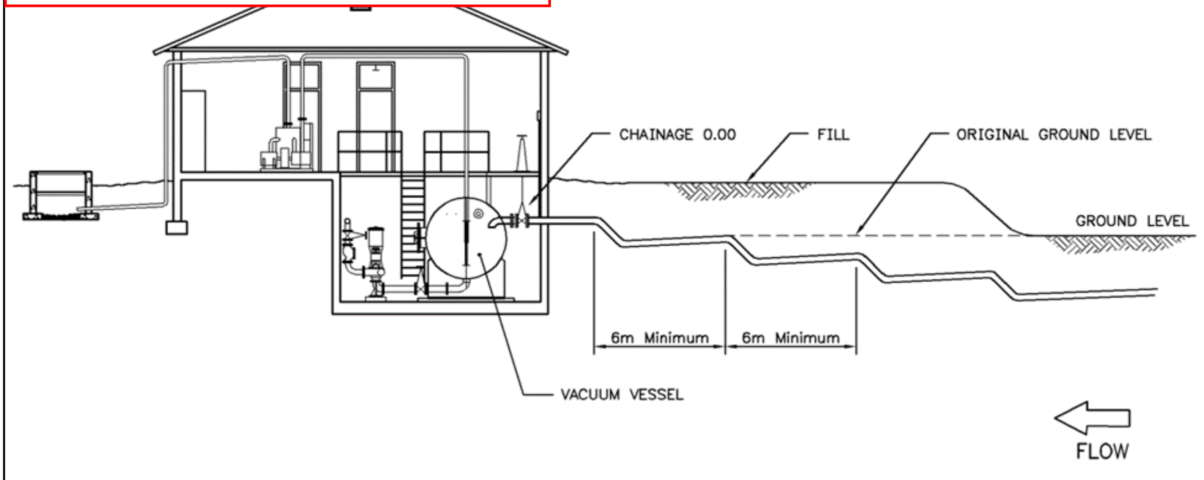


Figure 9-5 Method of lifting main pipelines into vacuum vessel

9.4.5 Connecting pipelines

Pipeline connections from branches or property services are to be made preferably within 6 m upstream of a lift and never within 6 m downstream of a lift as shown in Figure 9-6. These restrictions shall be addressed when planning location of pipelines lifts and branches. The 6 m upstream of the incoming pipeline connection shall be self-draining towards the receiving pipeline.

Service and branch pipeline connections to vacuum mains shall be made from the top of the largest pipe with a wye fitting that can be rolled up to a maximum of 45° should it be necessary. The designer shall ensure that the arrangement allows adequate soil compaction for protection of the connection.

Under no circumstances shall tees be used for connections to pipelines.

