PRESSURE SEWER SYSTEMS

HYDRAULIC DESIGN GUIDELINE

JUNE 2018

VERSION: 2.0

Version 2 authorised by Stuart Horvath on 13/06/2018

Contents

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1 General

1.1 Introduction

This guideline outlines Hunter Water's design requirements for Pressure Sewer Systems (PSS). Design and construction of PSS is considered to be 'Complex Works' and is only to be undertaken by competent consultants or contractors listed on the Register of Accredited Design Consultants and Construction Contractors for Developer Works.

This document is to be read in conjunction with the following design standards:

- Water Services Association Australia (WSAA) Pressure Sewerage Code of Australia Design (WSA-07-1.1 2007)
- The Hunter Water Addendum to WSA 07-2007
- The Hunter Water document, Pressure Sewer Systems - Planning and Design Guideline

If there is an inconsistency between this document and those listed above, this document takes precedent, however, the Designer is to confirm any interpretation with Hunter Water prior to proceeding further.

1.2 Hydraulic analysis and design progression

The PSS hydraulic design elements covered in this guideline include:

- Infrastructure layout and assessment of lot drainable areas
- Determination of collection tank loadings and storage requirements
- Estimation of network pipe flows and review of maximum pump heads and minimum pipe velocities
- Air movement assessment
- Wastewater age assessment

PSS hydraulic design is generally to be undertaken in two stages, being:

1. Preliminary hydraulic design as part of the 'Strategy Phase', and;
2. Detailed hydraulic design as part of the 'Complex Works Design Phase'.

A preliminary hydraulic design is required to confirm the feasibility of pressure sewer as an optimal servicing option. If pressure sewer is accepted by Hunter Water, then a detailed hydraulic design shall be undertaken to further investigate system performance and confirm technical requirements can be met, and to inform development of an optimised arrangement and system detailing. The investigation requirements for both preliminary and detailed hydraulic design are described in Section 1.3.

Table 1: Stages of pressure sewer hydraulic design

When hydraulic design is undertaken	How it is reported
Preliminary hydraulic design as part of the Servicing Strategy	A Preliminary Hydraulic Design Report attached as an appendix to the Servicing Strategy and a summary of key outcomes documented within the Servicing Strategy

Detailed hydraulic design as part of Complex Works design phase	A Detailed Hydraulic Design Report attached as an appendix to the Design Report and a summary of key outcomes documented within the Design Report

1.3 Requirements for hydraulic design

1.3.1 Preliminary hydraulic design

The preliminary design requires undertaking the following:

Lot drainage envelope assessment

The full requirements of this assessment are to be investigated, as this is an important aspect in the decision making process of whether pressure sewer is an appropriate servicing method.

Modelling – Preliminary hydraulic design

Modelling requirements for preliminary hydraulic design will typically comprise dry-weather and power failure scenarios only, however exact requirements will be communicated by Hunter Water at the Preliminary Hydraulic Design Meeting.

Modelling scenarios to be investigated and reported on shall include system performance at various stages of site development, as clarified at the Preliminary Hydraulic Design Meeting.

The methodology used for system modelling (dynamic or static modelling) is to be consistent with Hunter Water's requirements in Section 6.3 .

Wastewater age calculation

Only methodology A (section 9.2.1) of the wastewater age calculation is to be undertaken (i.e. wastewater age from the network as a whole).

Air movement assessment

An air movement assessment is not required for preliminary hydraulic design.

1.3.2 Detailed hydraulic design

All investigation tasks and design requirements covered within this guideline are to be addressed and documented as part of Detailed Hydraulic Design.

1.4 Meeting requirements

The Designer is required to meet with Hunter Water throughout the hydraulic design process to confirm investigation requirements, agree on key parameters and assumptions, discuss any project-specific issues, and to facilitate a collaborative approach to design. As a minimum, the following three meetings are required:

Preliminary hydraulic design meeting

Prior to commencing the preliminary hydraulic design a meeting is to be held with Hunter Water to discuss investigation requirements. Topics to be covered include project-specific design assumptions and parameters, confirming initial modelling scenarios to be tested (including staging assessment) and other hydraulic calculation requirements, and any other key concerns/issues associated with pressure sewer servicing the specific site. It may be possible to combine this meeting with the Strategy Progress Meeting.

Detailed hydraulic design meeting

Prior to commencement of the detailed modelling work, a meeting is to be held with Hunter Water to re-confirm design assumptions and parameters (which may be updated), to confirm the initial scenarios to be modelled for detailed hydraulic design (including scenarios for interim development stages), and to discuss any other project specific issues related to detailed hydraulic design. A target date for the follow-up Modelling Progress Meeting shall also be set.

Modelling progress meeting

The purpose of this meeting is for the Designer to present to Hunter Water the initial modelling results, and to discuss if there is a need for further scenario modelling, and other issues that have arisen as a result of an improved system understanding (following initial modelling). This is also an opportunity for the Designer to discuss any emerging hydraulic design issues, to seek further advice/guidance on any decision points, and to receive preliminary feedback from Hunter Water.

2 Layout of on-property infrastructure

2.1 Placement of on-property infrastructure

Hunter Water's standard configuration requirement is that on-site pressure sewer collection tanks are located at the street frontage of the lot to facilitate ongoing access for operation and maintenance activities. Refer to WSA 07 (including Hunter Water Addendum), and the 'Pressure Sewer Systems - Planning and Design Guideline' for details of Hunter Water's tank positioning requirements.

2.2 Lot drainage envelope assessment

2.2.1 General

The subdivision layout must be configured to achieve:

1. The majority (85%) of the lots draining to the street frontage; and
2. For those lots that drain away from the street frontage, a minimum drainable percentage of the lot area must be achieved. This shall be considered early on in the design of a sub-division.

For each individual lot, an assessment is to be undertaken to calculate the area of the lot that can drain to the nominated tank position (as per final placement intent and shown on design drawings). The methodology described in Section 2.2.2 is to be adopted for this assessment.

The minimum acceptable drainage area for a lot is provided in Table 2. The drainable area is to be inclusive of the area where buildings with plumbing are most likely to be located. The Designer is to identify any property that does not satisfy these criteria within the bounds of the collection tank positioning requirements. In the first instance, it must be demonstrated that at least 85% of all lots collectively within the proposed development satisfy requirements within table 2. For lots which do not meet the requirements the designer is to seek guidance from Hunter Water.

If a property does not meet the minimum drainable area, there are generally two options that can be considered:

1. To service the property by conventional gravity sewer.

2. To implement a mitigation measure that will enable sufficient lot drainage. These measures include revising the lot-layout or undertaking site earthworks (e.g. benching) to improve the drainage envelope. These measures are to be implemented by the Developer. Note: Hunter Water does not consider the installation of secondary private pump to be a suitable mitigation measure and is to be avoided at all times.

Table 2: Minimum area of lot to drain to the collection tank for new subdivisions

Area of Lot (A) [m^2]	Minimum Drainable Area
<=450m^2	70% of gross lot area

450m^2 to 900m^2	70% down to 50% as gross lot area increases (proportioned based on lot size) I.e. $\%\, min\ drainable = \frac{-2}{45} \times A + 90$
>= 900m^2	Lesser of either 50% of gross lot area, or 600m^2

The logic from Table 2 can be converted into the following Excel formula:

Min Drainable Area (m^2) = IF(**A**<=450,0.7*A,IF(AND(**A**<900,**A**>450),**A***((-2/45)***A**+90)/100,MIN(0.5***A**,600)))

2.2.2 Methodology

For each lot, report on the percent of drainable land, and provide a figure which shows the drainable area for the nominated tank location. This information is to be included in the Public Positive Covenant developed for the lot. Results are also to be summarised in the design report along with an interpretive discussion. Discuss the area of land identified as drainable relates to the likely positioning of buildings.

The assessment of drainable lot area is to assume the structure requiring drainage is constructed as slab-on-ground (and not elevated on piers). Base the assessment on the intended finished land surface profile of the block.

To assess the drainable area, it is expected that the ability to drain from various points around the lot will be assessed, and this is to be at a suitable resolution such that an envelope can be drawn with reasonable accuracy.

