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Adaptive Wastewater Solutions for Small Towns - Penshurst and Cudgee: Options Analysis Report

Version 2

wannonWATER

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Document Control Sheet

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EXECUTIVE SUMMARY

Decentralised Water Consulting (DWC) is currently assisting Wannon Water (WW) along with Southern Grampians Shire Council (SGSC) and Moyne Shire Council (MSC) to investigate options to improve wastewater management for the townships of Penshurst and Cudgee. Wastewater is currently managed by individual on-site wastewater management systems (on-site systems) in Penshurst and Cudgee with approval and performance regulated by SGSC and MSC respectively.

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

The Background Paper previously prepared summarised the initial outcomes of the first phase of the project which is focused on evaluating the current wastewater management situation in Penshurst and Cudgee and the regulatory context for pursuing options for these towns, beyond the traditional approaches of sewerage. This has subsequently led to engaging with both agencies and the community to develop a shared vision what will be achieved from the project.

This report provides the outcomes of the second phase of the investigations, specifically option development and assessment. This involved shortlisting a number of Solution Packages for each town and assessing these to determine the preferred.

As part of this Options Analysis Report we have;

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

The community engagement indicated that there is a need and community desire for improved wastewater management in Penshurst. Business and development opportunities were identified as key limitations of current wastewater management in the town. Thus town renewal was identified as a key driver for this investigation by the community.

This is less so the case in Cudgee in which wastewater management was not see as a key constraint for many residents who provided feedback. This is driven by the typical larger property size with less land capability constraints for wastewater management. Stormwater management and flooding, particularly in relation to new subdivision / development, however was identified as an important constraint by various community members.

The shortlisting process involved consideration of a range of elements to develop 3-4 Solution Packages that encapsulate the full range of viable methods for servicing these towns. Connection to an existing sewerage scheme was not progressed for either town due to the significant distance to the nearest existing network connection point (cost prohibitive);

- Approximately 26km from Penshurst to existing sewerage at Hamilton.
- Approximately 14km from Cudgee to existing sewerage at Warrnambool.

The tables and figures below outline and summarise the shortlisted Solution Packages which were assessed for either town.

Penshurst

Table E1: Option Shortlisting Summary – Penshurst

Solution Package	Solution Summary / Ethos	Details / Description
Business as Usual (BaU)	Upgrade of systems by owners over time as necessary. Limited / no capacity for town renewal / growth.	Business as Usual (BaU) with continuation of owner managed on-site wastewater management systems - 'Do Nothing' scenario. Alterations or upgrades to existing onsite systems to occur only as necessary, such as due to dwelling extensions or a system failure. This represents continuation of the existing situation into the future with no additional external assistance provided to home-owners from agencies like Wannon Water. Outcomes of Council's Domestic Wastewater Management Planning and stakeholder engagement indicate BaU is unlikely to meet regulatory or community objectives.
SP1 STEDS to Cluster Reuse (Excess to stormwater)	Strikes a balance between cost and high priority benefits (health and environment protection). Utilise simple, lower maintenance wastewater management approach close to source – in line with Integrated Water Management (IWM) approach. Places some limits on town renewal / growth due to limits on capacity to manage wastewater locally (within reserves / public open space). Excess treated effluent would continue to discharge to stormwater at lower volume and reduced impact.	Continued wastewater management on-property via secondary treatment system with subsurface irrigation / ETA trenches where full onsite containment is achievable (84 properties). Where full onsite containment is not achievable (217 properties), existing septic tanks are to be utilised (where possible) as part of STEDS (Septic Tank Effluent Drainage / Disposal System) scheme. All discharge of primary effluent collected from properties via gravity effluent sewer where possible. Drainage to cluster / precinct scale treatment (e.g. reed-bed, packed bed reactor or sand filter systems) and subsurface irrigation reuse areas, with any excess overflow discharge to upgraded stormwater (lined swales) drainage (to be directed away and bypass central Penshurst Wetland Gardens).
SP2 Cluster Based Reuse Systems	Cluster (precinct / block scale) approach with simple, low maintenance treatment and local water reuse and no on-property infrastructure. Treatment and plant water uptake within recirculating, planted Evapo-transpiration beds and winter storage. Subsurface irrigation of public open space for beneficial reuse during warmer months.	Continued wastewater management on-property via secondary treatment system with subsurface irrigation / ETA trenches where full onsite containment is achievable (84 properties). Construction of local gravity sewers to direct sewage from the 217 smaller, constrained properties to local, cluster systems within road reserves. Incorporates recirculating, lined, planted Evapo-transpiration beds (Rhizopod™ or similar) with winter storage to treat and reuse water for landscape watering. Excess recycled water will then be stored and used for public open space irrigation in warmer months. All effluent able to be managed at local cluster / precinct treatment systems and therefore does not require discharge to stormwater or construction of a larger sewer and central sewage management facility.

Solution Package	Solution Summary / Ethos	Details / Description
SP3 STEDS to Constructed Wetland	More conventional 'end of line' solution - STEDS collection system for central township area to a central wetland treatment and reuse facility (ecological restoration and amenity).	Continued wastewater management on-property via secondary treatment system with subsurface irrigation / ETA trenches where full onsite containment is achievable (84 properties). STEDS (Septic Tank Effluent Drainage / Disposal System) scheme for constrained / township properties (217) utilising existing on-lot septic tanks (where possible) with gravity collection and drainage via smaller diameter effluent sewer to 2 Septic Tank Effluent Pump (STEP) pump stations. Central treatment and effluent management / reuse via constructed wetland. Wetland would provide treatment, ecological restoration (habitat), amenity and liveability functions and would only require discharge to waters in wetter years under controlled conditions (e.g. >90^{th} % rainfall years) which mimics natural flow profile of the waterways. Allowance made for reuse by irrigation of Penshurst Oval.
SP4 Pressure Sewer to Lagoon Sewage Treatment Plant	Traditional Small Town Reticulated Sewerage solution for the township properties. Lagoon Treatment, winter storage and agricultural reuse (fodder crop).	Continued wastewater management on-property via secondary treatment system with subsurface irrigation / ETA trenches where full onsite containment is achievable (84 properties). The 217 constrained (township) properties to have on-lot grinder pressure units for collection and transfer via new pressure sewerage to Water Recycling Plant (WRP) for lagoon treatment / reuse via surface irrigation across fodder crops. Requires large winter storage dam.

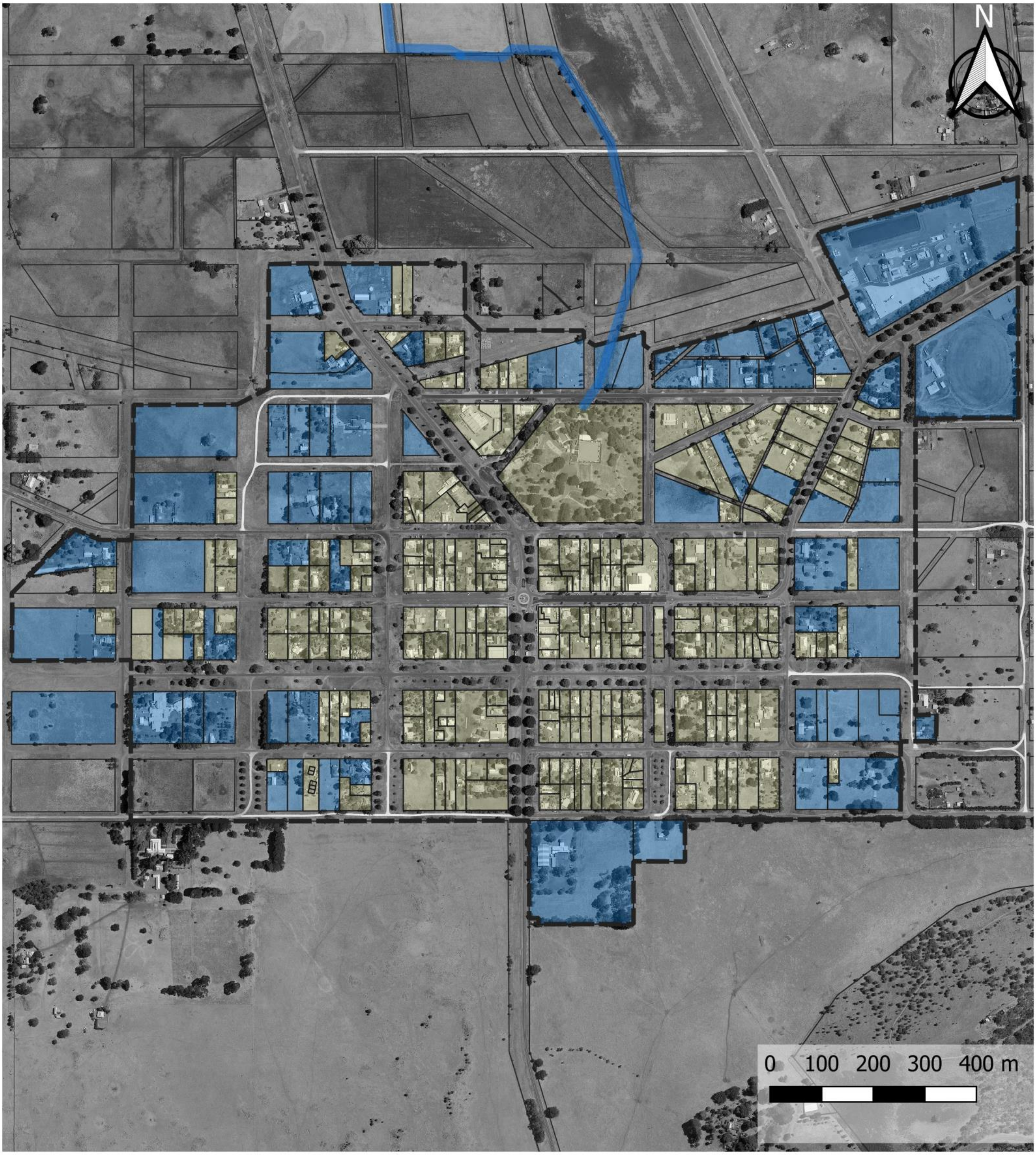

Figure 4: Penshurst General Servicing Layout - All Solution Packages

Service Area
Property Boundary
Watercourse

Servicing Details
Offsite Connection (STEDS / Gravity Sewer / Pressure Sewer)
Upgraded On-site Wastewater System

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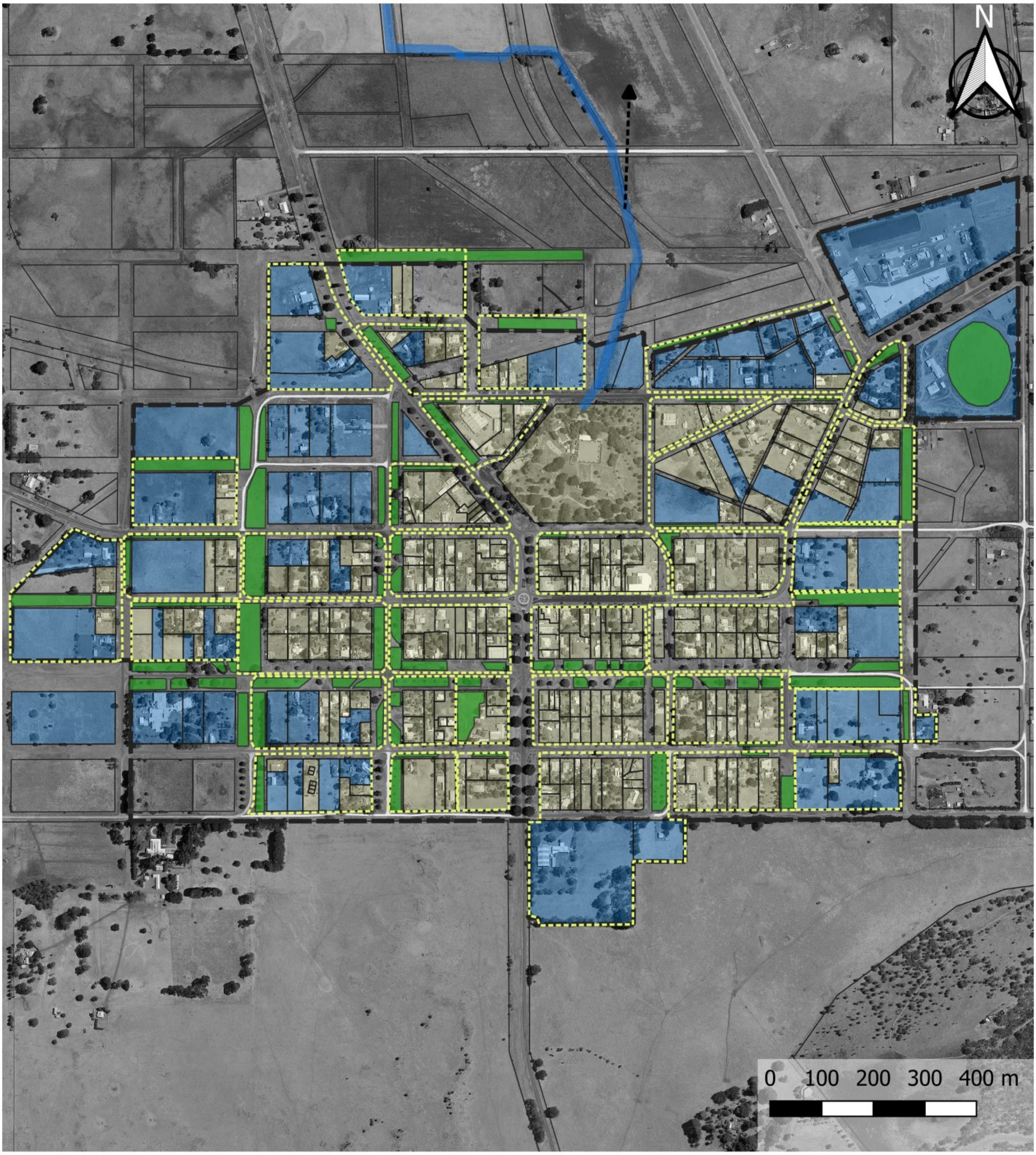

Figure 5: Penshurst Servicing Layout - Cluster / Precinct Reuse Sites Summary (SP1 & 2)

Service Area
Property Boundary
Watercourse
Cluster / Precinct Reuse Site Subcatchments
Potential Cluster / Precinct Reuse Site

Servicing Details

Offsite Connection (STEDS / Gravity / Pressure Sewer)
Upgraded On-site Wastewater System

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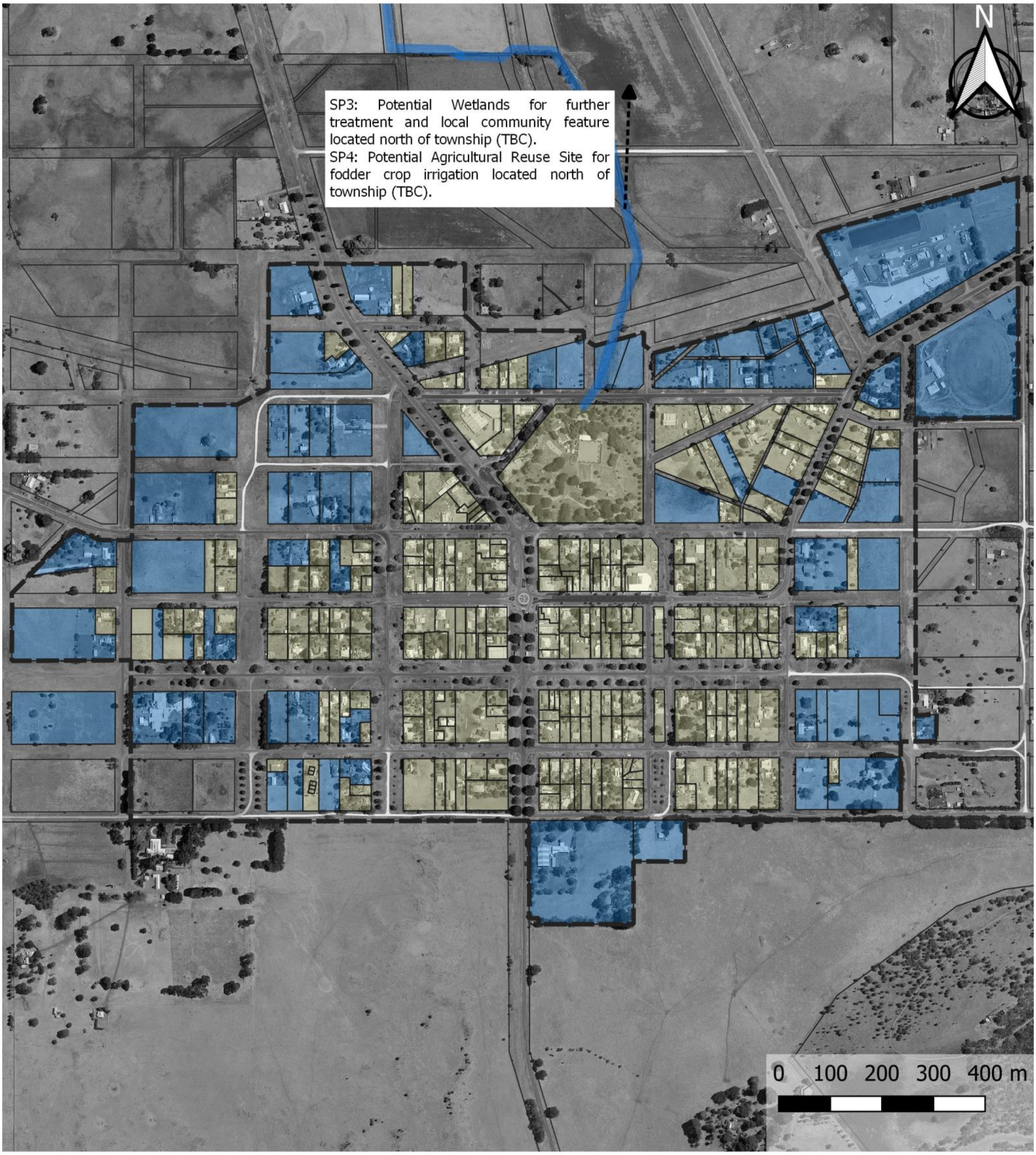

Figure 6: Penshurst Servicing Layout - Centralised Reuse Summary (SP3 & 4)

Service Area
Property Boundary
Watercourse

Servicing Details

Offsite Connection (STEDS / Gravity / Pressure Sewer)
Upgraded On-site Wastewater System

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Cudgee

Table E2: Option Shortlisting Summary – Cudgee

Solution Package	Solution Summary / Ethos	Details / Description
Business as Usual (BaU)	Upgrade of existing systems and installation of new systems by owners over time as necessary. Low density residential growth is unconstrained under this scenario. Township zone has some capacity for town renewal / growth but carries a residual health / environmental impact.	Business as Usual (BaU) with continuation of owner managed on-site wastewater management systems - discussed further below. Considered the preferred long-term solution by many community members during engagement. Compliance with the EPA Code of Practice for On-site Wastewater Management (EPA CoP) possible for 77% of properties in Cudgee.
SP1 Retain On-site Systems with Small Cluster System for Constrained Sites	Limits investment and infrastructure provision to sites unable to comply with regulatory requirements for on-site wastewater management. Avoids 'forcing' a service on properties that are currently sustainable and meet the needs of the community. Low Density Residential growth remains unconstrained. Moderate capacity for growth of the Township zone. Full beneficial reuse by irrigation of a small area of public open space.	Continued wastewater management on-property via owner managed on-site systems (BaU) on 50 properties. Allowance for renewal of systems at same rates and/or after a 20 year life. Systems assumed to be compliant with EPA CoP and associated MAV Land Capability Assessment (LCA) Framework. Have assumed a 5-10% failure rate due to owner management. Where full onsite containment is not achievable (15 properties) according to EPA CoP, on-site systems to be upgraded to partial containment systems for reuse by irrigation or land application via trenches. Excess effluent unable to be managed on-site directed to one of two cluster reuse sites. Partial on-lot effluent management reduces scale and cost of 'end of pipe' infrastructure. Effluent (pressure) sewer conveys secondary (Class C) effluent to cluster system. Cluster System 1 (near rail line) to consist of Rhizopod™ recirculating, lined, planted Evapo-transpiration beds with winter storage to treat and reuse water for landscape watering. Excess recycled water will then be stored and used for public open space irrigation in warmer months. Cluster System 2 (Cudgee School) to consist of an upgraded system for the school with capacity to receive sewage from the two adjacent constrained properties. Alternatively, constrained property on other side of Hallowells Lane could utilise an easement on adjacent vacant land for land application of effluent.

Solution Package	Solution Summary / Ethos	Details / Description
SP2 Retain On-site Systems and upgrade constrained sites. Build stormwater treatment / detention measures	Limits investment and infrastructure provision to sites unable to comply with regulatory requirements for on-site wastewater management. Avoids 'forcing' a service on properties that are currently sustainable and meet the needs of the community. Used to examine targeting of investment to address multiple elements of water cycle (wastewater and stormwater quality and quantity) given poor economy of scale for reticulated off-site wastewater solutions.	Continued wastewater management on-property via owner managed on-site systems (BaU) on 50 properties. Allowance for renewal of systems at same rates and/or after a 20 year life. Systems assumed to be compliant with EPA CoP and associated MAV Land Capability Assessment (LCA) Framework. Have assumed a 5-10% failure rate due to owner management. Where full onsite containment is not achievable (15 properties) according to EPA CoP, on-site systems to be upgraded to an advanced treatment and maximised land application system. These systems would be managed by a single management entity rather than individual owners. Construction of 2-3 stormwater management wetlands to consist of bioretention, wetland segments and high flow bypass to detention storage.
SP3 Partial On-site Containment / Reuse with Excess to Cluster Irrigation Site	Limits investment and infrastructure provision to sites unable to comply with regulatory requirements for on-site wastewater management. Hybrid decentralised / centralised solution that seeks to manage a safe amount of effluent on-site with the excess conveyed via sewer to a central site for either agricultural or public open space irrigation. Effluent (pressure) sewer costed to service the Township land use zone in addition to a small number of constrained low density residential lots to the immediate west.	Continued wastewater management on-property via owner managed on-site systems (BaU) on 50 properties. Allowance for renewal of systems at same rates and/or after a 20 year life. Systems assumed to be compliant with EPA CoP and associated MAV Land Capability Assessment (LCA) Framework. Have assumed a 5-10% failure rate due to owner management. Township zoned properties (along with small number of Low Density Residential Zone) to be upgraded to partial containment systems for reuse by irrigation or land application via trenches. Excess effluent unable to be managed on-site directed to one of two cluster reuse sites. Partial on-lot effluent management reduces scale and cost of 'end of pipe' infrastructure. Effluent (pressure) sewer conveys secondary (Class C) effluent to a single cluster / community effluent management / reuse system. Does not require a full Sewage Treatment Plant and more closely reflects a stormwater harvesting storage / treatment system (i.e. steel tank, control shed, pumps, media filtration) Likely to be Farming Zone land irrigated as either a fodder crop, carbon sequestration forest or public open space.

Figure 7: Cudgee Solution Package 1 Servicing Layout - Retain On-site Systems with Small Cluster System for Constrained Sites

Study Area
Property Boundary
Named / Intermittent Watercourse
Potential Cluster Reuse Site

Servicing Details
Connection to Cluster System or Advanced Onsite System Upgrade
Existing Onsite Wastewater System (Owner Managed)

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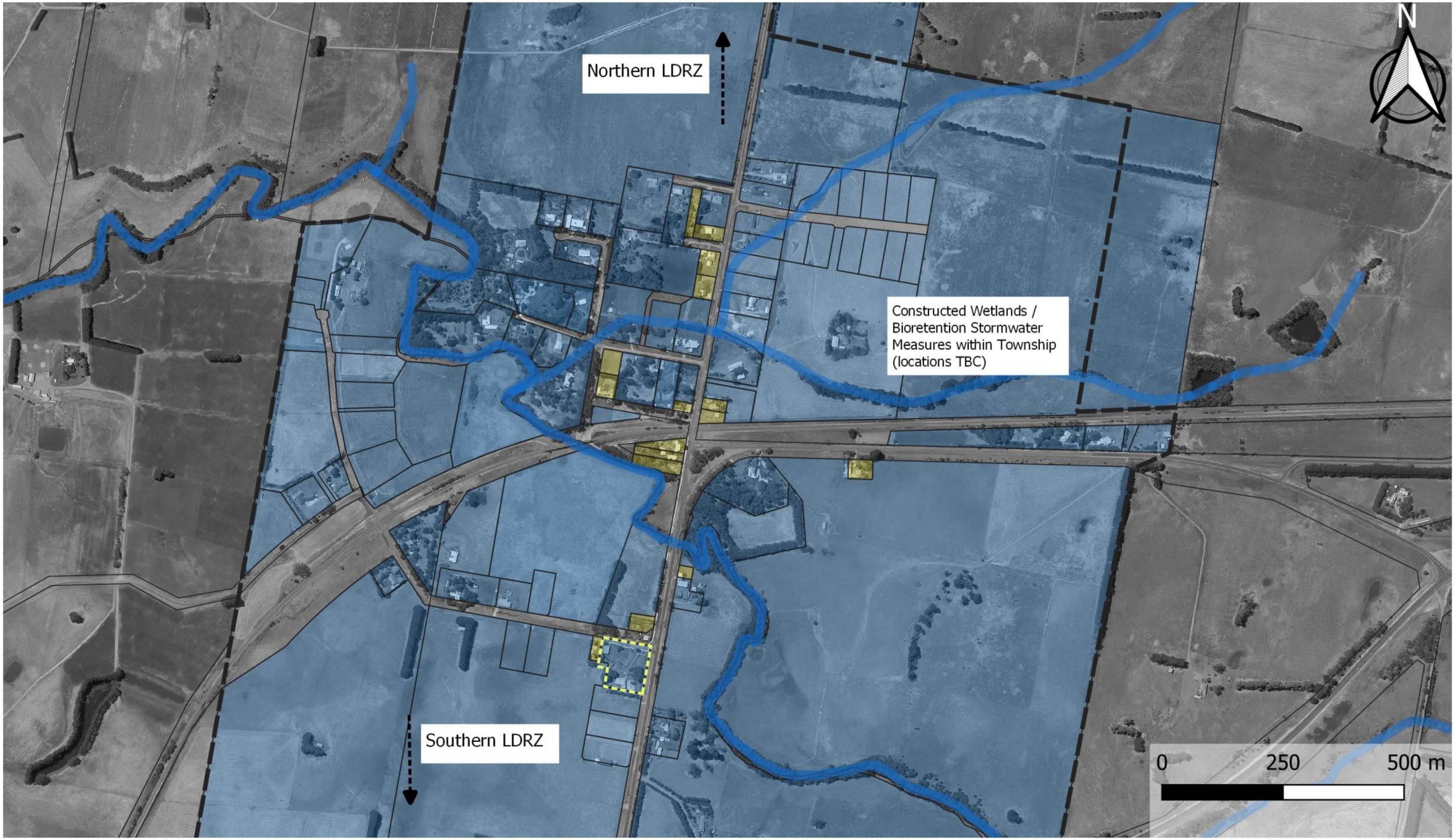

Figure 8: Cudgee Solution Package 2 Servicing Layout - Retain On-site Systems and Build Stormwater Treatment / Detention Measures

Study Area
Property Boundary
Named / Intermittent Watercourse
Potential Reuse Cluster Site

Servicing Details
Advanced Onsite System Upgrade or Connection to Cluster System
Existing Onsite Wastewater System (Owner Managed)

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Figure 9: Cudgee Solution Package 3 Servicing Layout - Partial On-site Containment / Reuse with Cluster Irrigation Site

Study Area
Property Boundary
Named / Intermittent Watercourse

Servicing Details

Upgraded Onsite System with Connection to Cluster System
Existing Onsite Wastewater System (Owner Managed)

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Whole of life, community cost estimates have been developed for each of the Solution Packages as part of this project to allow relative comparison as part of the CBA. The intention is for the costings of the identified preferred solution to be further refined and developed during Functional Design and business case development.

Table E3: Solution Package and BaU Cost Estimates for Penshurst

Scenario	CAPEX[1]		OPEX[1]		Asset[1] Renewals	Lifecycle Cost (NPV)[2]	
	Total ($M)	Per Lot ($k)	Total ($k)	Per Lot ($k)	Total ($M)	Total ($M)	Per Lot ($k)
BaU	$4.82M	$16k	$120.4k	$0.4k	$0.91M	$4.0M	$13.3k
SP1	$12.38M	$41.1k	$330.8k	$1.1k	$2.29M	$17.46M	$58k
SP2	$17.1M	$57k	$257.2k	$0.86k	$0.815M	$20.4M	$67.9k
SP3	$18.6M	$61.6k	$328.8k	$1.09k	$2.29M	$23.64M	$78.5k
SP4	$19.2M	$63.9k	$243k	$0.81k	$0.53M	$22.3M	$73.9k

Table E4: Solution Package and BaU Cost Estimates for Cudgee

Scenario	CAPEX[1]		OPEX[1]		Asset[1] Renewals	Lifecycle Cost (NPV)[2]	
	Total ($M)	Per Lot ($k)	Total ($k)	Per Lot ($k)	Total ($M)	Total ($M)	Per Lot ($k)
BaU	$1.04M	$16k	$26.6k	$0.41k	$0.44M	$0.97M	$14.9k
SP1	$1.94M	$29.8k	$98k	$1.5k	$0.33M	$2.74M	$42.2k
SP2	$2.94M	$45.2k	$110.8k	$1.71k	$1.33M	$4.2M	$64.4k
SP3	$3.00M	$46.2k	$99.2k	$1.53k	$0.25M	$3.92M	$60.3k

1. *These are total costs ($ 2019) prior to discounting depending on what year of analysis the spend occurs.*
2. *Net Present Value (NPV) over 25 years at a 7% discount rate (consistent with CBA).*

Options Analysis

The Cost Benefit Analysis (CBA) undertaken by Frontier Economics is the primary mechanism for option analysis for this investigation. As is commonplace when attempting to complete a CBA for a small town wastewater project (or often IWM project), a number of direct and indirect benefits have been identified and/or articulated by stakeholders that have proven challenging to include in the CBA at this stage. These potential benefits are discussed in detail in Appendix D and Section 7.1.

Table E5: Cost-benefit analysis results for Penshurst (Central case, 7% discount rate, $2019 prices)

	SP1	SP2	SP3	SP4
Capital costs	(9,878,628)	(14,486,422)	(15,847,263)	(16,511,364)
Operating costs	(2,473,083)	(1,672,275)	(2,451,704)	(1,514,723)
Renewal costs	(643,796)	228,439	(678,651)	324,745
Total costs	(12,995,507)	(15,930,258)	(18,977,618)	(17,701,343)
Environmental benefits	(32,126,525)	9,212,754	9,212,754	9,212,754
Health benefits	2,176,807	2,176,948	2,176,948	1,955,077
Amenity benefits	-	2,029,627	-	-
Total benefits	(29,949,719)	13,419,328	11,389,701	11,167,831
Net Present Value	(42,945,226)	(2,510,929)	(7,587,917)	(6,533,512)
Benefit-Cost Ratio	N/A	0.84	0.60	0.63

Table E6: Cost-benefit analysis results for Cudgee (Central case, 7% discount rate, $2019 prices)

	SP1	SP2	SP3
Capital costs	(895,548)	(1,787,012)	(2,001,812)
Operating costs	(793,290)	(909,770)	(787,644)
Renewal costs	33,121	(304,662)	(1,011,267)
Total costs	(1,655,718)	(3,001,444)	(3,800,723)
Environmental benefits	82,371	2,575,743	74,645
Health benefits	77,393	69,244	71,240
Total benefits	159,764	2,644,987	145,885
Net Present Value	(1,495,954)	(356,457)	(3,654,838)
Benefit-Cost Ratio	0.10	0.88	0.04

Table E7: Qualitative Comparison: Penshurst

	Advantages/Opportunities	Disadvantages/Risks
Business as Usual (BaU)	Continuation of existing onsite systems which are upgraded only as needed (either compliance failure or new development). Lowest total capital cost.	Limited to no potential for town renewal or growth (of both new or existing properties and businesses). Potential environmental and human health risks from continuation of inadequate onsite systems, due to constrained existing properties. With particular impacts at the Penshurst Wetland Gardens (local community and tourist feature).
SP1 STEDS to Cluster Reuse (Excess to stormwater)	Lowest capital costs of all SP's (SP1 was developed to balance capital costs and overall impacts to township). Utilisation of existing septic tankage (where possible) as part of upgraded wastewater scheme to minimise upfront capital costs. Gravity drainage system with minimised pumping of wastewater as close to source (reduced energy usage). Provides local reuse of effluent for greening of public open space in town and reducing heat during warmer periods. Provides some ability for individual property renewal and development of existing properties by removing need for on-lot wastewater reuse. Includes provision for stormwater drainage upgrades to reduced flows directly entering the Penshurst Wetlands.	Highest total operational and asset renewal costs. Cap on long-term growth potential for new developments without major infrastructure upgrades (depending on actual future growth). Residual discharge of treated effluent into stormwater which will potentially result in a net increase in pollutant loads to environment during cooler months. However there will be a net reduction of existing pollutant loads to Penshurst Wetlands (to be bypassed via new stormwater drainage). Need to progressively renew on-lot septic tanks over time.
SP2 Cluster Based Reuse Systems	Conveyance of all wastewater off-property (no need for upfront septic tank or pressure sewer unit). Gravity drainage system with minimised pumping of wastewater as close to source (reduced energy usage). Provides local reuse of effluent for greening of public open space in town and reducing heat during warmer periods. Full beneficial reuse scheme no need for discharge of effluent into stormwater (as per SP1) or waterways.	Higher capital cost compared to SP1 however lowest capital and whole of life cost of SP2-4. Uncertainty regarding cost for gravity sewer installation given shallow rock present across township. Decentralised nature of infrastructure will require adaptation with respect to existing governance and operation of the scheme.