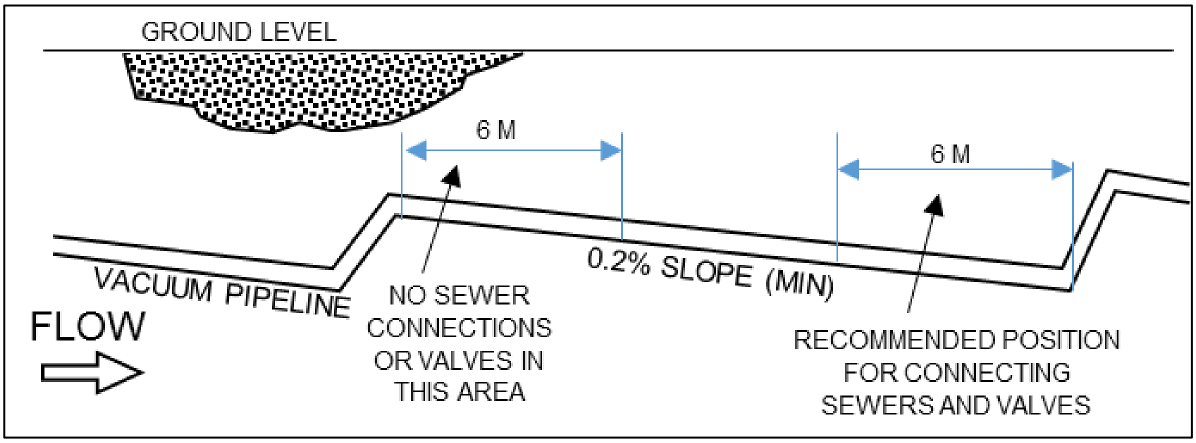


Figure 9-6 Connections to pipelines relative to invert levels

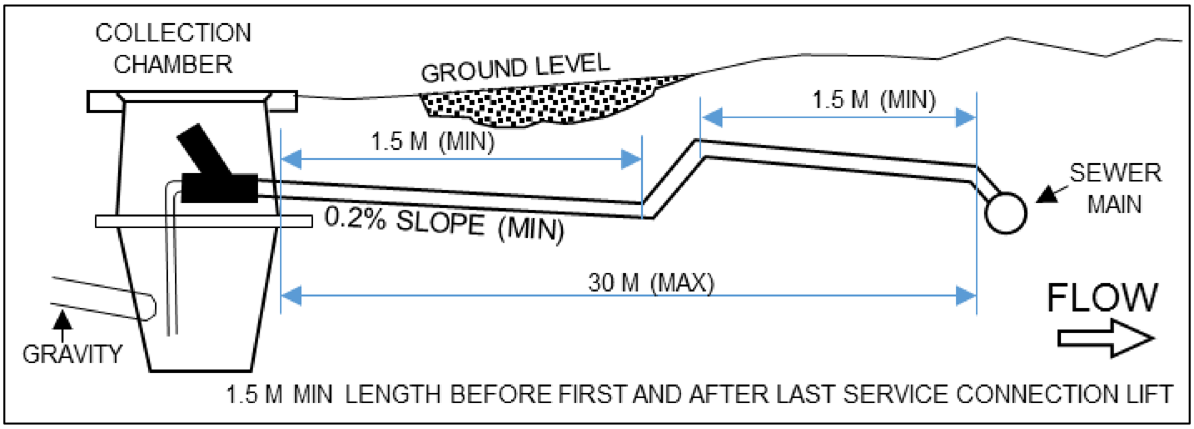


Figure 9-7 Service connections and static lifts

9.4.6 Bends

In vacuum pipelines, where large radius elbows when not available, bends shall be constructed in accordance with standard drawings.

9.4.7 Waterlogging

The pipeline profile shall consider reducing waterlogging at changes in gradient during emergencies in which vacuum pumps are not operating. In this scenarios, interface valves will continue to allow wastewater flow due to the remaining vacuum in the system with diminishing air-to-liquid ratios until the available vacuum is not sufficient to open the valve. The system shall be able to recover on its own once power is restored.

9.5 Pipe work and fittings for vacuum pipelines

9.5.1 General

Selection of materials, products and jointing methods shall be selected and specified for each project with the following requirements:

- Resistance to operating pressure
- Resistance to transported liquid characteristics (chemical and physical)
- Resistance to soil characteristics
- Adequate construction, maintenance and repair methods.

The preferable material for pipes and fittings is polyethylene (PE) with the diameters specified in Table 9.2. For industrial applications other materials may be used subject to recommendation by the system supplier and approval from Watercare.

Pipes laid in open cut trenches shall be PE 100 SDR 17.

Pipes used for horizontal directional drilling shall be PE 100 SDR 11.

PE pipe shall be cream coloured or with cream coloured stripes as per AS/NZS 4130:2009 for pressure wastewater applications.

Table 9.2 Pipe material and diameters

Material	***Mains, branches and fittings DN***	***Service connections pipe and fittings DN***	***Additional notes***
PE Series 1 PE 100	*125, 160, 200, 225, 250, 280, 320*	*90*	*Cream colour or black with cream stripes, jointing as specified in section 9.5.2*

Note: DN 280 and higher used only with recommendation from system supplier and approval by Watercare

9.5.2 Jointing of PE pipes and fittings

Electrofusion shall be used for jointing of PE pipes and fittings of less than DN 150. Pipes and fittings of DN 150 and larger may be jointed either with electrofusion or butt welding. Typical weld joints shall be by butt-welding. Invert lift sections shall be manufactured off-site (see section 9.5.3) and may be welded into the pipe string by electrofusion welds. Electrofusion welds shall be minimised as far as practicable.

9.5.3 Lifts

Lifts along the network shall be prefabricated with butt welded moulded bends with a short segment of straight pipe on both edges to allow connection to the pipeline on site (with electrofusion or butt welding).

9.6 Isolation valves

9.6.1 General

Isolation valves shall be installed in the system to provide total or partial sectioning of vacuum mains and branches. These valves shall be resilient seat gate valves rated PN 16 as per Watercare's material standard.

Valve shall be clockwise closing with a triangular-pattern cast iron spindle cap.

Flanges for joints on PVC and PE pipes and fittings shall be supplied by the manufacturer according to the class of pipe. Flanges shall be supplied complete with stainless steel backing flange drilled as per AS/NZS 4087 figure B7.

Gaskets for flanges shall be 3 mm minimum thickness FF EPDM rubber.