There are varying methods for undertaking this assessment (e.g. dependent on availability of access to GIS tools), but in all cases the following values need to be considered for each lot:

- The invert of the tank inlet-stub for connection of the customer sanitary drain. **(T)** [m AHD]T
- The depth to the invert (**D_{inlet}**) [m] is to be calculated based on drawings for the tank model installed. The invert is to be calculated assuming the tank is installed in its nominated position.
- The minimum gradient of the house drainage sanitary line. As default adopt 2%. **(S)** [%]
- An allowance for minimum cover above the drainage sanitary line, and vertical space for inspection shafts/boundary traps as required by AS 3500. As default adopt 0.5m. **(C)** [m]
- The straight line distance between the centroid of the point being assessed, and the tank inlet. **(L)** [m]
- The surface elevation of the point of land being assessed. **(E)** [m AHD]
  Depth of any engineered fill applied to the lot (i.e. benching) to raise the surface elevation. (**B**) [m]

Based on the above variables, a point on the lot (or sub-parcel of land) can be considered drainable if the following equation is true:

$$\left[E_{parcel} + B - \left(T + \frac{S}{100} \times L + C\right)\right] \geq 0$$

Where,

$$T = E_{tank} - D_{inlet}$$

If the above calculation is <0, then the assessed location is undrainable.

Drainage Assessment Tool: Hunter Water has an in-house GIS tool for assessing the lot drainage envelope based on the methodology described above. Designers are encouraged to contact Hunter Water and request Hunter Water undertake this

3 Layout of network infrastructure

3.1 General requirements

The system layout shall be in accordance with Section 5.1.1 of WSA 07 (with Hunter Water addendum).

In addition to these requirements:

- The system shall be designed to minimise the potential number of properties that are off-line if there is a break or blockage in the reticulation network. In general, a maximum cluster of 200 pressure sewer units discharging to a gravity connection from a single pressure sewer system zone is permitted. If the scheme exceeds this number, then multiple sub-systems (zones) discharging to a skeletal gravity network will be required.
- System layout is to be designed for a single direction of flow only, and as such looped reticulation networks are not permitted (as they can result in unpredictable and uneven distribution of flow). In some circumstances a network pattern with mainline isolation valves normally closed may be considered if there is significant benefit from the added redundancy.

3.2 Network outlet requirements

3.2.1 Discharge elevation

Hunter Water's default requirement is for the system outlet to be the highest point in the pressure system, such that the system remains fully-flooded. This is to prevent various issues associated with systems which have either partial pipe drainage, or that are reliant on valves to maintain pipes under-pressure. These issues include reduced system reliability, increased difficulty in system fault-finding, design and operational complexity, and greater maintenance requirements. For example, a failed air valve may result in air blockages or pipe collapse (as a result of negative pressures).

If it is not practical to have the system outlet at the highest point, Hunter Water may in some circumstances allow the use of a barometric loop up to 6m in height at the outlet. A Review of Environment Factors (REF) and development consent will be required for a barometric loop structure, as it is an above ground structure with the potential to create odour if poorly designed. Hunter Water does not permit the use of pressure sustaining valves (or similar) to maintain sewer pipes under-pressure.

3.2.2 Discharge location

The discharge point from a pressure sewer network is to be into a gravity network. Discharge is to be into a maintenance hole with protective coating and is to be free from the influence of any backwater effects in the gravity network.

Discharge directly into another rising main is generally not permitted due to incompatibility of pumps.

Flows discharged to the network outlet from the proposed pressure sewer scheme are to be calculated as part of the hydraulic design. This information is to be used for assessing capacity of the downstream gravity network to receive the discharged flows. Flows are to be estimated and reported on under a number of conditions, including dry weather, wet-weather, and system failure recovery. The requirements for reporting these flows are discussed in more detail in Section 6.5 of this document.

3.3 Vertical layout

Pressure sewer line grades require engineering design to minimise the requirement for air valves. If air valves are required their placement should be optimised. Flat grades are not permitted at any time.

4 Collection tank hydraulic loading

4.1 Dry weather collection tank inflow

This section provides guidance on the normal dry-weather hydraulic loads that are to be used as inflow into pressure sewer collection tanks.

4.1.1 Single residential dwellings

Prior to commencing system hydraulic design, the Designer is to confirm with Hunter Water the appropriate design flow to adopt for dry-weather collection tank inflow within a specific scheme.

Tank inflow rates are to be calculated assuming a sewer load rating of 150L/EP/day. For green-field single-dwelling residential subdivisions, tanks are to be modelled assuming an occupancy rate of 3.0 persons/dwelling, resulting in a nominal tank design inflow of **450 litres/property/day**.

For servicing of back-log areas, the design flowrate is to be based on analysis of historic water consumption rates within the specific service area, considering both average consumption and variability across properties. In basing design flowrate on historical consumption, note that customers may use more water when wastewater disposal is no longer an issue. Advice on the appropriate value to adopt is to be sought from Hunter Water.

4.1.2 Commercial/industrial hydraulic loadings and other types of dwellings

The appropriate design flowrate for dwellings other than single residential dwellings **(including commercial, industrial, and higher density residential)** is to be determined in consultation with Hunter Water

For green-field servicing, the design flowrate is to be based on assessment of likely wastewater production from a build-up of likely water consumption based on knowledge of the proposed development. If this detail is not available, wastewater loads are to be estimated following Appendix HW N 'Estimation of Equivalent Tenements (ET), Storm Allowance (SA) and Design Flow' in the Hunter Water Edition (Version 2) of WSA 02. If there is uncertainty, various wastewater production scenarios and their impact on system designs are to be considered.

For brown-field servicing, the design flowrate is to be based on analysis of historic water consumption and any available data on historic wastewater production. The design shall also consider any knowledge of likely future changes in the property's wastewater production profile.

4.2 Collection tank inflow profile

Unless more accurate information is known, the assumed diurnal pattern for normal dry weather inflow into a single residential collection tank shall be as per the pattern shown in Table 3 below. For non-residential development, refer to the demand factors specified in Table HW 2.6 in the Hunter Water Edition (Version 2) of WSA 03 – and select the most appropriate category. Note that the diurnal pattern adopted may be averaged over a longer time-step (up to 3hrs) for modelling purposes.

Table 3: Residential Diurnal Sewer Curve

Time (from)	Demand Factor
0:00	0.20
1:00	0.13
2:00	0.11
3:00	0.11
4:00	0.28
5:00	0.78
6:00	1.68
7:00	2.16
8:00	2.13
9:00	1.92
10:00	1.61
11:00	1.34
12:00	1.13
13:00	0.97
14:00	0.92
15:00	1.04
16:00	1.34
17:00	1.44
18:00	1.25
19:00	1.06
20:00	0.87
21:00	0.68
22:00	0.51
23:00	0.34
0:00	0.20
sum	24.00
average	1.0

4.1 Wet-weather inflow and infiltration

In traditional gravity sewer systems in the Hunter Water network, approximately 50% of inflow and infiltration (I/I) is contributed to the system by pipework owned by the customer, and 50% by Hunter Water owned reticulation pipework. The customer wet-weather inflow is most likely related to illegal connection of property stormwater drainage to the sewer line (e.g. roof down pipe), or inappropriately designed gully traps which have surfaces draining to them. The slower response infiltration component most often occurs because of broken or poorly sealed customer drainage lines.

I/I will be less for pressure sewer systems, than for gravity systems but it is still prudent for a design to make some allowances. In pressure sewer, infiltration in customer drainage lines remains, as will opportunities for wet-weather inflow via gully traps, through poorly sealed tanks, and illegal stormwater connections (though these are less likely). As such, Hunter Water requires the likely impact of wet-weather inflows on system performance to be investigated as part of the design process (refer to Section 7.3.2.2). The allowance made for assessment of I/I shall relate to the extent of I/I control for the project site.

5 Collection tank storage volumes

5.1 Storage volume components

The various storage volume components which make up the total storage requirement for a PSS collection tank are shown in and described below.

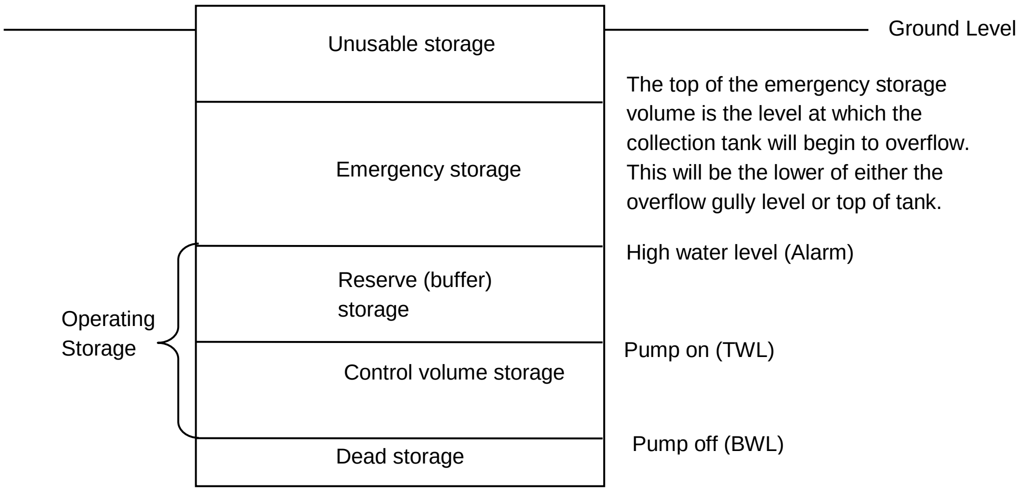

Figure 1: Storage Components of a PSS Collection Tank

Dead storage

This is determined by the minimum depth of submergence above the pump centreline for a specific pump model and is specified by the manufacturer.

