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Adaptive Wastewater Solutions for Small Towns - Penshurst: Functional Design Report

Version 4

30/04/2021

Document Control Sheet

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Revision / Checking History

Revision History	Date	Checked By		Issued By	
0	26 June 2020	JS		BAA	
1	23 December 2020	JS		BAA	
2	12 March 2021	JS		BAA	
3	30 April 2021	DH	D. Hourihan	BAA	

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The outcomes and recommendations contained in this report may have relied upon a range of information and data sources including information and discussions with the client, field investigations (limited to those described in this report), publicly available information and other sources. DWC have not verified the accuracy of third party data and any inaccuracies or inadequacies may influence the accuracy of our findings. Similarly, both the inherent variability of environmental and ground conditions and the passage of time can lead to changes in ground conditions and other factors which may affect the accuracy of our findings. The Client should seek advice from DWC on the accuracy of findings after more than six months has passed or where changes in relevant conditions are known to have occurred. Data and information collected during field investigations should not be taken as accurate and complete for all depths and locations across the site.

The report and services have been completed in accordance with relevant industry standards, guidelines and government legislation as of the date of publication unless stated otherwise. Where an engineering design is included, this design has been based on site and construction plans as provided by the Client and/or their representative and documented in the report. DWC accepts no liability for the impact of any changes to site conditions and / or building layout and extents on our design where DWC were not notified of the changes prior to completing our services. Additional costs may be incurred where work has already been completed.

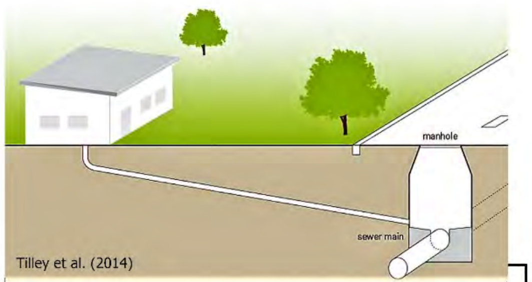
EXECUTIVE SUMMARY

Decentralised Water Consulting (DWC) have been working with Wannon Water (WW) and Southern Grampians Shire Council (SGSC) to investigate and design an option to improve wastewater management for the township of Penshurst. Wastewater is currently managed by individual owner managed on-site wastewater management systems (on-site systems) in Penshurst with approval and performance regulated by SGSC. On-site systems within these townships are of varying age, capacity and condition and previous feedback from Councils indicates the performance of these systems varies considerably.

This report contains a Functional Design for a Wastewater Management and Water Recycling Solution for Penshurst township. The Penshurst Water Recycling Solution was identified as the preferred option through technical and cost benefit analysis during the options assessment phase of the Adaptive Wastewater Solutions for Small Towns project. Reference can be made to the Options Analysis Report (2020) previously prepared by DWC for background information on the project and options assessment process.

Figure E1 below provides a summary and visual outline of the Penshurst Wastewater Management and Water Recycling Solution, including cost estimates (total community costs). A detailed breakdown of cost estimations for both capital and operational expenditure is provided in this report. In addition, Figure E2 provides an overview of the Penshurst Solution and the various proposed precinct based systems.

Adaptive, Precinct-Based Wastewater Solution for Penshurst



All wastewater from properties within Penshurst township with be collected and transported by a new Gravity Sewer system. This will include all greywater and blackwater.

Existing onsite (septic) systems will be decommissioned once connected to the sewer.

Treatment of wastewater will occur at local Precinct Water Recycling Systems (e.g. Rhizopods).

These natural based systems allow water to be taken up by plants or evaporated (like in a wetland).
They can also allow water to be stored within the treatment pods during colder, wetter periods.

Recycled water to be stored for Irrigation when conditions are favourable e.g. drier weather.

The storage has been sized for each Precinct to make sure overflow discharge is not necessary during colder, wetter periods.

Where there is excess recycled water, this can also be used to irrigate other community areas such as the playing field.

This will be done on an as-needs basis depending on how much water is available.

Recycled water to be used to green Public Open Space via Irrigation below the ground.

This will happen at night, underground to minimise any potential contact with the recycled water.

<u>Why has this system been proposed and what are the benefits?</u>

- This system applies proven small scale natural based technologies to treat and manage recycled water locally within the town.

- Penshurst is well suited to a Precinct based solution due to topography and the cost and complexity of conveying sewage to a single location. Importantly a large, costly treatment facility will not be required.

- Using Local Precinct Treatment Systems will provide Recycled Water for greening areas across the town while significantly minimising the costs needed to collect and treat it.

- The systems have be designed to be modular and can be built to service each Precinct as needed, both currently and into the future.

- The Recycled Water System has been designed factoring in the various constraints across the town such as shallow rock and groundwater usage.

- The Recycled Water System will drastically reduce the current nutrient loads entering the Penshurst Wetlands and nearby waterways, thereby improving the local ecology.

<u>Total Community Cost Estimates</u> (25yrs)

CAPEX: $13.53 - $15.74 million

OPEX: $186,900 per year

Renewal: $754,000

Life Cycle Cost (NPV) $15.56 - $17.68 million

Figure E1: Penhurst Wastewater Solution Summary

Figure E2: Penshurst Recycled Water Scheme Overview

Legend

Public Open Space Subsurface Irrigation
Precinct Recycling Systems
Potential Land Treatment Facility for Excess Recycled Water
Property Boundaries
Precinct Boundaries
Pump Station (Septic Tank Effluent Pump - STEP)
Sewer Alignment
Elevation Contours (approx. 0.5m)

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ABBREVIATIONS

Abbreviation	Description
WW	Wannon Water
SGSC	Southern Grampians Shire Council
PCG	Project Control Group
DWMP	Domestic Wastewater Management Plan
BaU	Business as Usual
SEPP (Waters)	State Environment Protection Policy (Waters)
CBA	Cost Benefit Analysis
EPA	Environmental Protection Authority Victoria
CoP	EPA Code of Practice (2016)
WSAA	Water Services Association of Australia
WSA 02—2014–3.1	Gravity Sewerage Design Code (2014)
PRS	Precinct Recycling Systems
POS	Public Open Space
ET pods	Evapotranspiration treatment pods (e.g. Rhizopods™)
LTS	Land Treatment System
STEP	Septic Tank Effluent Pump system
HEMP	Health and Environmental Management Plan
LCA	Land Capability Assessment (site and soil assessment)
MEDLI	Model for Effluent Disposal Using Land Irrigation
ANZECC	Australian and New Zealand Environment and Conservation Council
On-site system / septic system	On-site wastewater management system (treatment and effluent land application)

1 Introduction

Decentralised Water Consulting (DWC) have been working with Wannon Water (WW) and Southern Grampians Shire Council (SGSC) to investigate and design an option to improve wastewater management for the township of Penshurst. Wastewater is currently managed by individual owner managed on-site wastewater management systems (on-site systems) in Penshurst with approval and performance regulated by SGSC. On-site systems within these townships are of varying age, capacity and condition and previous feedback from Councils indicates the performance of these systems varies considerably.

This report contains a Functional Design for a Wastewater Management and Water Recycling Solution for Penshurst township. The Penshurst Water Recycling Solution was identified as the preferred option through technical and cost benefit analysis during the options assessment phase of the Adaptive Wastewater Solutions for Small Towns project. Reference can be made to the Options Analysis Report previously prepared by DWC for background information on the project and options assessment process.

A summary of the Penshurst Water Recycling Solution is provided below. Reference can also be made to Figures E1 and E2 in the Executive Summary for a visual outline summarising the overall solution.

Precinct Based Water Recycling Solution

- Cluster (precinct / block scale) approach given the topography and nature of development across Penshurst township. Involves simple, low maintenance treatment and local water reuse for greening of town.
- Construction of local gravity sewers to direct raw sewage from 270 existing properties within the Penshurst Service Area (Township Zone) to twelve (12) local, Precinct water recycling systems.
- On-property tanks are not required for 90% of properties and existing onsite (septic) wastewater systems are to be decommissioned for properties connected to the sewer system.
- Treatment and plant water uptake within recirculating, lined, planted Evapo-transpiration pods (Rhizopod™ or similar) with winter storage for reuse.
- Recycled water will be stored and used for restricted access Public Open Space (POS) subsurface irrigation in warmer months.
- Excess wastewater from properties in some Precincts will not be able to be recycled in the long-term and therefore will require additional local irrigation areas nearby. These additional irrigation systems will be established in designated reuse areas immediately outside of the Township Zone.
- A small number of larger properties (12 lots) have the capacity to contain all wastewater onsite with an upgraded on-site wastewater system. Therefore these systems will be upgraded and managed as part of the Penshurst Water Recycling Solution.

2 Background and Strategic Context

Wannon Water and SGSC form the core Project Control Group for this study working in conjunction with the Great South Coast IWM Forum and DELWP. SGSC has recently revised their Domestic Wastewater Management Plan (DWMP). As part of this DWMP, key high priority towns have been identified based on a number of factors including constraints / risks for onsite systems and potential future growth pressures. The PCG do not want inadequate wastewater management practices to impede the growth and liveability of these towns.

The PGC have confirmed that there is a need and community desire for improved wastewater management in Penshurst.   Based on technical assessments and community engagement undertaken as part of this project it has been clearly identified that continuation of the Business as Usual (BaU) wastewater management approach cannot meet long-term regulatory or community expectations. In particular, based on the best available data, the cost to Council and the community for the BaU approach is estimated to be in the order of approximately $7 Million (25yr NPV). Importantly this current wastewater management approach cost for Penshurst does not enable compliance for the majority of onsite systems, thereby ensuring adequate environment and human health protection.

Consequently, this project is critical to identify alternative, safe and sustainable long-term wastewater management strategies for small towns such as Penshurst. The wastewater solution functional design has been developed with consideration of key strategic objectives including;

- IWM Forum and Victorian Government objectives for greater consideration of alternative and adaptive water / wastewater management solutions.
- SEPP (Waters) and Council's DWMP require the consideration of solutions, including alternative risk management or mitigation strategies, for high priority towns such as Penshurst to maintain environmental and health protection.
- Wannon Water's statement of obligations and objectives under SEPP (Waters) outline the need to investigate potential solutions in conjunction with Councils for high risk towns.

2.1 Summary of Project Investigations

The project is being undertaken in four key phases with a summary of each of these provided in Figure 1 below for context.

The Background Paper prepared previously summarised the initial outcomes of the first phase of the project which is focused on evaluating the current wastewater management situation in Penshurst and the regulatory context for pursuing options for these towns, beyond the traditional approaches of sewerage.

An Options Analysis Report was subsequently prepared by DWC in early 2020 and included;

- consultation with the PCG and communities to obtain feedback and information to feed into the options shortlisting process;
- shortlisting of a number of key option packages for both towns in consultation with the PCG and incorporating community feedback;
- undertaking an assessment of these option packages based on an initial Cost Benefit Analysis (CBA) which incorporates liveability benefits, potential water savings (e.g. via irrigation), improvements to environmental impacts and potential health risks;
- outlining a preferred option package based on the options analysis outcomes; and
- outlining key principles associated with a governance and funding model for the preferred option.

From this, the PCG have undertaken internal engagement and elected to proceed with the recommended Wastewater Solution outlined in the Options Report for the functional design phase.

In addition, refinement of the CBA, application of the DELWP Cost Allocation Framework and further development of a governance and funding model have been undertaken concurrently with the functional design. The outcomes of this analysis are included as part of the Final Project Report.

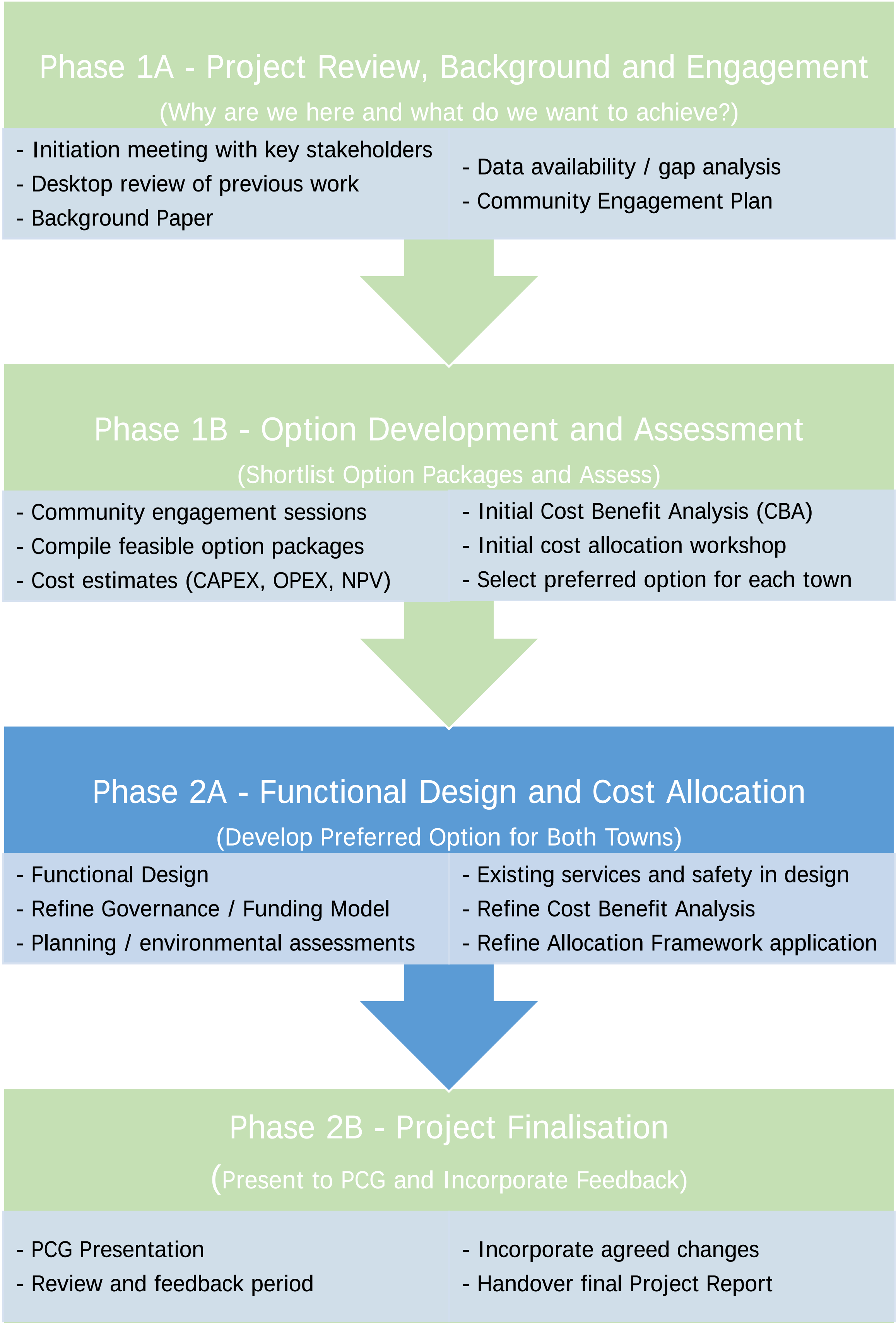

Figure 1 Structure of the Small Town Wastewater Investigation

3 Functional Objectives

This Functional Design outlines the functional requirements for the Penshurst Water Recycling Solution. The intention of this solution is to provide new wastewater management services to the existing Township Zone of Penshurst. The following functional objectives have been identified.

- Capacity to service all existing Township properties unable to contain wastewater on-site. Provision to expand the system to cater for an agreed level of growth within the Township Zone consistent with current strategic land use planning advice from Southern Grampians Shire Council.
- Meet the performance objectives of State Environment Planning Policy (SEPP - Waters) with respect to effluent management and the protection of surface and groundwater.
- Recycled water systems designed in accordance with *Use of Reclaimed Water Guidelines* EPA Victoria (2003) and *Australian Guidelines for Water Recycling* (EPHC, 2006).
- New sewers designed so that no surcharge occurs.
- Comply with Wannon Water sewer design requirements as per Water Services Association of Australia (WSAA) Gravity Sewerage Design Code (2014-3.1).
- Design for life span as per WSAA requirements.

3.1 Location and Service Area

The Penshurst Service Area has been defined based on the Township Zone (TZ) as defined by the Southern Grampians Planning Scheme. Within the Township Zone a lot may be used for a dwelling provided each dwelling is connected to reticulated sewerage or it can be demonstrated that all wastewater can be treated and retained within the lot in accordance with State Environment Protection Policy (SEPP – Waters).

The majority of lots within the TZ are 1,000 - 2,000m^2 and connection to the reticulated sewerage will be provided as part of this wastewater solution. In addition, a small number of lots outside of the TZ to the west have been included due to constraints to containing wastewater on-site. The Penshurst Primary School and Recreation Reserve (playing field) have also been included, however the Country Fire Authority (CFA) Training Facility has not given it is currently serviced by a standalone onsite system.

Table 1 Summary of Penshurst Service Area

	Details
Township	Penshurst
Total No. of Properties	280 - existing lots based on property cadastre (not parcels) within Penshurst Township boundary. Vacant lots (which currently cannot be developed) have been included as part of growth allowance (Upper Horizon Design).
Township Zone Area	143ha (approx.)
Land Use Zoning	Township Zone (TZ) – Main Township Public Park and Recreation Zone (PPRZ) – Penshurst Gardens and Caravan Park; Penshurst Recreation Reserve Farming Zone (FZ) – Surrounding Rural Properties (outside Service Area)
Planning Overlay	Sections of town within Heritage Overlay.
10th% lot size	620 m^2
Median lot size	1,510 m^2
95th% lot size	4,330 m^2
Council Area	Southern Grampians Shire Council
Climate	Average annual rainfall (722mm) and evapotranspiration (1,035mm) with cold winter weather.

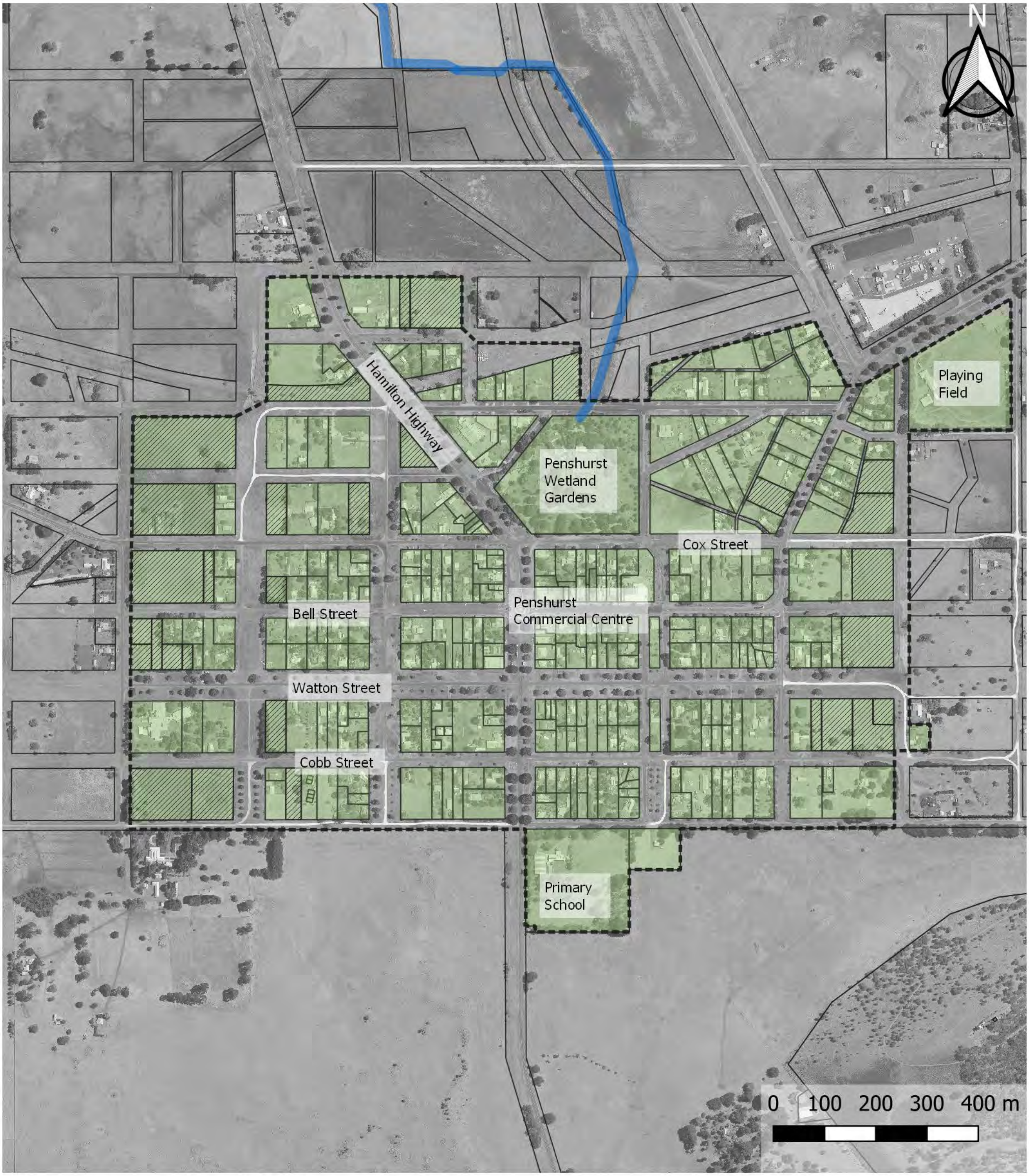

Figure 2: Penshurst Water Recycling Scheme - Servicing Layout

Legend

- Property Boundary
- Intermittent Watercourse
- Service Area
- Service Area Properties (Current Properties)
- Vacant Lots (Potential Future Growth Properties)

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4 Functional Requirements

4.1 Operational Philosophy

The proposed wastewater management solution for Penshurst involves installation of Precinct Recycling Systems (PRS) within the township for water reuse across local Public Open Space (POS).

Precincts have been delineated based on logical drainage catchments for the sewer reticulation in addition ensuring opportunities to enhance POS within the town can be cost effectively captured. Wastewater will be collected, treated and reused close to its source utilising relatively passive, vegetation based processes to ensure risks to human health and the environment are adequately managed.

All raw wastewater from properties within the Service Area (refer Section 3.1) is to drain to local precinct / cluster treatment and reuse systems via new reticulated gravity sewers. The focus of this solution is on local treatment and reuse in the most cost effective and sustainable configurations whilst achieving EPA requirements. Wastewater generated from properties within specific precincts have been grouped and directed based on topography and depths to achieve necessary drainage fall and cover. Refer to Section 4.5 for further details of these PRS and POS irrigation areas.

One advantage of this approach is that each PRS can adapt to the likely variability in future development within Penshurst. Similarly, construction of each PRS can occur at a rate or staging that suits available capital, willingness to connect and demand for service. A high level of automation, remote monitoring and control is proposed to enable efficient operation, monitoring and maintenance of distributed infrastructure. The modular nature of a number of PRS components also means operational issues can be isolated without necessarily needing the whole PRS to be shut down.

The overall Recycled Water Solution for Penshurst is summarised in Table 2 and Figure 3 below.

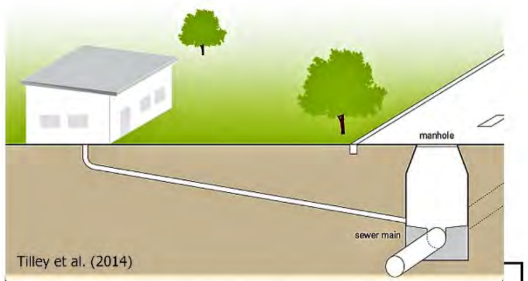
Table 2 Summary of Penshurst Recycled Water Solution

Component	Description
On-property	Decommission existing on-site wastewater (septic) systems for properties identified within the Service Area (~270 lots). Discharge of all wastewater to new gravity sewer. Approximately 18 properties will require a Grinder Pump or Septic Tank Effluent Pump (STEP) system to lift sewage into gravity sewers. Upgrade onsite wastewater systems to achieve full on-site containment on 12 lots – secondary treatment system with subsurface irrigation or evapotranspiration absorption (ETA) trenches to meet regulatory (EPA CoP) requirements. These properties are large enough to continue to rely on an on-site wastewater management system that meets EPA CoP requirements. As Penshurst grows, some of these properties will eventually have the opportunity to connect to a PRS. Grinder/STEP units and onsite systems to be managed by single competent and accountable authority (upgrade works and operation).
Collection	Twelve (12) gravity sewers collecting all wastewater from properties within Service Area. Conveyance to twelve (12) local cluster treatment / reuse systems. Three (3) small STEP (i.e. package) pump stations will be required to enable a small number of properties to be connected due to topographical constraints and cost considerations. Sewage will be transferred from these STEP pump stations via pressure sewer.
Treatment	Treat sewage utilising vegetated evapotranspiration treatment (e.g. Rhizopod™) systems at nominated reserves / public open spaces for restricted access subsurface irrigation reuse (greening of public open space – total 19.25 hectares based on future growth) at sustainable rates. Winter storage and enhanced evapo-transpiration of Rhizopod™ enables discharge to the environment to be prevented. Class C treatment (minimum) to be achieved as per EPA Guidelines (2003). Additional irrigation reuse sites are to be constructed adjacent to the main Township Zone to manage excess recycled water from Precinct 3,4 and 5 during winter periods (Land Treatment System). Precinct Recycling Systems (PRS) will feature remote monitoring and control to enable a high level of control without the need for on-site operators. Significant potential for smart control via automation and machine learning.
Water Reuse	Establish local precinct reuse (irrigation) for greening and planting of road reserves and other public open space at feasible locations. Subsurface irrigation with restricted access and overnight irrigation to minimise public exposure and risk. As risk based approach to managing excess recycled water has been developed that involves the irrigation of incremental depths of recycled water above plant water requirements for ~2-4 months of the year (typically July-October). This strategy has been modelled on a daily timestep for 60 years of climate data to confirm suitability. Nutrient and pathogen attenuation modelling has also been completed to confirm a high level of health and environmental protection.
Long-term growth	Capacity for town renewal / growth to better match long-term community and Council expectations. Precinct systems based on existing dwellings increasing to four-bedroom dwellings on existing lots in the long-term. Capacity to service development of all existing vacant land parcels within the Township land use zone. Growth allowance details provided in Section 4.2.

Table 3 Summary of Water Reuse (Irrigation) Strategy

Element	Description
End Use	Subsurface irrigation of local public open space with restricted access via overnight irrigation and subsurface irrigation system.
Irrigation Method	Pressure compensating subsurface drip irrigation in pressurised, automated zones with total size of 12.7ha (Ultimate size of 19.25ha including future growth). Irrigation pipes will be 200mm below ground and automatically / remotely monitored for breaks and leaks.
Irrigation Schedule	Beneficial Reuse (Deficit) schedule (typically Nov -June) Irrigation trigger: 5mm soil water deficit Irrigation depth (max): 2mm Rainfall shut off: >5mm Controlled by on-site weather station and soil water monitoring. Partial Beneficial Reuse (Land Treatment) schedule (Typically July-October) **Only when recycled water storage tank is full (approx. 100 days/yr):** Land application loading rate (max): 2mm per day Land application loading rate (average): ~1mm per day
Recycled water storage	Total 12ML storage tank volume (22ML Ultimate) across the Service Area to provide recycled water storage for each Precinct as necessary.
Loading Rates	245 mm/year irrigation depth (equates to average of 0.7mm/day). 220 mm/year is beneficial reuse (plant water demand) 25 mm/year is land treatment of excess recycled water Nitrogen Loading Rate: 100 kg/ha/year Phosphorus Loading Rate: 30 kg/ha/year

Adaptive, Precinct-Based Wastewater Solution for Penshurst



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Total Community Cost Estimates (25yrs)

CAPEX: $13.53 - $15.74 million

OPEX: $186,900 per year

Renewal: $754,000

Life Cycle Cost (NPV) $15.56 - $17.68 million

4.2 Design Flow Estimation

Reference can be made to Section 5.4 for details of the hydraulic design, design flow allowances (as per WSAA Sewerage Code) and pipe sizing. In addition, as per Crites and Tchobanoglous (1998) a daily peaking factor of 3 based on a small community system (Table 4-20) has been utilised for calculation of Peak Dry Weather Flow (PDWF) over the entire day (i.e. not instantaneous peak flow). This is to guide the design of treatment infrastructure.

For properties connected to the reticulated sewer the design discharge volume from each dwelling was developed based on the design criteria summarised in the table below

Table 4 Design Flow Summary

Element	Value	Reference
Average Dry Weather Flow (ADWF)	3.5 EP per lot @ 150 L/EP/day x no. of lots per Precinct (Current and Horizon)	WSA 02—2014–3.1 – Appendix C (2016 average occupancy in Penshurst is 2.3 persons)
Peak Dry Weather Flow (PDWF)	ADWF x d	
Peak Wet Weather Flow (PWWF)	PDWF + GWI + RDI	
Peaking factor (d)	Calculated from development catchment area (hectares) 3 (small community)	WSA 02—2014–3.1 – Appendix C Crites and Tchobanoglous (1998)
$\text{Portion}_{\text{Wet}}$	0.35	WSA 02—2014–3.1 – Appendix C
Leakage Severity Coefficient (C)	0.6	WSA 02—2014–3.1 – Table C1
$\text{Factor}_{\text{Containment}}$	1	WSA 02—2014–3.1 – Table C3
$I_{1,2}$	17.4	Bureau of Meteorology (BOM) – IFD Table

GWI = Groundwater Infiltration; RDI = peak rainfall dependent inflow and infiltration

4.2.1 Growth Allowance

A key design flow parameter for the Recycled Water Solution included establishing an acceptable Upper Design (Horizon) for assumed potential growth across Penshurst, including new dwellings on vacant land parcels and increased commercial patronage. Penshurst does not currently have a Structure Plan which could be used as a reference. SGSC did however prepare a draft Concept Plan based on initial analysis undertaken by strategic land use planning staff which identified key areas expected to experience growth within the future and estimated new dwelling numbers in these areas (refer to Appendix F).

It was identified during this Functional Design that there remains a significant number of vacant land parcels within the Township Zone area of Penshurst not nominated by SGSC as part of potential growth. These parcels have been included in the Horizon design on the basis that most will have a sewer connection available (or relatively close by) and at this stage are developable under the Planning Scheme.

This analysis identified 203 potential future residential connection (vacant parcels) lots within the Service Area.

DWC undertook analysis of the relative difference between existing properties and allotments (parcels) within each of the identified precincts within the township. SGSC have consistent issues in Penshurst with planning and building permit applications for allotments which are too small to sustainably contain all wastewater within the allotment boundaries. Therefore the number of allotments to be connected have used a conservative estimation of a suitable upper design horizon (i.e. ~75% increase to existing developed lots).

The precinct based approach adopted for this solution will enable expansion of capacity to be flexible and adapt to actual development rates and locations over time.

4.2.2 Design Flow Summary

Table 5 below provides a summary of the flow allowances and assumed number of lot connections for each Precinct Recycled Water system (current and horizon design flows).

Table 5 Design (Current) Wastewater Volumes Summary

Precinct ID	Current No. of Dwellings	ADWF (L/s)	ADWF (kL/day)	PDWF (L/s)	PDWF (kL/day)[1]	PWWF (L/s)
1	25	0.15	13.13	0.66	39.38	1.76
2	28	0.17	14.7	0.92	44.1	1.81
3	39	0.24	20.48	1.36	61.43	2.37
4	25	0.15	13.13	0.87	39.38	1.65
5	32	0.19	16.8	0.89	50.4	2.05
6	35	0.21	18.38	1.25	55.13	2.18
7	49	0.30	25.73	1.56	77.18	2.83
8	13	0.08	6.83	0.40	20.48	1.04
9[2]	-	-	-	-	-	-
10	14	0.09	7.35	0.51	22.05	1.05
11	11	0.07	5.78	0.41	17.33	0.86
12[2]	-	-	-	-	-	-
Total	**271**		**142**		**427**	

Note 1: peaking factor of 3 for small community (Crites and Tchobanoglous, 1998).

Note 2: Precinct 9 and 12 do not need to be developed initially as they are required to service future development of vacant land parcels only.

Table 6 Horizon (Future) Wastewater Volumes Summary

Precinct ID	Future No. of Connections	ADWF (L/s)	ADWF (kL/day)	PDWF (L/s)	PDWF (kL/day)[1]	PWWF (L/s)
1	38	0.23	20	1.01	59.85	2.37
2	36	0.22	18.9	1.19	56.70	2.21
3	54	0.33	28.35	1.89	85.05	3.12
4	41	0.25	21.53	1.42	64.58	2.47
5	60	0.36	31.5	1.67	94.5	3.32
6	46	0.28	24.15	1.64	72.45	2.74
7	67	0.41	35.18	2.13	105.53	3.66
8	37	0.23	19.43	1.13	58.28	2.26
9	40	0.24	21	1.43	63	2.43
10	17	0.103	8.93	0.62	26.78	1.22
11	16	0.097	8.4	0.60	25.2	1.16
12	22	0.13	11.55	0.70	34.65	1.51
Total	**474**		**249**		**747**	

Note 1: peaking factor of 3 for small community (Crites and Tchobanoglous, 1998).

4.3 Effluent / Recycled Water Quality Requirements

The Precinct Water Recycling Systems (treatment systems) are to produce Class C Recycled Water (as a minimum) as documented in EPA Victoria Publication 464.2 *Reclaimed Water Guidelines* (2003). This will allow irrigation of public opens space with restricted access through both overnight irrigation scheduling and use of subsurface irrigation as per the EPA Guidelines and Australian Guidelines for Water Recycling.

Table 7 Effluent Quality Criteria

Parameter	Design Value	Min. Target Requirement
Biochemical Oxygen Demand (BOD_5)	<20 mg/L	90th Percentile
Total Suspended Solids (TSS)	<30 mg/L	90th Percentile
E. coli	<100 orgs/100mL	Median
pH	6-9	90th Percentile

4.3.1 Monitoring Requirements

The proposed effluent quality monitoring regime will be as per Table 5 of EPA Reclaimed Water Guidelines, specifically for 'Municipal with controlled public access' (Class C) which consists of:

- Monthly effluent quality sampling for the above treatment parameters.

A Health and Environmental Management Plan (HEMP) will be required for this system. It is likely a single HEMP would be prepared that addresses the requirement of all twelve PRS. In addition to the standard recycled water quality monitoring requirements, the following list of activities are likely to form part of the HEMP.

- Periodic inspection of reuse (irrigation) areas to check for operational issues
- Annual soil sampling and analysis for nutrient, salinity, sodicity and other parameters
- Annual nutrient balance reporting (including grab sample of grass nutrient content)
- Recording of irrigated volumes and any operational issues and events of importance
- Recycled Water Management Plan monitoring and reporting activities.

In addition, the following monitoring activities are recommended. The purpose of these additional monitoring activities will be to validate the (slightly) non-conventional irrigation approach and provide data for real-time / automated control and decision making on recycled water management.

- Inflows and outflows from PRS pods to enable validation of the water balance (specifically Evapo-transpiration rates).
- Weather station to inform irrigation scheduling and validate water balance.
- Soil moisture probes (for irrigation areas in 2-3 differing landscape positions) across the service area to inform irrigation scheduling and monitor soil water performance.
- Lysimeters within and immediately downslope of 2-3 irrigation areas (for water quality sampling for effluent drained through the root zone of the irrigation areas).

A formal monitoring program will be required as part of implementation of the Penshurst Wastewater Solution.

4.4 Reticulated Sewerage

Sewer pipe sizings and grades have been developed based on the WSAA Gravity Sewerage Code (Version 2) – Sections 3 and 5. Functional design drawings for the main sewer alignments, including elevation longitudinal sections are provided in Appendix C. Sewer grades ranged from approximately 0.6% to 4.73%, with a small section graded at 6% in the Precinct 7 alignment.

Key sewer sizings are summarised in Table 8 below.

Table 8 Sewer Sizing

Sewer	Sizing
Sanitary drainage (from all dwellings to connection point)	DN100
Gravity reticulated sewerage (to precinct systems)	DN150

Analysis was undertaken to determine an appropriate sewer installation method for each Precinct based on the estimated rock depth (discussed in Section 5.2). Based on available soil depth information ~500mm has been assumed for the average soil depth to the limiting layer (either bedrock or large rock boulders). Based on the sewer alignments the preferred installation method was determined which included either trenching (at a range of excavation depths) or microtunnelling through rock. Microtunnelling would be limited to locations where trench excavation was not an option such as alignments near existing on-property development.

A summary of the estimated sewer lengths for each of these installation methods is presented below in Table 9.

Table 9 Sewer Installation Summary (Trenching and Drilling)

Sewer Installation Method	Approx. Length
Microtunneling (through rock)	1,730m
Trenching (<1.5m depth)	4,570m
Trenching (1.5-2.5m depth)	2,890m
Trenching (2.5-3.5m depth)	450m

In addition a summary of total sewer lengths for each Precinct (for both the current and future designs) is provided in Table 10. This includes the current estimated number of sewer maintenance chambers in addition to the STEP lift stations required to transfer sewage from a small number of locations up into the gravity sewer. Details of easements which will need to be established as part of the proposed sewer alignments are provided in Appendix C.

Table 10 Sewer Alignment Summary

Precinct ID	Total Sewer Length – Current ADWF (m)	% of Sewer through Public Land	% of Sewer through Private Land	No. of Maintenance Chambers	No. of STEP Sewer Lift Stations	*Additional* Sewer Length – Horizon ADWF (m)	Total Sewer Length – Ultimate (m)
1	760	70%	30%	8	-	240	1,000
2	930	71%	29%	14	-	110	1,040
3	1,300	68%	32%	9	-	90	1,390
4	970	71%	29%	7	-	200	1,170
5	850	36%	64%	15	2	230	1,080
6	1,450	91%	9%	12	-	130	1,580
7	1,990	69%	31%	30	-	40	2,030
8	710	77%	23%	20	-	400	1,110
9	-	100%	-	-	-	1,500	1,500
10	410	100%	-	18	1	60	470
11	330	81%	19%	12	-	0	330
12	-	100%	-	-	-	0	0
Total	**9.64 km**	**-**	**-**	**145**	**3**	**3 km**	**12.7 km**

4.5 Precinct Water Recycling System

4.5.1 Evapotranspiration Treatment System

Raw sewage from each precinct will drain via a new gravity sewer to each respective treatment system which consists of;

- Primary treatment (anaerobic digestion and solids settling) via large, watertight septic tanks;
- A recirculation / dosing tank containing pumps to transfer a mix of primary effluent and Evapo-transpiration pod effluent to the inlet of the first pod;
- Between 6-36 evapo-transpiration treatment pods connected in series with effluent flowing by gravity from one to another and draining back to the recirculation tank.
- An effluent pump well or chamber (typically part of the recirculation / dosing tank) to transfer recycled water to above ground storage tanks.

The recirculating, lined evapo-transpiration pods provide secondary treatment (through biological activity, filtration through the media and plant uptake), some winter storage and enhanced plant water uptake to minimise discharge and subsequent effluent management (irrigation) requirements. The treatment system design and layout are based on the Rhizopod™ system developed by Arris Water Treatment and Technology.

Based on information available from Arris, the expected effluent quality from the proposed Rhizopods™ (assumed in the design) is summarised in Table 11. These are considered suitably conservative design values based on water quality typically measured by Arris from these systems.

Table 11 Expected Treated Water Quality from Rhizopods™

Parameter	Treatment Design Target
pH	6 – 9
Total Dissolved Solids (TDS)	900 mg/L
Sodium Adsorption Ratio	6
Total Nitrogen (TN)	20 mg/L
Total Phosphorus (TP)	15 mg/L
Biochemical Oxygen Demand (BOD_5)	15 mg/L
Total Suspended Solids (TSS)	10 mg/L
E.coli	<100 colony forming units per 100mL

As can be seen the minimum treatment design criteria outlined in Table 7 are to be exceeded based on the expected treatment performance. An example of the system layout is provided in Figure 4 below. Figure 5 shows a typical cross section of a concrete based pod.

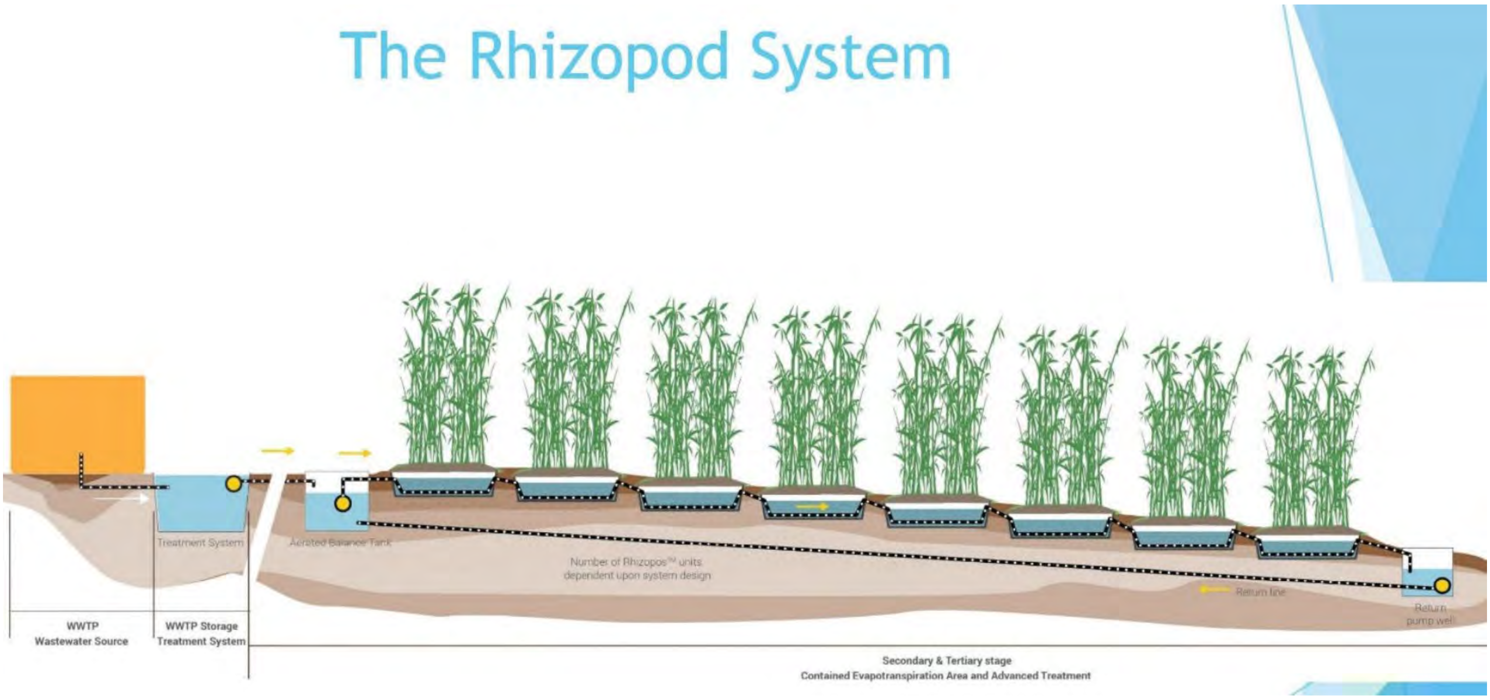


Figure 4 Example Treatment System Layout (Rhizopod™ provided by Arris)

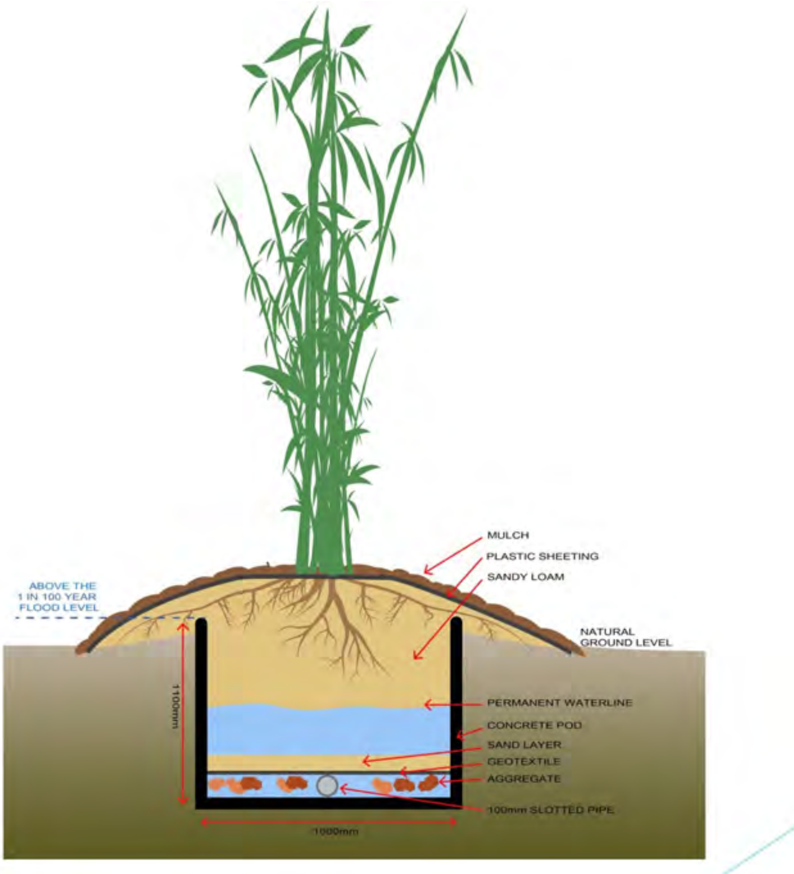
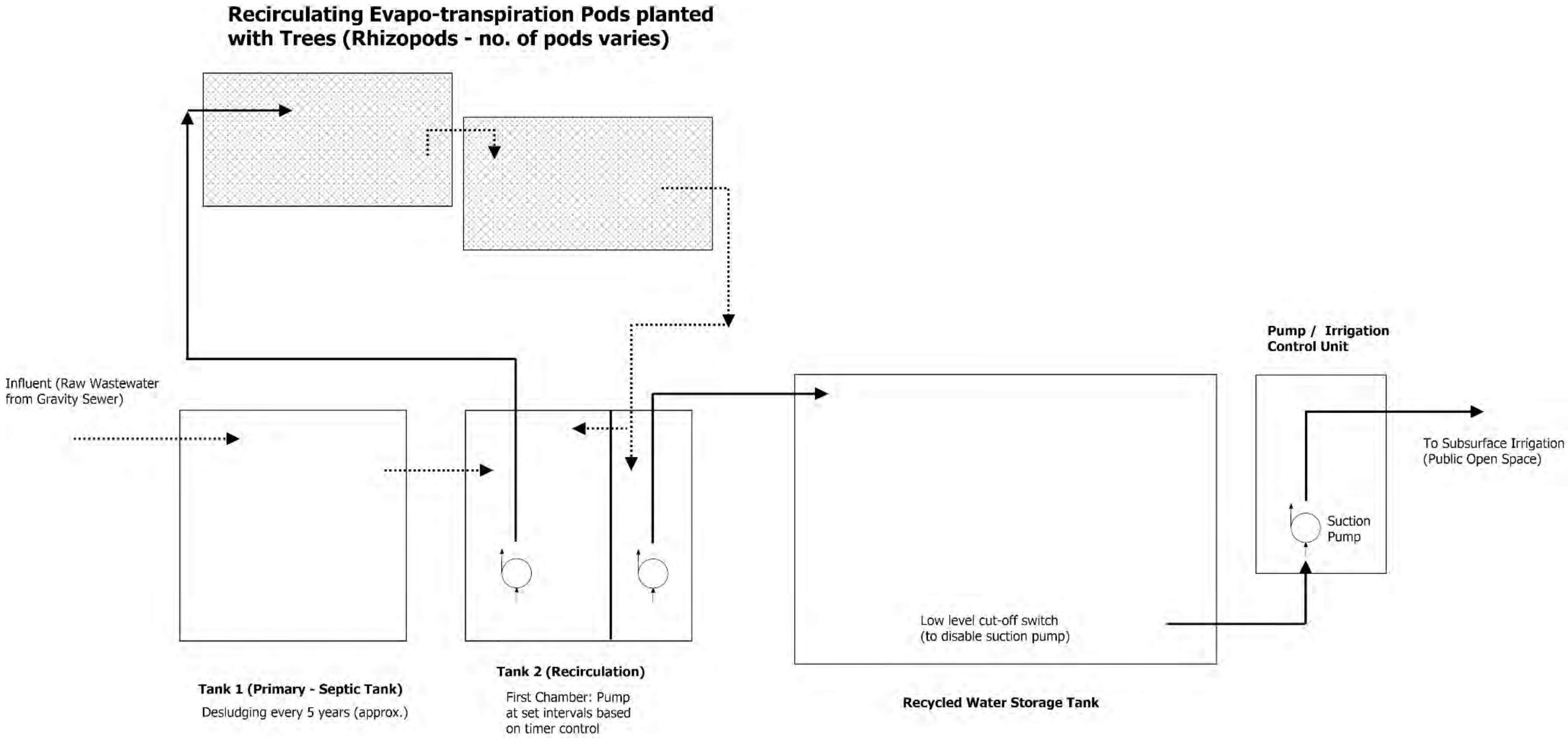


Figure 5 Typical Cross Section of Rhizopod™ Pod

There are a range of vegetation options ranging from high performance species such as bamboo to native grasses and shrubs. Decision making on plantings can (in part) be driven by aesthetic / landscaping needs. Figure 6 shows an example pod system landscaped as a native garden bed.