9.6.2 Isolation valve chamber

Chambers for isolation valves shall contain a dismantling arrangement for easy replacement of valve.

9.6.3 Isolation valve cover

Valve surface box shall be standard design for trafficable conditions according to Watercare's standard drawings with "VACUUM WW" or similar approved marked on the lid. It shall be coated with a wear resistant red coloured epoxy paint.

9.6.4 Valve locations

Isolation valves on the vacuum main shall be located at distances no greater than 500 m or 15 service connections, whichever is the lesser. Additionally, at every branch, isolation valves shall be installed immediately upstream of the branch both on the main and branch pipelines.

9.6.5 Inspection points

No inspection points shall be installed along the pipes in the wastewater network.

10 Collection Chambers and Buffer Tanks

10.1 Design criteria

10.1.1 General design requirements

Collection chambers shall be located in public roads and near property boundaries. Their purpose is to temporarily store the wastewater from the properties. Once a certain volume has accumulated, the vacuum interface valve opens and the wastewater is discharged into the vacuum pipeline.

Commonly the chambers house both the interface valve and the collection sump in one structure, with the latter being contained as to prevent any wastewater to come into contact with the exterior of the valve and the operator when valve is accessed. Other acceptable arrangement can have the interface valve and sump located in different pits when there are spatial restrictions.

The interface valve shall not to be located in the collection sump except when buffer tanks are used (see section 10.1.5).

The emergency storage capacity at collection chambers shall consider at least 8 hours of ADWF from all properties connected each chamber, to allow wastewater collection during emergencies.

When a floor elevation greater than 0.5 m exists within a property or between different properties, separate collection chambers shall be fitted to prevent property flooding.

Adequate sized air intakes shall be provided to allow for a correct operation of the vacuum wastewater system as well as to minimise noise and water trap unsealing when interface valve operates.

Service connections shall not be allowed on private roads.

All collection chambers and buffer tanks shall include a level sensor and an alarm for high wastewater level in sump.

10.1.2 Location

Collection chambers shall be located on public land, where 24 hour access can be guaranteed. They shall not be located inside properties. Property connections shall connect to collection chambers directly and without crossing other private properties.

10.1.3 Number of properties connected

A maximum of 4 connections shall be connected to a single chamber , but the following restrictions may reduce that number:

- Location, length and depth of gravity pipelines
- Chamber location on public land
- Depth of chamber
- Emergency storage requirements
- Maximum flow in chamber
- Single air intake for chamber servicing multiple properties
- The overall system shall have a maximum “house to collection chamber ratio” of 2.5:1.

Longer distances between a property and collection chamber imply deeper trenches for gravity pipelines and deep chambers. Fewer properties served by a collection chamber require shorter and shallower gravity pipelines. If a design meets the technical restrictions mentioned above, a trade-off analysis shall be performed to identify the most economical solution.

10.1.4 Maximum flows to collection chambers

Maximum design flow into a single collection chamber shall not exceed 0.2 l/s. For larger flows or when multiple vacuum interface valves are required, a buffer tank shall be used.

10.1.5 Buffer tanks

When design flows into a chamber exceed 0.2 l/s, multiple collection chambers or a buffer tank shall be used instead. They are used commonly for schools, apartments or other large volume wastewater discharging users.

Buffer tanks offer a larger storage capacity than regular collection chambers, allowing for larger instantaneous flows to discharge into it. Flow into the tank, number of interface valves and other requirements are shown in Table 10.1.

Table 10.1 Collection chamber and buffer tank limits

Incoming flow range	***Vacuum interface valves***	***Minimum vacuum main diameter at connection point***
Between 0.2 l/s and 1 l/s	*Single interface valve*	*DN 150*
Between 1 l/s and 1.9 l/s	*Dual interface valve*	*DN 200*
Above 1.9 l/s	*Consult with system supplier*	

Gravity or low pressure wastewater systems servicing a large group of properties shall not discharge into a buffer tank.

To prevent waterlogging in the vacuum pipelines, the following restrictions apply for buffer tank design:

- No more than 25% of the total system flow shall enter through buffer tanks
- No more than 50% of the total design flow of a single vacuum main should enter through buffer tanks.

For larger percentages than above, recommendation from system supplier shall be sought and presented to Watercare for approval.

10.1.6 Materials

The collection chamber shall be constructed of an adequate material to resist corrosion and contact with wastewater, as well as offering a smooth surface for self-cleaning. It shall also be able to withstand internal water pressure as well as any external loads.

For collection chambers, prefabricated PE or GRP are preferred. Concrete chambers are permitted with adequate corrosion protection as per Watercare standards.