Control volume storage

The control volume is the volume stored between the pump cut-in level (TWL), and the pump cut-out level (BWL). The control volume is to be set to promote relatively frequent pumping for short durations to minimise the time the sewage is stored in the tank to assist with septicity control.

Reserve storage

The reserve (or buffer) storage volume is used to attenuate peak flows. It is the volume required to store flows during times when the pump is running but the incoming flowrate exceeds the available pump discharge rate, or at times when the TWL is reached but the pump is prevented from cutting in due to excessive system pressures (noting this would not occur under normal dry weather operating conditions).

The minimum volume for the reserve storage is specific to an individual pump unit and is calculated as the maximum of the below:

1. The difference in the volume of maximum incoming flow less minimum outgoing flow. This volume shall be calculated such that alarms are not activated with

normal high output applications (such as domestic washing machines and the like). It can theoretically be calculated as the volume of incoming flow over the diurnal peak minus the volume of flow pumped from the collection chamber over the same period, assuming the pump flowrate at 50m of head (the maximum operating pressure under normal circumstances).

2. Total tank inflow over the maximum duration over which the pump may be prevented from cutting in due to excessive system pressures during normal system operation. This value can be determined from review of dynamic model results.
3. A reserve storage volume equal to 1 times the control volume storage.

Emergency storage

Storage volume required to minimise the likelihood of overflow from the collection chamber in the event of a system failure (e.g. pump mechanical failure, power failure, reticulation pipe failure). For minimum volume requirements refer to Section 5.2.

Unusable storage

This storage component will only exist if the overflow gully trap on the customer sanitary drain line (which connects to the tank) is at a lower elevation than the top of the tank. The unusable storage is then the tank storage component that is higher than the overflow gully trap. This component will likely exist for collection tanks that are installed at a higher ground level than the dwellings being drained to it.

5.2 Minimum emergency storage requirements

5.2.1 Single residential dwellings

5.2.1.1 *Storage requirement*

The nominal emergency storage requirement for single residential dwellings is to provide a minimum volume equivalent to 24 hours of the normal dry weather design inflow that will enter the collection tank based on an occupancy rate of 3.5 persons/dwelling and a sewer loading rate of 150L/EP/day. This results in a tank emergency storage volume requirement of **525 litres/property**.

For properties located within the direct hydrological catchment of the Grahamstown Dam drinking water supply, or within the Campvale Canal catchment (a pumped sub-catchment of Grahamstown Dam) the minimum storage requirement is upgraded to a volume equivalent to 48 hours of the normal dry weather design inflow. This results in an emergency storage volume requirement of 1050 litres/property. In provision of a larger storage tank with 48hrs of storage the Designer is to ensure the pump control levels are appropriately adjusted to minimise within-tank detention times.

Emergency storage requirements are to be confirmed with Hunter Water prior to system design. Where power interruptions or environmental constraints or other unique features might require additional storage over and above the set minimum requirements, these will be determined on a case-by-case basis.

5.2.1.2 *Storage calculation*

The emergency storage volume is to be calculated as the available tank storage above the high-water alarm level. Neither the 'unusable storage' component, nor the 'buffer storage' component may be included in the calculated volume (refer). As the unusable storage volume will not be known until such time the house is constructed, an estimate of the storage volume is to be made for design-stage calculations.

Hunter Water's preference is for full provision of the minimum emergency storage volume within the collection tank. If the full tank volume cannot be utilised, then the storage volume provided in the customer sanitary drain above the alarm level may also be included in calculation of the emergency storage volume.

At the design phase, calculations are to be presented for each lot, and the component of storage provided within the tank, versus outside of the tank clearly specified. Where the full requirement for emergency storage is not available within the tank and customer sanitary line, then additional storage is to be provided through the means as described in Section 7.2.1 of WSA 07.

5.2.2 Commercial/industrial and other types of dwellings

Emergency storage requirements for dwellings other than single residential dwellings **(including commercial, industrial, and higher density residential)** are to be reviewed by Hunter Water on a case-by-case basis.

6 Assessment of pipe flow and hydraulic analysis

6.1 Estimation of flow in a length of pipe

The calculation of likely flow within a proposed pressure sewer system is required to assess the hydraulic performance of a system and confirm suitable design.

The instantaneous flow in a length of pipe is dependent on the number of upstream pumps operating simultaneously. Predicting the number and location of customer pumps operating in a system at any one time is the greatest challenge to estimating flows in pressure sewer pipes. Factors which influence this include:

- the number of upstream properties connected to the system
- the flow delivered into each collection tank, including the total daily volume and the diurnal pattern of inflow
- the selection of the pump model and control volume settings (and therefore how much time the pump operates per day, and the number of discrete pump cycles per day)
- the time since the pump last operated and the flow that has since been delivered into the tank

6.2 Modelling performance objectives

Computer modelling is to be used to optimise system design, and assess the likelihood of the system meeting the following performance objectives:

- Minimum pipe self-cleansing velocities are achieved on a daily basis for a sufficient period of time (for requirements refer to Section 6.5).
- Under dry weather conditions, each individual pump must not exceed a pump head of 50m and shall operate for no more than 30 minutes in any one day.
- System recovery time after power failure is acceptable. As a guide, system recovery to normal operating patterns shall be achieved within 8 hours.
- The system is suitably robust to accommodate a range of inflows above and below the adopted 'design' values (including wet-weather inflows).
- The system is suitably robust to accommodate wet-weather inflows. As a guide, no pressure sewer collection tank shall surcharge when the system is modelled to take into account wet-weather inflows.

Modelling is also undertaken to inform other elements of system design:

- To enable calculation of the age of flow from the system as an input for assessment of odour and septicity potential.
- To determine the design flow from the system at discharge to the receiving gravity network.

The optimal system design can be developed through an iterative process of system adjustment (changes to both pipe layout and internal pipe diameters) followed by modelling to investigate performance impacts.

As a general rule, the smallest pipe diameter that satisfied the performance objectives shall be selected, as this will minimise within-pipe retention volumes (minimising sewage age and therefore related septicity/odour issues), and maximise flow velocities for pipe self-cleansing.

6.3 Methodology for analysis

There are two general approaches to estimating flows in a pressure sewer network, being;

- Static modelling, based on empirical or statistical data and as typically undertaken in spreadsheets or using basic Supplier design software
- Dynamic modelling; using dynamic hydraulic modelling software to actively represent system operation under various scenarios

Hunter Water requires dynamic modelling for any pressure sewer system that has greater than 15 connected lots discharging to any one point in a gravity system. Either static or dynamic modelling methodology can be adopted for systems with 15 or fewer properties connected. Hunter Water requirements for both static and dynamic approaches is provided further below in this document.

6.4 Assessing of hydraulic performance at interim development stages

The design of the pressure sewer scheme is to be optimised for the ultimate development.

However, modelling of the system at various interim stages of development will also be required to confirm acceptable system performance prior to the full delivery, or if this not achievable, to inform the development of an appropriate system management plan for interim operation (provided this is acceptable to Hunter Water and this will be reviewed on a project specific basis).

The Designer is to clarify with Hunter Water the interim stages to be modelled and for what model scenarios. This shall be discussed at both the initial Hydraulic Design Meeting and the Detailed Hydraulic Design Meeting.

In reviewing the performance of the system at various interim staging the following must be considered:

- Likely lot connection dates, rather than lot ‘release’ dates
- Ensuring the timed-release of lots aligns with any necessary capacity upgrades to sewer infrastructure downstream of the connection point
- Minimise excessive sewage detention times as linked to system odour and corrosion potential
- Achieving minimum requirements for peak pipe flow velocities as linked to pipe self-cleansing

6.5 Minimum velocity for pipe self cleansing

Self-cleansing refers to the flow velocity required to carry solids along the pipe. To maintain an unobstructed pipeline this velocity shall be sufficient to resuspend any settled matter in low flow, and to scour the pipe of any grease or slime that may otherwise form on the pipe wall.

