DECENTRALISED WATER CONSULTING

Un-sewered Village Wastewater Risk Assessment and Prioritisation for High-level Servicing Options

MIDCOAST council

5/08/2021

Document Control Sheet

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	Title	Un-Sewered Village Risk Assessment And Prioritisation For High-Level Wastewater Servicing Options
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Revision / Checking History

Revision History	Date	Checked By		Issued By	
R.0351.001.00	26 April 2021	BAA		JS	
R.0351.001.01	5 August 2021	BAA		AW	Aw.

Acknowledgment

DWC acknowledges the Traditional Custodians throughout Australia and their continuing connection to land, water, culture and community, and pays respect to their Elders past, present and future.

Limitations Statement

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

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

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1 Introduction

Decentralised Water Consulting (DWC) have prepared this report to assist MidCoast Council (MCC) in understanding the risks from On-site Sewage management systems in un-sewered villages across the Local Government Area (LGA). The report outlines the results from a risk prioritisation assessment designed to identify high risk villages and presents potential high-level options to improve wastewater management for these areas. Wastewater is currently managed in these villages by individual on-site and off-site wastewater management systems (systems) with approval and performance regulated by MidCoast Council. Based on available data and feedback from MCC the systems within these areas are of varying type, age, capacity and condition.

A previous risk prioritisation for small unsewered communities (*Small Communities Wastewater Risk Assessment*) was prepared in 2000. As part of this project DWC worked with MCC to update and revise the previous risk assessment process to reflect more recently available data and information. In addition, the assessment process was able to include key areas within the Gloucester Shire since becoming part of the MCC area of operation because of Council amalgamations.

The project consisted of the following elements:

- Review of previous prioritisation report,
- Data review and selection of villages,
- Development of a risk prioritisation methodology,
- Assessment and ranking of the agreed villages,
- Engagement with MCC,
- Development of high-level options (including initial cost estimation) with focus on top ranked villages,
- Development of example case studies for 5 selected villages.

The updated risk prioritisation process has utilised a Multi-Criteria Analysis (MCA) based on key categories and sub-categories developed in conjunction with MCC.

1.1 Project Drivers

The previous risk assessment completed in 2000 captured the LGA's of Great Lakes and Greater Taree, and therefore needs to now include Gloucester Shire as it has become part of the MCC area of operation. This project has leveraged off the previous on-site hazard mapping work completed as part of the MCC *On-site Sewage Development Assessment Framework* (DAF) project. This involved an assessment across the entire MCC LGA of land capability and receiving environment hazards related to On-site Sewage Management with a single hazard class label assigned to each property based on the identified constraints. The basis for the MCC DAF hazard class includes the relevant regulatory instruments, guidelines and standards applicable to on-site sewage management and therefore provides a robust basis for evaluating the sustainability and risks associated with continuation of owner managed on-site systems through the wastewater management strategy.

The intention of this project was to utilise existing assessments and data to apply a transparent, scientifically robust risk prioritisation process for un-serviced towns, villages and localities across the new MCC area of operation. Specifically, the technical outputs from the DAF project offered a sound basis for a Multi-Criteria Assessment (MCA) process formulated in conjunction with MCC stakeholders. The outcomes of this project will enable MCC to prioritise resourcing towards high-risk villages where the benefits of investment in improved wastewater services are likely to be maximised.

In addition, this project has included consideration of high-level servicing options that encapsulate a broader range of options at a wider variety of scales including decentralised servicing approaches. Since the 2000 study, there has been considerable progress in the technological, regulatory, governance and operational aspects of small and decentralised wastewater servicing approaches. Examples include the advent of remote monitoring and control, machine learning and IoT (Internet-of-Things) to enable centralised, real-time, automated operation and monitoring of decentralised systems. Additionally, there has been an increase in legislative structures to enable the delivery of decentralised water services (e.g. the *Water Industry Competition Act*) and increased consideration of water sensitive and liveability connections between water management and development.

2 Background

The basis of this project is an update and revision of a previous risk prioritisation for small unsewered communities *(Small Communities Wastewater Risk Assessment)* undertaken in 2000. Since the formation of the new MidCoast Council, it is timely for the assessment to include any high-risk villages identified within the Gloucester Shire. Importantly, given the time that has elapsed since the previous prioritisation was undertaken several of the areas have either been provided with reticulated sewer or require re-assessment due to changes that have occurred within the villages over the last 20 years. Table 1 below presents a list of villages located within the Great Lakes and Greater Taree regions identified in the previous risk assessment report as the highest priority for improved wastewater servicing.

Table 1 Key Village Ranking

Priority Group	Villages Great Lakes LGA	Villages Greater Taree LGA
1	Coomba Park	Bungay
	North Arm Cove	
	Stroud Road	
2	Allworth	Cedar Party
	Shearwater	Crowdy Head
3	Pindimar (North and South)	Forrest Downs
	Bundabah	
	Nerong	

2.1 Available Data

A summary of the available data and information collated by DWC and utilised as part of the risk prioritisation (MCA) process is provided in Table 2 below.

Table 2 Available Data Summary

Data	Description	Data Source
Properties / Lots	Cadastral layer – MCC	MCC
Suburbs / Localities	Defined suburbs and localities across MCC area.	MCC
Land Capability for Onsite Wastewater Management	Captured within Risk Mapping developed for MCC DAF.	DWC / MCC
Risk to Receiving Environments		

Data	Description	Data Source
Potable Water	Reticulated potable water layer	MCC Water Services
Watercourses / waterbodies	State-wide data layers	MCC
Sensitive Ecological Catchments	Catchments draining to sensitive Great Lakes waterbodies.	MCC
Drinking Water Catchments / Potable Groundwater Bores	Surface potable water catchments defined by MCC Water Services, including groundwater bores used for potable water extraction.	MCC
SEPP Coastal Zones (2018)	Latest SEPP Coastal / Aquaculture Zones included as part of DAF risk mapping discussed above.	MCC
SEPP Primary Production and Rural Development (2019) - Aquaculture Zones		
Stormwater Infrastructure	Available stormwater data for MCC.	MCC

3 Risk Based Prioritisation

3.1 High Risk Villages / Areas

An initial review of a list of high-risk villages provided by MidCoast Council (MCC) was undertaken by DWC based on available collated data sets and information (discussed in Section 2.1). This included determining the approximate number of high-risk properties within each of the MidCoast LGA villages based on the spatial layer provided by MCC. For the purposes of this report high-risk properties are defined as those with a property size <2,000m^2 and/or classed as high hazard under the DAF.

The study area selected for each village was determined based on detailed notes provided by MCC in conjunction with village LEP zoning information. This included the addition of potential village areas within the former Gloucester Shire regions not previously considered in the report prepared in 2000. Appendix B includes the detailed Village notes provided by MCC to define the study areas for this project.

3.2 Methodology

A Multi-Criteria Analysis (MCA) methodology was developed and applied to the risk assessment process. The broad categories and sub-categories selected for the risk assessment process are presented in Figures 1 – 5 below with a greater level of detail including the scoring methodology documented in Table 3. A summary of the basis and source data used for scoring each nominated area against the sub-categories is also presented. The selected criteria, their definition, proposed source data and scoring method were subject to review by MCC prior to completion of the MCA.

A distinction has been made between the *long-term sustainability* of on-site wastewater management versus the *current impacts and performance* of existing systems. This recognises that properties within the nominated villages may be suitable for long-term on-site wastewater management subject to upgrade of the existing system. In most situations, areas with the potential for safe and sustainable on-site sewage management will be most cost effectively serviced in this manner.

Inclusion of existing on-site system performance data into the risk assessment process was considered but not taken forward due to limitations on the availability of data. MidCoast Council confirmed that spatial on-site system type data is only available for the former Great Lakes LGA and therefore this may skew the results for high-risk villages in this LGA if utilised.

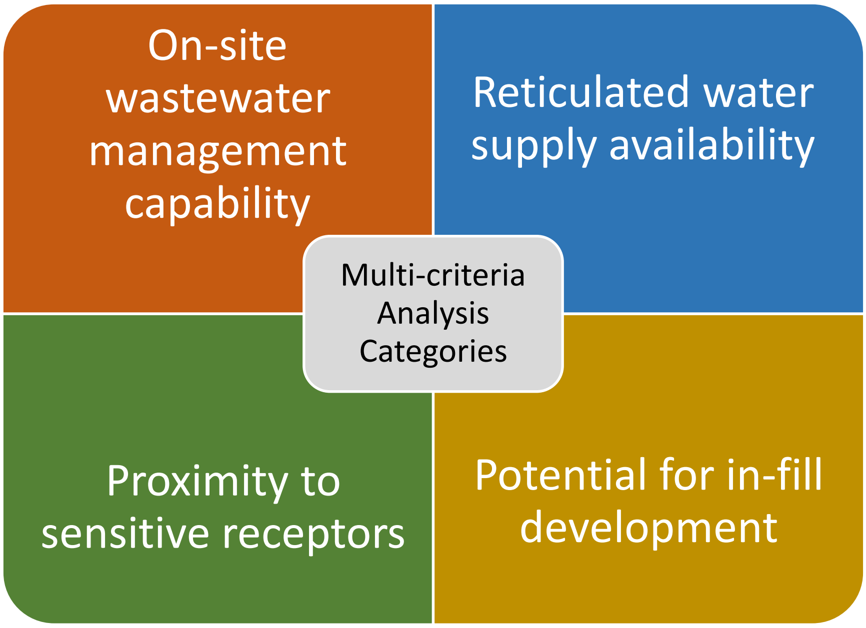


Figure 1 Multi-Criteria Analysis Categories

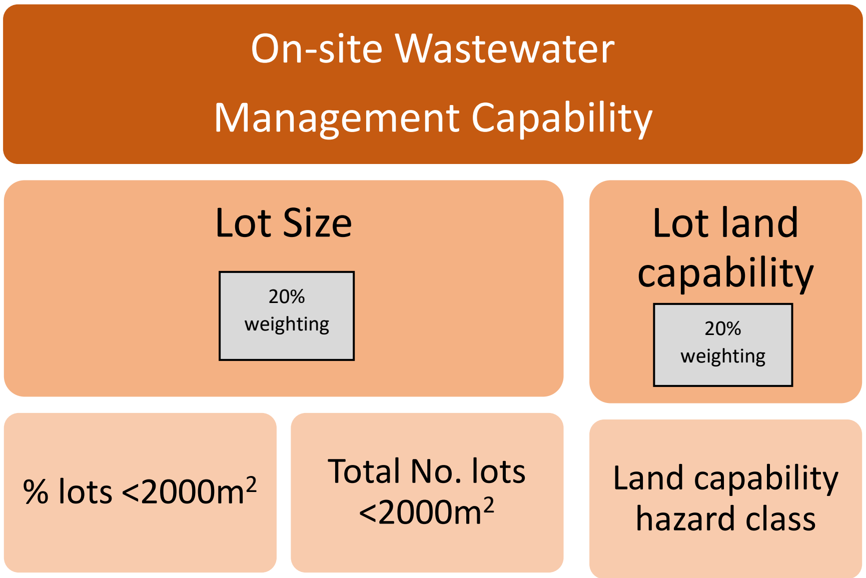


Figure 2 On-site Wastewater Sub-categories

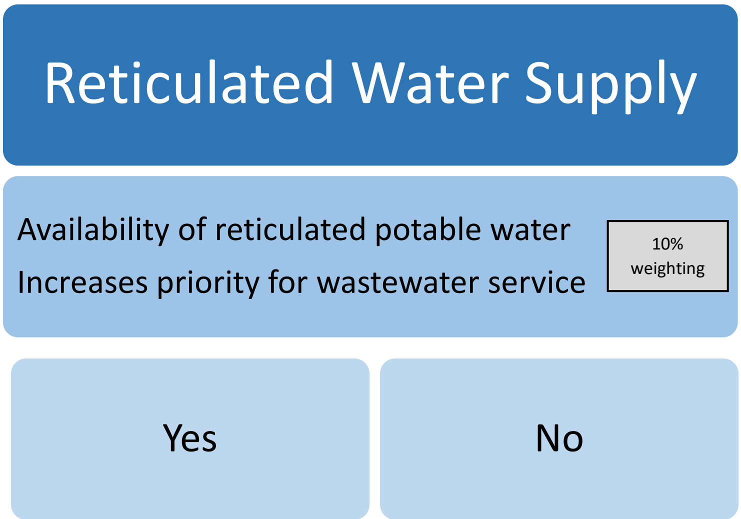


Figure 3 Reticulated Water Supply Scoring Method

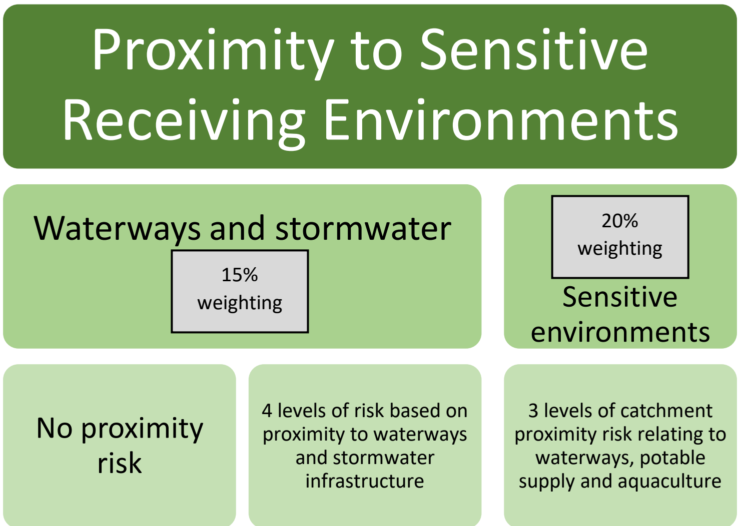


Figure 4 Proximity sub-categories and Scoring Method

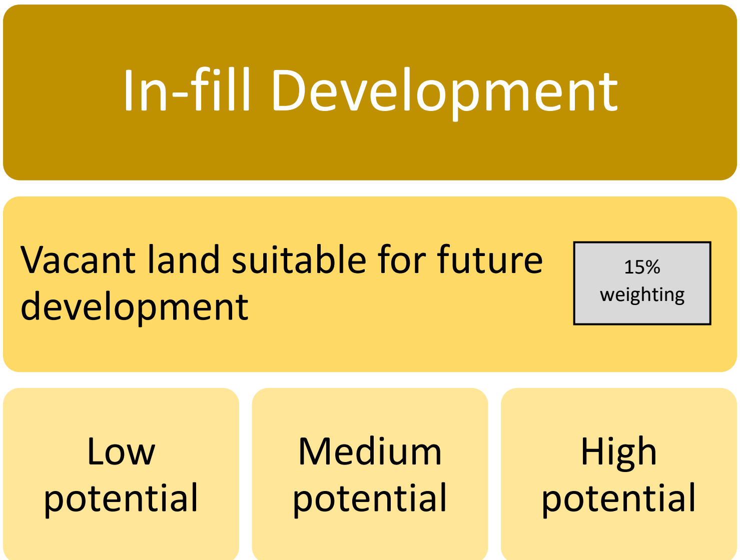


Figure 5 In-fill Development Scoring Method

Table 3 MCA Methodology Detail and Scoring

Category	Sub-category	Description	Scoring Method		Weighting
On-site Wastewater Management Capability	Lot size	% of lots <2,000m^2 or defined high hazard under the MCC DAF	**Percentage of Properties <2,000m^2 and/or DAF High Risk**		20%
			0 – 20%	0	
			21 – 40%	1	
			41 – 60%	3	
			61 – 80%	4	
			81 – 100%	5	
			Total No. of Properties <2,000m^2 and/or High Risk (added to above score with max. of 5)		
			<20	no change to score	
			21 – 30	+1	
			31 – 40	+2	
			41 – 50	+3	
			>50	Score = 5	
	Lot land capability	Land capability hazard based on hazard mapping developed for MCC DAF	**Average Land Capability Hazard Class**		20%
			Average High Hazard	5	
			Average Medium Hazard	3	
			Average Low Hazard	1	
Reticulated water supply availability	-	Availability of reticulated potable water			10%