Figure 6 Example of a Rhizopod™ Planted with Native Vegetation

A process schematic of the PRS treatment systems is provided in DWG-0352-001-00.



NTS

TITLE: Penshurst Wastewater System Process Schematic	**DRAWING NO:** 0352-001-00	**REV:** A		DECENTRALISED WATER CONSULTING
CLIENT: Wannon Water	**Sheet:** 1 of 1	**Drawn:** JS		
PROJECT: 0352	**Scale:** NTS	**Checked:** BAA		

4.5.2 Recycled Water Storage

Following treatment, recycled water is to be stored locally for each precinct prior to irrigation via subsurface dripline. Due to shallow rock constraints across the township, above ground recycled water storage tanks will be installed in the locations shown in Figure 9 to Figure 19. An example of these storage tanks is provided below.

Figure 7 Example Recycled Water Storage Tank

A proportion of stored recycled water will periodically be recirculated through the Evapo-transpiration treatment pods to maintain water quality and limit bacterial regrowth. Prior to irrigation recycled water will undergo filtration and UV disinfection.

Recycled water storages have been sized to ensure zero overflow events over 60 years of climate data using long-term continuous daily water balance modelling. Provision will be required for eduction of recycled water from each PRS to cater for operational failures / breakdowns that might prevent irrigation when an individual storage is near full. For most of the year (8-9 months) there will be ample storage capacity available due to irrigation demands for recycled water.

4.5.3 Recycled Water Subsurface Irrigation

Recycled water will be utilised for greening of Public Open Space (POS) across the township via Pressure Compensating Subsurface Drip Irrigation (subsurface irrigation). This consists of small diameter irrigation pipes designed to be buried approximately 200mm below ground in the root zone of plants. This dripline is fitted with slow rate emitters able to maintain an effectively constant flow rate over a wide range of operating pressures. This prevents accessibility to the public whilst ensuring surface run-off does not occur during rain events.

Subsurface irrigation will be integrated into the large POS and road reserves available throughout the township as summarised in the following Precinct figures. There is opportunity to establish paths and other liveability enhancements as part of establishment of POS irrigation in some or all of the areas. As part of Functional Design, consideration has been given to avoiding existing services and ensuring vehicular access to properties can be maintained (including existing informal driveways).

The irrigation system and strategy will consist of the following;

- Subsurface irrigation will occur overnight to minimise contact with the public in intermittent irrigation events. For example irrigation of six subzone may begin at 11pm with each sub zone irrigated for one hour and irrigation ceasing at 5am.
- One or more irrigation pump stations consisting of pump set, irrigation controls, valves and filtration.
- Dripline installed at ~200mm below ground at 800mm lateral spacings and 1.6 L/hour emitters at ~500mm spacings.
- Supply and flushing mains and sub-mains to dose irrigation zones and enable regular flushing of the pipework (with treated effluent). Where possible these will be installed in a common trench.
- Irrigation areas within each precinct will be split into appropriate zones to allow regular dosing of each area overnight.

Irrigation scheduling will operate under a deficit approach whenever the storage is not full. The following scheduling rules have been modelled.

- Irrigation trigger of 5mm soil water deficit;
- Daily application depth of 2mm;
- Rain shut-off threshold of 5mm (due to use of subsurface irrigation);

As shown in Section 5.6 and Appendix D, this results in an average annual irrigation depth of 220mm with plant water demand above rainfall reducing to effectively zero in the winter months and remaining low from May to September. Significantly more storage (almost three times) would be required to meet the historical target (EPA Vic, 1993 Wastewater Irrigation Guidelines) of no overflow in the 90th percentile rainfall year. This then also creates the need for management of a pipe overflow to a drain or waterway.

In order to capture the significant benefits associated with the precinct based solution, DWC has undertaken a risk evaluation of an alternative approach to managing excess recycled water that has been shown in Section 5.6 to deliver a very cost effective and arguably lower impact approach at this scale. Importantly, the relative improvement in health and environmental impact from Business as Usual to the proposed land application approach is substantial whilst only being incrementally different to a deficit irrigation performance level.

This approach involves incrementally 'over irrigating' when recycled storages are full to prevent overflow. Spread over the proposed subsurface irrigation areas, these volumes constitute 0.5 – 1.1 mm/day of application in soils that are capable of receiving much higher land application depths. Based on water balance modelling this is likely to occur sporadically from mid to late July through to November. These land application depths are well within the hydraulic, nutrient and pathogen assimilative capacity of the soil, plant environment in Penshurst.

Reference should be made to the risk evaluation presented in Section 5.6 for a detailed justification for this approach. In summary, this approach;

- Does not result in waterlogging of the soil over 60 years of modelling;
- Is expected to have a hydraulic performance level only incrementally different from a deficit approach;
- Is predicted to ensure receiving water quality impacts are effectively non-existent (meets low risk trigger concentrations for undisturbed ecosystems);
- Is predicted to achieve total pathogen die-off in a range of sensitivity testing models;
- Is not expected to have a significant impact on local hydrology and in fact will significantly improve baseflow hydrologic conditions in comparison to the existing situation; and
- Does not require point source discharge of Class C water into a receiving water environment which contributes significantly more pollutants to the catchment.

A typical profile of beneficial reuse versus land application can be seen in the following figure.

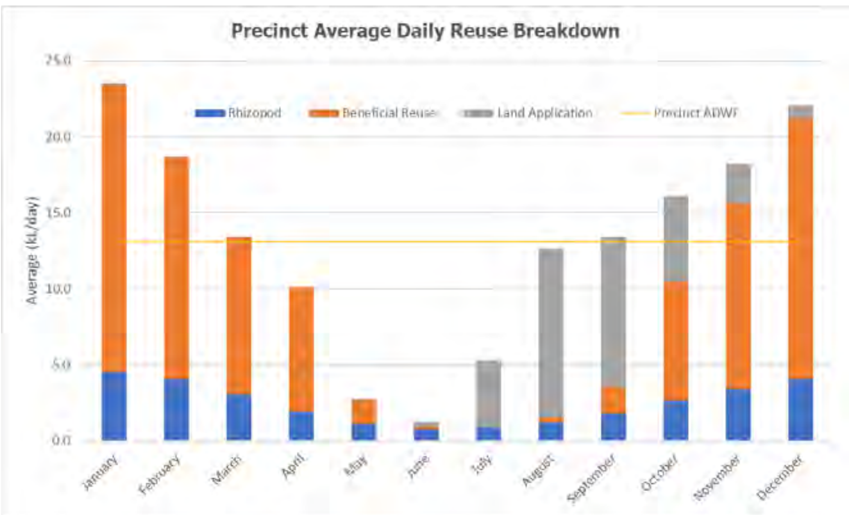


Figure 8 Monthly Water Balance Breakdown for Precinct 2

Depending on the volume of recycled water generated by some of the precincts (3,4 and 5), the system can have the ability to direct excess water to additional community areas as necessary. In particular, the Penshurst community playing field (oval) adjacent to Precinct 5 PRS will be provided additional recycled water for greening and improvement in local amenity. This will occur via recycled water storage overflow to a gravity sewer connected to the Recreation Reserve.

4.5.4 Setback Distances

Consideration of the separation distances of reuse areas and PRS infrastructure from properties, environmental receptors and existing services were taken into account as part of design. There is a need to maintain (and ideally improve) local amenity and groundwater / surface waters whilst ensuring long-term sustainability of the Penshurst Solution.

Appropriate minimum setback distances have been adopted for the recycled water irrigation systems as outlined in EPA Code of Practice (CoP) and Reclaimed Water Guidelines (2003), in addition to the WSAA Code setbacks for existing services. Key minimum setbacks considered are summarised in the table below (based on subsurface irrigation with restricted access).

Table 12 Minimum Adopted Setbacks (Secondary Treatment / Subsurface Irrigation)

Element	Min. Setback (m)
Property boundaries (irrigation area upslope / downslope)	1m / 1.5m
Roads	3m
Open stormwater drainage	3m
Water Main	1m
Telecommunication Cable	0.3m
Electrical Cable	0.5m
Intermittent waterways and waterbodies (non-potable – irrigation upslope)	30m
Groundwater bores (non-potable – upslope)	30m

4.5.5 Summary

The reuse (subsurface irrigation) areas have been determined based on available area throughout the township for the Precinct Water Recycling Systems with allowance for necessary minimum setbacks to receptors and existing services. A summary of the evapotranspiration treatment pods (ET pods), recycled water storage and irrigation areas is outlined in Table 13 below.

Proposed layouts for each of the PRS and POS Irrigation Areas are presented in Figure 9 to Figure 19 below. In addition, a summary of the key PRS components for each precinct is provided in Table 13.

Table 13 Precinct Water Recycling Systems Summary

<table>
<tr><th>Precinct ID</th><th>No. of ET Pods – Current</th><th>RW Storage (kL) - Current</th><th>POS Irrigation Area - Current (ha)</th><th>No. of ET Pods – Horizon</th><th>RW Storage (kL) – Horizon</th><th>POS Irrigation Area - Horizon (ha)</th></tr>
<tr><td>1</td><td>16</td><td>1,000</td><td>1.4</td><td>26</td><td>1,405</td><td>2</td></tr>
<tr><td>2</td><td>21</td><td>1,045</td><td>1.33</td><td>30</td><td>1,505</td><td>1.33</td></tr>
<tr><td>3</td><td>27</td><td>1,280</td><td>1.1</td><td>30</td><td>1,280</td><td>1.1</td></tr>
<tr><td>4</td><td>15</td><td rowspan="2">2,500 / 1,000</td><td rowspan="2">1.5 / 1</td><td>42</td><td rowspan="2">2,500 / 3,000</td><td rowspan="2">1.5 / 2.7</td></tr>
<tr><td>5[1]</td><td>24 / 20</td><td>24 / 60</td></tr>
<tr><td>6</td><td>24</td><td>1,275</td><td>2</td><td>32</td><td>2,630</td><td>2</td></tr>
<tr><td>7</td><td>36</td><td>2,160</td><td>2.47</td><td>50</td><td>4,150</td><td>2.47</td></tr>
<tr><td>8</td><td>9</td><td>520</td><td>0.7</td><td>35</td><td>1,435</td><td>1.63</td></tr>
<tr><td>9</td><td>-</td><td>-</td><td>-</td><td>27</td><td>1,690</td><td>1.7</td></tr>
<tr><td>10</td><td>9</td><td>520</td><td>0.65</td><td>9</td><td>680</td><td>0.85</td></tr>
<tr><td>11</td><td>6</td><td>410</td><td>0.55</td><td>10</td><td>600</td><td>0.77</td></tr>
<tr><td>12</td><td>-</td><td>-</td><td>-</td><td>12</td><td>845</td><td>1.2</td></tr>
<tr><td>Total</td><td>207</td><td>12 ML</td><td>12.7</td><td>387</td><td>22 ML</td><td>19.25</td></tr>
</table>

Note 1: Includes PRS and reuse area across adjacent Penshurst playing field (for excess recycled water).

Figure 9: Penshurst Recycled Water Scheme Overview

Legend

- Public Open Space Subsurface Irrigation
- Precinct Recycling Systems
- Potential Land Treatment Facility for Excess Recycled Water
- Property Boundaries
- Precinct Boundaries
- Pump Station (Septic Tank Effluent Pump - STEP)
- Sewer Alignment
- Elevation Contours (approx. 0.5m)

DECENTRALISED WATER CONSULTING

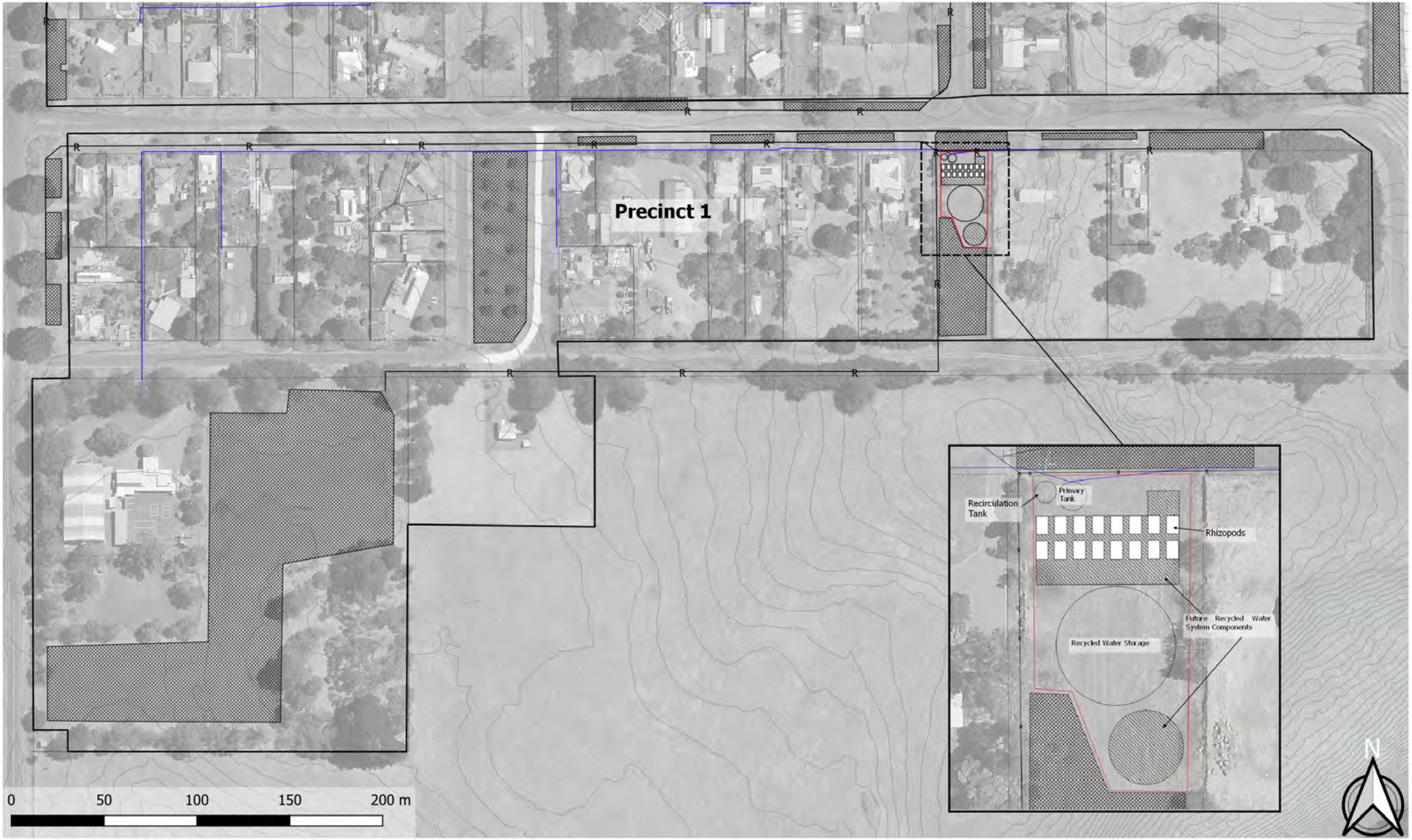


Figure 10: Precinct 1 Recycled Water Scheme

Legend

Public Open Space Irrigation
Sewer Alignment
Precinct Boundaries
Irrigation Mainline
Property Boundaries
Precinct Recycling Systems
Elevation Contours (approx. 0.5m)

DECENTRALISED WATER CONSULTING

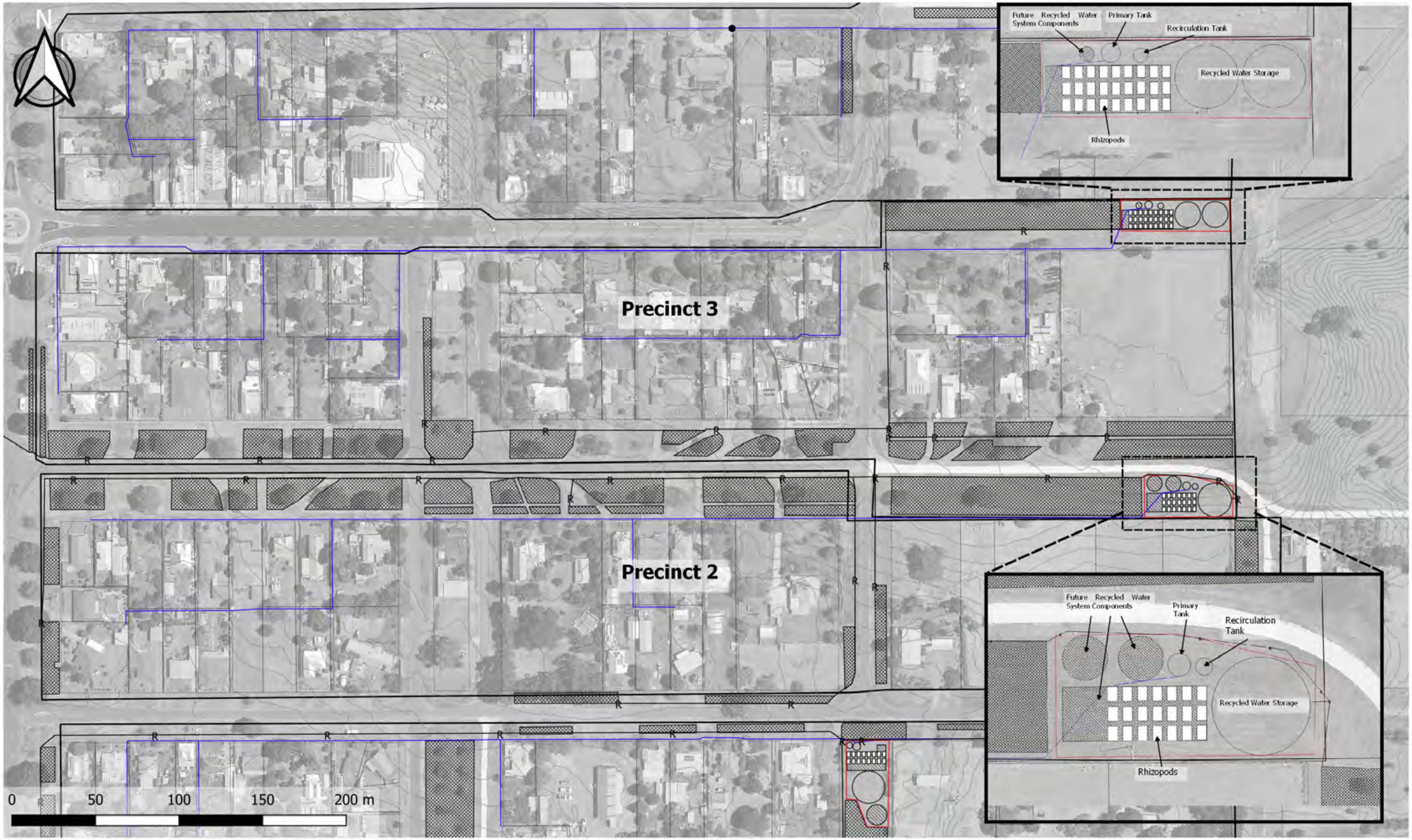


Figure 11: Precinct 2 and 3 Recycled Water Scheme

Legend

Public Open Space Irrigation
Sewer Alignment
Precinct Boundaries
Irrigation Mainline
Property Boundaries
Precinct Recycling Systems
Elevation Contours (approx. 0.5m)
Pump Stations (STEP)

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DECENTRALISED WATER CONSULTING

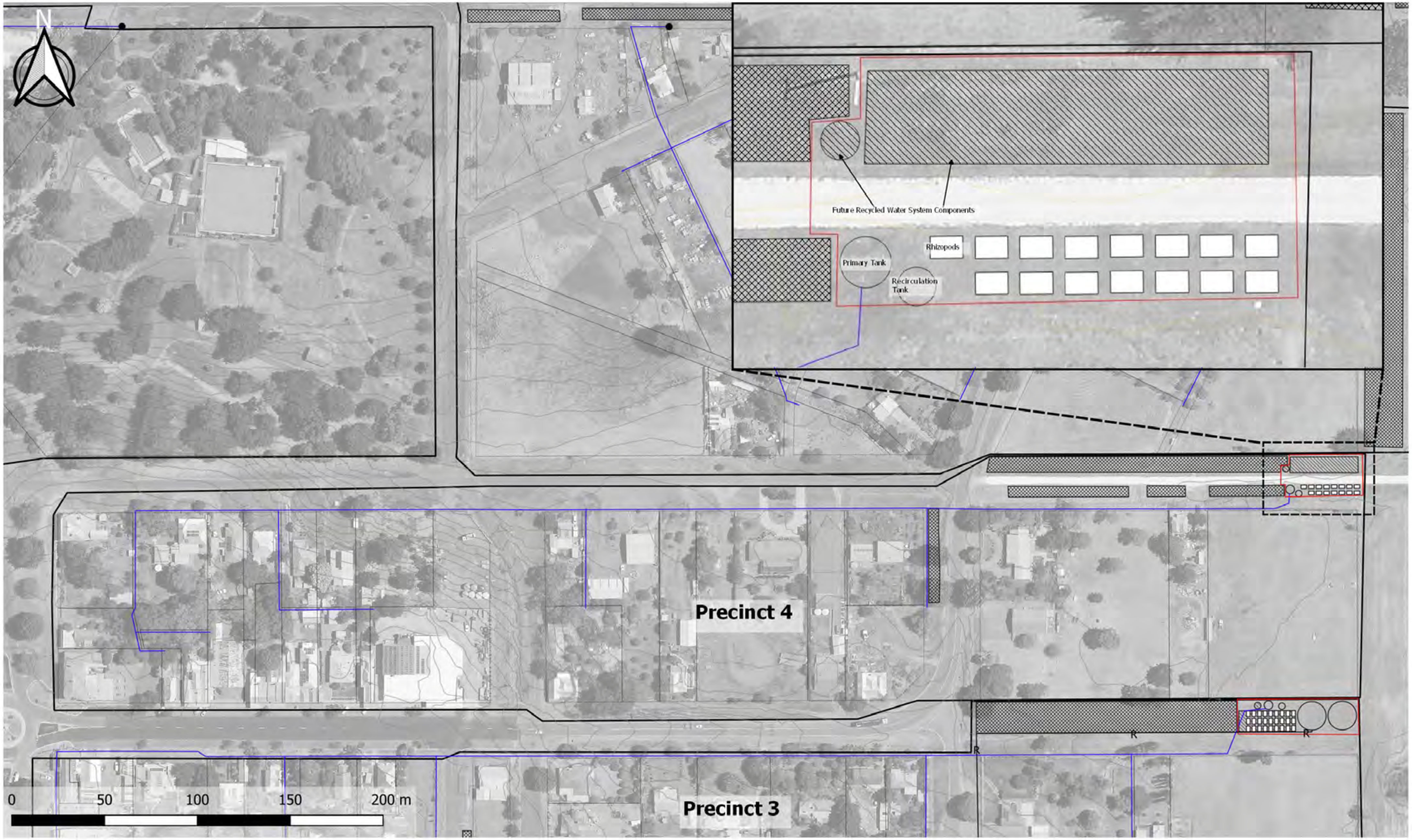

Figure 12: Precinct 4 Recycled Water Scheme

Legend

Public Open Space Irrigation
Sewer Alignment
Precinct Boundaries
Irrigation Mainline
Property Boundaries
Precinct Recycling Systems
Elevation Contours (approx. 0.5m)
Pump Stations (STEP)

DECENTRALISED WATER CONSULTING

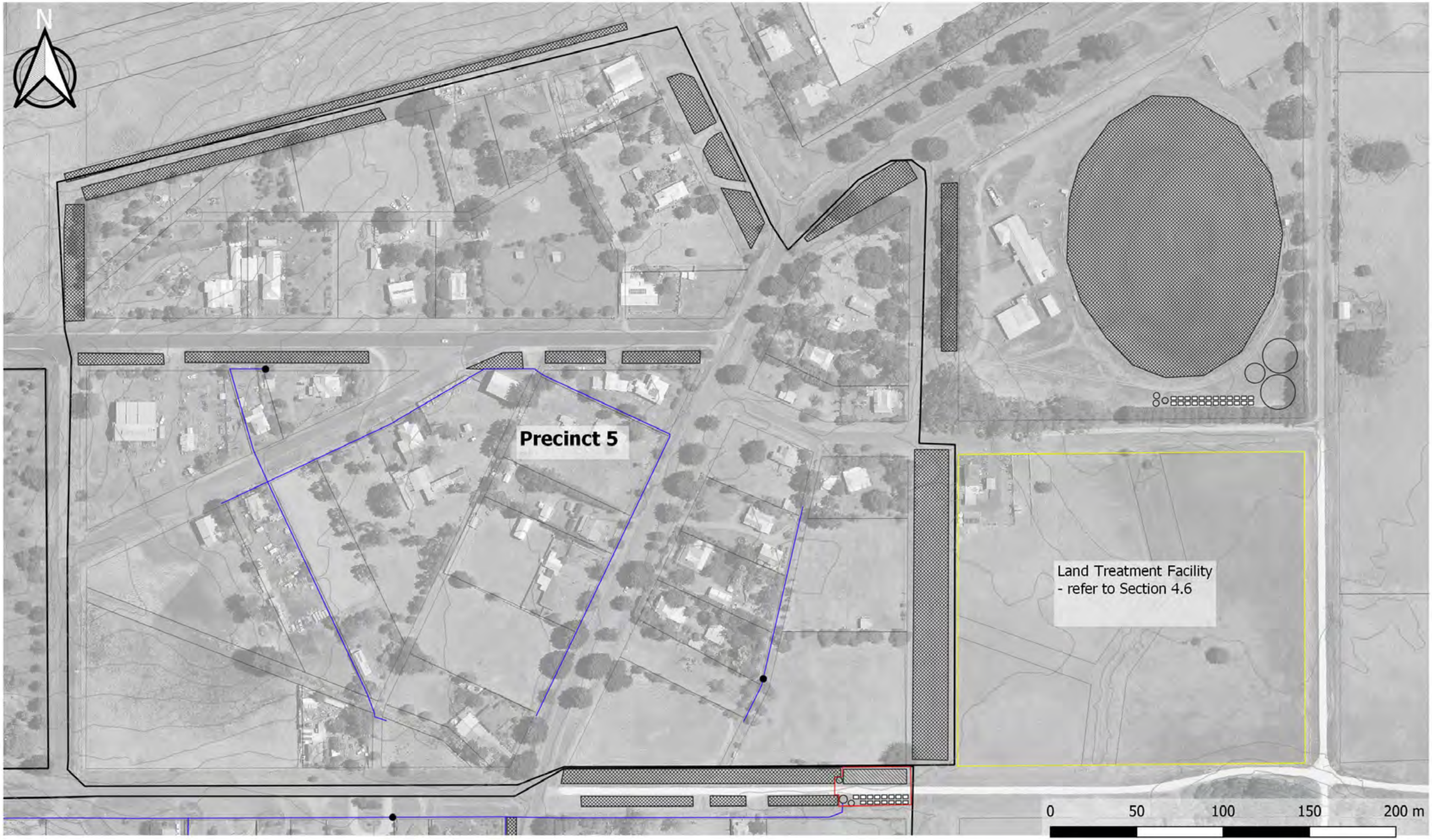

Figure 13: Precinct 5 Recycled Water Scheme

Legend

Public Open Space Irrigation
Property Boundaries
Sewer Alignment
Precinct Recycling Systems
Precinct Boundaries
Elevation Contours (approx. 0.5m)
Irrigation Mainline
Potential Land Treatment Facility for Excess Recycled Water
Pump Stations (STEP)

DECENTRALISED WATER CONSULTING

Figure 14: Precinct 6 Recycled Water Scheme

Legend

Public Open Space Irrigation — Sewer Alignment — Precinct Boundaries — Irrigation Mainline

Property Boundaries — Precinct Recycling Systems — Elevation Contours (approx. 0.5m)

DECENTRALISED WATER CONSULTING

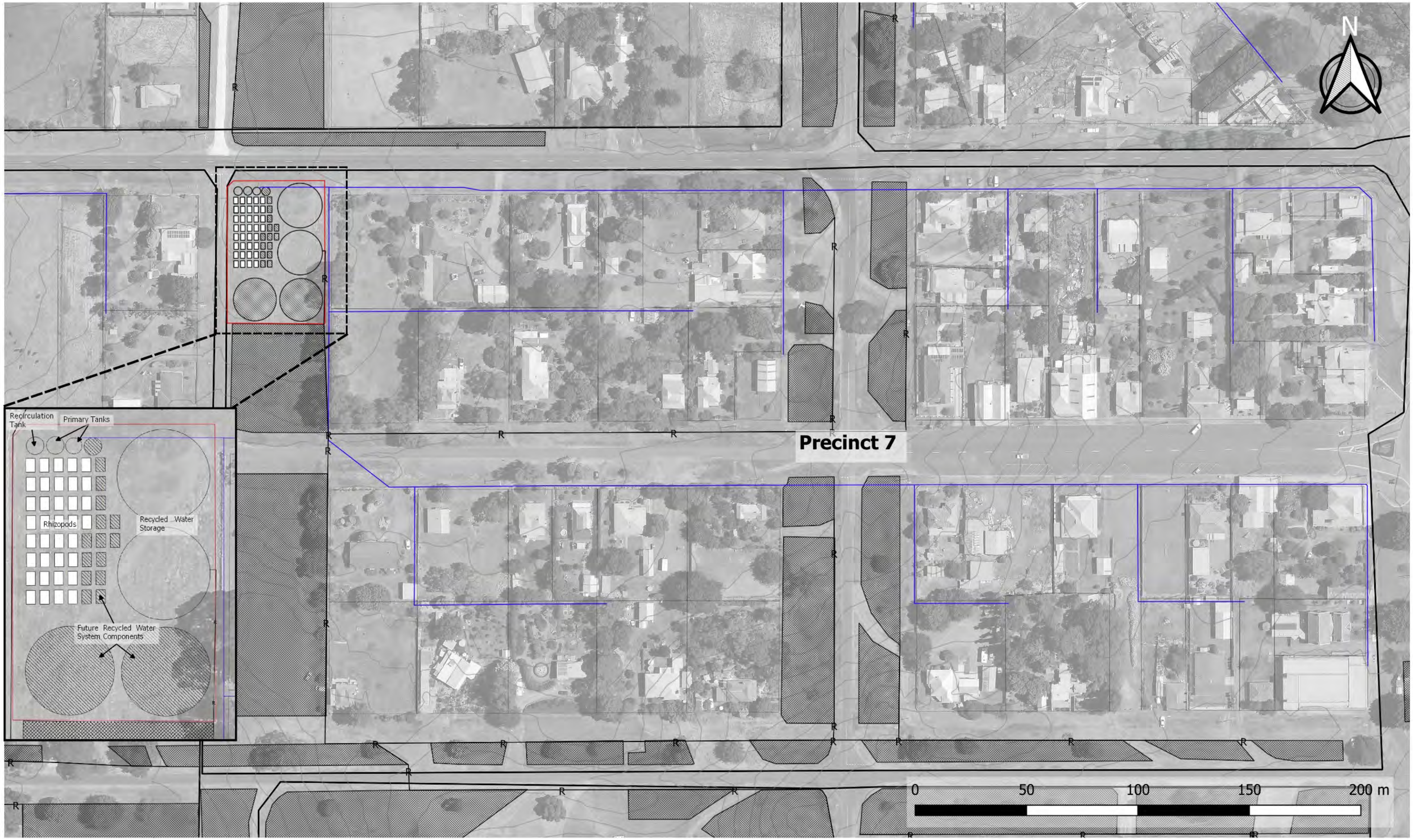

Figure 15: Precinct 7 Recycled Water Scheme

Legend

Public Open Space Irrigation
Sewer Alignment
Precinct Boundaries
Irrigation Mainline
Property Boundaries
Precinct Recycling Systems
Elevation Contours (approx. 0.5m)

DECENTRALISED WATER CONSULTING

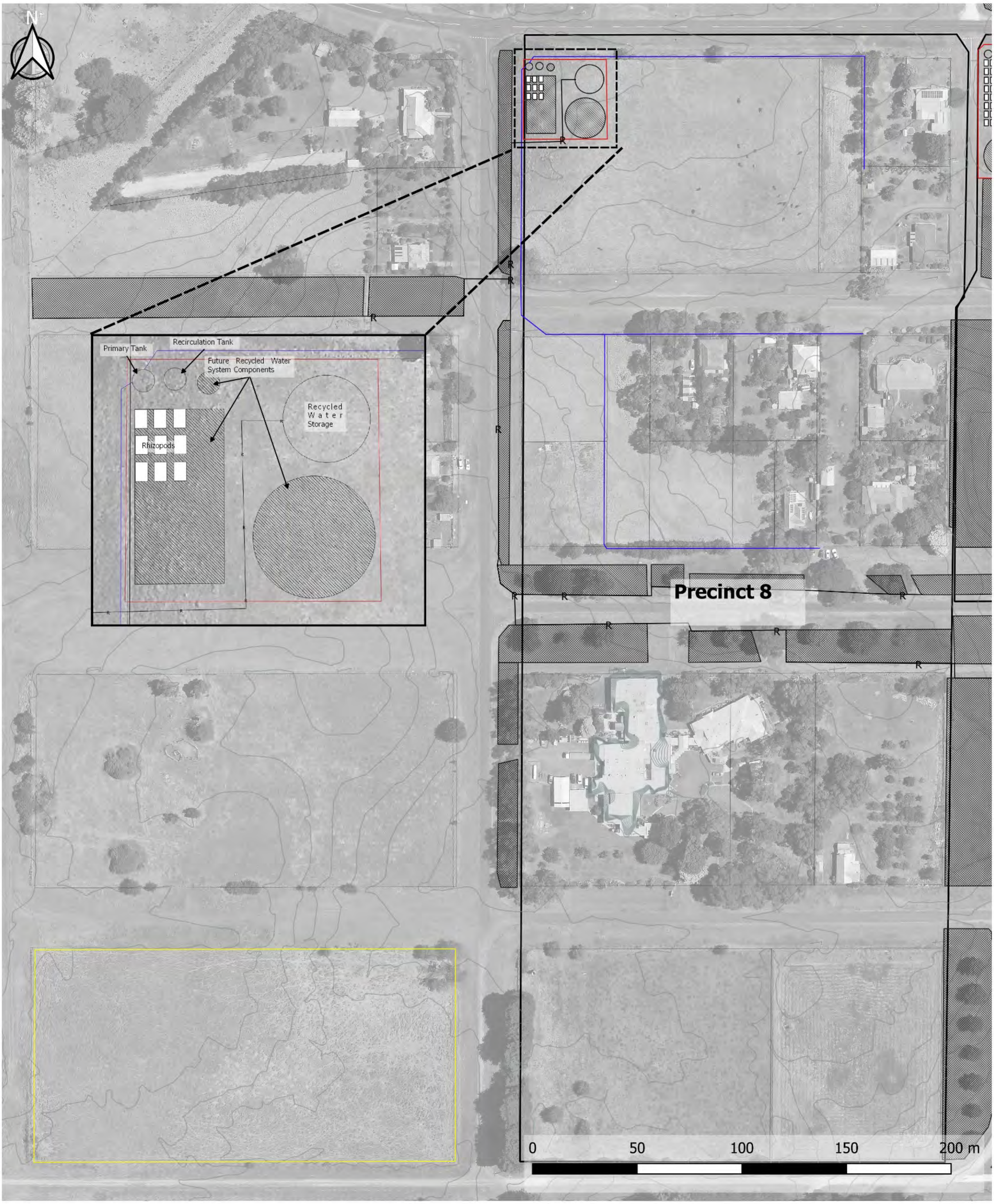

Figure 16: Precinct 8 Recycled Water Scheme

Legend

Public Open Space Irrigation

Precinct Boundaries

Property Boundaries

Elevation Contours (approx. 0.5m)

Sewer Alignment

Irrigation Mainline

Precinct Recycling Systems

Potential Land Treatment Facility for Excess Recycled Water

DWC
DECENTRALISED WATER CONSULTING

Figure 17: Precinct 9 Recycled Water Scheme

Legend

Public Open Space Irrigation
Sewer Alignment
Precinct Boundaries
Irrigation Mainline
Property Boundaries
Precinct Recycling Systems
Elevation Contours (approx. 0.5m)

DECENTRALISED WATER CONSULTING

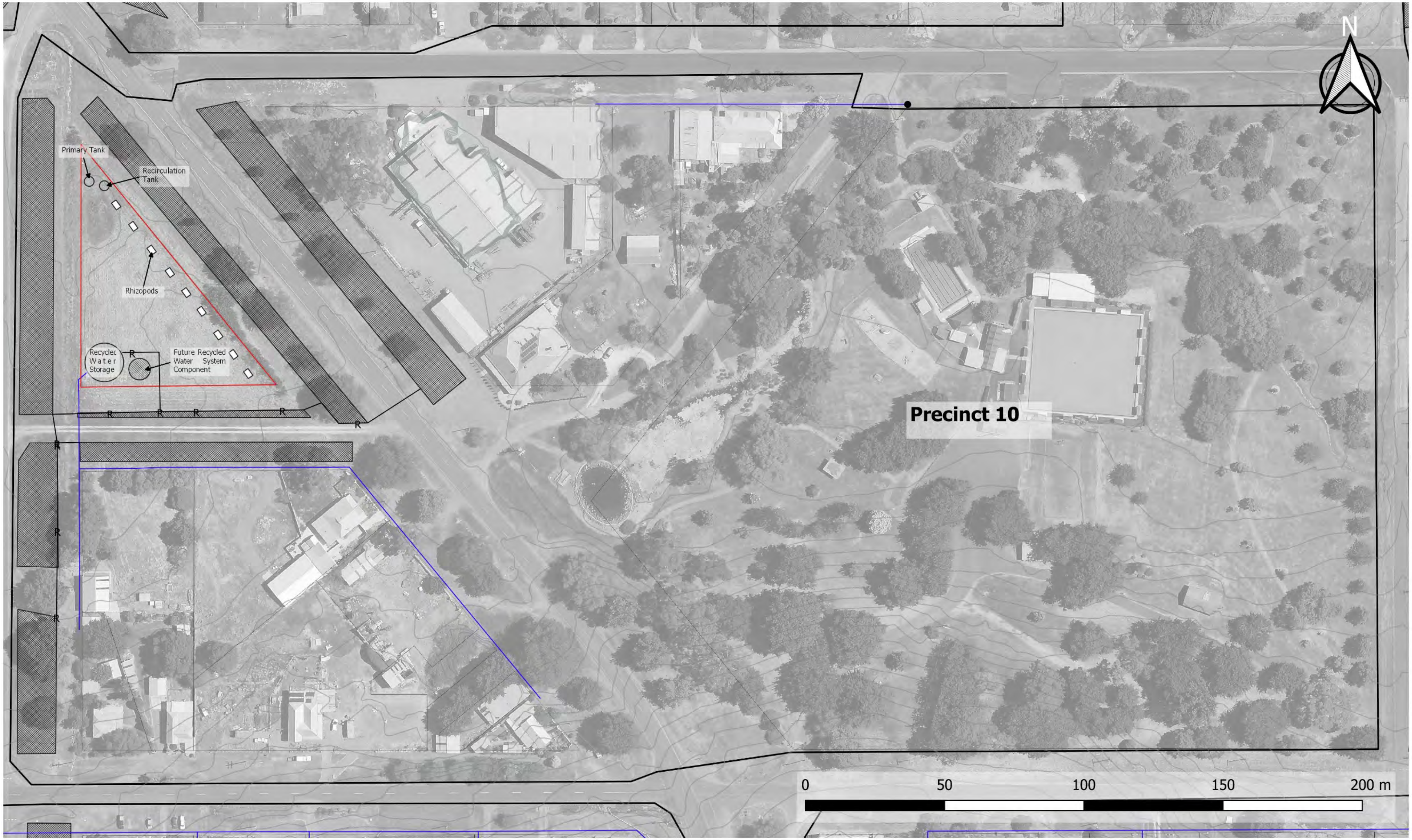

Figure 18: Precinct 10 Recycled Water Scheme

Legend

Public Open Space Irrigation
Sewer Alignment
Precinct Boundaries
Irrigation Mainline
Property Boundaries
Precinct Recycling Systems
Elevation Contours (approx. 0.5m)
Pump Stations (STEP)

DECENTRALISED WATER CONSULTING

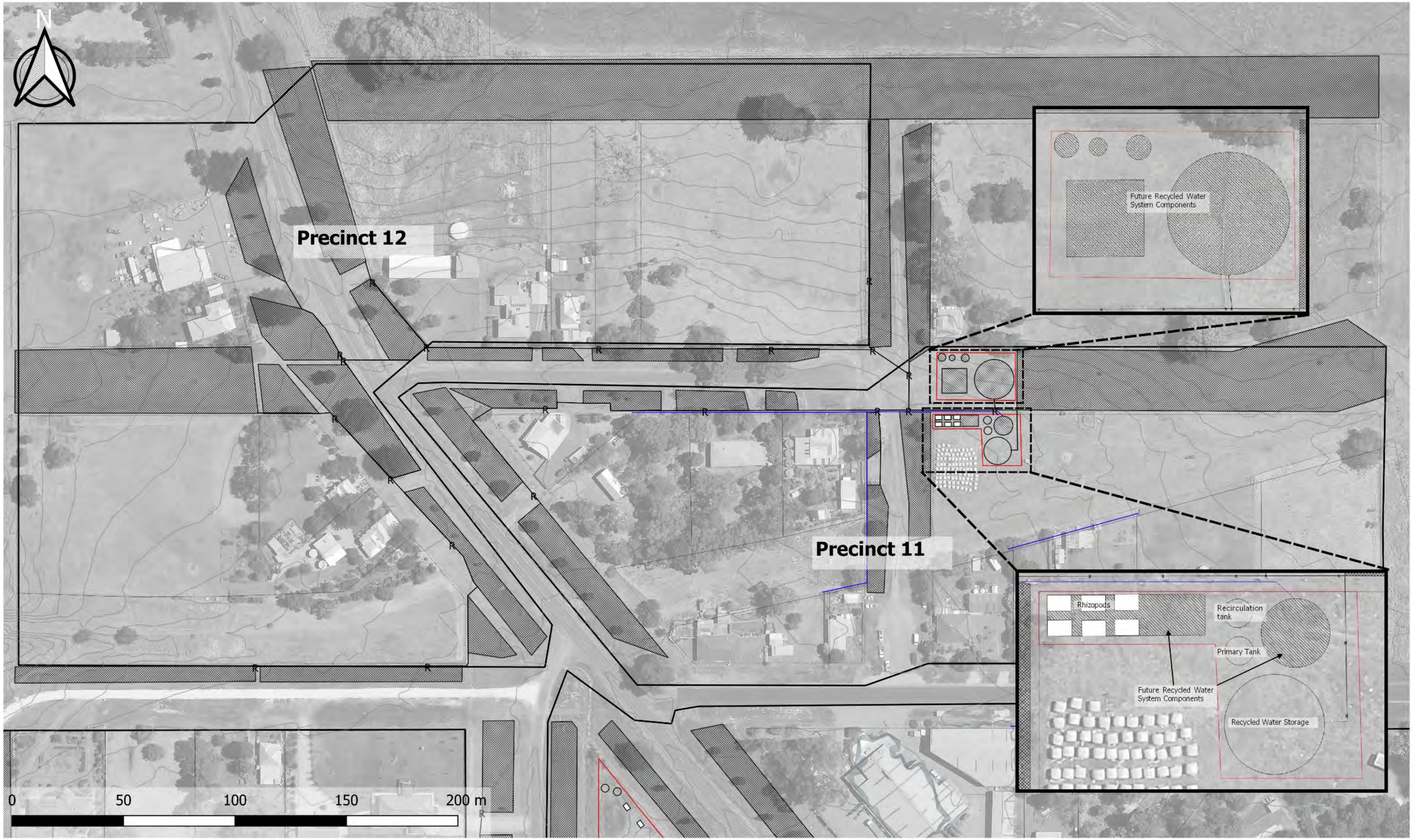

Figure 19: Precinct 11 and 12 Recycled Water Scheme

Legend

Public Open Space Irrigation
Sewer Alignment
Precinct Boundaries
Irrigation Mainline
Property Boundaries
Precinct Recycling Systems
Elevation Contours (approx. 0.5m)

DWC DECENTRALISED WATER CONSULTING

4.6 Land Treatment System

During the development of the Penshurst Wastewater Solution, it became apparent that there were three precincts (3,4 and 5) where it was unlikely to be feasible to safely manage full wastewater volumes within the precincts themselves. This is due to restricted available land, presence of commercial development with higher wastewater volumes and land capability constraints. In examining options for addressing this issue, it was observed that these three precincts are located near the Recreation Reserve with gravity fall from the Precinct 3 and 4 PRS.