For pressure sewer, Hunter Water requires minimum pipe self-cleansing velocities of 0.6m/s for pipe diameters above DN75, and for this velocity to be achieved on a daily basis for the durations in Table 4. Minimum velocities may be dropped to 0.4m/s for the smaller pipe sizes. Minimum velocity durations presented in Table 4 are not continuous but are the cumulative time over a typical day.

Target self-cleansing flows are to be reliably achieved when assessing system performance under normal dry weather operation. On occasions where self-cleansing flow targets are not met, the Designer is to provide detail of the daily velocities/durations being achieved, and an explanation of why this is acceptable.

Note that minimum required pipe velocities may exceed those for pipe self-cleansing, depending on the velocity requirements to move air through the system (*refer* Section 0).

Table 4: Minimum target self-cleansing flow (duration / velocity) for pressure sewer pipe design

Pipe PE 100 PN16	Min. self-cleansing velocity (m/s)	Min. total daily duration of self-cleansing velocity (mins)
DN 32 to 63	0.4	10
DN 75	0.6	30
DN 90 to 125	0.6	60
DN 140 to 180	0.6	90
> DN 200	0.6	120

Table Note: pipe lengths with only a single upstream connection are exempt from achieving the minimum duration requirement.

7 Dynamic modelling requirements

7.1 Introduction

This section documents Hunter Water's minimum requirements for carrying out dynamic modelling investigations for pressure sewer systems. Further modelling-supported investigations (beyond this guideline) may be required, dependent on the characteristics of the specific network being assessed.

7.2 Model set-up requirements

The requirements for model set-up for assessing pressure sewer networks are given below.

Pipework Modelling

- The model layout of the network and collection tanks is to be spatially correct and representative of likely on-site pipe lengths.
- Property service pipeline lengths are to be modelled as straight line distance between pump unit and connection point to reticulation network. The length of this pipe in the model is to be representative of the actual as-constructed pipe length for the specific lot.
- All pipework is to be modelled with assumed installation depth of 0.8m below ground level.
- All pipework is to be modelled with actual pipe internal diameters (not nominal) for specified pipe material (which will be PE 100, PN 16).
- An appropriate density of nodes are to be modelled to break up the pressure mains such that there is sufficient resolution for optimising changes in pipe diameter, pressures at high and low points can be determined, and pump heads at customer service connections can be determined.

Modelling of on-site collection tanks:

- Every pump unit is to be modelled separately for dynamic modelling.
- The actual pump curve (or a representative curve if a specific pump model is yet to be selected) is to be used in the modelling.
- The tank volume parameters (as based on tank diameter, depth) are to be representative of the specific units proposed to be installed for the development.
- Assigned pump unit operating levels shall be specific to each lot and are to be representative of the levels at which the unit will likely be installed. Based on the tank location, a tank surface level is to be identified from contour or civil earthworks plan (if applicable). Operating levels (alarm, pump cut-in, pump cut-out, pump suction) are to be deduced based on tank dimensions and factory-set operating levels. If there is a range of feasible tank locations, the most disadvantaged elevation is to be adopted for modelling.

- Pumps are to be modelled to shut-off when pressure at the pump exceeds the pump shut-off head. Value of shut-off to be confirmed with Hunter Water at commencement of modelling. The default shut-off head to adopt is 50m.
- Dry weather flows into each collection tank shall be modelled as following the 24hr diurnal water consumption pattern from Table HW2.6 'Diurnal Demand Factors' from WSA 03 Water Supply Code of Australia – Hunter Water Edition Version 2. Refer to requirements given in Section 4.2 of this document. This 30 minute diurnal pattern may be averaged over a longer time-step (up to 3 hours).
- The standard daily tank inflow volume adopted for modelling shall be consistent with the daily design inflow volume as agreed with by Hunter Water for the specific project. Refer to requirements given in Section 4.1 of this document.
- For modelling, it may be assumed that the tank will not overflow until the storage level reaches the tank lid surface level. *Note that in reality the tank may overflow below this level if property gully trap is lower than the tank (as may happen if the block slopes downhill from the tank).*

System outlet

- The modelled invert level for system outlet(s) shall be representative of the proposed design, and shall be the elevation of the system where is transitions from pressure to gravity flow. The value adopted shall be consistent with that shown on the system design drawing (once complete).

Time

- A maximum 15 second time interval is to be adopted for system modelling to provide resolution for pump and collection tank performance.
- Duration: Either 14 days or until the model stabilises (minimum 5 days results presented).

Roughness value

- A pipe roughness value of 0.60mm is to be applied in conjunction with the Colebrook-White formula.

Tank starting levels

- The model is to be initialised to have randomised tank starting levels, within the range of the assigned BWL and TWL for the tank. This is to be adopted for all scenarios except the "Abnormal Operating Scenarios" where alternate requirements for initial tank levels are provided. The Designer is to investigate and report on the sensitivity of the model results to the assigned randomised starting level.

7.3 Model scenarios

7.3.1 General

Table 5 details the baseline and provisional scenarios to be modelled for each pressure sewer scheme. Provisional scenarios are to be modelled at the request of Hunter Water. The scenarios to be modelled for a particular scheme are to be confirmed with Hunter Water prior to commencement of the modelling exercise (i.e. at the Preliminary and Detailed Hydraulic Design Meetings).

It is the Designer's responsibility to identify any additional scenarios which may need to be investigated to optimise the design or understand the operation of a specific scheme.

Each scenario is described in further detail below the table. The requirements for reporting model results are discussed in Section 7.4.

Table 5: Pressure sewer model scenarios

Scenario Description	Scenario ID	Description
Normal Operating (NO) Scenarios		
Baseline		
Dry weather (DW)	NO-DW	- For initial sizing of pipe diameters and network layout.
Wet weather (WW)	NO-WW	- Change tank inflow pattern by adding a wet-weather storm inflow on top of the standard inflow for one day. - Wet weather loading to be confirmed with Hunter Water. - All other modelling set-up as per the NO-DW scenario.
Abnormal Operating (AO) Scenarios		
Baseline		
Recovery from 24hr failure (FR) in dry weather	AO-24DW-FR	- Add a volume to each collection tank equivalent to 24hrs of standard tank inflow above a randomised starting level between tank BWL and TWL. - Model system recovery to normal operation (with concurrent standard dry weather inflow)
Provisional		
Recovery from 24hr failure (FR) in wet weather	AO-24WW-FR	- Add a volume to each collection tank equivalent to 24hrs of standard tank inflow plus an additional volume relating to wet-weather loading above a randomised starting level between tank BWL and TWL. - Wet weather loading to be confirmed with Hunter Water. - Model system recovery to normal operation (with standard dry weather inflow)
Recovery from system-wide full tanks	AO-TF-FR	- Start the model assuming the initial water level for each tank has risen to store 24hrs of dry weather tank inflow above the alarm level. - Model system recovery to normal operation (with concurrent standard dry weather inflow)
Sensitivity Scenarios (SS)		
Baseline		
Higher tank inflows (HI)	SS-HI	- Change inflow to tanks by increasing standard daily volume by a multiplying factor. Maintain standard diurnal inflow pattern. - Default factor for greenfield sites is 1.3, and for brownfield sites 1.4.

		- All other modelling set-up as per the 'Normal Operation, Dry Weather Tank Inflow' scenario.
Lower tank inflows (LI)	SS-LI	- Change inflow to tanks by decreasing standard daily volume by a multiplying factor. Maintain standard diurnal inflow pattern. - Default factor is 0.8. - All other modelling set-up as per the 'Normal Operation, Dry Weather Tank Inflow' scenario.
Alternate pump model (P2)	SS-P2	- Change modelled pump curve to an alternate pump model. Alternate pump curve to be confirmed with Hunter Water. - All other modelling set-up as per the 'Normal Operation, Dry Weather Tank Inflow' scenario.
Provisional		
Alternate roughness assumption (R2)	SS-R2	- Universally change modelled pipe roughness. Default change is to test roughness value of 0.15mm. - All other modelling set-up as per the 'Normal Operation, Dry Weather Tank Inflow' scenario.
Alternate tank control volume (CV2)	SS-CV2	- Change tank operating levels to represent installation of an alternate tank model. Alternate tank model to be confirmed with Hunter Water. - All other modelling set-up as per the 'Normal Operation, Dry Weather Tank Inflow' scenario.

7.3.2 Normal operating scenarios

7.3.2.1 *Dry weather (NO-DW)*

This model scenario is to be used as the basis for selection of the scheme's pipe sizes and pipe network layouts.

As such, the results from this scenario run shall be used for:

- Calculating system wastewater detention times.
- Reviewing pipe flow velocities and ability to achieve minimum velocities/durations.
- Reviewing maximum head at individual pump units and assessing if they remain within target limits.
- Calculating the DRY WEATHER design flow *from* the system (expected to occur once or twice per day).