Category	Sub-category	Description	Scoring Method		Weighting
		Captures existing village water infrastructure. Increased priority for wastewater service	Yes	3	
			No	1	
Proximity to sensitive receiving environments	Waterways / waterbodies and stormwater infrastructure	**Waterways** - Proximity of lots to intermittent versus perennial waterways / waterbodies as an indicator of the risk of pollutant transport **Stormwater** - Proximity of lots to stormwater pipes and pits\ Accuracy of provided data ~60-70% according to MCC	All properties within 100m distance to permanent / named waterway and/or waterbody	5	**15%**
			Drainage from approx. 50-75% of total properties to permanent / named waterway and/or waterbody	4	
			Drainage from approx. 1-50% of total properties to permanent / named waterway and/or waterbody	3	
			Drainage from approx. 1-50% of total properties to *intermittent* waterway / dam	2	
			No risk to waterway / waterbody	0	
			Add 1 point to score where stormwater infrastructure present within town / village to reflect elevated risk if failure of on-site systems occurs		
	Potable / ecologically sensitive catchments	Proximity of lots to potable water catchment or other sensitive catchments (defined in DAF) **Zone 1** – Direct hydraulic catchment to sensitive lake area	**Proximity Zone**		**20%**
			Within zone 1	Sub-score 5	
			Within zones 2 or 3	Sub-score 3	

Category	Sub-category	Description	Scoring Method		Weighting
		Zone 2 – Broader drinking water catchment (MidCoast Water defined areas) **Zone 3** – SEPP aquaculture zone (500m buffer)	Not within any zone	Sub-score 0	
In-Fill development	Vacant lots / Parcels that are potentially developable	Capture potential for development of existing vacant lots within the village extents, and thus potential for future growth capacity. Captures both the potential to exacerbate impact and justify a whole of town solution.	**Infill development potential**		**15%**
			Low potential	0	
			Medium potential	3	
			High potential	5	

3.2.1 MCC Workshop

The risk assessment and prioritisation processes were discussed at a workshop held at MCC offices on 25 June 2020.

The primary purpose of the workshop was to discuss and agree on the MCA methodology and the weightings for the six (6) sub-categories. Agreed weightings are presented in Table 3 with the Workshop Minutes provided in Appendix A.

3.3 Results of the Multi-Criteria Analysis

The MCA scoring for each sub-category across all un-serviced villages and the ranking or prioritisation is provided in Figure 6 below.

This figure presents the combined MCA scores for each village with the appropriate weighting applied to the relevant sub-category. A larger weighting means the specific sub-category is considered more important by MCC. The higher the stacked column, the greater the combined score and therefore the higher the risk from existing on-site wastewater management. This indicates a greater priority for consideration for an improved wastewater service.

As an example:

Coomba Park received the highest score of 5 for the land capability risk sub-category however a resulting score of 1 is obtained once the 20% weighting is applied. Thus, each sub-score was multiplied with the relevant weighting, and the sub-scores summed for each of the villages. In the case of Coomba Park a combined score of 4.6 was obtained out of a maximum score of 5.

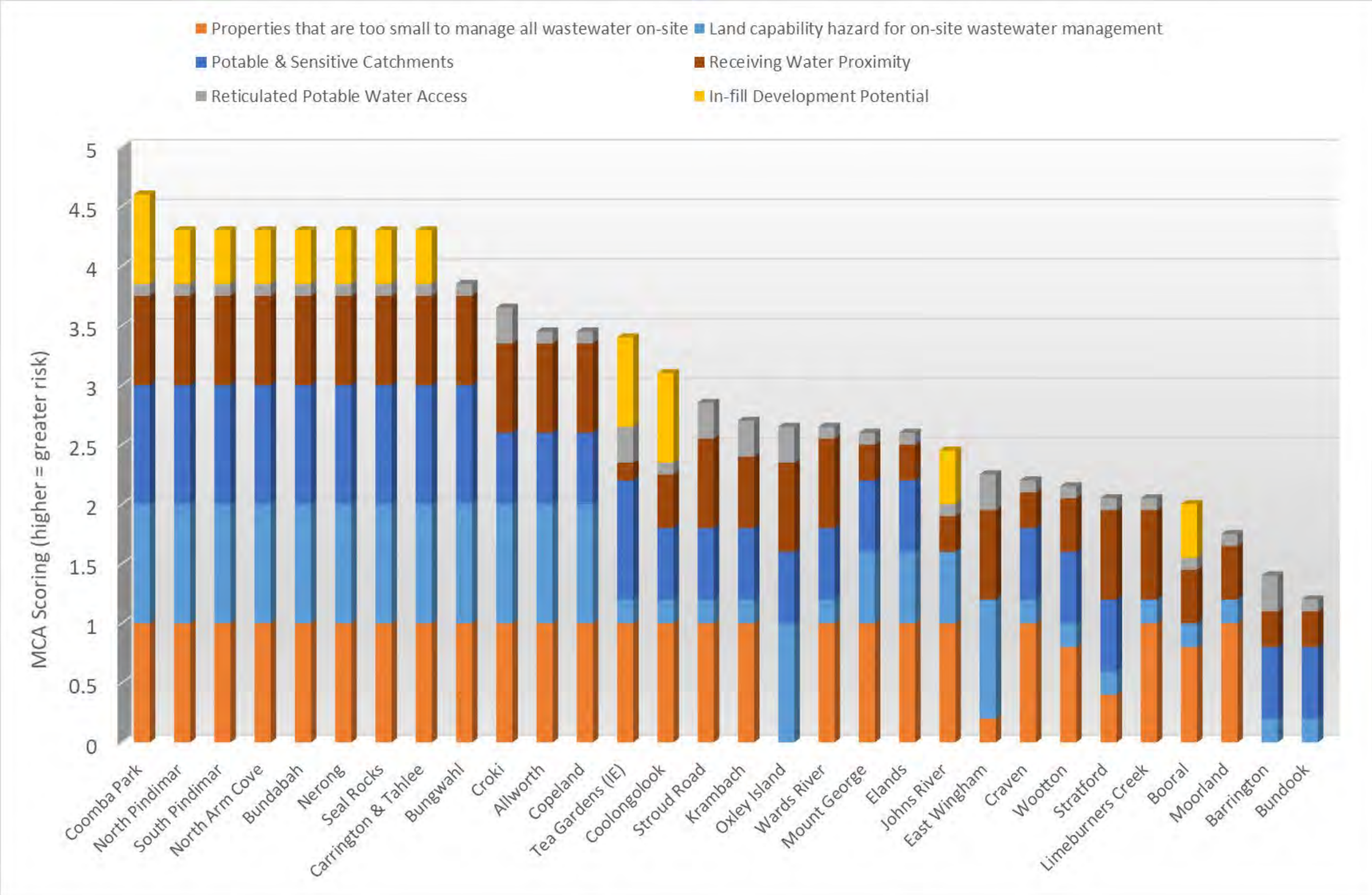


Figure 6 MCA Weighted Results

Based on the MCA prioritisation process the villages with the highest rank are summarised in Table 4.

Table 4 Key Villages by Ranking

Rank	Score	Village	Key Factors Influencing Rank
1	4.6	Coomba Park	Received highest score across all criteria other than reticulated water supply availability. Located on Wallis Lake with small sloping lots and low permeability soils. Significant potential for development of existing vacant lots.
2	4.3	North Pindimar	Received highest score for lot size, land capability, receiving environment sensitivity and proximity. Slightly less in-fill development potential than Coomba Park.
		South Pindimar	
		North Arm Cove	
		Bundabah	
		Nerong	
		Seal Rocks	
		Carrington & Tahlee	
9	3.9	Bungwahl	Comparable to the 6 villages ranked equal 2nd other than the in-fill development potential.
10	3.7	Croki	Constrained by property size, land capability (flooding and groundwater), proximity to Manning River and presence of aquaculture nearby. Limited in-fill growth potential compared to higher ranked areas. Receiving water less sensitive to ecological impact.
11	3.5	Allworth	Like Croki apart from the availability of a reticulated water supply (higher wastewater generation).
		Copeland	
13	3.4	Tea Gardens Industrial Estate	Driven by small lot size, sensitivity of catchment and in-fill potential.
14	3.1	Coolongolook	Small lot size, proximity to Wallis Lake and potential for in-fill development.

This ranking prioritises villages based on the risk and constraints associated with long-term on-site sewage management and development-based drivers for alternative wastewater servicing. It should be noted that the ranking does not take into consideration of the cost, relative ease of servicing or the willingness of property owners to pay for improved wastewater servicing.

4 High Level Options Development

Following the risk prioritisation process, DWC then proceeded to develop potential high level wastewater servicing solutions for 5 villages given the constraints and limitations present. Consideration was also given to broad servicing options considered most suitable for the remaining lower ranked areas.

4.1 Potential Wastewater Servicing Options

An initial review process was undertaken to identify potential high level wastewater servicing options that may be feasible for each of the villages.

The intention of the high-level options was to capture a range of servicing solutions from a traditional '*flush and forget*' conventional sewer option to decentralised solutions such as cluster or precinct scale systems incorporating Integrated Water Management (IWM) principles.

The initial review process shortlisted five potential servicing options. These options are not exhaustive but have the potential to be adjusted to capture a wide range of variations in servicing approach. Tanker removal of wastewater from properties within the village is an option already being undertaken for several highly constrained areas such as Coomba Park. Based on the likely wastewater generation and current Council experience however, this option is not likely to be economically viable or sustainable over the long-term and was not considered further in the selection process.

The key factors used to assign suitable high-level servicing options to each village is presented in Figure 7 with further information on each criteria detailed in Appendix E.

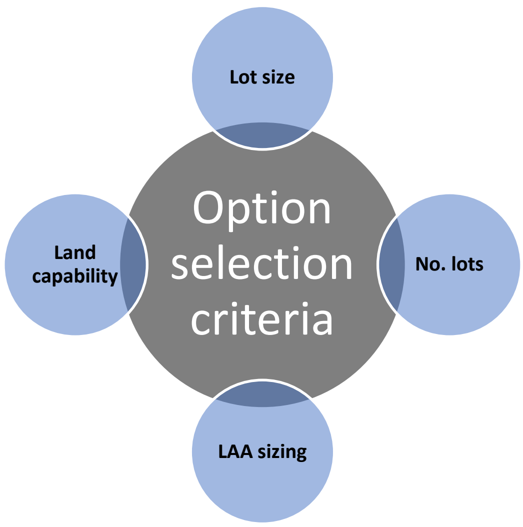


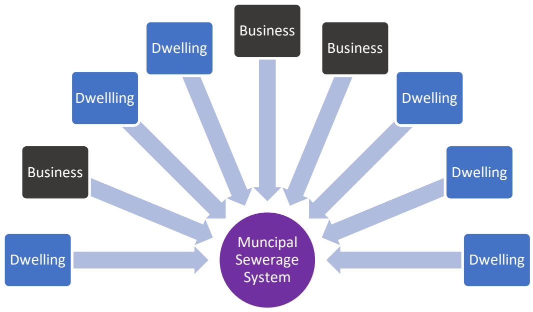
Figure 7 High level options selection criteria

A summary of key characteristics and potential high-level options(s) for the assessed villages are provided in Table 5.

4.1.1 Broad Servicing Options

Option 1 - Reticulated sewerage

Reticulated sewerage can be defined as '*A network of sewers managed by a sewerage service provider that is designed to convey sewage from any development, lot or subdivision to a centralised facility for treatment and disposal.*'



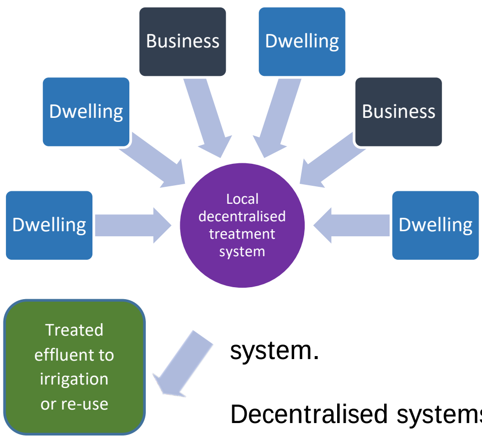
A reticulated system can be in the form of a traditional gravity sewer, a pressure system or a combination of the two types. Conventional sewerage systems and sewage treatment plants are operated and managed by municipal water and sewer authorities.

This system type involves delivery of gravity or low-pressure sewer including pump stations and rising mains to a connection point in an existing sewerage network or new central Sewage Treatment Plant (STP).

This approach is typically feasible for:

- Villages in proximity to existing sewerage networks such as Tea Gardens, and
- Higher density villages with smaller lot sizes such as Coomba Park.

Option 2 - Local decentralised cluster system



Decentralised wastewater management can be defined as '*The collection, treatment and reuse of wastewater at or near the point of generation.'* (Crites and Tchobanogolous, 1998). The term cluster system can be defined as the collection of wastewater from several adjacent buildings for conveyance to a decentralised wastewater treatment system.

Decentralised systems can provide a feasible and sustainable solution for villages considering construction of a new system or modification, replacement, or expansion of existing treatment systems. A decentralised cluster approach permits *'fit-for-purpose'* treatment system designs to be developed for each situation based on the unique characteristics of the project area. Cluster scale systems are ideally suited to villages with small lot sizes but lower density.

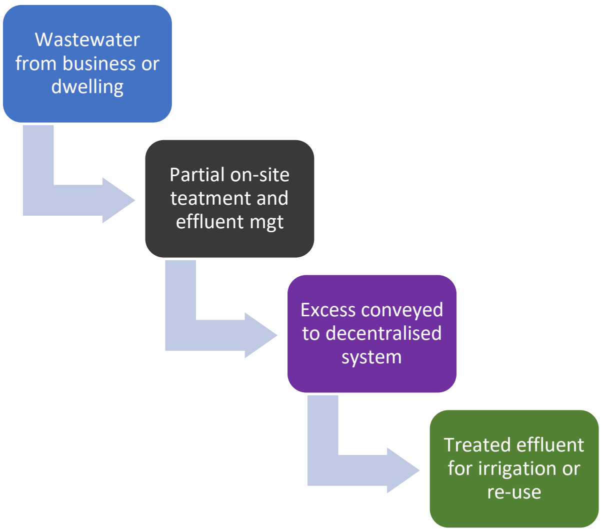
A cluster includes provision of a new localised reticulation system to collect sewage or treated effluent from properties for treatment and reuse. Re-use most commonly involves irrigation (or another land application method) of the treated effluent across community / public open space or agricultural land.

Cluster systems are typically set up at a precinct or small village scale to treat wastewater from a group of properties within the vicinity of a reuse site such as a public open space or private recycled water user. A range of technologies and scales can be considered with the aim of being adaptive to the safest and most feasible opportunities for each specific village (i.e. don't try and make the problem fit a predetermined solution). They typically enable more energy / carbon efficient servicing approaches by avoiding transporting sewage long distances and operating at scales that avoid significant wet weather inflows and enable use of low energy treatment technologies.

This method enables opportunities for on-property reuse of treated wastewater to reduce downstream treatment and irrigation infrastructure requirements. To operate effectively these systems need to be operated and managed by a Responsible Management Entity (RME) such as MidCoast Council or other licenced private water utility.