	Advantages/Opportunities	Disadvantages/Risks
	Provides ability for town renewal and development of existing properties by removing need for on-lot wastewater reuse. Improved capacity for town growth through sizing of proposed cluster systems and buffering capacity of Rhizopod™.	
SP3 STEDS to Constructed Wetland	Utilisation of existing septic tankage (where possible) as part of upgraded wastewater scheme to minimise upfront capital costs. Provides central blue / green space (wetlands) which can become a local feature close to town. Provides reuse capacity for greening of local sporting facility. Provides some ability for individual property renewal and development of existing properties by removing need for on-lot wastewater reuse. Improved capacity (from SP1) for town growth through sizing of wetlands.	Higher capital cost compared to SP1 and 2. Highest whole of life cost. Second highest total operational costs (just below SP1). Greater pipe installation and pumping costs / requirements due to wetlands being located outside of main township (management not as 'close to source'). Need to progressively renew on-lot septic tanks over time.
SP4 Pressure Sewer to Sewage Treatment Plant (Discharge to Water)	More conventional wastewater option that is typical of Wannon Water schemes. Potential for agricultural irrigation / reuse, in which fodder crops can be sold. Likely ability to maximise both town renewal and total long-term growth.	Highest capital cost of all SP's. Second highest life cycle cost. On-property grinder pods required (higher energy costs for customers). Water Recycling Plant (WRP) with greater infrastructure required as all wastewater treated at one central location (higher transport / treatment costs and greenhouse emissions). Limited to no improvements to town liveability or climate change resilience. Still has some constraints to long-term growth depending on lagoon and agricultural reuse capacity (suitable site or sites required). Discharge to waters may be required in future (greater treatment and compliance costs).

Table E8: Qualitative Comparison: Cudgee

	Advantages/Opportunities	Disadvantages/Risks
Business as Usual (BaU)	New and existing onsite systems to continue to be managed and progressively upgraded by owners as required. Environmental and human health impacts are estimated to be adequately managed via progressive upgrades of systems (provided systems installed in accordance with EPA CoP). Lowest total community costs. Consistent with LDRZ land use and current practice.	Issues with small number of constrained properties in township (to be left as owner managed). Flooding and stormwater issues around township not addressed by solution.
SP1 Retain On-site Systems with Small Cluster System for Constrained Sites	Cluster system and advanced onsite system upgrades (not owner managed) provide solution for small number of constrained properties in township. Local reuse of effluent for potential improved liveability and green spaces. Moderate improvement in environmental and human health risks (compared to BaU). Consistent with LDRZ land use and current practice. Appropriate solution for Township Zone.	Decentralised nature of infrastructure will require slight adaptation with respect to existing governance and operation of the systems. Flooding and stormwater issues around township not addressed by solution.
SP2 Retain On-site Systems and upgrade constrained sites. Build stormwater treatment / detention measures	Significantly improved total catchment nutrient loads to Brucknell Creek provided via new stormwater wetlands / measures. Flooding impacts also improved. Creation of water features throughout township (green / blue community space). Advanced onsite system upgrades (not owner managed) provide solution for small number of constrained properties in township.	Higher capital and operational costs to BaU and SP1. Decentralised nature of infrastructure will require slight adaptation with respect to existing governance and operation of the systems. Residual treated effluent to be discharged to stormwater (however controlled conditions overnight).
SP3 Partial On-site Containment / Reuse with Excess to Cluster Irrigation Site	High level of servicing for a larger number of township properties (not managed by owners). Potential for both on-lot and local reuse of effluent. Moderate improvement in environmental and human health risks (compared to BaU).	Highest capital costs of all SP's. High operational costs compared to BaU. Decentralised nature of infrastructure will require slight adaptation with respect to existing governance and operation of the systems. Flooding and stormwater issues around township not addressed by solution.

Preferred Options

Penshurst

Based on the outcomes of this options analysis, the current preferred wastewater servicing option is Solution Package 2 (SP2). It offers a cost-effective way to address current constraints to managing wastewater on-site for the majority of properties within the Township zone whilst also achieving other water cycle and liveability benefits by beneficially reusing 100% of wastewater, close to source to create enhanced public open space. It is a relatively low energy and low maintenance concept. However, the decentralised nature of infrastructure will require adaptation with respect to governance and operation. It is envisaged that refinement of the CBA will result in a BCR of 1 or higher for SP2. It is also likely that the difference between the BCR for SP2 compared to SP3 and 4 will remain similar or increase.

Cudgee

The outcomes of the options analysis for Cudgee provide less clarity. DWC consider the following options to be worth further consideration.

- Business as Usual, potentially supported by a more active regulatory inspection program and potentially grant funding to upgrade constrained / non containment sites.
- Solution Package 2 (SP2 - Upgrade constrained on-site systems and build stormwater treatment and detention measures) as a more holistic solution to the key water cycle management issues facing Cudgee.

Next Steps

Given the limited available data to inform the CBA, it will be prudent to ensure the PCG and other stakeholders are comfortable with the more qualitative assumptions and decisions made as part of this options investigation. DWC and Frontier are comfortable that the *relative* difference between options is appropriate and do not expect the difference in Benefit Cost Ratio (BCR) to change dramatically due to modification of options.

There are limited drivers to consider broader alternatives for Cudgee based on the outcomes of the CBA. The key decision for Cudgee lies in an agreed position on whether to proceed with a Business as Usual (BaU) approach or SP2 (integrated water cycle approach). Should a BaU strategy be determined to be the preferred solution, the following adjustments may warrant consideration.

- Inclusion of grant funding or part funding of on-site system upgrades for constrained and non-containment properties to accelerate achievement of regulatory performance objectives.
- Establishment of a more formal operational inspection program to ensure systems are operated and maintained in accordance with their Permit and the EPA CoP.

Funding and Governance

These governance and funding recommendations have been provided at a high level to help facilitate discussion in the options assessment. We understand that in practice our recommendations may not align with stakeholder appetite or aspirations. We invite feedback on our recommendations in the stakeholder consultation to better refine the funding and governance arrangements for the preferred option in Stage 2.

Penshurst

All (currently) quantified benefits are distributed to the broader Penshurst community as they are the key beneficiaries of increased health and environmental outcomes. The benefit of avoided upstream water supply costs are received by Wannon Water who supply water to Penshurst. Given economic regulation from the ESC ensures cost reflective pricing of water tariffs, the true beneficiary of the avoided upstream water supply costs is the customer base of Wannon Water.

Given the current stakeholder engagement, Wannon Water and Southern Grampians Shire Council (SGSC) are considered the only two parties realistically relevant for Penshurst. It is recommended for all options that Wannon Water is the lead agency for the wastewater options. This is because they are the most capable entity in delivering the solution packages at least cost and ensuring they are compliant to requirements (Such as EPA code of conduct).

For steps 3, 4 and 5, it is very important to note that the broader Penshurst community will be the primary funders of the infrastructure regardless of the governance option. As these beneficiaries will contribute regardless of the governance model, the governance and funding options should consider models which are practical to implement.

As water tariffs are periodically determined through the ESC, it is likely to provide a more effective method of cost recovery from the broader community compared to council rates. The price determination will also likely mean that costs are shared across the whole customer base. Whilst this is broader than the Penshurst community, it could be argued that the community beneficiaries are broader than the SGSC rate-paying base as visitors will derive benefit from increased amenity, environmental and health benefits. Water tariffs provide an effective and established transfer mechanism for the broader community (the core beneficiaries) to contribute to the costs of the preferred solution package (Step 4 in the cost allocation framework). SGSC should still be engaged with the delivery of the wastewater options given strong interactions with their broader role in the Penshurst community.

Cudgee

In this economic assessment, either the base case or SP2 will be the preferred option depending on the environmental benefits and appetite for expanded water cycle investment. For both options, Frontier recommends that there is little to no change to the current governance or funding arrangements in Cudgee, and that Moyne Shire Council continue to lead wastewater management. This is because the majority of benefits are associated with Moyne Shire Council through improved stormwater management. Wannon Water does not have the responsibility of stormwater management in Cudgee, and as such does not need to be included in the governance arrangements.

Moyne Shire Council should consider:

- Continued monitoring and assessing of pollution levels
- Exploring the potential of using council funds directed to stormwater management to fund the upfront and ongoing infrastructure. Council rates (or other mechanisms that collects revenue from Cudgee residents) represents the most appropriate funding model as Moyne Shire Council residents are the direct benefactors of improved amenity and local environmental outcomes (relevant for SP2)
- Considering policy mechanisms for encouraging gradual replacement of current systems if the base case is the preferred option (such as financial incentives or quality requirements)
- Assessing how wastewater management may provide a barrier for potential growth in the township

Glossary

A summary of key terms and concepts relating to this investigation is presented in the table below.

Table E9: Glossary

Term / Element	Definition / Description
EPA Code of Practice (CoP)	EPA Victoria guideline document for the assessment and design of on-site wastewater management systems in areas not serviced by reticulated sewerage. CoP is a risk based document (for suitability qualified consultants / installers) and provides minimum standards along with guidance for situations in which standards are not able to be strictly complied with.
Containment On-site (CoS)	The ability of a property to contain the design wastewater flow within the property boundaries (i.e. no effluent surcharging / run-off) and ensure no adverse impacts on groundwater or nearby receiving environments. Can be considered a high level of health and environmental protection when accompanied by management of on-site infrastructure by a central, competent authority.
Land Capability Assessment (LCA)	On-site assessment of the ability of a property to contain its wastewater on-site and any potential risks to the environment or human health from on-site wastewater management.
Best Practicable Option (BPO)	A feasible option that aims to provide the most benefits and / or the least harm to the environment (as a whole) at an affordable cost over the life of the system in the context of the site. Upgrade of existing on-site wastewater systems within the township to the best practicable option that maximises (but not necessarily achieves) full on-site containment. Residual discharge of excess greywater (treated via a bio-filter) is to be directed to stormwater drainage (bioretention swale). This option aims to retain existing septic system where possible.
Integrated Water Management (IWM)	Water management approach that aims to provide a holistic and forward thinking approach to all elements of the water cycle (movement of water through its various phases) including wastewater in addition to stormwater, potable / non-potable water supply and local watercourses. The intention is for this approach to be adaptive to temporal changes over the long-term and designed in conjunction with end users (community) with a place based element to design.
Bioretention Measure	Measures including swales, basins and raingardens (depending on scale) which aim to capture stormwater to be filtered through densely vegetated sand / loam filter media. Treated water either discharges via an underdrain, or potentially directly into groundwater in sandy environments. The water is treated via filtration, absorption and biological processes within the media / vegetation. Measures also provide retention of water to release it back into the environment in a manner more consistent with the natural flow regime.

Term / Element	Definition / Description
Biofilter	Biological filter utilised to treat excess greywater from BPO upgrade sites within the township. Can consist of slotted / drilled distribution pipe(s) for dosing of greywater across filter media (e.g. coconut fibre above sand / gravel layer) with discharge of treated water via an underdrain connected to stormwater drainage (bioretention swale for further treatment).
Reuse	Use of reclaimed / recycled water for a beneficial purpose e.g. irrigation of community playing fields.
Cluster Reuse (Irrigation) System	System to collect treated effluent from on-property systems for polishing (potentially Class B) and irrigation across community / public open space. Cluster systems are typically set up at a precinct scale to treat wastewater from a group of properties within the vicinity of the nominated community / public open space. Initial upfront on-property treatment allows for reduced cluster treatment infrastructure. Cluster system can typically consist of small control shed (filtration and ultraviolet disinfection) and wet weather storage tank.
Central or Cluster Reuse (Irrigation)	Surface irrigation of Class C or B effluent in an agricultural (non-edible) scenario such as fodder or grazing (e.g. Lucerne). Can be operated as hybrid recycled water / land application system or full beneficial reuse with discharge to waterway.
Commercial Reuse / Agricultural Irrigation	Supplemental supply to local growers for irrigation of hops / non-edible crops or local forestry. Feasibility dependent on market demand for alternative water supply and suitability of available sites.
Water Recycling Plant (WRP)	Facility that utilises a mix of biological, chemical and mechanical processes to treat raw sewage to a standard appropriate for either reuse (e.g. irrigation) or discharge to the environment.
Reticulated Sewerage	Low pressure sewer, pump stations and rising main to existing sewerage network or central Water Recycling Plant.

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1 Introduction

Decentralised Water Consulting (DWC) is currently assisting Wannon Water (WW) along with Southern Grampians Shire Council (SGSC) and Moyne Shire Council (MSC) to investigate options to improve wastewater management for the townships of Penshurst and Cudgee. Wastewater is currently managed by individual on-site wastewater management systems (on-site systems) in Penshurst and Cudgee with approval and performance regulated by SGSC and MSC respectively. 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.

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

The project is being undertaken in four phases (refer to Figure 1 for context), namely;

- Project Review, Background and Engagement (Why are we here and what do we want to achieve?)
- Option Development and Assessment (Shortlist Option Packages and assess these to determine preferred options)
- Functional Design and Cost Allocation (develop preferred option for both towns including governance / funding model)
- Project Finalisation (Present to agencies and incorporate feedback)

The Background Paper previously prepared summarised the initial outcomes of the first phase of the project which is focused on evaluating the current wastewater management situation in Penshurst and Cudgee and the regulatory context for pursuing options for these towns, beyond the traditional approaches of sewerage. This has subsequently led to engaging with both agencies and the community to develop a shared vision what will be achieved from the project.

As part of this Options Analysis Report we have;

- undertaken consultation with the PCG and communities of both towns to obtain feedback and information to feed into the options shortlisting process;
- shortlisted a number of key option packages for both towns in consultation with the PCG and incorporating community feedback;

- undertaken 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;
- outlined a preferred option package for both towns based on the options analysis outcomes; and
- outlined key principles associated with a governance and funding model for the preferred options for each town.

Both the technical investigations and community engagement has confirmed that there is a need and community desire for improved wastewater management in Penshurst, with less drivers or community desire in Cudgee. Continuation of the Business as Usual wastewater management approach cannot meet long-term regulatory or community expectations in Penshurst.

Consequently, this study is critical to identify alternative, safe and sustainable long-term wastewater management strategies for small towns such as these. The outcomes of this stage of the project provides a strong basis and direction for the project based on best available information and the community desires and vision for Penshurst and Cudgee.

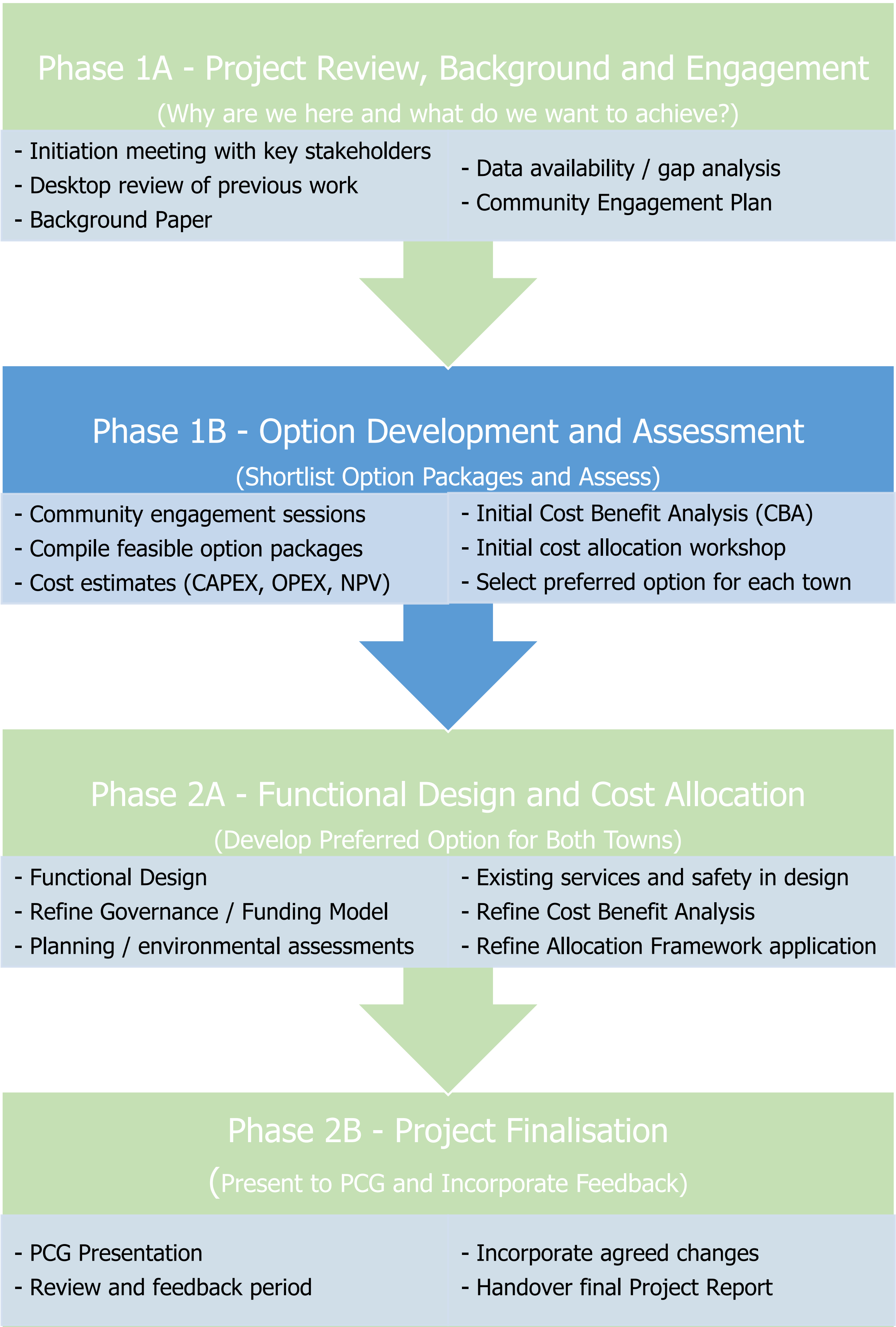

Figure 1 Structure of the Small Town Wastewater Investigation

2 Background Context

As discussed, DWC previously prepared a Background Paper which included a review and analysis of a range of information and data to characterise the current wastewater management situation within both townships, including;

- Existing on-site wastewater system audit and Permit information obtained.
- Land capability constraints for properties within the townships.
- Water quality / groundwater monitoring data available for either township.
- Potable water use based on data available from Wannon Water (Penhurst only as Cudgee is supplied by tank water).

Reference can be made to this Background Paper (DWC, 2019) for further information on the overall background context and state of current wastewater management. The sections below outline key background information that has been utilised in this options analysis phase of the project.

2.1 On-site System Information

2.1.1 Penshurst

DWC have previously undertaken analysis of available data on the type, age and condition of the various types of on-site wastewater management systems in Penshurst (as part of the Background Paper). Audit Program field inspection data has currently been obtained for a number of key townships including Penshurst. This data chiefly consisted of compliance information for each system in accordance with the EPA Code of Practice (2016), and in particular systems with major or critical non-compliance issues such as blocked or damaged wastewater disposal areas.

Of primary interest from the inspection data is the location and number of systems that incorporate some form of off-site discharge. This typically occurs with older 'split' systems where greywater is directed to stormwater drains or older sand filter systems where treated sewage was permitted under EPA guidelines to discharge off-site on properties considered unsuitable for full on-site containment predominantly in the 1980's.

Penshurst is the most densely populated unsewered small town within the SGSC municipality. Council's recent septic system audit identified ~93% (189) on-site systems inspected were not performing satisfactory and did not meet current public health and environmental standards.

The system audit data along with historical Permit data (as per previous approvals) was utilised by DWC to develop an approximate breakdown of expected systems across the township, and therefore characterise the existing case (and subsequently the Business as Usual) as best as possible.

Table 1 below summarises the assumed system breakdown for the *existing* township defined for this study (numbers refined from the previous Background Paper based on desktop analysis and fieldwork). Importantly, this assumed system type breakdown is considered conservative given many of the split systems will likely consist of either separate trenches for black and greywater dispersal or off-site discharge via failure of the dispersal area (i.e. not direct discharge) as identified in the audit outcomes. This data was subsequently utilised to develop assumed loads / flows for the existing (and Business as Usual) scenarios as part of options comparison and analysis.

Table 1 Existing Penshurst On-site Wastewater Management System Summary

Wastewater management system type	No. of systems (with %)
Primary Treatment (Septic Tank) – All wastewater to ETA trenches	24 (8%)
Split System – Septic tank to ETA trenches with off-site discharge of greywater	211 (70%)
Secondary Treatment (e.g. Treatment Plant) – subsurface irrigation	66 (22%)
Total	**301**

2.1.2 Cudgee

No on-site system inspection audit information was available for Cudgee. Thus the historical system Permit data summarised in the MSC DWMP 2018-2023 was utilised to assist in characterising the existing case for the township (as outlined in the Background Paper). The DWMP identified that most systems consider of either a septic tank to evapotranspiration absorption (ETA) trenches or Treatment Plant with irrigation. There were limited known offsite discharge systems given the typical larger lot size (compared to Penshurst), good soils for land application of effluent and relative newer age of many of the dwellings / systems.

This data was used in combination with fieldwork observations and desktop assessment of approximate dwelling (and hence system) age to define the approximate breakdown of existing systems across the main township of Cudgee. A summary of the assumed system type breakdown for the current development (based on desktop analysis and fieldwork) in Cudgee is provided below.

Table 2 Existing Cudgee On-site Wastewater Management System Permit Information

Wastewater management system type	No. of systems (with %)
Primary Treatment (Septic Tank) – All wastewater to ETA trenches	39 (60%)
Secondary Treatment (e.g. Treatment Plant) – Subsurface irrigation (assumed)	26 (40%)
Total	**65**

2.2 Water Use and Wastewater Generation

A statistical analysis of available water consumption data (2018-2019) was undertaken as part of the Background Paper to determine the water usage and approximate wastewater generation on average. The wastewater generation was calculated assuming that 75% of property water usage is hydraulically connected to the wastewater system and the remaining water volume is used externally. Data was only available from Wannon Water for Penshurst as Cudgee utilises tank water supply (there is a reticulated raw water supply for a small number of properties).

This data included both domestic and non-domestic water usage, along with groundwater extraction rates for the bore servicing Penshurst (data available for ~70% of the year). The specific data provided by WW for Council owned / operated infrastructure indicated a total water usage (2018-19) of approximately 6.58 ML/year and 19 kL/day.

The statistical analysis for WW billed water usage is presented in Table 3 below. The data statistics excludes some non-domestic facilities in which water usage is not representative of potential wastewater generation e.g. public pool, hospital, etc.

Table 3 Daily Water Use and Wastewater Generation Statistics

Property Type	Statistics	Water Usage (L/day)	Assumed Wastewater Generation (L/day)
Dwellings (domestic) only	Average	384	288
	Median		
All Data	Average	320	240
	Median	209	157

These statistics generally align with previous data obtained for other similar rural towns (e.g. Forrest) and therefore it is likely that similar domestic water usage would be expected in Cudgee. Importantly the overall water usage is not significant and therefore this limits the potential benefits of water reuse opportunities in either town.

The available bore data was extrapolated to estimate the general extraction for the total year (indicative only).

Table 4 Bore Water Extraction Data (2018/19)

Statistics	Water Rate (kL/day)	Water Rate (ML/yr)
Available Data (259 days)	195	50.45
Estimated (total year)		71

3 Characterise Business as Usual (BaU)

The Do Nothing / BaU scenario is important as it provides a baseline condition to compare any alternative options against. The consistent feedback from the Penshurst community session was that the current wastewater management situation within the town is unacceptable and an improvement is essential.

Feedback from the Cudgee community session indicated that the current wastewater management situation within the town varies in the observed issues / drivers and the need for an improvement. Approximately 50% of surveys submitted indicated that wastewater issues did not affect them.

A Business as Usual (BaU) scenario has been taken forward as a baseline for each town for comparison with the shortlisted Solution Packages as part to the economic analysis.

It is unrealistic to assume that there will be no change in wastewater management practices in either town over the next (say) 25 years in the absence of adoption of the preferred wastewater solution that arises from this project.

DWC have made the following assumptions for each town.

- Existing, older on-site wastewater management systems are replaced or renewed at an average rate of 4% per annum over the next 25 years through either;
    - voluntary replacement due to old age or failure;
    - a requirement as part of a planning or building permit process; and/or
    - an enforced upgrade due to a compliance issue.
- The total (average) cost of this upgrade is assumed to be $16,000 including approvals with an operational cost of $600 per annum (p.a.) including component replacement, servicing, power use and desludging.
- Existing on-site systems were assumed to cost the average owner approximately $200 p.a. (or $1,000 every 5 years, $2,000 per 10 years, etc.) to reflect periodic pump out of the septic tank, disposal field repairs, renewal or replacement and in some cases mechanical and electrical maintenance.

It is important to note that this BaU scenario has incorporated the findings of the on-site containment potential mapping documented in Section 3.1 below. More than half of the properties in the Penshurst study area are unlikely to be capable of full on-site containment in accordance with the EPA Code of Practice. Only a small minority of properties in the Cudgee study area are unlikely to be capable of full on-site containment in accordance with the EPA Code of Practice.

The environmental and health protection benefits for a BaU scenario assume on-site containment is maximised with excess effluent only discharged off-site where essential.

Cudgee is currently serviced by a higher proportion of on-site systems likely to be less than 10 years old due to more recent Low Density Residential Zone (LDRZ) subdivisions. The BaU scenario has been adjusted to reflect this by making the following distinction in asset age and life.

- Existing systems >10 years old (53%) will be upgraded early in the 25 year life cycle at a rate of ~10% p.a. and be largely replaced by more modern systems by year 10.
- Existing system <10 years old (47%) will start reaching the end of their asset life around year 7-10 and be renewed at a rate of ~4% p.a.

Owner managed on-site systems will have a typical asset life of 20 years resulting in early upgrades needing renewal between year 20 – 25.

A summary of the BaU scenarios for both towns are summarised in the table below.

Table 5 BaU Summary - Penshurst

Summary	Component	Description
Wastewater Retain full on-site containment where feasible. Partial upgrade of remaining on-site systems to best practicable option. Remains owner managed and council regulated. **Stormwater** n/a	On-property	*PREMISE OF SCENARIO IS TO RETAIN OWNER MANAGEMENT OF SEPTIC SYSTEMS AND REGULATION BY COUNCIL.* Incremental (owner driven) upgrade of existing septic systems to achieve full on-site containment where feasible or maximise containment (renew existing land application) over 25 year period. **Higher failure rate assumed based on less oversight and limited regulatory capacity.**
	Collection / Treatment	All treatment provided on-property (highly variable performance).
	Environmental / Human Health	Limited to no improvement in pollutant loads from on-site systems. EPA CoP requirements not achieved on at least 50% of properties.
	Water Management	All irrigation / land application on-property (highly variable performance).
	Water Cycle implications	Reticulated potable / groundwater water supply. Slightly reduced potable demand (residential garden, etc.). Otherwise BaU for water supply and water extraction.
	Liveability implications	Continued discharge of treated effluent to street drains. Encumbrance of properties with a 'maximised' on-site system. Some potential for greening of properties but predominantly effluent management.
	Long-term growth implications	Limited to gradual upgrade of systems (by owners) over time. Low rate of current on-site system improvement and continued high rate of non-compliance / issues e.g. odour, drainage to central wetland. New business may be constrained from establishing/expanding, which constrains business and employment growth. New properties would be required to install on-property works in accordance with current regulations to enable development. This will constrain some development given existing lot sizes. Some properties in Penshurst have been rendered undevelopable as a result.

The Business as Usual scenario does not assume full compliance with the EPA CoP for Penshurst. It is reflective of typical practice in Victoria and nationally, whereby on-site containment is maximised, effluent quality is improved with the overall objective of minimising human health and environmental impact. This is the recommended approach from 2.3.5 and 2.3.6 of the EPA CoP for existing small lots and existing off-site discharges. Furthermore, properties identified as CoS High Risk in the hazard mapping assume wastewater can be fully contained subject to a high level of design, construction and operational oversight despite the fact that many of these sites do not meet EPA CoP requirements.

Table 6 BaU Summary – Cudgee

Summary	Component	Description
Wastewater Retain full on-site containment where feasible. Partial upgrade of remaining on-site systems to best practicable option. Remains owner managed and council regulated. **Stormwater** n/a	On-property	*PREMISE OF SCENARIO IS TO RETAIN OWNER MANAGEMENT OF SEPTIC SYSTEMS AND REGULATION BY COUNCIL.* Incremental (owner driven) upgrade of older existing septic systems to achieve full on-site containment where feasible or maximise containment (renew existing land application) over 25 year period. Newer systems renewed at 20 year design life. **Higher failure rate assumed based on less oversight and limited regulatory capacity.**
	Collection / Treatment	All treatment provided on-property (variable performance).
	Environmental / Human Health	Moderate improvement in pollutant loads from on-site systems. EPA CoP requirements not achieved on about 6-8 properties.
	Water Management	All irrigation / land application on-property (variable performance).
	Water Cycle implications	Reticulated non-potable / roof water supply. Slightly reduced potable demand (residential garden, etc.). Otherwise BaU for water supply and water extraction.
	Liveability implications	Minor volumes of continued discharge of treated effluent to street drains due to small number of non-containment sites. Encumbrance of smaller properties (<2,000m^2) with a 'maximised' on-site system. Some potential for greening of properties but predominantly effluent management.
	Long-term growth implications	Limited to gradual upgrade of systems (by owners) over time. Low Density Residential Zone growth already feasible and occurring. New properties would be required to install on-property works in accordance with current regulations to enable development. Most properties in Cudgee are capable of this.

3.1 On-site Containment and Land Capability

The part of the Domestic Wastewater Management Plan (DWMP) 2018-2023 prepared by MSC, broad-scale land capability hazard mapping for onsite wastewater management has been prepared for the Shire, including Cudgee. This mapping included consideration of constraints as such;

- Climate / Slope / Soil / Drainage
- Sensitivity receiving environments e.g. watercourse, groundwater bores, etc.

DWC have also completed similar land capability hazard mapping for the recently revised SGSC DWMP. The respective maps for both towns were provided previously in the Background Paper. A refined hazard mapping approach has subsequently been adopted, based on more site specific data / methodology, to assist with informing the options development and analysis for the towns.

DWC have previously developed a risk based framework for classifying properties based on their ability to contain wastewater on-site (based on appropriate setbacks recommended in EPA CoP) whilst incorporating land capability constraints. A summary of the classification approach based on this framework is summarised in Appendix B.