7.3.2.2 *Wet weather (NO-WW)*

The system is to be modelled under a wet-weather scenario to verify satisfactory performance assuming a representative volume of inflow/infiltration (I/I) makes its way into the system as a result of rainfall events, as will likely occur as the system ages. Satisfactory performance is considered to be demonstrated if there is no usage of the tank emergency storage volumes (and therefore no tank high level alarms or tank overflows) during wet-weather modelling.

While pressure sewer systems are sometimes described as being free of I/I, it can occur in the non-pressurised portions of the system (e.g. the house sanitary drainage line, and into the tank). Although greenfield development may initially be free of wet-weather I/I, the problem is often known to emerge as a system ages. It is therefore prudent to review system performance with a reasonable I/I allowance and make adjustment (if necessary) to accommodate I/I in system design.

The storm inflow allowance adopted in modelling is to align with the level of I/I expected to be seen in the specific system given the anticipated level of system monitoring/control. The inflows to be modelled for wet-weather are to be confirmed with Hunter Water prior to commencement of modelling.

The scenario shall be used for:

- Confirming the system is able to accommodate wet weather inflows without any collection tank alarms being triggered or surcharging.
- Calculating the WET WEATHER design flow *from* the system.

7.3.3 Abnormal operating scenarios

Failure recovery scenarios are to be modelled to understand the system's likely recovery response to a system-wide failure that would prevent individual pump units from operating for a period of time. The cause of system wide failure would most likely be due to a network wide power failure. Another reason could be an intentional shut-down of the system to allow maintenance activities to be undertaken on the downstream receiving gravity sewer.

Three failure recovery starting conditions are described below. Unless advised otherwise by Hunter Water, the system is initially to be modelled for AO-24DW-FR. Results from this scenario are to be presented and discussed with Hunter Water (at the Modelling Progress Meeting). Dependent on system performance risk and characteristics the Designer may be requested to investigate system response for scenarios AO-24WW-FR and AO-TF-FR.

For each of these scenarios, the system recovery period is to be modelled assuming standard dry weather inflow is received by each tank over the recovery period.

These scenarios shall be used for:

- Calculating the FAILURE RECOVERY design flow from the system
- System recovery after power failure is acceptable. As a guide, system recovery to normal operating patterns shall be achieved within 8 hours.

7.3.3.1 *Failure recovery from system offline for 24hrs during dry-weather (AO-24DW-FR)*

Starting the model simulation assuming 24hrs of standard inflow has been received by each collection tank above a randomised pre-failure tank level. The pre-failure randomised level is to be set assuming a tank level between the control volume BWL and TWL. This scenario is less conservative than AO-TF-FR, as it makes use of the operating storage (including the reserve storage component) above the tank starting level.

For sewer systems with mixed servicing, the failure recovery scenario AO-24DW-FR, is to be modelled with concurrent dry weather flow loadings for the component of the network serviced by gravity flow. The impact of coinciding peaks from pressure sewer and gravity flows should be analysed.

7.3.3.2 *Failure recovery from system offline for 24hrs during wet-weather (AO-24WW-FR)*

This scenario assumes a coincident power failure over a storm response period. Modelling is to be the same as for AO-24DW-FR, however in addition to 24hrs of standard inflow into the tank, assume an additional wet-weather inflow volume has also been received.

For sewer systems with mixed servicing, the failure recovery scenario AO-24WW-FR, is to be modelled with concurrent wet weather flow loadings for the component of the network serviced by gravity flow. The impact of coinciding peaks from failure recovery flows and wet weather inflows, and for both pressure sewer and gravity system components, should be analysed.

7.3.3.3 *Failure recovery from full tanks (AO-TF-FR)*

Starting the model simulation assuming 24hrs of standard inflow has been received by each collection tank above the alarm level. This is a worst case scenario and basically relates to every tank in the network being full.

For sewer systems with mixed servicing, the failure recovery scenario AO-TF-FR, is to be modelled with concurrent dry weather flow loadings for the component of the network serviced by gravity flow. The impact of coinciding peaks from pressure sewer and gravity flows should be analysed.

7.3.4 Sensitivity scenarios

7.3.4.1 *Alternate dry weather tank inflows (SS-HI, SS-LI)*

Sensitivity investigations are to consider increases and decreases in dry weather flow loading rates. This testing is intended to capture variation in system loading that could be expected throughout the year because of factors such as changes in population densities within the catchment (e.g. due to holiday periods), or changes in water usage (e.g. clothes requiring higher level of washing in summer). It is also intended to capture uncertainty in the modelled sewer loads recognising the dry-weather inflows adopted may be different to the loads the system actually experiences once constructed.

Hunter Water's sensitivity factors are detailed below, however these are to be confirmed with Hunter Water prior to adoption for modelling.

Higher Tank Inflows (SS-HI)

For modelling of higher tank inflows the following baseline loading is to be applied for all residential connections within the PSS:

- Greenfield sites: a factor of 1.3 applied over the 24 hrs diurnal tank inflow pattern
- Brownfield sites: a factor of 1.4 applied over the 24 hrs diurnal tank inflow pattern

These scenario shall be used for:

- Confirming the robustness of the system for pumps operating within maximum pump head requirements.

Lower Tank Inflows (SS-LI)

For modelling of lower tank inflows the following baseline loading is to be applied for all residential connections within the PSS:

- Greenfield/Brownfield: a factor of 0.8 applied over the 24 hrs diurnal tank inflow pattern

These scenario shall be used for:

- Confirming the robustness of the system for achieving minimum velocity conditions and sensitivity of system detention times.

7.3.4.2 *Alternate pump units (SS-P2)*

The typical life of a pressure sewer domestic pump unit is approximately 8 years, based on the operational experience of Sydney Water which have had comparable systems operating for some time. As such, pump units can be expected to be replaced multiple times over the life-time of a pressure sewer network. Whilst a network shall be designed assuming a single pump model will be installed, it cannot be certain that the pumps will be replaced with the same model into the future.

There are currently several different manufacturers producing domestic pressure sewer pumps, and although these generally have similar *overall* capability, the relative difference in performance between individual pumps can be significant. As such, the system is to be modelled assuming an alternative pump model is installed and the capability of the system to comply with system operational requirements assessed.

The Designer is to confirm with Hunter Water an appropriate alternate pump unit to model for the specific network being assessed. Current pump models routinely installed in networks within Hunter Water's area of operation are E-One and Aquatec branded. As a baseline position, if either of these pumps is planned to be adopted, the alternate pump is to be tested in the sensitivity model run.

The system inflow to be assessed for pump model sensitivity testing is to be the 'Dry Weather – Standard Inflow' scenario.

7.3.4.3 *Alternate roughness assumptions (SS-R2)*

This sensitivity testing is to investigate the impact of different assumed pipe roughness on pipe head loss and therefore pump head and system performance. The Designer is to confirm with Hunter Water the alternate roughness values to be tested. As a baseline position, the smoother pipeline roughness value of 0.15mm should be adopted.

Alternate roughness values are to be tested on the 'Dry Weather – Standard Inflow' scenario.

7.3.4.4 *Alternate control volume (SS-CV2)*

The size of the collection tank control volume impacts how many times per day a pump will operate and the duration of each pump-out. This in turn impacts on the probability of synchronous pump operation. Control volumes are set differently by different collection tank manufacturers, and may also vary in time as level sensor products are replaced. Most tanks also allow for customisation of set tank operating levels, and user adjustment is another can be another cause of level variation.

To account for the fact the control volumes for some or all tanks in a particular system may change in time, sensitivity modelling with alternate control volumes shall be undertaken. The Designer is to confirm with Hunter Water the alternate control volumes to be tested.

This sensitivity testing is to be based on the 'Dry Weather – Standard Inflow' scenario (NO-DW).

7.4 Reporting of dynamic modelling

7.4.1 General

Reporting of pressure sewer modelling is to be documented in the Pressure Sewer Hydraulic Design Report. The broader requirements of this report are discussed in Section 12 of this document. The specific requirements for reporting on the pressure sewer dynamic modelling exercises are described below.

7.4.2 Modelling software

Description of modelling software adopted, included software version number and the Distributor. Any known limitations of the software and/or any quirks of the model build.

7.4.3 Plan of network model

The Designer is to include a plan of the modelled pressure sewer network. This figure is to clearly identify the key elements of the modelled system to aid in the interpretation of tabulated results.