It is proposed to construct a gravity recycled water main from the Precinct 3 and 4 Recycled Water Storages to a centralised Land Treatment System that incorporates the Recreation Reserve and potentially, some additional land to the south not currently included within the Township Zone or SGSC's concept plan for town growth. Approximately 20% of the recycled water from Precincts 3 and 4 would typically need to be managed at this central Land Treatment System (LTS). The majority of Precinct 5 recycled water would be managed here.

For the purpose of this Functional Design, this LTS has been designed in the same manner as the PRS and consists of the same treatment, storage and recycled water approach. It is envisaged that this site could be developed into a community facility that is interconnected with the Recreation Reserve. There are a range of alternative land treatment approaches that could be considered beyond the current assumed approach for this site. Potential options could include;

- Irrigated woodlot for carbon sequestration and/or carbon neutral firewood;
- Visual amenity, habitat and treatment wetland;
- Enterprise with a high yield / value recycled water demand such as horticulture, small industry, light commercial activities with high water demands;
- Additional playing fields;
- Dedicated natural process based treatment facility (potentially used to test and validate new approaches); or
- Some combination of these options.

This Functional Design establishes the land and infrastructure requirements to enable servicing of the Penshurst township to the Horizon design population whilst meeting regulatory objectives. Further investigation and design is required to formalise the location and configuration of the LTS. Further investigation may also identify valuable opportunities to attract investment via provision of a customised water source such as specialist horticulture.

4.7 Asset Requirements

The adopted design life for each asset are based on the WSAA Gravity Sewerage Code and summarised below.

Table 14 Typical Asset Design Life

Asset	Component	Expected Design Life (Years)
Sewer pipes / pits ETA pod tanks (concrete)	All	100
ETA pod	Pipework, media, vegetation, SCADA / controls	15
Pumps	All	7-10
Irrigation Systems	All non-civil components (incl. electrical)	20
STEP units (on-property)	All	20

4.8 Staging Requirements and Opportunities

The gravity sewerage pipework and PRS / irrigation systems will be delivered for each identified precinct in two key stages.

- Current Design Lots – based on current properties and development.
- Upper Design (Horizon) development – installation of infrastructure in modular 'blocks' as it occurs.

A possible trigger for installation of increased treatment and irrigation infrastructure might be the development of ten additional properties for example. The modular nature of the PRS has been designed so that limited change to treatment and irrigation processes is required. It will primarily be a case of connecting additional pods into the existing series or installing a second recycled water tank and connecting it to the existing one through a low level pipe.

It is proposed to construct all of the 12.7 hectare of POS irrigation from the outset. This is recommended to minimise the need for land application (over irrigation) events and manage disruption to the community.

4.8.1 Staging Opportunities

The precinct based design of the Penshurst Wastewater Solution offers significant opportunity to implement precincts in a flexible and adaptive manner. Initially, there is likely to be substantial benefit in constructing 1-2 precinct systems as a pilot or trial project. Engagement with the community may identify particular precincts where there is a strong desire within the community to participate and/or where existing on-site system performance and site constraints are creating a strong need for change.

Given the relatively novel approach being proposed, initially starting with 1-2 precincts and learning key lessons at a smaller scale is a more effective strategy. This would also offer an opportunity to collect performance data that will help provide confidence in the process and most likely enable design refinements.

4.9 Decommissioning Requirements

Existing septic tanks and land application areas to be decommissioned for all properties within the Service Area. This is to be undertaken by a licensed and qualified contractor.

5 Investigation and Design

5.1 Site and Soil (Land Capability) Assessment

Site and soil field information has been collected for Penshurst by DWC in 2019 and 2020 for the township to both confirm sewer alignments and cluster system locations. This information was also focused on the land capability for irrigation reuse sites to characterise potential constraints and factors to best manage any potential risks from the Recycled Water Solution. Test pits were excavated using a shovel and auger and soil laboratory analysis data was also obtained. This data was utilised to undertake a Land Capacity Assessment (LCA) for each of the nominated reuse sites in accordance with the EPA Code of Practice and MAV Land Capability Framework (in addition to *AS1547:2012*).

The key Land Capability Assessment (LCA) information is summarised in Table 15 below. Complete LCA information is provided in Appendix A.

Table 15 Summary of Land Capability Assessment (Township Area)

Criteria	Details	Constraint / Limitation	Comment / Action
Soil	Strongly structured silty loam to clay loam soils with typically shallow soil depth across the township based on excavated test pits (both DWC and previous SGSC data). Depth to rock or limiting layer is variable and depths from 360 to 520mm recorded by DWC. This generally correlates with information provided by SGSC. Average ~400-500mm depth to bedrock or rock boulders has been assumed for the functional design based on available information. Very high phosphorus sorption capacity based on laboratory analysis.	Moderate to Major	Good quality fill (~100mm) may need to be imported for some reuse areas as needed to provide a minimum separation distance of 600mm to rock (where possible). Subject to further depth to rock assessments. To be confirmed as part of detailed design. Soil texture and structure well suited for recycled water application. Conservative design loading rates to be adopted for all reuse areas.
Slope	Slopes across the township are typically <5% (~1-2% average) with slightly steeper slopes to the north towards the Penshurst Wetland Gardens (~9%).	Minor	Slope and erosion not a key constraint (no EMO for township). Steeper slopes to be avoided for water reuse.
Drainage / Groundwater	Potential for perched water-table to form along the shallow limiting layer where present. Soils are generally well drained and chiefly limited by shallow soil depth (as discussed above). General land-form of the township involves waxing to linear divergent slopes predominately heading to North East and North West. Penshurst Wetlands (Everflowing Spring) located in northern section of township are considered a valuable asset to the community. Therefore drainage to the Wetlands require consideration.	Moderate to Major	Conservative design loading rates to be adopted for all proposed irrigation areas to ensure sustainable long-term hydraulic performance. Upslope diversion drainage potentially required to capture and divert road run-off for irrigation areas with minimal existing stormwater infrastructure present. Not a key constraint within township. Hydrology impacts for Wetlands along with broader catchments assessed and discussed in Section 5.6.5.
Watercourses and Sensitive Receptors	Drainage from the Wetlands heads to the north via an adjacent intermittent waterway. The Wetlands and waterway are to be avoided for any recycled water irrigation (>30m setback).	Moderate	Nutrient and hydraulic modelling undertaken for proposed irrigation areas to demonstrate sustainable long-term performance (refer Section 5.6).
EPA CoP Setbacks	Able to achieve minimum setbacks as outlined in EPA CoP, along with WSAA Sewerage Code setbacks to existing services.	Minor to Moderate	Min. setbacks able to be accommodated (as per Section 4.5.
Vegetation / Exposure	Some large mature trees present along large road reserves. Not a key constraint for water reuse.	Minor	Trees to be avoided where possible.
Environmentally Significant Overlay (ESO) Vegetation	Not a constraint.	Nil	No impact on system.
Flooding	Not a constraint	Nil	No impact on system.

5.2 Geotechnical and Groundwater Assessment

No previous geotechnical data or reports are available from Wannon Water or SGSC for the Penshurst study area. However previous soil logs were provided by SGSC to give spatial guidance on relative depth to rock across the township. This information has been used to assist with informing potential issues with sewer installation and rock breaking that needs to be factored into the design.

Geological data (from Data.Vic web portal) indicates the township is located on volcanic plains (Western Plains) with basalt lithology. Available soil landscape information for Victoria indicates that the two key landscapes (Australian Soil Classification) across the township consist of the following.

Table 16 Penshurst Soil Landscapes

Landscape (ASC)	Typical Depth	Description
Rudosol (RUCY) – majority of township	0.5m	Shallow stony earths and dark clays with clay loam topsoil.
Sodosol (SOAB) – north east corner of township (lower lying)	>0.7m	

This information has been confirmed via soil test pits recorded by DWC across the township as discussed previously in Table 15.

5.2.1 Rock Depth

Variable rock depth which is typically shallow is a key constraint across the township area. Previous soil log information for Penshurst provided by SGSC indicates depth to rock or limiting layer ranges from around 100mm to 800mm depending on land form position. A summary of available soil log information provided by SGSC is presented in Appendix B.

As discussed previously, based on available soil depth information 500mm has been assumed for the average soil depth to the limiting layer (either bedrock or large rock boulders) for functional design.

In particular rock depth presents a key point of uncertainty for installation of gravity sewerage infrastructure (pits and pipes).

Thus shallow rock has been factored into the Penshurst functional design based on available information on rock depth, elevation (and therefore total pipe depths) and estimated costs for any rock drilling / removal which are conservative given the uncertainty.

5.3 Town Planning Assessment

Penshurst is governed by SGSC and subject to the Southern Grampians Planning Scheme. Planning and Zoning layers have been sourced for the town from Victorian Government via online web portal. Relevant zoning and planning requirements are summarised in the table below.

Table 17 Town Planning Assessment Summary

Aspect	Details
Heritage Overlay	Limited works proposed for heritage listed properties (see details below).
Township Zone (TZ)	All allotments to be provided reticulated sewerage connection point unless indicated – small number (12 lots) of on-site wastewater system upgrades.
Public Park and Recreation Zone (PPRZ)	Permit not required in PPRZ for irrigation, drainage or underground infrastructure. Penshurst Gardens and Caravan Park – may require specific planning permit.
Public Use Zone (PUZ4)	PUZ4 (to be utilised for transport access) through northern section of township. Water reuse to avoid the zoned accessway.
Special Use Zone (SUZ)	SGSC indicated area to the north of CFA Facility could be zoned SUZ. No water reuse or infrastructure proposed in this area as part of functional design.
Bio-conservation (Vegetation)	Based on *Native Vegetation - Modelled 2005 Ecological Vegetation Classes (with Bioregional Conservation Status)*. Environmentally significant vegetation is limited in township area. Removal of vegetation may trigger planning permit requirements, however this is not expected to be a key constraint (i.e. no significant or indigenous trees).

5.3.1 Heritage and Archaeology

Discussed above in Town Planning Assessment, buildings listed under the Heritage Overlay will have works limited to what is necessary (sanitary drainage) to minimise disturbance.

The Aboriginal Cultural Heritage Register and Information System (ACHRIS) indicates that the town has potential for Aboriginal heritage sites to be present. Therefore further engagement with Gunditj Mirring Traditional Owners Aboriginal Corporation is being undertaken as part of the Penshurst Wastewater Solution, in particular regarding the northern springs at the Penshurst Wetland Gardens.

5.4 Hydraulic Modelling / Design

Hydraulic design for gravity sewer flow allowances, pipe sizing and minimum grade have been undertaken based on the WSAA Gravity Sewerage Code. The outcomes are documented in Section 4.2 and 4.4.

5.5 Water Balance Modelling

Water balance calculations and modelling for evapotranspiration pod numbers and treatment design has been undertaken based on design material provided by Arris Water Treatment and Technology.

DWC developed a Recycling System Water Balance Model for testing and designing each of the Precinct Recycling Systems (PRS). This tool was utilised to test and optimise the specific configuration of each PRS based on the following key design parameters;

- Number of lots connected to the PRS (current and horizon)

- Number of ET treatment units (Rhizopods™)
- Recycled water storage volume
- Public Open Space (POS) irrigation area (local beneficial reuse) and / or other off-site reuse area (partial beneficial reuse)

The outcomes of this water balance modelling are summarised in Section 4.5 and full results are presented in Appendix D.

5.6 Water Reuse Modelling and Risk Evaluation

Given the nature of the proposed wastewater solution for Penshurst, modelling has been undertaken to ensure the system (specifically recycled water storage and irrigation system) meets the performance objectives in accordance with EPA Victoria *Guidelines for Environmental Management: Use of Reclaimed Water* (2003) and *Guidelines for Wastewater Irrigation* (1991). At the time of this report, EPA are also in the process of finalising a revised version of the Reclaimed Water Guidelines. Although this document has not been adopted at present, a review of the draft version was undertaken as part of the functional design.

The key criteria used to calculate the size of the recycled water storage and determine the irrigation schedule include;

- containment of all wastes in at least the 90th percentile wet year;
- protection of beneficial use values for any receiving groundwaters (including connected surface waters); and
- prevention of land degradation through excess accumulation of organic matter, nutrients, metals or salts.

As per the Guidelines for Wastewater Irrigation (EPA, 1991) an initial monthly water balance has been developed for the total proposed Penshurst recycled water system. This includes assessment of the potential water storage and irrigation requirements based on a 90th percentile rainfall year, to ensure that tank overflow does not occur.

EPA Vic Monthly Water Budget - 90th% (Annual) Rainfall Year		2016														
	Unit		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	
Evaporation (Class A Pan)	mm	A	204	188	146	86	52	35	42	57	75	107	132	172	1296	
Rainfall	mm	B1	35.2	28.6	34.4	47.2	113	71.2	129.4	63.2	152.6	98.6	33.8	40.2	847	
Effective Rainfall	mm	B2	26	21	24	31	73	46	84	41	99	64	24	28	563	
Potential Evapotranspiration	mm	C1	143	132	102	52	26	16	17	26	41	70	92	120	836	
Irrigation Requirement	mm	C2	116	110	78	21	0	0	0	0	0	5	69	92	492	
Net Evaporation from Lagoons	kL	D	0	0	0	0	0	0	0	0	0	0	0	0	0	
Volume of Wastewater	kL	E	4402	3976	4402	4260	4402	4260	4402	4402	4260	4402	4260	4402	**142.0**	
Total Water for Irrigation	kL	F	4402	3976	4402	4260	4402	4260	4402	4402	4260	4402	4260	4402	51830	
Area Required for Irrigation	ha	G													**12.7**	ha
Cumulative Storage	kL	H	4872	0	0	1603	6005	10265	14667	19069	23329	**27038**	22568	15253	**27.0**	ML
Crop factor		I	0.7	0.7	0.7	0.6	0.5	0.45	0.4	0.45	0.55	0.65	0.7	0.7		
Lagoon Area			ha													
EOY Storage		**15253**	kL													

It can be seen that significantly more storage is required (27 ML over the 12 precincts) to meet the traditional EPA target of no overflow in the 90th percentile rainfall year. However, there are significant limitation to the use of a lumped, discrete (i.e. not modelling a long-term continuous climate scenario) monthly water balance tool in this manner. In fact, DWC have built a daily MEDLI model using the above sizings (i.e. consistent with EPA Wastewater Irrigation Guidelines) and based on 60 year climate period only 70% beneficial reuse was achieved.

Given the scale of the system, daily calculations / modelling is highly applicable given the ability of landscape irrigation systems to deliver more frequent, shallower depths of effluent to the proposed POS irrigation areas. Daily models also account for soil water dynamics and plant growth in a more realistic manner.

To ensure agencies such as EPA Victoria are comfortable with the use of daily modelling, soil nutrient and pathogen dynamics have also been modelled to predict plant nutrient uptake, soil sorption / die-off and loads leached below the root zone. This provides a quantitative assessment of the potential for off-site impacts from the whole system. Salt loading has also been considered to ensure there is no excessive build-up of salts within the ET pods or irrigation areas. The Rhizopod™ system has not been designed as a 'closed' system and therefore accumulation of salts within the system will be managed via both the recirculation and irrigation of the highly treated effluent. Freshwater with low salinity can also be periodically pumped through the system if monitoring indicates high salt concentrations are a concern.

Water, nutrient and salt modelling has been undertaken using Model for Effluent Disposal using Land Irrigation (MEDLI). MEDLI currently represents the most sophisticated and technically robust modelling tool for designing effluent irrigation schemes available in Australia.

Summary of what the modelling found:

- Conservative irrigation scheduling with only a slight increase in applied water above plant water demand (in warmer months only) achieves an equivalent outcome to a strict beneficial reuse approach.
- A quantum improvement from the existing case can be expected for significantly lower cost than a full beneficial reuse approach.
- Improvement in the hydrology and nutrient loads based on the replacement of existing onsite systems and dispersing of wastewater flows / loads across a greater area.
- Improved health performance through the decommissioning of existing undersized onsite systems, including offsite discharge of wastewater.
- Achievement of health and water quality targets is readily achievable.

Performance modelling and impact assessments have been undertaken to ensure that the proposed wastewater treatment systems are performing effectively and that performance objectives can be achieved. DWC has completed daily modelling to demonstrate the high level of environmental and health system performance in accordance with EPA and Council requirements.

Water and nutrient modelling of the proposed wastewater system was undertaken using *Model for Effluent Disposal by Land Irrigation* (MEDLI), which is a nationally recognised wastewater management modelling tool and has been used to derive average annual hydraulic and nutrient loads from the water reuse systems (to surface and subsurface export routes).

MELDI has also been utilised for the sizing and design of the irrigation reuse systems. Adopted modelling parameters and results are presented in Appendix D.

5.6.1 Nutrient Results

Simulated results for nutrient loads in deep drainage (i.e. leaving soil below root zone) generated from the proposed Penshurst Precinct irrigation areas are summarised in the table below. Modelling was undertaken based on long-term simulation (60 years) for both beneficial reuse (deficit irrigation) and beneficial reuse with slight additional effluent application. In addition, the estimated nutrient loads (including off-site discharge of wastewater) developed as part of the Option Analysis report have been refined and included for comparison. This includes both existing owner managed on-site systems (based on system audit data from SGSC) and gradual upgrades to this systems over time as needed (Business as Usual in which systems are upgraded by home owners when required due to system failure or on-lot development).

These nutrients loads are summarised in Table 18 and the Precinct irrigation loads are prior to any downslope attenuation occurring (discussed in the following Section). It can be seen that a quantum improvement is achieved by the proposed Penshurst Wastewater Solution. This is to be expected given the high level of system failure and offsite discharge under both the existing case and Business as Usual.

Table 18 Nutrient Export Results Summary

Scenario	Effluent Conc.	HLR	NLR (TN / TP)	Nutrients Export Loads / Concentrations			
				TN		TP	
Units	mg/L (TN / TP)	mm/day (average / max.)	kg/ha/year	Average (mg/L)	Average (kg/year)	Average (mg/L)	Average (kg/year)
Existing On-site Systems	-	-	-	8.2	182	3.3	72
Business as Usual (Gradual upgrade of systems over 25yrs)	-	-	-	8.2	181	2.9	65
Precinct Systems (Deficit Irrigation)	35 / 12	0.7 / 2	100 / 30	0.02	0.79	0.001	0.03
Precinct Systems (Deficit Irrigation) + Additional Land Application	35 / 12	0.8 / 2	100 / 32	0.05	1.97	0.001	0.04

HLR = Hydraulic Loading Rate; NLR = Nutrient Loading Rate; TN = Total Nitrogen; TP = Total Phosphorus

5.6.2 Pollutant Attenuation

Pollutant attenuation factors were applied to PRS (MEDLI) loads prior to inclusion in a mass balance. Site specific attenuation factors were modelled to determine the potential impact of viruses, nitrates and phosphorus.

Simplistic two dimensional groundwater modelling has been undertaken to estimate the potential transport and fate of pathogens discharging below the root zone as deep drainage. A steady state analytical approach using the Domenico Equation was adopted for nitrogen / pathogens while the time variant approach was adopted for phosphorus. The Domenico equation calculates pollutant concentration at a given point from a finite, planar, continuous source of pollutant under steady state (i.e. equilibrium) conditions. The time variant approach accounts for the uptake and accumulation of pollutants in the soil over time and identifies potential for excess accumulation. A full description of the equation is provided in Alvarez and Illman (2006).

Effluent plume models are provided in Appendix D. The results are summarised in the following table. It can be seen that negligible off-site impacts are expected and water quality targets can be achieved under all scenarios tested. The long term nutrient loads are expected have a negligible increase on background loads and will provide a significant improvement on the current situation. Additionally, the nutrient loads are expected to reach the ANZECC low risk trigger of 0.015 mg/L for nitrogen and phosphorus just downslope of the irrigation area.

The ANZECC target is expected to be reached within <1m for nitrogen and phosphorus. It is important to note that the ANZECC low risk trigger is a highly conservative target representative of pristine water conditions and meeting this target prior to any receiving environment indicates that a high level of water treatment is being achieved.

Long-term virus plume modelling indicates adequate viral die-off subject to effective performance of the proposed secondary treatment system. For virus export modelling, the minimum distance required to achieve total viral dieoff (<0.5 MPN/L in the modelling) was evaluated and determined to be approximately 1-2m from the irrigation area. As such, a high quality of treatment is expected for both nutrients and pathogens before the plume reaches the nearest receptor (e.g. stormwater swale).

Table 19 Summary of Effluent Plume Modelling Outcomes

Parameter	Scenario	Result	Interpretation
Phosphorus	Average Annual	<0.5m setback	Distance required to achieve ANZECC low risk trigger concentration (0.015 mg/L) for FRP.
		>100 years	No breakout / excess accumulation expected during operational life of system.
Nitrate	Average Annual	<0.5m setback	Distance required to achieve ANZECC low risk trigger concentration (0.015 mg/L) for NO_x. – Conservative target
Virus	Average annual	~2m setback	Based on secondary treatment and partial disinfection with median decay rate. Total die-off achieved ~2m downslope of irrigation area.
	Conservative (system failure)	~4m setback	Treatment system failure (1-log reduction via irrigation) at 90th%ile decay and 95th percentile pathogen concentration[2]. Partial secondary treatment at conservative viral decay rate[1].

Note 1: All scenarios other than the median viral decay test assumed the 90th percentile (worst case or lowest) virus decay rates from literature (Yates et al 1985 and Schijven et al 2009).

Note 2: 95th percentile virus concentration in raw sewage from EPHC (2006).

5.6.3 Soil Water Performance

In addition, MEDLI modelling was also undertaken to determine potential alteration to soil water regimes based on the proposed irrigation areas across the township. The frequency and duration of saturated or near saturated soil conditions were simulated for a range of potential scenarios and are summarised in Figure 20. These included;

- No Effluent Land Application (from either existing onsite systems or the Penshurst Solution)
- Precinct Recycled Water System Irrigation (beneficial reuse only)

- Precinct Recycled Water System Irrigation (beneficial reuse with periodic, slight increase in irrigation rates)
- On-site Wastewater System Upgrade (Best Practicable Option based on typically limited available area for effluent application)
- Existing On-site Wastewater System (typically undersized due to limited available area for effluent application.

Sensitivity testing was undertaken based on conservative (upper) irrigation volumes for the modelling period to test the influence on the soil water characteristics. Importantly it should be noted that the No Irrigation scenario does not include any current soil water impacts from existing on-site wastewater systems. Therefore the results represent the relative change from improving the current effluent management situation by directing all recycled water into the ground (with off-site discharge into stormwater no longer occurring).

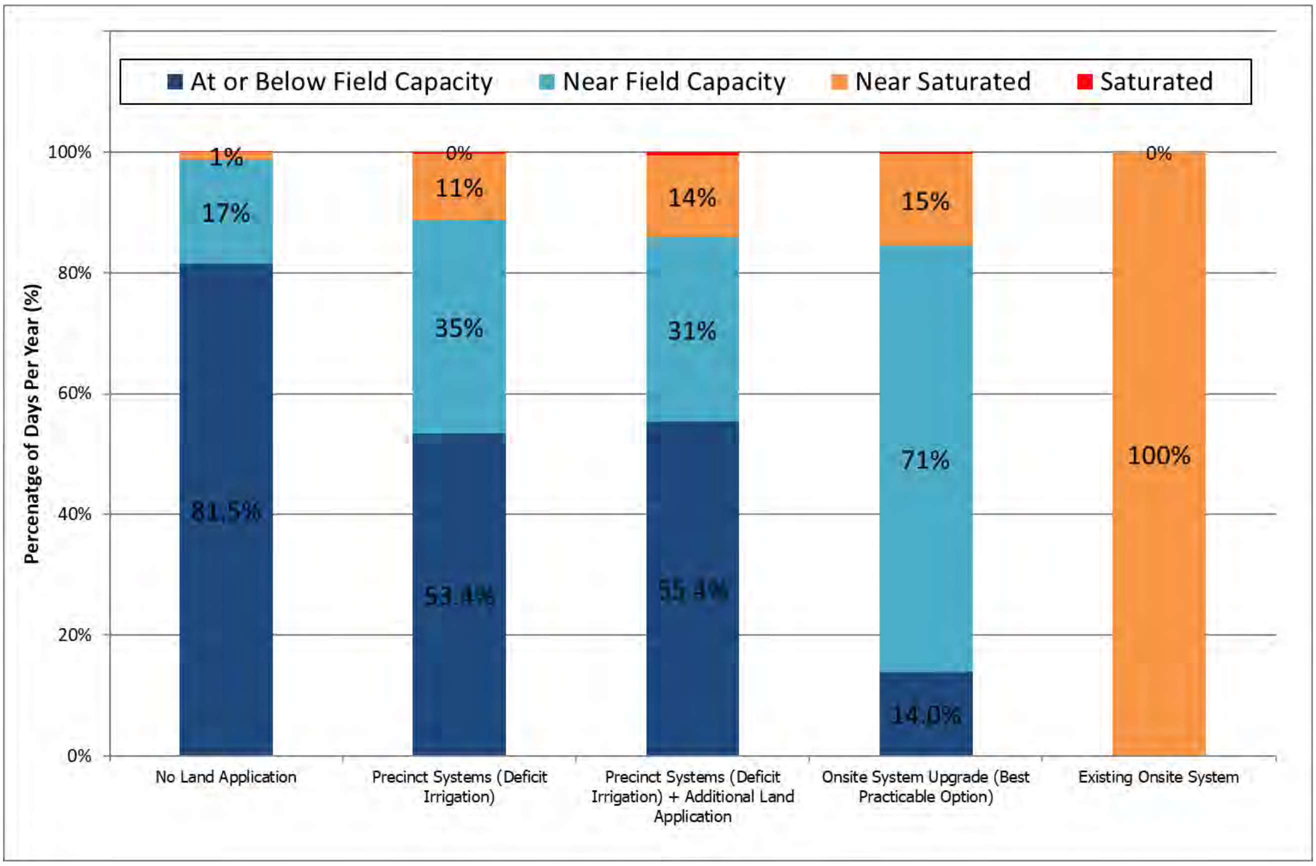

Figure 20 MEDLI Modelling Soil Water Balance Results

It can be seen that minimal saturation of the irrigation areas will occur given the conservative application rates and scheduling adopted for the proposed systems. Importantly, any recycled water irrigation (including a beneficial reuse irrigation schedule) will alter the amount and frequency of deep drainage by keeping soil 'wetter' more often. The difference in soil water regime between the deficit irrigation scenario and the approach proposed here is incremental. It can also be seen that the proposed solution is **not** comparable to a traditional on-site system which load soils at much higher rates.

5.6.4 High Level Recycled Water Risk Assessment

Public health risks associated with off-site export of pathogens or other toxicants will readily be addressed through the attenuation of pathogens and contaminants within the PRS and as lateral flow to receptors. As an added barrier of protection, it is recommended that Ultraviolet disinfection be included at the treatment system. Public health risks relating to access to the irrigation site by operators and members of the public should be addressed in accordance with the *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks* (Phase 1) (EPHC, 2006).

A screening level risk assessment has been undertaken for the Penshurst scheme in accordance with EPHC (2006) using the standard tables in Chapter 3. The proposed activity is best classified as "Landscape Irrigation" under the guidelines (Table 3.8).

Table 20 Summary of Screening Level Risk Assessment

Hazard	Likelihood / Consequence	Maximal Risk	Treatment	Residual Risk (Post Treatment)
Discharge of water with elevated nutrient, organic and faecal coliform concentrations due to overflow of storage tanks.	Unlikely / Major	High	Regular system inspection. Remote alarm alerting operators of high effluent levels. Upstream storage capacity in system.	Low
PRS Treatment Failure	Possible / Moderate	High	Remote monitoring and control of PRS Low wet weather infiltration sewer Robust, low risk treatment technology	Low
Runoff or excessive leaching of pollutants from irrigated zones due to over irrigation and poor management.	Unlikely / Moderate	Moderate	Automation and telemetry. Climate and soil water monitoring Subsurface irrigation. Deficit irrigation approach. Risk modelling used to determine conservative loading rates.	Low
Salinity and sodicity impacts.	Unlikely / Minor	Moderate	Conservative irrigation scheduling. Risk modelling informing design. Automation and telemetry. Soil lab analysis indicates low salinity / sodicity risks.	Low
Health impacts due to off-site export of pathogens in deep drainage.	Rare / Major	High	Significant log reduction in viruses / protozoa / bacteria, as per targets (EPHC, 2006) – refer Table 21 below. Secondary treatment (minimum). Subsurface irrigation. Restricted access / overnight irrigation. Withholding periods. Setback distances.	Low
Health impacts due to contamination of effluent irrigated grassed area and infection of persons due to inappropriate contact.	Rare / Major	High		Low
Pipe bursts / emergency overflow creating potential for human contact.	Unlikely / Moderate	Moderate	Active disinfection (UV).OH&S Procedures / PPE. Subsurface pipework.	Low

Table 21 Assumed Treatment Log Reductions for Proposed Solution

Measure	Viruses	Protozoa	Bacteria
Treatment Measures[1]			
Secondary Treatment (Class C) – conservative	0.5 – 2	0.5 – 2	1 – 3
Disinfection (UV)	1 – 3	>3	2 – 4
On-site Preventive Measures[2]			
Subsurface irrigation of grassed areas.	4		
Withholding periods (1-4 hours)	1		
No public access during irrigation, limited contact after.	2 – 3		
TOTAL (Target)[3]	9 – 13 (5)	11 – 14 (3.5)	10 – 15 (4)

Note 1: As per Table 3.4 (EPHC, 2006).

Note 2: As per Table 3.5 (EPHC, 2006).

Note 3: As per 'Landscape Irrigation' in Table 3.8 (EPHC, 2006).

Note 4: It is considered good practice to cap the assumed log reduction from any single control or treatment measure at 4 log to avoid a high level of reliance on any single control.

Based on this high level risk assessment, it can be seen that the proposed Recycled Water systems provide suitable factors of safety and barriers of protection to ensure (subject to appropriate management) that risks to human health are managed.

5.6.5 Hydrology Assessment

Initial analysis has been undertaken to assess the potential changes to existing hydrology within the broader sub-catchments of Penshurst township. Specifically given the Penshurst Recycled Water Solution involves reuse across the township, potential alteration in baseflow to local ephemeral waterways and drainage depressions has been considered.

Existing onsite wastewater management (septic) systems will already be contributing to existing baseflow via both on-lot effluent land application and discharge to stormwater drainage. This has been factored into the assessment given the existing systems will be decommissioned (or upgraded for a small number of properties) as part of the Penshurst Solution. The existing situation has been assessed based on an assumed four bedroom dwelling on each property to provide a consistent comparison with the Penshurst Recycled Water Solution (given it has been designed on this basis).

The indicative water balance (hydrology) assessment undertaken involves consideration of the following elements of the hydrologic cycle:

- Total runoff, consisting of;
    - o Baseflow
    - o Surface Runoff
- Evapotranspiration (not considered for conservatism).

A summary of the water balance input parameters is provided in Table 22 based on the hydrology and catchments shown in Figure 21, which are general in nature given it is a high-level assessment. This includes consideration of the specific sub-catchment (and existing onsite systems) draining directly to the Penshurst Wetlands as this has been mentioned by the community as a key issue.

Table 22 Hydrology Assessment Inputs Summary

<table>
<tr><th>Input</th><th>Sub-catchment 1 (Western)</th><th>Sub-catchment 2 (Eastern)</th><th>Wetlands Sub-catchment (within SC2)</th></tr>
<tr><td>Mean Annual Rainfall (mm)</td><td colspan="2">725</td><td>725</td></tr>
<tr><td>Catchment Area (ha)</td><td>180</td><td>253</td><td>44</td></tr>
<tr><td>Total RW Irrigation Area (ha) – Current Properties</td><td>6.37</td><td>6.33</td><td>3.93</td></tr>
<tr><td>Baseflow Index</td><td colspan="3">0.2</td></tr>
<tr><td>Catchment Impervious Fraction</td><td colspan="2">0.3 (approx.)</td><td>0.5 (approx.)</td></tr>
</table>

The results of the hydrology assessment are provided in Table 23 below. It can be seen that an overall improvement in the catchment hydrology is anticipated. Given the current onsite systems are typically not performing adequately due to constraints across the town, the proposed Penhurst Solution will provide a significant improvement in the relative volume (and quality) of treated water entering the soil and broader environment (including Penhurst Wetlands).

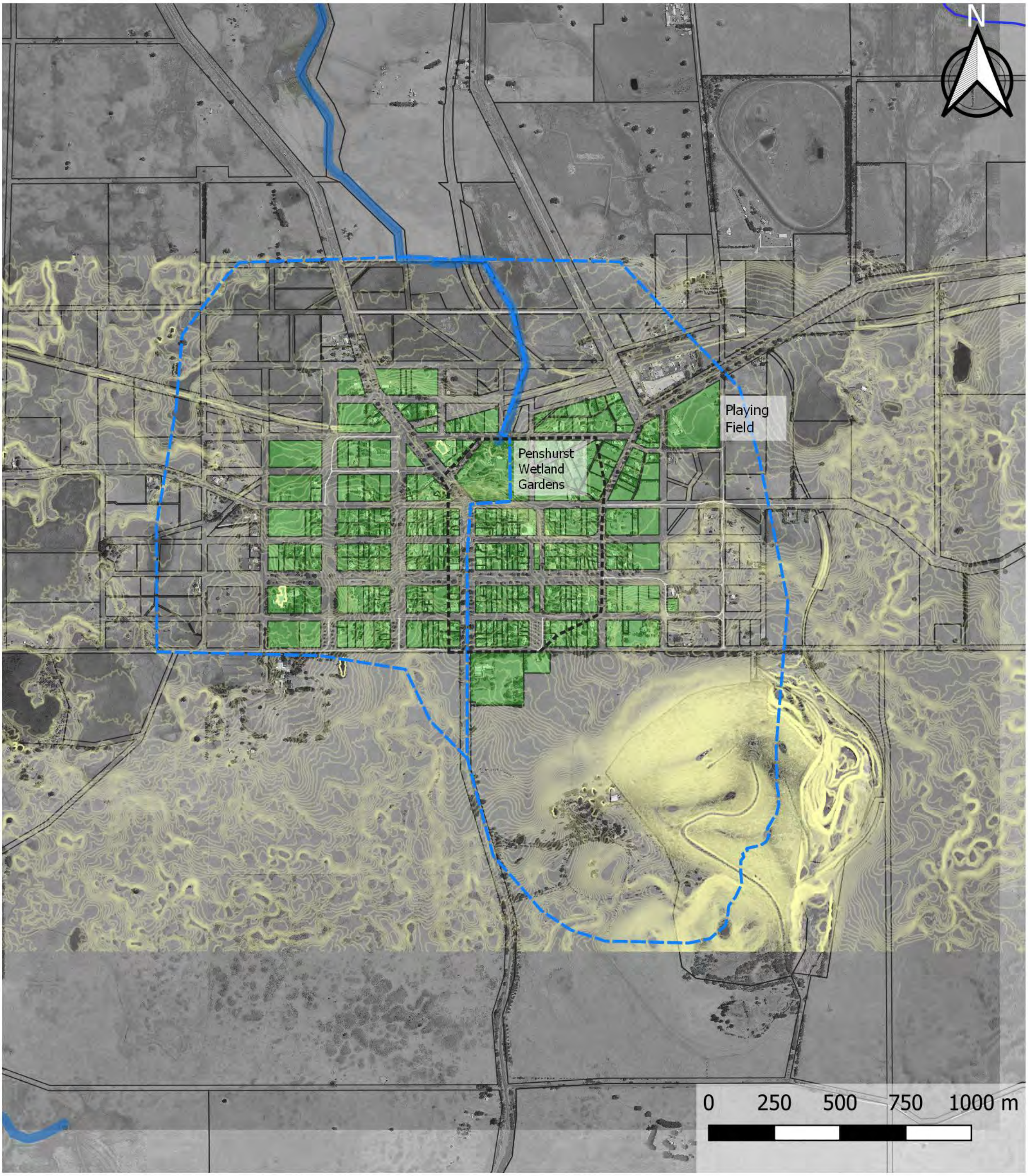

Figure 21: Penshurst - General Hydrology Catchments

Legend

Property Boundary

Intermittent Watercourse

Service Area Properties (Current & Future)

Broader Penshurst Catchments

Penshurst Wetland Subcatchment

Elevation Contours (0.5m)

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Table 23 Hydrology Assessment Summary (Catchments)

Parameter	Sub-catchment 1 (Western)		Sub-catchment 2 (Eastern)	
	Average	75th Percentile (*Upper Irrig.*)	Average	75th Percentile (*Upper Irrig.*)
Existing Baseflow Index (incl. Existing Onsite Systems)	0.25		0.24	
Natural Baseflow Index (Pre-existing)	0.2		0.2	
Annual Runoff Fraction	0.39		0.39	
Total Annual Runoff (ML)	508		711	
Mean Annual Baseflow (ML)	128		172	
Annual Surface Runoff (ML)	380		539	
Mean Annual Baseflow (ML) from Existing Onsite Systems	32.7		37.3	
Annual Baseflow Volume Reduction (ML)[1]	-21	-11.7	-25.8	-16.5
New Baseflow Index	0.22	0.23	0.21	0.22
New Mean Annual Baseflow (ML)	107	116	146	156
% Change in Mean Annual Baseflow	-16%	-9%	-15%	-10%
New Annual Runoff Fraction	0.38	0.38	0.37	0.38
New Total Annual Runoff (ML)	487	496	686	695
% Change in Total Annual Runoff	-4%	-2%	-4%	-2%

Note 1: With baseflows and off-site discharge removed from decommissioned existing onsite systems.

Table 24 Hydrology Assessment Summary (Penshurst Wetlands)

Parameter	Wetlands Sub-catchment (within SC2)	
	Average	75th Percentile (*Upper Irrig.*)
Existing Baseflow Index (incl. Existing Onsite Systems)	0.31	
Natural Baseflow Index (Pre-existing)	0.2	
Annual Runoff Fraction	0.59	
Total Annual Runoff (ML)	186	
Mean Annual Baseflow (ML)	58	
Annual Surface Runoff (ML)	128	
Mean Annual Baseflow (ML) from Existing Onsite Systems	25.9	
Annual Baseflow Volume Reduction (ML)[1]	-18.8	-13
New Base Flow Index	0.23	0.26
New Mean Annual Baseflow (ML)	39	45
% Change in Mean Annual Baseflow	-32%	-22%
New Annual Runoff Fraction	0.53	0.55
New Total Annual Runoff (ML)	167	173
% Change in Total Annual Runoff	-10%	-7%

Note 1: With baseflows and off-site discharge removed from decommissioned existing onsite systems.

5.7 Existing Services Investigations

Dial Before You Dig (DBYD) enquiries were made to determine existing services within Penshurst. The following is a summary of key agencies with utilities in the township. SGSC have indicated stormwater asset data is limited and incomplete and therefore field identification is recommended.

Table 25 Penshurst Existing Services

Agency	Service
Wannon Region Water Corporation (Wannon Water)	Water
Southern Grampians Shire Council	Roads, Stormwater Assets (limited data)
Powercor - Warrnambool	Electricity
Telstra VICTAS	Communications

The scope for any service field confirmation is limited to desktop for functional design and completed by contractor as part of next phase. This available BDYD data was utilised within GIS to approximate the location of infrastructure and necessary setbacks required for the functional design.

5.8 Siting and Easement Assessment

Proposed sewer alignments have been determined based on best available (Dial Before You Dig) information as discussed above in Section 5.7, along with information collected in the field.

Gravity sewer will be predominantly installed within road reserves where possible. When located within private property, the gravity sewer will be installed within a new easement (to be determined as part of Detailed Design phase). This will include any easement acquisition and vehicle access requirements.

In addition, Precinct water reuse irrigation areas has been sited and sized utilising the DBYD information to ensure sufficient setbacks to existing services can be accommodated.

Existing topographical data has been utilised for functional design of the Penshurst system and infrastructure. This includes high resolution 0.5m elevation contours available from SGSC to create a DEM along with confirmation via Vicmap 20m Digital Terrain Model available online. Additional sections of the Service Area will be surveyed as part of detailed design.

The sewer alignments developed for the functional design are presented in Figure 9 to Figure 19.

5.9 Safety in Design

A key safety aspect for the operational phase of the Penshurst Wastewater System is access to maintenance sewer access points (SAPS). ALL SAPs are to be accessed via a winch which comes off a Davit arm supported by a mounting cast at the top of the structure (as per Wannon Water specifications). Appropriate barriers will be installed as per Wannon Water requirements, with a tether point for fall prevention. All maintenance hole depths are expected to be less than 4m. All access points in the system will have appropriate Confined Space Entry (CSE) procedures in accordance with *Occupational Health and Safety Regulations 2007.*

Construction risk is viewed as being at a standard level with respect to trenching and boring activities. Typical safety hazards include:

- Trench collapse
- Fall from heights
- Slips, trips & falls
- Traffic
- Existing services (including overhead services)
- Plant and equipment

A formal safety in design assessment will be undertaken in the next phase of design (Detailed Design).

5.10 Odour, Ventilation and Corrosion Assessment

A preliminary odour, ventilation and corrosion assessment has been completed for the proposed sewer system based on general detention times, which have been calculated for the small length of pressure sewer and gravity discharge points. The sewer design presented in the Functional Design Drawings (Appendix C) has been undertaken to minimise septicity via ensuring adequate minimum grades are maintained, avoiding turbulence and providing adequate ventilation (as necessary).

Key items identified from this preliminary assessment include:

- The majority of the proposed sewer system will be open (vented sewers) with a minority of closed sewer (vented through boundary traps).
- Where any of the new pressure sewers connects into the gravity sewer, the receiving manhole shall be vented.
- Where the average detention time exceeds 4 hours, further assessment is required to determine if air filtering is required and appropriate equipment.

These sewer design elements will be finalised as part of Detailed Design. However, the very small sewer catchment size limits the potential for odour and corrosion impacts as detention times are short.

The Precinct Recycling Systems (ET pods, recycled water storage, POS irrigation) will be sealed units and are designed to minimum odour. Vegetated systems rarely display odour issues due to the odour adsorption and suppression provided by the vegetation.