For buffer tanks, these shall be fabricated of either GRP or concrete. Each material has its own benefits and disadvantages for installation and operation. Selection shall consider the specific site and operating restrictions.

10.1.7 Floatation

Design calculations shall be performed to make sure chamber and tank floatation won't occur. The basis of these calculations shall consider empty chambers and water table at surface level.

10.1.8 Air intake and breather pipes

Collection chambers and vacuum interface valves require air for their operation. Interface valves use breather pipes through which they inhale and exhale air for opening and closing. Intake of air in collection chamber is required for propulsion of the fluid into the pipeline and supplying the correct air-to-liquid ratio when the valve opens.

Breather pipes can be mounted inside the collection chamber, but when flooding issues are present, they shall be mounted externally in the air intake bollard.

For each chamber, a DN 150 air intake connected to the sump and externally mounted at a height of 500 mm above the 1 in 100 year flood level is required.

The external air intake shall be installed inside a bollard made of PE or another adequate material for its protection and aesthetical purposes. Location of the bollard shall be in road reserve and close to property boundaries.

Maximum length of the intake is 12 m, with up to 3 fittings (usually 45° bends). If additional fittings are required, maximum length is reduced 1.5 m per fitting. No 90° bends shall be used.

The air intake and bollard shall be located in public land and at least 3 m closer to the chamber than any property connected to the latter.

Valve and chamber monitoring and other telemetry equipment shall be fitted inside the bollard for ease of access and data transmission.

Alternatively, with specific approval from Watercare, individual DN 100 air intakes may be installed in public land, on each incoming gravity pipeline at least 6 m upstream of the chamber. This shall be the case for chambers with 4 connections.

House vents may not be used for system air intake. Use of check valves in intakes is not allowed without written endorsement from system supplier and approval from Watercare.

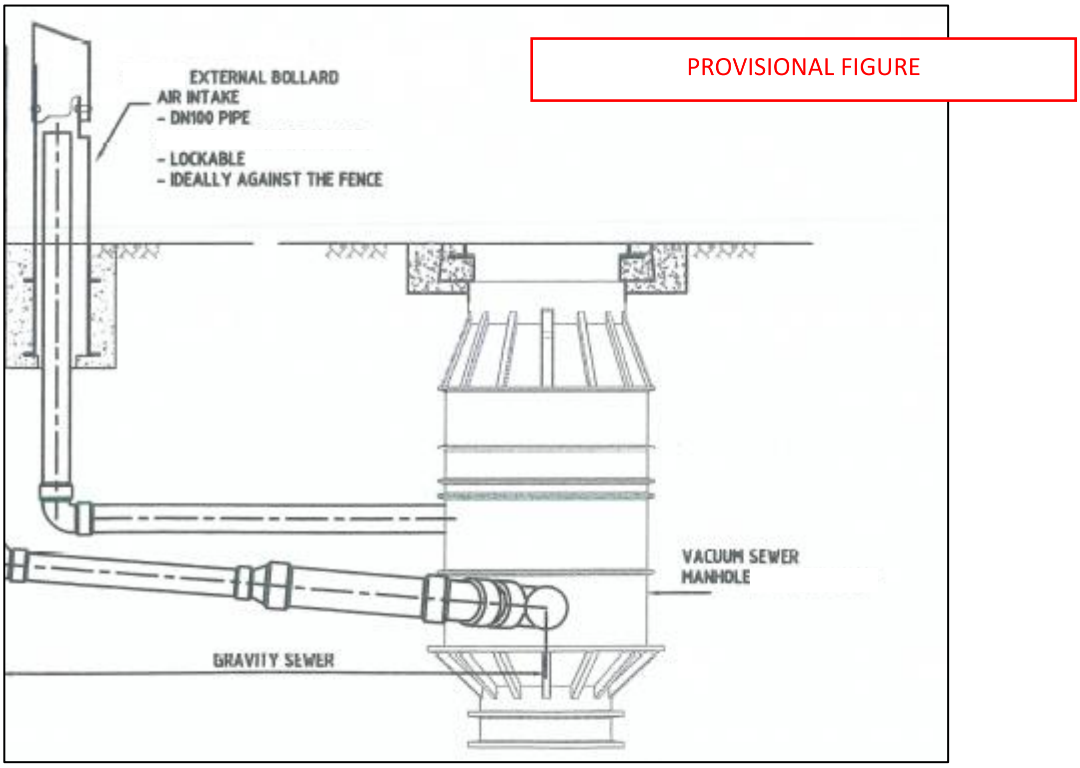


Figure 10-1 Example of collection chamber with external air intake

10.1.9 Emergency storage

The emergency storage capacity shall consider at least 8 hours of ADWF from all properties connected each chamber to allow wastewater collection during emergencies.