Option 3 – Partial on-site containment of wastewater

This method is suitable for medium sized properties where land capability constraints are not limiting but where there is insufficient land available for sustainable on-site management of full wastewater volumes. Excess effluent that cannot be managed on site would be pumped to an effluent (pressure) sewer for conveyance to local reuse facilities.



On-lot irrigation could be set at a reasonable minimum land area with opportunity to increase where available and suitable. Can also be controlled remotely via weather station to maximise irrigation during dry periods and reducing or eliminating during wet.

Advantages include significantly reduced design flows at local reuse sites and reduced treatment requirements due to on-site treatment to (typically) secondary quality effluent. Typically cost effective where lot sizes are 1,000 m^2 – 3,000 m^2.

Option 4 – Full On-site containment of wastewater

The continued full management of wastewater on-site can be considered subject to land capability and availability. On-site wastewater management technologies can deliver a very high level of performance at the lowest community cost subject to management and oversight by what the USEPA refer to in their Management Models (USEPA 2003) a Responsible Management Entity who are responsible for the effective operation and regulatory compliance of the systems..

Development of a suitable model for upgrade, ownership and management would be necessary for this option to be successful, given the significant constraints observed in many of the selected villages.

The continuation of the business-as-usual scenario of owner managed on-site systems would need to be evaluated from a risk perspective as part of a feasibility and business case development for suitable villages. There may be some villages with larger lot sizes or limited feasibility for alternative

options for whom business as usual will be the preferred option.

4.2 Cost Estimates

A range of indicative capital cost estimates have been calculated for the potential options. The costs are very high-level in nature and have been based on previous DWC projects involving the feasibility, design and delivery of decentralised servicing approaches under the governance of a public water utility. Further investigations and design work will be required to understand more accurate capital costs. Indicative costs for each village and option have been included in Table 5 below.

Table 5 Village Servicing Option and Cost Summary

Rank	Village	No. Lots	Servicing Option 1 Sewer	Servicing Option 2 Cluster system	Servicing Option 3 Partial On-site	Servicing Option 4 Full On-site	Cost[1] $ Million
1	Coomba Park	670					20 – 40
2	North Pindimar	91					9 – 14
	South Pindimar	137					
	North Arm Cove[2]	409					16 – 25
	Bundabah	125					6 – 10
	Nerong[2]	168					8 – 13
	Seal Rocks	73					4 – 6
	Carrington & Tahlee	40					2 – 4
9	Bungwahl[2]	74					4 – 6
10	Croki[2]	25 + 38 caravan park sites					2 – 4
11	Allworth	92					4 – 7
	Copeland	116					6 – 9
13	Tea Gardens (Industrial Estate)	38					Sewer
14	Coolongolook	77					4 – 6
15	Stroud Road	91					Sewer
16	Krambach	238					9 – 14
17	Oxley Island Mitchells Island	177 47					3 – 6
	Wards River	64					3 – 5
19	Mount George	97					5 - 8
	Elands	62					3 – 5
21	Johns River	173					8 – 14

Rank	Village	No. Lots	Servicing Option 1 Sewer	Servicing Option 2 Cluster system	Servicing Option 3 Partial On-site	Servicing Option 4 Full On-site	Cost[1] $ Million
22	East Wingham	65					Sewer
23	Craven	23					1 – 2
24	Wootton	23					1 – 2
25	Stratford	100					5 – 8
26	Limeburners Creek	58					3 – 5
27	Booral	53					3 – 4
28	Moorland	120					6 – 10
29	Barrington	91					2 – 3
30	Bundook[2]	79					1 – 3

Selected	Alternate Option	Un-suitable

[1]Cost indicative only [2]Case study village

5 Village Case Studies

To apply the high-level options in a real context, 5 case studies have been developed for the villages of:

- North Arm Cove,
- Croki,
- Nerong,
- Bungwahl, and
- Bundook.

These case studies have been selected in order to provide a wide cross section of the broad servicing options included in this report. The case studies highlight some of the benefits and constraints associated with their application. Further investigation and design work would be required to confirm feasibility.

Case Study 1

North Arm Cove

Pressure sewer to local treatment & reuse scheme

General Information

Risk Prioritisation Ranking
2 (equal)
Number of Lots
400
Lot Size (Median)
1015m^2
ADWF (kL/day)
215

Constraints to On-site Sewage Management

- Small lot size with limited to no land available for on-site wastewater management
- Major land capability constraints such as steep slopes, shallow soils and Coast SEPP
- Proximity to sensitive receptors such as Port Stephens and Karuah River (including aquaculture)

Selected High Level Option Summary

Component	Description
On-property	Decommission all existing on-site wastewater systems.
Collection	New low pressure sewerage system to collect all wastewater from properties and transfer to local cluster reuse system. Local pump station to transfer to Sewage Treatment Plant (STP) north of serviced properties.
Treatment	New STP to allow for restricted access irrigation across the potential reuse site show in the figure below (~20 hectares). Possible constructed wetland for effluent polishing, naturalisation and carbon sequestration.
Effluent Management	Surface or subsurface irrigation at cluster effluent reuse site - large potential reuse site shown in Case Study figure would allow for irrigation area of ~20 hectares (subject to further design and assessment). Potential use as woodlot (carbon forest) and/or recreational area (e.g. mountain bike trails). Given climatic constraints to reuse, utilise wetland / natural based systems to polish effluent, naturalise (quality and hydrology) prior to discharge of excess recycled water to estuary.
Cost (approx.)	$16 - $25 million

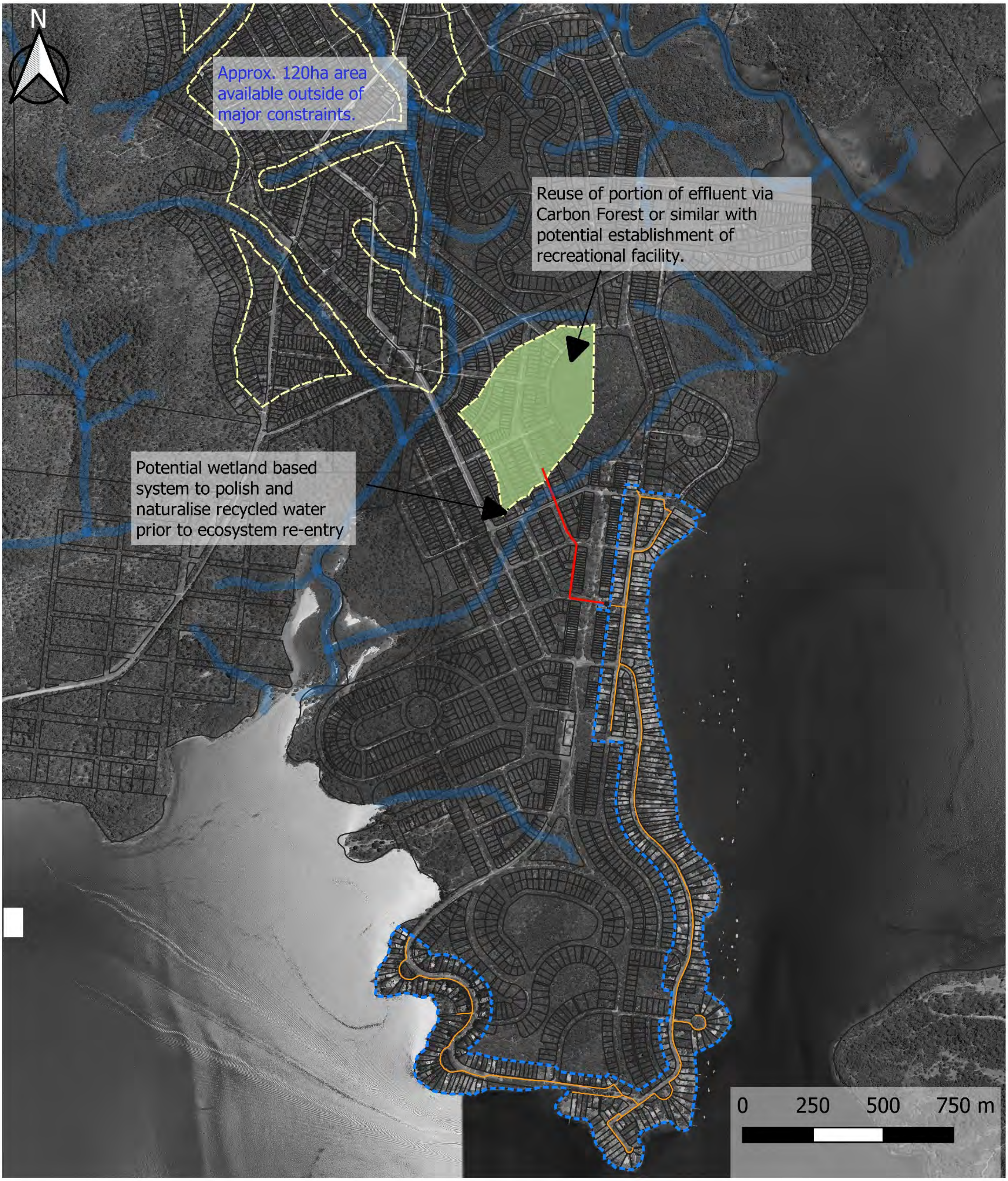


Figure: High Level Option - North Arm Cove Case Study

Village Area
Watercourse
Indicative Pressure Sewer Alignment
Indicative Sewage Pump Station
Indicative Rising Main
Example Reuse & Effluent Management Site (20ha)
Potential Effluent Reuse Areas

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Case Study 2

Croki

STEP Sewer to local cluster re-use scheme

General Information

Risk Prioritisation Ranking
10
Number of Lots
25 + 38 caravan park sites
Lot Size (Median)
810m^2
ADWF (kL/day)
18 (variable)

Constraints to On-site Sewage Management

- Generally small lot size with limited land available for on-site wastewater management
- Land capability constraints such as flooding potential, seasonal high groundwater and Coast SEPP
- Proximity to sensitive receptors such as Manning River and aquaculture

Selected High Level Option Summary

Component	Description
On-property	Decommission or re-configure existing on-site wastewater systems. Install Septic Tank Effluent Pump (STEP) units on each property.
Collection	Construct new effluent (pressure) sewer to collect primary effluent from properties and transfer to local cluster reuse system. Utilise upfront flow balancing at both the caravan park and cluster system to help buffer peak flows prior to the cluster treatment / land application system. This is estimated to be in the order of 120-150kL of flow balancing storage capacity (based on previous designs for similar sized systems).
Treatment	Secondary treatment system with treatment capacity of ~20kL/day subject to more detailed estimates of wastewater generation from the Croki caravan park.
Effluent Management	Raised effluent land application via two Wisconsin Mounds with an example location / layout shown in the following Case Study Figure . It is estimated that a total Land Application Area (LAA) of approximately 4,000m^2 would be required subject to detail design given the size of the town and associated constraints. This would need to be confirmed as part of a design based on specific estimation of wastewater flows from the caravan park. Alternatively, a raised subsurface irrigation could also be considered as a LAA option depending on the site-specific design.
Cost (approx.)	$1.4 – $2.0 million (total delivery cost)

Figure: High Level Options - Croki Case Study

Village Area
Watercourse
Wisconsin Mounds (~2,000m2 Each)
Secondary Treatment System (Indicative Location)
Indicative DN50-63 Effluent (Pressure) Sewer

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Case Study 3

Nerong

STEP / Pressure sewer to local cluster re-use scheme

General Information

Risk Prioritisation Ranking
2 (equal)
Number of Lots
168
Lot Size (Median)
660m^2
ADWF (kL/day)
90

Constraints to On-site Sewage Management

- Concentration of small lots with limited land available for on-site wastewater management.
- Significant land capability hazards
- Immediate proximity to potable and sensitive receptors including aquaculture.

Selected High Level Option Summary

Component	Description
On-property	Decommission or reconfigure (STEP) all existing on-site wastewater systems. Installation of pressure (grinder) sewer units on each property also an option.
Collection	New sewerage system (low pressure) to collect all wastewater from properties and transfer to local cluster reuse system.
Treatment	Cluster secondary treatment system to allow for restricted access irrigation across the potential reuse site show in the figure below. Incorporate flow balancing at the cluster system to help buffer peak flows due to intermittent occupancy of properties.
Effluent Management	Surface or subsurface irrigation at cluster effluent reuse site - large potential reuse site shown in Case Study figure which would allow for irrigated area of ~5 hectares (subject to further design and assessment).
Cost (approx.)	$5 - $10 million

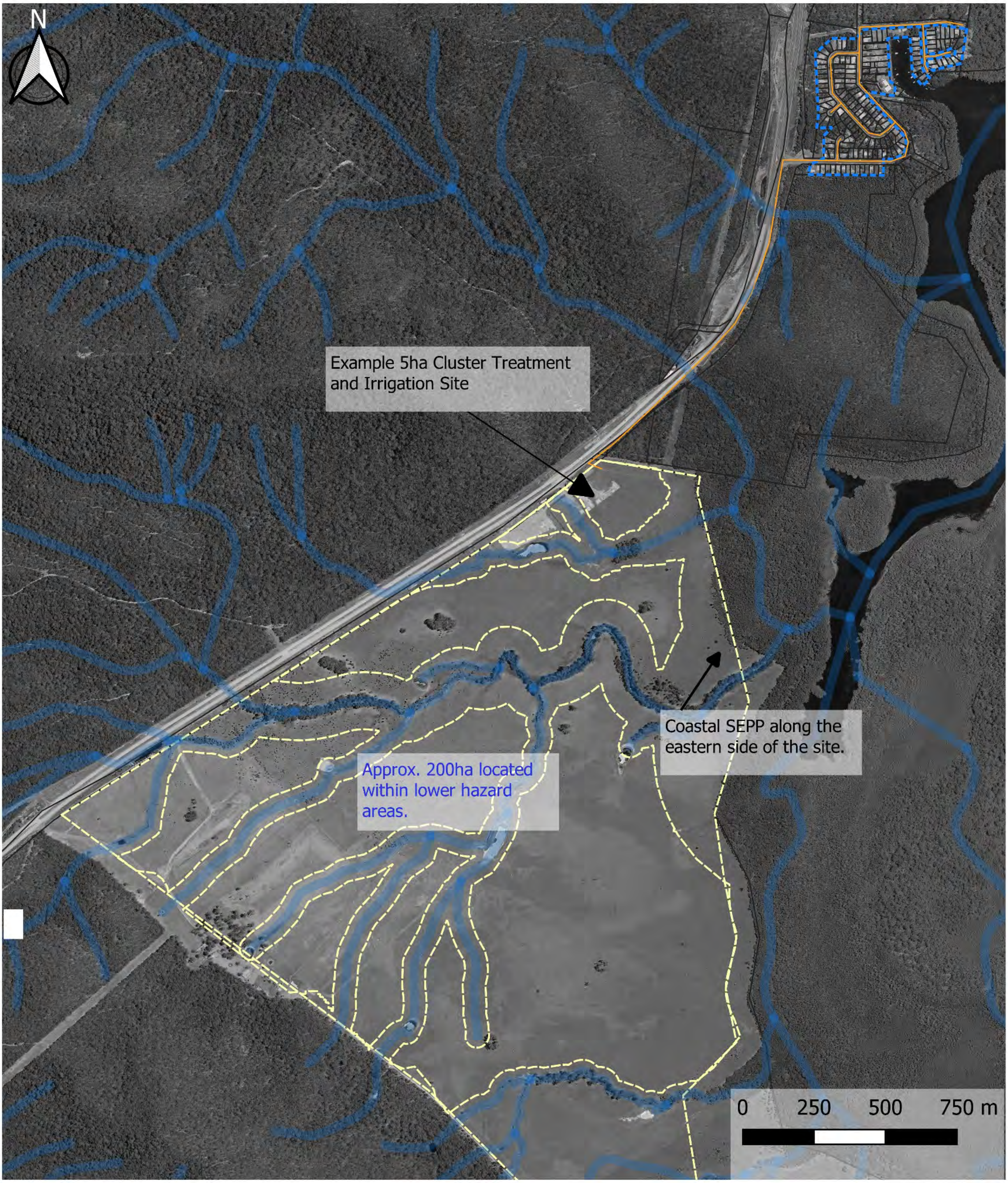

Figure: High Level Option - Nerong Case Study

Village Area
Watercourse
Indicative Sewer Alignment
Example Cluster Irrigation Site (5ha)
Potential Reuse Areas

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Case Study 4

Bungwahl

Partial on-site management with local cluster re-use scheme

General Information

Risk Prioritisation Ranking
9
Number of Lots
74
Lot Size (Median)
2000m^2 (overall) 4000m^2 (Dogwood Road)
ADWF (kL/day)
40 (20 kL/day at cluster system)

Constraints to On-site Sewage Management

- Wide variety of lot sizes, including larger lots with greater potential for on-site effluent management along with smaller constrained lots in the central village area.
- Land capability constraints including localized high groundwater, vegetation and climate.
- Proximity to sensitive receptors such as Corrigans Bay to the west, Neranie Bay to the south and Wamwarra Bay to the east of the village area.