The plan is to be legible, and presented over multiple pages if it is too complex to be shown on a single page. The information this plan is to show includes:

- Node IDs
- Link IDs
- System outlet point(s)
- On-site pump unit IDs

7.4.4 Model set-up

Describe the key elements of the model set-up. This is to include:

- Describing how the model meets the set-up requirements in Section 7.2 of this document (Model Set-up Requirements)
- A summary of the key hydraulic modelling parameters adopted (e.g. pipe roughness, fluid properties)
- Other key modelling assumptions

The Designer is to include in a report appendix with details of the set-up of model elements. This is to assist Hunter Water with interpretation of model results and provide clarity of adopted modelling assumptions. These tables are to include:

Pumps:

- Pump ID and assigned lot ID (cross-referenceable to an address, or lot/DP number)
- Pump Elevation (m AHD)
- Pump static head for each pump unit (i.e. elevation difference between the tank BWL and the highest point in the system)

Tanks:

- Tank ID and assigned lot ID (cross-referenceable to an address, or lot/DP number)
- Tank surface level (from survey / contours / DTM)
- Then from this, the deduced: BWL, TWL, Alarm Level

Outlets:

- For each discrete sub-system, the highest point at system transition from pressure to gravity (i.e. modelled system outlet elevation, noting this may be different from the design outlet elevation if there is a downward run to the system discharge point).

Nodes and links:

- Node ID, node elevation
- Link ID, link length, final adopted link internal diameter

7.4.5 Modelled equipment

Collection tanks: Document the assumed collection tank modelled, including tank geometry and off-the-shelf operating levels and corresponding volumes for each storage component (as described in Section 5.1). If more than one type of tank was modelled, provide information for all tanks.

Describe how the collection tank satisfies requirements for emergency storage (as described in Section 5.2).

Pump model: Document the pumps modelled (both primary and alternative), and provide curves in report appendix.

7.4.6 Model results

Results are to be presented for each scenario modelled, along with an interpretive discussion explaining system performance against Hunter Water requirements.

Primarily results shall be presented for the final optimised network arrangement and diameters. Intermediate results, from earlier system iterations shall also to be presented if they aid in justification of the final design.

Tabulated results shall be clearly presented in an Appendix, and a summary discussion of model results presented in the report.

7.4.6.1 *Normal operation – Dry weather (NO-DW)*

Links: Results to demonstrate that pipe minimum velocities as per Section 6.5 are achievable for each pipe link. For pipe links where minimum velocities are not achieved, discuss impact on system performance.

Links: In either tabular or figure form, show the maximum head loss per km for each link in the system. Comment on the distribution of link head loss.

Collection Tanks: Graph tank level over time, and label on graph the BWL, TWL and Alarm Level. Produce this graph for a sample of different tanks in the network to capture system variability. Include a graph for the most disadvantaged collection tank in the network (or multiple tanks if a branched network).

Pumps: Produce a table of pump ID, and the maximum pressure experienced at the pump, add another column to calculate maximum dynamic head (by subtracting static lift for each pump from pump pressure head). The maximum pump pressure is also to be shown on the network layout plan to allow for visual assessment.

Discuss peak pump heads throughout the system, and identify any pumps which experience pump heads greater than 50m.

For pumps which experience heads in excess of 50m at the pump node, produce a graph of pump head versus time.

Outlet Node: If there are multiple pressure sewer catchments, report values requested below for each sub-network.

Produce a graph of system discharge versus time. Comment on the results of this graph, including:

- the highest peak discharge flowrate from the pressure sewer network over the model run
- the average daily peak discharge over the days the model was run

Submit, in excel format, a table of time versus discharge from the system for the duration of the model run. This information may be used by Hunter Water to model pressure sewer discharges into our gravity network models.

7.4.6.2 *Normal operation – Wet weather (NO-WW)*

Report the same information as requested for Dry Weather operation (refer Section 7.4.6.2) with the following changes:

- **Links:** velocity is not required to be reported on.

7.4.6.3 *Abnormal operation – System-wide failure recovery (AO-FR)*

For each system-wide failure recovery scenario, report the same information as requested for Dry Weather operation (refer Section 7.4.6.2) with the following changes:

- **Links:** velocity is not required to be reported on.
- **Collection Tanks:** Produce a table of property ID and the maximum level reached by the tank (as a percentage, where 100% represents overflow), and for tanks

which reach 100%, the total time for which they are at 100% (representing the time they may be overflowing). Provide insightful comment on the results, including the maximum volume of sewage which may theoretically be lost from the system during the recovery time.

- **Collection Tanks:** Report on the % of the system recovered each hr, based on the water level in each collection tank at the end of the hr. Consider tanks with water level at or below TWL to be 'recovered'.
- **Collection Tanks:** Amend individual tank level graphing requirements to only graph tank level over time until the tank recovers.
- **Outlet Node:** Rather than comment on average daily flow, comment on the duration it takes for the system to recover and return to dry weather flow patterns

7.4.6.4 *Sensitivity scenarios (SS)*

For each system-wide sensitivity scenario, report the same information as requested for Dry Weather operation (NO-DW) (refer Section 7.4.6.2) with the following changes:

Alternative Roughness Scenario:

- **Outlet Node:** results are not required.
- **Links:** velocity is not required to be reported on.

7.4.7 Model export

The dynamic model files are to be exported and submitted to Hunter Water. Exported files are to be complete to allow each modelled scenarios reported-on to be re-created. Clearly label all files and provide instructions to facilitate independent model re-build.

8 Static modelling requirements

8.1 Introduction

There are two main steps to undertaking a static analysis design of pressure sewer systems:

- Determining the design flow in each pipe length
- For each segment of the system assess pipe head loss, pump head, pipe velocity, and go through an iterative process of pipe sizing.

8.2 Design flow based on empirical formulas

8.2.1 General

Empirical formulas for estimating design flows in pressure sewer pipes include the 'rational method' and 'instantaneous probability method'.

Some of the local Australian industry's experience with operating modern PSSs is that empirical design formulas typically over-estimate pipe flows, with over-estimates of up to 50%. This is a concern for Hunter Water, as oversized systems tend to have peakier flows (due to shorter run times associated with lower pump heads), longer pipeline detention times (and therefore increased risk of odour and septicity issues), and lower pipe velocities reducing the ability of the pipe to self-clean. For these reasons, Hunter Water requires dynamic modelling (which is known to achieve more reliable estimates) of pressure sewer systems where greater than 15 lots are connected.

8.2.2 Empirical methodology acceptable to Hunter Water

Design flows estimated by empirical formulas are the maximum flow rates occurring once or twice per day. Flow rates in excess of design flows will occur, based on the statistical randomness of simultaneous pump operation (i.e. if pump heads are not a limiting factor, there will be occasions when above average number of pumps operate together). Flow rates beyond design can also occur in wet-weather, and in recovery from widespread system power failure.

The 'rational method' empirical estimation method was developed based on assessment of data from various residential systems in the 1980s in the United States. Peak daily flowrate data versus total number of dwelling units connected was investigated by various parties and curves produced. The United States EPA then fitted a simplified equation to a collection of performance curves (of peak flow versus dwellings connected) from various sources and came up with a straight line formula, which when converted to metric units takes the form below:

$$Q = (AN + B) \times \frac{3.785}{60}$$

Where;

Q = Design flow (L/s)

A = A coefficient selected by the engineer (typically 0.5)

N = number of individual pump units connected, i.e. ET

B = a factor selected by the engineer (typically 20)

There are various limitations associated with using this formula including that water consumption rates on which the formula was originally generated (being from the US and 30 years ago) would be greater than current water consumption in Hunter Water's area of operation.However, for single residential systems with 15 or fewer properties connected Hunter Water will accept the use of the above formula, with adoption of A = 0.5, and B = 20. [Note that this is equivalent to the formula provided in Section 4.4.4.2 of WSA07, and adopting a B factor of 38]. Refer to Appendix 1 for comparison of pipe flow estimated using various empirical formulas.

For pipe flows calculated when using this methodology for 15 properties or fewer, the diameter of the reticulation pipework specified will generally be the minimum pipe diameter of DN50.

8.3 Reporting of empirical modelling

A plan is to be submitted showing the modelled network layout, and the ID of each pipe length. In the report document the empirical formula used to calculate pipe flow, and any other key assumptions.

Submit a table documenting the model set-up, including:

- Pipe ID, pipe length, and final pipe internal diameter adopted.
- Key assumptions in head loss calculations (i.e. roughness value adopted)
- Static lift assumed for each pressure sewer unit (include documentation of tank BWL)
- Invert level of system outlet

Results tables are to be submitted documenting:

- Flow in each pipe length
- Velocity in each pipe length
- Head loss in each pipe length
- Pump head (static and dynamic) for each pump unit

9 Design of downstream gravity infrastructure

9.1 General

The peak flows delivered into a gravity system downstream of pressure sewer discharge point will occur under either the scenarios of: (1) failure recovery from the pressuer sewer network, or (2) wet-weather loading across the entire catchment (inclusive of the pressure sewer subcatchment(s), and gravity subcatchment(s)).