5.11 Native Flora and Fauna

A small zone of endangered vegetation (to the south of township) is mapped within the low-resolution *Native Vegetation - Modelled 2005 Ecological Vegetation Classes* mapping data. However desktop review confirmed vegetation areas of significant ecological value are not identified as a key constraint with the Penshurst Service Area. Next steps as part of following design phase will include detailed flora and fauna survey of Penshurst Gardens and interconnected drainage paths and depressions.

Based on the results of the preliminary assessment the following environmental approvals may be required:

- A permit will need to be obtained from Southern Grampians Shire for the removal of vegetation
- A 'Permit to Take' will likely need to be obtained from DELWP for the removal of protected and listed flora species from Public Land (not expected).

5.12 Contaminated Land Assessment

Previous groundwater contamination assessments have been undertaken for the local CFA facility which is located adjacent to the Penshurst township Service Area.

No existing historical information on potential soil contamination has been identified for properties within the township Service Area. This is to be identified further as part of detailed design.

5.13 Flooding

Based on planning layers (Land Subject to Inundation) for the township along with flood information available from SGSC, flooding is not a constraint for Penshurst township.

5.14 Communication and Engagement Considerations

An engagement plan for this Project was previously prepared for Wannon Water and involved engagement at the various stages of the project. The intention is for consultation with the Penshurst community and stakeholders on the outcomes of the functional design.

The key stakeholders which are involved in this design and will require further consultation are summarised in the following table.

Table 26 Stakeholder Summary

Stakeholder	Consultation / Further Details to be Discussed	Status
Residents / Property owners	- Next stage of engagement to be undertaken. - Consultation on design and proposed system layouts.	Managed by PCG.
PCG	- Discussion with SGSC on planning permits possibly required. - Discussion of potential easement locations. - Discussion with DELWP on any planning permits involving vegetation removal.	Comments following Functional Design review.
DELWP	- Flora and fauna impact assessment taking into account impacts on any threatened species, populations, ecological communities and/or critical habitat.	Not a key constraint based on current information.
EPA Victoria	- Further discussion on proposed Recycled Water systems locations and characteristics.	Comments following Functional Design review.
Aboriginal Affairs Victoria	- Input into design and locations (as necessary). - Potential Aboriginal Cultural Heritage Assessment and Community Consultation (as necessary).	Discussion with PCG.
Heritage Victoria	- Following up with SGSC for any heritage sites.	Managed by PCG.

6 Cost Estimates

Cost estimates where developed for the functional design for each broader component of the Penshurst system. Upper and lower capital delivery cost estimates are provided in the table below.

Table 27 Capital Expenditure (CAPEX) Estimate Summary

	CAPEX (Lower)	CAPEX (Upper)
On Property Infrastructure	$444,000	$444,000
Collection Infrastructure	$3,511,420	$4,967,220
Treatment & Storage	$2,437,247	$2,437,247
Effluent Management / Reuse	$1,100,000	$1,100,000
Total Estimated Costs	*$7,492,667*	*$8,948,467*
Investigation & Design (20%)	$1,498,533	$1,789,693
Contingency / Overheads (30%)	$2,247,800	$2,684,540
TOTAL DELIVERY COST	**$11,239,000**	**$13,422,700**

In addition, estimates were developed for the operational / maintenance costs for each overall component of the Penshurst system, as summarised in the following table.

Table 28 Operational Expenditure (OPEX) Estimate Summary (2020$)

	OPEX (Lower)	OPEX (Upper)
On-site Wastewater System Upgrades (x 12)	$11,760	$15,290
On-property STEP units (transfer to gravity) (x 18)	$5,515	$7,170
Gravity sewer	$18,800	$24,440
STEP Pump Stations (x 3)	$4,425	$5,750
Cluster Rhizopods™ and RW Storage	$30,270	$39,350
POS Subsurface Irrigation	$21,565	$28,030
RW Transfer System	$5,900	$7,670
Central Land Treatment System (Recreational Reserve)	$34,985	$45,480
TOTAL OPERATING COSTS (per annum)	**$133,210**	**$173,170**

6.1 Governance and Funding

The Project Control Group are currently in the process of finalising a potential governance and funding model for the Penshurst wastewater solution. Current discussions are centred around Wannon Water being the preferred agency to deliver and manage the Penshurst Solution. Potential models include Wannon Water managing the sewer and treatment assets and Public Open Space Irrigation and Southern Grampians Shire Council having ongoing management of effluent area vegetation. The selection of effluent area vegetation could potentially be completed via consultation between both parties.

7 Project Risks and Controls

The purpose of the following table is to highlight any risks that are evident at this stage of the project and make suggestions on how they will be managed as the project progresses through the detailed design phase. It is envisaged that a formal Risk and Controls Register be developed should the project progress beyond the Functional Design stage.

Table 29 Project Risks and Controls Summary

Project Risk	Significance?	Recommended Controls	Resources
Geotechnical - Rock depth uncertainty	**Yes (Major)**	Contractor to obtained detailed bore logs as part of detailed design to confirm influence of rock depth on sewer and system construction.	Contractor bore logs to be obtained.
Land Capability Assessments	**Yes (Major)**	Land Capability Assessments to be undertaken for all proposed reuse areas – to conducted as part of depth to rock assessments.	Contractor TBC
Siting Assessment	**Yes (Major)**	Final fieldwork to confirm easements and pipe alignments.	Contractor TBC
Existing Services	**Yes (Moderate)**	Confirm locations relevant to works access.	DWC; approved services locator.
Survey	**Yes (Moderate)**	Survey for key sections of pipe alignments.	Registered surveyor
Contaminated Land Assessment	**Yes (Moderate)**	Confirmation of current assessment with CFA.	SGSC and CFA
Heritage Assessment	**TBC**	Confirm with Gunditj Mirring Traditional Owners as to the heritage status within town and need for further assessment.	PCG; Traditional Owners
Flora and Fauna Assessment	**TBC**	Confirm with SGSC, unlikely to be key constraint.	PCG; DWC
Flood Assessment	**No**	Not required.	-

8 Key Detailed Design Requirements

In addition to the standard detailed design requirements and project risk and control register provided above, the following key activities are of importance.

8.1 Community / Agency Consultation

Given the keen interest with the community in this project, they will need to be informed early on and through the design process, in particular regarding the following elements;

- Sewer servicing strategy for each property (i.e. off-site or on-site);
- Gravity sewer alignments through and adjacent to properties; and
- Connection point locations for each property (notification during construction phase).

As discussed engagement with key agencies such as EPA Victoria have already taken place and will ensure steady progress through the detailed design and approval phase.

8.2 Stormwater Management

Details of upslope stormwater diversion drainage (including subsoil drainage) will be necessary for a number of key reuse areas, given the shallow rock consistently recorded.

9 References

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Environment Protection and Heritage Council (2006) *Australian Guidelines for Water Recycling: Managing Health and Environmental Risk (Phase 1)*. Natural Resource Management Ministerial Council and Environment Protection and Heritage Council.

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EPA Victoria (2016) *Code of Practice for Onsite Wastewater Management*. EPA Publication 891.4.

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Standards Australia (2012) *AS/NZS1547:2012 On-site domestic wastewater management.* Standards Australia.

USEPA (2003) *Voluntary National Guidelines for Management of On-site and Cluster (Decentralised) Wastewater Treatment Systems*. USEPA. http://water.epa.gov/scitech/wastetech/upload/septic_guidelines.pdf

Victorian Auditor General (2006) *Protecting our environment and community from failing septic tanks*, Victorian Government.

Victorian Auditor-General's Office (2015) *Water Entities 2014-2015 Audit Snapshot*, Victorian Government.

Water Services Association of Australia (WSAA) Gravity Sewerage Code of Australia (Version 2.0, 2014-3.1)

Appendix A Land Capability Assessment

LCA Assessment Table

Property ID:	Penshurst Wastewater Solution - Township Systems
Property Address:	Penshurst, VIC
Date Completed:	15/07/2020
Overall Land Capability Class Rating:	**Moderate to Major**

Land Feature	**Description**	**Value**	**LCA Rating**	**Outcome**
Site Characteristics				
Aspect	North / North-East	North / North-East / North-West	Minor	No impact on design.
Exposure	High exposure	Full sun and/or high wind or minimal shading	Minor	No impact on design.
Climate	Penshurst, VIC	Excess of rainfall over evaporation in the wettest months	Major	Constraint can be managed by adopting a conservative Design Loading Rate (DLR).
Erosion potential	None observed. No Erosion Management Overlay.	Nil or minor	Minor	No impact on design.
Fill	Imported fill likely to be required due to shallow rock observed in adajcent historical test pits.	-	Major	Minimum of 100-200mm imported good quality fill required across the irrigation area.
Flood inundation frequency	-	Less than 1 in 100 years	Minor	No impact on design.
Groundwater bores	Groundwater bores located across Penshurst. Reuse areas not located upslope of bores. Minimum 30m setback able to be achieved.	Setback distance from bore complies with requirements in EPA Code of Practice 891.3 (as amended)	Moderate	Bores to be confirmed as part of detailed design. Not expected to be a major constraint.
Landslip	None observed.	Nil	Minor	No impact on design.
Rock outcrops (% coverage)	Shallow rock and bolders key constraint across township.	>20%	Major	Rock to be avoided where possible. Raising of reuse areas (100-200mm min.) with fill required due to common shallow rock across the area.
Slope form	Generally linear slope across site. Convergent slopes directly east of site.	Straight side-slopes	Moderate	Steeper convergent slopes to the east to be avoided.
Slope gradient (%)	Slopes typically <5% across township (1-2% average).	<10%	Minor	Subsurface irrigation preferred land application option for reuse areas.
Soil drainage (qualitative)	Shallow, strongly structured silty loam to clay loam. Slighty moist just below ground surface.	Some signs or likelihood of dampness	Moderate	Inspection undertaken in summer during warmer weather. Upslope and downslope stormwater diversion drainage to be installed as needed. Conservative Design Loading Rate to be adopted.
Soil drainage class		Moderately well drained. Water removed somewhat slowly in relation to supply, some horizons may remain wet for a week or more after addition	Moderate	
Stormwater run-on	Potential for upslope stormwater run-on.	Moderate likelihood of inundation by stormwater run-on	Moderate	Ensure all upslope run-on is diverted as required (as discussed above).
Surface waters - setbacks	Minimum 3m setback achievable to Council stormwater drainage swales.	Setback distance complies with requirements in EPA Code of Practice 891.3 (as amended)	Minor	Setback able to be achieved - performance modelling to be undertaken to demonstrate impacts to downstream receptors and human health risks are acceptable in accordance with EPA requirements.
Vegetation	Grassed areas with large, established trees along large road reserves.	Plentiful vegetation with healthy growth and good potential for nutrient uptake	Minor	Large tree to be avoided for reuse areas where necessary.
Soil Characteristics				
Electrical conductivity (dS/m)	0.4-1.6	0.8 - 2	Minor to Moderate	Non saline soils.
Emerson aggregate class (in context of sodicity)	3 (slaking 1) and 7 (topsoil)	7	Minor / Moderate	Not considered a constraint - low sodicity risk
Gleying	None observed	Nil	Minor	No impact on design.
Mottling	None observed	Very well to well-drained soils generally have uniform brownish or reddish colour	Minor	Stormwater diversion drainage to be installed to capture upslope run-on and subsoil drainage. Category 6 Soil DLR (conservative) to be adopted
pH	6.05-6.5 (Slightly acidic)	5.5 - 8 is the optimum range for a wide range of plants	Minor	No impact on design.
Rock fragments (%)	Gravel and rock typically present in soil profile.	>20%	Major	Rock to be avoided where possible. Raising of reuse areas (100-200mm min.) with fill required due to common shallow rock across the area.
Sodicity (ESP)	1.6 - 3.3%	<6%	Minor	Soils are non-sodic.
Depth to rock (m)	Shallow depth to bedrock or bolders is common constraint across township.	<1 m	Major	Able to be managed with diversion and shallow or raised land application.
Soil structure (pedality)	Strongly structured throughout profile	Moderately to highly structured	Minor	
Soil texture, indicative permeability	Strongly structured silty loam to clay loam.	Cat. 2b, 3a, 3b, 4a	Minor	Suitable soils for effluent reuse.
Watertable depth below base of LAA (m)	Perched watertable likely to occur along shallow rock.	<1.5 m	Major	Upslope diversion drainage required. Adopt conservative DLR (cat 6).
Phosphorus sorption capacity	>1,110 mg/kg (at 70%)	Very High	Minor	Very high P-sorption capacity.

LCA Assessment Table

Property ID:	Penshurst Wastewater Scheme - Penshurst Reserve and Adjacent Southern Reuse Site
Property Address:	Penshurst, VIC
Date Completed:	15/07/2020
Overall Land Capability Class Rating:	**Minor to Moderate**

Land Feature	Description	Value	LCA Rating	Outcome
Site Characteristics				
Aspect	North	North / North-East / North-West	Minor	No impact on design.
Exposure	High exposure	Full sun and/or high wind or minimal shading	Minor	No impact on design.
Climate	Penshurst, VIC	Excess of rainfall over evaporation in the wettest months	Major	Constraint can be managed by adopting a conservative Design Loading Rate (DLR).
Erosion potential	None observed. No Erosion Management Overlay.	Nil or minor	Minor	No impact on design.
Fill	Imported fill likely to be required due to shallow rock recorded within test pits (360 to 420mm below ground).	-	Major	Minimum of 100-200mm imported good quality fill required across the irrigation area.
Flood inundation frequency	-	Less than 1 in 100 years	Minor	No impact on design.
Groundwater bores	Groundwater bores located across Penshurst. Irrigation bore used for reserve to be confirmed.	Setback distance from bore complies with requirements in EPA Code of Practice 891.3 (as amended)	Moderate	Bores to be confirmed as part of detailed design and decommissioned if necessary. Not expected to be a major constraint.
Landslip	None observed.	Nil	Minor	No impact on design.
Rock outcrops (% coverage)	Shallow rock and bolders key constraint across township.	>20%	Major	Rock to be avoided where possible. Raising of reuse areas (100-200mm min.) with fill required due to common shallow rock across the area.
Slope form	Linear slope form.	Straight side-slopes	Moderate	Not a contraint
Slope gradient (%)	Slopes typically <5% across township - minor slopes (~1%) across Reserve and eastern section of study area.	<10%	Minor	Subsurface irrigation preferred land application option for reuse areas.
Soil drainage (qualitative)	Shallow, strongly structured silty loam to clay loam. Slighty moist just below ground surface.	Some signs or likelihood of dampness	Moderate	Inspection undertaken in summer during warmer weather. Upslope and downslope stormwater diversion drainage to be installed as needed. Conservative irrigation Design Loading Rate to be adopted.
Soil drainage class		Moderately well drained. Water removed somewhat slowly in relation to supply, some horizons may remain wet for a week or more after addition	Moderate	
Stormwater run-on	**Stormwater run-on potential from steeper upslope areas.**	High likelihood of inundation by stormwater run-on	Major	Ensure all upslope run-on is diverted as required (as discussed above) - to be included in detailed design.
Surface waters - setbacks	**Small constructed stormwater drain** tranversing through southern reuse area. Minimum 5-10m setback to be maintained.	Setback distance complies with requirements in EPA Code of Practice 891.3 (as amended)	Minor - Moderate	Setback able to be achieved - performance modelling to be undertaken to demonstrate impacts to downstream receptors and human health risks are acceptable in accordance with EPA requirements.
Vegetation	Grassed areas with minimial vegetation.	Plentiful vegetation with healthy growth and good potential for nutrient uptake	Minor	Areas very suitable for irrigation - Large trees to be avoided where necessary.
Soil Characteristics				
Electrical conductivity (dS/m)	0.4-1.6	0.8 - 2	Minor to Moderate	Non saline soils.
Emerson aggregate class (in context of sodicity)	3 (slaking 1) and 7 (topsoil)	7	Minor / Moderate	Not considered a constraint - low sodicity risk
Gleying	None observed	Nil	Minor	No impact on design.
Mottling	None observed	Very well to well-drained soils generally have uniform brownish or reddish colour	Minor	Stormwater diversion drainage to be installed to capture upslope run-on and subsoil drainage. Category 6 soil DLR (conservative) to be adopted
pH	6.05-6.5 (Slightly acidic)	5.5 - 8 is the optimum range for a wide range of plants	Minor	No impact on design.
Rock fragments (%)	Gravel and rock typically present in soil profile.	>20%	Major	Rock to be avoided where possible. Raising of reuse areas (100-200mm min.) with fill required due to common shallow rock across the area.
Sodicity (ESP)	1.6 - 3.3%	<6%	Minor	Soils are non-sodic.
Depth to rock (m)	Shallow depth to bedrock or bolders is common constraint across township.	<1 m	Major	Able to be managed with stormwater diversion and raised land application.
Soil structure (pedality)	Strongly structured throughout profile	Moderately to highly structured	Minor	
Soil texture, indicative permeability	Strongly structured silty loam to clay loam.	Cat. 2b, 3a, 3b, 4a	Minor	Suitable soils for effluent reuse.
Watertable depth below base of LAA (m)	Perched watertable likely to occur along shallow rock.	<1.5 m	Major	Upslope diversion drainage required. Adopt conservative DLR (Cat 6).
Phosphorus sorption capacity	>1,110 mg/kg (at 70%)	Very High	Minor	Very high P-sorption capacity.

Appendix B Soil Data & Depth to Rock Summary

ID no.	Address Completed	Depth to Rock / refusal due to basalt floater (m)	Soil Profile	Comment
1	76 Bell Street, Penshurst	0.5	Brown Loam, moderate structure	Basalt boulders present throughout
2	100-102 Bell Street Penshurst	0.2	Brown gravelly sandy loam, massive	Refusal on basalt floater
3	57 Burchett Street, Penshurst	0.1-0.15	Silty brown topsoil	Refusal on basalt floater
4	56 Chesswas Street Penshurst	0.15-0.4	-	Refusal on basalt floater
5	47-51 Cobb Street Penshurst	0.4-0.7	Light Clay, Moderate structure	Refusal on basalt floater
6	101 Cobb street Penshurst	0.1	Silty Topsoil	Refusal on basalt floater
7	33-39 Cox Street Penshurst	0.45-0.65	Black Silty Clay	Refusal on basalt boulder
8	53-55 Cox Street Penshurst	0.4-0.5	Brown / red loam	Refusal on basalt
9	10-13 Hamilton Highway Penshurst	0.4	Loamy topsoil	refusal on rocks and cobbles
10	49 Martin Street Penshurst	0.6	Weakly structured red loam topsoil moderately structured dark red silty clay loam subsoil	
11	9-11 Dunkeld Road Penshurst	0.25	Brown sandy gravelly silt	Refusal on basalt boulder
12	14 Dunkeld Road	0.8	0-300 Clayey Sand 300-500 Clayey Silt 500-800 Silty Clay	Refusal on rock
13	54 Scales Street, Penshurst	0.1-0.4	Silty Topsoil Silty Clay subsoil	Refusal on dense basalt cobbles
14	2-10 Thackery Street, Penshurst	0.2	Silty Topsoil	Refusal on 'Decomposing basalt - impassable with hand auger'
15	18-20 Thackery Street, Penshurst	0.4	Gravelly Sandy Loam	Refusal on Boulder
16	62 Watton Street, Penshurst	0.3-0.5	Clayey Silt	Refusal on Boulder Boulders visible to 300mm depth Local knowledge indicates increasing rock with depth
17	109 Watton Street, Penshurst	0.25	Gravelly Clayey Silt	Refusal on Boulder Boulders to 600mm visible
18	122-124 Watton Street, Penshurst	0.4-0.5	Silt / Clay topsoil	Refusal on rocks / cobbles impassable with hand auger
19	147 Bell Street, Penshurst	0.35	Silty Topsoil	Refusal on Basalt - Impassable with a hand auger
20	150-152 Watton Street, Penshurst	0.6	0-350 Sandy Silty topsoil 350-600mm Silty Sand	Refusal on Rock

Soil Bore Log

Client:	Wannon Water	**Test Pit No:**	**1**		
Locality:	Penshurst	Topography:	Undulaing Plains		
Site Address:	Penshurst Oval	Geology:			
Logged by:	DH	Soil Type:	Shallow Stony Earths, Dark Clays		
Date:	16-January-2020	slope:	~1%	aspect:	NNW
Project:	352	drainage:	Well Drained	exposure:	High
Excavation type:	Hand Auger / Shovel	surface condition:	Raised Playing Field	surface:	Mixed Grass

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structural Grade	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1–0.4			A	Silty Loam - Silty Clay Loam	Strong	Dark Brown	-	-	Slightly Moist	Increasing clay content with depth.
0.5		End of Test Pit at 420mm on Volcanic Bedrock.								
0.6										
0.7										
0.8										
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										
1.6										
1.7										
1.8										
1.9										
2.0										

Soil Bore Log

Client:	Wannon Water	**Test Pit No:**	**2**		
Locality:	Penshurst	Topography:	Undulaing Plains		
Site Address:	Penshurst Oval	Geology:			
Logged by:	DH	Soil Type:	Shallow Stony Earths, Dark Clays		
Date:	16-January-2020	slope:	~1%	aspect:	NNW
Project:	352	drainage:	Well Drained	exposure:	High
Excavation type:	Hand Auger / Shovel	surface condition:	Raised Playing Field	surface:	Mixed Grass

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structural Grade	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1										
0.2			A	Silty Loam - Clay Loam	Strong	Dark Brown	-	-	Slightly Moist	Increasing clay content with depth.
0.3										
0.4		Test pit terminated at 360mm on volcanic bedrock.								
0.5										
0.6										
0.7										
0.8										
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										
1.6										
1.7										
1.8										
1.9										
2.0										

Soil Bore Log

Client:	Wannon Water	**Test Pit No:**	**3**		
Locality:	Penshurst	Topography:	Undulaing Plains		
Site Address:	Watton Street, Penshurst	Geology:			
Logged by:	DH	Soil Type:	Shallow Stony Earths, Dark Clays		
Date:	16-January-2020	slope:	~1%	aspect:	NNE
Project:	352	drainage:	Well Drained	exposure:	High
Excavation type:	Hand Auger / Shovel	surface condition:	Undisturbed	surface:	Mixed Grass

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structural Grade	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP 3/1	A	Silty Loam	Strong	Dark Brown	-	Volcanic rock floaters present	Dry	High organic content.
0.2										
0.3										
0.4		TP3/2	B	Silty Loam	Strong	Red / Brown	-	Gravels and rocks present	Slightly Moist	High organic content. Clay content increasing with depth.
0.5										
0.6		Test pit terminated at 520mm of volcanic rock.								
0.7										
0.8										
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										
1.6										
1.7										
1.8										
1.9										
2.0										

Soil Bore Log

DECENTRALISED WATER CONSULTING

Client:	Southern Grampians Shire Council	**Cutting No:**	**2**		
Locality:	Penshurst	Topography:	Level to gently undulating plain		
Site Address:	-	Geology:	-		
Logged by:	DH	Land Unit:	242 (Unknown)		
Date:	05-February-2019	slope:	1%	aspect:	East-West
Project:	0255	drainage:	Poor	exposure:	High
Excavation type:	Hand Auger / Shovel	surface condition:	Disturbed Paddock	surface:	Mixed Grass

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structural Grade	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1 0.2			A	Loam	Strong	Dark Brown	-	-	Dry	Organics Present Analysis undertaken by excavating a shallow hole (no cutting)
		End of hole at 200mm (extent of excavating equipment)								
0.3										
0.4										
0.5										
0.6										
0.7										
0.8										
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										
1.6										
1.7										
1.8										
1.9										
2.0										

Soil Bore Log

Client:	Southern Grampians Shire Council	**Cutting No:**	**3**		
Locality:	Penshurst	Topography:	Undulating Rises		
Site Address:	-	Geology:	Tertiary Sediments		
Logged by:	DH	Land Unit:	Dundas Redgum		
Date:	05-February-2019	slope:	1%	aspect:	West
Project:	0255	drainage:	Poor	exposure:	High
Excavation type:	Hand Auger / Shovel	surface condition:	Cutting	surface:	Mixed Grass/Bedrock

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structural Grade	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP3/1	A	Loam	Strong	Dark Brown	-	-	Dry	
		End of cutting at 100mm on bedrock								
0.2										
0.3										
0.4										
0.5										
0.6										
0.7										
0.8										
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										
1.6										
1.7										
1.8										
1.9										
2.0										

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Website: http://www.lanfaxlabs.com.au
Lab address: 493 Old Inverell Road
Postal address: PO Box 4690 Armidale NSW 2350
Director: Dr Robert Patterson FIEAust, CPSS, CPAg
Soil Scientists and Environmental Engineers

Lanfax Laboratories

ABN 72 212 385 096
Quality Assurance and Quality Control by Approved Methods

Analysis of Soil Sample for Wastewater System Design

Client... Decentralised Water Consulting *Date* 30th January 2020
Soil sample received 21st January 2020 *Analysis completed*. 30th January 2020
Source of soil:

RESULTS – DWC 0352 Penshurst

(all units in milligrams per kilogram unless otherwise stated)

Parameter /Sample No.	TP 2/1	TP 2/2		Method
Client reference no.				
pH 1:5 in water	6.20	6.47		4A1
pH 1:5 in $CaCl_2$	5.41	5.33		4B1
E.C. (uS/cm)	163	43		3A1
Salinity hazard	Non-saline	Non-saline		Based on EC/Texture
Exch. calcium (mg kg^{-1})	1846	1483		15D3
Exch. potassium (mg kg^{-1})	1082	230		15D3
Exch. magnesium (mg kg^{-1})	612	460		15D3
Exch. sodium (mg kg^{-1})	65	93		15D3
Exch. acidity (cmol(+) kg^{-1})	0.1	0		15 G1.
Cation Exchange Capacity (meq+/100g)	17.4	12.2		calculation
Exch. Sodium Percentage	1.6	3.3		
Sodicity	Non-sodic	Non-sodic		
Base Saturation (%)	99.5	100		
Ca: Mg ratio	1.8	1.9		
Field Texture	Loam	Clay loam		Northcote 1979
Soil Colour (moist)	5YR 2/3 very dark reddish brown	2.5YR 3/3 dark reddish brown		Munsell Colour
Permeability Class	3	4		AS/NZS 1547:2012
LTAR (trenches) mm/day	15-25	10-15		AS/NZS 1547:2012
DLR (irrigation) mm/day	4.0	3.5		AS/NZS 1547:2012
Initial dispersion test	Water stable, swell	Slake 1		SAR5, EC 1 dS/m
Emerson's Aggregate Test	Class 7	*3/6 slake 1		

Reference: Rayment, G.E. and Lyons, D. J.(2011) *Soil Chemical Methods - Australasia.* CSIRO Publishing. Canberra. All methods in accordance with accreditation procedures.

NOTE: The dispersion test is done in solution that represents domestic wastewater, with sodium adsorption ratio of 5 and EC of 1 dS/m.

w/s = water stable in SAR5, EC 1 dS/m solution

Slake - severity of slaking 1,2 or 3. Reported slaking means no dispersion.

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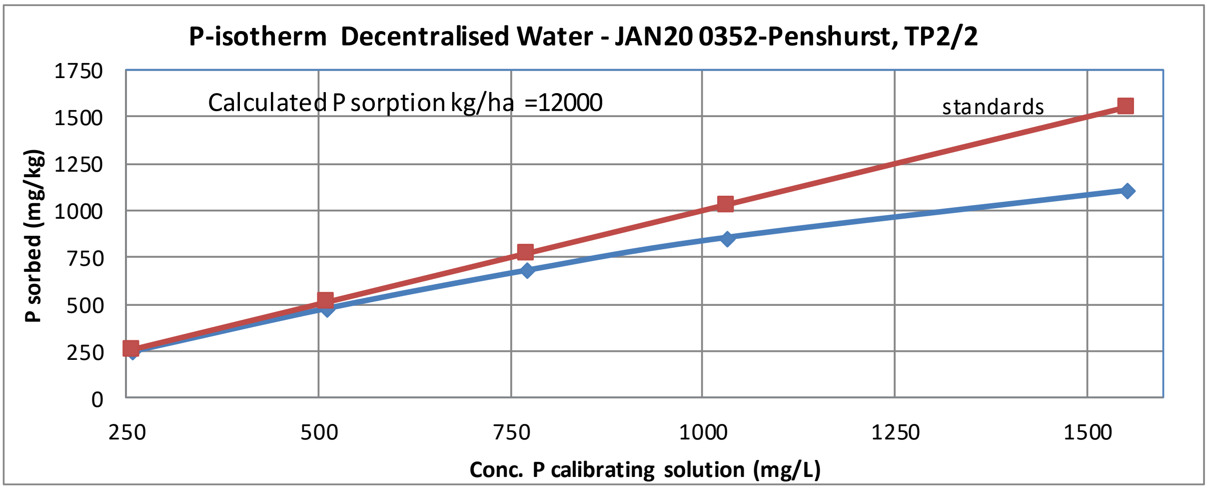

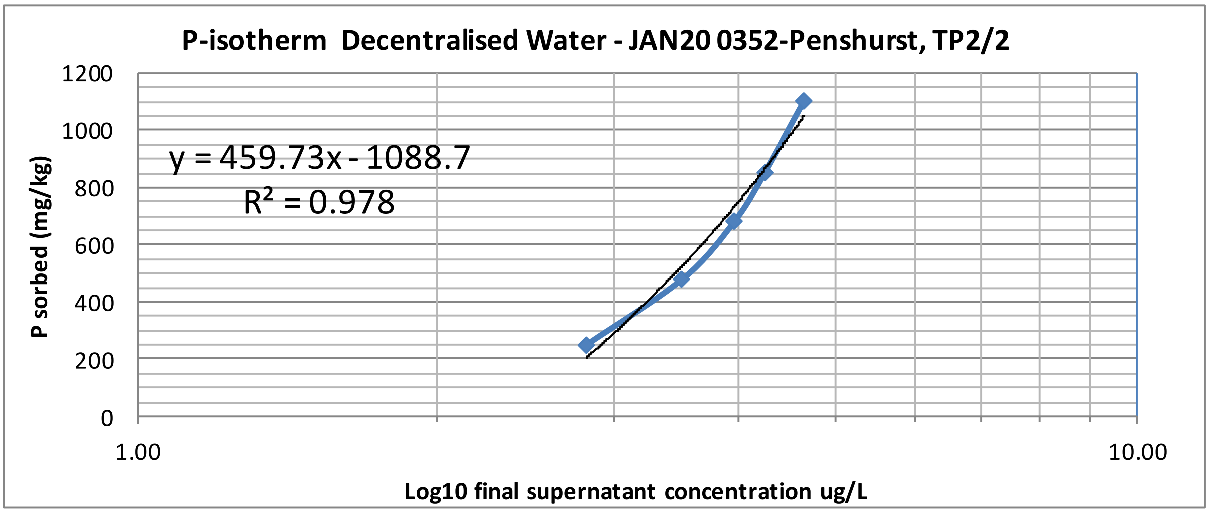

Percent sorbed is the proportion of the initial P sorbed during equilibration

Initial P mgP/L	filtrate P mg/L	sorbed P mg/kg	Sample I.D.	Percent sorbed (%)		Std line	filtrate C ugP/L	X-axis Log C	Y-axis
						P-isotherm Decentralised Water - JAN20 0:			
25.9	0.65	252.4	Decentralised Water - JAN20	97.5		259	651	2.81	252.4
51.2	3.21	479.8	0352-Penshurst, TP2/2	93.7		512	3214	3.51	479.8
77.3	9.06	682.2		88.3		773	9057	3.96	682.2
103.3	17.76	855.5		82.8		1033	17762	4.25	855.5
155.3	44.89	1104.0		71.1		1553	44886	4.65	1104.0

Calculated P sorption kg/ha = 12000

Methods: Rayment & Lyons 2011
pH Method 4A1 (water) 4B1 ($CaCl_2$)
EC Method 3A1
Exchangeable acidity (H^+, Al^{3+}) Method 15 G1
Cation Exchange Capacity Method 15D3 plus exchangeable acidity
Exchangeable sodium percentage ratio sodium to ECEC
P sorption modified method 9J1 - elevated equilibrating solutions, ICP determination of P

RPatterson

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Quality Assurance and Quality Control by Approved Methods

Analysis of Soil Sample for Wastewater System Design

Client... Decentralised Water Consulting *Date* 18th February 2019
Soil sample received 12th February 2019 *Analysis completed*. 18th February 2019
Source of soil:

RESULTS – DWC - 0255 - South Grampians

(all units in milligrams per kilogram unless otherwise stated)

Parameter /Sample No.	TP 3/1			Method
Client reference no.				
pH 1:5 in water	6.05			4A1
pH 1:5 in $CaCl_2$	5.17			4B1
E.C. (uS/cm)	128			3A1
Salinity hazard	Non-saline			Based on EC/Texture
Exch. calcium (mg kg^{-1})	1913			15D3
Exch. potassium (mg kg^{-1})	502			15D3
Exch. magnesium (mg kg^{-1})	408			15D3
Exch. sodium (mg kg^{-1})	69			15D3
Exch. acidity (cmol(+) kg^{-1})	0			15 G1.
Cation Exchange Capacity (meq+/100g)	14.5			calculation
Exch. Sodium Percentage	2.1			
Sodicity	Non-sodic			
Base Saturation (%)	100			
Ca: Mg ratio	2.8			
Field Texture	loam			Northcote 1979
Soil Colour (moist)	7.5YR 2/3 very dark brown			Munsell Colour
Permeability Class	3			AS/NZS 1547:2012
LTAR (trenches) mm/day	15-25			AS/NZS 1547:2012
DLR (irrigation) mm/day	4.0			AS/NZS 1547:2012
Initial dispersion test	Water stable, no swell			SAR5, EC 1 dS/m
Emerson's Aggregate Test	Class 8			

Reference: Rayment, G.E. and Lyons, D. J.(2011) *Soil Chemical Methods - Australasia.* CSIRO Publishing. Canberra. All methods in accordance with accreditation procedures.

NOTE: The dispersion test is done in solution that represents domestic wastewater, with sodium adsorption ratio of 5 and EC of 1 dS/m.

w/s = water stable in SAR5, EC 1 dS/m solution

Slake - severity of slaking 1,2 or 3. Reported slaking means no dispersion.

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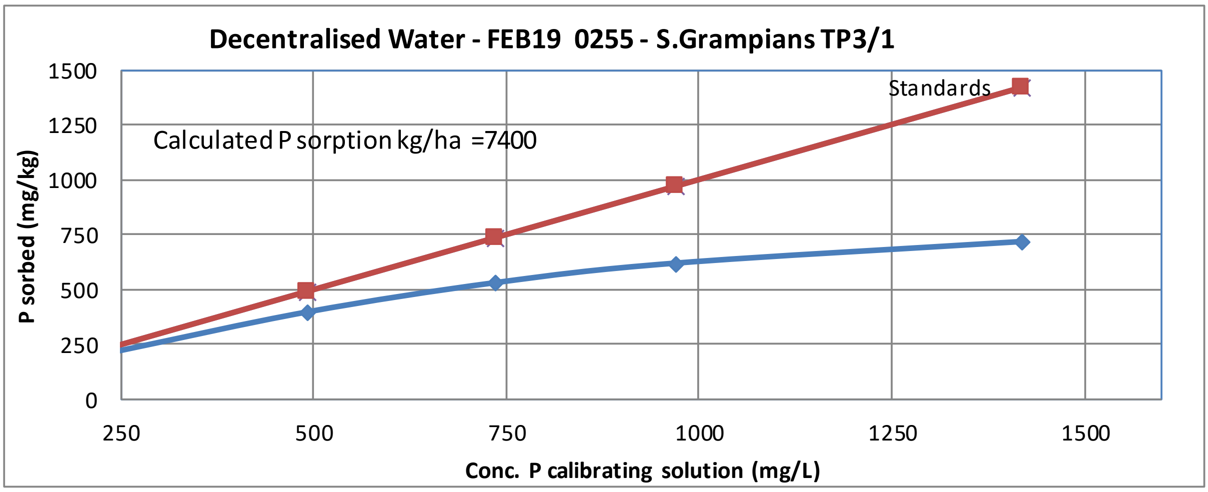
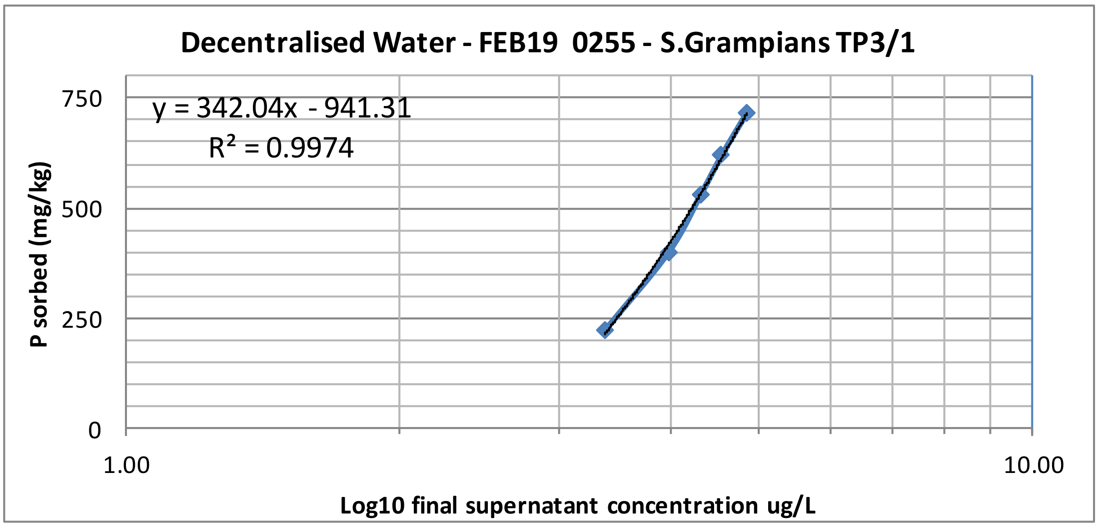




Percent sorbed is the proportion of the initial P sorbed during equilibration						Decentralised Water - FEB19 0255 - S.Gran			
Initial P	filtrate	sorbed P	Sample	Percent		Std line	filtrate	X-axis	Y-axis
mgP/L	P	mg/kg	I.D.	sorbed			C	Log C	
	mg/L			(%)			ugP/L		
24.5	2.37	221.6	Decentralised Water - FEB19	90.3		245	2370	3.37	221.6
49.2	9.26	399.3	0255 - S.Grampians TP3/1	81.2		492	9263	3.97	399.3
73.5	20.35	531.2		72.3		735	20348	4.31	531.2
97.0	35.00	620.1		63.9		970	35004	4.54	620.1
141.8	70.07	717.6		50.6		1418	70069	4.85	717.6
Calculated P sorption kg/ha =			7400						

Methods: Rayment & Lyons 2011
pH Method 4A1 (water) 4B1 ($CaCl_2$)
EC Method 3A1
Exchangeable acidity (H^+, Al^{3+}) Method 15 G1
Cation Exchange Capacity Method 15D3 plus exchangeable acidity
Exchangeable sodium percentage ratio sodium to ECEC
P sorption modified method 9J1 - elevated equilibrating solutions, ICP determination of P

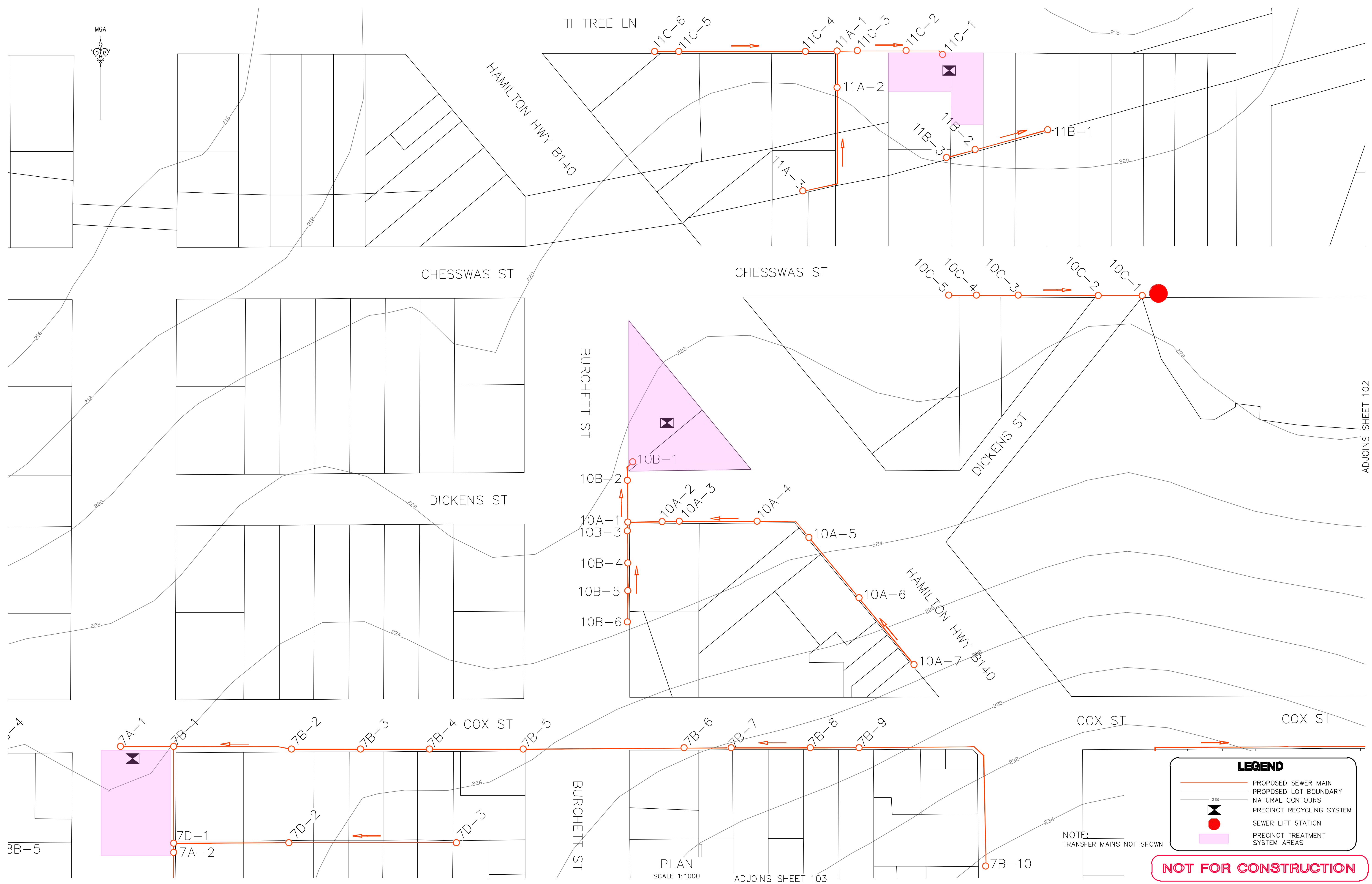
R Patterson

Dr Robert Patterson FIEAust, CPSS(3), CPAgoil Scientist and Environmental Engineer

Appendix C Sewer Functional Design Drawings

Easements for ADWF Design

Precinct	Address	DWC ID	Length of Easement (m)	Total Length of Easement (If across multiple properties)
	2 Martin Street, Penshurst	47	31	
	6 Martin Street, Penshurst	49	19	100
	89 Cobb Street, Penshurst	51	50	
1	83 Cobb Street, Penshurst	42	50	50
	16 Martin Street, Penshurst	55	7	
	86 Cobb Street, Penshurst	52	21	
	84 Cobb Street, Penshurst	50	19	
	82 Cobb Street, Penshurst	48	20	
	81 Watton Street, Penshurst	45	20	182
	80 Cobb Street, Penshurst	43	20	
	78 Cobb Street, Penshurst	40	21	
	74-76 Cobb Street, Penshurst	37	3	
	73-75 Watton Street, Penshurst	1	51	
	64 Cobb Street, Penshurst	133	21	
	66 Cobb Street, Penshurst	137	3	74
2	65 Watton Street, Penshurst	145	50	
	84-86 Watton Street, Penshurst	12	20	
	83 Bell Street, Penshurst	15	20	
	82 Watton Street, Penshurst	10	20	114
	80 Watton Street, Penshurst	8	23	
	79 Bell Street, Penshurst	84	31	
	23 French Street, Penshurst	5	41	41
	22-24 French Street, Penshurst	295	10	
	66 Watton Street, Penshurst	152	20	
	62-64 Watton Street, Penshurst	147	40	
	60 Watton Street, Penshurst	144	15	
	58 Watton Street, Penshurst	140	16	154
	56 Watton Street, Penshurst	136	7	
	23 Scales Street, Penshurst	131	21	
	55 Bell Street, Penshurst	138	4	
	53 Bell Street, Penshurst	134	21	
	48 Watton Street, Penshurst	118	20	
	46 Watton Street, Penshurst	116	21	91
3	28 Scales Street, Penshurst	119	50	
	86 Bell Street, Penshurst	90	36	
	88 Bell Street, Penshurst	94	10	
	92 Bell Street, Penshurst	96	13	133
	36 Martin Street, Penshurst	98	21	
	85 Cox Street, Penshurst	95	53	
	76B Bell Street, Penshurst	317	8	
	78 Bell Street, Penshurst	319	21	
	80 Bell Street, Penshurst	85	19	102
	82B Bell Street, Penshurst	86	16	
	81 Cox Street, Penshurst	89	38	
4	67 Cox Street, Penshurst	303	51	51
	51-57 Chesswas Street, Penshurst	293	82	82
	15 Factory Lane, Penshurst	307	136	136
5	10 Factory Lane, Penshurst	315	49	49
	9 Burchett Street, Penshurst	73	4	
	1 Burchett Street, Penshurst	71	20	60
	9 Burchett Street, Penshurst	73	36	
6	103-105 Watton Street, Penshurst	64 (multiple)	59	59
	122-124 Watton Street, Penshurst	284	40	
	128 Watton Street, Penshurst	128	41	134
	130-132 Watton Street, Penshurst	227	3	
	129-131 Bell Street, Penshurst	224	50	
	22-24 Burchett Street, Penshurst	275	40	40
	97 Bell Street, Penshurst	259	4	
	100 Watton Street, Penshurst	267	20	97
	102 Watton Street, Penshurst	269	20	
	105 Bell Street, Penshurst	268	53	
	35 Martin Street, Penshurst	246	40	68
	97 Cox Street, Penshurst	247	28	
	103 Cox Street, Penshurst	254	51	51
	107 Cox Street, Penshurst	258	51	51
	118-120 Bell Street, Penshurst	212	40	
	124 Bell Street, Penshurst	214	40	160
	126-128 Bell Street, Penshurst	217	41	
7	130-132 Bell Street, Penshurst	219	39	
	150-152 Watton Street, Penshurst	175	50	100
	149-151 Bell Street, Penshurst	236	50	
8	133-135 Cox Street, Penshurst	222	51	51