Selected High Level Option Summary

Component	Description
On-property	Decommission existing septic systems and install new best practice on-site wastewater systems to achieve partial on-site management whilst meeting regulatory requirements. All excess advanced secondary effluent not managed on-site to be directed to a new effluent pressure sewer. The amount of on-site irrigation can be set at a reasonable minimum land area with opportunity to increase where available and suitable. Can also be controlled remotely via weather station to maximise irrigation during warmer, dry periods and limit during cooler, wet periods. Larger properties suitable for full on-site management subject to best practice upgrade. For this option to be effective, systems would need to be operated and managed by a single competent and accountable authority (both the upgrade works and on-going system operation).
Collection	Small diameter effluent (pressure) sewer collecting excess effluent not able to be managed on-site, for conveyance to local cluster reuse (irrigation) system.
Treatment	Advanced secondary treatment provided on-lot with polishing at local cluster reuse facility. This allows for reduced cluster treatment infrastructure. Central reuse system could consist of small control shed (filtration and ultraviolet disinfection) and wet weather storage tank.
Effluent Management	Surface or subsurface irrigation at cluster reuse site using excess effluent not managed / reused on properties. Large potential reuse site shown in figure below. Alternatively, could use Wisconsin Mounds for a smaller footprint.
Cost (Approx.)	$4 - $6 million

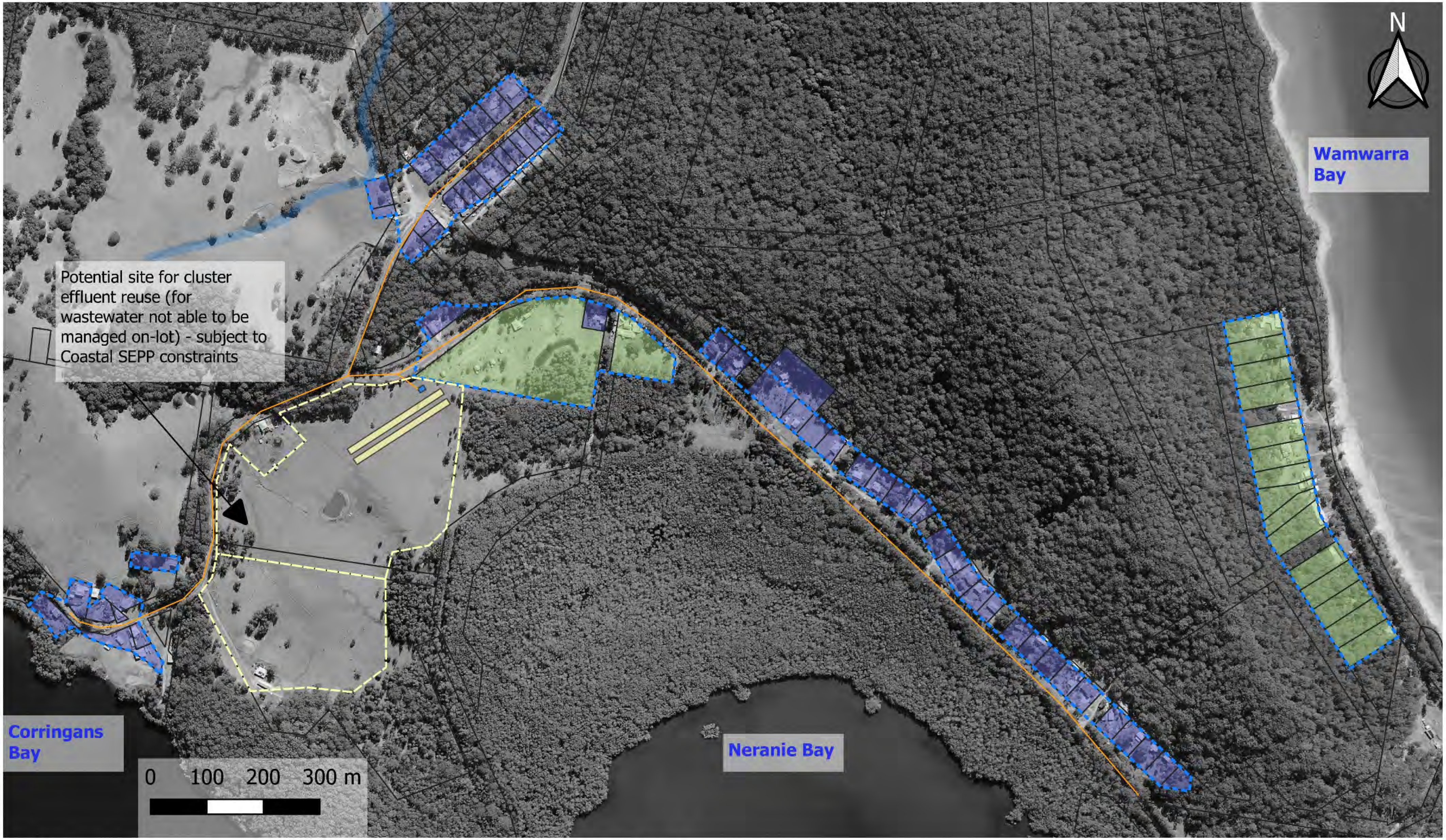

Figure: High Level Option - Bungwahl Case Study

Village Area

On-lot Servicing Option

Full On-site Wastewater Management

Partial On-site Wastewater Management

Watercourse

Indicative Effluent Sewer Alignment

Cluster Reuse System Footprint

Indicative Wisconsin Mound Footprint

Potential Effluent Reuse Site

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Case Study 5
Bundook

Full on-site management via system upgrade

General Information

Risk Prioritisation Ranking
30
Number of Lots
71
Lot Size (Median)
4055m^2
ADWF (kL/day)
41

Overview

Bundook was selected as a case study village as it is located within the former Gloucester Shire (which was not previously considered in the risk assessment in 2000). The locality consists of typically larger and less constrained lots relative to the other high-risk villages. There is potential for future development given the higher likelihood of installing an on-site wastewater system which can meet MCC requirements. The village is still subject to several land capability constraints including steeper slopes in some areas and intermittent watercourses and farm dams within a number of properties.

Based on high level investigation of the village, there is the potential for full on-site wastewater management via upgraded on-site systems for the properties within the village area. This could involve independent operation and management of systems if justified by the risks.

Selected High Level Option Summary

Component	Description
On-property	Decommission existing septic systems and install new best practice on-site wastewater systems (e.g. advanced secondary treatment system with subsurface irrigation or evapotranspiration absorption (ETA) trenches/beds) to achieve full on-site management where feasible to meet regulatory requirements. For this option to be effective the on-site systems would need to be managed by a single competent and accountable authority (both the upgrade works and on-going system operation) with MCC oversight.
Off-property	Effluent tanker removal (partial pump-out) for lots that are constrained and are unable to sustainably manage all wastewater on-site in the long-term.
Cost (Approx.)	$1.5 – 2.5 million

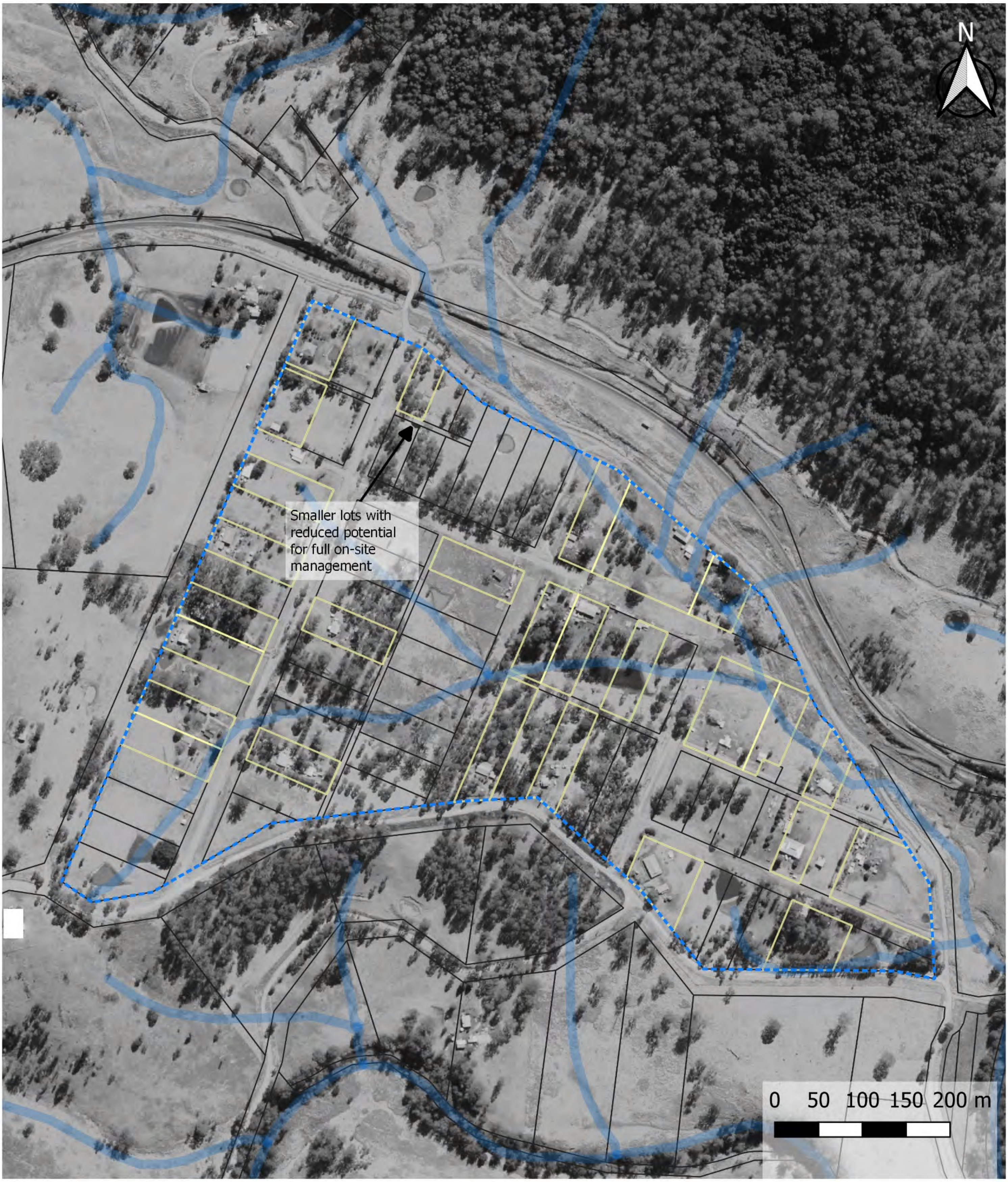

Figure: High Level Options - Bundook Case Study

Village Area
Watercourse
Lots Currently Developed

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6 Next Steps?

Based on the high-level options presented and discussed in the previous sections, there are a range of further information and studies required to progress potential design options for each specific village.

Future investigation, design and planning steps are presented in the following flow chart.

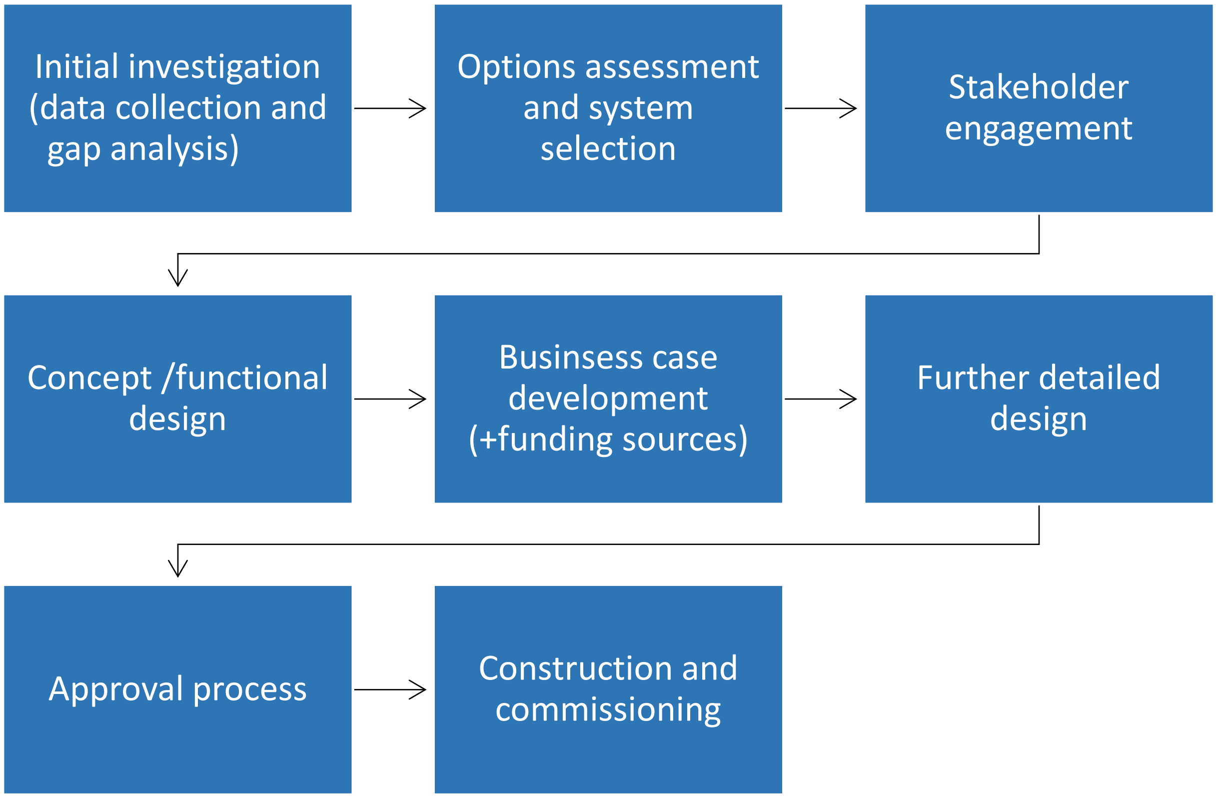


Figure 8 Next steps flowchart

A summary of potential further studies and investigation considered for the high-level options presented is provided in Table 6.

An important consideration for the villages used in the case studies is the completion of comprehensive land capability assessments for the villages identified as potential cluster reuse sites. Given the constrained nature of the high-risk villages, a representative group of on-property assessments should also be considered. It is recommended that a sufficient level of investigation should be performed across the village areas to capture the broad characteristics such as topography and soil landscapes that may be encountered.