Hunter Water requires the sizing of gravity infrastructure downstream of pressure connections to have capacity for the higher flows generated from these two scenarios. This is required as Hunter Water is not licenced to allow system discharge during dry-weather conditions.

The critical scenario is dependent on the composition of the upstream network (in terms of the number of gravity and pressure sewer connections) and the layout of the network, and therefore needs to be assessed on a system-specific basis.

9.2 Developments with 100% pressure sewer servicing

This section describes the design flows to be adopted for determining the capacity requirements of existing gravity infrastructure downstream of a development that is to be serviced with 100% pressure sewer connection.

9.2.1 Existing pump stations

The capacity requirement of an existing downstream pump station is taken as the worst case (i.e. higher flow) of the following two scenarios:

- Scenario 1: Wet-weather:

  The design flow calculated by adding together the following two components:

  Proposed pressure sewer network: flow from the wet-weather design storm that produces the maximum network discharge (averaged over 15 minutes).

  Existing pump station catchment: the wet-weather design flow from the pump station's existing catchment, plus any other growth in the catchment since design.

- Scenario 2: Failure recovery scenario:

  The design flow calculated by adding together the following two components:

  Proposed pressure sewer network: the maximum peak pump discharge from the pressure sewer network (averaged over 15 minutes) for the failure recovery scenario AO-24DW-FR.

  Existing pump station catchment: the dry weather design flow from the pump station's existing catchment.

9.2.2 Existing gravity pipes

The capacity requirement of existing downstream gravity pipes is taken as the worst case (i.e. higher flow) of the following two scenarios:

- Scenario 1: Wet-weather

  The design flow calculated by adding together the following two components:

  Proposed pressure sewer network: flow from the wet-weather design storm that produces the maximum network discharge (averaged over 15 minutes).

  Existing gravity pipe catchment: the wet-weather design flow for the gravity pipe's existing catchment, plus any other growth in the catchment since design.

- Scenario 2: Failure recovery scenario

  The design flow calculated by adding together the following two components:

  Proposed pressure sewer network: the maximum peak pump discharge from the pressure sewer network (averaged over 15 minutes) for the failure recovery scenario AO-24DW-FR.

  Existing pump station catchment: the dry weather design flow from the pump station's existing catchment.

9.3 Developments with combined gravity sewer / pressure sewer servicing

This section describes the design flows to be adopted for determining the capacity requirements of gravity infrastructure within a proposed development with combined pressure sewer / gravity sewer servicing.

9.3.1 Proposed pump stations

Design the pump stations to have a pump capacity to transfer the worst case (i.e. higher flow) of the following two scenarios:

- Scenario 1: Wet-weather

  The design flow calculated by adding together the following two components:

  Pressure sewer component: produces the maximum peak pump station inflow (averaged over 15 minutes).

  Gravity sewer component: the same wet-weather design flow applying concurrently in the gravity catchment.

- Scenario 2: Failure recovery

The design flow calculated by adding together the following two components:

Pressure sewer component: the maximum peak pump station inflow (averaged over 15 minutes) for the failure recovery scenario AO-24DW-FR.

Gravity sewer component dry weather loading over the proposed gravity network.

9.3.2 Proposed gravity mains

Design gravity pipework for a design flow that it is the worst case (i.e. higher flow) of the following two scenarios:

- Scenario 1: Wet-weather

  The design flow calculated by adding together the following two components:

  Pressure sewer component: flow from the tested storm event that produces the maximum discharge (averaged over 15 minutes).

  Gravity sewer component: the same wet-weather design flow applying concurrently in the gravity catchment.

- Scenario 2: Failure recovery

  The design flow calculated by adding together the following two components:

  Pressure sewer component: the maximum pipe flow (averaged over 15 minutes) for the failure recovery scenario AO-24DW-FR.

  Gravity sewer component dry weather loading over the proposed gravity network.

10 Wastewater age calculation

10.1 General

Wastewater age is to be calculated to inform an analysis of system risk to odour and septicity and any mitigation measures required. Wastewater age calculations are to be calculated based on the scenario 'Normal Operation – Dry Weather' (NO-DW) as described in Section 7.3.2.

Wastewater age calculations are to consider both;

- detention time in the collection tank prior to pumping, and
- travel time in the pipework system.

Both the above components are to be reported separately, and also summed together for calculation of overall age.

The Designer is to report on both the average, and also the range of expected wastewater age from the system. A key limitation of reporting average wastewater age only, is that for systems following standard diurnal residential inflow patterns, age will vary across the day in-line with wastewater consumption patterns. This is particularly the case for small networks, where average age calculations may result in under-estimate of times.

10.2 Calculation methodology

A standard methodology for calculating wastewater age that is accepted by Hunter Water is detailed below. Alternate calculation methodologies may also be adopted, following approval by Hunter Water.

Wastewater age is to be calculated following two different approaches – considering the network 'on a whole', and also the average age from each individual connection.

Wastewater age is to be calculated assuming normal dry-weather collection tank inflows. Wastewater age is to be calculated for the ultimate system, and at key interim stages of development.

Both the results and key input values are to be presented in the Hydraulic Design Report.

10.2.1 Calculation A) Wastewater age from the network on a whole

Total average age of wastewater leaving the network

- $T_D = T_R + T_T$

Time in Reticulation Network

- $T_R = \frac{V_N}{I_N} \times 24$

Time in Collection Tank

- $T_T = \frac{V_T}{I_T} \times 24$

Where:

T_D = total average age of wastewater leaving the system (hrs)

T_R = average time of wastewater in reticulation network (hrs)

T_T = average time of wastewater in collection tank (hrs)

I_N = daily volume of inflow into the network from all connected properties (m^3) or (kL)

I_T = daily volume of inflow into the network from an individual property (m^3) or (kL)

V_N = the total volume in the PSS reticulation network upstream of the outlet, including volume in individual property discharge lines (m^3)

V_T = collection tank control volume (m^3)

Range of ages of wastewater from the network

The Designer is also to report on the typical range of sewage age (in addition to the average).

For this calculation, use the time-series graph of system discharges (as produced from the dynamic model), and work backwards from various starting times 't' to calculate how many hours pass for the volume under the hydrograph to equal the total volume of the PSS network (V_N).

As a minimum pick two starting times; t_1 as a time relating to the end of a low-flow period, and t_2 as a time relating to the end of a high-flow period.

Apply the same methodology to add-on within-tank detention times.

10.2.2 Calculation B) Wastewater age from <u>individual connections</u>

This methodology investigates the average age of wastewater on leaving the system as coming from an individual property. This calculation does not need to be undertaken for every property in a scheme, but rather for a spread of properties throughout the system – ranging from close to far from the system outlet. This methodology looks at the average flow through each pipe length as this would vary from the number of upstream property connections.

- Calculate the volume within each "pipe length" in the system. (A "pipe length" is the lesser of the distance between successive property connections or pipe diameter change.)
- Calculate the average travel time for a slug of wastewater travelling through each pipe length. Calculate this by dividing the volume within the pipe length by the average flow through that pipe. Average pipe flow can be calculated by either:
  - Extracting from the model (include any time of zero or minimal pipe flow), or
  - Calculated by working out the average daily flow through each pipe length (from knowing the number of upstream pressure sewer connections, and the adopted inflow per connection).
- For each property connection, sum the average travel times for each pipe length between the property and the system outlet. This provides, for each property, the average time wastewater has spent in the reticulation network prior to leaving the system.
- Add to this time the average age spent in the collection tank (as per Calculation A methodology).

Average age of wastewater based on the age from individual connections

The average age from the system as a whole can be estimated using the age from individual property connections. This can be calculated by summing the wastewater age estimated for individual properties and dividing by the number of properties assessed. This method assumes equal contribution of flow from each connection, and a representative spread of distances from the outlet, otherwise adopt appropriate weightings. Compare these results to those using Calculation A methodology.

11 Air Movement Assessment

11.1 Theory

Refer to WSA 07 (Appendix A) for a general discussion on air management in pressure sewers. Chapter A3 of WSA 07 is to be replaced with the following text.

Hunter Water requires automatic combination air-release/vacuum break valves to be placed at significant high points including where pumped flows do not purge air from the system daily. For example, gas pockets can form at minor high points and downward sloping closed pipes where the slope increases significantly. Air valves may also be required on downward sloping pipe where a sufficient velocity and duration of flow is not achieved to move the air to the next air valve or upward sloping pipe section.

The potential for gas collection is to be estimated for a system using the Walski et al equation given below (or alternate method if prior project-specific approval is given by Hunter Water).