240124-ENG-101(B)

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B	02/03/2021	REVISED ISSUE	SS	CB	DWC	DWC

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CLIENT
PENSHURST FUNCTIONAL DESIGN

DWC DECENTRALISED WATER CONSULTING

PROPERTY DESCRIPTION
PENSHURST TOWNSHIP
SHIRE OF SOUTHERN GRAMPIANS
VICTORIA

PROJECT
PROPOSED SEWER

PLAN TITLE
SEWER PLAN
SHEET 1

SURVEYED	DATUM		PROJECT No.	DISCIPLINE	NUMBER	REV.
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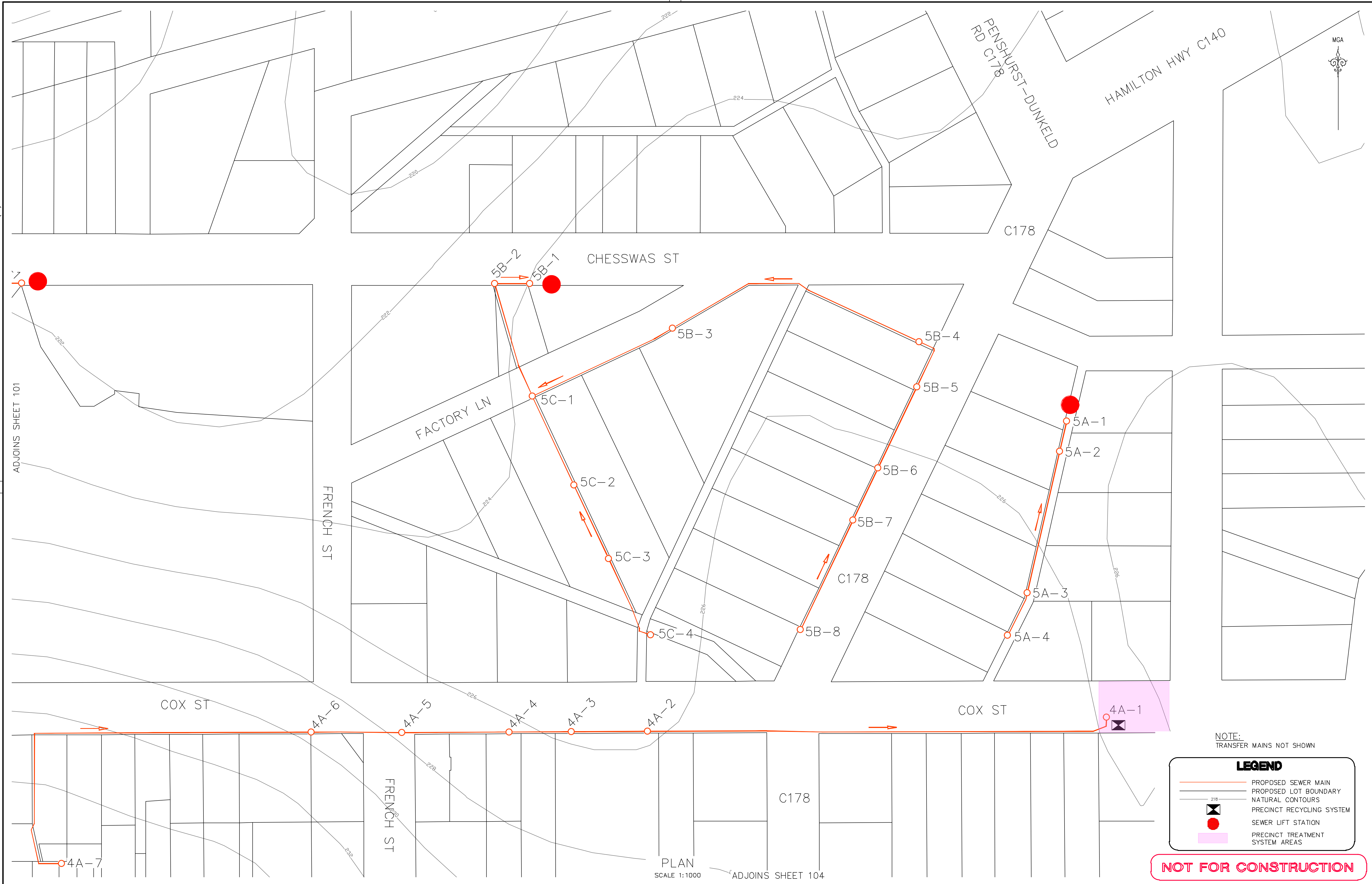

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PLAN TITLE: SEWER PLAN SHEET 2

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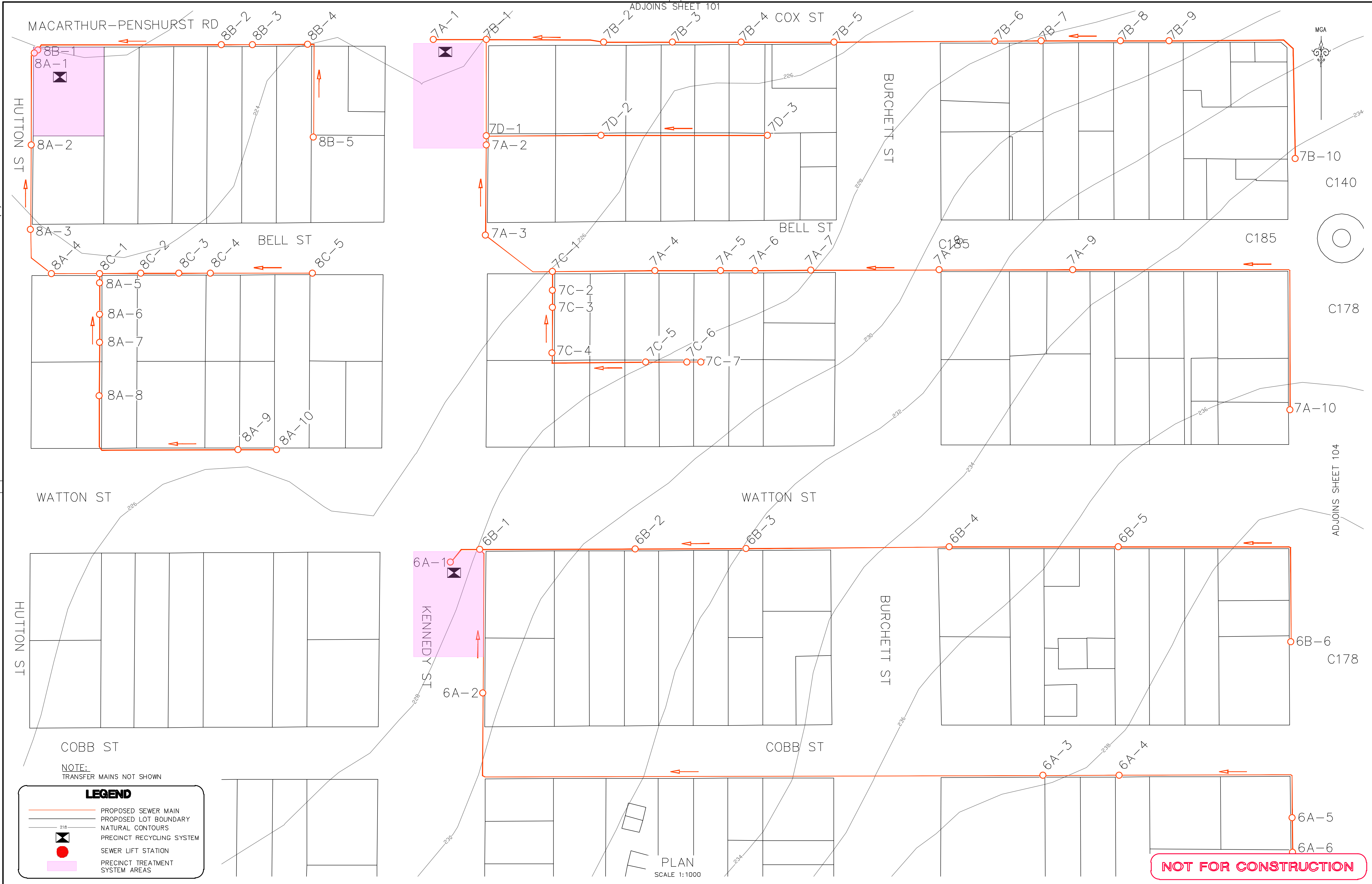

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DWC DECENTRALISED WATER CONSULTING

PROPERTY DESCRIPTION
PENSHURST TOWNSHIP
SHIRE OF SOUTHERN GRAMPIANS
VICTORIA

SURVEYED: ADW Johnson
DATUM: N/A A.H.D.

PROJECT: PROPOSED SEWER
PLAN TITLE: SEWER PLAN SHEET 3

PROJECT No.		DISCIPLINE		NUMBER	REV.
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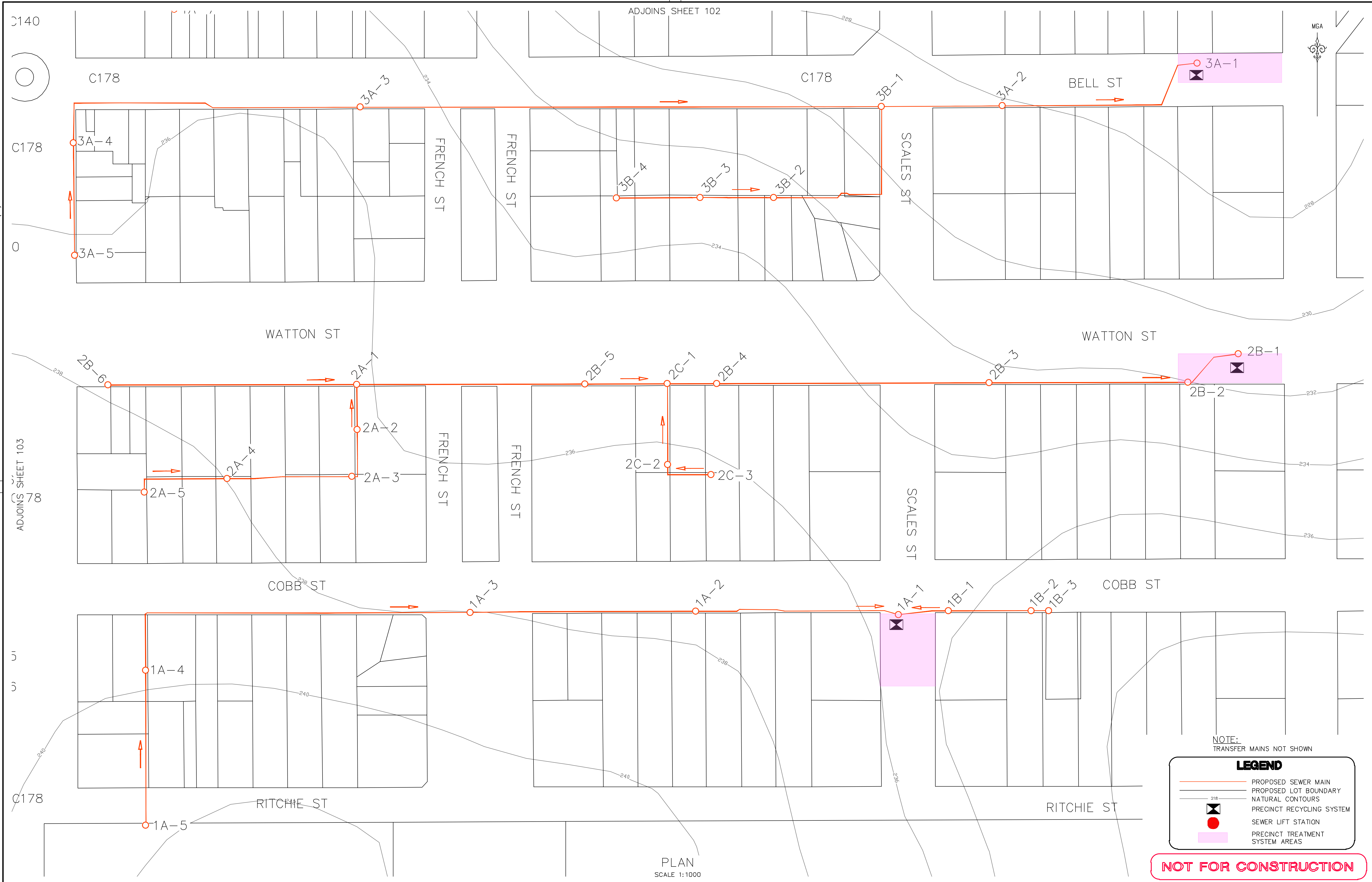

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A1 / A3
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PROPERTY DESCRIPTION
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SHIRE OF SOUTHERN GRAMPIANS
VICTORIA

SURVEYED ADW Johnson
DATUM N/A A.H.D.

PROJECT
PROPOSED SEWER

PLAN TITLE
SEWER PLAN
SHEET 4

PROJECT No.		DISCIPLINE		NUMBER	REV.
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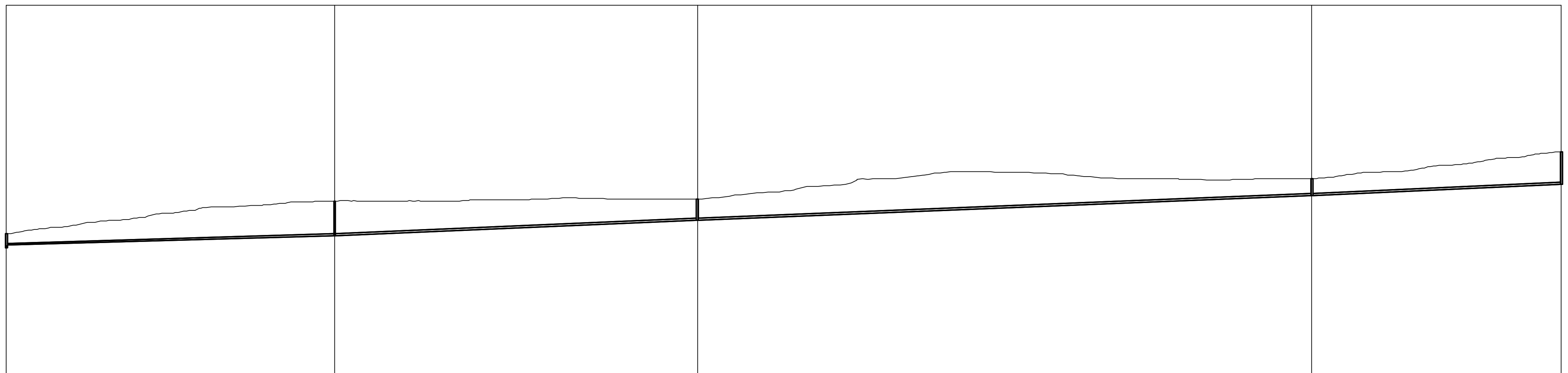

	1A-1		1A-2		1A-3		1A-4		1A-5
MAINTENANCE HOLE NUMBER	1A-1		1A-2		1A-3		1A-4		1A-5
MAINTENANCE HOLE TYPE									
PIPE SIZE		150 uPVC-SN8-1A							
GRADE		0.59%		0.84%		0.81%		0.89%	
DATUM R.L. 213		118.15		130.68		221.37		89.87	
DEPTH TO INVERT	1.027 0.827		2.496 2.496		1.533 1.533		1.211 1.211		2.340 2.340
INVERT LEVEL	230.500 230.700		231.400 231.400		232.500 232.500		234.300 234.300		235.100 235.100
FINISHED SURFACE LEVEL	231.527		233.896		234.033		235.511		237.44
CHAINAGE	0		118.15		248.83		470.2		560.08

LINE 1A

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B	02/03/2021	REVISED ISSUE	SS	CB	DWC	DWC

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SECTION VERTICAL SCALE 1:200 (0 2 4 6 8 10m)

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ABN 62 129 445 398

CLIENT
PENSHURST FUNCTIONAL DESIGN
DWC DECENTRALISED WATER CONSULTING

PROPERTY DESCRIPTION
PENSHURST TOWNSHIP
SHIRE OF SOUTHERN GRAMPIANS
VICTORIA

SURVEYED: ADW Johnson
DATUM: N/A A.H.D.

PROJECT: PROPOSED SEWER
PLAN TITLE: LONGITUDINAL SECTION LINE 1A

PROJECT No.	DISCIPLINE	NUMBER	REV.
240124	SEW	201	B

Plotted By: iainb Plot Date: 11/03/21 - 16:03 Cad File: C:\Users\iainb\AppData\Local\Temp\AcPublish_636\240124-ENG-101(B).dwg

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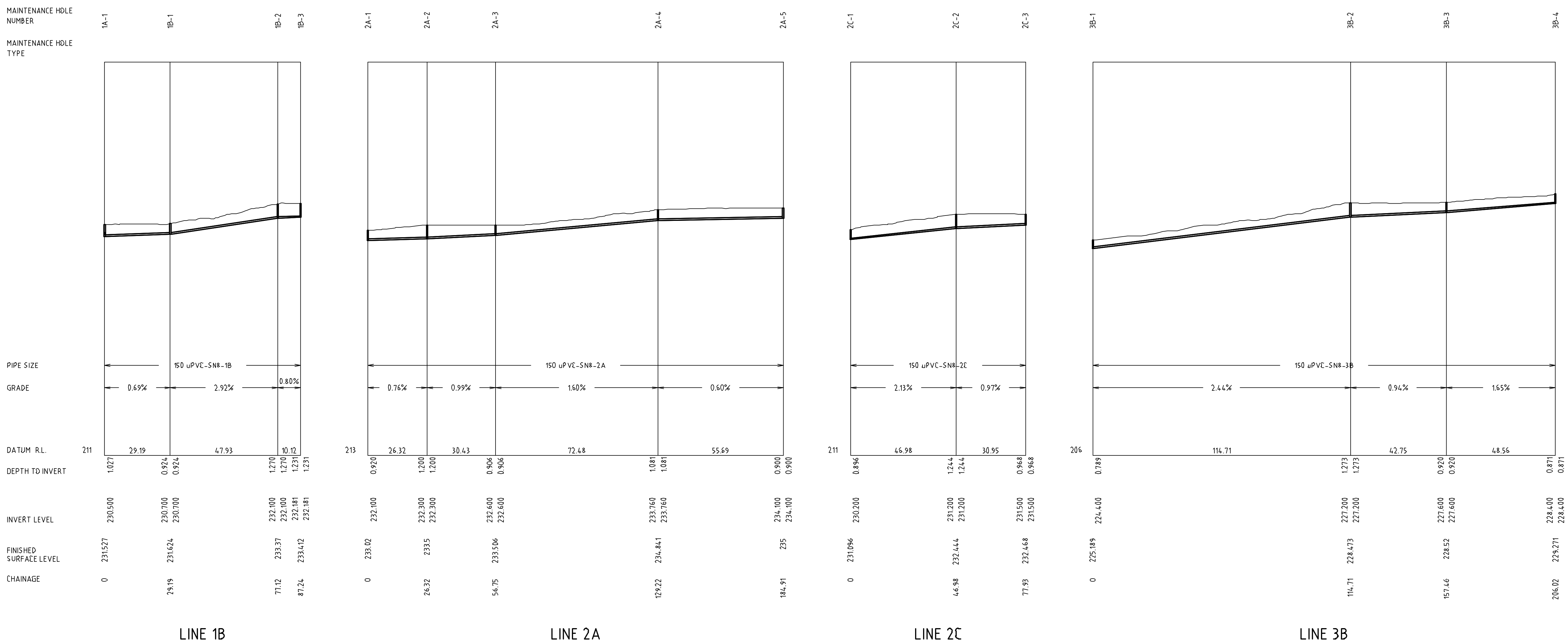

NOT FOR CONSTRUCTION

REV.	DATE	AMENDMENT	DRAWN	CHECK	DESIGN	VERIFY
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DESIGN FILE N:\JOBNUMBER\Design\12D\

SCALES
HORIZONTAL SCALE 1:1000
SECTION VERTICAL SCALE 1:200

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CLIENT
PENSHURST FUNCTIONAL DESIGN
DWC DECENTRALISED WATER CONSULTING

PROPERTY DESCRIPTION
PENSHURST TOWNSHIP
SHIRE OF SOUTHERN GRAMPIANS
VICTORIA

SURVEYED ADW Johnson
DATUM N/A A.H.D.

PROJECT
PROPOSED SEWER

PLAN TITLE
LONGITUDINAL SECTION
LINE 1B, 2A, 2C, 3B

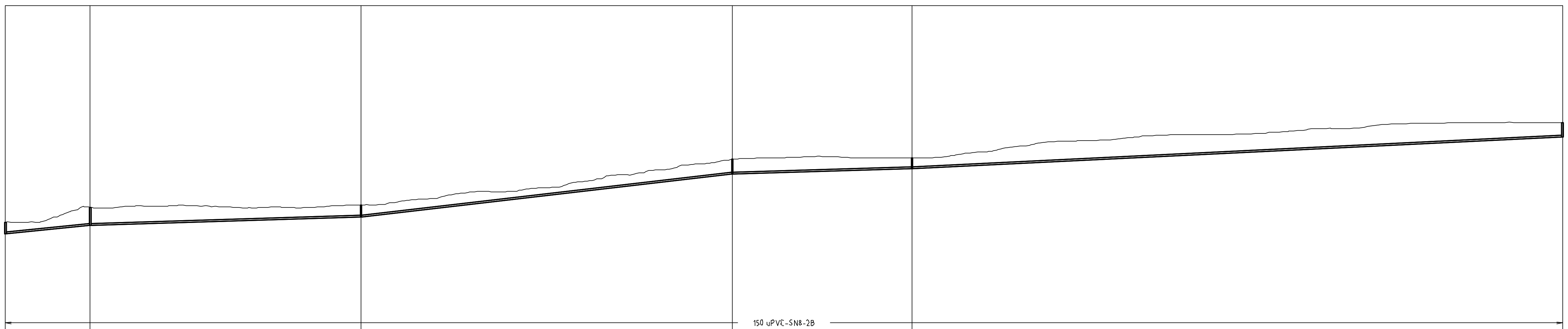
PROJECT No. 240124 – DISCIPLINE SEW – NUMBER 202 REV. B

100mm AT FULL SIZE

This plan includes coloured information. If you have a black and white copy you do not have all of the information. This note is coloured RED.

Plotted By: iainb Plot Date: 11/03/21 – 16:03 Cad File: C:\Users\iainb\AppData\Local\Temp\AcPublish_636\240124-ENG-101(B).dwg

240124-ENG-101(B)



	2B-1	2B-2	2B-3	2B-4	2B-5	2B-6
MAINTENANCE HOLE NUMBER	2B-1	2B-2	2B-3	2B-4	2B-5	2B-6
MAINTENANCE HOLE TYPE						
DEPTH TO INVERT	0.965 0.965	1.516 1.516	1.008 1.008	1.258 1.258	0.919 0.919	1.231
INVERT LEVEL	224.600 224.600	225.309 225.309	226.000 226.000	229.641 229.641	230.100 230.100	232.800
FINISHED SURFACE LEVEL	225.565	226.826	227.008	230.899	231.019	234.031
CHAINAGE	0	36.03	151.14	309.06	385.54	662.18

	2B-1 to 2B-2	2B-2 to 2B-3	2B-3 to 2B-4	2B-4 to 2B-5	2B-5 to 2B-6
PIPE SIZE	150 uPVC-SN8-2B				
GRADE	1.97%	0.6%	2.31%	0.6%	0.98%
DATUM R.L. 209	36.03	115.1	157.93	76.48	276.63

LINE 2B

NOT FOR CONSTRUCTION

100mm AT FULL SIZE

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REV.	DATE	AMENDMENT	DRAWN	CHECK	DESIGN	VERIFY
A	22.12.2020	REVISED ISSUE	IB	CB	DWC	DWC
B	02/03/2021	REVISED ISSUE	SS	CB	DWC	DWC

SCALES
0 10 20 30 40 50m HORIZONTAL SCALE 1:1000
0 2 4 6 8 10m SECTION VERTICAL SCALE 1:200

DESIGN FILE N:\JOBNUMBER\Design\12D\
ALL DIMENSIONS ARE IN METRES U.N.O. DO NOT SCALE

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ABN 62 129 445 398

CLIENT
PENSHURST FUNCTIONAL DESIGN
DWC DECENTRALISED WATER CONSULTING

PROPERTY DESCRIPTION
PENSHURST TOWNSHIP
SHIRE OF SOUTHERN GRAMPIANS
VICTORIA

SURVEYED ADW Johnson
DATUM N/A A.H.D.

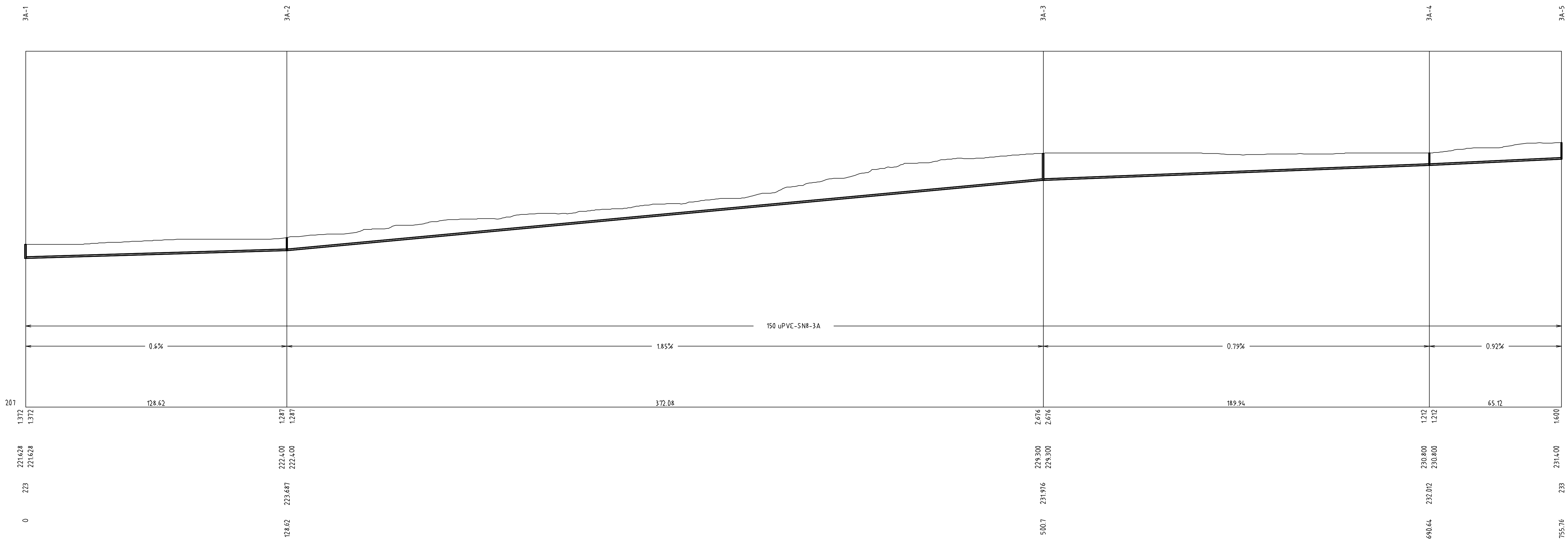
PROJECT
PROPOSED SEWER

PLAN TITLE
LONGITUDINAL SECTION
LINE 2B

PROJECT No. 240124 – DISCIPLINE SEW – NUMBER 203 REV. B

Plotted By: iainb Plot Date: 11/03/21 – 16:03 Cad File: C:\Users\iainb\AppData\Local\Temp\AcPublish_636\240124-ENG-101(B).dwg

240124-ENG-101(B)



LINE 3A

NOT FOR CONSTRUCTION

100mm AT FULL SIZE

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A	22.12.2020	REVISED ISSUE	IB	CB	DWC	DWC
B	02/03/2021	REVISED ISSUE	SS	CB	DWC	DWC

DESIGN FILE N:\JOBNUMBER\Design\12D\

SCALES

HORIZONTAL SCALE 1:1000

SECTION VERTICAL SCALE 1:200

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CLIENT

PENSHURST FUNCTIONAL DESIGN

DWC DECENTRALISED WATER CONSULTING

PROPERTY DESCRIPTION

PENSHURST TOWNSHIP
SHIRE OF SOUTHERN GRAMPIANS
VICTORIA

SURVEYED: ADW Johnson

DATUM: N/A A.H.D.

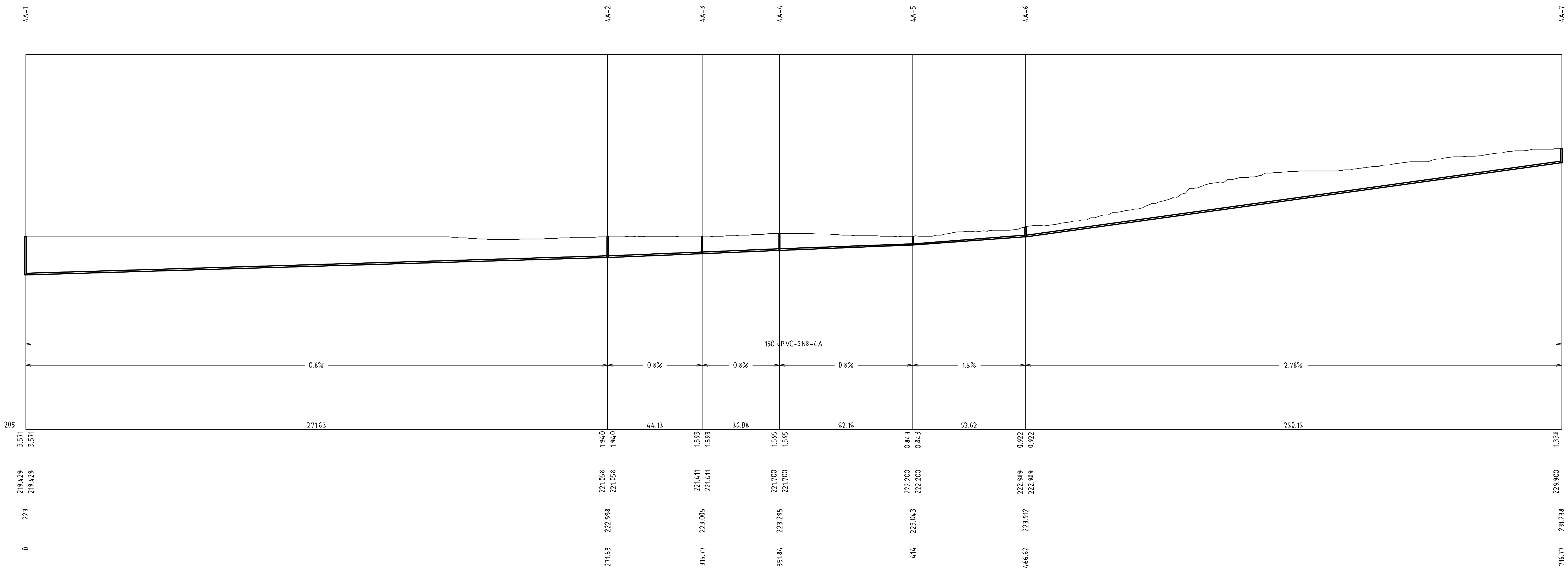
PROJECT: PROPOSED SEWER

PLAN TITLE: LONGITUDINAL SECTION LINE 3A

PROJECT No.		DISCIPLINE		NUMBER	REV.
240124	-	SEW	-	204	B

Plotted By: iainb Plot Date: 11/03/21 - 16:03 Cad File: C:\Users\iainb\AppData\Local\Temp\AcPublish_636\240124-ENG-101(B).dwg

240124-ENG-101(B)



LINE 4A

NOT FOR CONSTRUCTION

100mm AT FULL SIZE

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REV.	DATE	AMENDMENT	DRAWN	CHECK	DESIGN	VERIFY
A	22.12.2020	REVISED ISSUE	IB	CB	DWC	DWC
B	02/03/2021	REVISED ISSUE	SS	CB	DWC	DWC

SCALES

HORIZONTAL SCALE 1:1000

SECTION VERTICAL SCALE 1:200

DESIGN FILE N:\JOBNUMBER\Design\12D\

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CLIENT

PENSHURST FUNCTIONAL DESIGN

DWC DECENTRALISED WATER CONSULTING

PROPERTY DESCRIPTION

PENSHURST TOWNSHIP
SHIRE OF SOUTHERN GRAMPIANS
VICTORIA

SURVEYED ADW Johnson

DATUM N/A A.H.D.

PROJECT

PROPOSED SEWER

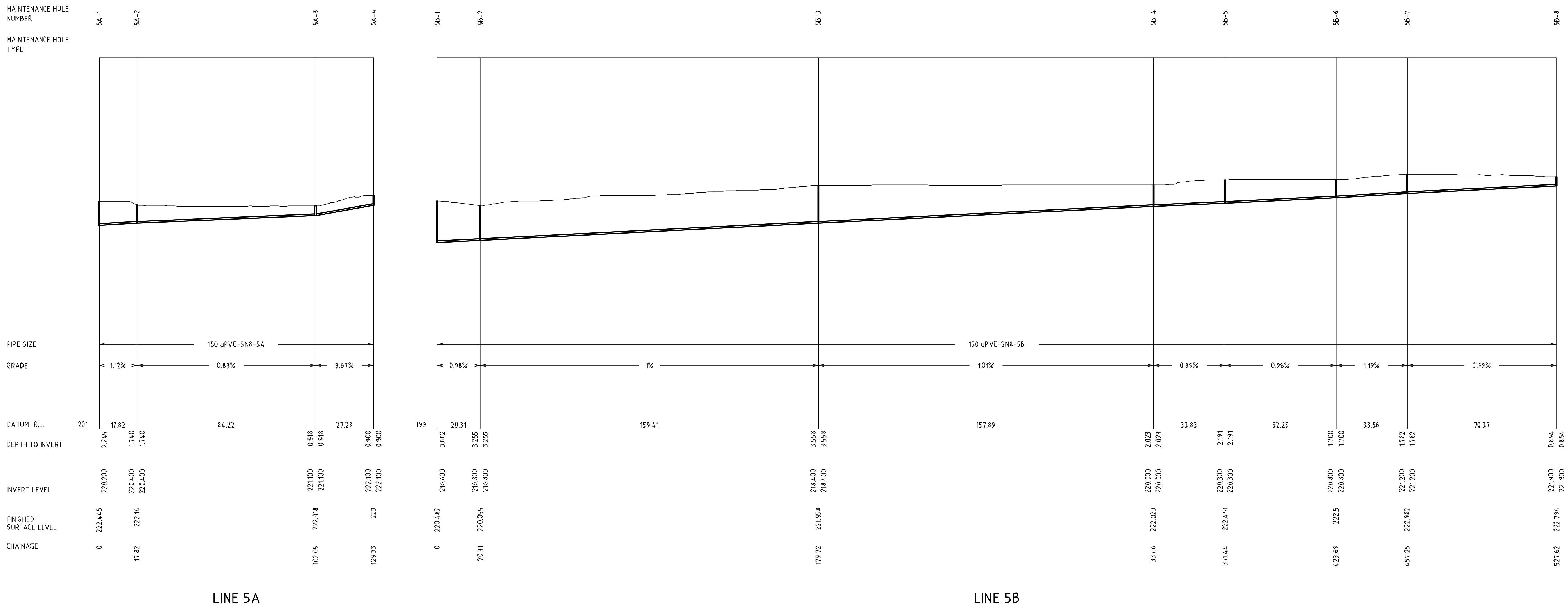
PLAN TITLE

LONGITUDINAL SECTION
LINE 4A

PROJECT No.	DISCIPLINE	NUMBER	REV.
240124 -	SEW -	205	B

Plotted By: iainb Plot Date: 11/03/21 - 16:03 Cad File: C:\Users\iainb\AppData\Local\Temp\AcPublish_636\240124-ENG-101(B).dwg

240124-ENG-101(B)



NOT FOR CONSTRUCTION

REV.	DATE	AMENDMENT	DRAWN	CHECK	DESIGN	VERIFY
A	22.12.2020	REVISED ISSUE	IB	CB	DWC	DWC
B	02/03/2021	REVISED ISSUE	SS	CB	DWC	DWC

SCALES
HORIZONTAL SCALE 1:1000
SECTION VERTICAL SCALE 1:200

DESIGN FILE N:\JOBNUMBER\Design\12D\
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CLIENT
PENSHURST FUNCTIONAL DESIGN
DWC DECENTRALISED WATER CONSULTING

PROPERTY DESCRIPTION
PENSHURST TOWNSHIP
SHIRE OF SOUTHERN GRAMPIANS
VICTORIA

SURVEYED ADW Johnson
DATUM N/A A.H.D.

PROJECT
PROPOSED SEWER

PLAN TITLE
LONGITUDINAL SECTION
LINE 5A, 5B

PROJECT No.	DISCIPLINE	NUMBER	REV.
240124	SEW	206	B

100mm AT FULL SIZE

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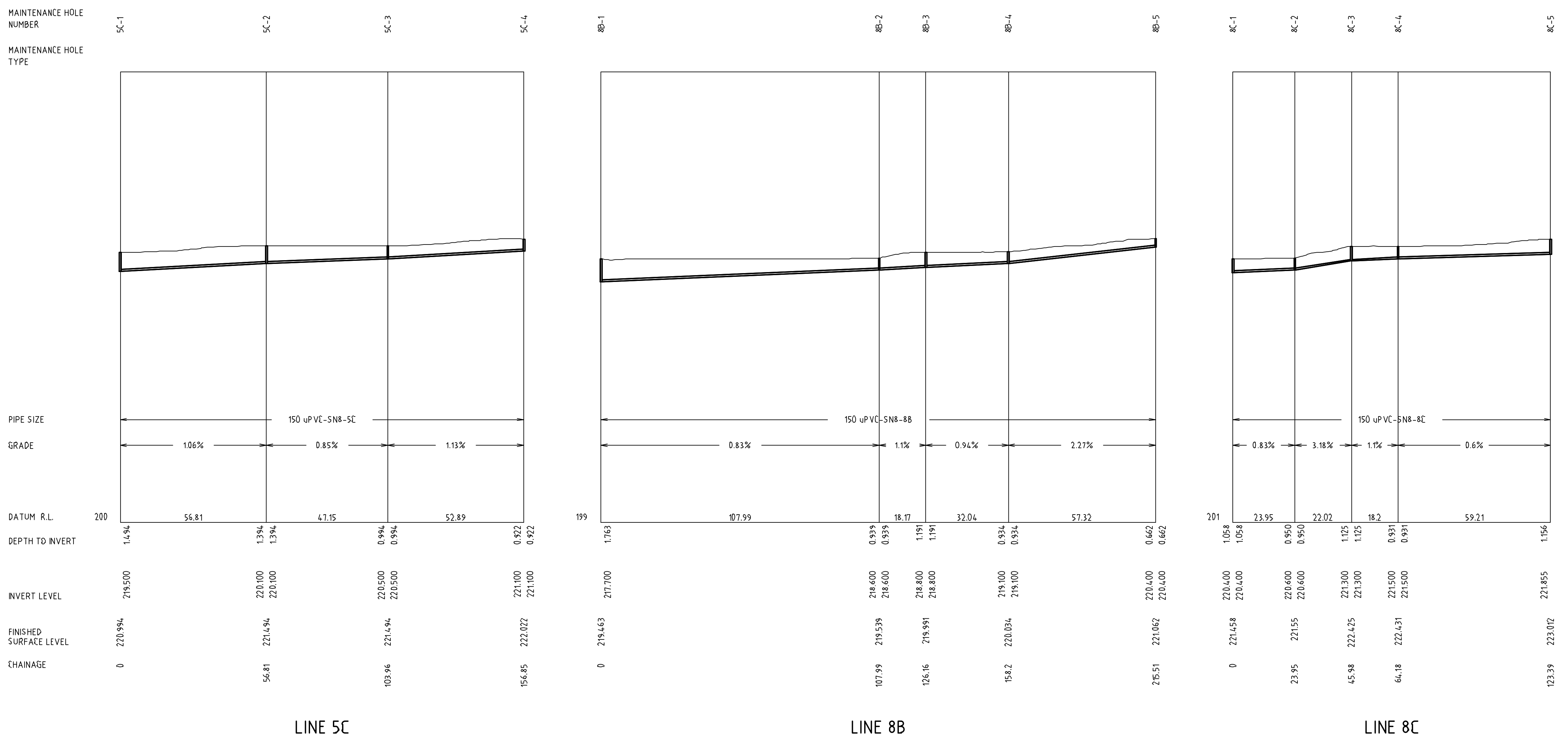
240124-ENG-101(B)



NOT FOR CONSTRUCTION

REV.	DATE	AMENDMENT	DRAWN	CHECK	DESIGN	VERIFY
A	22.12.2020	REVISED ISSUE	IB	CB	DWC	DWC
B	02/03/2021	REVISED ISSUE	SS	CB	DWC	DWC

SCALES
0 10 20 30 40 50m
HORIZONTAL SCALE 1:1000
0 2 4 6 8 10m
SECTION VERTICAL SCALE 1:200

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CLIENT
PENSHURST FUNCTIONAL DESIGN
DWC
DECENTRALISED WATER CONSULTING

PROPERTY DESCRIPTION
PENSHURST TOWNSHIP
SHIRE OF SOUTHERN GRAMPIANS
VICTORIA

SURVEYED ADW Johnson
DATUM N/A A.H.D.

PROJECT
PROPOSED SEWER

PLAN TITLE
LONGITUDINAL SECTION
LINE 5C, 8B, 8C

PROJECT No. 240124 - DISCIPLINE SEW - NUMBER 207 REV. B

100mm AT FULL SIZE

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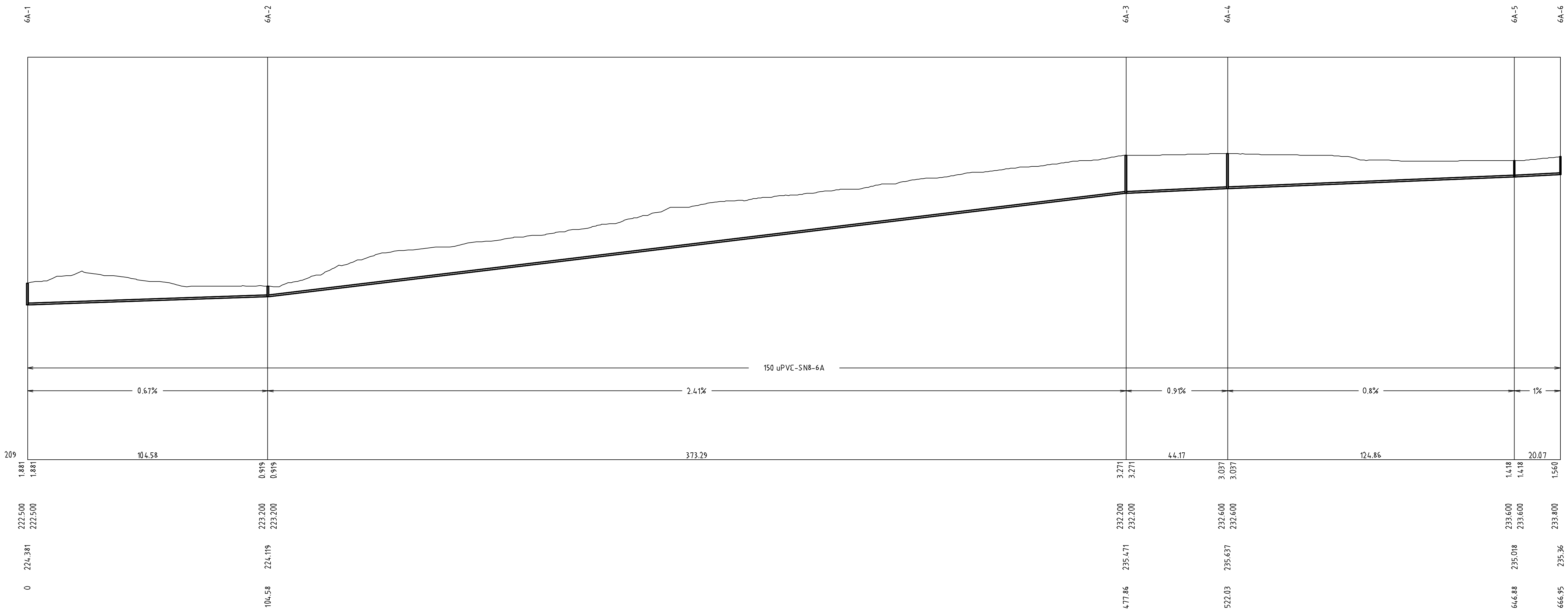
Plotted By: iainb Plot Date: 11/03/21 - 16:03 Cad File: C:\Users\iainb\AppData\Local\Temp\AcPublish_636\240124-ENG-101(B).dwg

240124-ENG-101(B)



LINE 6A

NOT FOR CONSTRUCTION

100mm AT FULL SIZE

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REV.	DATE	AMENDMENT	DRAWN	CHECK	DESIGN	VERIFY
A	22.12.2020	REVISED ISSUE	IB	CB	DWC	DWC
B	02/03/2021	REVISED ISSUE	SS	CB	DWC	DWC

DESIGN FILE N:\JOBNUMBER\Design\12D\

SCALES

HORIZONTAL SCALE 1:1000

SECTION VERTICAL SCALE 1:200

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ABN 62 129 445 398

CLIENT

PENSHURST FUNCTIONAL DESIGN

DWC DECENTRALISED WATER CONSULTING

PROPERTY DESCRIPTION

PENSHURST TOWNSHIP
SHIRE OF SOUTHERN GRAMPIANS
VICTORIA

SURVEYED ADW Johnson

DATUM N/A A.H.D.