In order to characterise the Business as Usual (BaU) scenario for each town and determine potential upgrade solutions for existing on-site wastewater management systems, DWC have undertaken an analysis of ability for individual properties to contain all wastewater on-site in accordance with the EPA CoP. Following this a general risk based analysis has been undertaken of key hazards related to sustainable long-term Containment On-site (CoS).

The typical small property size in Penshurst (and thus limited available area for effluent management) is one of the key constraints to sustainable on-site effluent management. This is in addition to the shallow permeable soils and sensitive groundwater environment beneath the town. Cudgee features intermittent watercourses through the town and observed flood impacts are present in Cudgee. However, field investigations identified that overall, site and soil conditions are well suited to on-site wastewater management. Under current Victorian Planning Schemes (based on Low Density Residential zoning) the minimum lot size for long-term sustainable on-site wastewater management is 4,000m^2. This is in comparison to property sizes ranging from ~350m^2 to 2,500 m^2 in the town zone of Penshurst. The typical (median) property size in Cudgee is larger (4,000-5,000m^2).

The results of this on-site containment assessment are summarised in Table 7 and Figure 2 / Figure 3 below and are based on the **properties** (and not the existing systems). It can be seen that the majority of properties in Penshurst (72%) are not capable of installing a system that is compliant with current EPA CoP requirements and would be unlikely to be able to fully contain on-site. This is predominately due to the small lot size across the main township. This is however not the case for Cudgee as it is much less constrained with both property size and land capability constraints.

Approximately 28% of properties in Penshurst (within potential service area) are considered readily capable (Low/Medium Risk) of on-site containment using more traditional on-site wastewater management technologies and practices.

The results for Cudgee suggest a much higher level of containment potential. Approximately 15% of properties cannot full contain all wastewater and 31% of properties (within potential service area) could potentially fully contain on-site, but would require a higher cost system with additional oversight and management to ensure they are performing as required.

Table 7 Onsite Containment Statistics

Long-term On-site Containment	**No. of Lots (%)**	**No. of Lots (%)**
	Penshurst	**Cudgee**
Full on-site containment not possible	237 (72%)	16 (15%)
Full on-site containment possible at higher cost	0 (0%)	33 (31%)
Full on-site containment possible	90 (28%)	56 (53%)

Each map represents the anticipated *long-term sustainability* of on-site wastewater management for each property in both towns. It assumes each lot is eventually upgraded to meet the current Victorian and Australian Standards. Where this isn't possible (primarily due to property size), the system would need to be provided with some form of off-site service (such as reticulated sewerage) or upgraded to the best practicable option that seeks to minimise off-site discharge of effluent and pollutants (EPA CoP, 2016). What these maps are illustrating is that for a large proportion of properties in Penhurst, the upgrade of existing on-site systems is highly unlikely to meet current regulatory requirements regardless of the level of investment and oversight.

For Cudgee on the other hand, it is likely that the majority of properties could sustainably manage all wastewater on-site via either the existing or an upgraded on-site system.

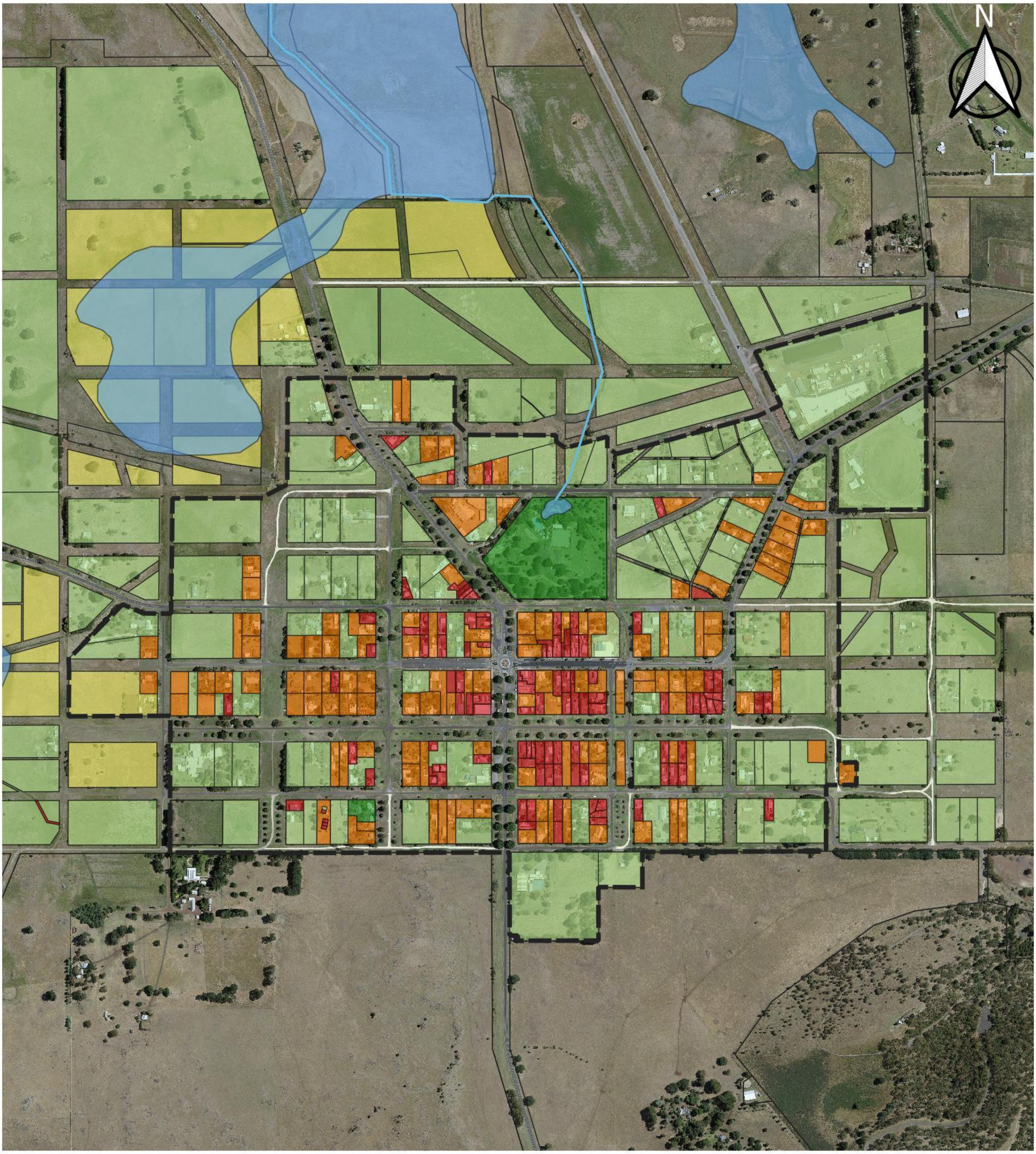

Figure 2: Penshurst On-site Containment Hazard Map

Legend

Study Area

Property Boundary

Waterbody

Watercourse

On-site Containment Hazard Class

CoS Low

CoS Medium

CoS High

Partial / Limited CoS

Non CoS

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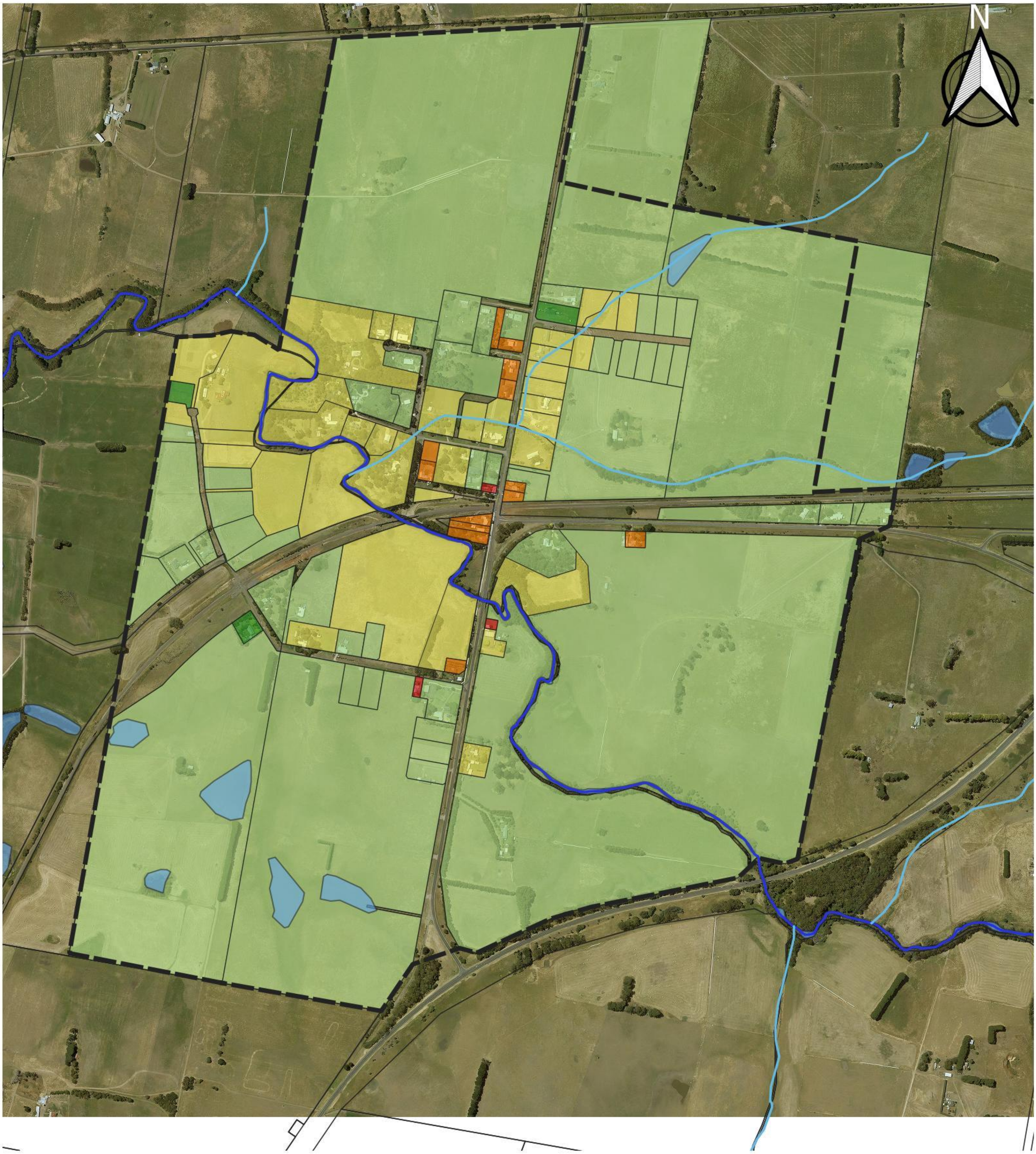

Figure 3: Cudgee On-site Containment Hazard Map

Legend

- Study Area
- Property Boundary
- Waterbody
- Named Watercourse
- Intermittent Watercourse

On-site Containment Hazard Class

- CoS Low
- CoS Medium
- CoS High
- Partial / Limited CoS
- Non CoS

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4 Compiling Potential Servicing Options

Following preparation of the Background Paper in November 2019, DWC worked in consultation with Wannon Water/ PCG and the Community to discuss and develop a range of initial potential servicing elements / options for each town. Initial elements were identified that could potentially form a set of logical option packages relevant to each town.

The various options / elements considered;

- the scale of application (e.g. on-property, street, cluster or whole of town);
- the type of servicing element (e.g. collection, treatment, reuse, management, regulation); and
- water cycle element / source (wastewater, in additional to stormwater, water supply and discharge to waterways).

Discussions with the PCG and community were used to obtain thoughts and feedback on potential individual wastewater (or stormwater) elements and therefore guide the formation of dedicated Solution Packages. These shortlisted Solution Packages are discussed in Section 5 and a summary of the key options / elements considered is presented in Appendix A.

A key intention of this option analysis stage of the project was for solutions to include consideration of the following;

- Protection of human health and natural environment from adverse impact from untreated wastewater, including waterways at Cudgee and protection of the groundwater source in Penshurst that is directly connected to the Wetland Garden ponds in the centre of town.
- Decentralised technologies which can provide treatment and reuse of treated effluent close to source and therefore reduce energy requirements, whilst potentially providing additional benefits such as improved liveability / local amenities.
- Options that leverage the existing willingness for collaboration between the State and local governments, water authority, regional agencies, and local communities.
- Provide direction on governance arrangements and funding models for the construction, ownership, operation, monitoring and maintenance and ongoing costs for each option.
- Opportunities for existing town and business renewal which would otherwise not occur without the implementation of new wastewater management options.
- Opportunities for properties presently not able to sustainably manage domestic wastewater onsite.
- Reuse of treated wastewater that value adds to the township’s amenity and sustainability (i.e. Integrated Water Management).

4.1 Initial Options Consideration

The table below provides an introduction to potential options that where discussed with the community of each town as potentially available for consideration. These were subsequently investigated and shortlisted following feedback from engagement and analysis documented in the following report sections.

Table 8 Potential Alternative Wastewater Management Strategies

Strategy / Model	Description
Managed On-site Wastewater Management Systems	On-site Wastewater management systems upgraded and managed / operated (also potentially owned) by a Responsible Management Entity (RME) such as a water authority, Council or private utility, as discussed in Section 3.6 of the VAGO report (2018) based on US EPA governance model. The Park Orchards Trial project being undertaken by Yarra Valley Water is an example of this, in which ~100 properties have been assessed with upgraded on-site systems.
Decentralised / Cluster Wastewater Management System	System to collect sewage or treated effluent from on-property systems for recycled water (typically Class C or B) and irrigation across community / public open space. Cluster systems are typically set up at a precinct scale to treat wastewater from a group of properties within the vicinity of the nominated community / public open space. Allows opportunities for on-property reuse of treated wastewater to reduce downstream infrastructure / irrigation requirements. To be operated and managed by RME.
Integrated Water Management (IWM)	Water management approach that aims to provide a holistic and forward thinking approach to all elements of the water cycle (movement of water through its various phases) including wastewater in addition to stormwater, potable / non-potable water supply and local watercourses. The intention is for this approach to be adaptive to temporal changes over the long-term and designed in conjunction with end users (community) with a place based element to design. Examples include Best Practicable Option upgrades to existing on-site systems with any excess wastewater not able to be contained on-lot sent to upgraded stormwater infrastructure (biofilters / constructed wetlands), as considered by Barwon Water for Forrest township.
Funded on-site system upgrade grants.	Seek external funding to assist home owners in system upgrades. The Blackwood Septic Tank Project is one Victorian example of such a project. This project involved Council led Land Capability Assessments and tender / construction oversight. Another example includes the Mount Macedon project. Operation and management of systems continues to be home owner responsibility, which is a key potential risk given owners are typically not experienced with onsite systems (thus the need for a RME discussed above).
Reticulated Sewerage (Conventional)	Delivery of gravity or low pressure sewer, pump stations and rising main to existing sewerage network or central Water Recycling Plant. Would be likely delivered and managed by Wannon Water (currently no plans to extend network) and cost prohibitive which is why alternative wastewater options are being explored for these two towns.

4.2 Community Engagement: Opportunities and Constraints

DWC and the PCG participated in a 'drop-in' session held for each town across December 2019 to January 2020, which involved the following.

- Engagement with the community via a drop-in session within each town to obtain valuable information and insights into past, present and potential future wastewater management issues and solutions.
- Discussions with the community highlighted key issues and problem areas for each town. This also allowed the community to identify potential opportunities within their town from their unique viewpoint e.g. highlight potential wastewater reuse areas that could be utilised as part of options taken forward.
- A short survey was also prepared by DWC in consultation with the PCG to provide the community with some key questions of what they might want a potential solution to look like and achieve. Surveys were made available both at the session in hard copy and online (electronic).

The outcomes of the community sessions were subsequently complied by DWC with assistance from Wannon Water to help in the options shortlisting process and are discussed in the following section.

4.2.1 Community Feedback

The key feedback comments / themes from the community session are summarised in table below and full details of community feedback is provided in Appendix E.

Table 9 Summary of Key Penshurst Community Comments

Comment	Discussion / Incorporation into Options
Provide capacity for town renewal and cater for growth / business opportunities	Business and development opportunities and renewal of the existing township was identified as key elements in Penshurst which are currently limited by wastewater management. Approximately 64% of surveys (14 submitted in total) indicate that limited business and development opportunities were the most important aspect that they experience as a result of wastewater management. Furthermore, 43% of respondents identified enhancement of these opportunities as the most important aspect they were seeking from these investigations. Thus existing town renewal and potential growth has been factored into all Solution Packages and details for each are discussed in Section 5. Existing residential dwellings have been assumed to be increased to a four bedroom dwelling in the long-term.
Protection of environmental and human health	Another high priority objective that was identified by the community (~43% of surveys indicated it was a key issue for the town). Drainage of wastewater into the Penshurst Wetland Gardens in the north of the township was of particular concern, given the potential issues of local amenities and health. Thus all identified Solution Packages have been developed to provide an improvement to health and environmental risks within the township (including the Penshurst Wetlands).
Consideration of reticulated sewerage	This has been taken forward as a potential option for consideration (in particular Solution Package 4 which is a 'traditional' sewerage option) This has taken into consideration both gravity and pressure sewer, in addition to smaller diameter effluent sewer given the ability to achieve gravity fall on majority of lots within the township. Pressure sewer on the other hand can include innovative (e.g. smart controllers) elements and is typically less disruptive during installation.

Comment	Discussion / Incorporation into Options
Provide value for money	Due to the potential cost implications for the community, Solution Package 1 was developed to strike a balance between up front capital investment (to address the poor economies of scale typically associated with small town wastewater schemes) and reduction in risks to human health and the environment (high priority objectives as discussed above). However, some discharge to the stormwater system is anticipated from the precinct / cluster systems during wetter / cooler months. This option would involve improvement to both wastewater and stormwater management and therefore potentially provides dual benefits to the community whilst trying to ensure costs are manageable. Utilising existing septic tanks was also considered (for both SP1 and 3) to investigate potential minimisation of costs given issues with tank installation within the shallow rock across the town.
Shallow soils present in Penshurst	Concerns were raised during the community consultation session held in Penshurst regarding the shallow soil depth across the township, and the unconfined aquifer directly beneath. A number of soil test pits were excavated by DWC in town for confirmation of soil depth. This key constraint has been considered and incorporated into the assessment of both potential on-property and cluster / community wastewater management systems. The installation of shallow ETA trenches for partial treatment of wastewater on-site, the utilisation of subsurface irrigation which pulse doses effluent at a conservative Design Loading Rate and the utilisation of treatment systems with maximised evapotranspiration (e.g. wetlands, reed beds) have all been considered.
Sensitive groundwater environment	The shallow rock and wetlands in Penshurst provide a connection between surface water and the sensitive groundwater environment (via ponds at Penshurst Wetlands). This is a key design consideration for all potential options. As such, Solution Package 1 includes provision for additional stormwater drainage to direct surface water around the central Wetlands (due to some residual discharge of treated effluent from the proposed cluster reuse systems). A high quality of treatment has been specified for all Solution Packages to reduce the likelihood of contamination from wastewater sources.
Use of treated water for local Community / Public Open Space.	A number of community members were supportive of the idea of utilising treated water for irrigation of local community areas / public open spaces. This has been included as part of Solutions Package 1 and 2. The current potential reuse sites have been selected based on available land and proximity to town.
Potential Effluent Re-Use Sites	The community identified that the Penshurst sports oval / recreational reserve and racecourse (to the north) as potential effluent re-use sites which could benefit the town. The use of these sites has been considered and assessed and it was determined that: 1. The sports oval has very shallow soil (~400mm) and currently already experiences saturated soils during wetter months. As such, the use of the oval for irrigation is possible under a beneficial reuse scheme where irrigation only occurs when the soil is experiencing a soil water deficit. However, this will result in limited volumes of wastewater being able to be applied each year; 2. The racecourse is located north of the township and downstream from the Country Fire Authority (CFA) depot. At this stage, this site has not been considered further.

Table 10 Summary of Key Cudgee Community Comments

Comment	Discussion / Incorporation into Options
Some community members not experiencing significant wastewater management issues	The Cudgee community session and surveys indicated that a number of people within the community do not identify wastewater management as a key problem for them (~50% of respondents experience no wastewater issues). This has been considered as part of the Solution Packages, with a focus on localised wastewater issues within the main township (in which there is a number of smaller constrained properties) in which a greater level of oversight and management is likely to assist in addresses issues. Whilst solutions have been investigated to improve the overall wastewater management of the town and reduce impacts on the receiving environment, it is likely that the existing BaU situation will provide sufficient management of these risks (provided systems are designed in accordance with EPA CoP).
Protection of local waterways and the environment	Approximately half of the survey respondents identified the health of the local waterways and environment as being the most important outcome of the wastewater investigation. As such, the Solutions Packages aim to provide a net decrease in pollutants reaching the waterways / environment from both wastewater (and stormwater in the case of SP2) sources.
Consideration for how new development impacts the natural environment	A key discussion point was surrounding new subdivision and the management of both additional wastewater and stormwater flows. Increase in development and impervious area can result in increased overland flow heading through the main township, which may transport stormwater pollutants from properties to downstream waterways. A flood study has been commissioned by MSC to assess how flooding impacts can be mitigated through the main section of the township. It is likely that additional upslope detention and formalised drainage will be required to transmit flows down to Brucknell Creek. Thus consideration has been given to providing improvements to stormwater management / treatment (via Integrated Water Management) as part of Solutions Package 2.
Provide value for money	As with Penshurst the Solution Packages assessment has focused on providing the best value for money to the community, including potential benefits identified as part of the CBA. The potential cost of traditional wastewater infrastructure (e.g. reticulated sewage) would be significant for Cudgee given the small current size of the town. The proposed Solutions Packages were developed as lower cost options which address the localised wastewater and stormwater issues / constraints present in Cudgee. These constraints include a small number of properties which cannot contain wastewater on-site due to the very small size of the lot (SP1) and the potential stormwater run-on from the new subdivision located to the north of the site (SP2). SP1 involves managing wastewater from non-containment properties on public land (either road / railway reserve or at the primary school) and SP2 includes the improvement of stormwater management in the immediate township.

4.3 Options Development & Shortlisting

As discussed above, community feedback was sought on the range of initial potential servicing ideas and options for each town that were presented by DWC and the PCG. Additional ideas and opportunities were also put forward by the Community. In addition, field data collected by DWC (soil test pits, available areas for potential effluent management, etc.) was also analysed to determine and shortlist a number of distinct option packages for both towns to be carried forward for assessment.

The intention of the developed Solution Packages was to effectively group the wide range of options / elements (servicing scale / type, water cycle component, etc.) into viable servicing approaches which could be meaningfully compared. The Packages aim to capture the distinct range of community opinions, ranging from a 'flush and forget' preference (conventional sewerage) through to interest in smaller footprint, more sustainable and local solutions.

For Penshurst, all Packages assume a single accountable authority will manage and maintain the upgraded systems. <u>This includes all on-site treatment and irrigation components.</u>

Details of governance and funding sources will be explored and better defined during the cost allocation process in Phase 2 of the project.

Long-term growth has been considered as part of the Packages (as per the community feedback) to provide enhanced potential for residential development and businesses to start up or expand.

The shortlisting process included consideration of a large array of potential options and elements. In particular, a number of key aspects which were considered in detail as part of option selection and shortlisting included the following.

4.3.1 Water Recycling & Beneficial Reuse

A key focus of this small town wastewater investigation is the consideration of Integrated Water Management (IWM) concepts. The capturing and utilisation of recycled water for domestic / local reuse potentially forms an important IWM opportunity and thus it been considered as part of investigations for both towns.

A monthly water balance was developed based on Penshurst climatic data to determine the potential reuse / receiving capacity for water recycling, in particular for domestic usage such as garden watering. The monthly calculations (in millimetres) are summarised below.

Table 11 Penshurst Climatic Analysis for Potential Irrigation Demand

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
PET (Pasture)[1]	100	85	69	44	26	18	21	29	40	58	70	89	651
Retained Rainfall[2]	31	24	34	42	54	57	65	70	62	52	46	39	578
Potential Irrigation	69	61	34	1	0	0	0	0	0	6	24	50	73

Note 1: Potential evapotranspiration (Penman Monteith) for reference pasture.

Note 2: Retained rainfall calculated from monthly rainfall x 0.8 factor

It can be seen that summer is the only time of the year in which there is the potential demand for recycled water for irrigation in Penshurst. It is not an area that is in need of a large amount of recycled water for most of the year with potential total annual demand of ~73mm (based on monthly analysis). MEDLI modelling was subsequently undertaken for estimating the reuse potential of treated effluent at potential local cluster irrigation sites and is discussion further in the following sections.

In additional, there appears to be limited internal water recycling capacity in Penshurst (or Cudgee) given the relatively modest water usage (as discussed in Section 2.2). Based on typical breakdown of domestic internal water usage, it is estimated that only ~100L/day potential usage would be expected per property for toilet flushing (which typically only constitutes ~20-30% of water usage) and laundry washing.

Further to this, there would be significant issues and associated costs in retrofitting existing dwellings with the capacity for utilising recycled water for toilet flushing and laundry (cold water). New third pipe reticulation would be required from a dedicated Water Recycling Facility to provide high quality (Class A) water to each dwelling. Given the issues (and considerable anticipated costs) with installation of pipes within existing dwellings, slabs, etc. it is a very difficult to achieve the necessary benefits and economies of scale for towns of this size.

Thus high level treatment of water for recycling was considered but was unlikely to generate sufficient additional benefits, compared to capital / operational expenditure (which is likely to be very high for these towns) particularly compared to other potential options subsequently taken forward in the shortlisted Solution Packages.

4.3.2 Rock Depth

Discussions with the community and fieldwork undertaken by DWC identified shallow depth of rock as a key constraint in Penshurst which requires consideration for any option taken forward. In particular it presents a key point of uncertainty for installation of tankage and pipes under both;

- offsite servicing approach – installation of gravity or pressure sewerage;

- onsite wastewater management - upgraded septic systems and installation of effluent land application areas (e.g. shallow ETA trenches).

Thus shallow rock has been factored into the shortlisting of selected Solution Packages based on available information of rock depth, elevation (and therefore total pipe depths) and estimated costs for any rock drilling / removal which has been minimised given the uncertainty.

4.3.3 Liveability / Local Amenities

Another potential IWM concept which has been considered as part of option shortlisting is potential introduction of new green / blue spaces within the towns to improve liveability / local amenities, which can provide additional benefits such as reducing heat effects during warmer months (which will be exacerbated in the long-term due to climate change). These have been incorporated into a number of solutions within Penshurst and were also considered in Cudgee. In particular, green spaces and wetlands can provide a feature within the town that improves the amenity for both locals and tourists. This has been factored into the assessment (CBA) to determine relative benefits for each shortlisted Solution.

4.3.4 Energy Usage

Given the influence of climate change, another focus has been on the use of more 'passive' systems to manage wastewater closer to source with limited need for pumping to transfer to these (thus reducing overall greenhouse emissions). The use of local 'cluster' and precinct wastewater management systems have therefore been considered to minimise transfer distances of effluent. This also provides a source of local reuse water for reserves / public open spaces and has considered the use of more 'natural' systems such as wetlands and reed-beds to minimise energy requirements and associated emissions.

4.3.5 Wastewater Design Basis

Water use data was utilised in conjunction with inspection and previous audit data for Penshurst and Cudgee for the characterising of site specific dwelling and commercial / business (where possible) wastewater generation. The option design / development process has been based on an assumed minimum four bedroom dwelling on each property, based on typical contemporary dwelling size and capturing future design flows once properties are developed.

For properties connected to a reticulated sewer (effluent / gravity / pressure) and design flow of 500 L/day has been assumed based on previous design numbers adopted by water utilises (Yarra Valley Water, Barwon Water). This design flow is comparable to YVW's assumed 516 L/day for sewer design and equates to an average occupancy of ~3 equivalent persons, which is sufficiently conservative for towns such as Penshurst and Cudgee. In addition, sensitivity testing was undertaken using the 'actual' wastewater flow based on existing water use data (refer Section 2.2) which equated to ~300 - 350L/day. Therefore 350L/day was also tested for sizing of potential local cluster reuse systems and constructed wetlands.

Cluster / precinct scale wastewater management systems were sized based on the total number of potential properties that could be connected, based on drainage direction and elevation (whilst considering shallow rock depth). These cluster / precinct catchments are summarised in Section 5.1 (for Penshurst SP1 and 2) and involved calculations of the relative receiving capacity (hydraulic / nutrient loading) for each subcatchment utilising MEDLI. Precinct specific calculations (including water balance analysis) was also undertaken to determine potential sizing and number of Rhizopod™ units. This is a proprietary system which aims to maximise evapotranspiration and recirculate effluent to minimise discharge of treated effluent, depending on sizing and number of units installed. As use of more natural and passive systems were discussed by the community, these were taken forward for consideration as part of cluster reuse systems for both towns.

Assumption of ultimate development at an average four bedrooms per equivalent dwelling has also been taken forward for properties in which an upgraded (or existing) on-site wastewater management system is proposed. This equates to a full design flow of 900L/day per property and captures long-term wastewater generation and effluent land application / irrigation sizing, as per the EPA Code of Practice (2016).

4.3.6 Option Design Basis & Assumptions

A summary of the overall design basis for the option development is presented in the table below.

Table 12 Design Basis Summary

Component	Details
On-property wastewater generation / on-site system design flow	Water use data utilised in conjunction with inspection and previous audit data for Penshurst and Cudgee for characterising dwelling and commercial / business (where possible) wastewater generation. Refer to Section 4.3.5 for further details of design basis for option development / design. Assumption of ultimate development at an average four bedrooms per equivalent dwelling taken forward for both towns to capture long-term wastewater generation and effluent land application / irrigation sizing. On-site effluent land application based on EPA CoP (2016) and MAV (2014) Land Capability Assessment (LCA) Framework.
On-site System Audit / Permit Data	Previously compiled and described in Section 3 of Background Paper.
On-property Containment Potential	GIS analysis undertaken of useable land for effluent management across both towns with field validation for a selection of key properties. Refer to Section 3.1 for further details. Adopts an LCA approach to assessing the capacity of managing (or containing) wastewater on-site.
Cost Estimates	Cost estimates consist of total Capital Delivery Costs and whole of life cycle costs (25 year Net Present Value) developed for option comparison and assessment. Estimates have been derived from the best available data on Wannon Water sewerage infrastructure projects in addition to both on-site wastewater and integrated water management projects from Victoria (as a priority) and Australia. Further detail can be found in Appendix C. This includes costs for asset renewal and on property power consumption.
Soil	Data sourced from both Victorian Resources Online and soil test pits excavated by DWC in both towns. Soils in Penshurst township generally consist of well drained, shallow soils (silty loams to clay loam) above rock (perched watertable forming when wet). Cudgee soils consist of deep, well structured (loam to clay loam) soils which are highly suitable for effluent land application. DWC have significant experience in both on-site wastewater and effluent irrigation assessment and design. DWC have evaluated soil constraints and assigned design parameters based on Victorian EPA guidelines and national best practice. Supported by field and laboratory soil analysis of reference sites during field visits of both towns.
Climate	Interpolated rainfall, pan evaporation, temperature, humidity and solar radiation sourced from SILO Data Drill. Rainfall / evapotranspiration data also sourced from Bureau of Meteorology (BoM).
Effluent Quality Standards	Developed based on EPA Victoria (2003) *Use of Reclaimed Water Guidelines* along with EPHC (2006) *Australian Guidelines for Water Recycling* (National Guideline).
Sustainable Irrigation / Land Application Design	MEDLI utilised to test sustainable land application within both towns based on specific climatic / soil data within the region. A conservative Design Loading Rate (DLR) of 10mm/day (ETA trenches) and 2mm/day (subsurface irrigation) was taken forward for on-site containment for modelling and design in Penhurst – allows for shallow bedrock and ensures that horizontal wastewater movement through the topsoil (and potential breakout) is minimised. Cudgee soil loadings rates where higher (3.5mm/day for subsurface irrigation) given the deep, well suited soils observed. Effluent irrigation (reuse) elements were designed based on a deficit irrigation approach with winter storage in accordance with EPA (2003)

Component	Details
Stormwater Management / Treatment	Long-term hydrological / water quality MUSIC modelling was utilised to determine background nutrient loads and assist with estimating potential stormwater treatment from wetlands / bioretention measures (as considered in Cudgee). Refer to Section 6.2.1 for details of existing case characterisation and background load estimates.