Table 6 Potential Further Studies

<table>
<tr><th>No.</th><th>Option</th><th>Further Studies / Information Required</th></tr>
<tr><td>1</td><td>Connection to reticulated sewer</td><td rowspan="2">- Reticulation alignments, sizing, grades and depths
- Treatment system sizing and constructability
- Identification of potential central / local treatment and reuse sites – consideration of suitability (shortlisting) and land acquisition
- Site and soil (land capability) assessments for effluent management / reuse sites
- Planning / environmental / health compliance – incl. performance modelling (MEDLI / groundwater) for design justification
- Recycled water risk assessment
- Community and stakeholder engagement
- Costing estimations (CAPEX, OPEX & NPV) and Cost Benefit Analysis
- Funding / governance arrangements and Business Case development
- Define regulatory requirements for preferred option(s) and identify elements that do not fit current regulatory structures</td></tr>
<tr><td>2</td><td>Local decentralised / cluster treatment and reuse system</td></tr>
<tr><td>3</td><td>Full on-site containment of wastewater</td><td rowspan="3">- Site and soil (land capability) assessments for on-site systems
- On-site system option analysis and preferred designs
- Environmental / health compliance – incl. performance modelling (MEDLI / groundwater) for design justification
- Community and stakeholder engagement
- Costing estimations (CAPEX, OPEX & NPV) and Cost Benefit Analysis
- Funding / governance arrangements and Business Case development
- Define regulatory requirements for preferred option(s) and identify elements that do not fit current regulatory structures
- Stormwater (e.g. MUSIC) modelling and WSUD measure sizing (if considered as part of IWM strategy)</td></tr>
<tr><td>4</td><td>Partial / Limited on-site containment of wastewater</td></tr>
<tr><td>5</td><td>Integrated Water Management (IWM)</td></tr>
</table>

7 References

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

MidCoast Council (2020) On-site Sewage Development Assessment Framework (Draft)

MidCoast Water (2000) Small Communities Wastewater Risk Assessment. Prepared by MCW.

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

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

Appendix A: Workshop Minutes

DECENTRALISED WATER CONSULTING

WORKSHOP: MCC Unserviced Villages MCA

MINUTES | JUNE 25, 2020 | 9:30 AM – 12:30 PM | MCC (COUNCIL CHAMBERS), 4 BREESE PARADE, FORSTER

MEETING CALLED BY	Adam Turville (Mid Coast Council)
TYPE OF WORKSHOP	Discussion of Multi Criteria Analysis (MCA) for risk prioritisation of unserviced villages across MCC area.
FACILITATOR	Ben Asquith (Decentralised Water Consulting)
NOTE TAKER	Jack Sharples (Decentralised Water Consulting)
ATTENDEES	Ben Asquith, Jack Sharples, Adam Turville, Tracey Hamer, Malcolm Hunter, Alexandra Macvean, Gary Mead, Prue Tucker, Aaron Kelly (remote), Michael Griffiths (remote).
APOLOGIES	Georgina Martin, Rachael Abberton

1 Background

Attendees were engaged in a workshop to discuss current progress with the high risk unserviced villages project and provide final input into the risk prioritisation (Multi Criteria Analysis) process for the nominated villages.

2 Objectives

1. Provide understanding of current progress with project including the draft criteria / scoring methodology (provided previously to MCC) and selected villages to be assessed (as per MCC planners' feedback).
2. Discussion of any data availability for finalisation of MCA process.
3. Finalisation of how infill development potential is to be factored into MCA process (not currently included).
4. The appropriate weightings for MCA to be determined based on feedback from all attendees.
5. Initial discussion of draft village ranking based on MCC experience.

3 Key Discussion Items

1. Water quality data has not been included given it is incomplete for the whole MCC LGA and therefore will create prioritisation bias for areas in which significant data is available (specifically North Arm Cove).
2. Croki is village with strong interest from Progress Association. Important to ensure assessment is robust and impartial. Sensitive catchment hazard appropriate to be set to Medium (DAF Zone 2)

given village is directly adjacent to Aquaculture Zones. Current Draft MCA ranking reflects this (refer figures below).

3. Key discussion around infill (town) growth and if and how to best to include in the MCA. Infill development potential is to be included in the MCA and has been weighted accordingly (refer Table 1 below). This has been included as a semi-quantitative sub-measure based advice from strategic planners that informed a relative scoring as agreed by all attendees during the Workshop (results presented in figures below).
4. Marine Protected Areas (Marine Parks) not directly included given the large number of villages in proximity or draining to a protected marine area. Although Allworth is not within proximity of Aquaculture Zones (500m buffer) it is directly upslope and therefore set to Medium (DAF Zone 2) sensitive catchment hazard.
5. Influence of proximity to existing sewerage connection point discussed as part of MCA. To be included as part of next stage of option development for high ranked villages, given other factors need to be considered such as existing sewer capacity.

4 Outcomes

The primary outcome of the workshop was the development of weightings for the six (6) sub measures provided previously to MCC. Each broad category and sub measure was discussed amongst the group. Discussion was held to determine an agreed weighting (relating to proportional importance) for each sub measure based on all attendees. In additional the relative scoring for the In-fill Development Potential sub measure were developed for each village based on MCC discussion and feedback.

The MCA methodology and agreed weightings are summarised in Table 1 below. The draft MCA scoring for each sub measure across all unserviced villages and the draft ranking or prioritisation is provided in Figure 1.

Table 1 MCA Methodology Summary - Prioritisation Sub-measure Weightings

Category	Sub-Measure	Description	Scoring Method	Weighting
Sustainability of On-site Wastewater Management	Lot Size	Number and % of lots <2,000m^2 and therefore considered High Hazard for on-site wastewater management (as per Mid Coast Council Final Draft DAF).	**Percentage of <2,000m^2 (High Risk) Properties** 0 – 20% = 0 21 – 40% = 1 41 – 60% = 3 61 – 80% = 4 80 – 100% = 5 **Total No. of <2,000m^2 Properties** (added to above score with max. of 5) <20 = no change to score 20-30 = add 1 to score 30-40 = add 2 to score 40-50 = add 3 to score >50 = Score equals five in all circumstances	**20%**
	Land Capability	Land capability hazard for on-site wastewater management based on Hazard Mapping developed for MCC Development Assessment Framework (DAF).	Average Land Capability Hazard class for lots within township. Average High Hazard = 5 Average Medium Hazard = 3 Average Low Hazard = 1	**20%**
Potable Water Access	-	Access to potable water for unsewered lots within village / township. Captures existing water infrastructure in towns, and thus increases priority for wastewater service.	Yes = 3 No = 1	**10%**

Category	Sub-Measure	Description	Scoring Method	Weighting
Receiving Environment Sensitivity & Proximity	Proximity to waterways / waterbodies	Proximity of township properties to sensitive waterways / waterbodies	All properties directly adjacent to permanent / named waterway and/or waterbody = 5 Partial drainage (~75%) of total properties to permanent / named waterway and/or waterbody = 4 Partial drainage (~50%) of total properties to permanent / named waterway and/or waterbody = 3 Partial drainage (~50%) of total properties to intermittent waterway / dam = 2 No risk to waterway / waterbody = 0 Add 1 point to score where stormwater infrastructure present within town / village to reflect elevated risk if failure of onsite systems occur.	**15%**
	Sensitivity of waterways / waterbodies	Sensitivity of waterways / waterbodies		
	Stormwater infrastructure	Proximity of properties to stormwater pipes / pits. Accuracy of provided data ~60-70% according to MCC.		
	Potable / sensitive catchments	Proximity of township properties to potable or sensitive catchments. Defined as part of DAF: Zone 1 – Direct hydraulic catchment to sensitive Lakes areas. Zone 2 – Broader drinking water catchment (Mid Coast Water defined areas) and Aquaculture Zones	Within Zone 1 = sub-score of 5 Within Zone 2 = sub-score of 3 Not within either Zone = sub-score of 0	**20%**
In-Fill Development Potential	Vacant Lots / Parcels that are developable	Capture potential for Development / Section 68 Applications for existing vacant lots within the village extents, and thus potential for future growth capacity.	**Infill development potential.** Low Potential = 0 Moderate Potential = 3 High Potential = 5	**15%**

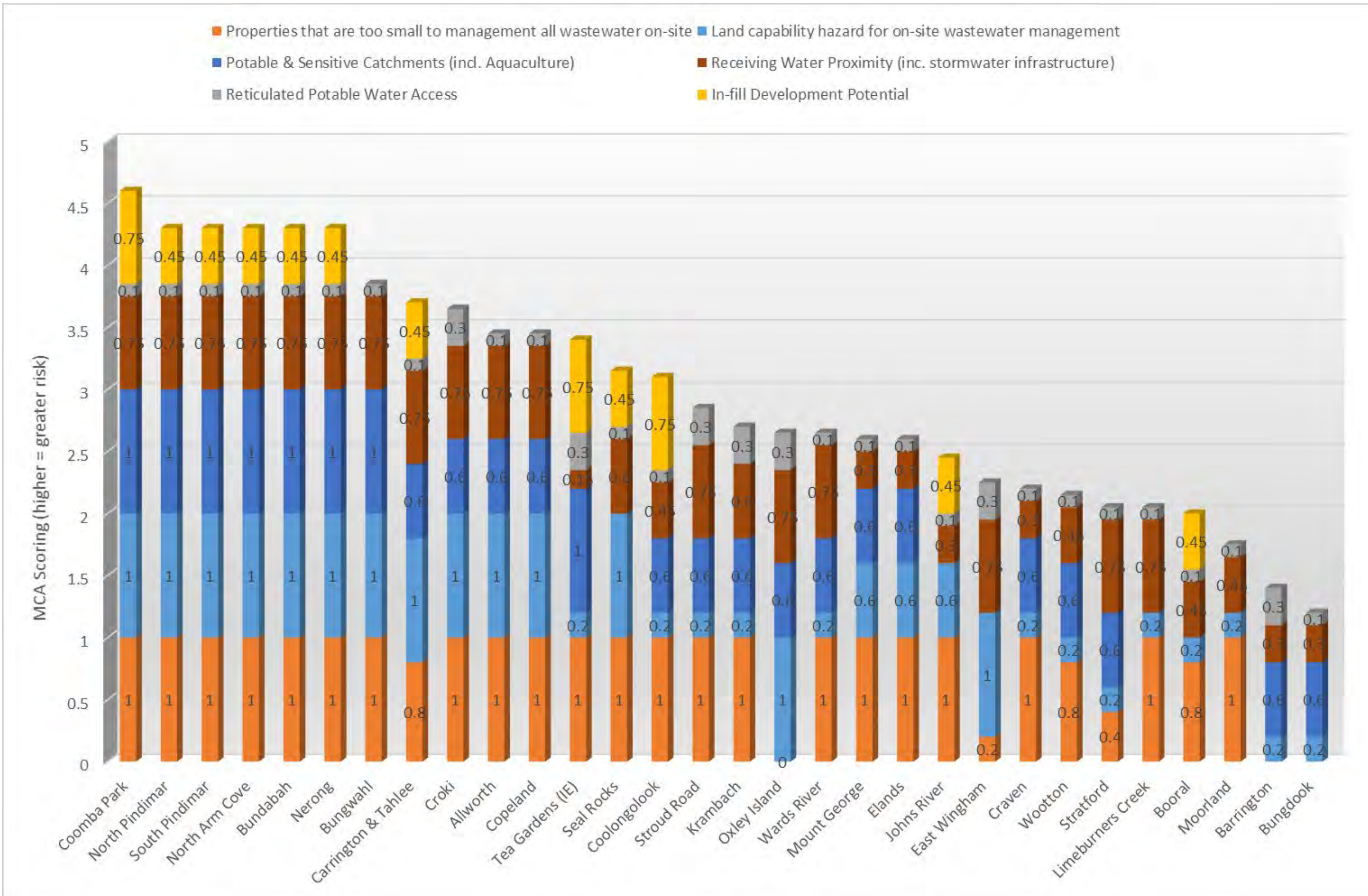


Figure 1 Draft MCA Weighted Scoring

5 Next Steps

DWC are seeking feedback from MCC on these workshop minutes and outcomes, in particular regarding the draft ranking of villages. The highest ranked villages are summarised in Table 2 below.

The intention is for DWC to move onto developing potential wastewater servicing solutions with a focus on the top 5 to 10 key villages. However, consideration will be given to the development of servicing solutions with potential to be applied in other lower ranked areas.

Table 2 Draft Village Ranking

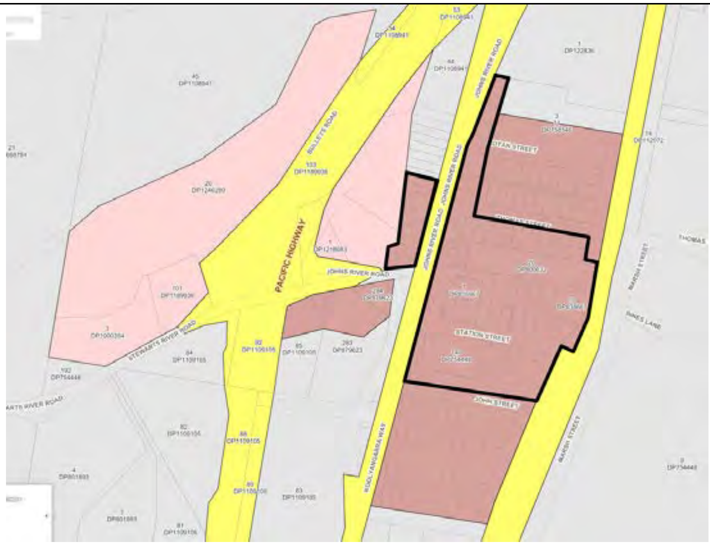
Rank	Village
1	Coomba Park
2 (all)	North Pindimar
	South Pindimar
	North Arm Cove
	Bundabah
	Nerong
7	Bungwahl
8	Carrington & Tahlee
9	Croki
10	Allworth
11	Copeland
12	Tea Gardens (Industrial Estate)
13	Seal Rocks
14	Coolongolook