PROJECT

PROPOSED SEWER

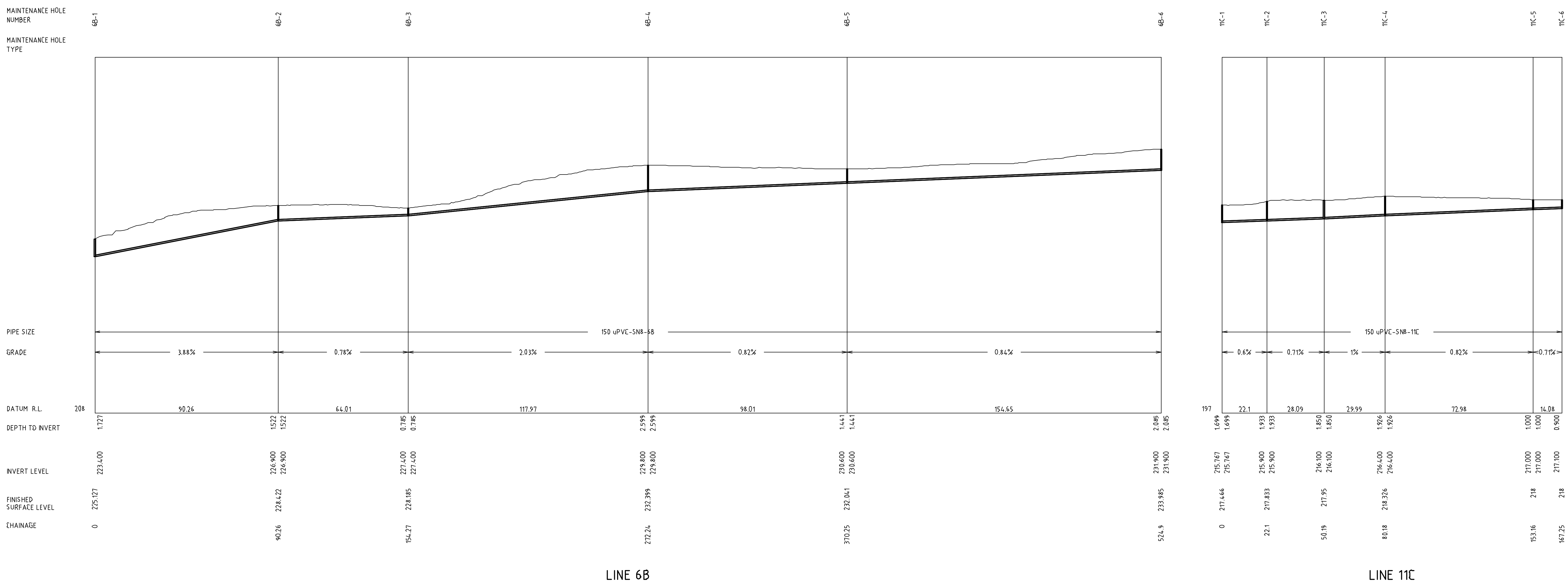
PLAN TITLE

LONGITUDINAL SECTION
LINE 6A

PROJECT No.		DISCIPLINE		NUMBER	REV.
240124	-	SEW	-	208	B

Plotted By: iainb Plot Date: 11/03/21 - 16:03 Cad File: C:\Users\iainb\AppData\Local\Temp\AcPublish_636\240124-ENG-101(B).dwg

240124-ENG-101(B)



NOT FOR CONSTRUCTION

REV.	DATE	AMENDMENT	DRAWN	CHECK	DESIGN	VERIFY
A	22.12.2020	REVISED ISSUE	IB	CB	DWC	DWC
B	02/03/2021	REVISED ISSUE	SS	CB	DWC	DWC

DESIGN FILE N:\JOBNUMBER\Design\12D\

SCALES

0 10 20 30 40 50m
HORIZONTAL SCALE 1:1000
0 2 4 6 8 10m
SECTION VERTICAL SCALE 1:200

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CLIENT
PENSHURST FUNCTIONAL DESIGN
DWC
DECENTRALISED WATER CONSULTING

PROPERTY DESCRIPTION
PENSHURST TOWNSHIP
SHIRE OF SOUTHERN GRAMPIANS
VICTORIA

SURVEYED: ADW Johnson
DATUM: N/A A.H.D.

PROJECT: PROPOSED SEWER

PLAN TITLE: LONGITUDINAL SECTION
LINE 6B, 11C

PROJECT No. 240124 – DISCIPLINE SEW – NUMBER 209 REV. B

Plotted By: iainb Plot Date: 11/03/21 - 16:03 Cad File: C:\Users\iainb\AppData\Local\Temp\AcPublish_636\240124-ENG-101(B).dwg

100mm AT FULL SIZE

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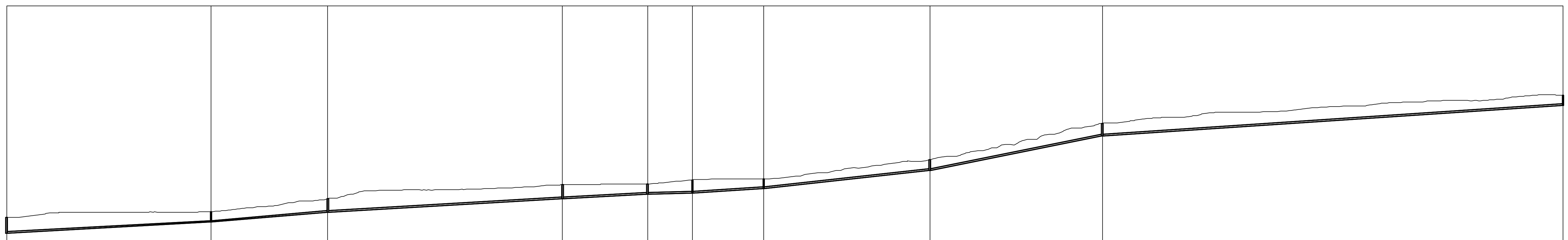
240124-ENG-101(B)



MAINTENANCE HOLE NUMBER	7A-1	7A-2	7A-3	7A-4	7A-5	7A-6	7A-7	7A-8	7A-9	7A-10
MAINTENANCE HOLE TYPE										
DEPTH TO INVERT	1.409	0.931 / 0.931	1.208 / 1.208	1.268 / 1.268	0.937 / 0.937	1.199 / 1.199	0.899 / 0.899	0.960 / 0.960	1.136 / 1.136	0.919 / 0.919
INVERT LEVEL	219.600	220.600 / 220.600	221.500 / 221.500	222.700 / 222.700	223.100 / 223.100	223.200 / 223.200	223.600 / 223.600	225.245 / 225.245	228.343 / 228.342	231.100 / 231.100
FINISHED SURFACE LEVEL	221.009	221.531	222.708	223.968	224.037	224.399	224.499	226.204	229.479	232.019
CHAINAGE	0	91.76	144.16	249.55	287.66	307.82	339.89	414.39	491.84	698.65

PIPE SIZE: 150 uPVC-SN8-7A

DATUM R.L. 205

Segment	7A-1 to 7A-2	7A-2 to 7A-3	7A-3 to 7A-4	7A-4 to 7A-5	7A-5 to 7A-6	7A-6 to 7A-7	7A-7 to 7A-8	7A-8 to 7A-9	7A-9 to 7A-10
GRADE	1.09%	1.72%	1.14%	1.05%	0.5%	1.25%	2.21%	4%	1.33%
LENGTH	91.76	52.4	105.38	38.11	20.16	32.07	151.95	77.45	206.81

LINE 7A

NOT FOR CONSTRUCTION

100mm AT FULL SIZE

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A	22.12.2020	REVISED ISSUE	IB	CB	DWC	DWC
B	02/03/2021	REVISED ISSUE	SS	CB	DWC	DWC

SCALES

0 10 20 30 40 50m HORIZONTAL SCALE 1:1000

0 2 4 6 8 10m SECTION VERTICAL SCALE 1:200

DESIGN FILE N:\JOBNUMBER\Design\12D\

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ABN 62 129 445 398

CLIENT

PENSHURST FUNCTIONAL DESIGN

DWC DECENTRALISED WATER CONSULTING

PROPERTY DESCRIPTION

PENSHURST TOWNSHIP
SHIRE OF SOUTHERN GRAMPIANS
VICTORIA

SURVEYED ADW Johnson

DATUM N/A A.H.D.

PROJECT

PROPOSED SEWER

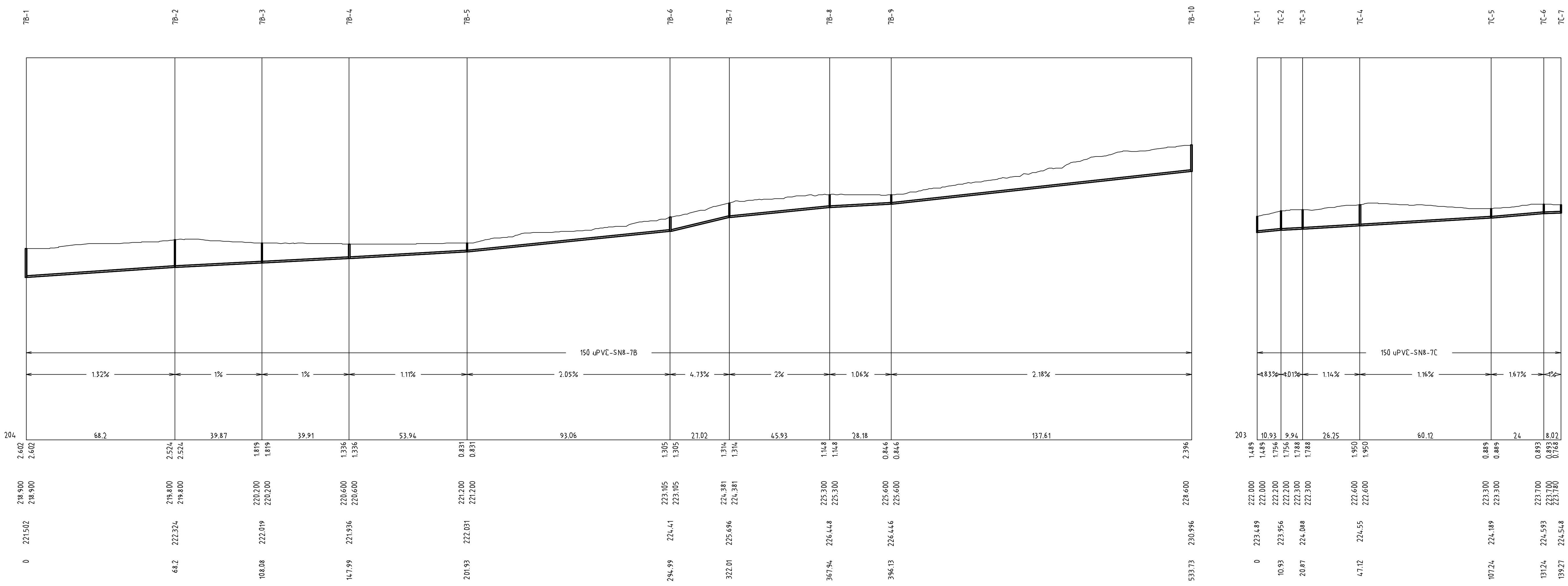
PLAN TITLE

LONGITUDINAL SECTION
LINE 7A

PROJECT No.		DISCIPLINE		NUMBER	REV.
240124	-	SEW	-	210	B

Plotted By: iainb Plot Date: 11/03/21 - 16:03 Cad File: C:\Users\iainb\AppData\Local\Temp\AcPublish_636\240124-ENG-101(B).dwg

240124-ENG-101(B)



LINE 7B

LINE 7C

NOT FOR CONSTRUCTION

100mm AT FULL SIZE

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A	22.12.2020	REVISED ISSUE	IB	CB	DWC	DWC
B	02/03/2021	REVISED ISSUE	SS	CB	DWC	DWC

SCALES

HORIZONTAL SCALE 1:1000

SECTION VERTICAL SCALE 1:200

DESIGN FILE N:\JOBNUMBER\Design\12D\

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CLIENT

PENSHURST FUNCTIONAL DESIGN

DWC DECENTRALISED WATER CONSULTING

PROPERTY DESCRIPTION

PENSHURST TOWNSHIP
SHIRE OF SOUTHERN GRAMPIANS
VICTORIA

SURVEYED: ADW Johnson

DATUM: N/A A.H.D.

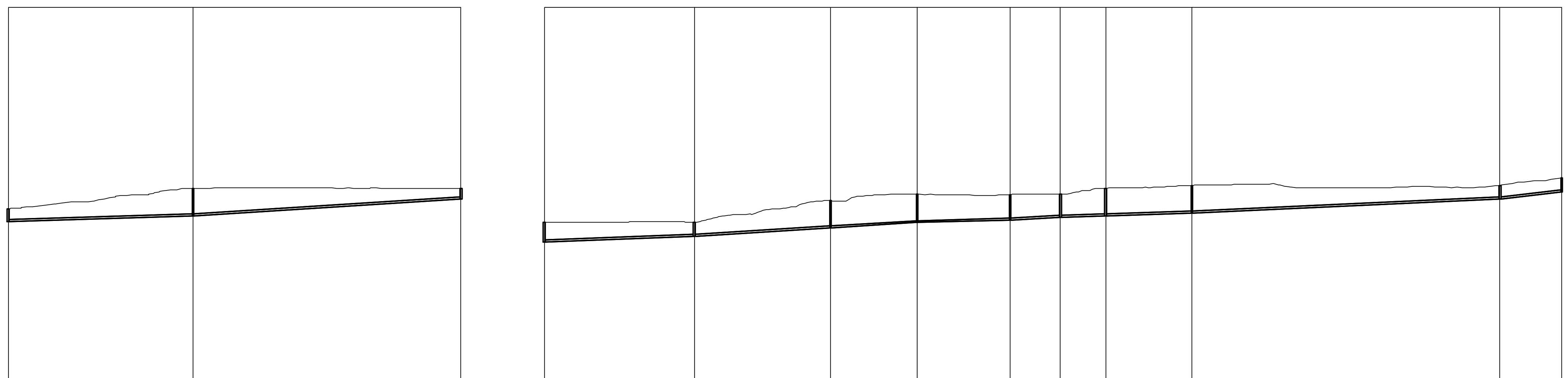
PROJECT: PROPOSED SEWER

PLAN TITLE: LONGITUDINAL SECTION LINE 7B, 7C

PROJECT No.	DISCIPLINE	NUMBER	REV.
240124	SEW	211	B

Plotted By: iainb Plot Date: 11/03/21 - 16:03 Cad File: C:\Users\iainb\AppData\Local\Temp\AcPublish_636\240124-ENG-101(B).dwg

240124-ENG-101(B)



PIPE SIZE: 150 uPVC-SN8-7D

MAINTENANCE HOLE NUMBER	7D-1	7D-2	7D-3
MAINTENANCE HOLE TYPE			
DEPTH TO INVERT	0.913	1.974 / 1.974	0.775 / 0.775
INVERT LEVEL	220.600	221.000 / 221.000	222.200 / 222.200
FINISHED SURFACE LEVEL	221.513	222.974	222.975
CHAINAGE	0	66.69	163.23

DATUM R.L. 201	7D-1 to 7D-2	7D-2 to 7D-3
GRADE	0.6%	1.24%
Length	66.69	96.54

LINE 7D

PIPE SIZE: 150 uPVC-SN8-8A

MAINTENANCE HOLE NUMBER	8A-1	8A-2	8A-3	8A-4	8A-5	8A-6	8A-7	8A-8	8A-9	8A-10
MAINTENANCE HOLE TYPE										
DEPTH TO INVERT	1.400	1.035 / 1.035	1.982 / 1.982	2.042 / 2.042	1.826 / 1.826	1.649 / 1.649	1.983 / 1.983	1.980 / 1.980	0.982 / 0.982	1.043 / 1.043
INVERT LEVEL	218.100	218.500 / 218.500	219.100 / 219.100	219.500 / 219.500	219.700 / 219.700	219.900 / 219.900	220.000 / 220.000	220.200 / 220.200	221.200 / 221.200	221.700 / 221.700
FINISHED SURFACE LEVEL	219.5	219.535	221.082	221.542	221.526	221.549	221.983	222.18	222.182	222.743
CHAINAGE	0	54.06	103.16	134.48	167.99	186.05	202.37	233.39	344.49	366.82

DATUM R.L. 200	8A-1 to 8A-2	8A-2 to 8A-3	8A-3 to 8A-4	8A-4 to 8A-5	8A-5 to 8A-6	8A-6 to 8A-7	8A-7 to 8A-8	8A-8 to 8A-9	8A-9 to 8A-10
GRADE	0.74%	1.22%	1.28%	0.6%	1.11%	0.61%	0.64%	0.9%	2.24%
Length	54.06	49.1	31.32	33.52	18.06	16.32	31.02	111.11	22.32

LINE 8A

NOT FOR CONSTRUCTION

REV.	DATE	AMENDMENT	DRAWN	CHECK	DESIGN	VERIFY
A	22.12.2020	REVISED ISSUE	IB	CB	DWC	DWC
B	02/03/2021	REVISED ISSUE	SS	CB	DWC	DWC

DESIGN FILE N:\JOBNUMBER\Design\12D\

SCALES
HORIZONTAL SCALE 1:1000 (0 10 20 30 40 50m)
SECTION VERTICAL SCALE 1:200 (0 2 4 6 8 10m)

ALL DIMENSIONS ARE IN METRES U.N.O. DO NOT SCALE

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CLIENT
PENSHURST FUNCTIONAL DESIGN
DWC DECENTRALISED WATER CONSULTING

PROPERTY DESCRIPTION
PENSHURST TOWNSHIP
SHIRE OF SOUTHERN GRAMPIANS
VICTORIA

SURVEYED: ADW Johnson
DATUM: N/A A.H.D.

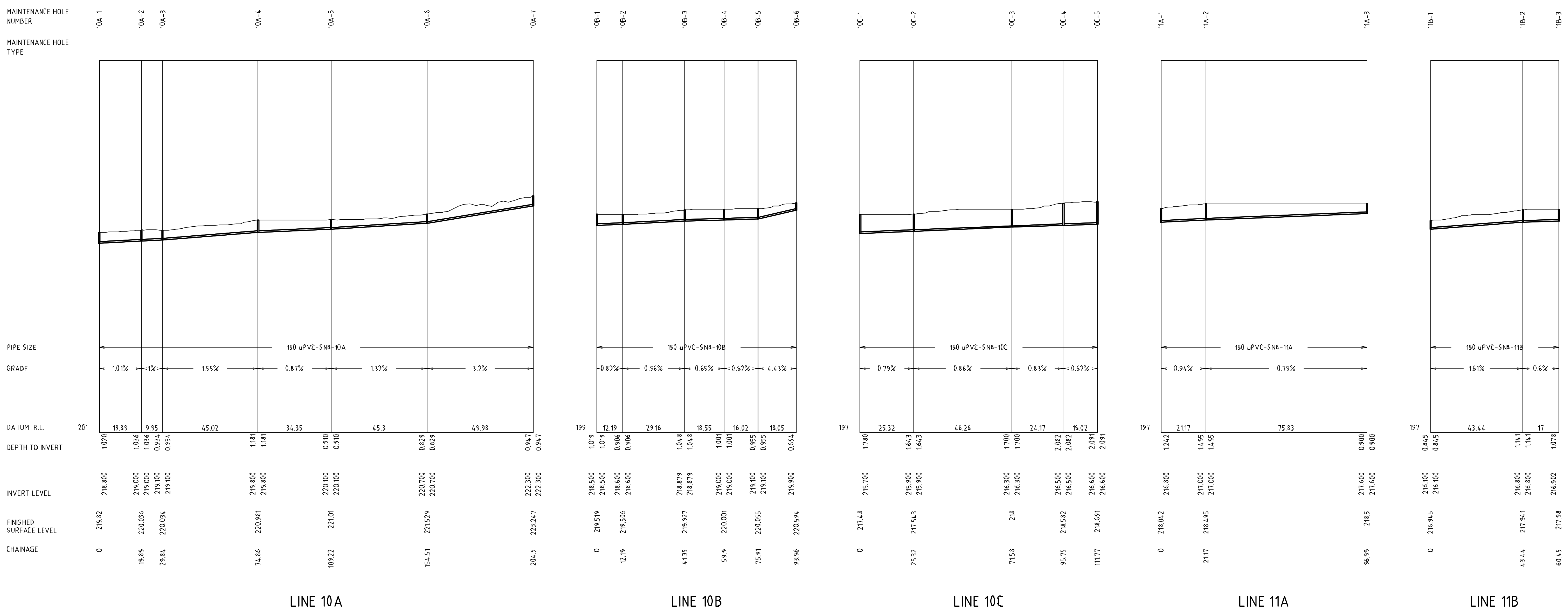
PROJECT: PROPOSED SEWER

PLAN TITLE: LONGITUDINAL SECTION LINE 7D, 8A

PROJECT No. 240124 - DISCIPLINE SEW - NUMBER 212 REV. B

Plotted By: iainb Plot Date: 11/03/21 - 16:03 Cad File: C:\Users\iainb\AppData\Local\Temp\AcPublish_636\240124-ENG-101(B).dwg

240124-ENG-101(B)



NOT FOR CONSTRUCTION

REV.	DATE	AMENDMENT	DRAWN	CHECK	DESIGN	VERIFY
A	22.12.2020	REVISED ISSUE	IB	CB	DWC	DWC
B	02/03/2021	REVISED ISSUE	SS	CB	DWC	DWC

SCALES
HORIZONTAL SCALE 1:1000
SECTION VERTICAL SCALE 1:200

DESIGN FILE N:\JOBNUMBER\Design\12D\
ALL DIMENSIONS ARE IN METRES U.N.O. DO NOT SCALE

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CLIENT
PENSHURST FUNCTIONAL DESIGN
DWC DECENTRALISED WATER CONSULTING

PROPERTY DESCRIPTION
PENSHURST TOWNSHIP
SHIRE OF SOUTHERN GRAMPIANS
VICTORIA

SURVEYED ADW Johnson
DATUM N/A A.H.D.

PROJECT
PROPOSED SEWER

PLAN TITLE
LONGITUDINAL SECTION
LINE 10A, 10B, 10C, 11A, 11B

PROJECT No. 240124 – DISCIPLINE SEW – NUMBER 213 REV. B

Plotted By: iainb Plot Date: 11/03/21 - 16:03 Cad File: C:\Users\iainb\AppData\Local\Temp\AcPublish_636\240124-ENG-101(B).dwg

100mm AT FULL SIZE

This plan includes coloured information. If you have a black and white copy you do not have all of the information. This note is coloured RED.

Appendix D Modelling Design & Results

MEDLI Modelling Soil Profile Inputs

Parameter	Soil Layer 1	Soil Layer 2	Soil Layer 3	Source
Soil Layer Thickness (mm)	100	250	150	Soil Log
Air Dry (% v/v)	*4*			
Lower Storage Limit (% v/v)	10	10	18	MEDLI Technical Manual, (Hazelton and Murphy)
Permanent Wilting Point (mm)	*10*	*25*	*27*	62
Drained Upper Limit (% v/v)	34	34	34	MEDLI Technical Manual, (Hazelton and Murphy)
Field Capacity (mm)	*34*	*85*	*51*	170
Total Porosity (% v/v)	43	43	49	MEDLI Technical Manual
Saturated Water Content (% v/v)	**39.99**	**39.99**	**45.57**	
Bulk Density (g/cm3)	1.4	1.4	1.4	
Saturated Hydraulic Conductivity (mm/hr)	63.0	63.0	**0.22**	MEDLI Technical Manual (assumed conservative amount)
Texture/Structure	***Silty Loam***	***Silty Loam***	***Clay Loam***	Soil Log
Additional Details	*Strong*	*Strong*	*Strong*	Soil Log

Horizontal Saturated Hydraulic Conductivity Calculations - Limiting Layer

Base Case				
Soil 1				
Soil Horizon / Layer	Depth (m)	kSat Vertical (mm/day)	Weighted Vertical kSat (mm/day)	
1	0.00		0	0
2	0.15	1500	750	62.5
3	0.15	1000	500	
4			0	
Total	0.30		1250	

Area	Area (m2)
1	1,000
2	0
3	0
Total	**1,000**

Area			
Parameter	Value	Unit	
Ksat	1.25	m/day	
Hyd. Grad.	0.02		
Porosity	0.1		
Width	35	m	
LAA	1,000	m2	
CS-SA	10.5	m2	
Hksat	0.25	m/day	
Flow	2.625	m3/day	
LAA HLR	**2.6**	**mm/day**	
MEDLI Input	**0.22**	**mm/hour**	*(doubled for input into MEDLI)*

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Parameter	Variable	Value	Unit	Source
Contaminant		Virus Partial Treatment		from Level 1
Target Concentration	C_T	5.00E-01	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Domenico - Steady state — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 2 directions

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to pollutants in all phases (e.g. field derived value

Parameter	Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	8.00E+01	mg/l	*Partial Disinfection Scenario (Precinct 2)*
Half life for degradation of contaminant in water	$t_{1/2}$	6.00E+00	days	*Median Decay (6 days)*
Calculated decay rate	λ	1.16E-01	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	2.30E+02	m	*Width of LAA*
Plume thickness at source	Sy	4.00E-03	m	*SSI DLR (x2) applied over LAA*
Saturated aquifer thickness	da	4.00E-01	m	*From Soil profile*
Bulk density of aquifer materials	ρ	1.60E+00	g/cm^3	*Hazelton & Murphy (2007)*
Effective porosity of aquifer	n	1.00E-01	fraction	*Hazelton & Murphy (2007)*
Hydraulic gradient	i	5.00E-02	fraction	*Based on contours*
Hydraulic conductivity of aquifer	K	1.25E+00	m/d	*Ksat Calcs (Profile 3 - Clay Loam)*
Distance to compliance point	x	1.90E+00	m	*Distance to Achieve Target*
Distance (lateral) to compliance point perpendicular to flow direction	z	[redacted]	m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	3.00E-01	l/kg	*see options*
Longitudinal dispersivity	ax	3.80E-02	m	*see options*
Transverse dispersivity	az	3.80E-03	m	*see options*
Vertical dispersivity	ay	3.80E-04	m	*see options*

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

Parameter	Variable	Value	Unit
Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	3.00E-01	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc	[redacted]	fraction
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc,n}$	[redacted]	l/kg
Sorption coefficient for ionised species	$K_{oc,i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	3.00E-01	l/kg

Define dispersivity (click brown cell and use pull down list)

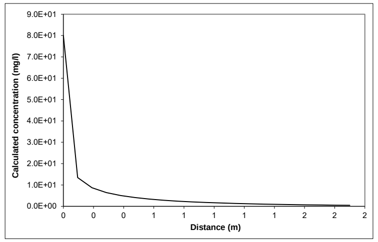
User defined values for dispersivity

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	3.80E-02	1.90E-01	3.80E-02	m
Transverse dispersivity	**az**	3.80E-03	1.90E-02	3.80E-03	m
Vertical dispersivity	**ay**	3.80E-04	1.90E-03	3.80E-04	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report ax = $0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Calculated concentrations for distance-concentration graph

Domenico - Steady state
From calculation sheet

Distance	Concentration
	mg/l
0	8.0E+01
0.1	1.35E+01
0.2	8.69E+00
0.3	6.44E+00
0.4	5.06E+00
0.5	4.11E+00
0.6	3.40E+00
0.7	2.86E+00
0.8	2.42E+00
0.9	2.07E+00
1.0	1.78E+00
1.0	1.54E+00
1.1	1.34E+00
1.2	1.16E+00
1.3	1.02E+00
1.4	8.91E-01
1.5	7.82E-01
1.6	6.88E-01
1.7	6.06E-01
1.8	5.35E-01
1.9	4.73E-01

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared with the Level 3 remedial target to determine the need for further action.

Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Calculated Parameters

Parameter	Variable	Value	Unit
Groundwater flow velocity	v	6.25E-01	m/d
Retardation factor	Rf	5.80E+00	fraction
Decay rate used	λ	1.16E-01	d^{-1}
Rate of contaminant flow due to retardation	u	1.08E-01	m/d
Contaminant concentration at distance x, assuming two-way vertical dispersion	C_{ED}	4.73E-01	mg/l
Attenuation factor (two way vertical dispersion, CO/CED)	**AF**	**1.69E+02**	

Site being assessed:	Penshurst PRS (Precinct 2)
Completed by:	Jack Sharples
Date:	########
Version:	1

Remedial Targets

Remedial Target		**8.46E+01**	**mg/l**	For comparison with measured groundwater concentration.
Domenico - Steady state				
Distance to compliance point		**1.9**	**m**	
Concentration of contaminant at compliance point	C_{ED}/C_0	**4.73E-01**	**mg/l**	Domenico - Steady state

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.

R&D Publication 20 Remedial Targets Worksheet, Release 3.2

Level 3 - Groundwater

See Note

Input Parameters (using pull down menu)

Parameter	Variable	Value	Unit	Source
Contaminant		Virus EXTREME		from Level 1
Target Concentration	C_T	5.00E-01	mg/l	from Level 1

Select analytical solution (click on brown cell below, then on pull-down menu)

Domenico - Steady state — Equations in HRA publication

Approach for simulating vertical dispersion: Simulate vertical dispersion in 2 directions

Select nature of decay rate (click on brown cell below, then on pull-down menu)

Approach for simulating degradation of pollutants: Apply degradation rate to pollutants in all phases (e.g. field derived value

Parameter	Variable	Value	Unit	Source of parameter value
Initial contaminant concentration in groundwater at plume core	C_0	8.00E+01	mg/l	*Partial Disinfection (Precinct 2)*
Half life for degradation of contaminant in water	$t_{1/2}$	4.30E+01	days	*Conservative Decay (43 days)*
Calculated decay rate	λ	1.61E-02	$days^{-1}$	
Width of plume in aquifer at source (perpendicular to flow)	Sz	2.30E+02	m	*Width of LAA*
Plume thickness at source	Sy	4.00E-03	m	*SSI DLR (x2) applied over LAA*
Saturated aquifer thickness	da	4.00E-01	m	*From Soil profile*
Bulk density of aquifer materials	ρ	1.60E+00	g/cm^3	*Hazelton & Murphy (2007)*
Effective porosity of aquifer	n	1.00E-01	fraction	*Hazelton & Murphy (2007)*
Hydraulic gradient	i	5.00E-02	fraction	*Based on contours*
Hydraulic conductivity of aquifer	K	1.25E+00	m/d	*Ksat Calcs (Profile 3 - Clay Loam)*
Distance to compliance point	x	4.10E+00	m	*Distance to Achieve Target (WC)*
Distance (lateral) to compliance point perpendicular to flow direction	z		m	
Distance (depth) to compliance point perpendicular to flow direction	y		m	
Time since pollutant entered groundwater	t	1.00E+100	days	*time variant options only*
Parameters values determined from options				
Partition coefficient	Kd	3.00E-01	l/kg	*see options*
Longitudinal dispersivity	ax	2.54E-01	m	*see options*
Transverse dispersivity	az	2.54E-02	m	*see options*
Vertical dispersivity	ay	2.54E-03	m	*see options*

Select Method for deriving Partition Co-efficient (using pull down menu)

User specified value for partition coefficient

Entry if specify partition coefficient (option)			
Soil water partition coefficient	Kd	3.00E-01	l/kg
Entry for non-polar organic chemicals (option)			
Fraction of organic carbon in aquifer	foc		fraction
Organic carbon partition coefficient	Koc		l/kg
Entry for ionic organic chemicals (option)			
Sorption coefficient for related species	$K_{oc.n}$		l/kg
Sorption coefficient for ionised species	$K_{oc.i}$		l/kg
pH value	pH		
acid dissociation constant	pKa		
Fraction of organic carbon in aquifer	foc		fraction
Soil water partition coefficient	Kd	3.00E-01	l/kg

Define dispersivity (click brown cell and use pull down list)

User defined values for dispersivity

		Enter value	Calc value	Xu & Eckstein	m
Longitudinal dispersivity	**ax**	2.54E-01	4.10E-01	2.54E-01	m
Transverse dispersivity	**az**	2.54E-02	4.10E-02	2.54E-02	m
Vertical dispersivity	**ay**	2.54E-03	4.10E-03	2.54E-03	

Note values of dispersivity must be > 0

For calculated value, assumes ax = 0.1 *x, az = 0.01 * x, ay = 0.001 * x

Xu & Eckstein (1995) report $ax = 0.83(\log_{10}x)^{2.414}$; az = ax/10, ay = ax/100 are assumed

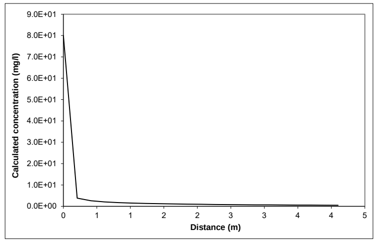
Calculated Parameters

Parameter	Variable	Value	Unit
Groundwater flow velocity	v	6.25E-01	m/d
Retardation factor	Rf	5.80E+00	fraction
Decay rate used	λ	1.61E-02	d^{-1}
Rate of contaminant flow due to retardation	u	1.08E-01	m/d
Contaminant concentration at distance x, assuming two-way vertical dispersion	C_{ED}	4.89E-01	mg/l
Attenuation factor (two way vertical dispersion, CO/CED)	**AF**	**1.64E+02**	

Remedial Targets

Remedial Target	**8.18E+01**	**mg/l**	For comparison with measured groundwater concentration.
Domenico - Steady state			
Distance to compliance point	**4.1**	**m**	
Concentration of contaminant at compliance point C_{ED}/C_0	**4.89E-01**	**mg/l**	Domenico - Steady state

Care should be used when calculating remedial targets using the time variant options as this may result in an overestimate of the remedial target.
The recommended value for time when calculating the remedial target is 9.9E+99.



Note graph assumes plume disperses vertically in one direction only. An alternative solution assuming the centre of the plume is located at the mid-depth of the aquifer is presented in the calculation sheets.

Note

This sheet calculates the Level 3 remedial target for groundwater, based on the distance to the receptor or compliance located down hydraulic gradient of the source Three solution methods are included, the preferred option is Ogata Banks.

By setting a long travel time it will give the steady state solution, which should be used to calculate remedial targets.

The measured groundwater concentration should be compared
with the Level 3 remedial target to determine the need for further action.
Note if contaminant is not subject to first order degradation, then set half life as 9.0E+99.

This worksheet should be used if pollutant transport and degradation is best described by a first order reaction. If degradation is best desribed by an electron limited degradation such as oxidation by O2, NO3, SO4 etc than an alternative solution should be used

Site being assessed:	Penshurst PRS (Precinct 2)
Completed by:	Jack Sharples
Date:	########
Version:	1

Calculated concentrations for distance-concentration graph

Domenico - Steady state
From calculation sheet

Distance	**Concentration**
	mg/l
0	**8.0E+01**
0.2	**3.83E+00**
0.4	**2.63E+00**
0.6	**2.09E+00**
0.8	**1.76E+00**
1.0	**1.52E+00**
1.2	**1.35E+00**
1.4	**1.21E+00**
1.6	**1.10E+00**
1.8	**1.01E+00**
2.1	**9.30E-01**
2.3	**8.61E-01**
2.5	**8.00E-01**
2.7	**7.46E-01**
2.9	**6.98E-01**
3.1	**6.55E-01**
3.3	**6.15E-01**
3.5	**5.80E-01**
3.7	**5.47E-01**
3.9	**5.17E-01**
4.1	**4.89E-01**

MEDLI REPORT - FULL RUN

Enterprise: **Penshurst**

Description:
Penshurst Precincts V2 - Soil 3

Client: **Wannon Water**

MEDLI User: Deni Hourihan

Scenario Details:
This scenario represents the irrigation under both a beneficial reuse scenario and a land treatment scenario when required due to storage limitations.
The chosen daily wastewater irrigation volumes represent an average year for total irrigation volume (made up of both BR and LT irrigation practices).
Penshurst Precinct - Assumed 1000m2 area
Assumed some Clay Loam in the Soil Profile

DESCRIPTION

Climate Data: Observed Penshurst SILO Data (Post Office), -37.88°, 142.29°

Run Period: 01/01/1960 to 31/12/2019 60 years, 0 days

Climate Statistics:

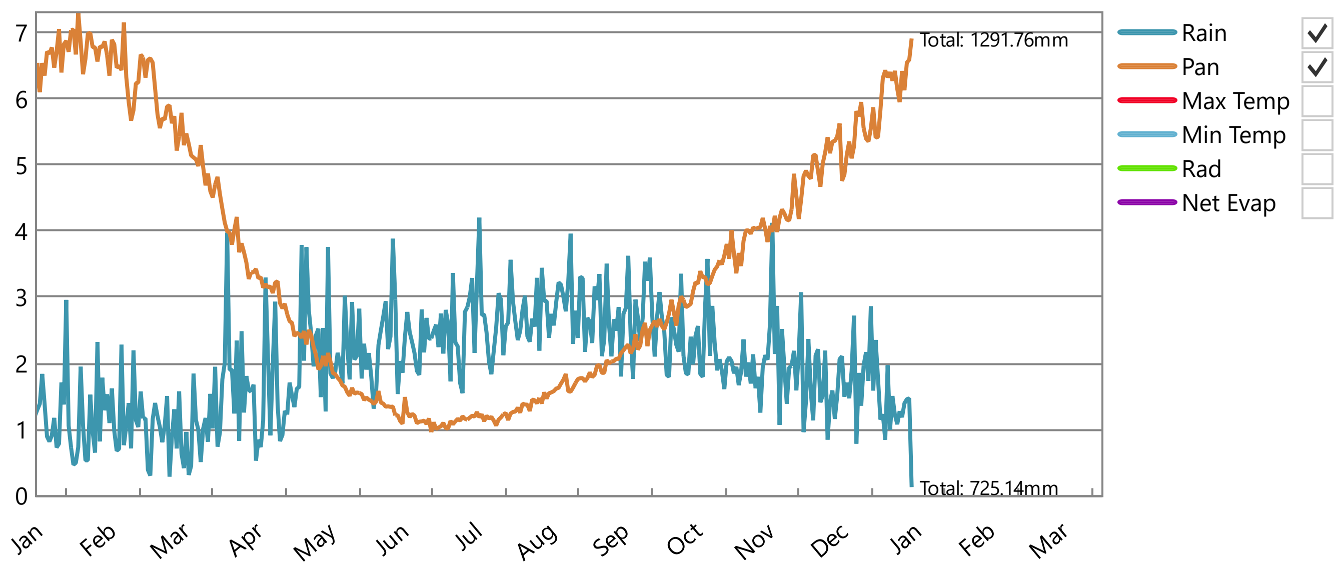
	5th Percentile	50th Percentile	95th Percentile
Rainfall (mm/year)	505	725	1009
Pan Evaporation (mm/year)	1160	1278	1455

Climate Data:

Chart Table

Monthly Daily

Daily Average Across Run Period



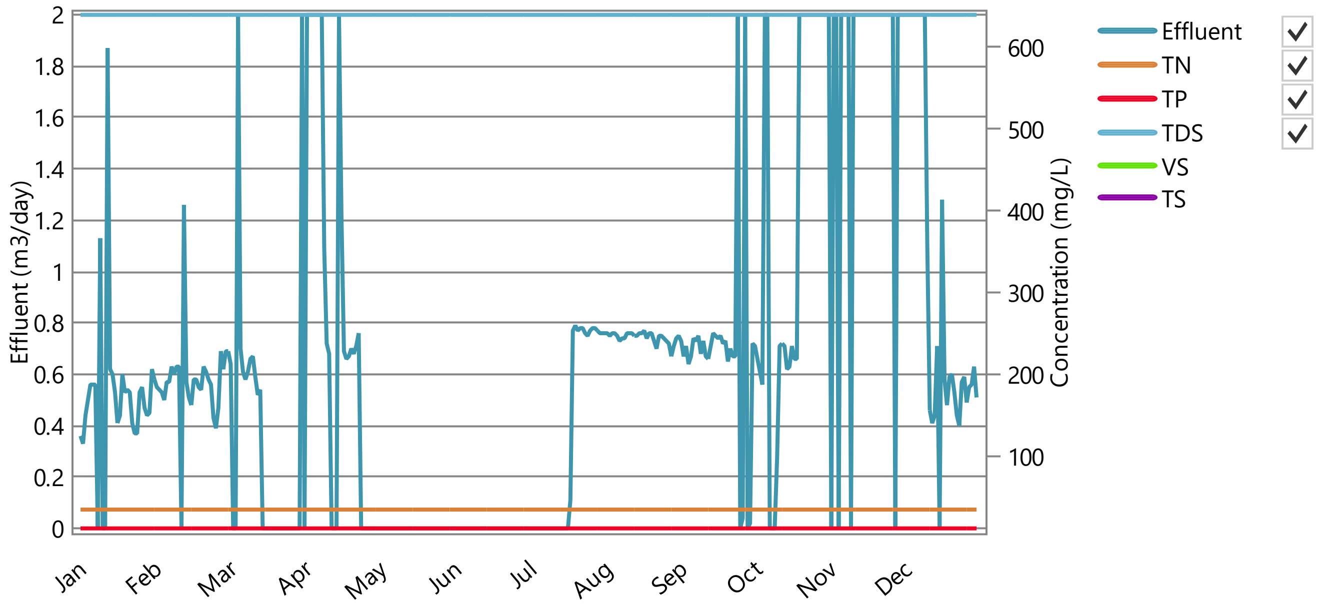
DESCRIPTION

Effluent type: New Generic System

Wastestream before any recycling or pretreatment

Average daily quantity and flow-weighted average quality:

■ Chart ☐ Table



Wastestream after any recycling and pretreatment if applicable

Effluent quantity: 242.28 m3/year or 0.66 m3/day (Min-Max: 0.00 - 2.00)

Flow-weighted average (minimum - maximum) daily effluent quality entering pond system:

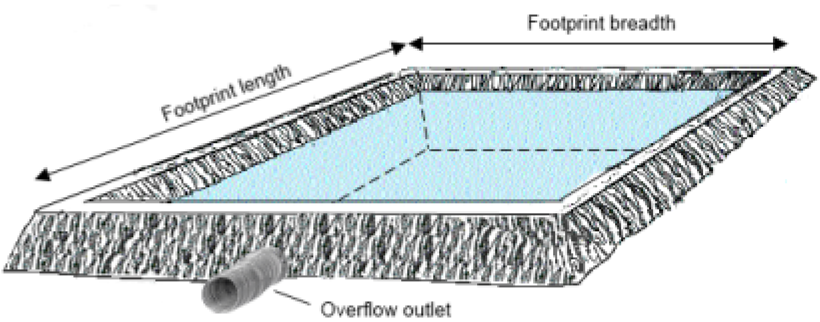
	Concentration (mg/L)	Load (kg/year)
Total Nitrogen	35.00 (0.00 - 35.00)	8.48 (8.48 - 8.49)
Total Phosphorus	12.00 (0.00 - 12.00)	2.91 (2.91 - 2.91)
Total Dissolved Salts	640.00 (0.00 - 640.00)	155.06 (154.98 - 155.30)
Volatile Solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total Solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)