5 Summary of Potential Wastewater Solutions

As discussed above, the data collated from both community engagement and fieldwork undertaken by DWC was utilised to inform the develop of a number of key shortlisted Solution Packages for each town based the unique characteristics of each. These options were developed and tested utilising MEDLI (for effluent land application sizing) and MUSIC (for background catchment nutrient loads) to determine the viability and impacts of the various Package elements.

Connection to an existing sewerage scheme was not progressed for either towns due to the significant distance to the nearest existing network connection point (cost prohibitive);

- Approximately 26km from Penshurst to existing sewerage at Hamilton.
- Approximately 14km from Cudgee to existing sewerage at Warrnambool.

The following sections summarise and outline the shortlisted Solution Packages for either town.

5.1 Penshurst

5.1.1 Solution Package 1 – STEDS to Local Cluster Management Systems (Residual to Stormwater)

This approach seeks to strike a balance between up front capital investment (to address the poor economies of scale typically associated with small town wastewater schemes) and reduction in risks to human health and the environment (high priority objectives). Feedback from the community has identified wastewater discharge, particularly within the centre of the town, is impacting on the central ponds / wetlands to the north, which are a community / tourist feature and are directly connected to groundwater. The use of existing on-property septic tanks (where possible) will limit up front capital requirements and enable a relatively passive solution for the township. Drainage from constrained properties will be configured as part of a Septic Tank Effluent Drainage / Disposal System (STEDS) scheme.

It also incorporates Integrated Water Management (IWM) principles by providing local wastewater management and beneficial reuse to create green public spaces as close to source as possible.

The trade-off of this option is the need to retain a residual discharge to stormwater in lieu of a whole of town sewerage network. However, this stormwater discharge has been configured to not only limit impact and risk but to provide many benefits, including improved wastewater management which includes controlled discharge to upgraded stormwater (lined swales). However as described below, it places limits on commercial development and property renewal / growth due to the residual off-site discharge.

There is potential to also incorporate Bioretention Basins downstream of the Penshurst Wetlands for capturing broader stormwater drainage and nutrient loads from the township. This is provided the assumed benefits are greater than the capital / operational expenditure (unlikely to be viable based on current cost estimates).

Solution Package is summarised in the following table.

Table 13 SP1 Summary

Summary	Component	Description
Wastewater On-property management / reuse (only where full containment is possible). Utilise existing septic tanks where possible for STEDS scheme. Management of septic tank effluent by precinct / cluster treatment systems for reuse at reserves / public open space. Excess recycled water unable to be reused to be discharged to lined swales. **Stormwater** Improve stormwater management (formalised / upgraded swales) in certain areas.	On-property	Upgrade existing septic systems to achieve full on-site containment on larger lots where feasible (84 lots) – secondary treatment system (e.g. aerated treatment unit or recirculating media filters) with subsurface irrigation or evapotranspiration absorption (ETA) trenches to meet regulatory (EPA CoP) requirements. Properties that cannot fully contain all wastewater on-site (217 lots) will have the existing septic tank (where possible) converted as part of a Septic Tank Effluent Drainage System (STEDS). All primary treated effluent will discharge off-site to gravity effluent sewer network. All systems managed by single competent and accountable authority (upgrade works and operation).
	Collection	Small diameter (gravity) effluent sewer collecting excess primary treated effluent from lots where full containment is not achievable. Conveyance to local cluster reuse systems.
	Treatment	Treat primary effluent utilising vertical flow reed-bed and packed bed reactor treatment systems (with 28 day storage) at nominated reserves / public open spaces for subsurface irrigation reuse (greening of public open space) at sustainable rates. Discharge of excess recycled water (during cooler months) into upgraded stormwater drainage (formalised lined swales), to ensure drainage is diverted around the central Penhurst Wetland to Murdum Creek (or other suitable waterway).
	Environmental / Human Health	>100% *increase* in TN/TP wastewater nutrient loads from BaU. However, removal of impact from Penshurst Wetland and local groundwater. Achievement of human health protection targets.
	Liveability	Establish and maintain green open space throughout town. Potential negative impacts associated with conveyance of recycled water via lined swales.
	Water Cycle	Establish local cluster irrigation (greening of reserves and public open space) at feasible locations. Continued on-property reuse of wastewater on larger lots. Residual (highly treated) wastewater discharge into upgraded stormwater (swales). Reduced water extraction/demand for residential and road reserve / public open space land application. Total nutrient export predicted to increase. However, will bypass most sensitive receptors (wetlands, local groundwater). However, improved human health risks from reduced effluent exposure potential.
	Long-term growth	Limited capacity to cater for town growth due to limited capacity of cluster irrigation sites. Would allow for renewal of existing properties / businesses. New developments on smaller, constrained properties would require new septic tank for connection to STEDS scheme.

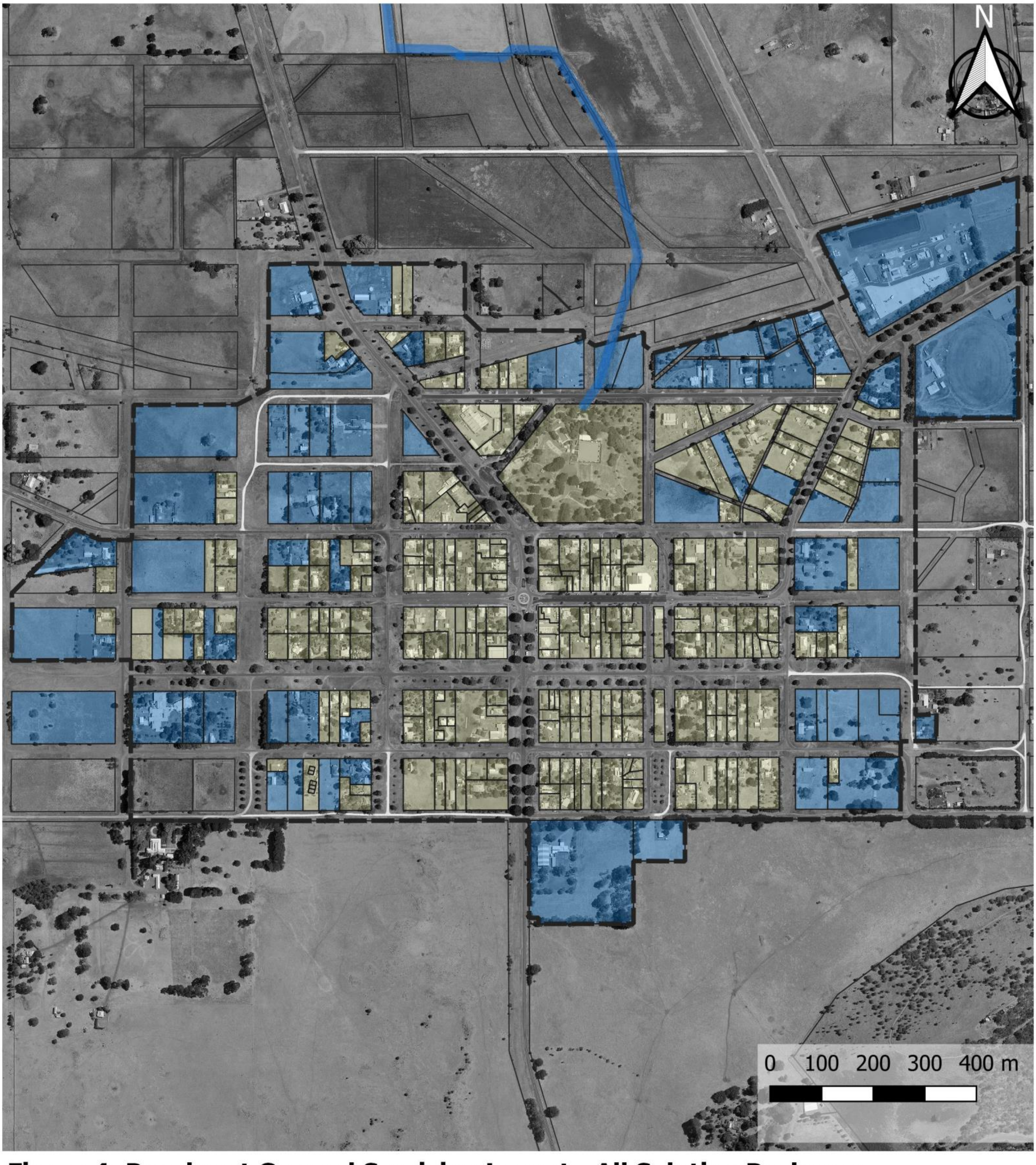

Figure 4: Penshurst General Servicing Layout - All Solution Packages

Service Area
Property Boundary
Watercourse

Servicing Details
Offsite Connection (STEDS / Gravity Sewer / Pressure Sewer)
Upgraded On-site Wastewater System

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During development and analysis of SP1 it became apparent that limiting capital investment was also going to influence the catchment scale environmental impact / benefit of the option. This is due to elimination of on-site land application and establishment of beneficial reuse which reduces the volume of sewage applied to land within the town. This has positive impacts on the water quality in Penshurst Wetland in addition to reducing downslope groundwater impacts. However, the total volume of recycled water (whilst of a higher quality) is predicted to result in an increase in nutrient loads discharged downstream of the wetlands.

An alternative SP1 sub-option was considered that featured the following in addition to SP1 as described above.

- Renewal of existing stormwater drainage infrastructure throughout the investigation area with a mix of grassed swales and pipes/pits.
- Construction of bioretention basin(s) to provide both stormwater detention and stormwater / excess wastewater treatment and attenuation prior to waterway discharge.

These additions are a significant increase in investment (effectively double). However, they enable a much more significant environmental benefit through treatment of stormwater in addition to providing benefits with respect to avoided costs for flooding and drainage impacts.

5.1.2 Solution Package 2 – Gravity Sewer to Local Cluster Management Systems

All raw wastewater to drain to enhanced local precinct / cluster treatment and reuse systems via gravity sewers. These cluster reuse systems have been sized and costed for significantly higher levels of reuse which eliminates the need for downstream infrastructure. Feedback from the community has also identified that commercial town renewal / growth is a key driver. This option provides enhanced ability for commercial and property renewal / growth and includes more capacity for growth whilst meeting EPA requirements.

Solution Package 2 is summarised in the following table.

Table 14 SP2 Summary

Summary	Component	Description
Wastewater Discharge (gravity sewer) of all wastewater to local precinct / cluster treatment and reuse systems. On-property management / reuse (only where full containment is possible). **Stormwater** n/a	On-property	Upgrade existing septic systems to achieve full on-site containment on larger lots (84 lots) where feasible – secondary treatment system (e.g. aerated treatment unit or recirculating media filters) with subsurface irrigation or evapotranspiration absorption (ETA) trenches to meet regulatory (EPA CoP) requirements. Decommission existing septic system for properties that cannot fully contain all wastewater on-site (217 lots). Discharge of all wastewater to new gravity sewer. All systems managed by single competent and accountable authority (upgrade works and operation).
	Collection	Gravity sewer collecting all wastewater from properties within Service Area where full containment is not achievable. Conveyance to local cluster treatment / reuse systems.
	Treatment	Treat sewage from smaller properties utilising evapotranspiration / wetland treatment (e.g. Rhizopod™) system at nominated reserves / public open spaces for subsurface irrigation reuse (greening of public open space – approximately 6 hectares in total) at sustainable rates. Winter storage and enhanced evapo-transpiration of Rhizopod™ enables discharge to the environment to be prevented.
	Environmental / Human Health	≥96% TN/TP reduction in wastewater nutrient loads. Achievement of human health protection targets.
	Liveability	Establish and maintain green open space throughout town.
	Water Cycle	Establish local cluster irrigation (greening and planting of public open space) at feasible locations (road reserves / public open space). Reduced water extraction/demand for residential and road reserve / public open space land application. Significantly improved wastewater management (flow and pollutant loads) into existing ponds / wetlands which are directly connected to groundwater. Significantly improved human health risks from reduced effluent exposure potential.
	Long-term growth	Capacity for town renewal / growth to better match long-term community and Council expectations. Cluster systems based on existing dwellings increasing to four bedroom dwellings on existing lots in the long-term.

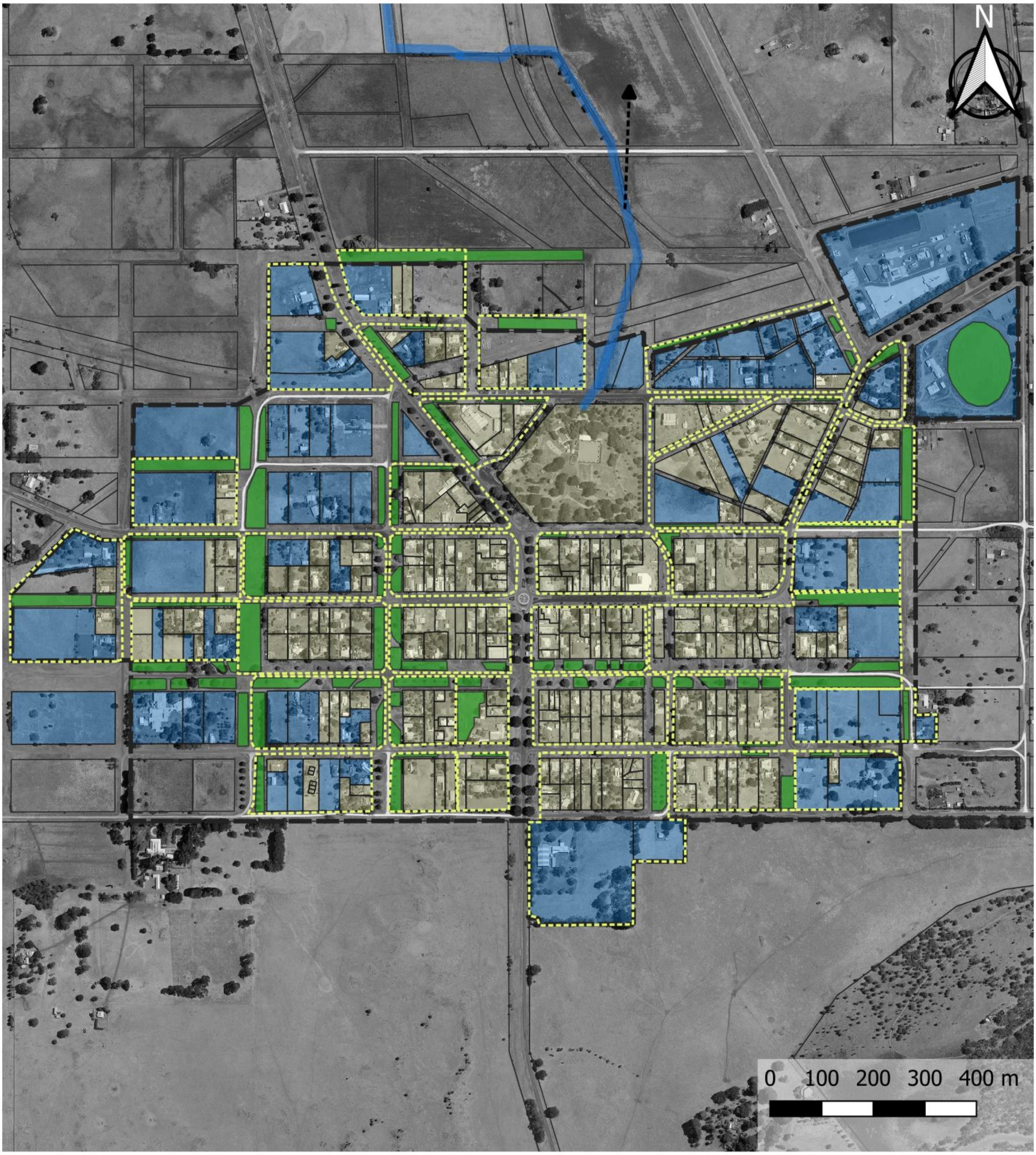

Figure 5: Penshurst Servicing Layout - Cluster / Precinct Reuse Sites Summary (SP1 & 2)

Service Area
Property Boundary
Watercourse
Cluster / Precinct Reuse Site Subcatchments
Potential Cluster / Precinct Reuse Site

Servicing Details

Offsite Connection (STEDS / Gravity / Pressure Sewer)
Upgraded On-site Wastewater System

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5.1.3 Solution Package 3 – STEDS to Constructed Wetlands

A more conventional 'whole of town' wastewater management approach (Septic Tank Effluent Drainage / Disposal System (STEDS) scheme) to maximise town growth / renewal potential, given it is a strong driver identified by the community. Similar to SP1, however constructed wetlands will instead provide 'end of line' management of all STEDS primary treated wastewater.

This option involves no on-property wastewater management on smaller, constrained properties and thus provides enhanced ability for commercial and property renewal / growth and does not include discharge into stormwater (thus providing greater ability to achieve EPA requirements).

Solution Package is summarised in the following table.

Table 15 SP3 Summary

Summary	Component	Description
Wastewater Partially (primary) treated wastewater conveyed via reticulated effluent sewerage and treated at 'end of line' constructed wetlands. **Stormwater** n/a	On-property	Upgrade existing septic systems to achieve full on-site containment on larger lots (84) where feasible – secondary treatment system (e.g. aerated treatment unit or recirculating media filters) with subsurface irrigation or evapotranspiration absorption (ETA) trenches to meet regulatory (EPA CoP) requirements. Utilise existing septic systems (where possible) as part of STEDS scheme on properties not able to achieve full containment (217 properties). All systems managed by a single competent and accountable authority.
	Collection	Smaller diameter gravity effluent sewer collecting primary treated effluent from STEDS properties where full containment is not achievable. Conveyance to local treatment / irrigation systems.
	Treatment	Constructed wetland system will provide necessary treatment and storage / reuse of effluent for ecosystem restoration and community amenity. Infrequent controlled discharge to environment (typically >90^{th} % rainfall years). Reuse by irrigation at Penshurst Oval.
	Environmental / Human Health	≥96% TN/TP reduction in wastewater nutrient loads. Achievement of human health protection targets.
	Liveability	Provision of a green / blue community amenity space (wetland). Greening of local sporting facility.
	Water Cycle	New constructed wetlands to provide sufficient storage for controlled discharge to mimic the natural flow profile of waterways. No on-lot wastewater management within township and thus significantly reduced groundwater contamination potential. Significantly improved wastewater management (flow and pollutant loads) into existing ponds / wetlands. Significantly improved human health risks from limited effluent exposure potential.

Summary	Component	Description
	Long-term growth	Capacity for town / renewal growth likely to match all expectations from community / Council and typical sized dwellings (four bedrooms) on new and existing properties in the long-term. New developments on smaller, constrained properties would require new septic tank for connection to STEDS scheme. New developments would require new septic tank (for connection to STEDS scheme) if full containment is not viable (as per CoS hazard mapping outside of service area).

5.1.4 Solution Package 4 – Reticulated Sewerage to Water Recycling Plant

Conventional reticulated sewerage solution to maximise town growth / renewal potential, given it is a strong driver identified by the community.

Reticulated sewerage is the traditional wastewater solution provided by Wannon Water and this option most closely represents this servicing solution.

This option involves no on-property wastewater management on smaller, constrained properties and thus provided enhanced ability for commercial and property renewal / growth.

Solution Package is summarised in the following table.

Table 16 SP4 Summary

Summary	Component	Description
Wastewater All raw wastewater conveyed via reticulated pressure sewerage and treated at WRP. **Stormwater** n/a	On-property	Upgrade existing septic systems to achieve full on-site containment on larger lots (84) where feasible – secondary treatment system (e.g. aerated treatment unit or recirculating media filters) with subsurface irrigation or evapotranspiration absorption (ETA) trenches to meet regulatory (EPA CoP) requirements. Decommission all septic systems and install pressure sewer units on each property. All systems managed by a single competent and accountable authority.
	Collection	Sewer collecting all raw wastewater from properties where full containment is not achievable. Conveyance to local treatment / irrigation systems. This sewer would operate as a pressure sewer.
	Treatment	Water Recycling Plant (WRP) with lagoon treatment of all raw sewage with storage via dams – greater infrastructure required as all wastewater treated at one central location.
	Environmental / Human Health	≥96% TN/TP reduction in wastewater nutrient loads. Achievement of human health protection targets.
	Water Management	Surface irrigation of central reuse site (~20 hectares of fodder crop). Allowance for a range of irrigation rates and strategies.
	Water Cycle	No on-lot wastewater management within township and thus significantly reduced groundwater contamination potential. Significantly improved wastewater management (flow and pollutant loads) into existing ponds / wetlands. Significantly improved human health risks from limited effluent exposure potential.
	Long-term growth	Capacity for town / renewal growth likely to match all expectations from community / Council and typical sized dwellings (four bedrooms) on new and existing properties in the long-term. New developments would require new pressure sewer grinder pod unit if full containment is not viable (as per CoS hazard mapping outside of service area).

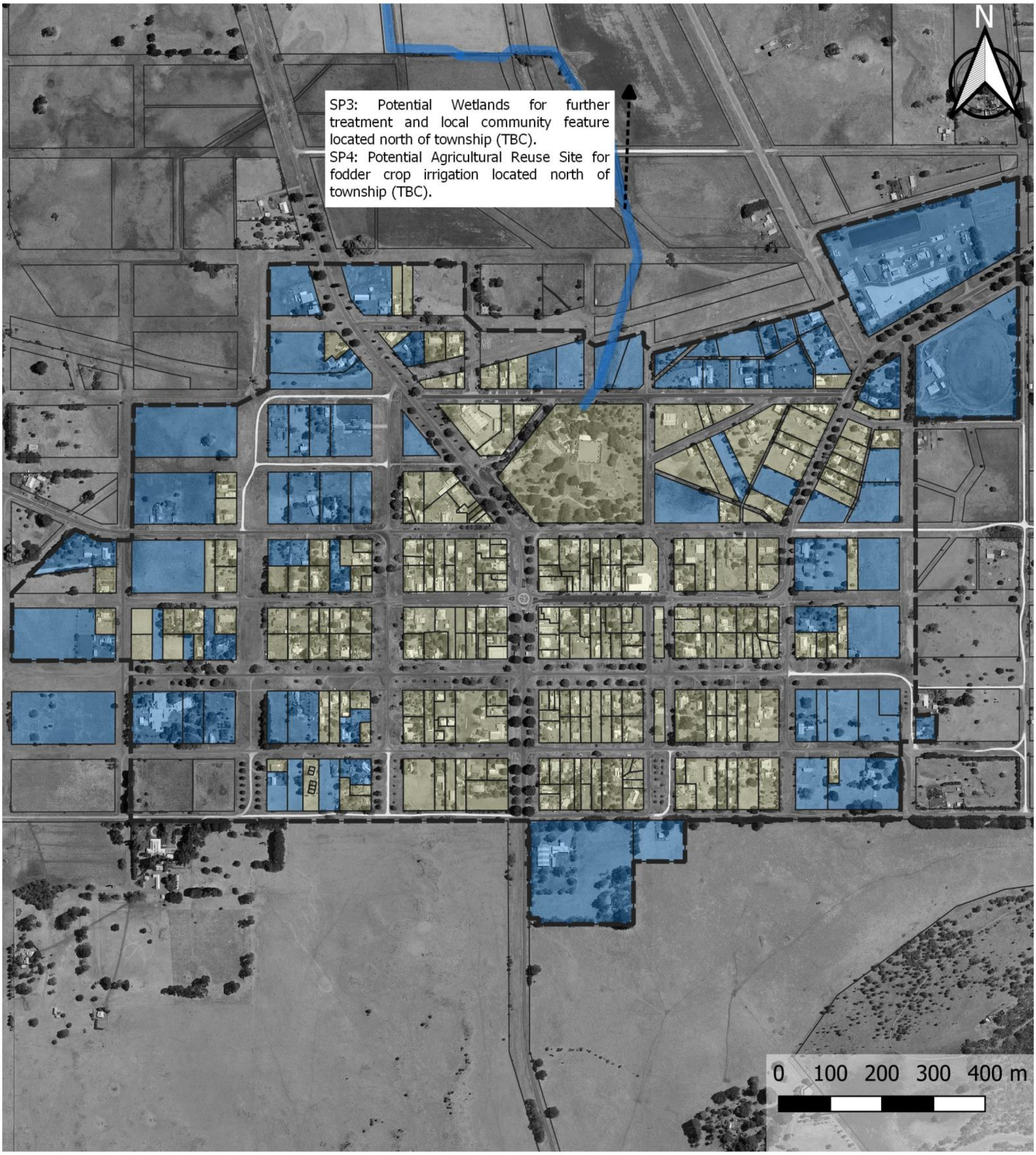

Figure 6: Penshurst Servicing Layout - Centralised Reuse Summary (SP3 & 4)

Service Area
Property Boundary
Watercourse

Servicing Details
Offsite Connection (STEDS / Gravity / Pressure Sewer)
Upgraded On-site Wastewater System

DECENTRALISED WATER CONSULTING

5.2 Cudgee

5.2.1 Solution Package 1 – Retain On-site Systems with Small Cluster System for Constrained Sites

This approach seeks to limit unnecessary infrastructure spending in improved wastewater services where the existing on-site systems and properties are capable of sustainable on-site containment. This decision was made following the analysis of the Business as Usual (BaU) scenario, current levels of on-site system renewal, land capability and on-site containment risk mapping. Given approximately 75% (50) of properties within the investigation area are considered well suited to on-site wastewater management, it was quickly determined that the costs of replacing what are predominantly more modern on-site systems (designed and constructed in accordance with contemporary requirements) would clearly exceed any potential benefits by a large margin.

A 'fit for purpose' servicing strategy has been adopted for the more constrained properties considered unable to contain all wastewater on-site (15 properties). There are two main locations within Cudgee that contain these non-containment properties (refer Figure below). Solution Package 1 (SP1) involves replacing these on-site systems with secondary treatment systems configured to manage a sustainable portion of secondary effluent (Class C recycled water) on-site. Land application / reuse would be limited to a maximum quantity with any excess generated above this volume conveyed to a small cluster management system (Cluster 1 and 2 in Figure below).

Current analysis suggests that average wastewater loads will be able to be managed on site on the majority of these 15 properties. Excess volumes conveyed to the cluster systems will predominantly consist of peak flows generated as a result of activities such as multiple washing loads, parties, long-term guests etc. Eight of the fifteen constrained sites will not be connected to this cluster system and instead will be upgraded with an advanced on-site treatment and land application system capable of overcoming constraints. These systems will be remote monitored and controlled to minimise the risk of operational failure.

Under SP1, the 50 existing on-site systems would continue to be managed by individual property owners with their performance regulated by Council. On-site system renewal rates have been assumed to remain consistent with the BaU scenario. In contrast, the 15 partial containment / constrained site systems will be the responsibility of a single management entity (such as Wannon Water) and managed as part of a single asset along with the cluster systems.

Cudgee Solution Package 1 is summarised in the following table.

Table 17 SP1 Summary

Summary	Component	Description
Wastewater Retain existing on-property management / reuse (only where full containment is possible). Management of constrained properties by two small cluster treatment systems for effluent management via public open space irrigation. **Stormwater** None	On-property	Retain existing on-site systems on larger lots where full on-site containment is feasible (50 lots) and compliance with the EPA CoP a realistic expectation. Approximately 40% of these systems are <10 years old and likely to be functioning effectively (subject to adequate management). BaU on-site system renewal rates assumed for these 50 systems. These systems to be managed by owners and regulated by council. Properties that cannot fully contain all wastewater on-site (7 lots) will have the existing system replaced (unless existing system is deemed adequate) with a secondary treatment system to manage a portion of effluent on-site. Discharge to land application will be controlled to prevent overloading. Excess unable to be managed on-site will be discharged to an effluent (pressure) sewer. More isolated highly constrained properties (8) to be upgraded to an advanced secondary on-site system with remote monitoring and control to enable full on-site containment. Non-containment / constrained property systems managed by single competent and accountable authority (upgrade works and operation).
	Collection	Small diameter effluent sewer collecting excess secondary treated effluent from lots where full containment is not achievable. Conveyance to local cluster reuse systems.
	Treatment	Treat sewage from smaller properties utilising evapotranspiration / wetland treatment (e.g. Rhizopod™) system at nominated reserve / public open space for subsurface irrigation reuse (greening of public open space – approximately 1 hectares in total) at sustainable rates. Winter storage and enhanced evapo-transpiration of Rhizopod™ enables discharge to the environment to be prevented.
	Environmental / Human Health	22%/45% *decrease* in TN/TP wastewater nutrient loads from BaU. Achievement of human health protection targets.
	Liveability	Limited benefit or impact on liveability. Does result in establishment of a minor amount of green space.
	Water Cycle	Establish local cluster irrigation (greening of reserve) at one location. Continued on-property reuse of wastewater on larger lots.
	Long-term growth	No constraint to growth within large extent (150 ha) of developable LDRZ land given unsewered minimum lot size of 4,000m^2 is the current minimum for sustainable on-site wastewater management. Limited capacity for modest growth within the Township Zone through subdivision of larger lots. Would require partial on-site containment to not exceed capacity of small cluster system.

Figure 7: Cudgee Solution Package 1 Servicing Layout - Retain On-site Systems with Small Cluster System for Constrained Sites

Study Area
Property Boundary
Named / Intermittent Watercourse
Potential Cluster Reuse Site

Servicing Details
Connection to Cluster System or Advanced Onsite System Upgrade
Existing Onsite Wastewater System (Owner Managed)

DECENTRALISED WATER CONSULTING

5.2.2 Solution Package 2 – Retain On-site Systems and Build Stormwater Treatment / Detention Measures

Solution Package 2 (SP2) also proposed to retain existing on-site systems on properties capable of sustainable on-site containment. This decision was made following the analysis of the Business as Usual (BaU) scenario, current levels of on-site system renewal, land capability and on-site containment risk mapping. Given approximately 75% (50) of properties within the investigation area are considered well suited to on-site wastewater management, it was quickly determined that the costs of replacing what are predominantly more modern on-site systems (designed and constructed in accordance with contemporary requirements) would clearly exceed any potential benefits by a large margin.

As a point of difference to SP1, SP2 examines the economic benefit of investing in multi-purpose water management infrastructure in order to maximise benefits given the relatively minor amounts of off-site discharge of sewage (in lieu of a similar investment in an off-site solution for wastewater only). Under this scenario, all 15 constrained / non-containment properties would be upgraded to an advanced on-site wastewater management system which would minimise the volume of off-site discharge and significantly reduce the risk associated with the discharge (advanced secondary effluent quality with UV disinfection).

During community engagement, a consistent piece of feedback related to stormwater management within the Cudgee township. Under SP2, allowance has been made for construction of 2-3 stormwater treatment and detention measures. These measures would be configured to achieve the following.

- Receive and treat off-site effluent discharges during dry weather conditions.
- Receive and treat the majority of stormwater runoff events to reduce nutrient loads to Brucknell Creek.
- Provide a wetland for habitat and visual amenity benefits.
- Provide stormwater detention to prevent local flooding impacts.

Solution Package 2 is summarised in the following table.