Appendix B: Multi Criteria Analysis (MCA) Results

			Sustainability of On-site Wastewater Management							**Reticulated Potable Water Access**			**Receiving Environment Sensitivity / Proximity**								**In-fill Development Potential**				
		Total Lots	Properties that are too small to management all wastewater on-site				Land capability hazard for on-site wastewater management						Potable & Sensitive Catchments			Receiving Water Proximity					Properties and parcels that are undeveloped - and have the capacity to be developed.				
			% <2,000m2 Lot Size	No. <2,000m2 Lot Size	**Sub-score**		Ave. Land Capability Hazard Class	**Sub-score**		Comment (Y/N)	**Sub-score**		Comment	**Sub-score**		Comment	Score	SW infrastructure?	**Sub-score**			**Sub-score**			
					1-5			1,3 or 5			1 or 3			0,3 or 5			1-5	(Y/N)	1-5			0 / 3 / 5		*Combined Score*	**RANK**
					20%			**20%**			**10%**			**20%**					**15%**			15%			
LGA	**Village / Township**				**Calcs**			**Calcs**			**Calcs**											Calcs			
GLC	Coomba Park	672	**99%**	668	**5**	1	High	**5**	1	N	**1**	0.1	Zone 1 (Sensitive Catchment)	**5**		Haz could probably be 5 but because there is SW ir	**4**	Y	**5**	0.75		**5**	0.75	*4.6*	**1**
GLC	North Pindimar	125	**78%**	98	**5**		High	**5**		N	**1**	0.1	Zone 1 (Sensitive Catchment)	**5**			**5**	Y	**5**	0.75		**3**	0.45	*4.3*	**2**
GLC	South Pindimar	120	**90%**	108	**5**		High	**5**		N	**1**	0.1	Zone 1 (Sensitive Catchment)	**5**			**5**	Y	**5**	0.75		**3**	0.45	*4.3*	**2**
GLC	North Arm Cove	460	**93%**	430	**5**		High	**5**		N	**1**	0.1	Zone 1 (Sensitive Catchment)	**5**			**5**	Y	**5**	0.75		**3**	0.45	*4.3*	**2**
GLC	Bundabah	199	**98%**	196	**5**		High	**5**		N	**1**	0.1	Zone 1 (Sensitive Catchment)	**5**			**5**	Y	**5**	0.75		**3**	0.45	*4.3*	**2**
GLC	**Nerong**	173	**97%**	168	**5**		High	**5**		N	**1**	0.1	Zone 1 (Sensitive Catchment)	**5**			**5**	Y	**5**	0.75		**3**	0.45	*4.3*	**2**
GLC	**Seal Rocks**	76	**100%**	76	**5**		High	**5**		N	**1**	0.1	Zone 1 (Sensitive Catchment)	**5**		Beachfront lots and caravan park drain directly to b	**5**	N	**5**	0.75		**3**	0.45	*4.3*	**2**
GLC	Carrington & Tahlee	**88**	**80%**	**70**	**5**		High	**5**		N	**1**	0.1	Zone 1 (Sensitive Catchment)	**5**			**5**	Y	**5**	0.75		**3**	0.45	*4.3*	**2**
GLC	Bungwahl	74	**50%**	37	**5**		High	**5**		N	**1**	0.1	Zone 1 (Sensitive Catchment)	**5**		Appears as though most of the poperties drain to C	**5**	N	**5**	0.75		**0**		*3.9*	**9**
GTCC	**Croki**	35	**100%**	35	**5**		High	**5**		Y	**3**	0.3	Zone 2 (Aquaculture Buffer Zone)	**3**		Whole study area drains to Manning River	**5**	N	**5**	0.75		**0**		*3.7*	**10**
GLC	**Allworth**	94	**90%**	85	**5**		High	**5**		N	**1**	0.1	Drains to Aquaculture (but not within 500mm buffer Zone 1 area) - adjacent to Marine Park so set to 3.	**3**		Site drains to Karuah River	**5**	Y	**5**	0.75		**0**		*3.5*	**11**
GSC	Copeland	118	**87%**	103	**5**		High	**5**		N	**1**	0.1	Zone 2 (Drinking Water Catchment)	**3**			**5**	N	**5**	0.75		**0**		*3.5*	**11**
GLC	Tea Gardens (IE)	35	**74%**	26	**5**		Low	**1**		Y	**3**	0.3	Zone 1 (Sensitive Catchment)	**5**		Doesn't appear to drain to any significant receiving	**0**	Y	**1**	0.15		**5**	0.75	*3.4*	**13**
GLC	**Coolongolook**	70	**76%**	53	**5**		Low	**1**		N	**1**	0.1	Zone 2 (Drinking Water Catchment)	**3**		Flows from intermittent WCs go to the Coolongoloo	**2**	Y	**3**	0.45		**5**	0.75	*3.1*	**14**
GLC	Stroud Road	78	**83%**	65	**5**		Low	**1**		Y	**3**	0.3	Zone 2 (Drinking Water Catchment)	**3**		Eastern and Western Sites drain to permanent Wat	**5**	Y	**5**	0.75		**0**		*2.9*	**15**
GTCC	Krambach	211	**65%**	137	**5**		Low	**1**		Y	**3**	0.3	Zone 2 (Drinking Water Catchment)	**3**		Drains to permanent watercourses to the north and	**4**	N	**4**	0.6		**0**		*2.7*	**16**
GTCC	Oxley Island	182	**2%**	3	**0**		High	**5**		Y	**3**	0.3	Zone 2 (Aquaculture Buffer Zone)	**3**		Whole area is surrounded by permanent Watercous	**5**	N	**5**	0.75		**0**		*2.7*	**17**
GLC	Wards River	56	**91%**	51	**5**		Low	**1**		N	**1**	0.1	Zone 2 (Drinking Water Catchment)	**3**			**4**	Y	**5**	0.75		**0**		*2.7*	**17**
GTCC	Mount George	76	**49%**	37	**5**		Medium	**3**		N	**1**	0.1	Zone 2 (Drinking Water Catchment)	**3**	0.6		**2**	N	**2**	0.3		**0**		*2.6*	**19**
GTCC	Elands	71	**76%**	54	**5**		Medium	**3**		N	**1**	0.1	A portion of the southern study area is located wihtin the catchment (hazard may be reduced)	**3**	0.6		**2**	N	**2**	0.3		**0**		*2.6*	**19**
GTCC	Johns River	80	**58%**	46	**5**	1	Medium	**3**	0.6	N	**1**	0.1		**0**		Drains to intermittent Watercourses	**2**	N	**2**	0.3		**3**	0.45	*2.5*	**21**
GTCC	East Wingham	27	**37%**	10	**1**	0.2	High	**5**	1	Y	**3**	0.3		**0**		Directly on Manning River	**5**	Y	**5**	0.75		**0**		*2.3*	**22**
GSC	Craven	20	**95%**	19	**5**	1	Low	**1**	0.2	N	**1**	0.1	Zone 2 (Drinking Water Catchment)	**3**	0.6	This may drain to the permanent WC, however the	**2**	N	**2**	0.3		**0**		*2.2*	**23**
GLC	Wootton	15	**73%**	11	**4**	0.8	Low	**1**	0.2	N	**1**	0.1	Zone 2 (Drinking Water Catchment)	**3**	0.6	SW pits may be within study area. Considering they	**2**	Y	**3**	0.45		**0**		*2.2*	**24**
GSC	Stratford	81	**31%**	25	**2**	0.4	Low	**1**	0.2	N	**1**	0.1	Zone 2 (Drinking Water Catchment)	**3**	0.6		**5**	N	**5**	0.75		**0**		*2.1*	**25**
GLC	Limeburners Creek	49	**88%**	43	**5**	1	Low	**1**	0.2	N	**1**	0.1		**0**		DEM appears to be skewed - Site appears flat	**5**	Y	**5**	0.75		**0**		*2.1*	**26**
GLC	Booral	39	**59%**	23	**4**	0.8	Low	**1**	0.2	N	**1**	0.1		**0**		While the Karuah River is located ~400m away, mo	**2**	Y	**3**	0.45		**3**	0.45	*2.0*	**27**
GTCC	Moorland	91	**80%**	73	**5**	1	Low	**1**	0.2	N	**1**	0.1		**0**		Just over 50% drain to a permanent WC (in northern study area).	**3**	N	**3**	0.45		**0**		*1.8*	**28**
GSC	Barrington	61	**2%**	1	**0**		Low	**1**	0.2	Y	**3**	0.3	Zone 2 (Drinking Water Catchment)	**3**	0.6		**2**	N	**2**	0.3		**0**		*1.4*	**29**
GSC	Bungdook	77	**3%**	2	**0**		Medium	**1**	0.2	N	**1**	0.1	Zone 2 (Drinking Water Catchment)	**3**	0.6	Intermittent WCs through village - however setbac	**2**		**2**	0.3		**0**		*1.2*	**30**

Appendix C: MCC Village Extents

Location	Current or Proposed Draft Zone layer (Zoning In exhibition Feb-April 2020)	Aerial Imagery
Moorland – existing dwellings in the Village zone (note site off Church St – include whole site, RU5 mapping error) Est. approx. capacity 40-50 lots if sewered.		

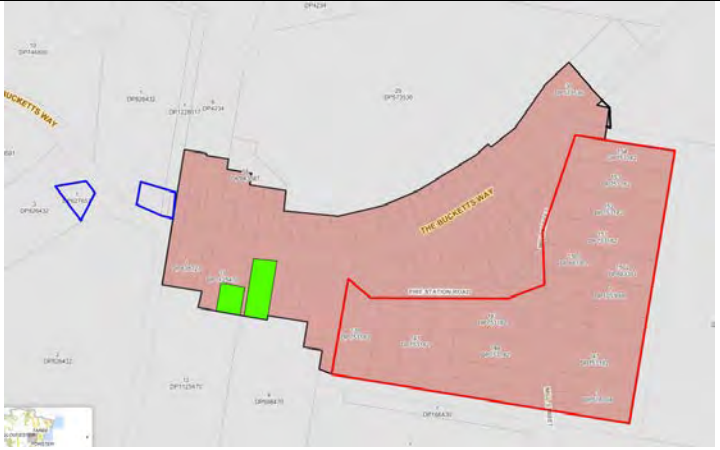
Johns River – only lots with existing dwellings within Black outline - urban sized allotments within Village zone with existing dwellings Note: Housing Strategy – only properties within black outline to be retained in Village zone. Land in SW village zone to go to R5, other land in Dept Industry ownership and heavily vegetated – to be rezoned to environmental zone (consistent with Bungwahl) Est. approx. capacity – 30 -40 lots if sewered.		

Mount George – RU 1 Zoned allotments with existing dwellings within Black Outline -

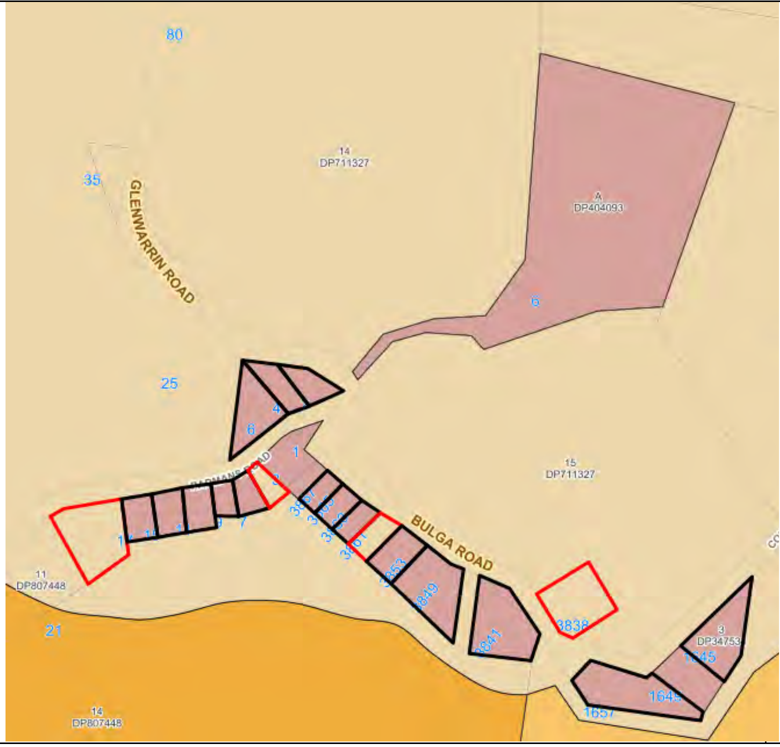
Allotments to be considered for rezoning as part of Rural Strategy to recognise urban allotments within a 'small village' context. No additional subdivision potential to be created with rezoning

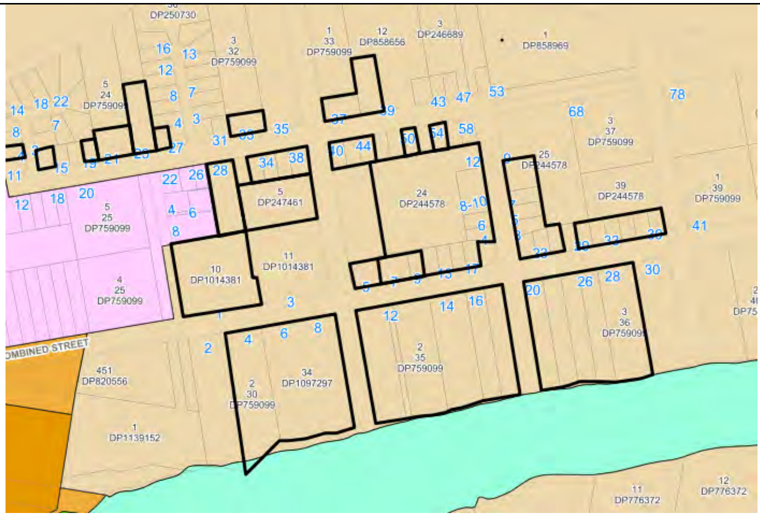
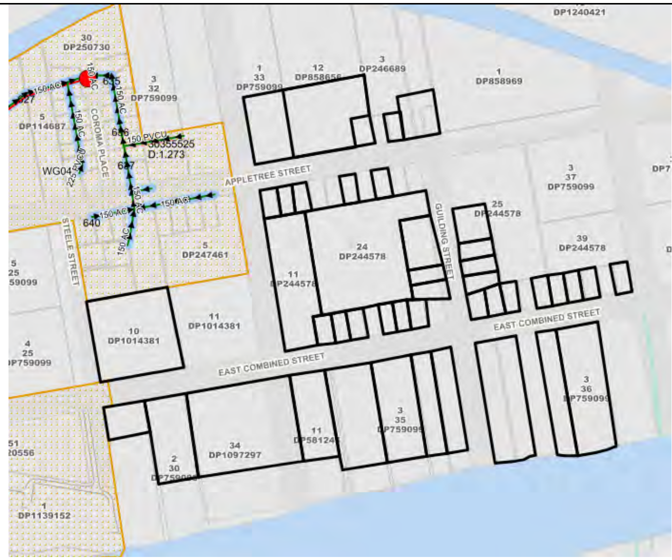
Possible enforcement of minimum lot size for consolidation as part of new LEP if not sewered

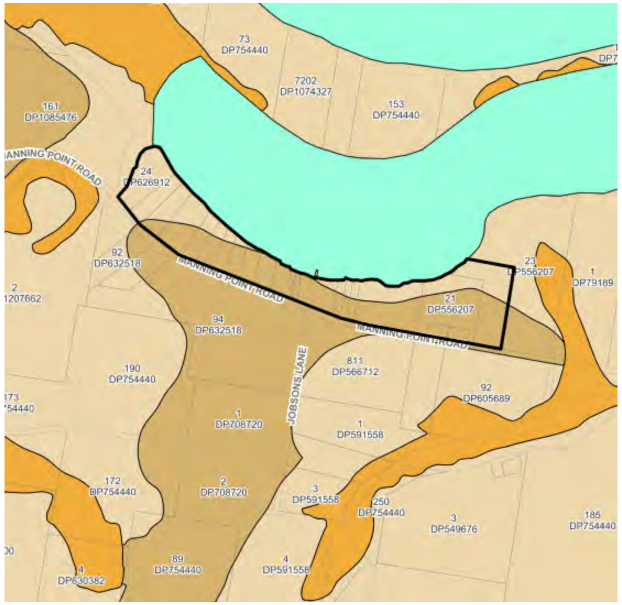
If sewered- Est approx. capacity 50-60 lots

Krambach – existing lots with dwellings in Black outline and 4 additional allotments outlined in blue (NW) Rural strategy to consider rezoning large lots E, SE & NE to R5 (red outline) – topography constrains additional subdivision Area in red outline to be considered for rezoning to R5 as part of Rural Strategy (possible un-sewered) Includes public facilities and commercial premises If sewered – Est approx. capacity 50-60 lots		

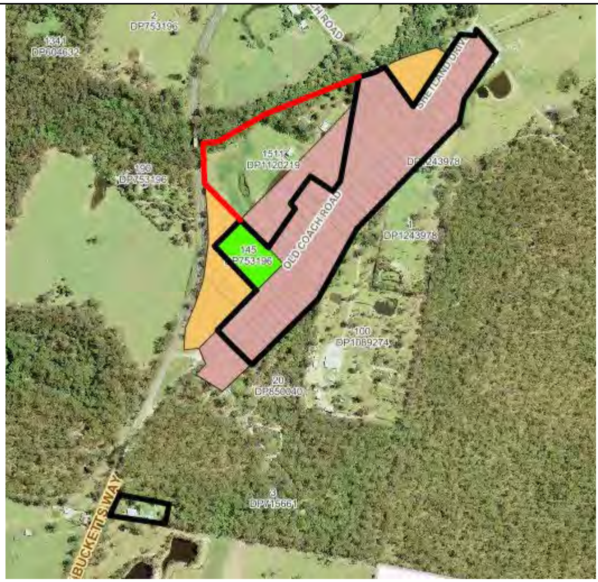
Croki - existing lots with dwellings in village zone in Black outline Rural strategy to consider rectification of RU5 zone boundary with property boundaries and/or possible back zoning due to severe flooding. Caravan park in green outline. Further expansion of development, subdivision or further dwellings in Croki not supported due to flood impacts also associated with evacuation route limitations (one road in and out). LEP consolidation clause may be appropriate. If sewered – Est. approx. capacity for 20 dwellings + existing caravan park.	 	