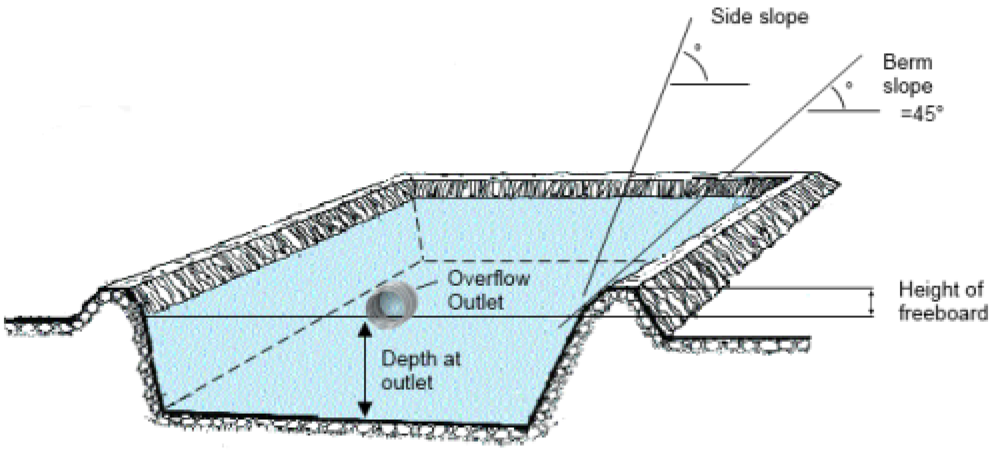
DESCRIPTION

Pond system: 1 closed storage tank

Pond system details:

	Pond 1
Maximum pond volume (m3)	3.00
Minimum allowable pond volume (m3)	0.00
Pond depth at overflow outlet (m)	1.20
Maximum water surface area (m2)	2.50
Pond footprint length (m)	1.58
Pond footprint width (m)	1.58
Pond catchment area (m2)	2.50
Average active volume (m3)	0.00





Irrigation pump limits:

Minimum pump rate limit (ML/day)	0.00
Maximum pump limit	As scheduled

Shandying water:

Annual allocation of fresh water available for shandying (m3/year)	0.00
Maximum rate of application of fresh water (ML/day)	0.00
Nitrogen concentration (mg/L)	0.00
Salinity (dS/m)	0.00
Minimum shandy water is used	False

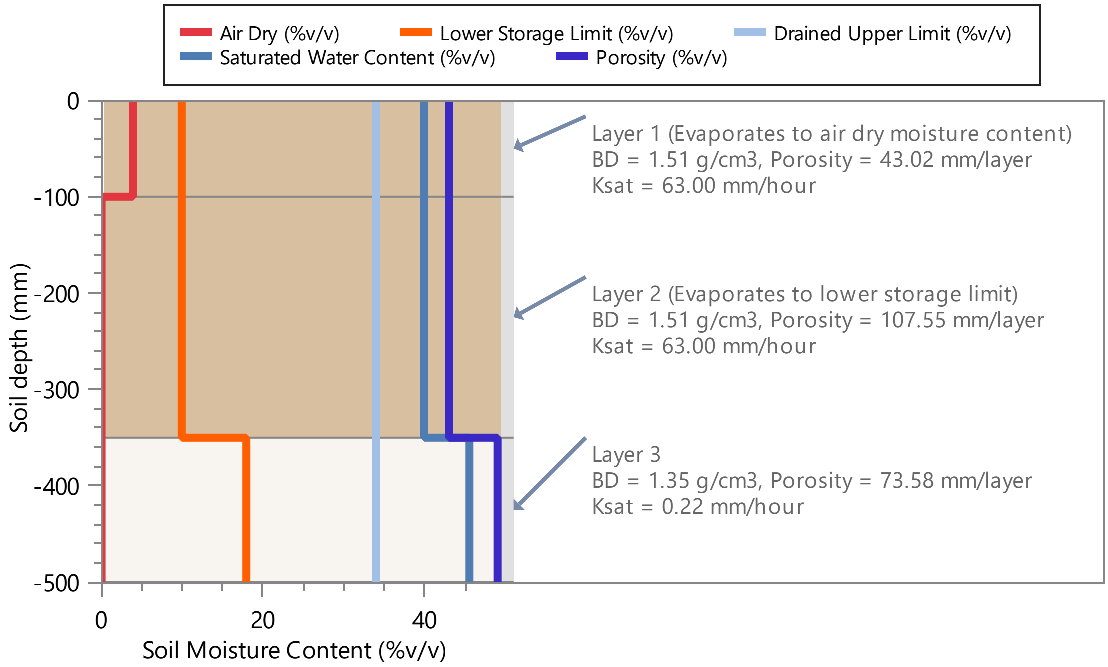
DESCRIPTION

Land: Penshurst Precinct V3 - Clay Loa

Area (m2): 1000.00

Soil Type: Penshurst Precincts, 500.00 mm defined profile depth

Profile Porosity (mm)	224.15
Profile saturation water content (mm)	208.32
Profile drained upper limit (or field capacity) (mm)	170.00
Profile lower storage limit (or permanent wilting point) (mm)	62.00
Profile available water capacity (mm)	108.00
Profile limiting saturated hydraulic conductivity (mm/hour)	0.22
Surface saturated hydraulic conductivity (mm/hour)	63.00
Runoff curve number II (coefficient)	91.00
Soil evaporation U (mm)	8.00
Soil evaporation Cona (mm/sqrt day)	4.00



Plant Data: Continuous Kikuyu 1 Pasture

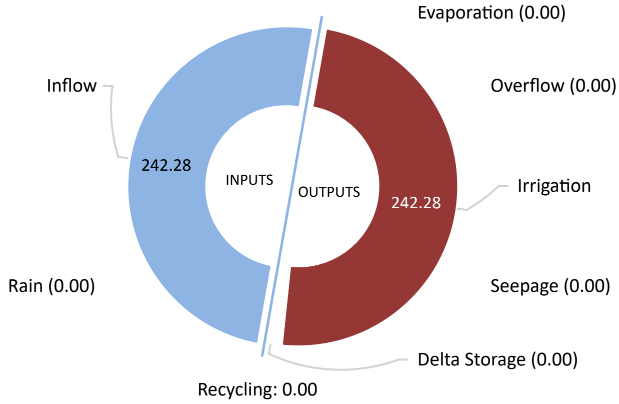
Average monthly cover (fraction) (minimum - maximum)	0.87 (0.65 - 0.96)
Maximum crop factor at 100% cover (mm/mm) (Maximum crop coefficient 0.8 x Pan coefficient 0.8)	0.64
Total plant cover (both green and dead) left after harvest (fraction)	1.00
Maximum potential root depth in defined soil profile (mm)	500.00
Salt tolerance	Moderately tolerant
Salinity threshold EC sat. ext. (dS/m)	3.00
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.03

PERFORMANCE

Pond System Water Performance - Overflow: 1 closed storage tank

Capacity of wet weather storage pond: **3 m3**

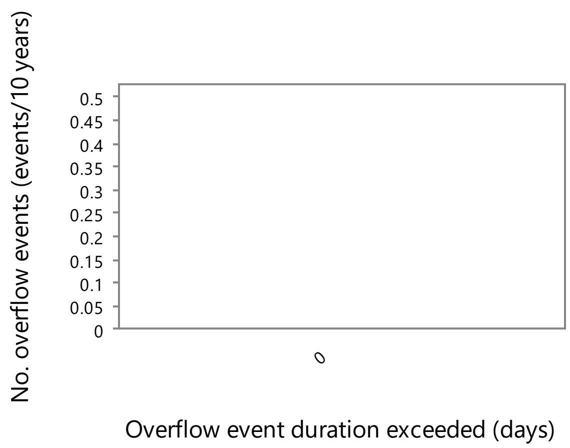
Pond System Water Balance (m3/year)

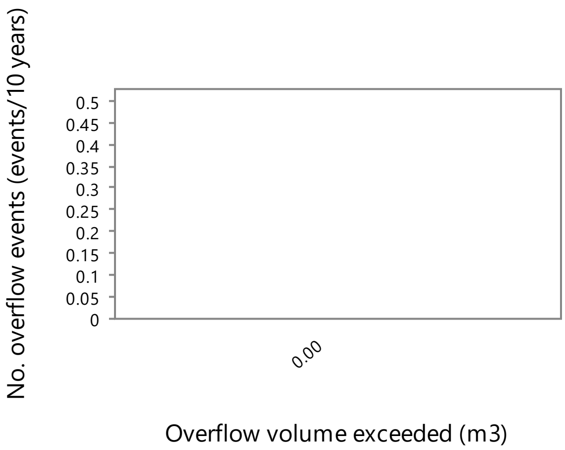


Name	Value
Rain	0.00
Inflow	242.28
Recycling	0.00
Evaporation	0.00
Overflow	0.00
Irrigation	242.28
Seepage	0.00
Delta Storage	0.00

Overflow Diagnostics

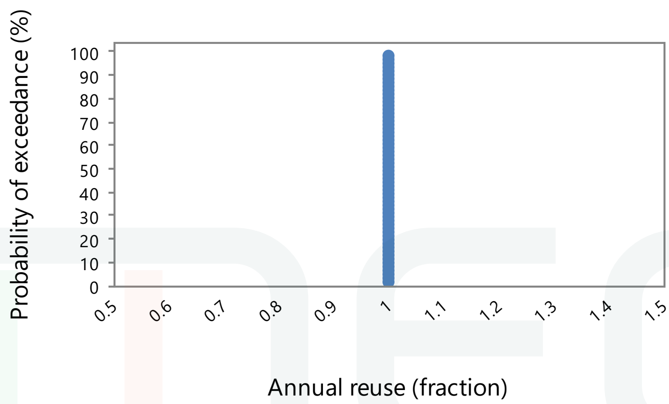
Volume of overflow (m3/year)	0.00
No. days pond overflows (days/year)	0.00
Average duration of overflow (days)	0.00
Effluent Reuse (Proportion of Inflow + Net Rain Gain that is Irrigated) (fraction)	1.00
Probability of at least 90% reuse (fraction)	1.00





Export plot

Export plot



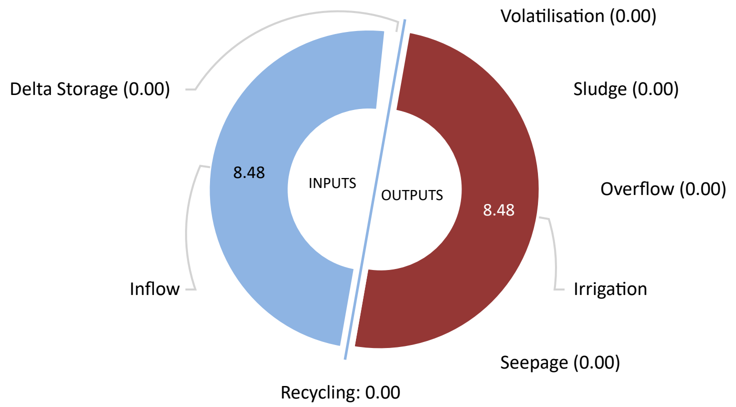
Export plot

PERFORMANCE

Pond System Performance - Nutrient: 1 closed storage tank

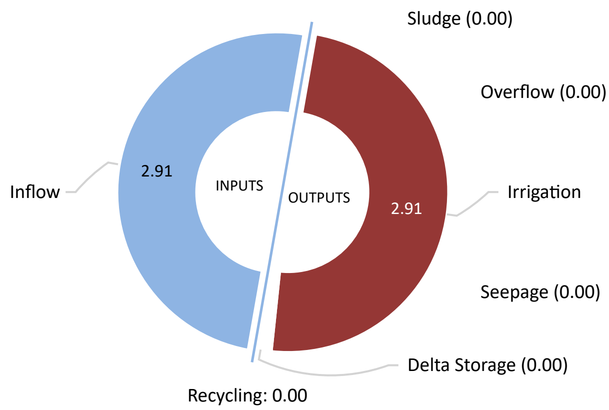
Pond System Nutrients and Salt Balance:

Nitrogen Balance (kg/year)



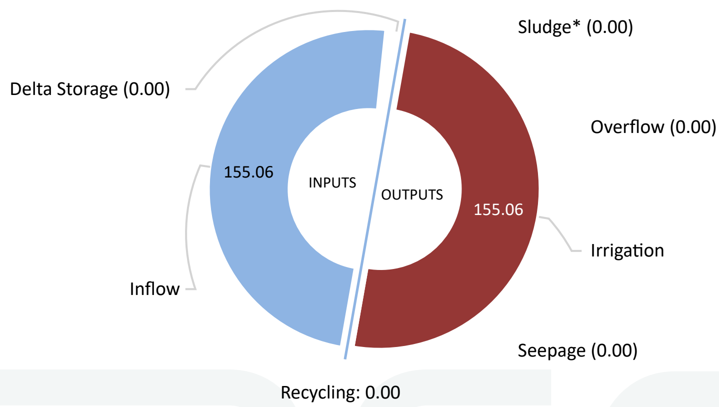
Name	Value
Inflow	8.48
Recycling	0.00
Volatilisation	0.00
Sludge	0.00
Overflow	0.00
Irrigation	8.48
Seepage	0.00
Delta Storage	0.00

Phosphorus Balance (kg/year)



Name	Value
Inflow	2.91
Recycling	0.00
Sludge	0.00
Overflow	0.00
Irrigation	2.91
Seepage	0.00
Delta Storage	0.00

Salt Balance (kg/year)



Name	Value
Inflow	155.06
Recycling	0.00
Sludge*	0.00
Overflow	0.00
Irrigation	155.06
Seepage	0.00
Delta Storage	0.00

* Salt removal in sludge is not calculated from the pond salt balance. However if salt could be assumed to be present in the sludge at the same concentration as in the pond supernatant (up to a maximum of salt added in inflow) - then salt accumulation in the sludge could be 0.00 kg/year

Pond System Sludge Accumulation: 0.00 kg dwt/year

PERFORMANCE

Pond System Performance - Nutrient: 1 closed storage tank

Pond Nutrient Concentrations and Salinity:

Average across simulation period	Pond 1
Average nitrogen concentration of pond liquid (mg/L)	35.00
Average phosphorus concentration of pond liquid (mg/L)	12.00
Average salinity of pond liquid (dS/m)	1.00

Value on final day of simulation period	Pond 1
Final nitrogen concentration of pond liquid (mg/L)	35.00
Final phosphorus concentration of pond liquid (mg/L)	12.00
Final salinity of pond liquid (dS/m)	1.00

PERFORMANCE

Irrigation Performance:

Water Use: (assumes 100% Irrigation Efficiency)

Pond water irrigated (m3/year)	242.28
Average Shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Total water irrigated (m3/year)	242.28
Proportion of irrigation events requiring shandying (fraction of events)	0.00
Proportion of years shandying water allocation of 0 m3/year is exceeded (fraction of years)	0.00
Average exceedance as a proportion of annual shandy water allocation (fraction of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)

Irrigation Quality:

Average nitrogen concentration of irrigation water - before ammonia loss during irrigation (mg/L)	35.00
Average nitrogen concentration of irrigation water - after ammonia loss during irrigation (mg/L)	34.30
Average phosphorus concentration of irrigation water (mg/L)	12.00
Average salinity of irrigation water (dS/m)	1.00

Irrigation Diagnostics:

Proportion of Days pond volume below min. vol. for irrigation (fraction)	0.31
Proportion of Days irrigation occurs (fraction)	0.69

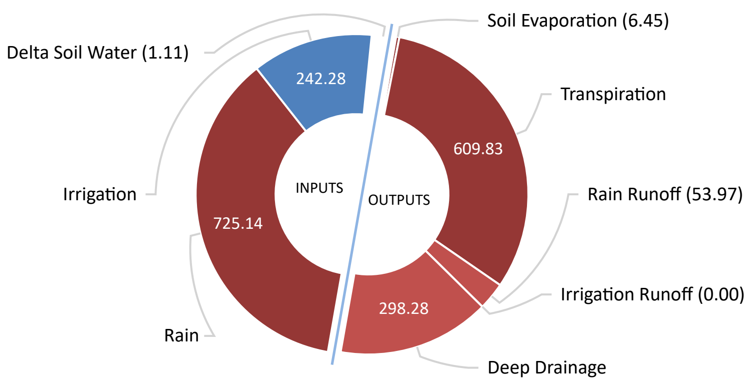
PERFORMANCE

Land Performance - Soil Water

Paddock: Penshurst Precinct V3 - Clay Loa, 1000 m2
Soil Type: Penshurst Precincts, 108.00 mm PAWC at maximum root depth

Land Water Balance (mm/year):

■ mm/year ☐ % Total inputs



Name	Value
Rain	725.14
Irrigation	242.28
Soil Evaporation	6.45
Transpiration	609.83
Rain Runoff	53.97
Irrigation Runoff	0.00
Deep Drainage	298.28
Delta Soil Water	-1.11

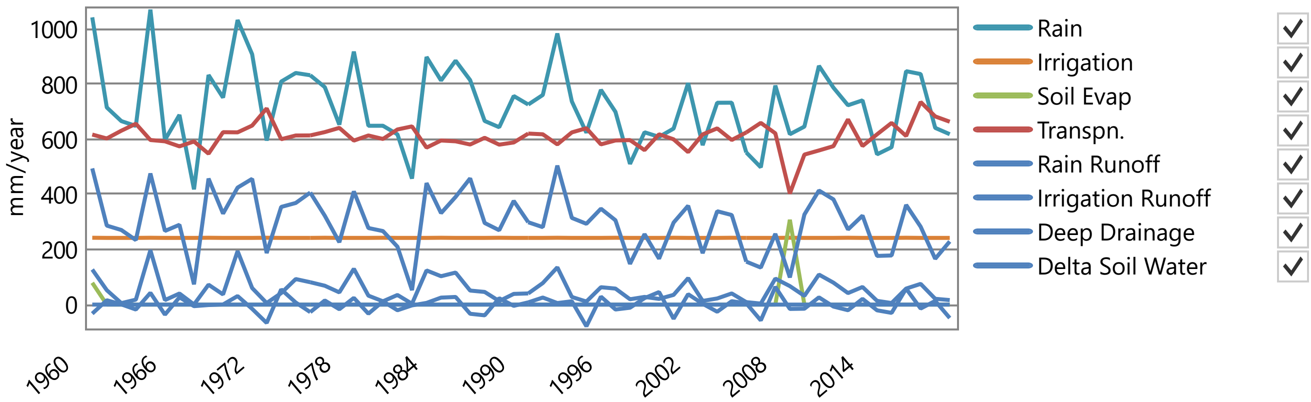
Average Monthly Totals (mm):

☐ Chart ■ Table

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Rain	36.9	30.9	42.5	54.8	69.7	70.3	84.1	87.5	76.8	64.4	57.4	49.8	725.1
Irrigation	15.9	16.0	9.8	26.1	0.0	0.0	9.6	23.1	21.0	37.3	52.0	31.5	242.3
Soil Evap	0.9	0.4	0.2	0.8	0.5	0.4	0.4	0.5	0.9	0.8	0.6	0.1	6.5
Transpn.	78.8	63.4	49.1	37.5	26.3	19.5	23.2	32.9	45.8	68.8	82.0	82.4	609.8
Rain Runoff	2.0	0.6	1.1	2.7	3.7	3.2	6.2	11.2	8.4	4.3	6.4	4.1	54.0
Irrigation Runoff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Deep Drainage	2.9	0.0	0.3	3.3	12.6	31.9	51.9	66.8	51.9	32.5	28.4	15.7	298.3
Delta Soil Water	-31.9	-17.5	1.5	36.6	26.6	15.2	11.9	-0.9	-9.1	-4.7	-7.9	-20.9	-1.1

Average Annual Totals (mm/year):

■ Chart ☐ Table



PERFORMANCE

Land Performance - Soil Nutrient

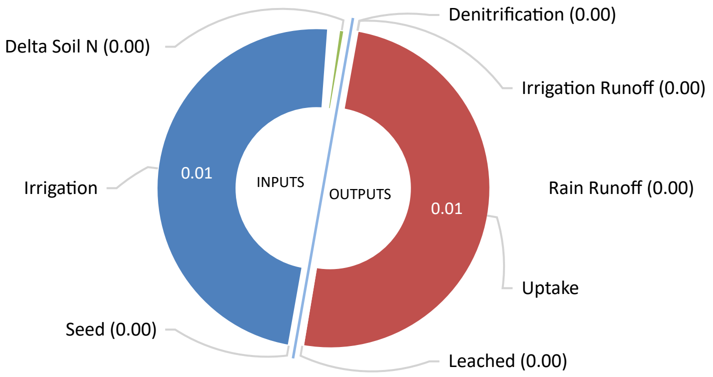
Paddock: Penshurst Precinct V3 - Clay Loa, 1000 m2

Soil Type: Penshurst Precincts

Irrigation ammonium volatilisation losses (kg/m2/year): 0.00

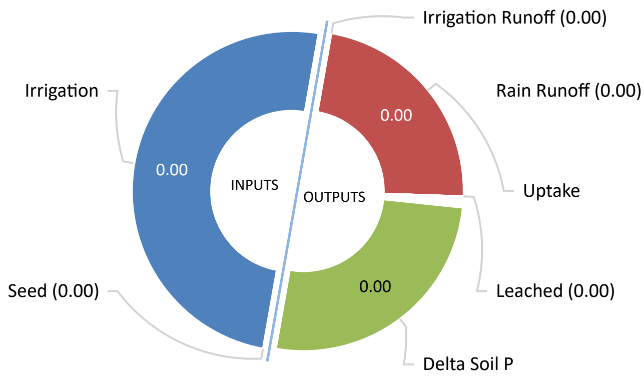
Proportion of total nitrogen in irrigated effluent as ammonium (fraction): 0.20

Land Nitrogen Balance (kg/m2/year)



Name	Value
Seed	3.50E-06
Irrigation	0.01
Denitrification	9.45E-06
Irrigation Runoff	0.00
Rain Runoff	0.00
Uptake	0.01
Leached	2.22E-05
Delta Soil N	-8.83E-05

Land Phosphorus Balance (kg/m2/year)



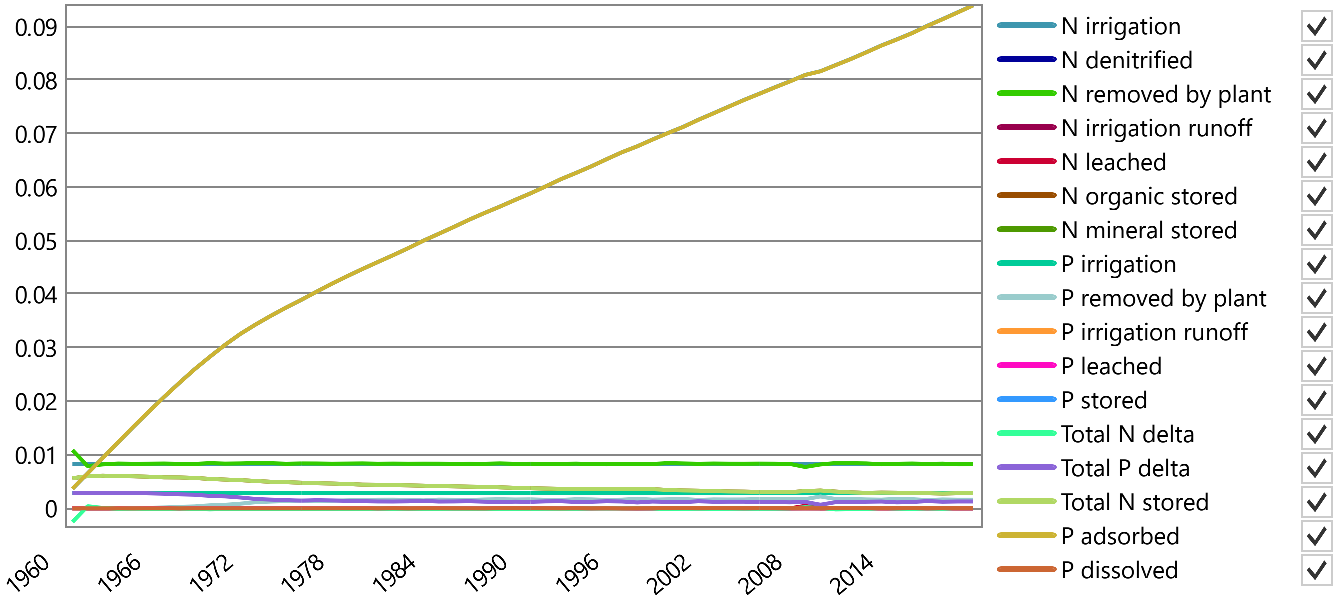
Name	Value
Seed	3.00E-07
Irrigation	2.91E-03
Irrigation Runoff	0.00
Rain Runoff	0.00
Uptake	1.35E-03
Leached	3.03E-07
Delta Soil P	1.55E-03

PERFORMANCE

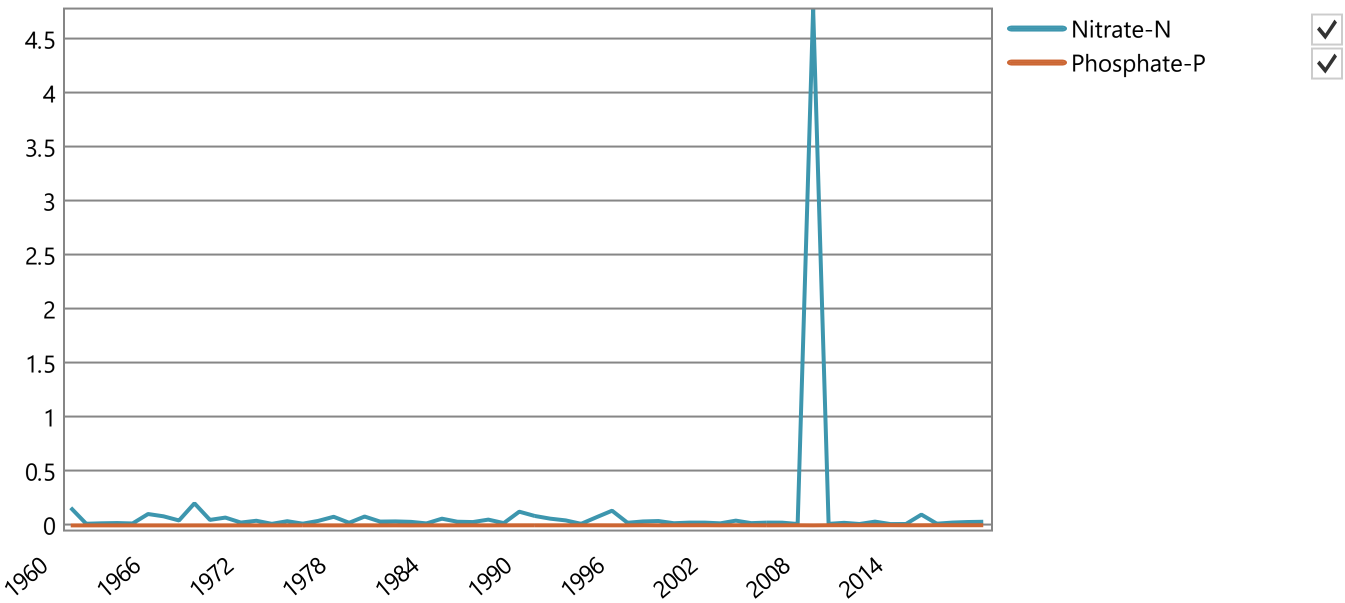
Land Performance - Soil Nutrient

Paddock: Penshurst Precinct V3 - Clay Loa, 1000 m2 **Soil Type**: Penshurst Precincts

Annual Nutrient Totals (kg/m2):



Annual Nutrient Leaching Concentration (mg/L):



PERFORMANCE

Plant Performance and Nutrients

Paddock: Penshurst Precinct V3 - Clay Loa, 1000 m2

Soil Type: Penshurst Precincts

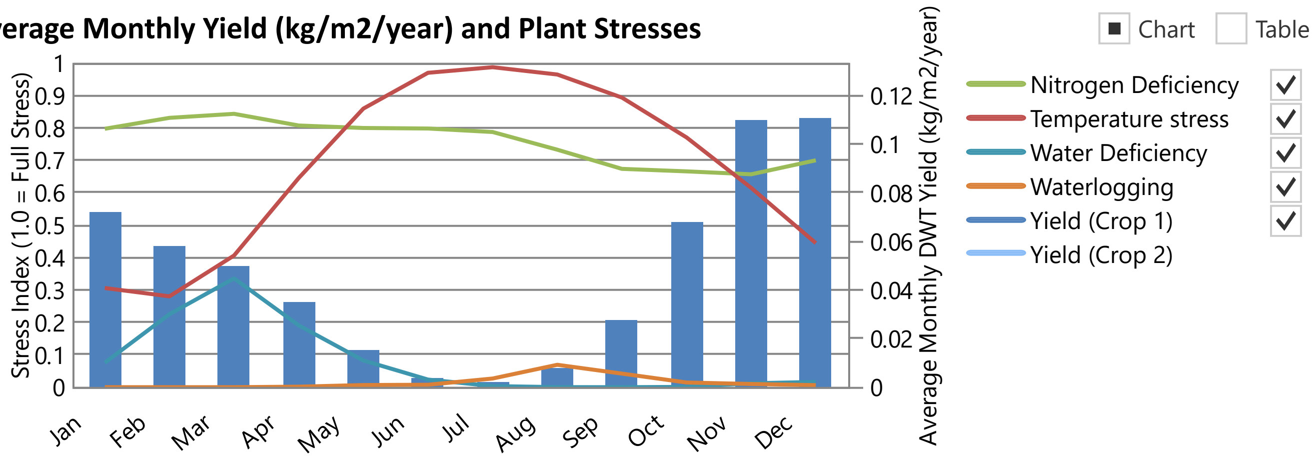
Plant: Continuous Kikuyu 1 Pasture

Average annual shoot dry matter yield (kg/m2/year)	0.56 (0.51 - 0.74)
Average monthly plant (green) cover (fraction) (minimum - maximum)	0.87 (0.65 - 0.96)
Average monthly root depth (mm) (minimum - maximum)	497.04 (494.15 - 500.00)

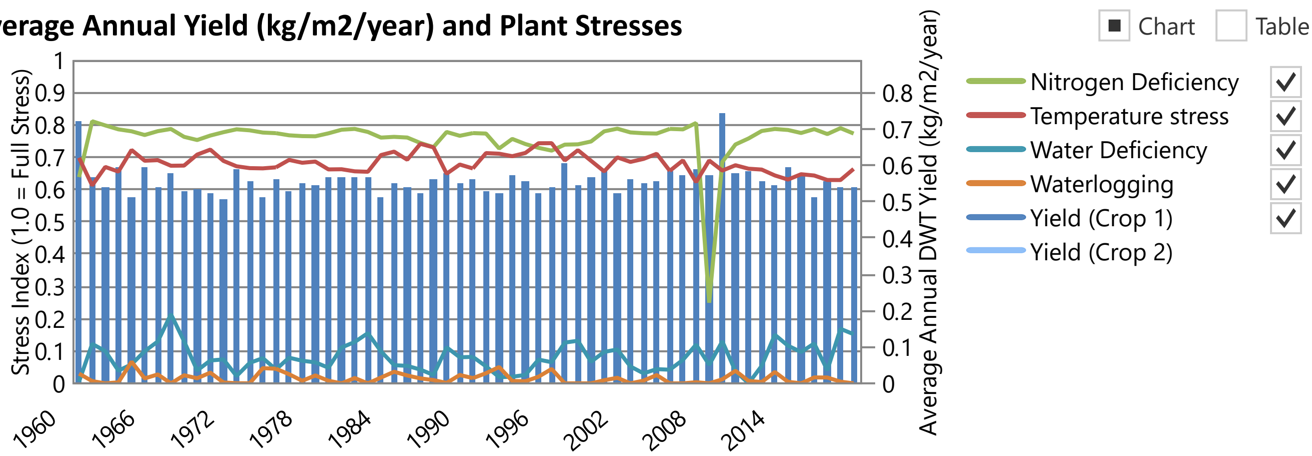
Nutrient Uptake (minimum - maximum):

Average annual net nitrogen removed by plant uptake (kg/m2/year)	0.01 (0.01 - 0.01)
Average annual net phosphorus removed by plant uptake (kg/m2/year)	0.00 (0.00 - 0.00)
Average annual shoot nitrogen concentration (fraction dwt)	0.01 (0.01 - 0.02)
Average annual shoot phosphorus concentration (fraction dwt)	0.002 (0.000 - 0.003)

Average Monthly Yield (kg/m2/year) and Plant Stresses



Average Annual Yield (kg/m2/year) and Plant Stresses



No. of harvests/year: 1.00 (normal), 0.02 (forced by crop death due to water stress (0.02))
No. days without crop/year (days/year): 0.02 due to water stress (0.02)

PERFORMANCE

Land Performance

Paddock: Penshurst Precinct V3 - Clay Loa, 1000 m2 **Soil Type**: Penshurst Precincts

Plant: Continuous Kikuyu 1 Pasture

Salt tolerance	Moderately tolerant
Salinity threshold EC sat. ext. (dS/m)	3.00
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.03
No. years assumed for leaching to reach steady-state (years)	10.00

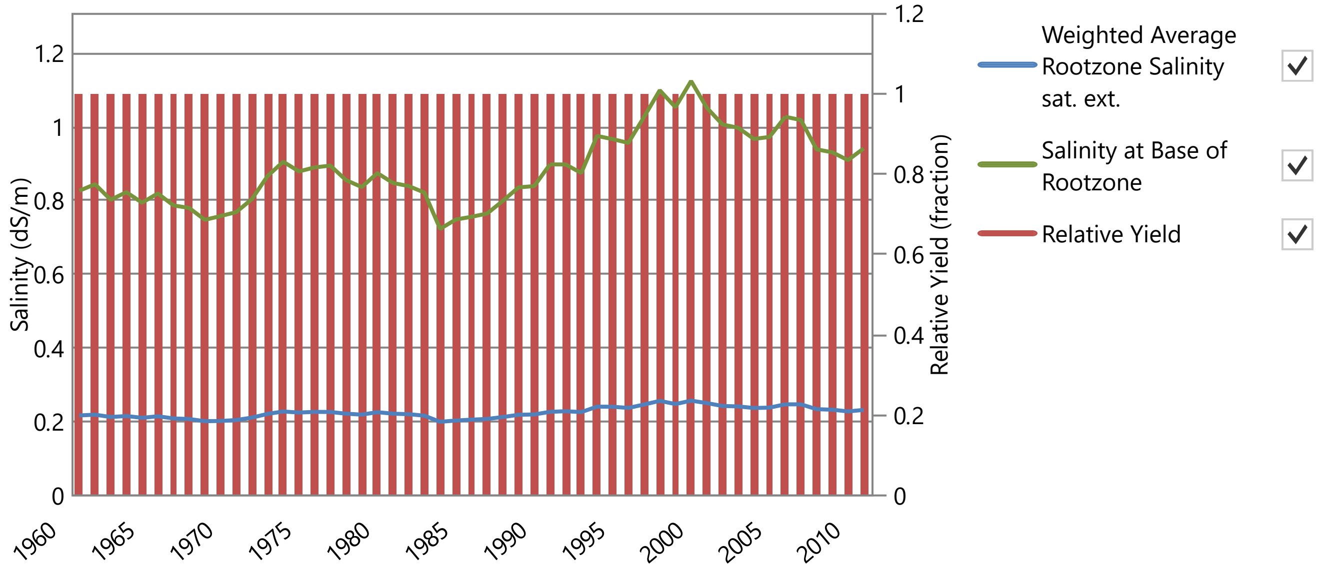
Soil Salinity:

Salinity of infiltrated water (Average salinity of rainwater = 0.03 dS/m) (dS/m)	0.29
Salt added by rainfall (kg/m2/year)	0.01
Average annual effluent salt added & leached at steady state (kg/m2/year)	0.17
Average leaching fraction based on 10 year running averages (fraction)	0.58
Average water-uptake-weighted rootzone salinity sat. ext. (dS/m)	0.23
Salinity of the soil solution (at drained upper limit) at base of rootzone (dS/m)	0.89
Relative crop yield expected due to salinity (fraction)	1.00
Proportion of years that crop yields would be expected to fall below 90% of potential due to salinity (fraction)	0.00

Average Annual Rootzone Salinity and Relative Yield:

■ Chart ☐ Table

All values based on 10 year running averages



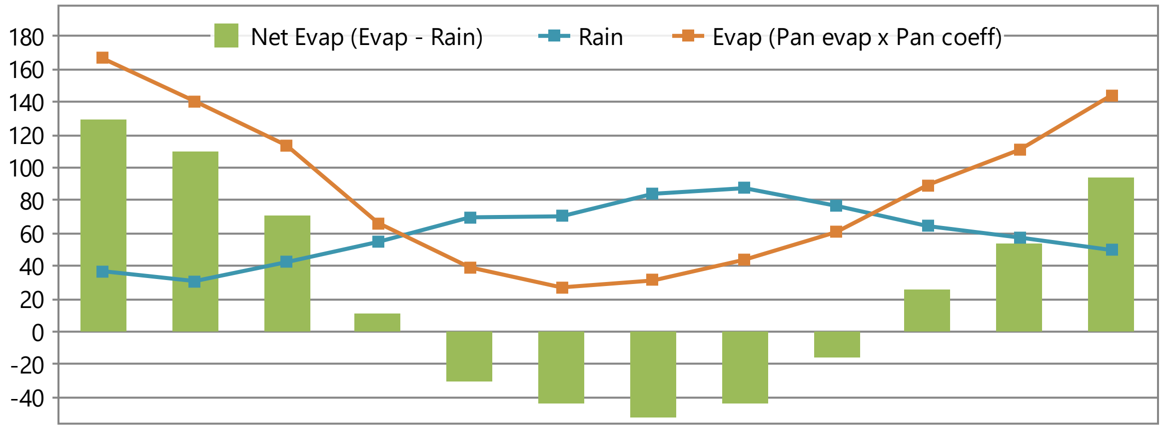
DIAGNOSTICS

Sustainability Diagnostics: Penshurst

Averaged Historical Climate Data Used in Simulation (mm)

Location: Observed Penshurst SILO Data (Post Office), -37.88°, 142.29°

Run Period: 01/01/1960 to 31/12/2019 60 years, 0 days



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	36.9	30.9	42.5	54.8	69.7	70.3	84.1	87.5	76.8	64.4	57.4	49.8	725.1
Evap	166.4	140.4	113.6	66.3	39.3	27.1	31.3	44.0	60.8	89.5	110.9	144.0	1033.4
Net Evap	129.5	109.5	71.1	11.5	-30.4	-43.3	-52.8	-43.5	-16.0	25.1	53.5	94.1	308.3
Net Evap/day	4.2	3.9	2.3	0.4	-1.0	-1.4	-1.7	-1.4	-0.5	0.8	1.8	3.0	0.8

DIAGNOSTICS

Sustainability Diagnostics: Penshurst

Pond System: 1 closed storage tank

New Generic System - 242.28 m3/year or 0.66 m3/day generated on average

Effluent entering pond system after any pretreatment and recycling

Average (Minimum-Maximum) influent quality calculated for 244.25 non-zero flow days, after any pretreatment and recycling.

Constituent	Concentration (mg/L)	Load (kg/year)
Total Nitrogen	35.00 (0.00 - 35.00)	8.48 (8.48 - 8.49)
Total Phosphorus	12.00 (0.00 - 12.00)	2.91 (2.91 - 2.91)
Total Dissolved Salts	640.00 (0.00 - 640.00)	155.06 (154.98 - 155.30)
Volatile Solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total Solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)

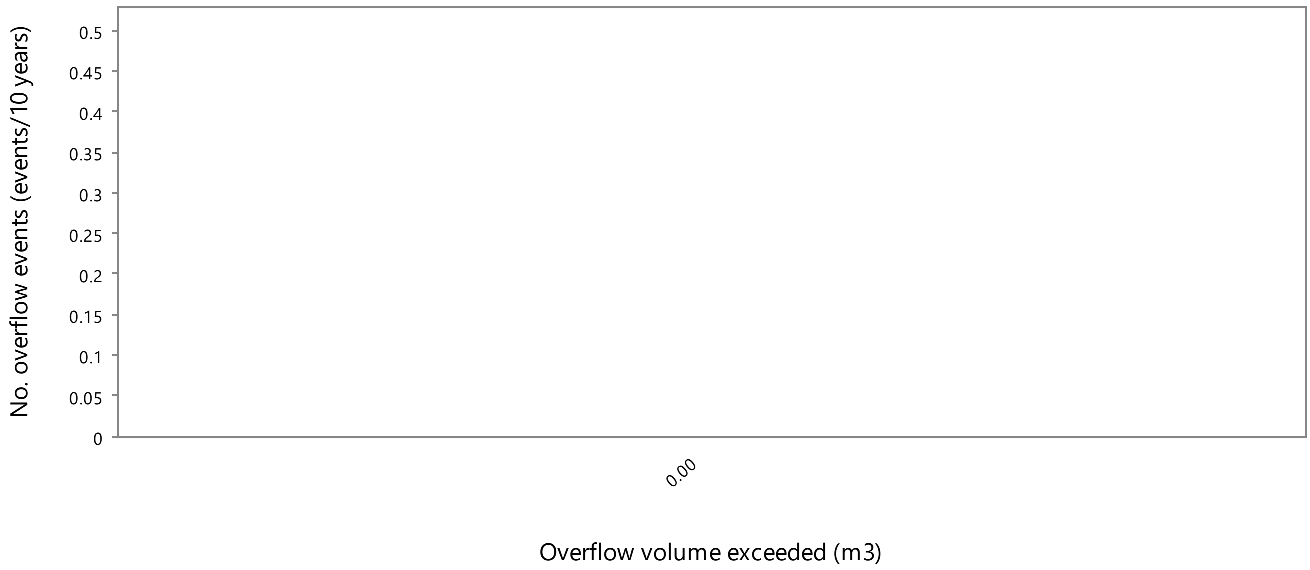
Last pond (Wet weather store): 3.00 m3

Theoretical hydraulic retention time (days)	4.52
Average volume of overflow (m3/year)	0.00
No. overflow events per year exceeding threshold* of 0.00 m3 (no./year)	0.00
Average duration of overflow (days)	0.00
Effluent Reuse (Proportion of Inflow + Net Rain Gain that is Irrigated) (fraction)	1.00
Probability of at least 90% effluent reuse (fraction)	1.00
Average salinity of last pond (dS/m)	1.00
Salinity of last pond on final day of simulation (dS/m)	1.00
Ammonia loss from pond system water area (kg/m2/year)	0.00

* The threshold is the volume equivalent to the top 1 mm depth of water of a full pond

Overflow exceedance:

Chart Table



Export plot

DIAGNOSTICS

Sustainability Diagnostics: Penshurst

Irrigation Information

Irrigation: 1000 m2 total area (assumed 100% irrigation efficiency)

	Quantity/year	Quantity/m2/year
Total irrigation applied (m3)	242.28	0.24
Total nitrogen applied (kg)	8.31	0.01
Total phosphorus applied (kg)	2.91	0.00
Total salts applied (kg)	155.06	0.16

Shandying

Annual allocation of fresh water for shandying (m3/year)	0.00
Average Shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Average exceedance as a proportion of annual shandy water allocation (% of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)
Proportion of irrigation events requiring shandying (fraction of events)	0.00
Minimum shandy water is used	False

Irrigation Issues

Proportion of Days irrigation is prevented when triggered (fraction)	0.31
Proportion of Days irrigation occurs (fraction)	0.69

DIAGNOSTICS

Sustainability Diagnostics: Penshurst

Paddock Land: Penshurst Precinct V3 - Clay Loa: 1000 m2

Irrigation: Flood with 0.1% ammonium loss during irrigation

Irrigation triggered every 1 days
Irrigate a fixed amount of 2.00 mm each day
Irrigation window from 1/1 to 31/12 including the days specified
A minimum of 0 days must be skipped between irrigation events

Soil Water Balance (mm): Penshurst Precincts, 108.00 mm PAWC at maximum root depth

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	36.9	30.9	42.5	54.8	69.7	70.3	84.1	87.5	76.8	64.4	57.4	49.8	725.1
Irrigation	15.9	16.0	9.8	26.1	0.0	0.0	9.6	23.1	21.0	37.3	52.0	31.5	242.3
Soil Evap	0.9	0.4	0.2	0.8	0.5	0.4	0.4	0.5	0.9	0.8	0.6	0.1	6.5
Transpn.	78.8	63.4	49.1	37.5	26.3	19.5	23.2	32.9	45.8	68.8	82.0	82.4	609.8
Rain Runoff	2.0	0.6	1.1	2.7	3.7	3.2	6.2	11.2	8.4	4.3	6.4	4.1	54.0
Irr. Runoff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Drainage	2.9	0.0	0.3	3.3	12.6	31.9	51.9	66.8	51.9	32.5	28.4	15.7	298.3
Delta	-31.9	-17.5	1.5	36.6	26.6	15.2	11.9	-0.9	-9.1	-4.7	-7.9	-20.9	-1.1

Soil Nitrogen Balance

Average annual effluent nitrogen added (kg/m2/year)	0.01
Average annual soil nitrogen removed by plant uptake (kg/m2/year)	0.01
Average annual soil nitrogen removed by denitrification (kg/m2/year)	9.45E-06
Average annual soil nitrogen leached (kg/m2/year)	2.22E-05
Average annual nitrate-N loading to groundwater (kg/m2/year)	2.22E-05
Soil organic-N kg/m2 (Initial - Final)	4.53E-03 - 2.89E-03
	3.66E-03 - 1.03E-06
Average nitrate-N concentration of deep drainage (mg/L)	0.07
Max. annual nitrate-N concentration of deep drainage (mg/L)	4.78