Table 18 SP2 Summary

Summary	Component	Description
Wastewater Retain existing on-property management / reuse (only where full containment is possible). Management of constrained properties by provision of managed advanced on-site upgrades with residual off-site discharge directed to stormwater treatment measures. **Stormwater** Construction of 2-3 stormwater treatment / detention / wetland measures to mitigate stormwater impacts and receive residual effluent discharges.	On-property	Retain existing on-site systems on larger lots where full on-site containment is feasible (50 lots) and compliance with the EPA CoP a realistic expectation. Approximately 40% of these systems are <10 years old and likely to be functioning effectively (subject to adequate management). BaU on-site system renewal rates assumed for these 50 systems. These systems to be managed by owners and regulated by council. Properties that are highly constrained or cannot fully contain all wastewater on-site (15 lots) will have the existing system upgraded to an advanced secondary on-site system with remote monitoring and control to maximise the effluent managed on-site. Excess unable to be managed on-site will be discharged to the stormwater drain overnight. Non-containment / constrained systems managed by single competent and accountable authority (upgrade works and operation).
	Collection	Excess (advanced secondary quality effluent with disinfection – Class B recycled water) treated effluent will be discharged intermittently under controlled conditions overnight into stormwater drains to be conveyed to stormwater management measures.
	Treatment	Treat stormwater and excess effluent loads via a combination of bioretention filters and wetlands. Designed to provide 50% nutrient reduction and incorporate a high flow bypass to adequate detention to limit the 1% AEP peak flow to undeveloped rates. Wetland component to be configured to provide flow attenuation and habitat / amenity value.
	Environmental / Human Health	40%/20% TN/TP reduction in wastewater nutrient loads compared to BaU (87%/71% TN/TP for Existing Case). ~50% nutrient load reduction from study area stormwater runoff. Achievement of human health protection targets.
	Liveability	Creation of water features throughout township (green / blue community space).
	Water Cycle	Significantly improved total catchment nutrient loads to Brucknell Creek. Reduced flooding impacts. Significantly improved human health risks from reduced effluent exposure potential.
	Long-term growth	No constraint to growth within large extent (150 ha) of developable LDRZ land given unsewered minimum lot size of 4,000m^2 is the current minimum for sustainable on-site wastewater management. Limited capacity for modest growth within the Township Zone through subdivision of larger lots. Would require full on-site containment to be maintained on any new lots.

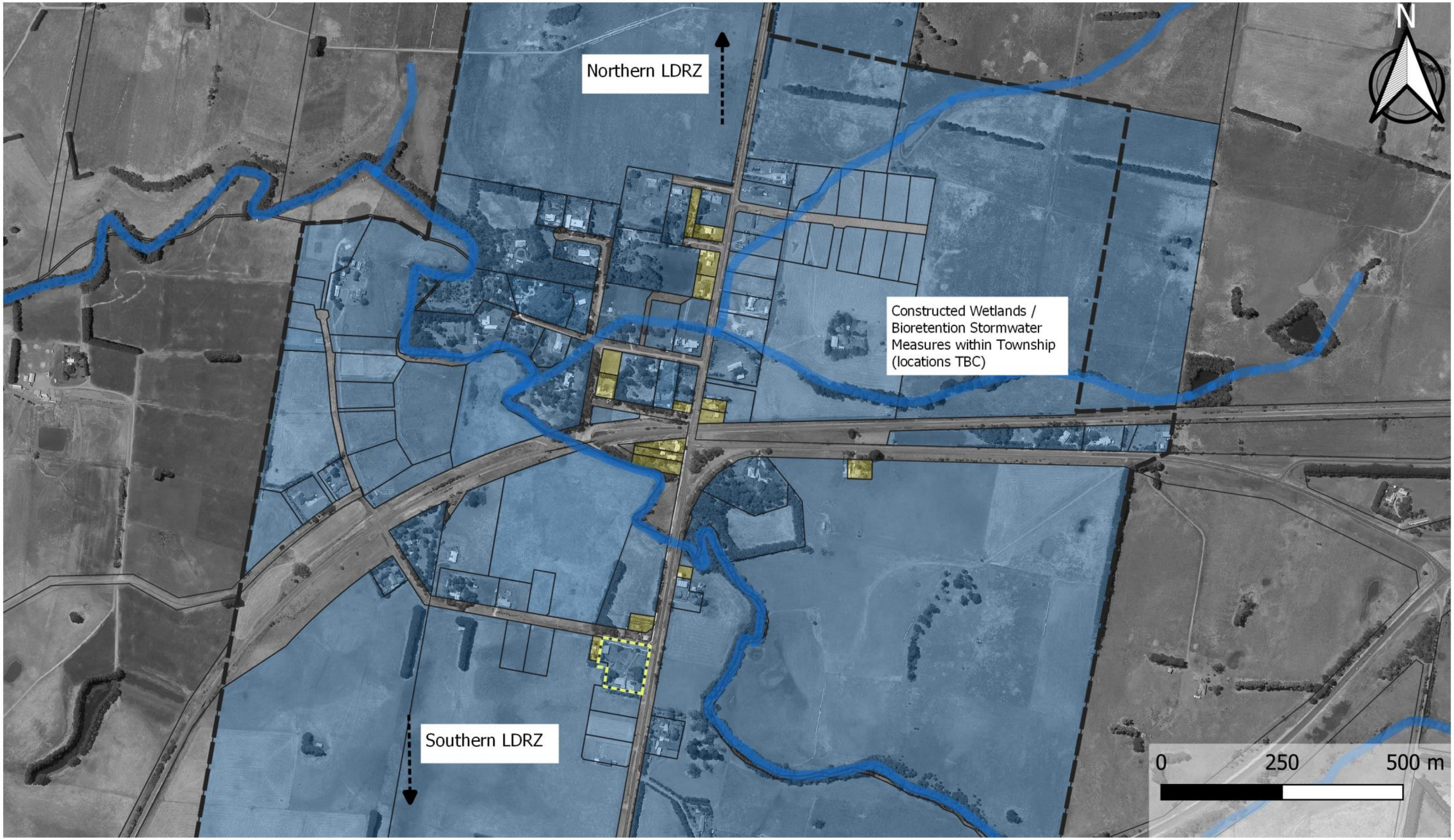

Figure 8: Cudgee Solution Package 2 Servicing Layout - Retain On-site Systems and Build Stormwater Treatment / Detention Measures

- Study Area
- Property Boundary
- Named / Intermittent Watercourse
- Potential Reuse Cluster Site

Servicing Details

- Advanced Onsite System Upgrade or Connection to Cluster System
- Existing Onsite Wastewater System (Owner Managed)

DECENTRALISED WATER CONSULTING

5.2.3 Solution Package 3 – Partial On-site Containment /Reuse with Cluster Irrigation Site

Solution Package 3 is a hybrid decentralised / centralised solution that seeks to manage a safe amount of effluent on-site with only the excess conveyed via sewer to a central site for either agricultural or public open space irrigation. An effluent (pressure) sewer has been costed to service the Township land use zone in addition to a small number of constrained low density residential lots to the immediate west (refer to Figure 9 below).

Solution Package 3 is summarised in the following table.

Table 19 SP3 Summary

Summary	Component	Description
Wastewater Retain existing on-property management / reuse (only where full containment is possible). Management of constrained properties by partial on-site containment systems with excess to a central cluster irrigation site. **Stormwater** n/a	On-property	Retain existing on-site systems on larger lots where full on-site containment is feasible (50 lots) and compliance with the EPA CoP a realistic expectation. Approximately 40% of these systems are <10 years old and likely to be functioning effectively (subject to adequate management). BaU on-site system renewal rates assumed for these 50 systems. These systems to be managed by owners and regulated by council Properties within the Township Zone in addition to adjacent constrained LDRZ sites (39 lots total) will have the existing system replaced (unless existing system is deemed adequate) with a secondary treatment system to manage a portion of effluent on-site. Discharge to land application will be controlled to prevent overloading. Excess unable to be managed on-site will be discharged to an effluent (pressure) sewer. All partial containment systems managed by a single competent and accountable authority.
	Collection	Smaller diameter effluent (pressure) sewer collecting secondary treated effluent (Class C recycled water) from partial containment properties. Conveyance to local irrigation / reuse system.
	Treatment	Treatment provided on-lot. Allowance for polishing prior to irrigation via media filtration. Reuse by irrigation of either agricultural crop (e.g. fodder) or public open space.
	Environmental / Human Health	30%/60% TP/TN reduction in wastewater nutrient loads compared to BaU (75%/90% compared to Existing Case). Achievement of human health protection targets.
	Liveability	Potentially used to create a green space for community
	Water Cycle	Agricultural reuse and production.
	Long-term growth	No constraint to growth within large extent (150 ha) of developable LDRZ land given unsewered minimum lot size of 4,000m^2 is the current minimum for sustainable on-site wastewater management. Capacity for moderate to high growth within the Township Zone through subdivision of larger lots. Would require a partial containment system on any new lot.

Figure 9: Cudgee Solution Package 3 Servicing Layout - Partial On-site Containment / Reuse with Cluster Irrigation Site

Study Area
Property Boundary
Named / Intermittent Watercourse

Servicing Details

Upgraded Onsite System with Connection to Cluster System
Existing Onsite Wastewater System (Owner Managed)

DECENTRALISED WATER CONSULTING

5.3 Cost Estimates

Cost estimates have been developed for each of the Solution Packages as part of this project to allow relative comparison as part of the CBA. The intention is for the costings of the identified preferred solution to be further refined and developed during Functional Design and business case development. This includes capital (upfront) cost estimates along with operational costs and asset renewal costs over 25 years. The capital cost estimates include total project delivery costs (including overheads, design, approvals) and a 20% contingency / risk margin.

Importantly, all cost estimates include costs associated with wastewater management traditionally borne by individual property owners (i.e. whole of life, whole of community costs). This is appropriate for a CBA during options evaluation as it enables a holistic evaluation of costs, benefits and the distribution of costs/benefits amongst parties. It also prevents on-going costs associated with maintenance and eventual replacement of existing on-site systems from being omitted (almost as an external cost) from the economic analysis.

Table 20 Solution Package and BaU Cost Estimates for Penshurst

Scenario	CAPEX[1]		OPEX[1]		Asset[1] Renewals	Lifecycle Cost (NPV)[2]	
	Total ($M)	Per Lot ($k)	Total ($k)	Per Lot ($k)	Total ($M)	Total ($M)	Per Lot ($k)
BaU	$4.82M	$16k	$120.4k	$0.4k	$0.91M	$4.0M	$13.3k
SP1	$12.38M	$41.1k	$330.8k	$1.1k	$2.29M	$17.46M	$58k
SP2	$17.1M	$57k	$257.2k	$0.86k	$0.815M	$20.4M	$67.9k
SP3	$18.6M	$61.6k	$328.8k	$1.09k	$2.29M	$23.64M	$78.5k
SP4	$19.2M	$63.9k	$243k	$0.81k	$0.53M	$22.3M	$73.9k

Table 21 Solution Package and BaU Cost Estimates for Cudgee

Scenario	CAPEX[1]		OPEX[1]		Asset[1] Renewals	Lifecycle Cost (NPV)[2]	
	Total ($M)	Per Lot ($k)	Total ($k)	Per Lot ($k)	Total ($M)	Total ($M)	Per Lot ($k)
BaU	$1.04M	$16k	$26.6k	$0.41k	$0.44M	$0.97M	$14.9k
SP1	$1.94M	$29.8k	$98k	$1.5k	$0.33M	$2.74M	$42.2k
SP2	$2.94M	$45.2k	$110.8k	$1.71k	$1.33M	$4.2M	$64.4k
SP3	$3.00M	$46.2k	$99.2k	$1.53k	$0.25M	$3.92M	$60.3k

3. *These are total costs ($ 2019) prior to discounting depending on what year of analysis the spend occurs.*

4. *Net Present Value (NPV) over 25 years at a 7% discount rate (consistent with CBA).*

It is important to note these are preliminary estimates only and will be dependent on a wide range of factors that are yet to be defined or investigated. Presented estimates can be considered in the order of +/-30% accuracy based on the Solutions Packages outlined in this report. A more refined and comprehensive cost estimate will be prepared as part of Functional Design for the preferred Solution Package for each town. These current cost estimates are sufficient to enable comparison between Solution Packages and have been developed from the same cost basis. More detail is provided in Appendix C.

6 Options Analysis Inputs

As described previously, an options analysis process has been undertaken for each of the shortlisted Solution Packages for each town. This process included utilising long-term continuous water and pollutant mass balance modelling data (MEDLI, MUSIC) and previously defined statistical performance information to both;

- determine the minimum size requirements for key components in order to comply with relevant design codes; and
- estimate the residual impact on human health and the environment associated with each Solution Package (compared to BaU).

These outcomes have then enabled cost estimates for these Solution Packages (CAPEX, OPEX and lifecycle) to be defined. They have also provided the quantitative values for evaluation of overall Solution Package performance with regards to environmental and health protection, improved liveability and potential for long-term renewal or development of each town (as just during community feedback). The economic and performance inputs to the Cost Benefit Analysis (CBA) have also been derived from collaboration with Frontier Economics.

6.1 Preliminary Health Risk Assessment

Based on DWC's previous experience, it would be anticipated that residual health risks would be present where some form of off-site discharge (either all wastewater or greywater only) is occurring within either township. Based on the Penshurst on-site system audit data, ~10 systems (~5%) were noted to have some form of off-site discharge / drainage occurring. This is to be expected given the typical small lot size in the immediate township. The recent MSC DWMP indicates that off-site discharge is not commonplace in Cudgee (and was not observed during DWC's fieldwork). This is to be expected given the larger typical larger lot size and good quality soils observed, and therefore more area is typically available for sustainable long-term effluent management.

A preliminary microbial risk assessment has been undertaken to enable two outcomes.

- To compare the relative residual health risk associated with the existing situation and BaU scenario.
- To evaluate if residual health risks associated with each Solution Package for each town meet target thresholds for human health protection and disease burden in a population.

The adopted procedure is consistent with the approach recommended in the Australian Drinking Water Guidelines and Australian Guidelines for Water Recycling. Reference can be made to Section 3.2 and 3.3 of this document (EPHC, 2006) for more detail. This approach is also consistent with World Health Organisation (WHO) protocols for assessment of health risks associated with waterborne disease.

It should be noted that this assessment is preliminary in nature and is based on some inputs from published data (in the absence of local data). Where possible, outputs from the dynamic modelling of wastewater systems (for Monbulk based on previous work (BMT WBM, 2015b)) have been used to inform inputs to the risk assessment.

Rotavirus has been adopted for this assessment based on the immediate availability of published values for use as preliminary inputs.

6.1.1 Exposure Pathways

The following potential exposure pathways were examined as part of this assessment.

- Routine exposure to reasonable quantities of ponded sewage from hydraulically surcharging on-site wastewater systems (backyards) under the Do Nothing/BaU scenario.
- Routine exposure to very small quantities via indirect ingestion of secondary effluent under Do Nothing/BaU scenario involving on-lot land application (comparable to backyard garden watering in EPHC, 2006).
- Sporadic exposure to open stormwater drains containing partially or fully treated sewage as a result of existing or continued off-site discharge.

6.1.2 Inputs

The following table summarises the basis for key inputs to the preliminary human health risk assessment.

Table 22 Basis for Inputs to Human Health Risk Assessment

Input	Basis
Virus concentration (MPN/L)	Do Nothing / BaU – virus concentration outputs from previous daily modelling for Monbulk (BMT WBM, 2015b) under a variety of surcharge frequency ranges. EPHC (2006) 95th% typical concentrations in raw sewage with log reductions from EPHC (2006) applied.
Exposure/event (L)	Most conservative of 90th % modelled surcharge volume (Monbulk) or values from Table 3.3 of EPHC (2006).
No. Events/year	Do Nothing backyard exposure: One person/week at each exposure site. Do nothing stormwater: nominal 20 persons/year Backyard irrigation (onsite containment): 90 per household/year
Dose response constants	EPHC (2006) for rotavirus (Cryptosporidium for stormwater)
Ratio of illness/infection	EPHC (2006) for rotavirus (Cryptosporidium for stormwater)
Susceptibility fraction	EPHC (2006) for rotavirus (Cryptosporidium for stormwater)

Input	Basis
Disease burden (DALY[1]/case)	EPHC (2006) for rotavirus (Cryptosporidium for stormwater)
Dose equivalent to DALY	EPHC (2006) for rotavirus (Cryptosporidium for stormwater)

DALY – Disability Adjusted Life Year

6.1.3 Outputs

The following figure summarises the total DALYs and DALYs per person per year for each scenario for both towns. The total DALYs reflect the total disease burden that can be attributed to wastewater and stormwater management. The WHO and EPHC (2006) require proposed activities to not create a disease burden that is greater than 10^{-6} DALYs/person/year. This threshold has been used as a measure of success for human health protection in addition to achievement of full on-site containment.

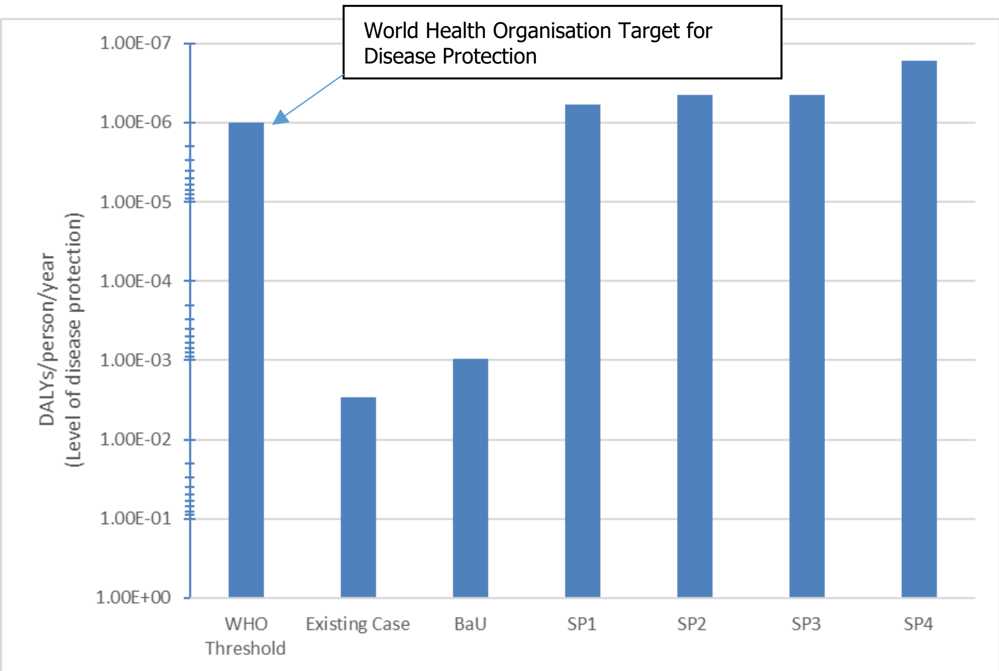

Figure 10 Estimated Level of Disease Protection for Penshurst (Current, Business as Usual and Solutions)

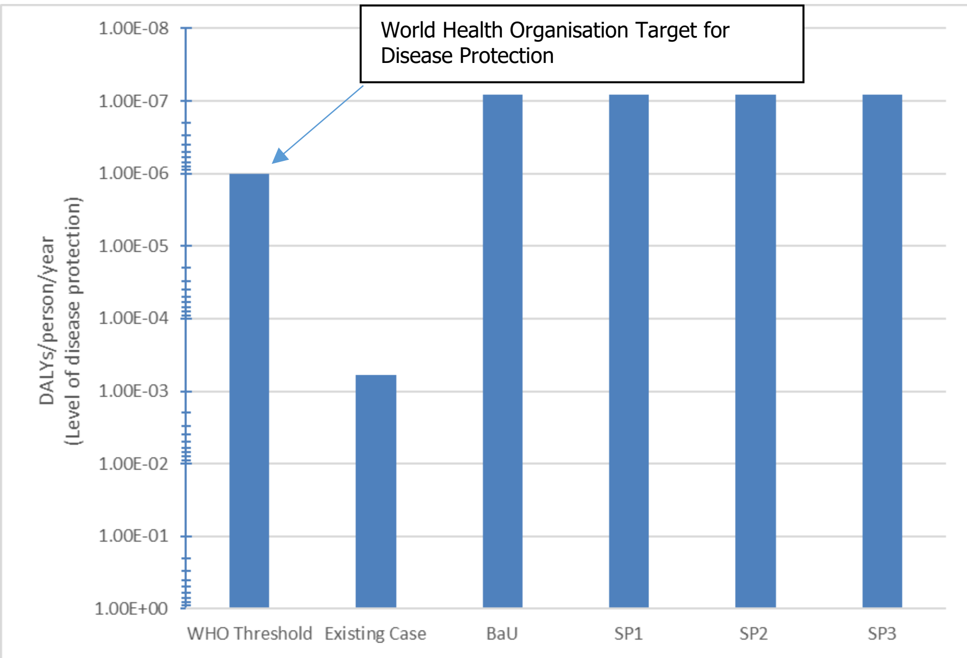

Figure 11 Estimated Level of Disease Protection for Cudgee (Current, Business as Usual and Solutions)

For Penshurst, it can be seen that both the Existing Case and BaU scenarios are estimated to only provide roughly half of the minimum recommended level of disease protection according to Australian and global guidelines (WHO/EPHC, 2006). This includes the BaU scenario where it is assumed there is a gradual upgrade of systems by property owners under a BaU scenario (refer to Section 3 for more information). It can be seen that all proposed SPs achieve this minimum WHO target .

The disease protection for Cudgee is similar under the Existing Case, however is achieved under all the scenarios assessed including the BaU, as the upgrade of existing system in the current context provides a much lower level of health risk given the larger lot size and limited land capability constraints (compared to Penshurst).

6.2 Estimated Wastewater Loads

On-site system audit / permit data from both Councils, along with previous modelling investigations by DWC, were utilised to estimate the pollutant loads (nitrogen, phosphorus and DALYs) expected to be discharging to surface or groundwater environments from the existing on-site systems / properties. The existing system audit data were reviewed and systems were categorised (as best as possible) based on the existing treatment system and land application / disposal method (as discussed in Section 2.1).

DWC has previously undertaken extensive daily wastewater modelling for Yarra Valley Water for deriving wastewater flows / loads for a number of large areas including Park Orchards, Monbulk and North Warrandyte. The Park Orchards modelling included calibration based on site specific information for ~100 lots within the area and is based in a similar soil type to the Forrest township (BMT WBM, 2014 & 2015a).

This data was statistically analysed to generate typical wastewater flows / loads for a range of on-site wastewater system types. Thus, this data was utilised to develop collective average annual and total lifecycle (25 year) loads for each township by calculating proportional loads based on the number of different system types present, based on this available data, fieldwork observations and desktop assessment of approximate dwelling (and hence system) age. In addition, site specific MEDLI modelling was undertaken to determine estimated flows and loads from the cluster / precinct and wetland treatment systems.

The results of the estimated wastewater nutrient loads and disease burden are summarised in the tables below (total 25 year lifecycle). It is important to note that Cudgee SP2 (Table 24) includes the additional benefits of improved stormwater management and treatment via proposed wetlands / bioretention. The estimated total lifecycle reduction in TN and TP from these measures are 1,325kg and 175kg respectively, hence the significant total % improvement to BaU.

It can be seen that a significant improvement is achieved from all SPs for both towns. The modelled loads from these proposed cluster and wetland systems were found to be negligible, with the key exception of SP1 Penshurst, in which total nutrient export is predicted to increase (see Table 23 below). However, importantly the residual nutrient discharge from the proposed cluster systems will bypass (via new drainage swales) the highly sensitive receptors within the immediate township (wetlands / local groundwater).

Table 23 Total Lifecycle (25yr) Nutrient Loads / DALYs (with % Reductions) – Penshurst

Scenario	TP (kg)	TN (kg)	Total DALYs
BaU	1,872	4,900	12.8
SP1	6,325 (+238%)[1]	21,900 (+347%)[1]	6.5×10^{-3} (100%)
SP2	75 (96%)	25 (99%)	4.9×10^{-3} (100%)
SP3	75 (96%)	25 (99%)	4.9×10^{-3} (100%)
SP4	75 (96%)	25 (99%)	1.8×10^{-3} (100%)

Note 1: Net increase in total loads includes loads discharging from cluster systems into stormwater drainage (swales).

Table 24 Total Lifecycle (25yr) Nutrient Loads / DALYs (with % Reductions) – Cudgee

Scenario	TP (kg)	TN (kg)	Total DALYs
BaU	99	58	0.63
SP1	76 (22%)	32 (45%)	0.26 (58%)
SP2 – Wastewater SP2 – Stormwater	79 (20%) 175 (50%)[1]	35 (40%) 1,325 (50%)[1]	0.31 (51%)
SP3	81 (18%)	37 (36%)	0.33 (47%)

Note 1: Estimated nutrient loads reductions from stormwater measures (wetland / bioretention).

6.2.1 Stormwater Vs Wastewater

An initial general assessment was previously undertaken (as part of the Background Paper) to estimate the relative stormwater and wastewater loads typically expected to be generated for towns such as Penshurst and Cudgee. The charts previously presented have been refined as part of this options analysis stage to include the estimate improvements for SP for both stormwater and wastewater.

The charts below provide a summary of the proportion of nutrients derived from both stormwater and wastewater sources for both towns. This is a common method for allowing comparison of 'background' (stormwater derived loads which typically dominate) and wastewater derived loads. This provides a relative comparison of average loads entering nearby waterways from sources other than wastewater and therefore a relative benchmark.

As discussed above, this has been based on system audit and Permit data (and refined based on desktop analysis) and utilising extensive previous modelling results for these systems from previous DWC studies. These results are presented to provide an initial characterisation of the current state (existing case) of both towns and the relative improvements via both BaU and the proposed SPs. These estimates of pollutant loads (nitrogen and phosphorus) expected to be discharging to surface or groundwater environments from all wastewater sources are summarised (green colouring) below.

Stormwater modelling was also completed using Model for Urban Stormwater Improvement Conceptualisation (MUSIC) to derive these background nutrients loads. Existing onsite wastewater systems are predicted to be a moderate contributor to total nitrogen loads and a larger contributor to total phosphorus loads in Penshurst. These contributions are strongly influenced by the proportion of onsite systems currently discharging partially treated effluent and untreated greywater (split systems) directly into stormwater drains, which is a greater risk factor for Penshurst. Thus upgrades to these systems result in significant improvements to nutrient export from wastewater sources.

The wastewater loads from Cudgee are expected to be significantly less than background loads including the existing case. Solution Package 2 provides additional benefits with reduction of stormwater loads via the installation of wetland / bioretention measures. The relative improvements are greater in the context of the immediate Cudgee township, as these background loads are based on broader drainage catchments.

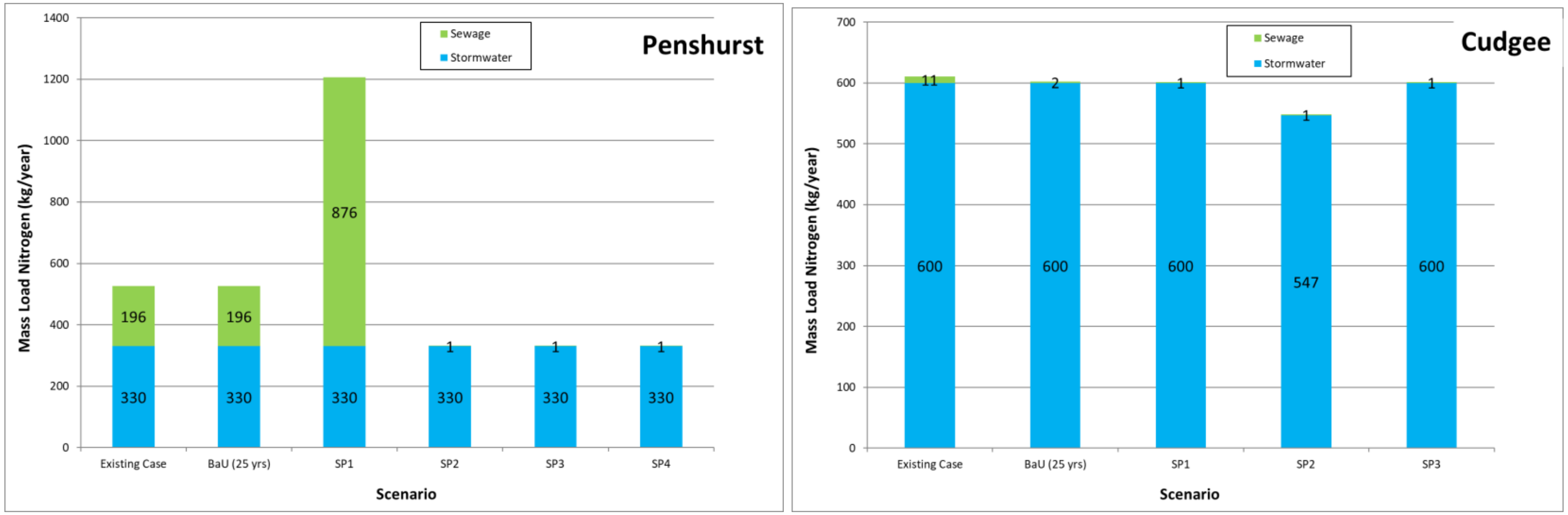

Figure 12 Total Nitrogen Estimates (Annual Average)

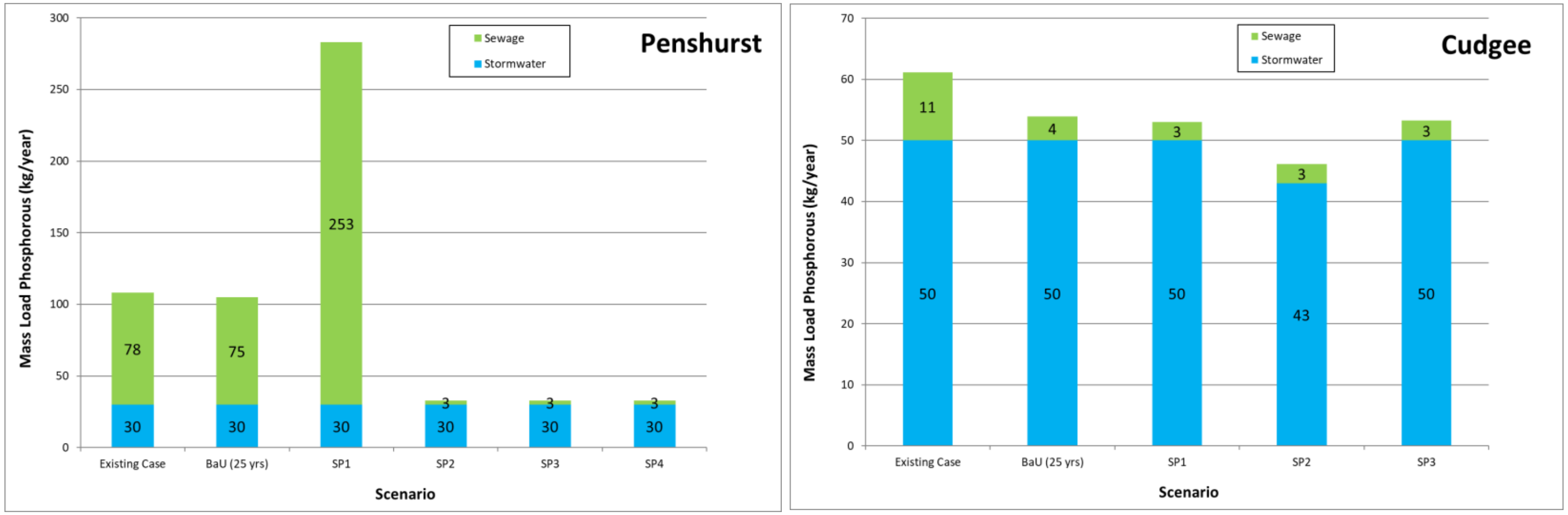

Figure 13 Initial Total Phosphorus Estimates (Annual Average)

6.3 Cost Benefit Analysis Process

The main economic costs and benefits were identified through the technical and engineering assessment conducted by DWC and the completion of a Cost Benefit Analysis (CBA) by Frontier Economics.

The costs and benefits associated with the project options included:

- Capital and ongoing operational and maintenance costs associated with the stormwater and wastewater elements of each option.
- Environmental benefits associated with a reduction in nutrient pollutants to the Wannon and Glenelg Rivers and local waterways.
- Health benefits through improved management of wastewater and elimination of human contact / exposure risks.
- Potable water savings associated with the stormwater and wastewater solutions.
- Creation or enhancement of green and blue spaces within each township and associated liveability and amenity benefits.

The costs and benefits that are associated with each Solution Package are summarised in Table 25.

Table 25 Costs and Benefits for Penshurst Solutions (relative to BAU)

	SP1	SP2	SP3	SP4
Capital and Ongoing Costs				
Wastewater	Yes	Yes	Yes	Yes
Stormwater	Yes	-	-	-
Benefits				
Potable water savings (liveability / water security)	Possible	Possible	Minor	Minor
Reduction in Total Nitrogen to Environment (surface water, groundwater)	No[1]	Yes	Yes	Yes
Health impacts (DALYs)	Yes	Yes	Yes	Yes
Liveability (green public spaces, cooling)	Limited	Yes	No	No

Note 1: While total loads exported from wastewater increase, they are diverted away from the Penshurst Wetland.