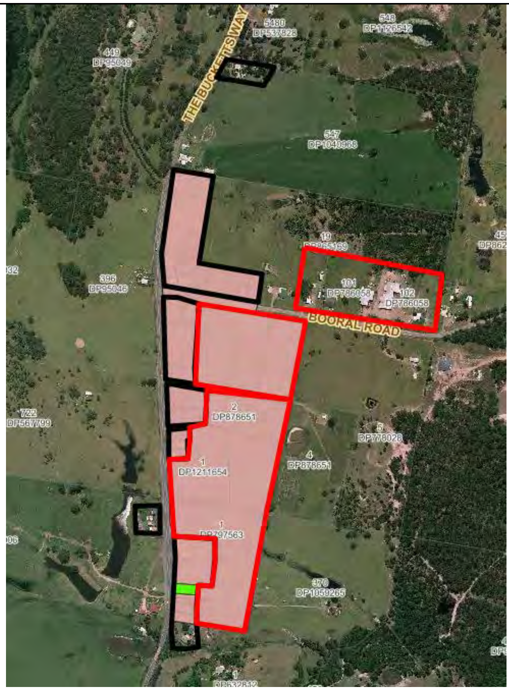
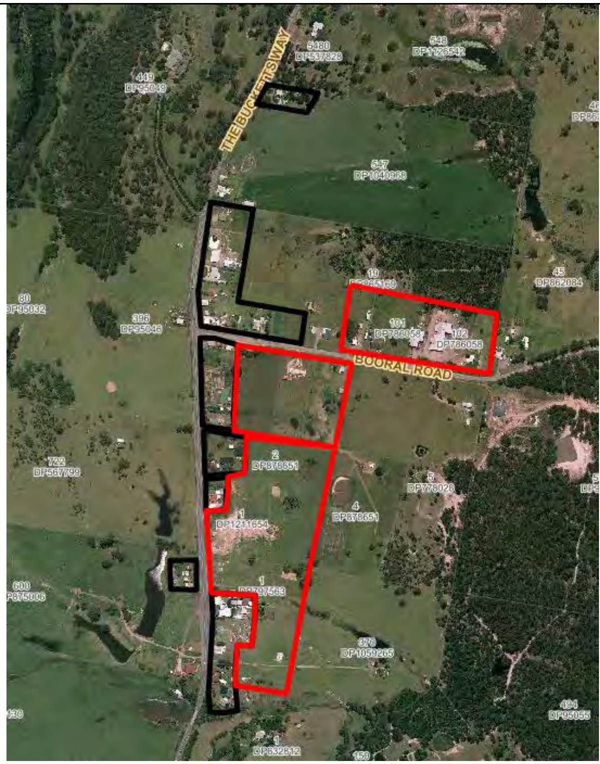
Elands – existing lots with dwellings in Black outline and 4 additional allotments outlined in red Rural strategy to consider rezoning of additional lots in red outline to village zone. Est. approx. capacity 20-25 lots.		

East Wingham – existing lots with dwellings in black outline only Lots significantly constrained due to Manning River 1% AEP Flooding due to convergence point with Cedar Party Creek – high velocity hazard restrictions with risk to life and property. Rezoning as part of Rural Strategy will not be considered – further subdivision or dwellings discouraged If sewer extended – Est. additional capacity for 45 -50 existing dwellings only.	 	 

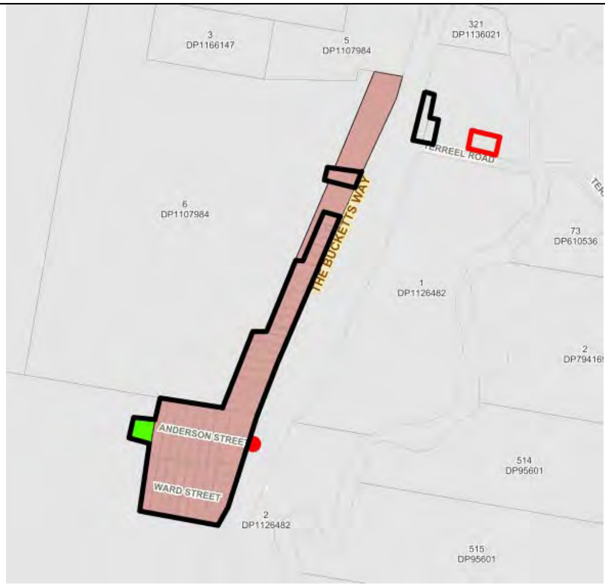
Oxley Island – existing dwellings in rural zones in black outline Rural Strategy to consider possible rezoning to R5 Large Lot Residential – however further subdivision or dwellings discouraged Consider oyster processing facility. Capacity for 22 existing dwellings and oyster processing facility.		

Allworth – existing lots with dwellings in village zone and additional dwellings to west (in red outline but outside village zone) and toilet facilities within foreshore reserves. Rural Strategy - Village zoned land to south west to be considered for R5 instead of village given vegetated state. Approximately 9ha in single ownership. If sewered – Est. approx. capacity 50-60 lots		

Limeburner's Creek – existing lots within dwellings in village zone and one potential additional to south as shown. Rural Strategy - Allotments to NW and various other parcels only suitable for R5, RU4 and/or E4 based on lot size, vegetation, flooding and existing land uses If sewered – Est. approx. capacity 30 - 40 lots		

Booral – existing lots with dwellings in village zone including school. Three small allotments outside village zone identified Rural Strategy - Areas in red outline are potentially suitable for R5, RU4 and IN activities based on existing activities and lot sizes. Booral – industrial activities have located here as a result of road access to larger centres west and south. If sewered – Est. approx. capacity 20-30 lots		

Stroud Road – lots with existing dwellings in village zone and adjoining to NW (black outline). Allow for additional half a dozen – some larger sites would be suitable for subdivision if sewer available – (blue outline NW and village area SE). Allow for school, railway and substation facilities (within black outline) If sewered – Est. approx. capacity 20-30 lots		

Wards River – lots with existing dwellings in village zone (black outline). Two additional lots outside of village zone (black outline). Also allow for a few additional lots within village area and black outline – some larger lots could subdivide if sewer. Also – consider relocation of “Wards River Toilets” (red outline) to recreation area – out of potential flood. Rural Strategy – rezone village area outside of black outline to rural – flood affected and not suitable for development If sewered - Est. approx. capacity 30-40 lots.		

Coomba Park (west) and Coomba Park (east) - lots with existing dwellings in village zone (black outline).

All lots in village zone are priorities. No further expansion possible. High current lot occupation.No further expansion to village zone to be considered as part of Rural Strategy.

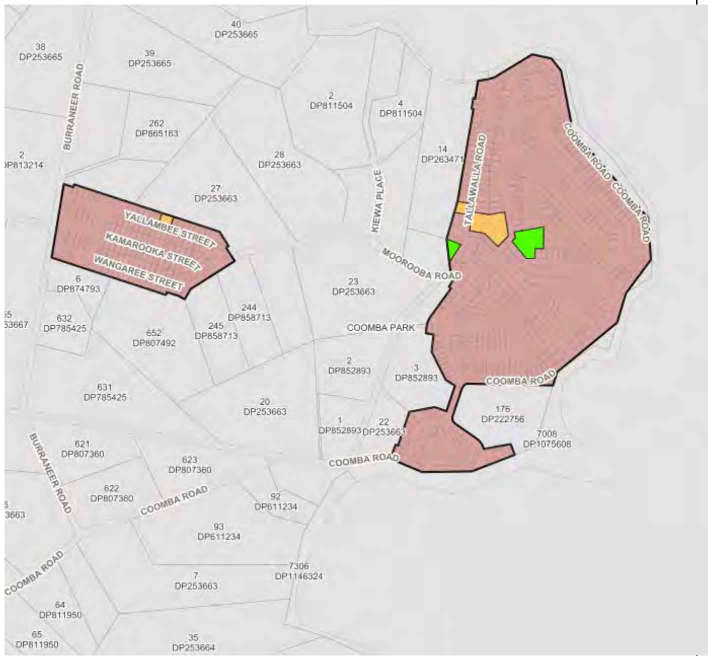
High current lot occupation with further potential for facilities and shops to allow self-sustaining community.

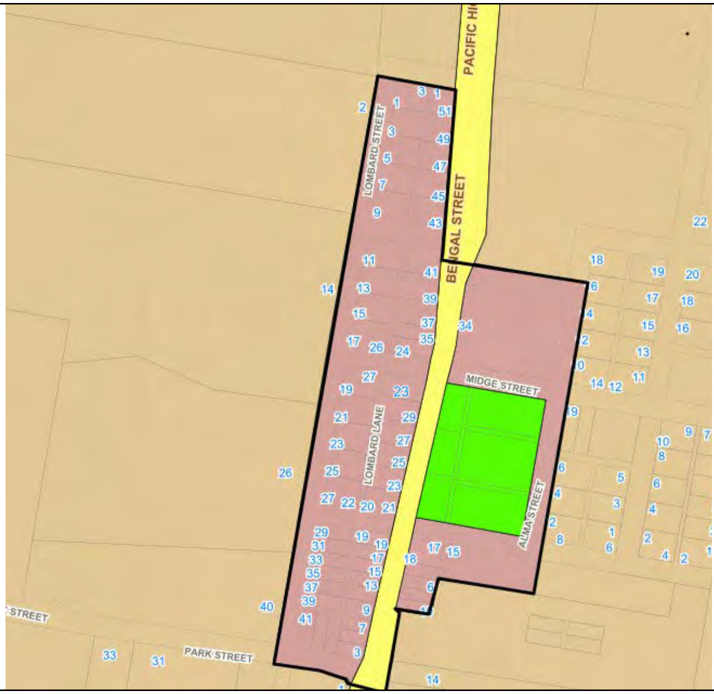
All individual lot ownership. Rural Strategy unlikely to warrant changes.

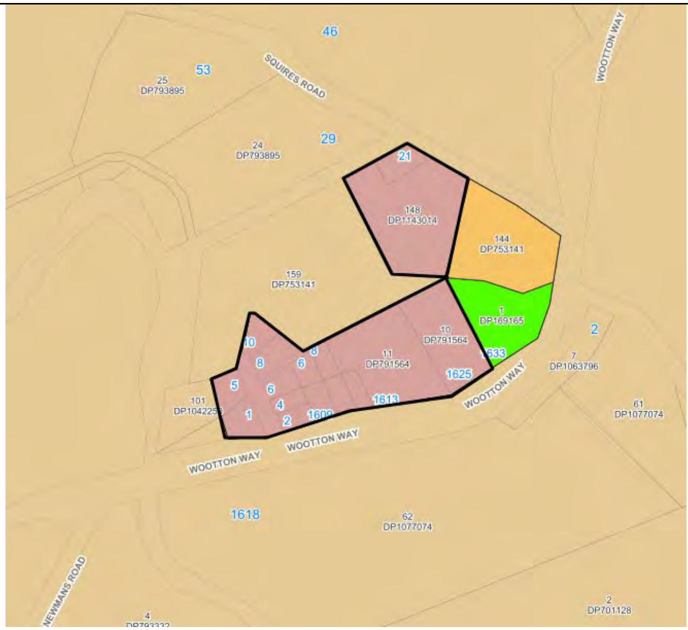
If not sewered possible consolidation clause in LEP.

Allow for numerous public toilet facilities and general store

If sewered - Est. approx. capacity for 250 – 300+ lots.



Coolongolook -lots with existing dwellings in village zone (black outline) Five additional lots outside of village zone (red outline outline). Highway service town which includes service stations, restaurants and cafes and public toilets in green recreation area. If sewered – Est. approx. capacity 50-60 lots, with additional consideration of commercial scale developments.		

Wootton - lots with existing dwellings in village zone (black outline) Rural strategy to consider rezoning of additional lots in red outline to village zone. Subdivision potential if sewered. Consider Wootton community hall and facilities in Public Recreation Zone. If sewered – Est. approx. capacity 30+ lots.		

North Pindimar Village area - village zone only (black outline)

Known OSS issues (pump out prevalent) preventing development of undeveloped lot in village area.

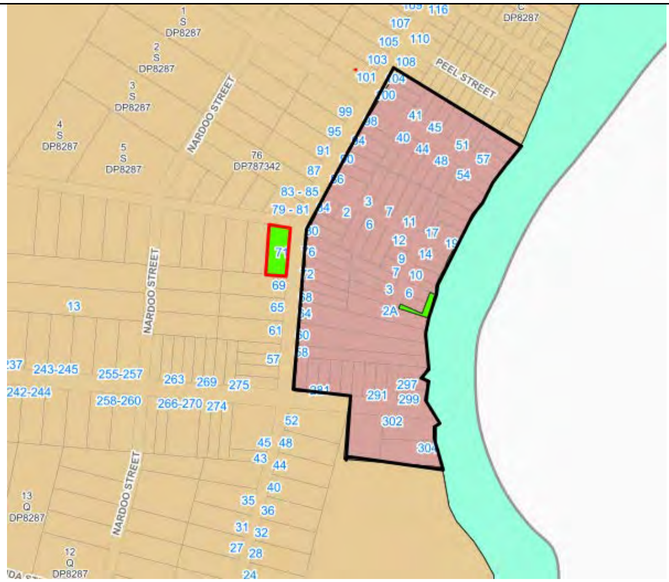
All individual lot ownership. Some flooding and development constraints such as sensitive vegetation communities with threatened species and bushfire.

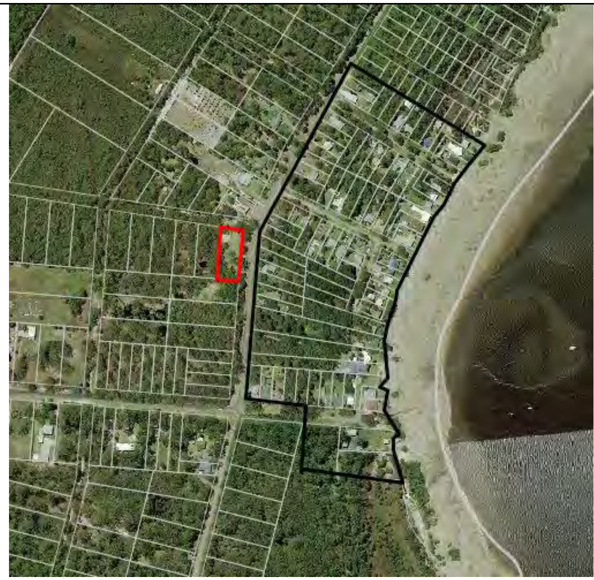
If not sewered possible lot consolidation or minimum lot size clause for OSS in LEP.

No preliminary considerations in Rural strategy for village zone extension.