The total storage capacity of a sump is larger than the normal operating volume. It considers the volume from the base of the sump up to the lowest ground level served by the sump.

Additionally, the incoming gravity pipelines leading to each chamber are also considered for storage capacity up to the same point described above or up to 0.5 m below the level at which an overflow will occur.

For additional storage capacity, larger sumps may be used and/or gravity pipelines may be increased from DN 150 to DN 225, but maintaining DN 150 design slopes. Alternatively, a separate location for sump and valve chamber can be used.

10.1.10 Covers and frames

Covers for collection and interface valve chambers shall provide an access opening of at least 600 mm in diameter or 900 x 600 mm.

All covers within the network shall be watertight and be rated class D as per AS 3996-2006 standard.

Materials, specifications and installation shall be in accordance with the requirements specified in Watercare's standard drawings.

10.2 Vacuum interface valves

10.2.1 General

Vacuum interface valves for vacuum wastewater systems shall comply with AS 4310-2004.

Interface valve operation shall be activated by level of liquid in sump and vacuum in the wastewater system. Each valve shall be adjusted to remain open as required by the design air-to-liquid ratio.

Valves shall fail safe in the closed position and prevent any backflows from vacuum pipelines into the collection chamber.

Valves shall be able to operate while submerged with a breather pipe to supply air and during anticipated extreme weather.

Suction pipes shall be provided by the valve supplier and its DN shall not be larger than that of the interface valve or connection pipeline.

Demountable and re-usable flexible coupling suitable for vacuum service shall be used for interface valve installation.

Interface valves to be connected to an individual lateral.

Interface valve shall be at a depth that allows access without entering the collection chamber. The recommended maximum depth to invert is 740 mm.

10.2.2 Telemetry and instrumentation

Each interface valve in the system shall include monitoring of valve status (open/close and cycle counter) and valve opening time. End of line pressure shall be monitored at furthest collection chambers of each main. Alarms shall be generated in case of valve failure or prolonged vacuum pressure loss.

10.3 Service connections

10.3.1 General

Service connections are defined as the pipe connection between collection chamber and vacuum pipeline. Its length is dependent on chamber and pipeline location.

10.3.2 Design criteria

Design of service connections shall conform to the general and particular requirements specified in Section 9.

Where lifts in the service connections would imply the pipe being close or above the finished surface levels, the pipe shall be laid with a minimum slope of 0.2% or a drop between lifts of 110 mm, whichever is the greater.

Each service connection to have only 1 vacuum interface valve connected to it.

All service connections in which lifts are installed shall be detailed in the design drawings.

11 Pumping System and Discharge Pipe Work

11.1 Hydraulic design

Hydraulic design, pump selection, discharge pipe work and rising mains shall refer to Watercare's standards for wastewater pumping stations and incorporate the parameters specified in this document.

Discharge pipe work shall also be consistent with the assumptions adopted in the hydraulic design of the pumping system in the previous section.

11.2 Pump selection

11.2.1 General

The operation of the pumps shall be checked against the calculated system curves at low level cut-out and overflow level in the vacuum vessel.

Pumps may have a horizontal or vertical configuration and be rated and configured for dry-well service. Pumpsets shall be capable of operate while submerged in the event of dry well of vacuum station becoming flooded. This requires a closed-coupled motor and for electrical decontactors to be located above the vacuum station floor.

Pump passage diameter should be capable of passing a 60 mm spherical solid for DN 80 pressure main and a 75 mm for DN 100.

Noise level measurements and controls shall be implemented as specified in Watercare's standard for wastewater pump stations.

Pump and pipework seals should be rated for vacuum operation.

11.2.2 Total dynamic head

When calculating the required total dynamic head of the system, in addition to the static head and friction losses, the head required to overcome the vacuum in the vessel shall be included.

The vacuum head to overcome is defined as the average of the operating pressure range inside the vessel, normally between -55 kPa and -65 kPa. Higher pressure range can be required as defined by the final reticulation design.

11.2.3 Others

Seal for pump shaft shall be mechanical oil-bath type suitable for vacuum service.

Self-priming pumps are recommended for the vacuum pump station.

In case standard pumps are considered, equalisation lines for each pump between its discharge side and the vacuum vessel shall be detailed in the design drawings. These lines shall be fabricated in DN 25 PN 12 PVC with demountable and fitted with two DN 25 ball valves. Recommendation for standard pump selection shall be sought from the system supplier and be submitted to Watercare for approval.