Table 26 Costs and Benefits for Cudgee Solutions (relative to BAU)

	SP1	SP2	SP3
Capital and Ongoing Costs			
Wastewater	Yes	Yes	Yes
Stormwater		Yes	
Benefits			
Flood hazard reduction	No	Yes (wetlands)	No
Potable water savings (liveability / water security)	Possible	Possible	Possible
Reduction in Total Nitrogen to Environment (surface water, groundwater)	Yes	Yes – significant[1]	Yes
Health impacts (DALYs)	Yes	Yes	Yes
Liveability (green public spaces, cooling)	Possible	Possible	Possible

Note 1: Both wastewater and stormwater load reductions to Brucknell Creek.

Benefits – Direct and Indirect

A number of benefits were considered by Frontier Economics are part of the CBA. This included;

- Reduced health impacts - Total DALYs and DALYS/person/year as per estimations discussed in Section 6.1.
- Nutrient reductions – TN / TP for each option compared to Existing Case / BaU. This includes groundwater impacts below Penshurst given the ability for existing land applied effluent to transmit along shallow rock to central Penshurst Wetland Gardens (ponds).
- Water savings from irrigation on-property, via reserves / Public Open Spaces at precinct 'cluster' systems.
- Liveability benefits such as creation of green public spaces within town (potentially enhanced with walking and recreational facilities) and temperature benefits associated with greening landscape.
- Flood hazard reduction specifically in Cudgee as this was a key issue identified by the community from potential subdivision / development, which has occur significantly within the last five to ten years.

6.3.1 Health Impacts

Health impacts of the various scenarios are assessed based on estimates of disability adjusted life years (DALYs) that were estimated by DWC. DALYs are a measure of burden of disease and estimate years of life lost due to premature death, as well as years of healthy life lost due to disability from disease and injury, based on the disability weight of a condition (ranging from 0 for a year of perfect health to 1 representing death). The DALY approach has been adopted in Australia by the Australian Institute of Health and Welfare.

DALYs have been calculated based on the impact of gastrointestinal illness on a community based on the varying levels of exposure risk as documented in Section 6.1.

6.3.2 Nutrients

One expected benefit of the scenarios is an improvement in water quality due to the reduction in pollutants discharging to receiving waterways. Waterways and waterbodies can be degraded by traditional drainage options that increase the velocity, volume and contamination levels of water travelling off developed areas and into the hydrological system. This results in damaged habitat, reduced water quality, and channel erosion; all of which limit our ability to enjoy our water resources while limiting the ability of flora and fauna to live in their natural environment.

Sustainable effluent management practices (either via conveyance to a Water Recycling Plant, constructed wetland or local land application and effluent reuse) can help reduce the pollutant loads discharging to local waterways and waterbodies. Furthermore, by using IWM to harvest, retain, and infiltrate stormwater, runoff is more able to mimic natural flow regimes which restore rivers, streams and creeks, and helps our bays stay free from nutrients and pollutants. Reduced demand on potable water can also help river health if it makes more environmental water available.

Pollutant load reductions were developed total nitrogen (TN), total phosphorus (TP) and disease burden (DALYs) to help quantify the potential benefits of each Solution Package.

7 Outcomes of Option Analysis

The Cost Benefit Analysis (CBA) undertaken by Frontier Economics is the primary mechanism for option analysis for this investigation. Full details of the CBA process and results can be found in Appendix D. As is commonplace when attempting to complete a CBA for a small town wastewater project (or often IWM project), a number of direct and indirect benefits have been identified and/or articulated by stakeholders that have proven challenging to include in the CBA at this stage. These potential benefits are discussed in detail in Appendix D and below.

To assist stakeholders in evaluating options, a supporting qualitative comparison has also been completed. It is envisaged that some of these more qualitative benefits and costs or risks will be incorporated into the CBA for the preferred solutions during Phase 2 of the project.

7.1 Cost Benefit Analysis

The following is a summary of the key outcomes of the CBA. Reference should be made to Appendix D for the full Economic Analysis Note from Frontier Economics. In summary, the CBA involves the following.

- Establishing the whole of life community costs and benefits for an agreed Business as Usual (BaU) or 'Base Case' scenario that represents what is likely to occur in the absence of an investment in any of the Solution Packages (Options).
- Estimating whole of life community costs and benefits associated with the shortlisted options (Solution Packages).
- Subtracting the BaU costs and benefits from Solution costs and benefits to determine the relative difference in investment and benefit of each option compared to a BaU scenario.
- Dividing benefits by costs to produce a Benefit Cost Ratio (BCR) that will be ≥1 if the investment is expected to deliver benefits that equal or exceed the investment required.

Key outcomes are summarised below. It is important to note that included benefits are currently limited to environmental, health and amenity / liveability benefits largely due to a lack of data or due to the need for more design and analysis to enable some other benefits to be meaningfully calculated. Avoided costs associated with the upgrade and on-going management and oversight of on-site systems is also captured in the CBA through the difference in costs between BaU and any given Solution Package.

7.1.1 Penshurst

The CBA results are presented in the following table. Frontier have emphasised that the BCR's are low due to the fact that some benefits have not been incorporated at this stage. They have also identified the appraisal period (currently 25 years) as a potential influence on low BCRs. SP2 has been identified as the option with the highest BCR at 0.84. This BCR increases to 1.11 where a discount rate of 4% is adopted and 1.24 if the upper value of cost of nitrogen in waterways is used.

Table 27 Cost-benefit analysis results (Central case, 7% discount rate, $2019 prices)

	SP1	SP2	SP3	SP4
Capital costs	(9,878,628)	(14,486,422)	(15,847,263)	(16,511,364)
Operating costs	(2,473,083)	(1,672,275)	(2,451,704)	(1,514,723)
Renewal costs	(643,796)	228,439	(678,651)	324,745
Total costs	(12,995,507)	(15,930,258)	(18,977,618)	(17,701,343)
Environmental benefits	(32,126,525)	9,212,754	9,212,754	9,212,754
Health benefits	2,176,807	2,176,948	2,176,948	1,955,077
Amenity benefits	-	2,029,627	-	-
Total benefits	(29,949,719)	13,419,328	11,389,701	11,167,831
Net Present Value	(42,945,226)	(2,510,929)	(7,587,917)	(6,533,512)
Benefit-Cost Ratio	N/A	0.84	0.60	0.63

With the exception of SP1 (discussed further below), all other options for Penshurst are strongly influenced by capital cost and asset renewal. SP2 is also identified by DWC and Frontier as the option for Penshurst with the most potential indirect benefits. Specifically, the establishment of green space throughout the town and the effect on liveability (often valued based on evidence of increased property prices).

SP1 sought to examine the trade-off between high capital investment for sewerage reticulation and stormwater infrastructure by targeting nutrient reductions from both elements of the water cycle. The SP1(a) presented above is one of two scenarios tested as part of this investigation. The other scenario involved renewal and enhancement of the stormwater management system for the Penshurst township (SP1b - refer to Section 5.1.1 for more detail).

SP1a is a lower cost, more targeted approach that primarily includes stormwater swales to convey excess recycled water from the precinct / cluster reuse systems to a lower risk point of discharge below the Penshurst Wetland. As can be seen in Table 23 (Section 6.2) the result is a net *disbenefit* in terms of environmental impacts. This is because the total nitrogen load (used in the CBA as the proxy for environmental benefits) increases as a result of removing on-site land application and restricting recycled water irrigation to a beneficial use approach (i.e. no effluent disposal or land application). As discussed in Appendix D (Frontier Economic Note for Penshurst) this is a limitation of using total investigation area TN loads to waterways as the measure of environmental benefits. That being said, it was agreed by a range of stakeholders during engagement on the draft version of this report that it was not appropriate to ignore the impact of pushing nutrient loads further down the catchment. The results presented in Table 27 reflect this agreed outcome.

A key outcome from SP1 is the diversion of current sewage discharges (both surface discharge and a significant shallow groundwater flow) from Penshurst Wetland and other groundwater discharge points in the lower areas of town (e.g. spring activity). It was noted by community members during consultation that spring water from the lower end of Penshurst was once considered a very clean water source but has been observed to deteriorate as pan toilet systems were converted to septic tanks and development increased.

SP1b was developed to provide a whole of water cycle benefit with respect to stormwater and wastewater impacts on water quality and health in addition to flooding and drainage impacts. Whilst a significant reduction in stormwater nutrient loads would be achieved, this would primarily offset the increase in loads from excess recycled water. Importantly, it would also divert most of the runoff and some of the shallow groundwater feeding the Penshurst Wetland which has the potential to have a negative impact on the viability of this waterbody due to hydrologic impacts.

During the options analysis and cost estimation process it became apparent that the benefits of this approach we clearly not going to match the significant capital cost even once allowing for liveability benefits (public open space greening) and avoidance of disturbances to life from drainage and wastewater impacts. Whilst SP1b would have a positive BCR, it would be considerably less than SP2-4 and consequently, this option has not been progressed further.

As discussed in Section 4.3.1 demand for recycled water is limited in Penshurst, influenced strongly by the local climate. Rainfall provides a surplus of soil moisture for ~7 months in an average year with plant water demand very low (72mm/year above rainfall). At present, the areas nominated in SP1 and 2 for Public Open Space (POS) irrigation are not actively irrigated. Consequently, there is no current potable water use that can be avoided through irrigation of these areas. Preliminary estimates of the cost (and feasibility) of providing a ‘third pipe’ recycled water supply to individual existing houses clearly indicated costs would exceed benefits by an order of magnitude as a minimum. This is strongly influenced by the minimal demand for garden irrigation and the cost of retrofitting plumbing at old houses on sites with shallow rock.

Frontier identified the potential for liveability / green space benefits to be incorporated into the CBA through an assumed increase in property value (Appendix D). DWC recommended further examination of this benefit (given it has potential to significantly influence the BCR) and this has also been incorporated into the CBA. As noted above, this benefit predominantly applies to SP2. SP4 has effectively no liveability benefits whilst SP3 has moderate potential via the central surface wetland feature but given this would be located north of the town, the potential amenity / liveability benefits were not readily transferable to an increase in property prices. For SP2, this 4% uplift in property value is considered to be a conservative proxy benefit that likely captures a range of liveability outcomes such as cooling and positive mental health outcomes.

In light of these observations, DWC is comfortable with the CBA outcomes for Penshurst and the identification of SP2 as the current preferred option.

7.1.2 Cudgee

The outcomes of the CBA for Cudgee are presented in Table 28. Of paramount importance when considering these results are the outcomes of the BaU characterisation presented in Section 3. Land capability investigations undertake for this study (which included soil profiling and laboratory analysis) have confirmed that the majority of properties in the Cudgee investigation area are well suited to on-site wastewater management. Moderate constraints exist on some properties that can typically be managed through relatively conventional design and technology measures already adopted for newer on-site systems in Cudgee. It is also noted that many of the existing on-site systems in Cudgee are fairly new (i.e. <10 years old) and are likely to be providing a reasonable level of human health and environmental protection. The majority of the investigation area is zoned Low Density Residential (LDRZ) and typically permitted for unsewered development via owner managed on-site systems.

As a result, our analysis has identified that the BaU scenario is likely to deliver reasonable benefits on the current situation which in itself is not significantly poor relative to other towns in the area.

Table 28 Cost-benefit analysis results (Central case, 7% discount rate, $2019 prices)

	SP1	SP2	SP3
Capital costs	(895,548)	(1,787,012)	(2,001,812)
Operating costs	(793,290)	(909,770)	(787,644)
Renewal costs	33,121	(304,662)	(1,011,267)
Total costs	(1,655,718)	(3,001,444)	(3,800,723)
Environmental benefits	82,371	2,575,743	74,645
Health benefits	77,393	69,244	71,240
Total benefits	159,764	2,644,987	145,885
Net Present Value	(1,495,954)	(356,457)	(3,654,838)
Benefit-Cost Ratio	0.10	0.88	0.04

The Benefit Cost Ratio (BCR) for SP1 and SP3 is very low and supports the outcomes of BaU characterisation in suggesting there is limited economic benefit in wastewater servicing strategies beyond on-site wastewater management. Notwithstanding, there are a small (~10) number of smaller, constrained properties that are unlikely to be able to contain all their wastewater on-site. SP2 is a clear preferred approach should stakeholders wish to mitigate risks from these properties. It effectively seeks to focus investment on improved stormwater management and treatment to achieve health and environmental (primarily water quality) improvements across multiple parts of the water cycle.

It is likely that the nature of stormwater management works developed as part of SP2 would address some of the local drainage issues identified recently in addition to preventing any failing on-site systems from discharging into neighbouring properties and creating localised health risks. There is scope to include a costed benefit in relation to avoided flood / drainage impacts which would most likely elevate the BCR above one for SP2 in Cudgee.

7.2 Qualitative Comparison

The following tables summarises some of the main advantages, disadvantages and risks associated with the shortlisted options for Penshurst and Cudgee.

Table 29 Qualitative Comparison: Penshurst

	Advantages/Opportunities	Disadvantages/Risks
Business as Usual (BaU)	Continuation of existing onsite systems which are upgraded only as needed (either compliance failure or new development). Lowest total capital cost.	Limited to no potential for town renewal or growth (of both new or existing properties and businesses). Potential environmental and human health risks from continuation of inadequate onsite systems, due to constrained existing properties. With particular impacts at the Penshurst Wetland Gardens (local community and tourist feature).
SP1 STEDS to Cluster Reuse (Excess to stormwater)	Lowest capital costs of all SP's (SP1 was developed to balance capital costs and overall impacts to township). Utilisation of existing septic tankage (where possible) as part of upgraded wastewater scheme to minimise upfront capital costs. Gravity drainage system with minimised pumping of wastewater as close to source (reduced energy usage). Provides local reuse of effluent for greening of public open space in town and reducing heat during warmer periods. Provides some ability for individual property renewal and development of existing properties by removing need for on-lot wastewater reuse. Includes provision for stormwater drainage upgrades to reduced flows directly entering the Penshurst Wetlands.	Highest total operational and asset renewal costs. Cap on long-term growth potential for new developments without major infrastructure upgrades (depending on actual future growth). Residual discharge of treated effluent into stormwater which will potentially result in a net increase in pollutant loads to environment during cooler months. However there will be a net reduction of existing pollutant loads to Penshurst Wetlands (to be bypassed via new stormwater drainage). Need to progressively renew on-lot septic tanks over time.
SP2 Cluster Based Reuse Systems	Conveyance of all wastewater off-property (no need for upfront septic tank or pressure sewer unit). Gravity drainage system with minimised pumping of wastewater as close to source (reduced energy usage). Provides local reuse of effluent for greening of public open space in town and reducing heat during warmer periods. Full beneficial reuse scheme no need for discharge of effluent into stormwater (as per SP1) or waterways.	Higher capital cost compared to SP1 however lowest capital and whole of life cost of SP2-4. Uncertainty regarding cost for gravity sewer installation given shallow rock present across township. Decentralised nature of infrastructure will require adaptation with respect to existing governance and operation of the scheme.

	Advantages/Opportunities	Disadvantages/Risks
	Provides ability for town renewal and development of existing properties by removing need for on-lot wastewater reuse. Improved capacity for town growth through sizing of proposed cluster systems and buffering capacity of Rhizopod™.	
SP3 STEDS to Constructed Wetland	Utilisation of existing septic tankage (where possible) as part of upgraded wastewater scheme to minimise upfront capital costs. Provides central blue / green space (wetlands) which can become a local feature close to town. Provides reuse capacity for greening of local sporting facility. Provides some ability for individual property renewal and development of existing properties by removing need for on-lot wastewater reuse. Improved capacity (from SP1) for town growth through sizing of wetlands.	Higher capital cost compared to SP1 and 2. Highest whole of life cost. Second highest total operational costs (just below SP1). Greater pipe installation and pumping costs / requirements due to wetlands being located outside of main township (management not as 'close to source'). Need to progressively renew on-lot septic tanks over time.
SP4 Pressure Sewer to Sewage Treatment Plant (Discharge to Water)	More conventional wastewater option that is typical of Wannon Water schemes. Potential for agricultural irrigation / reuse, in which fodder crops can be sold. Likely ability to maximise both town renewal and total long-term growth.	Highest capital cost of all SP's. Second highest life cycle cost. On-property grinder pods required (higher energy costs for customers). Water Recycling Plant (WRP) with greater infrastructure required as all wastewater treated at one central location (higher transport / treatment costs and greenhouse emissions). Limited to no improvements to town liveability or climate change resilience. Still has some constraints to long-term growth depending on lagoon and agricultural reuse capacity (suitable site or sites required). Discharge to waters may be required in future (greater treatment and compliance costs).

Table 30 Qualitative Comparison: Cudgee

	Advantages/Opportunities	Disadvantages/Risks
Business as Usual (BaU)	New and existing onsite systems to continue to be managed and progressively upgraded by owners as required. Environmental and human health impacts are estimated to be adequately managed via progressive upgrades of systems (provided systems installed in accordance with EPA CoP). Lowest total community costs. Consistent with LDRZ land use and current practice.	Issues with small number of constrained properties in township (to be left as owner managed). Flooding and stormwater issues around township not addressed by solution.
SP1 Retain On-site Systems with Small Cluster System for Constrained Sites	Cluster system and advanced onsite system upgrades (not owner managed) provide solution for small number of constrained properties in township. Local reuse of effluent for potential improved liveability and green spaces. Moderate improvement in environmental and human health risks (compared to BaU). Consistent with LDRZ land use and current practice. Appropriate solution for Township Zone.	Decentralised nature of infrastructure will require slight adaptation with respect to existing governance and operation of the systems. Flooding and stormwater issues around township not addressed by solution.
SP2 Retain On-site Systems and upgrade constrained sites. Build stormwater treatment / detention measures	Significantly improved total catchment nutrient loads to Brucknell Creek provided via new stormwater wetlands / measures. Flooding impacts also improved. Creation of water features throughout township (green / blue community space). Advanced onsite system upgrades (not owner managed) provide solution for small number of constrained properties in township.	Higher capital and operational costs to BaU and SP1. Decentralised nature of infrastructure will require slight adaptation with respect to existing governance and operation of the systems. Residual treated effluent to be discharged to stormwater (however controlled conditions overnight).

	Advantages/Opportunities	Disadvantages/Risks
SP3 Partial On-site Containment / Reuse with Excess to Cluster Irrigation Site	High level of servicing for a larger number of township properties (not managed by owners). Potential for both on-lot and local reuse of effluent. Moderate improvement in environmental and human health risks (compared to BaU).	Highest capital costs of all SP's. High operational costs compared to BaU. Decentralised nature of infrastructure will require slight adaptation with respect to existing governance and operation of the systems. Flooding and stormwater issues around township not addressed by solution.

7.3 Preferred Options

7.3.1 Penshurst

Based on the outcomes of this options analysis, the current preferred wastewater servicing option is Solution Package 2 (SP2). It offers a cost-effective way to address current constraints to managing wastewater on-site for the majority of properties within the Township zone whilst also achieving other water cycle and liveability benefits by beneficially reusing 100% of wastewater, close to source to create enhanced public open space. It is a relatively low energy and low maintenance concept. However, the decentralised nature of infrastructure will require adaptation with respect to governance and operation. It is envisaged that refinement of the CBA will result in a BCR of 1 or higher for SP2. It is also likely that the difference between the BCR for SP2 compared to SP3 and 4 will remain similar or increase.

7.3.2 Cudgee

The outcomes of the options analysis for Cudgee provide less clarity. DWC consider the following options to be worth further consideration.

- Business as Usual, potentially supported by a more active regulatory inspection program and potentially grant funding to upgrade constrained / non containment sites.
- Solution Package 2 (SP2 - Upgrade constrained on-site systems and build stormwater treatment and detention measures) as a more holistic solution to the key water cycle management issues facing Cudgee.

8 Next Steps

Given the limited available data to inform the CBA, it will be prudent to ensure the PCG and other stakeholders are comfortable with the more qualitative assumptions and decisions made as part of this options investigation. DWC and Frontier are comfortable that the *relative* difference between options is appropriate and do not expect the difference in Benefit Cost Ratio (BCR) to change dramatically due to modification of options. Notwithstanding, there are a small number of 'sub-options' that were developed and considered that may form a modification to some of the Solution Packages.

These include the following for Penshurst.

- SP1b: incorporate expanded stormwater management upgrades as described in Section 5.1.1 and 7.1.1 in order to offset excess recycled water discharge and provide whole of water cycle benefits (at greater cost).
- SP4: adopt the constructed wetland effluent management system proposed as part of SP3 in lieu of lagoon treatment and agricultural irrigation for improved liveability benefits.

There are limited drivers to consider broader alternatives for Cudgee based on the outcomes of the CBA. The key decision for Cudgee lies in an agreed position on whether to proceed with a Business as Usual (BaU) approach or SP2 (integrated water cycle approach). Should a BaU strategy be determined to be the preferred solution, the following adjustments may warrant consideration.

- Inclusion of grant funding or part funding of on-site system upgrades for constrained and non-containment properties to accelerate achievement of regulatory performance objectives.
- Establishment of a more formal operational inspection program to ensure systems are operated and maintained in accordance with their Permit and the EPA CoP.

8.1 Funding and Governance

Frontier Economics have undertaken a preliminary analysis of governance and funding models for the preferred solutions as part of their work (Appendix D). This analysis has been undertaken using the DELWP Cost Allocation Framework as guidance and is presented at this stage to guide engagement during Phase 2 and eventual agreement amongst parties to a governance and funding model. The following material has been drawn from the Frontier Economics Economic Analysis Notes in Appendix D.

The DELWP Coast Allocation Framework has five stages and include:

1. Allocate the benefits to each party
2. Allocate roles, responsibilities and cost to parties

3. Compare costs and benefits

4. Transfer between parties

5. Define gap and transfer unquantifiable benefits

These governance and funding recommendations have been provided at a high level to help facilitate discussion in the options assessment. We understand that in practice our recommendations may not align with stakeholder appetite or aspirations. We invite feedback on our recommendations in the stakeholder consultation to better refine the funding and governance arrangements for the preferred option in Stage 2.

8.1.1 Penshurst

All (currently) quantified benefits are distributed to the broader Penshurst community as they are the key beneficiaries of increased health outcomes. There is a strong argument that environmental outcomes are a broader, whole of government or certainly catchment benefit. This will be explored more as part of the funding model development during Phase 2.

Increased amenity benefits from improved greenspace would accrue to the broader community. Given the amenity benefits are likely through increased property prices, the distribution of these benefits will likely be localised to the Penshurst township.

The second step to allocate costs based on roles and responsibilities. The DELWP Cost Allocation Framework allows for the allocation of roles and responsibilities based on appropriate expertise, experience, legal accountabilities and business risk. Given the current stakeholder engagement, Wannon Water and Southern Grampians Shire Council (SGSC) are considered the only two parties realistically relevant for governance in Penshurst. Key points to consider in the allocation of roles and responsibilities include:

- Under the Environment Protection Act 1970 (soon to be 2018), State Environment Protection Policy (Waters) and the Health and Wellbeing Act 2008, Councils are required to ensure on-site systems do not impact on human health or the environment. They are also responsible for the provision of stormwater and open space services.
- The Statement of Obligations for Wannon Water state that the corporation, when considering types of sewerage services to be provided to unsewered urban areas, must consider fit for purpose options and identify the costs, benefits and risks to the community and customer base.
- For wastewater systems designed to manage more than 5000 litres a day, the monitoring of compliance shifts away from councils and to the Victorian EPA.

It is recommended for all options that Wannon Water is the lead agency for the wastewater components. This is because they are the most capable entity in delivering the solution packages at least cost and ensuring they are compliant to requirements (Such as EPA code of conduct). Whilst

SGSC are legally responsible for ensuring the existing systems are compliant, the Statement of Obligations for Wannon Water emphasises that Wannon Water should engage with councils and consider sewerage servicing options that are fit for purpose. As a result, there is no legal barrier for Wannon Water providing the sewerage infrastructure for Penshurst. Furthermore, the proposed solution packages may create systems that manage flows of more than 5000 litre/day, which are the responsibility of EPA to monitor and should be managed by Wannon Water.

For steps 3, 4 and 5, it is very important to note that the broader Penshurst community will be the primary funders of the infrastructure regardless of the governance option - either through council rates or through water tariffs (excluding any state or federal government grants or funding which would be attributed to broader regional and state benefits). As these beneficiaries will contribute regardless of the governance model, the governance and funding options should consider models which are practical to implement.

As water tariffs are periodically determined through the ESC, it is likely to provide a more effective method of cost recovery from the broader community compared to council rates. The price determination will also likely mean that costs are shared across the whole customer base. Whilst this is broader than the Penshurst community, it could be argued that the community beneficiaries are broader than the SGSC rate-paying base as visitors will derive benefit from increased amenity, environmental and health benefits. Water tariffs provide an effective and established transfer mechanism for the broader community (the core beneficiaries) to contribute to the costs of the preferred solution package (Step 4 in the cost allocation framework).

SGSC should still be engaged with the delivery of the wastewater options given strong interactions with their broader role in the Penshurst community. Some infrastructure, such as grass swales for stormwater management and (potentially) local cluster irrigation, would usually be the responsibility of SGSC. SGSC might consider either being the lead agency for the capital and ongoing costs of this particular infrastructure, or lower council rates where these wastewater and stormwater management functions are transferred to Wannon Water.

8.1.2 Cudgee

In this economic assessment, either the base case or SP2 will be the preferred option depending on the environmental benefits and appetite for expanded water cycle investment. For both options, Frontier recommends that there is little to no change to the current governance or funding arrangements in Cudgee, and that Moyne Shire Council continue to lead wastewater management. This is because the majority of benefits are associated with Moyne Shire Council through improved stormwater management. Wannon Water does not have the responsibility of stormwater management in Cudgee, and as such does not need to be included in the governance arrangements.

Moyne Shire Council should consider:

- Continued monitoring and assessing of pollution levels

- Exploring the potential of using council funds directed to stormwater management to fund the upfront and ongoing infrastructure. Council rates (or other mechanisms that collects revenue from Cudgee residents) represents the most appropriate funding model as Moyne Shire Council residents are the direct benefactors of improved amenity and local environmental outcomes (relevant for SP2)
- Considering policy mechanisms for encouraging gradual replacement of current systems if the base case is the preferred option (such as financial incentives or quality requirements)
- Assessing how wastewater management may provide a barrier for potential growth in the township

It is noted that potential growth in Cudgee has been identified as a potential driver for alternative wastewater solutions. This growth may require different governance and funding arrangements as described above and a change in the preferred solution package. It is difficult to determine the appropriate arrangements without understanding the preferred options and nature of the development growth. It is noted that there are no formal land use planning instruments adopted by Council to confirm a level and type of growth that would require a change in wastewater management (given the available land is currently zoned Low Density Residential and is appropriate for unsewered residential development). The current governance and funding arrangements should be reconsidered if a solution package is chosen as an enabler for development, or significant infill development occurs without changes to the wastewater servicing options.

8.2 Information and Investigations Required to Progress Options

The following table summarises the key investigations, data and information required to enable Functional Design and development of a governance and funding model for the preferred options. They represent items that DWC, Frontier and the PCG will need to address in order to refine the design and economic inputs for the preferred options in addition to provide adequate information to enable the DELWP Cost Sharing Framework to be applied.

Table 31 Summary of Investigations and Information Critical to Phase 2 of Project

Study Component	Item
Functional Design	- Reticulation alignments, sizing and cost refinement - Liaise with SGSC to obtain available geotechnical and capability data to support rock depth assumptions - Precinct system sizing and constructability - Identification of potential central treatment / reuse sites - Preliminary recycled water risk assessment - MEDLI / MUSIC modelling and WSUD measure sizing
Cost Benefit Analysis	- Review and potentially refine environmental benefit metric - Develop agreed appraisal period and position of asset life for the varying types and scales of infrastructure (preferred options)
Governance and Funding	- Define regulatory requirements for preferred options - Identify elements that don’t fit current regulatory structures - Introduce a first pass governance model to participating agencies for consideration and discussion

8.3 PCG Option Selection

Based on the Option Analysis outcomes the PCG subsequently selected Solution Package 2 as the preferred option for Penshurst. This was supported by Wannon Water and SGSC (at the Council meeting on 13 May 2020).

For Cudgee, consideration was given to the Business as Usual scenario in addition to SP2. MSC elected to take a BaU scenario forward for further consideration for Cudgee.

9 References

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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.

Appendix A: Options Shortlisting Summary

Table A1 Options Shortlisting

Option	Scale	Inclusion for Penshurst?	Inclusion for Cudgee?	Details / Explanation
Utilising existing treatment systems / land application	Lot-scale	SP1 & 3 (where possible)	Yes (all SPs)	Existing septic tanks only in Penshurst are to be utilised where possible as part of Septic Tank Effluent Drainage System (STEDS) scheme (Penhurst SP1 & 3). The intention is for BaU to continue for broader less constrained properties in Cudgee outside of main township zone.
New, upgraded secondary treatment system	Lot-scale	Considered as part of all SPs for larger lots only	Considered as part of all SPs & BaU	Replace / upgrade existing septic systems to achieve full on-site containment on viable properties in Penshurst – new secondary treatment system (e.g. aerated treatment unit or recirculating media filters) with subsurface irrigation or evapotranspiration absorption (ETA) trenches / beds to meet regulatory (EPA CoP) requirements. Lot size limitations in Penshurst, along with shallow rock observed (mentioned by residents) as key constraint for installing new systems / tanks. On-property wastewater management investigated but not taken forward for Penshurst.
Septic Tank Effluent Pump (STEP) / Septic Tank Effluent Gravity (STEG)	Lot-scale	Considered as part of SP1, SP3 and SP4	SP3	New watertight, compliant septic tank to be installed on-site with either gravity or pressure discharge of partially treatment (liquid) portion of wastewater to sewer network. To be further treated downstream – provides reduced infrastructure requirements due to reduced flows / loads being sent off-site. Can potentially be more viable (economically, construability, etc.) for towns with characteristics and number of properties as Penshurst. This is less so the case for Cudgee given the larger typical property size (i.e. greater CoS potential) and reduced number of total properties.

Option	Scale	Inclusion for Penshurst?	Inclusion for Cudgee?	Details / Explanation
Biofilter	Lot-scale	Considered (potential as part of SP1)	Potential as part of SP2	Biological filter utilised to treat excess greywater from BPO upgrade sites within the town. Can consist of slotted / drilled distribution pipe(s) for dosing of greywater across filter media (e.g. coconut fibre above sand / gravel layer) with discharge of treated water via an underdrain connected to stormwater drainage (bioretention swale for further treatment).
Rhizopod™ System	Lot-scale / Precinct-scale	Considered as part of SP2	SP1	Recirculating, lined Evapo-transpiration beds that provide secondary treatment, winter storage and enhanced plant water uptake to minimise discharge and subsequent effluent management costs.
Bioretention Measure	Lot-scale / Precinct-scale	Considered (potential as part of SP1)	Yes (SP2 with Wetlands)	Measures including swales, basins and raingardens (depending on scale) which aim to capture stormwater to be filtered through densely vegetated sand / loam filter media. Treated water either discharges via an underdrain, or potentially directly into groundwater in sandy environments. The water is treated via filtration, absorption and biological processes within the media / vegetation. Measures also provide retention of water to release it back into the environment in a manner more consistent with the natural flow regime.
Wetlands / Reed Beds	Precinct-scale / Whole-of-town	SP1, 2 & 3	SP2	Provide a means of treatment and naturalisation of both wastewater and stormwater loads / flows, as part of integrated water management (IWM) and hence has been taken forward for consideration in both towns.