For pipes with a downhill gradient with respect to the direction of flow:

- when P' is greater than 1.0 gas pockets will tend to move downstream, and

- when P' is less than one 1.0 gas pockets will not be moved downstream.

$$P' = \frac{0.88V^2}{gDS^{0.32}}$$

V = pipe flow velocity (m/s)
g = gravitational acceleration (m/s^2)
D = diameter (m)
S = slope (m/m)*
*Note the Walski equation as produced in WSA 07 has incorrectly report this value in units of %.

Rearranging the Walski equation:

$$v = \left(\frac{P'gDS^{0.32}}{0.88}\right)^{\frac{1}{2}}$$

The minimum pipe velocity for air movement can therefore be determined substituting in P' = 1 as follows:

$$v_{min} = \left(\frac{1gDS^{0.32}}{0.88}\right)^{\frac{1}{2}}$$

Gas movement does not need to be assessed for pipes which run uphill with respect to the direction of flow – as air will naturally move to the higher end of the pipe.

Two key aspects to consider in applying the above equation are the *duration* and *reliability* of achieving the minimum pipe flow velocity to move gases along the pipe.

For a gas pocket to be successfully transported downstream to the next air valve or system outlet, there needs to be continuous duration of flow above the minimum velocity for a time long enough for the air pocket to move beyond any intermediate low points in the pipe.

The flowrate and duration required to move gas pockets through the system must be assessed to occur at least once a day, using system inflows expected during normal dry weather operating conditions.

If a sufficient duration to move the gas along a downward sloping pipe gradient to either an air valve or an upward sloping pipe cannot be reliability achieved on a daily basis, then an air valve will be required.

11.2 Presentation of results

The design Consultant is to undertake an air movement assessment and present their calculations in table form, with one table per pressure sewer branch (cross-referenced to the system plan) and pipe lengths assessed from upstream to downstream. The following table headings are required as minimum:

- Pipe link ID
- Pipe length, L (m)
- Pipe Grade, S (m/m)
- Target Air Release Point (give chainage, or ID cross-referenced to marked-up plan)
- Minimum velocity for air movement for pipe length, v_{min} (m/s)
- Travel time for air to clear pipe length when moving at minimum velocity (seconds/minutes)
- Maximum duration of continuous flow per dry day above minimum velocity (must be reliable – e.g. average over simulation period) (seconds/minutes)
- Sufficient air movement (yes/no)

12 Hydraulic design report

12.1 General

A "Pressure Sewer Hydraulic Design Report" is to be prepared for each pressure sewer scheme and is to document the investigations as required by this hydraulic design guideline. The report is to be written as a stand-alone document.

Two editions of the report are to be issued – as follows:

- Pressure Sewer Preliminary Hydraulic Design Report – submitted with the Servicing Strategy
- Pressure Sewer Detailed Hydraulic Design Report – submitted with the Design Report in the Complex Works Design Phase

The report will be reviewed by Hunter Water. For each submission, the Designer should account for a DRAFT submission and a FINAL submission. Additional DRAFT submissions may be required if the Designer does not adequately address all Hunter Water comments, and/or if additional project information becomes available which necessitates another report revision.

12.2 Example report structure

An example overview of an appropriate set-out for the Pressure Sewer Hydraulic Design Report is provided in Figure 2 below.

The Designer is also to include any other information that is relevant to the hydraulic design of the pressure sewer network within this report.

The structure of both the preliminary and detailed hydraulic design report is to be consistent. The content in the detailed hydraulic design report is to build-on and be an update of the content in the initial hydraulic design report. Where a report section heading is not relevant for the 'Preliminary Investigation Submission' it is still to be included as a heading, with a comment noting content to be provided in the 'Detailed Investigation submission'.

Figure 2: Example structure for a Pressure Sewer Hydraulic Design Report

Introduction
Background
Reference to Hunter Water approval to investigate pressure sewer
Description of Development
Site topography
Number of dwellings and type of dwellings
Development staging
Nearby development and any intent to accommodate within scheme
Lot Drainage Envelope Assessment
Collection Tank Loading
Collection Tank Storage Requirements
Network Arrangement
Network Outlet
Baseline Pipework Layout (including any key constraints in developing the layout, e.g. other services,)
Network Modelling
- **Modelling software**
- **Model Set-up**
- **Modelled Equipment**
- **Model Results**
  - **Ultimate**
    - **Normal Operating Scenarios**
    - **Abnormal Operation Scenarios**
    - **Sensitivity Scenarios**
  - **Interim Stage 'X' (Report for interim stages 1, 2, 3…etc. as required)**
    - **Normal Operating Scenarios**
    - **Abnormal Operation Scenarios**
    - **Sensitivity Scenarios**
- **Revised network layout and pipe sizing**

Wastewater Age Assessment
Air Movement Assessment
Final Network Layout
As adopted based on combined results from the network modelling, air movement assessment, wastewater age assessed, and drainage envelope assessment.
Description of valve locations (air valves, flushing points, stop valves).
Conclusions
Appendices
Figures / plans
- **Subdivision Plan with Contours**
- **Network layout options**
- **Final network layout**

Model Set-up Data
Model results
- **Figures**
- **Tables**

Calculation details
- **Drainage Envelope Assessment**
- **Wastewater Age Calculation**
- **Air Movement Assessment**

12.3 Additional reporting detail

12.3.1 General

In addition to reporting on the hydraulic investigations described in this guideline, the Pressure Sewer Hydraulic Design Guideline is to include detail on the following.

12.3.2 Subdivision plan with contours

The Designer is to include with the report submission a plan of the proposed sub-division identifying the individual property boundaries and proposed access roads. This plan is also to identify any staged-release of different parts of the subdivision.

Show the assumed location of the collection tanks, together with an overlay of contours of the proposed finished surface levels of the subdivision (minimum contour interval of 1m, and show contours with elevations labelled).

The Designer is to document the source of their terrain elevation data.

12.3.3 Revised network layout and sizing

For the final optimised network layout, describe the general philosophy for sewer alignment, and discuss any special features/considerations for the particular system layout. Include documentation of any significant crossing, constrained sections of the alignment, or other special features of the system.

Document the total length of each dia. pipe. Pipe diameter is to be reported as both internal diameter and the corresponding nominal diameter for the pipe material/pressure class adopted. Distinguish between street reticulation pipework versus on-property pipework (i.e. pipework from the collection chamber to the network).

A network model figure is to be presented identifying the pipe diameter proposed to be adopted for the system as a result of the modelling analysis. A table of link ID, and final pipe diameter is also to be reported.

12.3.4 Network construction sequencing

Describe the sequencing of the delivery of the proposed network.

Discuss any interim network operational requirements.

13 Document Control

TRIM: HW2007-2177/55/10.006

Document owner	Mandatory reviewers	Document approver
Manager Investment & Asset Planning	**Asset Standards & Strategy Engineer**	**Chief Investment Officer**

Document version history

Version	Name of author	Summary of changes	Approval date	Approved by	Periodic review
1.0	**S Groves**	**Initial Release**	**01/03/2018**	**D. Cleary**	**2 years**
2.0	**S Groves**	**Initial Release**	**13/06/2018**	**S Horvath**	**2 years**

Appendix 1 – Comparison of pipe flow and hydraulic design methods

Most single residential pressure sewer pumps on the market discharge flow in the range of 0.5L/s to 0.75L/s dependent on pump head. Based on a standard tank inflow rate of 450 L/ET/day, and adopting an average pump rate of 0.6L/s and a control volume of 150L, a single pump unit would typically operate for 4 minutes per cycle, and for a total of 12 minutes per day across 3 cycles. Removing say 12hrs of the day when there is very low potential for wastewater generation (e.g. night sleep time, middle of the day when at work), this leaves 12hrs when inflow is likely to trigger a pump cycle. Over the 12hrs, the probability of a single pump unit running is therefore 12min out of 12x60min which is 1.6%. As such, for systems with 15 pumps or less, the probability of more than one pump running reliably at the same time as another pump, and over the full pump cycle at not just an edge overlap, is relatively low.

Error! Reference source not found. shows the pipe flow estimated for systems with 0-15 pressure sewer units using three common empirical formulas. The rational method as recommended by Hunter Water produces flowrates of 0.6 to 1.2L/s for system with 1 to 15 pump units. This is the equivalent of 1 or 2 pumps operating simultaneously. The E-One probability method and the WSA rational method (where a B value of 76 is adopted), are considered to be less probable producing flow results requiring 2-4 pumps to reliably coincide in their daily operation (when looking at 2-15 pumps). For these reasons, use of these two formulas for design is not endorsed by Hunter Water.

Figure 3: Comparison of pipe flow estimated using various empirical formulas