Soil Phosphorus Balance

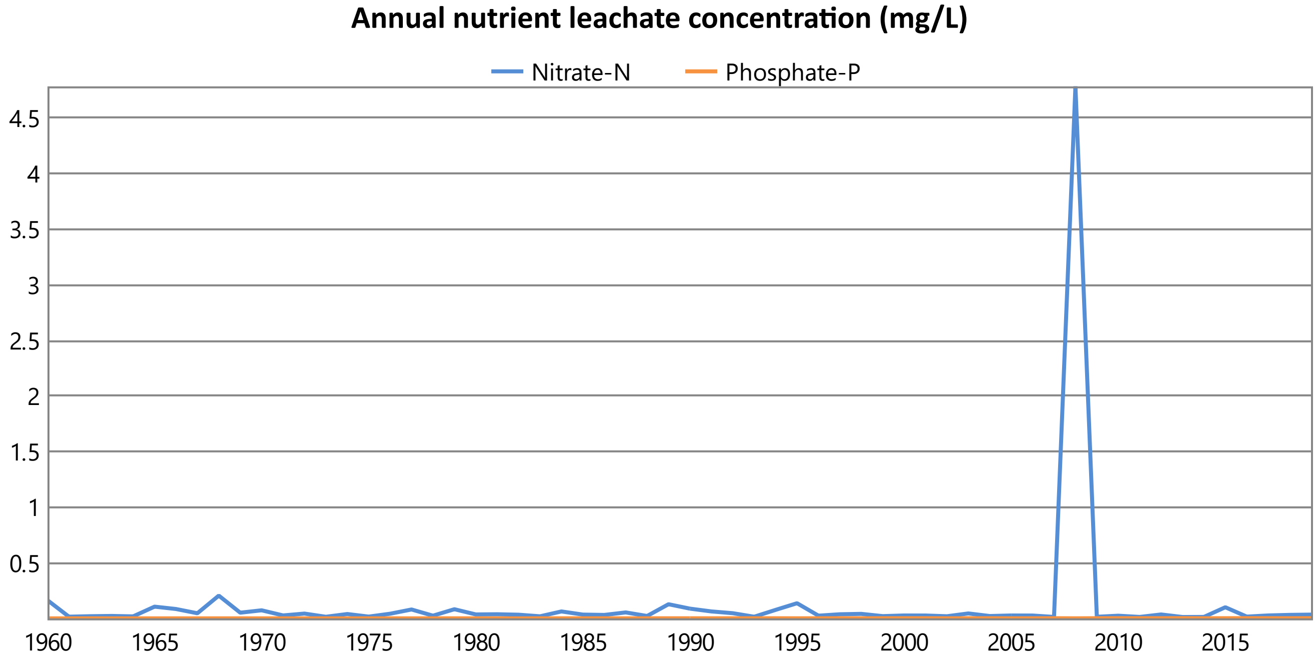
Average annual effluent phosphorus added (kg/m2/year)	2.91E-03
Average annual soil phosphorus removed by plant uptake (kg/m2/year)	1.35E-03
Average annual soil phosphorus leached (kg/m2/year)	3.03E-07
Dissolved phosphorus (kg/m2) (Initial - Final)	0.00 - 2.40E-05
Adsorbed phosphorus (kg/m2) (Initial - Final)	7.31E-04 - 0.09
Average phosphate-P concentration in rootzone (mg/L)	0.10
Average phosphate-P concentration of deep drainage (mg/L)	1.02E-03
Max. annual phosphate-P concentration of deep drainage (mg/L)	2.15E-03
Design soil profile storage life based on average infiltrated water phosphorus concn. of 3.18 mg/L (years)	157.02

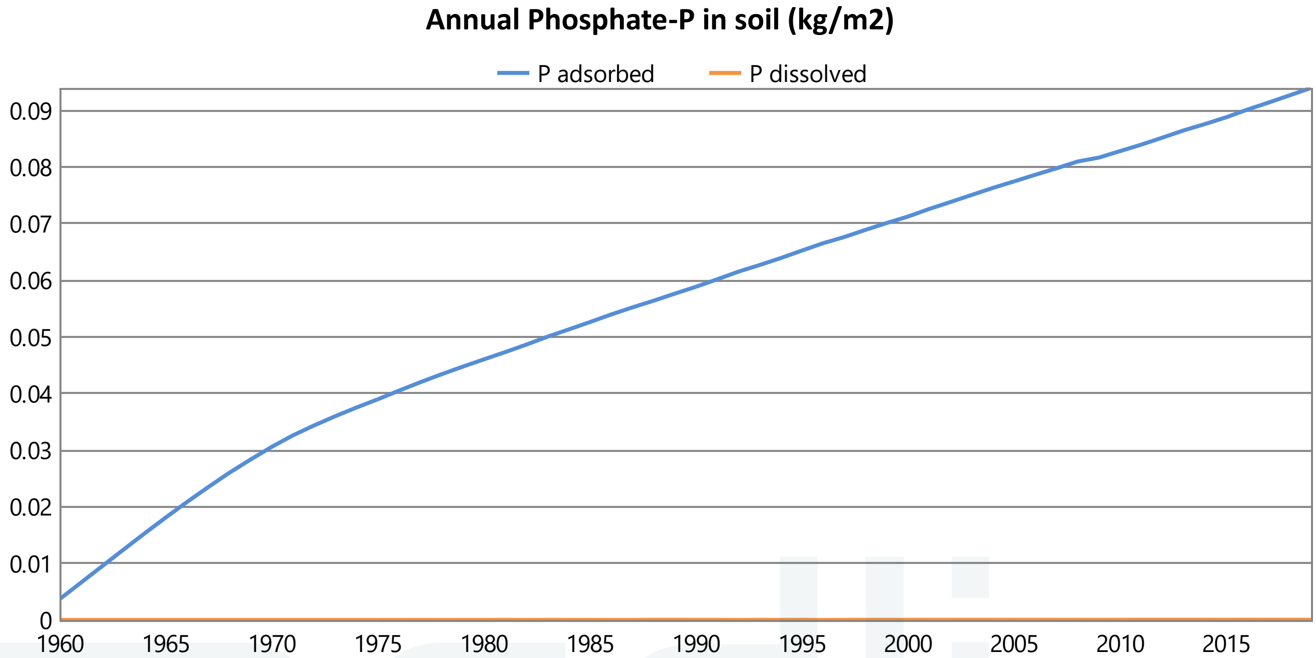
DIAGNOSTICS

Sustainability Diagnostics: Penshurst

Paddock Land: Penshurst Precinct V3 - Clay Loa: 1000 m2

Irrigation: Flood with 0.1% ammonium loss during irrigation





DIAGNOSTICS

Sustainability Diagnostics: Penshurst

Paddock Plant Performance: Penshurst Precinct V3 - Clay Loa: 1000 m2

Average Plant Performance (Minimum - Maximum): Continuous Kikuyu 1 Pasture

Average annual shoot dry matter yield (kg/m2/year)	0.56 (0.51 - 0.74)
Average monthly plant (green) cover (fraction)	0.87 (0.65 - 0.96)
Average monthly crop factor (fraction)	0.56 (0.41 - 0.62)
Total plant cover (both green and dead) left after harvest (fraction)	1.00
Average monthly root depth (mm)	497.04 (494.15 - 500.00)
Average number of normal harvests per year (no./year)	1.00 (0.00 - 2.00)
Average number of normal harvests for last five years only (no./year)	1.00
Average number of crop deaths per year (no./year)	0.02 (0.00 - 1.00)
Average number of crop deaths for last five years only (no./year)	0.00
Average annual nitrogen deficiency index (0 = no stress, 1 = full stress) (coefficient)	0.76 (0.25 - 0.81)
Average January temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.31 (0.15 - 0.54)
Average July temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.99 (0.93 - 1.00)
Average monthly water stress index (0 = no stress, 1 = full stress) (coefficient)	0.08 (0.00 - 0.34)
Average monthly waterlogging index (0 = no stress, 1 = full stress) (coefficient)	0.02 (0.00 - 0.07)
No. days without crop/year (days)	0.02

Soil Salinity - Plant salinity tolerance: Moderately tolerant

Assumes 1.0 dS/m Electrical Conductivity = 640 mg/L Total Dissolved Salts
All values based on 10 year running averages

Salinity of infiltrated water (Average salinity of rainwater = 0.03 dS/m) (dS/m)	0.29
Salt added by rainfall (kg/m2/year)	0.01
Average annual effluent salt added & leached at steady state (kg/m2/year)	0.17
Average leaching fraction based on 10 year running averages (fraction)	0.58
Average water-uptake-weighted rootzone salinity sat. ext. (dS/m)	0.23
Salinity of the soil solution (at drained upper limit) at base of rootzone (dS/m)	0.89
Relative crop yield expected due to salinity (fraction)	1.00
Proportion of years that crop yields would be expected to fall below 90% of potential due to salinity (fraction)	0.00

DIAGNOSTICS

Run Messages

Messages generated when the scenario was run:

Full run chosen

Appendix E Cost Estimate Details

DECENTRALISED WATER CONSULTING

Capital Delivery Cost Estimate
Small Towns Wastewater Investigation

Penshurst Solution

Version 5.0
Date 8/10/2020
Summary Precinct / Cluster Based Treatment and Reuse: Lower Estimate

Component	Description	Unit	Quantity	Rate	Subtotal	Total
ON PROPERTY INFRASTRUCTURE						$ 444,000
On-site system upgrade - Full containment	Supply and installation of secondary treatment system and EPA compliant effluent LAA (blue properties on Servicing Layout). Includes connection to effluent sewer where available.	Lots	12	$ 16,000	$ 192,000	
Non-containment upgrade (Pumped)	Supply and install Septic Tank Effluent Pump (STEP) unit, property line and boundary kit.	Lots	18	$ 14,000	$ 252,000	
RETICULATION / COLLECTION INFRASTRUCTURE						$ 3,511,420
Gravity sewer (DN150) Trench Excavation 0-1.5m	Supply, installation, backfill and testing of gravity sewer at 0-1.5m depth. Trench excavation with allowance for rock breaking (hammer) from 0.5m. Includes welded and/or single piece joins and mintenance structures. Allowance for CCTV and vacuum testing	m	4872	$ 150	$ 730,800	
Gravity sewer (DN150) Trench Excavation 1.5-2.5m	Supply, installation, backfill and testing of gravity sewer at 1.5-2.5m depth. Trench excavation with allowance for rock breaking (hammer) from 0.5m. Includes welded and/or single piece joins and mintenance structures. Allowance for CCTV and vacuum testing	m	2933	$ 200	$ 586,600	
Gravity sewer (DN150) Trench Excavation 2.5-3.5m	Supply, installation, backfill and testing of gravity sewer at 2.5-3.5m depth. Trench excavation with allowance for rock breaking (hammer) from 0.5m. Includes welded and/or single piece joins and mintenance structures. Allowance for CCTV and vacuum testing	m	449	$ 280	$ 125,720	
Micro-tunnelling DN150 in Basalt	Bore install centralise and grout a 150 in a 350(min) bore (no excavation of shafts) ~100 Mpa basalt. All pipe supplied and drill waste(ground and water only) to be left of site Common accuracy +/-10mm	m	1386	$ 1,200	$ 1,663,200	
Property Branches		No.	268	$ 200	$ 53,600	
Access / Maintenance Chambers 0-1.5m	Assumes on every ~100m and change in direction. Includes excavation, installation, backfill compaction, testing. Allowance for rock from 0.5m	No.	190	$ 1,850	$ 351,500	
TREATMENT AND STORAGE						$ 2,437,247
Cluster Rhizopod System	Supply and install of aerated balance tank, pumps, pods and SCADA based control system.	Pod	187	8000	$ 1,496,000	
Treated effluent storage (Steel Tanks)	Above ground steel (lined) storage tanks on gravel base (Based on 33 of 350kL tanks)	kL	350	Cost Curve	$ 941,247	
EFFLUENT MANAGEMENT AND REUSE						$ 1,100,000
Subsurface irrigation of Public Open Space	Supply and install zoned, automated pressure compensating subsurface irrigation systems. Restricted access irrigation (overnight).	ha	11	$ 60,000	$ 660,000	
Recycled water main	DN50 PE100 recycled water pressure main from SMF to Penshurst Oval for beneficial reuse	m	500	$ 200	$ 100,000	
Recycled Water Pump Station	Supply and install PE or GRP Septic Tank Effluent Pump (STEP) stations	Unit	3	$ 20,000	$ 60,000	
Land Treatment System		Ha	3	$ 50,000	$ 150,000	
Civil and Ancillary Infrastructure		No.	1	$ 50,000	$ 50,000	
Monitoring System		LS	1	$ 20,000	$ 20,000	
Land purchase		ha	4	$ 15,000	$ 60,000	

TOTAL ESTIMATED COSTS		**$ 7,492,667**
Investigation & Design	20%	$ 1,498,533
Risk and Opportunity	10%	$ 749,267
Wannon Water Supervision, PM, Overheads & Indirects	10%	$ 749,267
Allowance for Scope Growth/Functionality/Operational Requirements	10%	$ 749,267
	50%	**$ 3,746,334**
TOTAL DELIVERY COST		**$ 11,239,001**

DECENTRALISED WATER CONSULTING

Capital Delivery Cost Estimate
Small Towns Wastewater Investigation

Penshurst Solution

Version 5.0
Date 8/10/2020
Summary Precinct / Cluster Based Treatment and Reuse: Higher Estimate

Component	Description	Unit	Quantity	Rate	Subtotal	Total
ON PROPERTY INFRASTRUCTURE						$ 444,000
On-site system upgrade - Full containment	Supply and installation of secondary treatment system and EPA compliant effluent LAA (blue properties on Servicing Layout). Includes connection to effluent sewer where available.	Lots	12	$ 16,000	$ 192,000	
Non-containment upgrade (Pumped)	Supply and install Septic Tank Effluent Pump (STEP) unit, property line and boundary kit.	Lots	18	$ 14,000	$ 252,000	
RETICULATION / COLLECTION INFRASTRUCTURE						$ 4,967,220
Gravity sewer (DN150) Trench Excavation 0-1.5m	Supply, installation, backfill and testing of gravity sewer at 0-1.5m depth. Trench excavation with allowance for rock breaking (hammer) from 0.5m. Includes welded and/or single piece joins and mintenance structures. Allowance for CCTV and vacuum testing	m	4572	$ 210	$ 960,120	
Gravity sewer (DN150) Trench Excavation 1.5-2.5m	Supply, installation, backfill and testing of gravity sewer at 1.5-2.5m depth. Trench excavation with allowance for rock breaking (hammer) from 0.5m. Includes welded and/or single piece joins and mintenance structures. Allowance for CCTV and vacuum testing	m	2887	$ 300	$ 866,100	
Gravity sewer (DN150) Trench Excavation 2.5-3.5m	Supply, installation, backfill and testing of gravity sewer at 2.5-3.5m depth. Trench excavation with allowance for rock breaking (hammer) from 0.5m. Includes welded and/or single piece joins and mintenance structures. Allowance for CCTV and vacuum testing	m	449	$ 500	$ 224,500	
Micro-tunnelling DN150 in Basalt	Bore install centralise and grout a 150 in a 350(min) bore (no excavation of shafts) ~100 Mpa basalt. All pipe supplied and drill waste(ground and water only) to be left of site Common accuracy +/-10mm	m	1732	$ 1,450	$ 2,511,400	
Property Branches		No.	268	$ 200	$ 53,600	
Access / Maintenance Chambers 0-1.5m	Assumes on every ~100m and change in direction. Includes excavation, installation, backfill compaction, testing. Allowance for rock from 0.5m	No.	190	$ 1,850	$ 351,500	
TREATMENT AND STORAGE						$ 2,437,247
Cluster Rhizopod System	Supply and install of aerated balance tank, pumps, pods and SCADA based control system.	Pod	187	8000	$ 1,496,000	
Treated effluent storage (Steel Tanks)	Above ground steel (lined) storage tanks on gravel base (Based on 33 of 350kL tanks)	kL	350	Cost Curve	$ 941,247	
EFFLUENT MANAGEMENT AND REUSE						$ 1,100,000
Subsurface irrigation of Public Open Space	Supply and install zoned, automated pressure compensating subsurface irrigation systems. Restricted access irrigation (overnight).	ha	11	$ 60,000	$ 660,000	
Recycled water main	DN50 PE100 recycled water pressure main from SMF to Penshurst Oval for beneficial reuse	m	500	$ 200	$ 100,000	
Recycled Water Pump Station	Supply and install PE or GRP Septic Tank Effluent Pump (STEP) stations	Unit	3	$ 20,000	$ 60,000	
Land Treatment System		Ha	3	$ 50,000	$ 150,000	
Civil and Ancillary Infrastructure		No.	1	$ 50,000	$ 50,000	
Monitoring System		LS	1	$ 20,000	$ 20,000	
Land purchase		ha	4	$ 15,000	$ 60,000	

TOTAL ESTIMATED COSTS		**$ 8,948,467**
Investigation & Design	20%	$ 1,789,693
Risk and Opportunity	10%	$ 894,847
Wannon Water Supervision, PM, Overheads & Indirects	10%	$ 894,847
Allowance for Scope Growth/Functionality/Operational Requirements	10%	$ 894,847
	50%	**$ 4,474,234**
TOTAL DELIVERY COST		**$ 13,422,701**

DECENTRALISED WATER CONSULTING

Operational Cost Estimate
Small Towns Wastewater Investigation

Solution Package 2

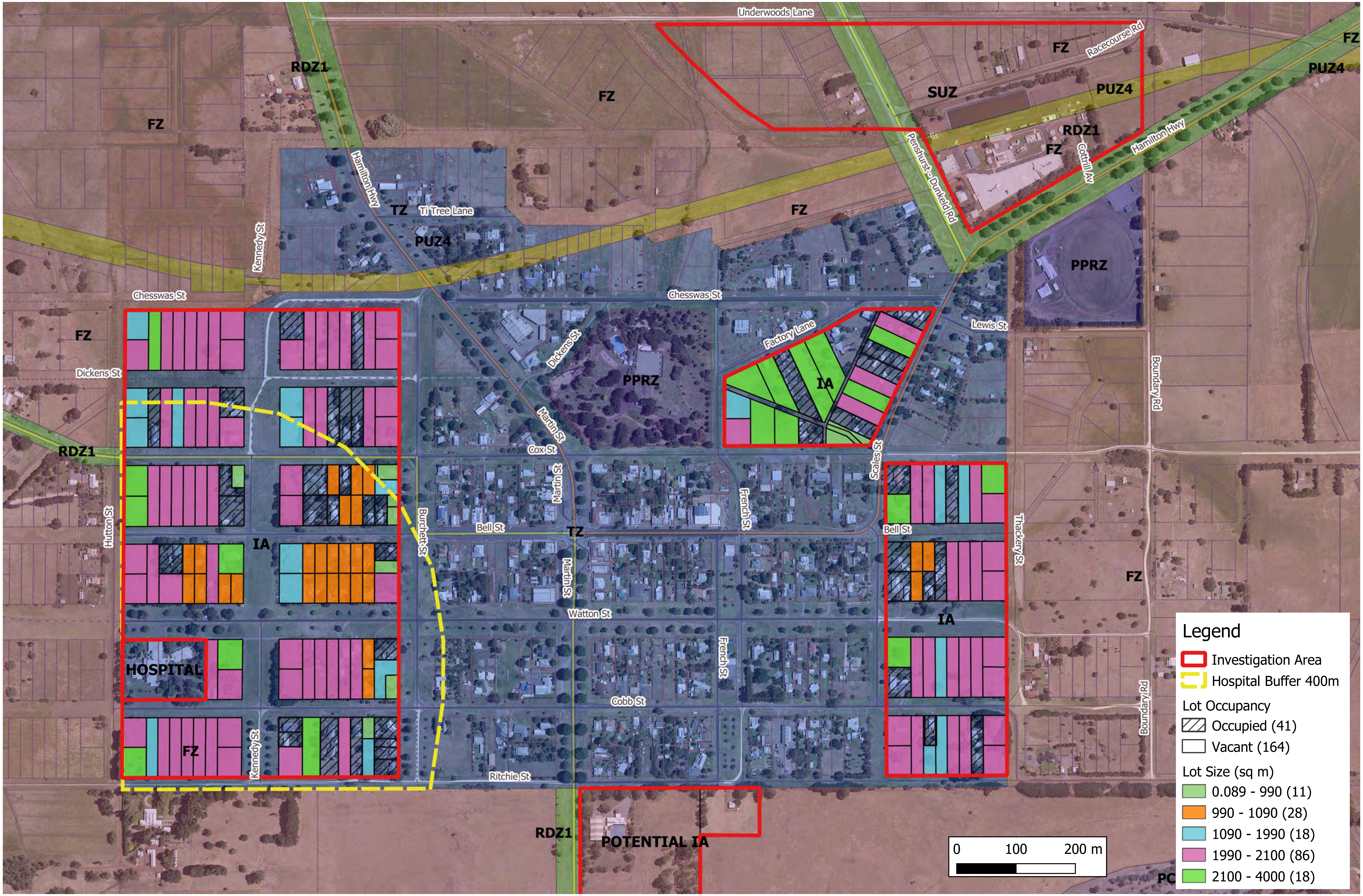
Version 5.0
Date 8/10/2020
Summary Precinct / Cluster Based Treatment and Reuse

Component	Description	Unit	Quantity	Rate	Subtotal	Total
ON PROPERTY INFRASTRUCTURE						$ 17,273
On-site system upgrade - Full containment	Cost based on previous investigations including Park Orchards and Forrest. Includes; - Periodic (3 month) inspection and service; - Power costs (based on typical mid range technology) - Annualised cost rate for 3 yearly pump out (incl secondary sludge) - Annualised cost rate for M&E component replacement (blower, irrigation pump,controls) - Annualised cost for minor LAA repairs.	Lots	12	$ 980	$ 11,760	
On property STEP transfer units		Lots	18	$ 306	$ 5,513	
RETICULATION / COLLECTION INFRASTRUCTURE						$ 23,221
Gravity Mains (Standard)	Based on Yarra Valley Water per metre rate (same for pressure and gravity)	m	9640	$ 1.95	$ 18,798	
STEP Pump Station		unit	3	$ 1,474	$ 4,423	
TREATMENT AND STORAGE						$ 30,271
Cluster Rhizopod System	Includes annual inspection and vegetation management. Power usage and M&E component replacement.	LS	1	$ 30,271	$ 30,271	
EFFLUENT MANAGEMENT AND REUSE						$ 62,444
Subsurface irrigation of Public Open Space	Supply and install zoned, automated pressure compensating subsurface irrigation systems. Restricted access irrigation (overnight).	LS	1	$ 21,563	$ 21,563	
Recycled Water Pump Stations		LS	4	$ 1,474	$ 5,897	
Land Treatment System		LS	1	$ 34,984	$ 34,984	
	TOTAL ESTIMATED COSTS					**$ 133,209**
	Risk and Opportunity				10%	$ 13,321
	Wannon Water Supervision, PM, Overheads & Indirects				10%	$ 13,321
	Allowance for Scope Growth/Functionality/Operational Requirements				10%	$ 13,321
					30%	**$ 39,963**
	TOTAL DELIVERY COST					**$ 173,172**

Appendix F Penshurst Strategic Concept Plan (Draft)

PENSHURST CONCEPT PLAN

SOUTHERN GRAMPIANS SHIRE COUNCIL

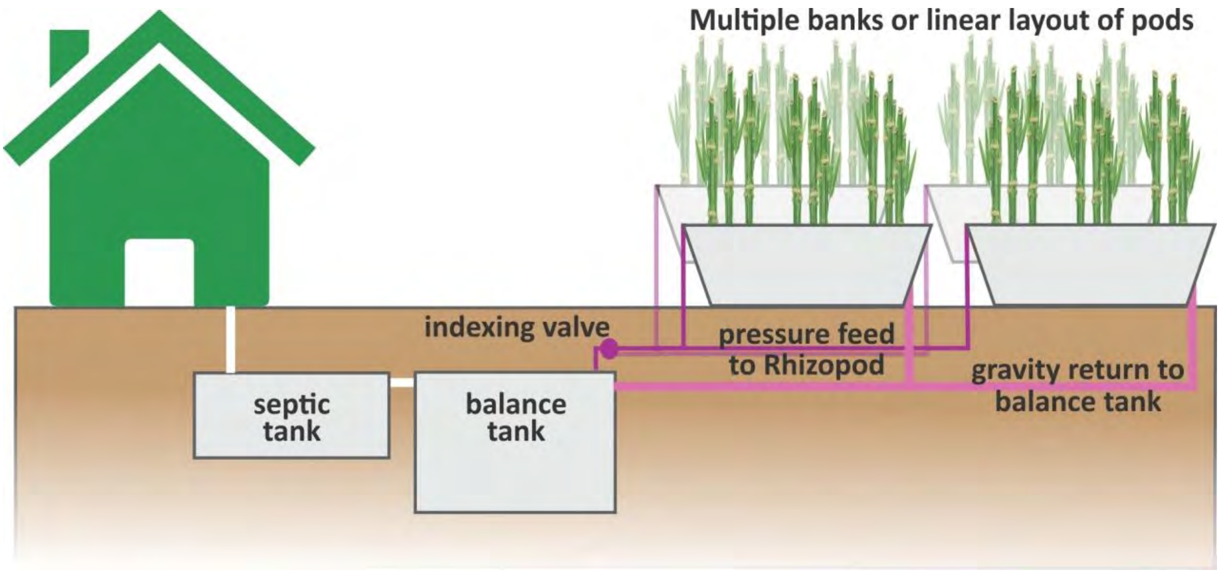


Appendix G Rhizopod^{TM} Fact Sheet & Example Photos

Understanding Rhizopods®

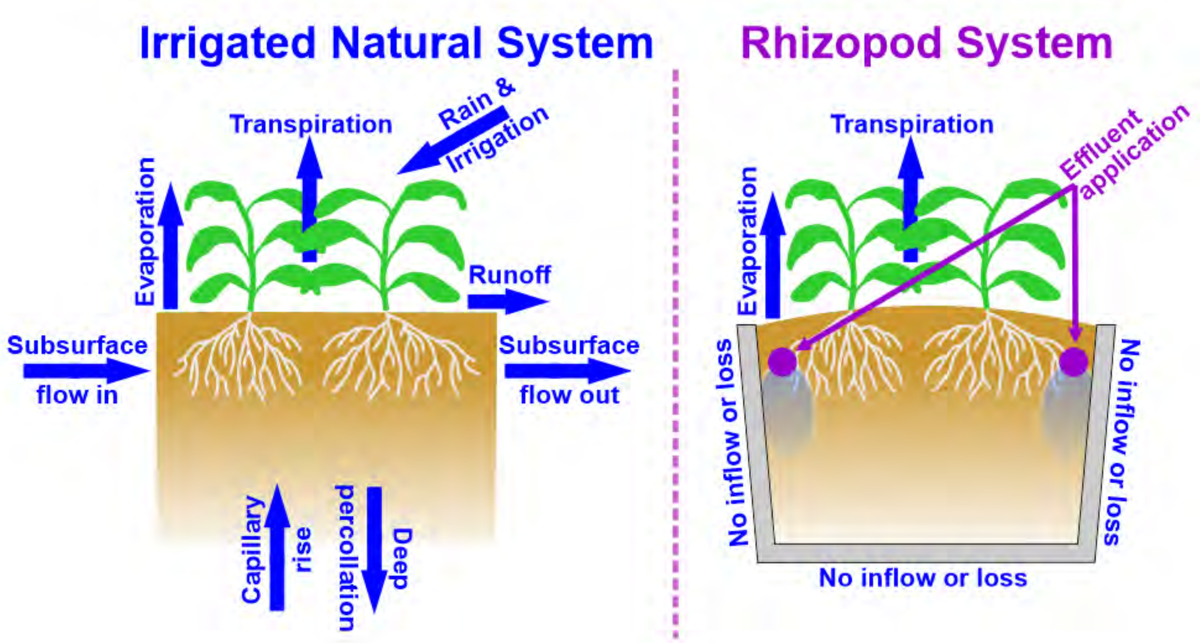
Arris can design, construct, maintain, and operate Rhizopod® systems

The Rhizopod® system is a "Zero Discharge" wastewater dispersal method that can be used with Septic Tanks or Aerobic Treatment Units. Wastewater from the house or commercial premise passes to the on-site effluent treatment system and then into the Rhizopod® system for dispersal through a closed soil-plant system where water is taken up by the plants and is transpired to the atmosphere. Water not taken up by the plant is recirculated to a balance tank which is used to pulse feed wastewater to the pods throughout the day. The recirculating nature of the design, exclusion of groundwater and the balance tank have resulted in a relatively small footprint for the Rhizopod® system.



The system consists of a series of pods of soil (tanks sunk into the ground or within a raised garden bed). Specially selected plants are grown in each pod. They are chosen for high water uptake, quick growth rate, biological activity during winter, and the ability to flourish under the climatic conditions of a specific site. Specific plant species lists have been developed for different climatic regions across Australia.

In a natural irrigated system, there is a complex interaction between water inputs and outputs whereas the Rhizopod® System has only one input of wastewater and the output is through plant evapotranspiration and soil evaporation. In the Rhizopod® system, treated wastewater can be irrigated to maintain maximum soil water content (<10kPa suction) ensuring plants use the maximum water possible.



Modified from: Allan et al (1998) "FAON Irrigation and Drainage Paper 56"

Rhizopod® systems have become the preferred or only dispersal method available to meet compliance at sites where the available area for dispersion is too small to sustainably manage treated wastewater dispersal.

Common reasons to use a Rhizopod® include:

- Block of land too small to fit a standard effluent treatment and management system;
- Set back requirements from property boundaries, water courses, or bores cannot be met;
- Unsuitable soils for wastewater dispersal;
- A sensitive environment requires a "no-release" system;
- High water tables.

The Rhizopod® system may be the only option open to landholders when they cannot meet the requirements of local government, State and Federal, on-site dispersal codes of practice and/or standards using other dispersal techniques.

The Rhizopod® system may be successfully installed on sites with very poor soils and relatively close to environmentally sensitive areas.

Many soil types are unsuitable for the long-term application of wastewater. Some sites are so close to environmentally sensitive areas that the required set back distances make the development of the land unviable. The Rhizopod® system imports soil suitable for the long-term application of wastewater. The wastewater is treated and reused within a contained environment, minimising the applicable set back distances. Plants grown in the channel allow all the wastewater to be reused; with a holding tank providing wet weather storage. This allows the Rhizopod® system to be successfully installed on sites with very poor soils and relatively close to environmentally sensitive areas. Rhizopod® system installations have been approved by the Queensland Regulator as 'no-release' – which reduces the annual licence fee and the monitoring requirements. If required, the technology can be adjusted so that it produces 'fit for purpose' recycled water.

The dual drivers for the development of Rhizopod® technology were to create a system that is independent of the local soil type and that can also treat wastewater in a contained manner.

Existing Rhizopod® Systems

Rhizopod® systems have been installed and operating since 1997 (formerly promoted as the Recirculating Evapotranspiration Trenches (RET) system). It has been built on a foundation of >20 years of peer reviewed research and development. Ben Kele (Arris) developed this technology during his Master's degree at the Centre for Plant and Water Science at the Central Queensland University.

The Rhizopod® system is very flexible and has been used in installations of single units on public toilets through to decentralised systems of up to 1,600 EP, e.g. caravan parks and for small clusters of houses (small settlements, remote farms, hotels).

> ***Early Rhizopod® installations have been in operation for more than 20 years and continue to function sustainably and cost effectively.***

Rhizopod® System Design for Specific Sites

The Rhizopod® system (like other on-site wastewater systems) needs to comply with local government, State and National codes and standards for on-site wastewater management. This includes setback distances for infrastructure, plumbing installation, and site evaluation and design conditions. It is recommended that the design of the system includes the following assessments.

Site Evaluation

An evaluation of site suitability is required in accordance with codes and standards, including:

- Provision of a site plan showing allotment dimensions, location of existing and proposed buildings and structures, and details of the proposed system and any earthworks required for its installation;
- Summary of site constraints, such as land area and slope, flooding potential and location of watercourses;
- Control measures required, such as surface water diversion from the septic and balance tanks;
- Details of any roof or cover added to prevent the entry of rainwater into the open pod system; and
- Water balance calculation for the site and any specific climate related considerations, and any limitations of the system.

Water Balance Calculation

A water balance model is used to calculate the size of the Rhizopod® required at each site. A water balance model is a calculation of all water inputs and outputs at a specific location and includes:

- Local rainfall data for the site (based on Bureau of Meteorology historical data);
- Evapotranspiration potential (how much water evaporates from a soil surface and transpires from a plant growing in it, if there was an unlimited supply of water);
- Crop coefficient (how much water is taken up by a specific plant as a ratio of the water taken up by a reference plant); and
- Wastewater volume.

Water balance models can be developed for site specific locations on request by Arris. It is anticipated that water balance models will be produced for regions across the State and archived to reduce costs in the future.

Climate data is accessed from Bureau of Meteorology SILO where coordinates can be used to obtain daily data sets for a specific location.

The water balance model is a day step model that is run for forty years and simply considers inputs, design wastewater flows, and outputs (water that is used by plants in the pods). How can you be sure this works? The model is one that is widely used in agriculture to model irrigation water balances for a single paddock, complete farms or an irrigation district. The modelling is based on the FAO Crop Evapotranspiration - Guidelines for Computing Crop Water Requirements - FAO Irrigation and Drainage Paper 56 using the Penman-Monteith method for calculating reference and crop evapotranspiration from meteorological data and crop coefficients.

Water Conservation

It is recommended that household water reduction facilities be installed as part of the development specifications. Refer to AS1547:2012 – Table H2 which recognises full water reduction facilities to include use of reduced flush 4.5/3 litre water closets, shower-flow restrictors, aerator taps and outlets, front load washing machines and flow/pressure control valves on all water use outlets.

A key feature of the Rhizopod® System design is to minimise water inputs as this will dramatically influence the number of pods required and the time between pump-outs. It is important to understand that the pods need to be pumped out periodically to maintain good soil condition and plant function. As water is used by the plants, salts in the water from cleaning agents and waste accumulates and affects plant function. Periodic removal of wastewater from the pods will keep the system functional as designed.

Typical Rhizopod® Designs

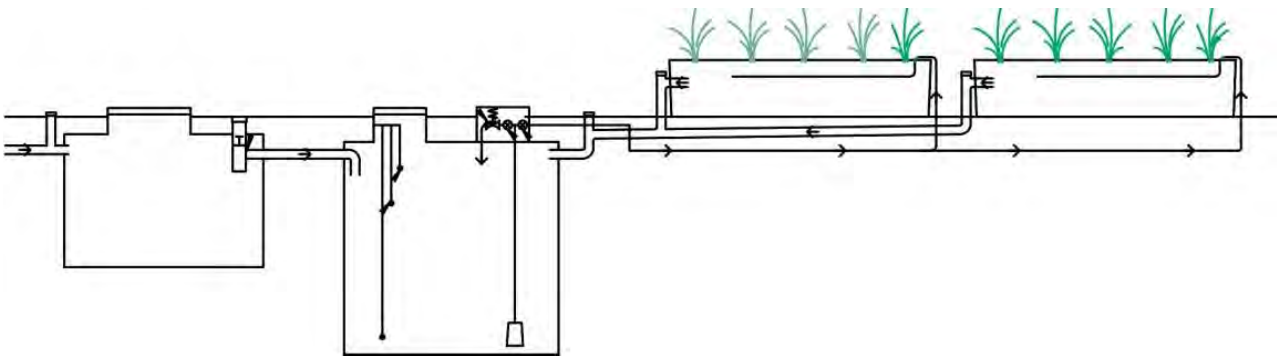
Rhizopods® have been approved for installation and been installed in:

- New South Wales;
- Northern Territory;
- Queensland;
- South Australia; and
- Victoria.

Rhizopods® are AS/NZS 1546.1 compliant and meet the requirements of the AS/NZ 1547:2012 Onsite Wastewater Management Standards and the Codes of practice in the States where Rhizopods® have been installed.

They can be installed on both flat and sloping sites.

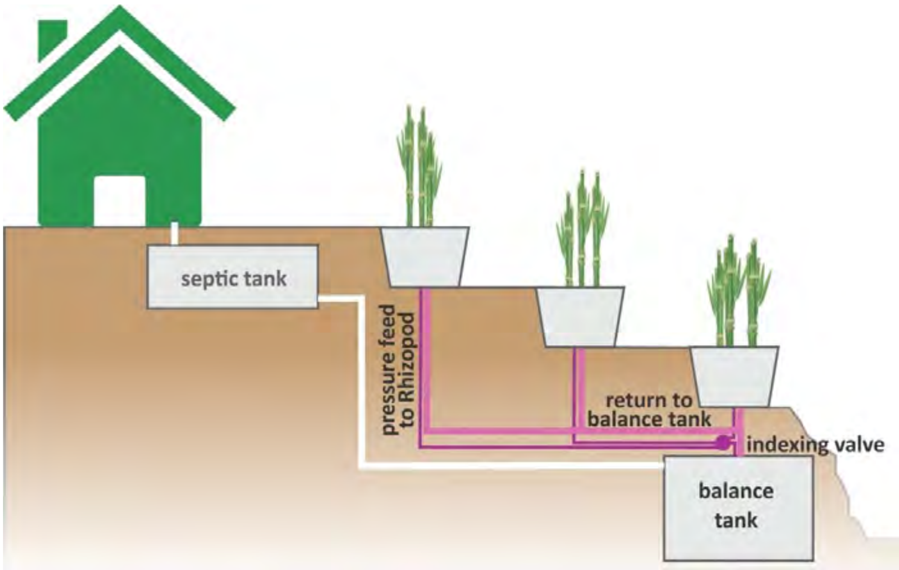
Flat Site Installation



Pods can be added to the system to meet the requirements of any situation, site layout, design flow and climatic conditions.

Terraced Installation

The terrace installation can be designed to retain soil to mitigate cost of expensive retaining walls when creating level sites.



Examples of Rhizopod® Installations

Case Study 1 - Mintaro, South Australia

The site was constrained due to its proximity to a local ephemeral creek where the 50m setback as required by SA code (Appendix A) and AS/NZ 1547:2012 could not be achieved. Due to this, the land holder was unable to develop the bed and breakfast business he had planned.

The solution has been to install a Rhizopod® system. The owner had significant input into the installation and the pods are used as a visual screen against his neighbour’s property.

Concrete pods were chosen due to poor soil and proximity of basement rock. The advantage of the concrete pods over plastic pods is that they support the soil and coarse aggregate that is used in the pods. They can be used on steep sites where the pods have been cut back into the hill. They can be used for landscaping and be placed as soil retaining walls. Plastic pods (not available in South Australia) are used specifically on level sites where the pods are partially buried.

Installation: December 9th 2016

6 Rhizopods® pods were installed and watered with mains water until the B&B is to be used. Due to environmental conditions, above ground pods were required and have been used.

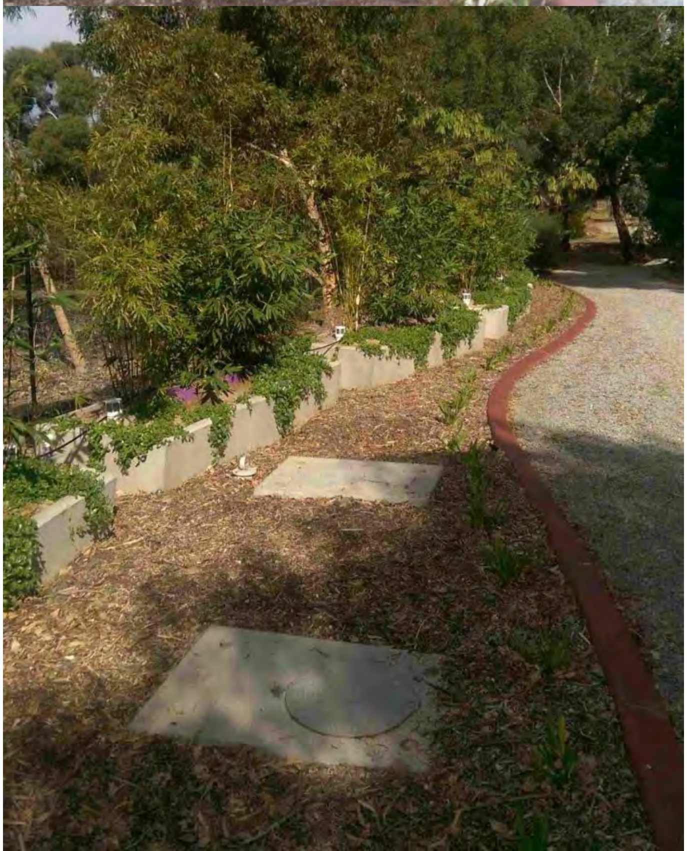
Bamboo varieties selected were a combination of Oldhamii and Gracillis. The varieties were selected for their ability to withstand cool and frosty conditions that can be experienced in the Clare Valley. Site suitable plants are always selected to improve the efficiency of wastewater use

Site inspection: January 31st 2017

The pods had been landscaped and a succulent groundcover had been planted in front of the pods, cascading over the side.

Pods were still being watered with mains water as there was no effluent production.

It is evident that the pods can be planted and become a feature of the garden.



Final inspection: April 16th 2017

The bamboo and groundcover have grown significantly from the wastewater.

In time, the groundcover will cover the pods further, adding to the aesthetics of the pod installation.

Site Visit: January 2018

The bamboo has thickened to full canopy and the groundcover has developed to cover pods.

Case Study 2 - Keppel Sands Caravan Park, Queensland

The Keppel Sands Caravan Park is a popular holiday location situated on the edge of the Great Barrier Reef Marine Park. The caravan park is owned by the Livingstone Shire Council.

Rhizopods® were used for this project as there were strict environmental conditions with respect to nutrient discharges to mitigate the risk of the nutrients migrating to the marine environment. As the Rhizopod® system is zero discharge, it completely mitigates any off-site impacts of nutrients associated with wastewater dispersal.

Due to the strict environmental conditions on the site the caravan park wastewater was stored in a holding tank for off-site removal. This was costing the caravan park $90,000 per annum for the pump-out dispersal of wastewater.

Construction: June, 2015

24 plastic pods were used due to:

- light weight/ease of handling;
- larger size therefore less pods required.

Installation of the pods showing internal plumbing and gravel bed. The pods are submerged to two thirds the height of the pods. This practice enables protection from flooding from overland flow.

The pods are filled with a sandy loam growing media and then landscaped with native soil. In this case, the native soil was sandy and was suitable to use as the growing media in the pods.

Completion of installation: June, 2015

The most suitable model determined was to install 24 pods in four rows of six pods.

Pods are planted with a high-water use bamboo, Bambusa Oldhamii.

Site inspection: 2017

The extent of canopy development can be clearly seen from above.

Understanding Rhizopod® Performance

Understanding the performance of your Rhizopod® system is an important factor in its use and will provide you with years of trouble-free service following installation and into the future.

As pointed out in the Service and Installation Manual, the Rhizopod® system relies on the plants in the Rhizopod® to use wastewater. There are many factors that affect plants' ability to use water which include:

- climatic conditions: temperature, humidity, wind and rainfall can impact plants' need for water;
- light energy: as plant function is driven by sunlight energy;
- plant type: plants use different amounts of water, for example some bamboos can use nearly double the water required by turf;
- condition and health of the plant: for plants to maximise their water use they need to be maintained in a healthy growing condition; and
- age of plants: as it is largely the canopy of the plants that use water, the development of the canopy is important in maximising water use.

For these reasons, Rhizopods® need to be installed so that they are:

- not shaded, the more sun the greater the evapotranspiration (water use); and
- on sites that are not sheltered from wind as wind increases evapotranspiration.

The system has been modelled and engineered so that there is a balance between effluent inflow and the need to pump-out the balance tank, as above. The development of the canopy is the most important aspect in ensuring water usage. It is important to understand that the Rhizopod® system's capacity to treat wastewater is at its lowest on the day of installation. The plant selection and canopy development are critical in the use of water, hence as the canopy grows and gets larger the capacity of the pods increases. For this reason, pump-outs may be required more frequently in the first two years of operation but will diminish over time and reflect the water balance model.

Key understandings include:

- the Rhizopod® model is a site-specific model, it is a 40year day step model which models daily inputs from wastewater (peak design flow) and outputs from plant evapotranspiration (FAO 56). Rhizopods may perform differently to the results in of the design water balance model due to how canopy develops and seasonal climate variability;
- variations in the production of effluent from the design flows will impact the need for pump-outs;
- in the early years before full canopy has developed there will likely need to be more pump-outs than the model predicts;
- until canopy develops fully to protect the pods from rain incursion, rainfall may contribute to the water balance adding further to the potential need for pump-outs;
- in winter time, the Rhizopod® system will use less water than in summer and the water use may be less than effluent inflow;
- the Rhizopod® plants are maintained in a healthy growing condition to maximise water use; and
- both an audible alarm and a mechanical gauge will be installed within the holding tank with greater than four days' spare capacity (of the design flow) to enable adequate time for the householder to have the holding tank pumped out to protect human and/or environmental health.

Like any potted plant it is the owner's responsibility to maintain the plants in a healthy condition, this may require supplementary watering during periods of low wastewater flow low level maintenance. A supplementary watering system will be installed on installation. The critical take home message is that for the Rhizopods® to function as designed the plants need to be healthy.

As the landholder, please sign below to confirm your understanding of the key requirements, limitations and obligations of the safe and sustainable operation of the Rhizopod® system.

Signature: ____ Date: ______________________

Print Name: ____

In a signed copy to be attached to the wastewater application and submitted to Council

Pods at Sevenhill January 2020

Pods at Sevenhill June 2019

Pods at Sevenhill March 2019

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