Option	Scale	Inclusion for Penshurst?	Inclusion for Cudgee?	Details / Explanation
Cluster Reuse (Irrigation) System	Precinct-scale / Whole-of-town	SP1 & 2	SP1	System to collect treated effluent from on-property systems for polishing (potentially Class B) and irrigation across community / public open space. Cluster systems are typically set up at a precinct scale to treat wastewater from a group of properties within the vicinity of the nominated community / public open space. Initial upfront on-property treatment allows for reduced cluster treatment infrastructure. Cluster system can typically consist of small control shed (filtration and ultraviolet disinfection) and wet weather storage tank. There is also the potential for evapotranspiration / wetland type systems as discussed with residents during engagement, including Rhizopod™ system. This can provide the opportunity for minimised discharge of treated wastewater from the precinct cluster area (depending on available sizing / area) during warmer months, with local reuse via irrigation of reserves.
Central or Cluster Reuse (Irrigation)	Precinct-scale / Whole-of-town	SP1 & 2	SP3	Surface irrigation of Class C or B effluent in an agricultural (non-edible) scenario such as fodder or grazing (e.g. Lucerne). Can be operated as hybrid recycled water / land application system or full beneficial reuse with discharge to waterway.
Commercial Reuse / Agricultural Irrigation	Precinct-scale / Whole-of-town	Potential in SP4	N/A	Supplemental supply to local growers for irrigation of non-edible crops or local industry. Feasibility dependent on market demand for alternative water supply and suitability of available sites. Not taken forward based on limited opportunities identified in consultation for both towns.
Water Recycling Plant (WRP)	Precinct-scale / Whole-of-town	SP4	N/A	Facility that utilises a mix of biological, chemical and mechanical processes to treat raw sewage to a standard appropriate for either reuse (e.g. irrigation) or discharge to the environment. Given larger size of Penshurst this has been taken forward, however this has not for Cudgee given it is cost prohibitive.

Option	Scale	Inclusion for Penshurst?	Inclusion for Cudgee?	Details / Explanation
Effluent sewer	Precinct scale / Whole-of-town	Yes	Partially (SP3)	Operates in exactly the same manner as a pressure sewer. However, on-lot treatment means it is only required to convey primary or secondary quality effluent.
Reticulated sewerage.	Whole-of-town	Yes	No	This has been taken forward as a potential option only for Penshurst (Solution Package 4) based on consultation for both towns. The focus has been on pressure sewer as initial assessment of gravity sewer has indicated it would involve greater overall costs due to variable topography and ability to achieve gravity fall on lots. Low pressure sewer, pump stations and rising main to existing sewerage network or central Water Recycling Plant (WRP).
Transfer to existing Sewage Treatment Plant (STP)	Whole-of-town	No	No	Distance to existing sewerage connection and STP was determined to be cost prohibitive for both towns due to significant distance; - Approx. 26km from Penshurst to existing sewerage at Hamilton. - Approx. 14km from Cudgee to existing sewerage at Warrnambool. Reticulated sewerage with local WRP was taken forward in Solution Package 4 (Penshurst).

Appendix B: Hazard Mapping Summary

A summary of the hazard mapping methodology is provided below.

Table A2 CoS Hazard Mapping Classification

Classification	Contain On-site?	EPA CoP?	Derivation	Description
CoS Low Risk	Yes	Yes	Lot size ≥4,000m^2 and no sensitive receiving environments present.	Few/minor constraints to on-site wastewater management and low risk receiving environment.
CoS Medium Risk			Lot size >2,500m^2 and <4,000m^2 and/or in close proximity to sensitive receiving environments (e.g. watercourse).	Individual and/or cumulative hazards slightly elevate the likelihood and/or consequence of on-site system failure.
CoS High Risk			Lot size <2,500m^2 and/or in close proximity to sensitive receiving environments (e.g. watercourse).	Individual and/or cumulative hazards significantly elevate the likelihood and/or consequence of on-site system failure. Best practice design, construction, maintenance and oversight essential to manage risk and meet regulatory objectives for health and ecosystem protection.
Partial / Limited CoS	Exceptional circumstances	No	Available area < required to CoS but > 100m^2.	Insufficient suitable land available for CoS strictly in accordance with EPA CoP. Full CoS may be possible subject to advanced engineering and oversight where the provision of an off-site solution is cost prohibitive. However, either a full or partial off-lot solution will be required on most of these properties to meet the objectives of the SEPP.
Non CoS	No		Available area < 100m^2.	Effectively no suitable land available for CoS. Full off-site solution is essential to meet the objectives of the SEPP.

Appendix C: Cost Estimate Summary

Component	Scenario	Capital Cost Basis	Notes
Existing on-site wastewater management system upgrades	BaU (gradual owner upgrades)	Typical contractor rates for supply and installation of septic tanks, secondary treatment systems, absorption trenches/beds, pressure subsurface compensating irrigation. Also allowance for 5% of land application systems requiring renewal or repair p.a.	Current market rates for an installation by an individual property owner (checked against local delivered costs) **that meets EPA CoP**.
	Penshurst SP2 (Authority managed)	Water Authority contractor rates for supply and installation of septic tanks, secondary treatment systems, absorption trenches/beds, pressure subsurface compensating irrigation. Delivered rates obtained from the Yarra Valley Water Park Orchards On-site Containment Trial.	Slightly higher costs for Metropolitan Melbourne adjusted by 10% for regional project.
Partial On-site Containment Systems	Residential (Cudgee SP1-3)		
	Commercial (Cudgee SP1-3)		Based on site specific analysis and information (including site visits). Typically included a flow balancing tank and pump set as a minimum. Some included additional treatment capacity due to larger flows and loads.
Advanced On-site System Upgrade	Cudgee SP1 and 2		
Septic Tank Effluent Pump (STEP) Unit	Penshurst SP1-2	Estimate based on supply price of STEP tank(s), pump, controls with construction based on typical plumbing contractor rates.	Limited requirement for STEP units. Based on local (Australian) tanks.
Pressure Sewer Unit	Penshurst SP4	Typical supply and installation rates as provided by unit suppliers and installation contractors. Includes PS unit, property discharge line, boundary kit and smart controller.	
On Property Plumbing and Electrical Costs	All	Rates taken from Birregurra project and adapted based on a pressure sewerage or on-site upgrade arrangement. Typically involves reduced lengths of plumbing upgrades due to location of pressure sewer / upgraded system near original septic tank where possible.	Min. 60% of properties with a pump assumed to need electrical upgrade. Nominal allowance made for upgrade or replacement of sanitary drainage under building.
Pressure sewerage (reticulation)	Penshurst SP4 Cudgee SP1 and 3	Barwon Water (APES) cost estimate tool using delivered contract rates and typical design arrangements for a pressure sewer.	Typically 63 – 90mm PE

Component	Scenario	Capital Cost Basis	Notes
Gravity sewerage (reticulation)	Penshurst SP1-3	Based on supply and construction rates from previous metropolitan Melbourne projects, adjusted for inflation at 80% rates due to regional location. Additional $150/m nominal allowance for sections of sewer likely to require rock breaking or drilling. Digital elevation model analysis used to estimate length of sewer likely to be deeper than rock.	The presence of shallow, hard bedrock in Penshurst creates uncertainty around cost estimates. These estimates will need to be reviewed and ideally, refined during Functional Design.
STEP Pump Station	Penshurst SP3	Materials costed based on FRP underground tanks (for conservatism) and pumps sized based on estimated duty. Construction rates based on STEP installation costs from previous Melbourne projects.	Receives primary treated effluent rather than raw sewage.
Irrigation / Discharge polishing	Penshurst SP1-3 Cudgee SP3	Cost rates obtained from Monbulk Integrated Water Cycle Business Case (BMT WBM, 2015) and checked against current rates for supply and installation of key components.	Based on above ground steel water tanks, typical control shed on slab and contractor rates for media filtration, UV disinfection, irrigation pump set and controller and ancillary components (e.g fencing, access).
Above Ground Steel Tanks	Most	Cost curve based on recently delivered projects. Includes supply and install of tank and suitable liner and connections. Labour, preparation of pad, safety equipment, fencing.	
Cluster Rhizopod™	Penshurst SP2 Cudgee SP1	Budget cost estimates from supplier based on similar nearby projects. Allowance for bulk supply cost adjustments. Sized based on water balance modelling for a nearby project in similar climate.	Functional design to include project specific design modelling.
Water Recycling Plant (Lagoons)	Penshurst SP3	Based on recent Barwon Water projects (including Birregurra) and budget estimates from suppliers.	Lagoon / wetland (similar cost) or MBR treatment used to test the scenario with an MBR being required for a licenced discharge to waterways.
Recycled Water Storage Dam	Penshurst SP4	Based on civil rate for Water Authority delivered recycled water projects in non-metropolitan areas of Victoria and NSW. Adjusted for inflation. Includes a per m^3 of storage rate and scaled, fixed cost for ancillary infrastructure.	Subject to site selection and geotechnical investigations.

<table>
<tr><th>Component</th><th>Scenario</th><th>Capital Cost Basis</th><th>Notes</th></tr>
<tr><td>Wastewater (and dry weather stormwater) treatment wetlands</td><td>Penshurst SP1</td><td>Adopted the most limiting (upper) pro-rata cost rate based on surface area and/or volume using both WSUD (Melbourne Water 2013 and BMT WBM, 2015) and wastewater treatment wetlands.

Adopted typical contract rates based on estimated material quantities and construction effort for reed beds (horizontal and vertical flow).</td><td rowspan="4">Checked against historical (2012) Melbourne Water WSUD developer services cost rates for WSUD measures.</td></tr>
<tr><td>Bioretention Basins and Grassed Swales</td><td>Penshurst SP1

Cudgee SP2</td><td>Adopted the most limiting (upper) pro-rata cost rate based on surface area and/or volume using both WSUD (Melbourne Water 2013 and BMT WBM, 2015).</td></tr>
<tr><td>Constructed Wetlands</td><td>Penshurst SP3

Cudgee SP2</td><td>Wastewater wetland costed based on pro rata rates for free water surface wetland construction. Site specific earthworks and HDPE liner estimates.

Stormwater wetland based on WSUD (Melbourne Water 2013) cost guidelines.</td></tr>
<tr><td>Stormwater pipes and pits</td><td>Penshurst SP1

Cudgee SP2</td><td>Typical contractor rates for Greater Melbourne.</td></tr>
<tr><td>Subsurface Irrigation of Public Open Space</td><td>Penshurst SP1-3

Cudgee SP1 and 3</td><td>Adopted cost per m^2 of ha installation rate for subsurface irrigation based on delivered water authority and private contracts in Victoria and NSW at similar scales.</td><td></td></tr>
<tr><td>Surface spray irrigation (agricultural)</td><td>Penshurst SP4</td><td>Based upon zoned grid of impact sprays or wobblers (due to topographical constraints on most potential sites).

Allowance made for site preparation and crop / pasture establishment using NSW DPI cost rates as a guide. Also includes for stormwater management.</td><td>Assumes fully funded and operated by Barwon Water or equivalent.</td></tr>
<tr><td>Land Purchase</td><td>All</td><td>Adopted Southern Grampian values for applicable land use type in Victorian Valuer General statistics (https://www.propertyandlandtitles.vic.gov.au/property-information/property-prices)</td><td>Adopted most limiting for general agricultural land (no infrastructure) between Penshurst and Cudgee.</td></tr>
</table>

Appendix D: CBA Reports (Frontier Economics)

Penshurst wastewater options analysis

Economic Analysis Note

This note is structured as follows:

- Economics Analysis Framework – setting out the methodology for the economic analysis
- Economics Analysis Results – detailing the results of the economic analysis
- Funding and governance arrangements – guided by the DELWP cost allocation framework

Economic Analysis Framework

Overview

This economic analysis framework sets out the methodology used to complete the Cost-Benefit Analysis (CBA) for the Penshurst wastewater options analysis. This CBA framework is consistent with Victorian Department of Treasury and Finance's Investment Guidelines. **Table 3** summarises the key assumptions which underpin the CBA:

Table 1: CBA key assumptions and parameters

Assumption/ Parameter	Value	Source (where applicable)
Year discounted to:	1 January 2020 (2019-20 financial year)	
Price base:	1 July 2019	
Design/construction start	2020	Based on cost profile provided by DWC
Design/construction duration	2 years	Based on cost profile provided by DWC
Benefits profile	100% of benefits begin after capital work is complete.	Based on pollutant and DALY flow profiles provided by DWC
Appraisal period	25 years from first full year of benefits	Based on flow data provided by DWC. Note this does not align with the asset life of each option

<table>
<tr><td>Discount rate used</td><td>7% real</td><td>Department of Treasury and Finance (2013), Economic Evaluation for Business Cases: Technical guidelines</td></tr>
<tr><td>Capital cost data</td><td>Solution Package 1 - $12.37 mil
Solution Package 2 - $17.14 mil
Solution Package 3- $18.55 mil
Solution Package 4 - $19.23 mil</td><td>Cost data provided by DWC</td></tr>
<tr><td>Operating cost data</td><td>Solution Package 1 - $330,766/yr
Solution Package 2 - $257,238/yr
Solution Package 3- $328,803/yr
Solution Package 4 - $242,772/yr</td><td>Cost data provided by DWC</td></tr>
<tr><td>Renewal cost data</td><td>Solution Package 1 - $2.294 mil
Solution Package 2 - $815,200
Solution Package 3 - $2.284 mil
Solution Package 4 - $530,890</td><td>Cost data provided by DWC</td></tr>
<tr><td>Pollutant flow data (compared to existing case)</td><td><table>
<tr><td></td><td>Flow</td><td>TP</td><td>TN</td></tr>
<tr><td>SP 1</td><td>+ 18%</td><td>+224%</td><td>+347%</td></tr>
<tr><td>SP 2</td><td>-87%</td><td>-96%</td><td>-99%</td></tr>
<tr><td>SP 3</td><td>-87%</td><td>-96%</td><td>-99%</td></tr>
<tr><td>SP 4</td><td>-87%</td><td>-96%</td><td>-99%</td></tr>
</table></td><td>Pollutant flow data provided by DWC</td></tr>
<tr><td>Changes in DALY</td><td>SP 1 - 1.3 DALYs reduction
SP 2 - 1.3 DALYs reduction
SP 3 - 1.3 DALYs reduction
SP 4 - 1.3 DALYs reduction</td><td>DALY data provided by DWC</td></tr>
<tr><td>Cost per kg of TN in waterways</td><td>Low - $323 /kg/year
Medium - $3,926 /kg/year
High - $6,645 /kg/year</td><td>Based on the construction of large wetlands that Melbourne Water would be required to undertake to remove pollutants if no other interventions are in place</td></tr>
</table>

VSLY	Low - $41,393 **High - $180,000**	Low - Median total income (excl. gov allowances) for Southern Grampians LGA, 2017 High – PMC VSLY guidance note 2014

Note: Bold items indicate parameters used in the central case. Parameters are escalated to 2019 prices where applicable

Note one inconsistency with DTF guidelines is the 25-year appraisal period, which is based on available data on benefit flows rather than the true asset lives of the solution packages. It is expected that most options have longer assets lives and as such benefit (and operating/renewal cost) streams will continue for longer. Instead of making assumptions about pollution flows beyond the 25 years, an appraisal period of 25 has been chosen. However this will inherently reduce the benefits of options with longer asset lives and will be explored in the Stage Two CBA analysis.

Base Case

The base case for the CBA has been provided by DWC and includes the following:

- Existing, older on-site wastewater management systems are replaced or renewed at an average rate of 4% per annum over the next 25 years through either;
  - voluntary replacement due to old age or failure;
  - a requirement as part of a planning or building permit process; and/or
  - an enforced upgrade due to a compliance issue.
- The total (average) cost of this upgrade is assumed to be $16,000 including approvals with an operational cost of $600 per annum (p.a.) including component replacement, servicing, power use and desludging.
- Existing on-site systems were assumed to cost the average owner approximately $200 p.a. (or $1,000 every 5 years, $2,000 per 10 years, etc.) to reflect periodic pump out of the septic tank, disposal field repairs, renewal or replacement and in some cases mechanical and electrical maintenance

It is important to note that this base case scenario has incorporated the findings of the on-site containment potential mapping. More than half of the properties in the Penshurst study area are unlikely to be capable of full on-site containment in accordance with the EPA Code of Practice. The environmental and health protection benefits for a base scenario assume on-site containment is maximised with excess effluent only discharged off-site where essential.

Solution packages

This CBA has been completed for four solution packages (SPs) provided by DWC– SP1, SP2, SP3 and SP4.

Table 2 provides an overview of the scope of each option. Further details can be found in the business case.

Table 2: Key features of project options

Solution package	Description
Solution package 1: STEDS to Cluster Reuse (Excess to stormwater)	Utilises existing septic tanks as part of a STEDS (Septic tank effluent drainage/disposal system) scheme. All discharge is collected from properties by gravity effluent sewers. Drainage occurs to cluster/precinct scale treatment and subsurface irrigation areas. Excess flow discharged to upgraded stormwater (grass swales) drainage (directed away to bypass Penshurst Wetland Gardens) Places some limits on town renewal / growth due to limits on capacity to manage wastewater locally (within reserves / public open space).
Solution package 2: Cluster Based Reuse Systems	Involves the construction of local gravity sewers to direct sewerage for township properties. Incorporates recirculating evapotranspiration beds with winter storages to treat and reuse water for landscape watering. Excess recycled water will be used for public open space. Households with full on-site containment continue with on-property wastewater management.
Solution package 3: STEDS to Constructed Wetland	STEDS (Septic tank effluent drainage/disposal system) for township towns utilising existing on-lot septic tanks with gravity collection and drainage to 2 septic tank effluent pump stations (STEPs). Central treatment at a constructed wetland, providing treatment., ecological restoration and amenity functions. Households with full on-site containment continue with on-property wastewater management.
Solution package 4: Pressure Sewer to Sewage Treatment Plant (Discharge to Water)	Traditional Small-Town Reticulated Sewerage solution for the 217 township properties. This includes lagoon Treatment, winter storage and agricultural reuse (fodder crop). Households with full on-site containment continue with on-property wastewater management.

An option not taken forward is connection to existing sewerage networks (e.g. Hamilton) as the distance to the network proved cost prohibitive relative to the solution packages described in

Table 2.

Costs

P50 cost estimates have been profiled based on available cost data from DWC. This includes capital cost data, operating expenditure and renewal expenditure. Renewal costs include renewal of on-lot components, local treatment/storage and effluent management.

It should be noted that it is assumed there is no residual asset value at the end of the appraisal period.

Benefits

The benefits included in the CBA have been developed to incorporate available data from DWC. The benefits used in the CBA include:

- Avoided environmental costs from total nitrogen loads in waterways
- Health benefits from reduced exposure to wastewater
- Amenity benefits from greenspace

We discuss these benefits in more detail below.

Environmental benefits

One expected benefit is the improvement in water quality due to the reduction in pollutants. Sustainable IWN management practices can help reduce pollutant loads in waterways and are more able to mimic natural flow regimes.

A range of valuation techniques are available to estimate the environmental benefits of improved waterway health. However, most of these techniques require a detailed understanding of the receiving waterways and the incremental change to waterway health which is beyond the scope of this initial CBA. For this CBA, environmental benefits have been calculated at a high level through the use of an indicative value of water quality derived from the Melbourne Water stormwater offset costs, currently at $6,645 per kg of nitrogen removed per year.

The price is based on the construction of large wetlands that Melbourne Water would be required to undertake to remove pollutants if no other interventions are in place. If the benefits of constructing these particular wetlands exceed the costs, the cost can represent a lower-bound for the benefits of reducing nitrogen in the waterways.

It is important to note that the $6,645/kg/year is based on the maximum cost of constructing a wetland to reduce nitrogen loads in the Melbourne Water jurisdiction. It is unreasonable to assume that this cost is representative of Penshurst, where land is more available and the receiving wetlands are fundamentally different to those in Melbourne Water’s jurisdiction. Constructed wetlands also bring other benefits to the community such as increased amenity. As such, using the cost of the wetlands as a proxy of the value may also be incorporating broader benefits that may not be relevant for Penshurst. In the same study, a low cost of $323/kg/year and a weighted average cost of $3,926/kg/year are also calculated.

In the absence of a better understanding of environmental benefits from the different servicing options, a value of $3,926/kg/year has been adopted for the central estimate in this CBA. This assumption is tested using the low and high values from Melbourne Water in the sensitivity analysis.

Health benefits

The current wastewater servicing option for Penshurst currently does not meet the EPA Code of Practice and as such poses a risk to community health. This risk includes exposure to untreated wastewater and contamination of local waterways. The solution packages all aim to address this by aligning with EPA code of practice and significantly decreases instances of contamination and exposure.

Disability adjusted life years (DALYs) have been provided by DWC for each solution package, and directly relate to reduced exposure risk of wastewater incremental to the base case. The value of a DALY lost in the CBA is set to be equal to median total income for the Southern Grampians Shire. Median income is recommended as the willingness to pay to reduce DALYs as it theoretically represents the median marginal product of an individual in Penshurst.

This value should represent a conservative scenario as it only takes into account the direct productivity loss of that year. It does not take into the intrinsic value of the DALY to an individual. As such, an upper bound of $180,000 is included in the central case. This value represents the willingness to pay for an individual to avoid one DALY, as described by the Prime Minister and Cabinet guidance note on the value of a statistical life. The median income is instead used in the sensitivity analysis.

Health benefits associated with increased recreation on improved green space, whilst potentially a relevant benefit, has not been quantified given overlap with amenity benefits.

Amenity benefits

Some Solution Packages provide amenity benefits for the local community through improved irrigation of greenspace.

For Solution Packages 1 and 2**,** excess recycled water can be provided to the community sports fields on an as-needs basis. Remaining recycled water will be used to irrigate greenspace located. In addition, the treatment of recycled water through natural based systems may provide additional community amenity benefits.

Solution Packages 3 and 4 do not provide amenity benefits from improved greenspace as recycled water is not provided. Amenity benefits captured from improved environmental outcomes (such as in the Penshurst Wetlands) is already captured through the environmental benefits.

The benefits associated with improved greenspace include:

- **Increase in active and passive recreation benefits associated with higher quality greenspace**. Particularly in dry years, recycled water irrigation can maintain the quality of greenspace for active and passive recreation. It can also enable improvements in other aspects of this greenspace, such as higher quality turfs. This increase in quality provides benefits for those who use the greenspace for active and passive recreation, and can encourage higher rates of recreation in the community. Evidence suggests that the uplift in active recreation is around 5% when greenspace is of higher quality.[1]
- **Urban amenity associated with greener streetscapes and public areas.** Irrigation of greenspace in public spaces can help maintain these spaces at a higher quality during dry periods. This provides urban amenity benefits for those that live nearby to these spaces. There may be minor urban cooling impacts for those located nearby to the greener areas.

These benefits can be monetised through an expected uplift in property prices for the Penshurst community. An uplift in property prices can be considered the value of living nearby to accessible, high quality greenspace, and would therefore capture all of the benefits discussed above.

[1] For example, see Water Services Association of Australia, 2019, Health benefits from Water centric liveable communities, a report prepared by Frontier Economics. Available from https://www.wsaa.asn.au/publication/health-benefits-water-centric-liveable-communities

For the property uplift, Rosetti (2013) finds that around 8% of property prices are attributable to greenspace.[2] Given our understanding of the greenspace in Penshurst under the base case and project case, more conservative uplifts of 4% for SP2 has been applied. This also recognises the study was undertaken in Australian capital cities and may not be entirely applicable for regional towns such as Penshurst.

This uplift is applied to all existing households in Penshurst (301) once construction is complete. The uplift is applied to a median property price in the region of approximately $193,000.[3]

Benefits not included in the CBA

Table 3 provides an overview of the identified benefits not included in the CBA and why they have not been considered quantitatively.

For Stage Two of the Penshurst options assessment these benefits will be explored in more detail.

Table 3: Overview of benefits *not* included in CBA

Benefits not included in CBA	Reason for exclusion in CBA
Avoided upstream water costs from recycled water use	A lack of understanding on the extent of irrigation water replacing existing potable water use
Reduced wastewater disruption (frequency and duration)	Lack of data on disruption frequency and duration, and an appropriate willingness to pay to avoid this frequency.
Reduced likelihood of water restrictions through increased availability of recycled water	Will depend on the use of irrigation water which is uncertain. Likely to be minor given small population and water access coming from groundwater
Health benefits associated with increased green space (e.g. recreation, urban heat, mental health)	Likely overlap with amenity benefits
Increased groundwater availability from water quality improvements	Lack of data on whether impacted groundwater would be accessed
Benefit directly associated with meeting EPA requirements	No associated monetisation method available, and likely to double-count environmental and health benefits
Specific environmental benefits from servicing options (e.g. willingness to pay for improved waterway outcomes)	Will likely be double counting with proxy value used for reduced nitrogen levels. Lack of data and local WTP for environmental outcomes

[2] Rossetti.J (2013), Valuation of Australia's Green Infrastructure: Hedonic Pricing Model Using the Enhanced Vegetation Index. The Hedonic Pricing Model suggests that a one standard deviation increase in the Enhanced Vegetation Index, within a postal code region leads to a house price premium of between 8.62% and 15.57%.

[3] Valuer-General Victoria, 2019, median property price for June 2019 in Hamilton, Victoria

	makes it difficult to value other potential environmental benefits
Agricultural output from increased recycled water access	A lack of data on whether the recycled water would help increase production of fodder crop for SP 4. It is likely it would replace existing groundwater use which would have limited quantifiable benefit.

Out of all the benefits not included, amenity benefits associated with increased blue and green space is likely to be the most major exclusion. Data availability on how the green and blue space is likely to improve means that this benefit can only be discussed qualitatively at this stage. It should be noted that amenity benefits that directly relate to improved environmental benefits might overlap with the environmental benefits estimated with the reduced nitrogen loads.

One quantifiable benefit would derive from increased property price values from increased green and blue space. For example, Rosetti (2013) finds that around 8% of property prices are attributable to greenspace.[4] If we apply this value to all Penshurst households (301) with a median property price of $193,000[5], an indicative open space amenity benefit would be approximately $4.04 million for SP2 in NPV.

It is likely that households close to this greenspace would have similar benefits associated, however a better understanding of the green space improvements would be required to include this benefit in the CBA analysis. The percentage uplift in property prices would also need to be representative of the Penshurst region. The 8% property uplift percentage is capturing property price increases for capital cities across Australia and is likely not representative of regional south-west Victoria.

Avoided upstream water supply costs from increased use in recycled water may also represent a benefit that could be quantified in Phase 2 with a better understanding on how recycled water will replace potable water. At this stage it is unclear at to the volumes of recycled water available, and whether this recycled water will be used for irrigation where existing potable water is currently used. Currently Southern Grampians Shire Council (SGSC) may use other sources of water (e.g. the local groundwater) or not irrigate at all

One benefit difficult to determine but has been raised in stakeholder engagement is the enabling of infill development. Currently, the requirement of on-site containment through septic tanks limits developments below a certain property size. This can significantly constrain infill development and may be a factor of slow or declining growth in regional towns. Benefits of town growth might include increases in surrounding property prices, increased economic activity in the town and improved community environment.

Whilst changes to wastewater management is an important enabler for town growth, it will not necessarily guarantee development in the town. Town development will occur due to a range of factors, and attributing town development benefits just to one enabling factor such as wastewater is not appropriate in an economic assessment such as this. With this said, it should be an important consideration in the decision making process of the preferred option.

[4] Rossetti.J (2013), Valuation of Australia's Green Infrastructure: Hedonic Pricing Model Using the Enhanced Vegetation Index. The Hedonic Pricing Model suggests that a one standard deviation increase in the Enhanced Vegetation Index, within a postal code region leads to a house price premium of between 8.62% and 15.57%. A conservative measure of 8% has been adopted for illustrative purposes

[5] Valuer-General Victoria, 2019, median property price for June 2019 in Hamilton, Victoria

Finally, the value of avoided upstream water supply costs is theoretically represented by the long run marginal cost. This cost represents the cost of supplying and additional unit assuming all factors of water production can be varied. Typical costs include direct marginal costs of water supply (including treatment and pumping) and a small proportion of future fixed capital costs to replace and augment supply and network assets.

Whilst in theory it is an appropriate measure, estimating an LRMC is difficult to achieve given significant uncertainty on future augmentations. The variable components of the Wannon Water tariffs for Penshurst may instead be used as a proxy for LRMC. As these tariffs are determined through the price determination process with the Essential Services Commission, they provide the best indication of water supply costs.

Sensitivity Analyses

Given that the CBA is somewhat high-level due to data availability, it is important that robust sensitivity analyses are completed in order to reflect the key uncertainties around the project. The sensitivity analyses for this CBA are:

- Applying a 4% and 10% real discount rate to the central case analysis
- Applying the higher and lower estimates for the value of water quality improvements to the central estimate
- Applying the upper bound value for health benefits to the central estimate

These sensitivity analyses are considered to be the most reasonable approach to testing the uncertainties with respect to the Penshurst wastewater options.

Economic Analysis

Results

The results of the CBA are presented below. This analysis is based on the methodology set out in the previous section.

Table 4: Cost-benefit analysis results (Central case, 7% discount rate, $2019 prices)

	SP 1	SP 2	SP 3	SP 4
Capital costs	(9,878,628)	(14,486,422)	(15,847,263)	(16,511,364)
Operating costs	(2,473,083)	(1,672,275)	(2,451,704)	(1,514,723)
Renewal costs	(643,796)	228,439	(678,651)	324,745
Total costs	(12,995,507)	(15,930,258)	(18,977,618)	(17,701,343)

Environmental benefits	(32,126,525)	9,212,754	9,212,754	9,212,754
Health benefits	2,176,807	2,176,948	2,176,948	1,955,077
Amenity benefits	-	2,029,627	-	-
Total benefits	(29,949,719)	13,419,328	11,389,701	11,167,831
Net Present Value	(42,945,226)	(2,510,929)	(7,587,917)	(6,533,512)
Benefit-Cost Ratio	N/A	0.84	0.60	0.63

These results show that the Benefit Cost Ratio (BCR) for the various solution packages are in the range 0.60-0.84 (excl SP1). Whilst these BCR results are low it is important to be clear that this has been a partial economic analysis based on limited available data and conservative assumptions.

From the CBA, SP2 is the preferred option as it has the highest BCR – given it has the lowest cost out of all the options that achieve pollutant load reductions, and provides amenity benefits.

SP1 has negative total benefits because of the increased pollutant loads. This would suggest that investment is being made to achieve a disbenefit. Although pollutant loads are increasing, these pollutant loads will bypass the central groundwater and Penshurst wetlands. The single value applied to pollutants does not recognise the distribution of these pollutants onto different waterways. As indicated in the stakeholder engagement, the Penshurst community value the Penshurst wetlands highly and reductions in pollutants to these wetlands would be considered a benefit. Unfortunately the methodology does not recognise differences in receiving waterways and as such SP1 has an associated disbenefit for pollutant loads. To avoid confusion the BCR for this option has not been reported in the table.[6]

If SP1 is the preferred option, the valuation of environmental benefits will be refined to account for the different values attached to different waterways. However it is important to emphasis that SP1 does increase pollutant loads which may have impacts downstream even if it bypasses the Penshurst wetlands and ponds.

It is important to emphasis that all options are not equal when considering unquantified benefits. In particular:

- SP3 in particular includes the development of a new wetland which may provide additional amenity and recreation benefits.
- SP4 is unlikely to have significant liveability benefits as the option does not include improved green space outcomes.
- SP2 may have avoided upstream water benefits if recycled water is used to displaces potable water demand. SP3 is only expected to have minor reuse of wastewater for consumptive use.
- SP4 may have minor agricultural benefits from irrigation of fodder crop (or equivalent).

[6] SP1 has a negative BCR (-2.44)

The above discussion suggests the unquantified benefits are likely to confirm SP2 as the preferred option in the economic analysis, recognising that SP3 may also have notable amenity benefits through the additional wetland as well.

Sensitivity Analyses

As per the economic framework, the following presents a number of sensitivity analyses which have been undertaken as part of the economic analysis.

The sensitivity analyses show that when varying key uncertainties with respect to the CBA that the BCR for the preferred option ranges from 0.07-1.01. Sensitivities on the value of TN removed from the waterways has the greatest variation in results, where the low estimate for SP2 has a BCR of 0.08 to 1.01 for the high estimate. This emphasises the importance of reduced pollutant loads for the preferred solution package, and clarifying the environmental benefits for the preferred option is an important next step for the economic analysis.

This broad range shows that there is considerable uncertainty surrounding the value for money proposition.

Table 5: Cost-benefit sensitivity analysis results (4% discount rate, $2019 prices)

	SP 1	SP 2	SP 3	SP 4
Capital costs	(9,249,487)	(13,921,492)	(15,301,297)	(15,974,653)
Operating costs	(3,309,602)	(2,205,121)	(3,280,115)	(1,987,824)
Renewal costs	(879,671)	199,652	(904,444)	351,447
Total costs	(13,438,759)	(15,926,960)	(19,485,856)	(17,611,029)
Environmental benefits	(44,309,165)	12,706,305	12,706,305	12,706,305
Health benefits	2,874,166	2,874,361	2,874,361	2,639,592
	-	2,148,410	-	-
Total benefits	(41,434,999)	17,729,075	15,580,666	15,345,897
Net Present Value	(54,873,758)	1,802,115	(3,905,190)	(2,265,132)
Benefit-Cost Ratio	N/A	1.11	0.80	0.87

Table 6: Cost-benefit sensitivity analysis results (10% discount rate, $2019 prices)

	SP 1	SP 2	SP 3	SP 4
Capital costs	(10,229,054)	(14,776,139)	(16,119,051)	(16,774,403)
Operating costs	(1,922,319)	(1,315,577)	(1,906,121)	(1,196,206)
Renewal costs	(483,400)	234,138	(521,643)	296,012
Total costs	(12,634,774)	(15,857,579)	(18,546,815)	(17,674,597)
Environmental benefits	(24,341,067)	6,980,159	6,980,159	6,980,159
Health benefits	1,710,699	1,710,806	1,710,806	1,500,822
	-	1,920,430	-	-
Total benefits	(22,630,368)	10,611,394	8,690,965	8,480,981
Net Present Value	(35,265,142)	(5,246,184)	(9,855,851)	(9,193,616)
Benefit-Cost Ratio	N/A	0.67	0.47	0.48

Table 7: Cost-benefit sensitivity analysis results (Low cost of nitrogen in waterways, 7% discount rate, $2019 prices)

	SP 1	SP 2	SP 3	SP 4
Capital costs	(9,878,628)	(14,486,422)	(15,847,263)	(16,511,364)
Operating costs	(2,473,083)	(1,672,275)	(2,451,704)	(1,514,723)
Renewal costs	(643,796)	228,439	(678,651)	324,745
Total costs	(12,995,507)	(15,930,258)	(18,977,618)	(17,701,343)
Environmental benefits	(2,643,115)	757,952	757,952	757,952
Health benefits	2,176,807	2,176,948	2,176,948	1,955,077
	-	2,029,627	-	-
Total benefits	(466,308)	4,964,527	2,934,900	2,713,029
Net Present Value	(13,461,815)	(10,965,731)	(16,042,718)	(14,988,313)
Benefit-Cost Ratio	0.04	0.31	0.15	0.15

Table 8: Cost-benefit sensitivity analysis results (High cost of nitrogen in waterways, 7% discount rate, $2019 prices)

	SP 1	SP 2	SP 3	SP 4
Capital costs	(9,878,628)	(14,486,422)	(15,847,263)	(16,511,364)
Operating costs	(2,473,083)	(1,672,275)	(2,451,704)	(1,514,723)
Renewal costs	(643,796)	228,439	(678,651)	324,745
Total costs	(12,995,507)	(15,930,258)	(18,977,618)	(17,701,343)
Environmental benefits	(54,376,149)	15,593,160	15,593,160	15,593,160
Health benefits	2,176,807	2,176,948	2,176,948	1,955,077
	-	2,029,627	-	-
Total benefits	(52,199,342)	19,799,735	17,770,108	17,548,238
Net Present Value	(65,194,849)	3,869,477	(1,207,510)	(153,105)
Benefit-Cost Ratio	N/A	1.24	0.94	0.99

Table 9: Cost-benefit sensitivity analysis results (low VSLY, 7% discount rate, $2019 prices)

	SP 1	SP 2	SP 3	SP 4
Capital costs	(9,878,628)	(14,486,422)	(15,847,263)	(16,511,364)
Operating costs	(2,473,083)	(1,672,275)	(2,451,704)	(1,514,723)
Renewal costs	(643,796)	228,439	(678,651)	324,745
Total costs	(12,995,507)	(15,930,258)	(18,977,618)	(17,701,343)
Environmental benefits	(32,126,525)	9,212,754	9,212,754	9,212,754
Health benefits	479,821	479,852	479,852	430,946
	-	2,029,627	-	-
Total benefits	(31,646,705)	11,722,232	9,692,605	9,643,700
Net Present Value	(44,642,212)	(4,208,025)	(9,285,013)	(8,057,643)
Benefit-Cost Ratio	N/A	0.74	0.51	0.54

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Potential governance and funding model

For all options, potential funding models have been considered using the DELWP Cost Allocation Framework as guidance. These funding models have been prepared at a high level to guide the options analysis report. The governance and funding models will be revised for the preferred option as part of Phase 2 of the consultancy.

The DELWP Cost Allocation Framework has five stages and include:

1. Allocate the benefits to each party
2. Allocate roles, responsibilities and cost to parties
3. Compare costs and benefits
4. Transfer between parties
5. Define gap and transfer unquantifiable benefits

All quantified benefits are distributed to the broader Penshurst community as they are the key beneficiaries of increased health and environmental outcomes.

Increased amenity benefits from improved greenspace would accrue to the broader community. Given the amenity benefits are likely through increased property prices, the distribution of these benefits will likely be localised to the Penshurst township. The benefit of avoided upstream water supply costs are received by Wannon Water who supply water to Penshurst. Given economic regulation from the ESC ensures cost reflective pricing of water tariffs, the true beneficiary of the avoided upstream water supply costs is the customer base of Wannon Water.

The second step to allocate costs based on roles and responsibilities. The DELWP Cost Allocation Framework allows for the allocation of roles and responsibilities based on appropriate expertise, experience, legal accountabilities and business risk. Given the current stakeholder engagement, Wannon Water and Southern Grampians Shire Council (SGSC) are considered the only two parties realistically relevant for Penshurst. Key points to consider in the allocation of roles and responsibilities include:

- Under the Health and Wellbeing Act 2008, Councils are required to ensure on-site systems do not impact on human health. They are also responsible for the provision of stormwater and open space services.
- The Statement of Obligations for Wannon Water state that the corporation, when considering types of sewerage services to be provided to unsewered urban areas, must consider fit for purpose options and identify the costs, benefits and risks to the community and customer base.
- For wastewater systems designed to manage more than 5000 litres a day, the monitoring of compliance shifts away from councils and to the Victorian EPA.

It is recommended for all options that Wannon Water is the lead agency for the wastewater options. This is because they are the most capable entity in delivering the solution packages at least cost and ensuring they are compliant to requirements (Such as EPA code of conduct). Whilst SGSC are legally responsible for ensuring the existing systems are compliant, the Statement of Obligations for Wannon

Water emphasises that Wannon Water should engage with councils and consider sewerage servicing options that are fit for purpose. As a result, there is no legal barrier for Wannon Water providing the sewerage infrastructure for Penshurst. Furthermore, the proposed solution packages may create systems that manage flows of more than 5000 litre/day, which are the responsibility of EPA to monitor and should be managed by Wannon Water.

For steps 3, 4 and 5, it is very important to note that the broader Penshurst community will be the funders of the infrastructure regardless of the governance option - either through council rates or through water tariffs. As these beneficiaries will contribute regardless of the governance model, the governance and funding options should consider models which are practical to implement.

As water tariffs are periodically determined through the ESC, it is likely to provide a more effective method of cost recovery from the broader community compared to council rates. The price determination will also likely mean that costs are shared across the whole customer base. Whilst this is broader than the Penshurst community, it could be argued that the community beneficiaries are broader than the SGSC rate-paying base as visitors will derive benefit from increased amenity, environmental and health benefits. Water tariffs provide an effective and established transfer mechanism for the broader community (the core beneficiaries) to contribute to the costs of the preferred solution package (Step 4 in the cost allocation framework).

SGSC should still be engaged with the delivery of the wastewater options given strong interactions with their broader role in the Penshurst community. Some infrastructure, such as grass swales for stormwater management and local cluster irrigation, would usually be the responsibility of SGSC. SGSC might consider either being the lead agency for the capital and ongoing costs of this particular infrastructure, or lower council rates where these wastewater and stormwater management functions are transferred to Wannon Water.

Frontier has provided these governance and funding recommendations at a high level to help facilitate discussion in the options assessment. We understand that in practice our recommendations may not align with stakeholder appetite or aspirations. We invite feedback on our recommendations in the stakeholder consultation to better refine the funding and governance arrangements for the preferred option in Stage 2.

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Cudgee wastewater options analysis

Economic Analysis Note

This note is structured as follows:

- Economics Analysis Framework – setting out the methodology for the economic analysis
- Economics Analysis Results – detailing the results of the economic analysis
- Funding and governance arrangements – guided by the DELWP cost allocation framework

Economic Analysis Framework

Overview

This economic analysis framework sets out the methodology used to complete the Cost-Benefit Analysis (CBA) for the Cudgee wastewater options analysis. This CBA framework is consistent with both Victorian Department of Treasury and Finance's Investment Guidelines. **Table 3** summarises the key assumptions which underpin the CBA:

Table 1: CBA key assumptions and parameters

Assumption/ Parameter	Value	Source (where applicable)
Year discounted to:	1 January 2020 (2019-20 financial year)	
Price base:	1 July 2019	
Design/construction start	2020	Based on cost profile provided by DWC
Design/construction duration	2 years	Based on cost profile provided by DWC
Benefits profile	100% of benefits begin after capital work is complete.	Based on pollutant and DALY flow profiles provided by DWC
Appraisal period	25 years from first full year of benefits	Based on flow data provided by DWC. Note this does not align with the asset life of each option

<table>
<tr><td>Discount rate used</td><td>7% real</td><td>Department of Treasury and Finance (2013), Economic Evaluation for Business Cases: Technical guidelines</td></tr>
<tr><td>Capital cost data</td><td>Solution package 1 - $1.94 mil
Solution package 2 - $2.94 mil
Solution package 3- $18.55 mil</td><td>Cost data provided by DWC</td></tr>
<tr><td>Operating cost data</td><td>Solution package 1 - $98,100 per year after upgrades complete
Solution package 2 - $110,638 per year after upgrades complete
Solution package 3- $99,234 per year after upgrades complete</td><td>Cost data provided by DWC</td></tr>
<tr><td>Renewal cost data</td><td>Solution package 1 - $325,600
Solution package 2 - $1.329 mil
Solution package 3 - $2,10 mil</td><td>Cost data provided by DWC</td></tr>
<tr><td>Pollutant flow data (compared to base case)</td><td><table><tr><td></td><td>TP</td><td>TN</td></tr><tr><td>SP 1</td><td>22%</td><td>45%</td></tr><tr><td>SP 2</td><td>197%</td><td>2341%</td></tr><tr><td>SP 3</td><td>28%</td><td>56%</td></tr></table></td><td>Pollutant flow data provided by DWC. Significant reductions in SP2 associated with reduced stormwater runoff compared to the base case</td></tr>
<tr><td>Changes in DALY</td><td>SP 1 – 0.143 DALYs reduction
SP 2 – 0.143 DALYs reduction
SP 3 – 0.099 DALYs reduction</td><td>DALY data provided by DWC</td></tr>
<tr><td>Cost per kg of TN in waterways</td><td>Low - $323 /kg/year
Medium - $3926 /kg/year
High - $6,645 /kg/year</td><td>Based on the construction of large wetlands that Melbourne Water would be required to undertake to remove pollutants if no other interventions are in place</td></tr>
<tr><td>VSLY</td><td>Low - $41,985
High - $180,000</td><td>Low - Median total income (excl. gov allowances) for Moyne Shire LGA, 2017
High – PMC VSLY guidance note 2014</td></tr>
</table>

Note: Bold items indicate parameters used in the central case. Parameters are escalated to 2019 prices where applicable

Note one inconsistency with DTF guidelines is the 25-year appraisal period, which is based on available data on benefit flows rather than the true asset lives of the solution packages. It is expected that most options have longer assets lives and as such benefit (and operating/renewal cost) streams will continue for longer. Instead of making assumptions about pollution flows beyond the 25 years, an appraisal period of 25 has been chosen. However this will inherently reduce the benefits of options with longer asset lives and will be explored in the Stage Two CBA analysis.

Base Case

The base case for the CBA has been provided by DWC and includes the following:

- Existing, older on-site wastewater management systems are replaced or renewed at an average rate of 4 systems a year until 2030, ramping down to one system upgrade a year until the end of the appraisal period. This is due to
  - voluntary replacement due to old age or failure;
  - a requirement as part of a planning or building permit process; and/or
  - an enforced upgrade due to a compliance issue.
- The total (average) cost of this upgrade is assumed to be $16,000 including approvals with an operational cost of $600 per annum (p.a.) including component replacement, servicing, power use and desludging.
- Existing on-site systems were assumed to cost the average owner approximately $200 p.a. (or $1,000 every 5 years, $2,000 per 10 years, etc.) to reflect periodic pump out of the septic tank, disposal field repairs, renewal or replacement and in some cases mechanical and electrical maintenance

It is important to note that this Base case scenario has incorporated the findings of the on-site containment potential mapping. Some of the properties in the Cudgee study area are unlikely to be capable of full on-site containment and as such the base case does not achieve full reductions in pollutant loads.

Solution packages

This CBA has been completed for three solution packages (SPs) provided by DWC– SP1, SP2 and SP3. **All** the options assume the community continue to gradually upgrade their existing systems on the larger (>4,000m^2) properties. Consequently, the solution packages include the initial investment but are followed by a more prolonged investment on the gradual upgrade of on-site systems.

Table 2 provides an overview of the scope of each option. All the options assume the community continue to gradually upgrade their existing systems on the larger (>4,000m^2) properties. Consequently, the solution packages include the initial investment but are followed by a more prolonged investment on the gradual upgrade of on-site systems.

Table 2: Key features of project options

Solution package	Description
Solution package 1: Small Cluster Systems for Constrained Properties + Retain Sustainable On-site Systems	Solution package 1 involves business as usual for existing properties capable of managing all wastewater on-site in accordance with EPA which is owner managed systems upgraded in an ad hoc manner. There are some isolated, constrained properties that would have an advanced on-site system managed by a central entity using remote monitoring (7 properties). The other 7 constrained properties would have an upgraded-on site system managing part of the design effluent flow inside the site and excess recycled water would then be pumped into a pressure sewer to a couple of small cluster systems.
Solution package 2: BaU with Stormwater Detention, Treatment and Wetland Feature	One of the pressing issues identified during consultation was perceived inadequate management of stormwater in some areas of Cudgee. Some of these issues appear to be impacting on the performance of on-site systems on lots that otherwise should be capable of sustainable on-site management. Given the limited health and environmental impact of the BaU, this option looks to target investment to ensuring the limited impacts from periodic discharge of sewage into waterways are adequately polished and naturalised. In addition, these stormwater treatment and detention measures will reduce some of the background nutrient impacts associated with stormwater runoff. These stormwater derived TN reductions have been artificially added to the pollutant reduction calculations.
Solution package 3: Partial On-site Reuse / Containment with Excess to Small Irrigation (Reuse) System	Involves retention of BaU for onsite systems on larger lots. Smaller / constrained sites to have a new secondary treatment system installed that irrigates recycled water for residential reuse (restricted access). Excess effluent would be pumped via a pressure sewer to a central location for storage, polishing and reuse by (most likely) irrigation.

Costs

P50 cost estimates have been profiled based on available cost data from DWC. This includes capital cost data, operating expenditure and renewal expenditure. Renewal costs include renewal of on-lot components, local treatment/storage and effluent management.

It should be noted that it is assumed there is no residual asset value at the end of the appraisal period.

Benefits

The benefits included in the CBA have been developed to incorporate available data from DWC. The benefits used in the CBA include:

- Avoided environmental costs from total nitrogen loads in waterways
- Health benefits from reduced exposure to wastewater

We discuss these benefits in more detail below

Environmental benefits

One expected benefit is the improvement in water quality due to the reduction in pollutants. Sustainable IWN management practices can help reduce pollutant loads in waterways and are more able to mimic natural flow regimes.

A range of valuation techniques are available to estimate the environmental benefits of improved waterway health. However, most of these techniques require a detailed understanding of the receiving waterways and the incremental change to waterway health which is beyond the scope of this initial CBA. For this CBA, environmental benefits have been calculated at a high level through the use of an indicative value of water quality derived from the Melbourne Water stormwater offset costs, currently at $6,645 per kg of nitrogen removed per year.

The price is based on the construction of large wetlands that Melbourne Water would be required to undertake to remove pollutants if no other interventions are in place. If the benefits of constructing these particular wetlands exceed the costs, the cost can represent a lower-bound for the benefits of reducing nitrogen in the waterways.

It is important to note that the $6,645/kg/year is based on the maximum cost of constructing a wetland to reduce nitrogen loads in the Melbourne Water jurisdiction. It is unreasonable to assume that this cost is representative of Cudgee, where land is more available and the receiving wetlands are fundamentally different to those in Melbourne Water's jurisdiction. Constructed wetlands also bring other benefits to the community such as increased amenity. As such, using the cost of the wetlands as a proxy of the value may also be incorporating broader benefits that may not be relevant for Cudgee. In the same study, a low cost of $323/kg/year and a weighted average cost of $3,926/kg/year are also calculated.

In the absence of a better understanding of environmental benefits from the different servicing options, a value of $3,926/kg/year has been adopted for the central estimate. This assumption is tested using the low and high values from Melbourne Water in the sensitivity analysis.

Health benefits

The current wastewater servicing option for Cudgee currently does not meet EPA Code of Practice and as such poses a risk to community health. This risk includes exposure to untreated wastewater and contamination of local waterways. The solution packages all aim to address this by aligning with EPA code of practice and significantly decreases instances of contamination and exposure.

Disability adjusted life years (DALYs) have been provided by DWC for each option and directly relate to the improved health benefits from reduced exposure risk. The value of a DALY lost in the CBA is set to be equal to median total income for the Moyne Shire LGA. Median income is recommended as the willingness to pay to reduce DALYs as it theoretically represents the median marginal product of an individual in Cudgee.

This value should represent a lower-bound as it only takes into account the direct productivity loss of that year. It does not take into the intrinsic value of the DALY to an individual. As such, an upper bound of $180,000 is included in the central case. This value represents the willingness to pay for an individual to avoid one DALY, as described by the Prime Minister and Cabinet guidance note on the value of a statistical life. The median income value is included in the sensitivity analysis.

Health benefits associated with increased recreation on improved green space, whilst potentially a relevant benefit, has not been quantified given data limitations.

Benefits not included in the CBA

Table 3 provides an overview of the identified benefits not included in the CBA and why they have not been considered quantitatively.

For Stage Two of the Cudgee options assessment these benefits will be explored in more detail.

Table 3: Overview of benefits *not* included in CBA

Benefits not included in CBA	Reason for exclusion in CBA
Avoided upstream water costs from recycled water use	A lack of understanding on the extent of irrigation water replacing existing potable water use
Reduced wastewater disruption (frequency and duration)	Lack of data on disruption frequency and duration, and an appropriate willingness to pay to avoid this frequency.
Reduced likelihood of water restrictions through increased availability of recycled water	Will depend on the use of irrigation water which is uncertain. Likely to be minor given small population and irrigation volumes
Amenity benefits from increased green and blue space	Lack of data on where improved incremental green and blue space would occur.
Health benefits associated with increased green space (e.g. recreation, urban heat, mental health)	Increased green-space unlikely in Cudgee case study and impact expected to be minor given small population affected.
Benefit directly associated with meeting EPA requirements	No associated monetisation method available, and likely to double-count environmental and health benefits
Specific environmental benefits from servicing options (e.g. willingness to pay for improved waterway outcomes)	Will likely be double counting with proxy value used for reduced nitrogen levels. Lack of data and local WTP for environmental outcomes makes it difficult to value other potential environmental benefits
Enabling town growth as infill plots are not constrained by on-site wastewater containment requirements	Not considered a direct impact of improved wastewater management, but changes to wastewater management an important enabler

Amenity benefits associated with increased blue and green space may be an important benefit stream. Data availability on how the green and blue space is likely to improve means that this benefit can only be discussed qualitatively at this stage. It should be noted that amenity benefits that directly relate to improved environmental benefits might overlap with the environmental benefits estimated with the reduced nitrogen loads.

One quantifiable benefit would derive from increased property price values from increased green and blue space. For example, Rosetti (2013) finds that around 8% of property prices are attributable to greenspace.[1] If we apply this value to all Cudgee households (65) with a median property price of $193,000[2], an indicative open space amenity benefit would be approximately $ 873,132 in NPV.

A better understanding of the green space improvements would be required to include this benefit in the CBA analysis. At a high level, the solution packages for Cudgee are unlikely to significantly improve the quantity or quality of greenspace. However, they may increase the quality of Brucknell Creek (the local waterway) and this may have associated property benefits for Cudgee properties. The percentage uplift in property prices would also need to be representative of the Cudgee region. The 8% property uplift percentage is capturing property price increases for capital cities across Australia and is likely not representative of regional south-west Victoria.

One benefit difficult to determine but has been raised in stakeholder engagement is the enabling of infill development. Currently, the requirement of on-site containment through septic tanks limits developments below a certain property size. This can significantly constrain infill development and may be a factor of slow or declining growth in regional towns. Benefits of town growth might include increases in surrounding property prices, increased economic activity in the town and improved community environment.

Whilst changes to wastewater management is an important enabler for town growth, it will not necessarily guarantee development in the town. Town development will occur due to a range of factors, and attributing town development benefits just to one enabling factor such as wastewater is not appropriate in an economic assessment such as this. With this said, it should be an important consideration in the decision making process of the preferred option.

Finally, avoided upstream water supply costs from increased use in recycled water may also represent a benefit that could be quantified in Phase 2 with a better understanding on how recycled water will replace potable water. SP3 includes irrigation for residential use due to secondary treatment on-site on constrained households, but there are only very few constrained households and this irrigation might not displace existing irrigation demand.

Sensitivity Analyses

Given that the CBA is somewhat high-level due to data availability, it is important that robust sensitivity analyses are completed in order to reflect the key uncertainties around the project. The sensitivity analyses for this CBA are:

- Applying a 4% and 10% real discount rate to the central case analysis;

[1] Rossetti.J (2013), Valuation of Australia's Green Infrastructure: Hedonic Pricing Model Using the Enhanced Vegetation Index. The Hedonic Pricing Model suggests that a one standard deviation increase in the Enhanced Vegetation Index, within a postal code region leads to a house price premium of between 8.62% and 15.57%. A conservative measure of 8% has been adopted for illustrative purposes

[2] Valuer-General Victoria, 2019, median property price for June 2019 in Hamilton, Victoria

- Applying the higher and lower estimates for the value of water quality improvements to the central estimate
- Applying the lower bound value for health benefits to the central estimate

These sensitivity analyses are considered to be the most reasonable approach to testing the uncertainties with respect to the Cudgee wastewater options.

Economic Analysis

Results

The results of the CBA are presented below. This analysis is based on the methodology set out in the previous section.

Table 4: Cost-benefit analysis results (Central case, 7% discount rate, $2019 prices)

	SP 1	SP 2	SP 3
Capital costs	(895,548)	(1,787,012)	(2,001,812)
Operating costs	(793,290)	(909,770)	(787,644)
Renewal costs	33,121	(304,662)	(1,011,267)
Total costs	(1,655,718)	(3,001,444)	(3,800,723)
Environmental benefits	82,371	2,575,743	74,645
Health benefits	77,393	69,244	71,240
Total benefits	159,764	2,644,987	145,885
Net Present Value	(1,495,954)	(356,457)	(3,654,838)
Benefit-Cost Ratio	0.10	0.88	0.04

These results show that the Benefit Cost Ratio (BCR) for the various solution packages are in the range 0.02 to 0.86. SP2 is clearly preferred to SP1 and SP3 for the central case as it has the capacity to significantly reduce nitrogen loads from stormwater runoff.

These BCR values for SP1 and SP3 are extremely low, and suggest that for every dollar spent only 2-6 cents is returned as benefits to the community. This is because the base case has significant reductions in pollutant loads directly from wastewater. SP1 and SP3 do not achieve significant incremental reductions in pollutants from wastewater or stormwater relative to the base case. For example, SP1 has a total NPV cost of $236,500 per constrained property – more than the approximate median house price in the region.

From the CBA, the base case is still the best option when considering the quantified benefits as all other options do not deliver value for money outcomes for Cudgee.

Whilst this BCR for SP2 is still below one, this has been a partial economic analysis based on limited available data and conservative assumptions. It is important to explore unquantified benefits, and might include:

- Enabling town growth as infill development no longer restricted through on-site containment requirements
- Improved health outcomes from avoidance of periodic overflow events not already captured in the health benefits
- Increased irrigation from SP3 – which might increase amenity and have avoided upstream water saving benefits.
- Improved wastewater services – reducing disruptions

Enabling town growth may be a significant benefit for the town of Cudgee given its proximity to Warrnambool. The business as usual wastewater option of septic tanks restricts infill development as new developments require the ability to have on-site containment. Stakeholder engagement suggested some of those in the community would value town growth and this may be better enabled through the wastewater solution packages. As described previously, changes to wastewater management is an important enabler for town growth, but it does not necessary lead to growth. As it is not a direct impact, it cannot be quantified in the economic analysis but should be considered as an important factor as part of the decision-making process.

For SP2, amenity may be another important factor as significant reductions in pollutant loads from improved stormwater management may improve waterway quality. The stormwater treatment and detention may also provide incremental greenspace compared to the base case.

It is important to note that it is unlikely that amenity, irrigation and reduced disruption benefits for SP1 and SP3 will be significantly more than SP2 to make these the preferred options.

In conclusion, the base case is the preferred option under the central case when only considering the quantified costs and benefits. Given improved wastewater and stormwater management might enable further town growth and may provide additional amenity benefits, it is likely that SP2 delivers value for money when considering unquantified benefits.

Sensitivity Analyses

As per the economic framework, the following presents a number of sensitivity analyses which have been undertaken as part of the economic analysis.

The sensitivity analyses show that when varying key uncertainties with respect to the CBA that the BCR for the preferred option ranges from 0.09 to 1.48. Sensitivities on the value of TN removed from the waterways drives significant variation in results – and creates significant uncertainty on whether SP2 or the base case is the preferred option.

As discussed previously, the value used to measure the environmental benefits is based on the offset values estimated by Melbourne Water. It is unlikely that the costs of nitrogen runoff is as significant as

Port Phillip given the higher total pollutant loads in urban environments and the constrained environment the infrastructure must exist in. It may be argued that the central estimate in this CBA may overstate environmental benefits unless the pollutant loads are impacting particularly sensitive environments. This question needs attention in Stage 2 when SP2 is likely to be compared in more detail against the base case – particularly to confirm the specific environmental benefits from the reduced pollutants and to quantify these benefits with tailored monetisation factors relevant to Cudgee.

Table 5: Cost-benefit sensitivity analysis results (4% discount rate, $2019 prices)

	SP 1	SP 2	SP 3
Capital costs	(902,600)	(1,837,060)	(2,014,371)
Operating costs	(1,075,336)	(1,241,580)	(1,069,873)
Renewal costs	53,102	(479,902)	(1,250,618)
Total costs	(1,924,834)	(3,558,542)	(4,334,862)
Environmental benefits	93,669	3,535,777	81,708
Health benefits	86,473	78,021	77,643
Total benefits	180,142	3,613,798	159,351
Net Present Value	(1,744,692)	55,256	(4,175,511)
Benefit-Cost Ratio	0.09	1.02	0.04

Table 6: Cost-benefit sensitivity analysis results (10% discount rate, $2019 prices)

	SP 1	SP 2	SP 3
Capital costs	(883,065)	(1,735,107)	(1,968,636)
Operating costs	(610,018)	(695,174)	(604,783)
Renewal costs	23,001	(194,299)	(825,037)
Total costs	(1,470,082)	(2,624,579)	(3,398,456)
Environmental benefits	72,961	1,960,282	68,259
Health benefits	69,794	61,954	65,623
Total benefits	142,755	2,022,236	133,882
Net Present Value	(1,327,327)	(602,343)	(3,264,574)
Benefit-Cost Ratio	0.10	0.77	0.04

Table 7: Cost-benefit sensitivity analysis results (Low cost of nitrogen in waterways, 7% discount rate, $2019 prices)

	SP 1	SP 2	SP 3
Capital costs	(895,548)	(1,787,012)	(2,001,812)
Operating costs	(793,290)	(909,770)	(787,644)
Renewal costs	33,121	(304,662)	(1,011,267)
Total costs	(1,655,718)	(3,001,444)	(3,800,723)
Environmental benefits	6,777	211,912	6,141
Health benefits	77,393	69,244	71,240
Total benefits	84,170	281,156	77,381
Net Present Value	(1,571,548)	(2,720,288)	(3,723,342)
Benefit-Cost Ratio	0.05	0.09	0.02

Table 8: Cost-benefit sensitivity analysis results (High cost of nitrogen in waterways, 7% discount rate, $2019 prices)

	SP 1	SP 2	SP 3
Capital costs	(895,548)	(1,787,012)	(2,001,812)
Operating costs	(793,290)	(909,770)	(787,644)
Renewal costs	33,121	(304,662)	(1,011,267)
Total costs	(1,655,718)	(3,001,444)	(3,800,723)
Environmental benefits	139,418	4,359,606	126,342
Health benefits	77,393	69,244	71,240
Total benefits	216,811	4,428,850	197,582
Net Present Value	(1,438,907)	1,427,406	(3,603,141)
Benefit-Cost Ratio	0.13	1.48	0.05

Table 9: Cost-benefit sensitivity analysis results (Low VSLY, 7% discount rate, $2019 prices)

	SP 1	SP 2	SP 3
Capital costs	(895,548)	(1,787,012)	(2,001,812)
Operating costs	(793,290)	(909,770)	(787,644)
Renewal costs	33,121	(304,662)	(1,011,267)
Total costs	(1,655,718)	(3,001,444)	(3,800,723)
Environmental benefits	82,371	2,575,743	74,645
Health benefits	17,303	15,481	15,928
Total benefits	99,674	2,591,224	90,573
Net Present Value	(1,556,044)	(410,220)	(3,710,150)
Benefit-Cost Ratio	0.06	0.86	0.02

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Potential governance and funding model

For any IWM project, it is important to establish potential governance and funding models guided by the DELWP cost allocation framework.

In this economic assessment, either the base case or SP2 will be the preferred option depending on the environmental benefits. For both options, Frontier recommends that there is little to no change to the current governance or funding arrangements in Cudgee, and that Moyne Shire Council continue to lead wastewater management. This is because the majority of benefits are associated with Moyne Shire Council through improved stormwater management. Wannon Water does not have the responsibility of stormwater management in Cudgee, and as such does not need to be included in the governance arrangements.

Moyne Shire Council should consider:

- Continued monitoring and assessing of pollution levels
- Exploring the potential of using council funds directed to stormwater management to fund the upfront and ongoing infrastructure. Council rates (or other mechanisms that collects revenue from Cudgee residents) represents the most appropriate funding model as Moyne Shire Council residents are the direct benefactors of improved amenity and local environmental outcomes (relevant for SP2)
- Considering policy mechanisms for encouraging gradual replacement of current systems if the base case is the preferred option (such as financial incentives or quality requirements)
- Assessing how wastewater management may provide a barrier for potential growth in the township

It is noted that Cudgee may experience significant growth over the appraisal period which will necessitate wastewater solutions. This growth may require different governance and funding arrangements as described above and a change in the preferred solution package. It is difficult to determine the appropriate arrangements without understanding the preferred options and nature of the development growth. The current governance and funding arrangements should be reconsidered if a solution package is chosen as an enabler for development, or significant infill development occurs without changes to the wastewater servicing options.

Frontier has provided these recommendations at a high level to help facilitate discussion in the options assessment. We understand that in practice our recommendations may not be applicable or realistic. We invite feedback on our recommendations in the stakeholder consultation to better refine the funding and governance arrangements for the preferred option in Stage 2.

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Appendix E: Community Feedback Summaries

Please refer to Survey spreadsheet files for both towns within attached Appendix E (.zip) folder.

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