Secondary consideration for toilet in memorial park (red outline)

If sewered – Est. approx. capacity 40-50+ lots.





South Pindimar village area - village zone only (black outline) Known OSS issues (pump out prevalent) preventing development of undeveloped lot in village area. All individual lot ownership. Some flooding and development constraints such as sensitive vegetation communities with threatened species and bushfire. If not sewered possible lot consolidation or minimum lot size clause for OSS in LEP. No preliminary considerations in Rural strategy for village zone extension. If sewered – Est. approx. capacity 60+ lots		

Pindimar rural extent

Majority of paper subdivision lots do not have dwelling entitlement; are environmentally sensitive, several lots have been transferred back to Council (see green shading) either voluntarily or through unpaid rates.

Sporadic dwelling entitlements – resulting in a fractured development pattern.

Rural strategy to consider priorities and principles for paper subdivisions.

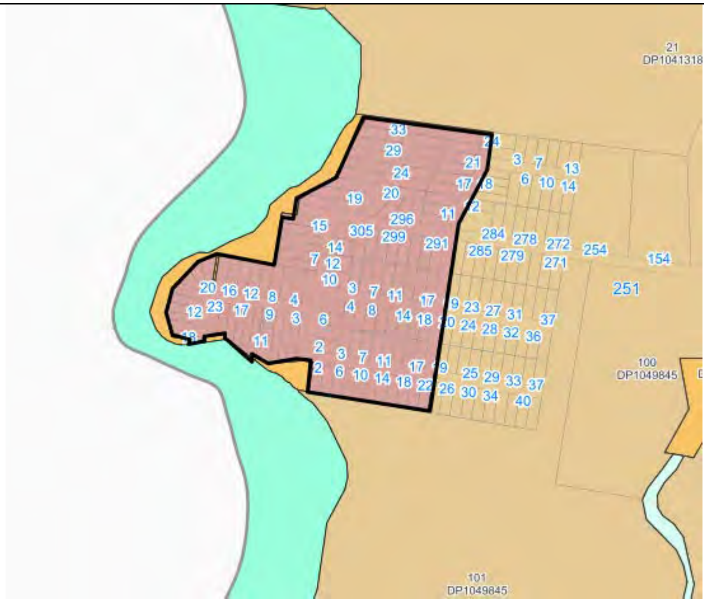
Bundabah - village zone only (black outline) – small number of additional existing dwellings should also be considered

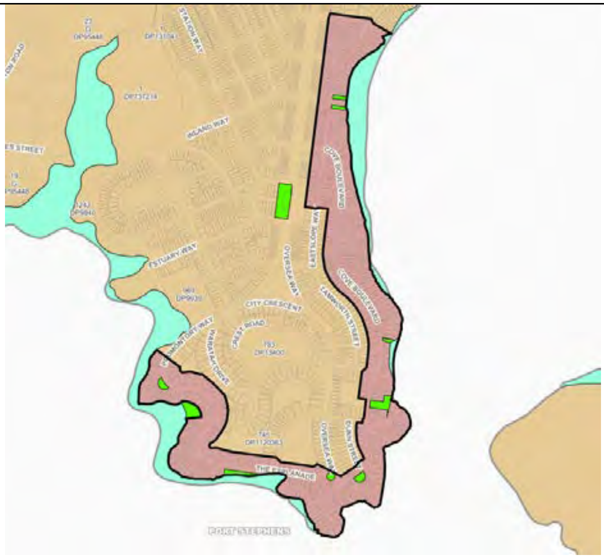
Known OSS issues (pump out prevalent) preventing development of undeveloped lot in village area.

All individual lot ownership. development constraints such as sensitive vegetation communities with threatened species and bushfire. No preliminary considerations in Rural strategy for village zone extension.

If not sewered possible lot consolidation or minimum lot size clause for OSS in LEP.

If sewered – Est. approx. capacity 80 + lots.



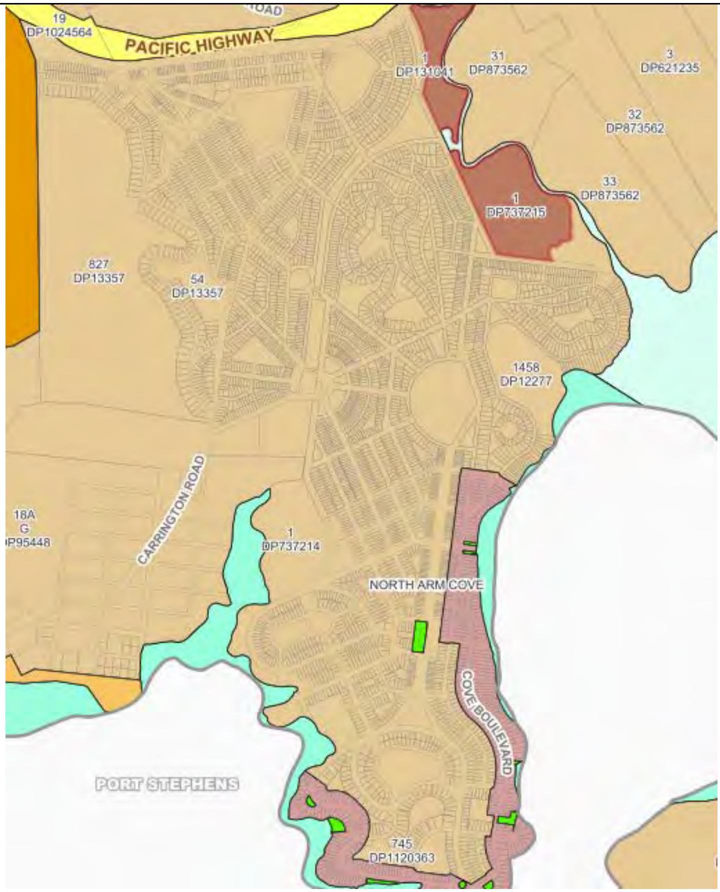
North Arm Cove - village zone only (black outline) Known OSS issues (pump out prevalent) preventing development of undeveloped lot in village area. All individual lot ownership. development constraints such as sensitive vegetation communities with threatened species and bushfire. No preliminary considerations in Rural strategy for village zone extension. If not sewered possible lot consolidation or minimum lot size clause for OSS in LEP. If sewered – Est. approx. capacity 100+ lots.	 	

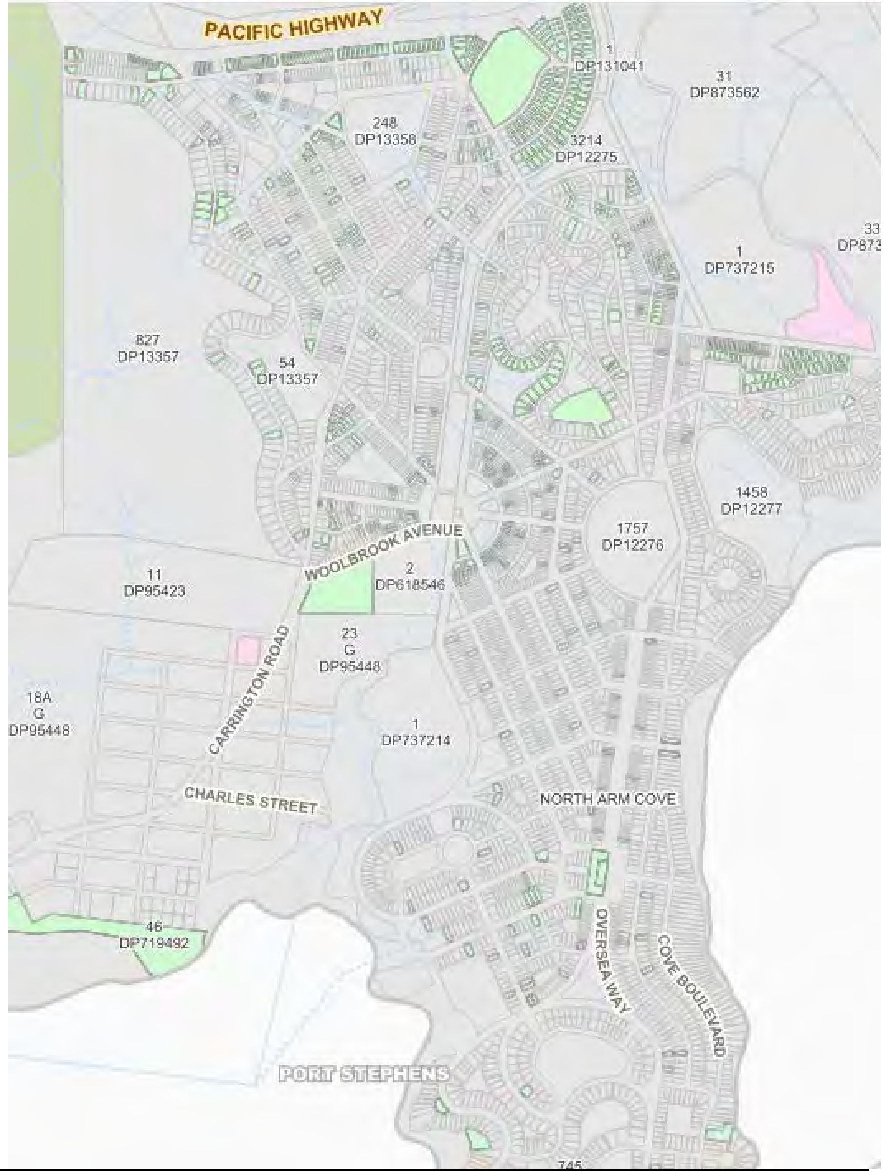
North Arm Cove rural extent – outside of village zone area

Majority of paper subdivision lots do not have dwelling entitlement; are environmentally sensitive - several lots have been transferred back to Council (see green shading) either voluntarily or through unpaid rates.

Sporadic dwelling entitlements – fractured development pattern
Sporadic dwelling entitlements throughout resulting in a fractured development pattern.

Rural strategy to consider priorities and principles for paper subdivisions.





Carrington & Tahlee - village zone only (black outline)

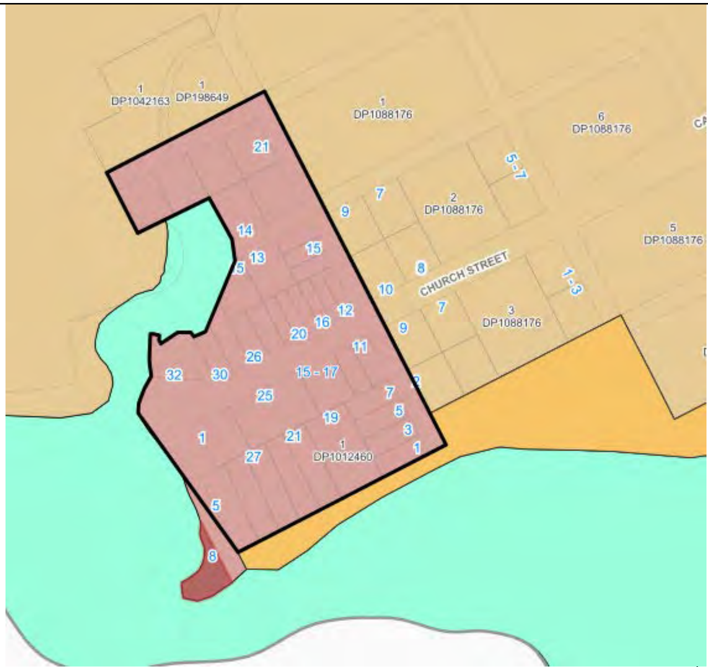
No preliminary considerations in Rural strategy for village zone extension.

Undeveloped Lots outside village zone do not have dwelling entitlement or are environmentally sensitive.

If not sewered possible lot consolidation or minimum lot size clause for OSS in LEP.

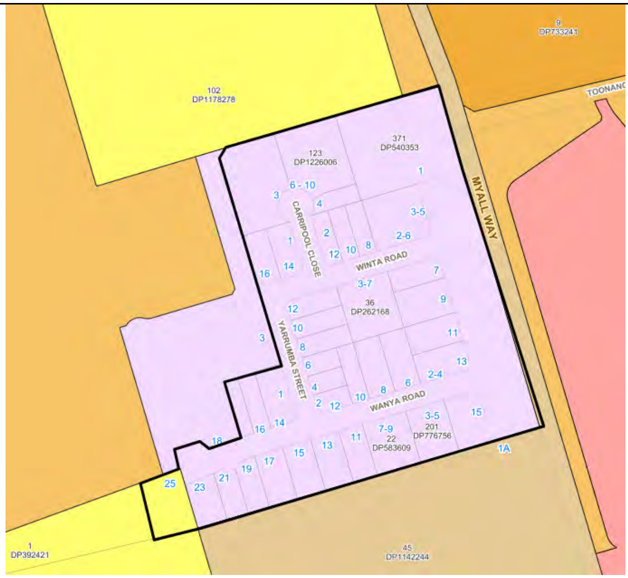
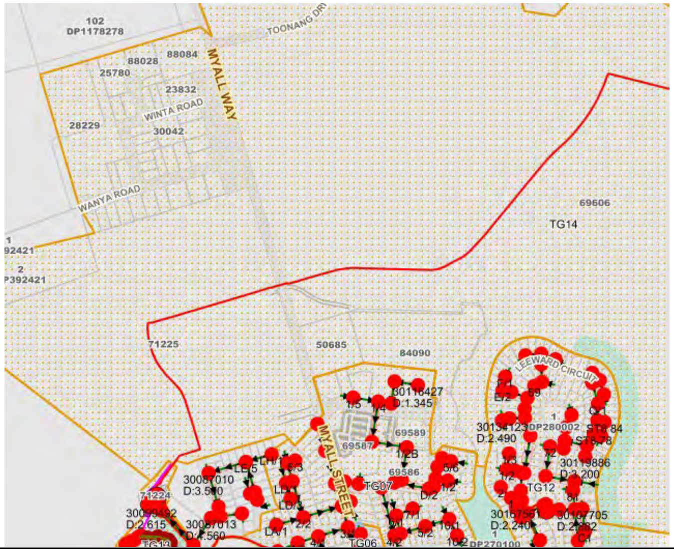
If sewered – Est. approx. capacity 30+ lots.

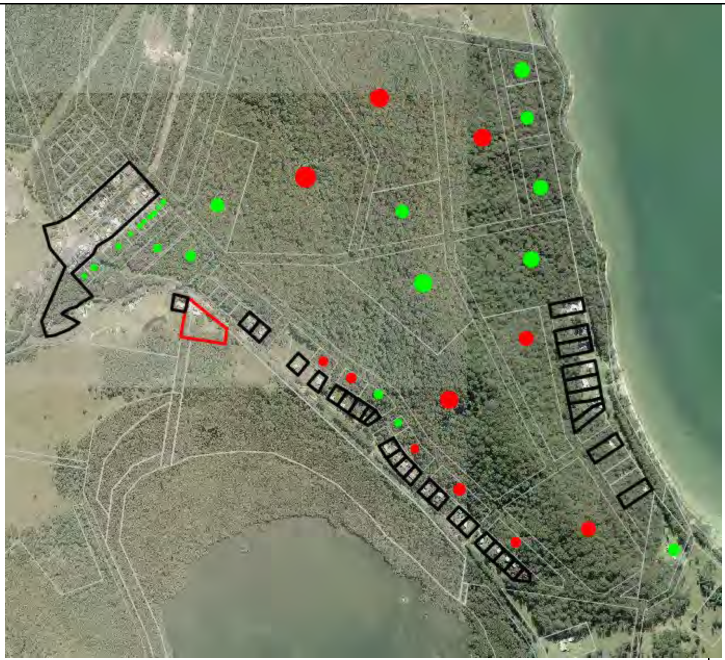
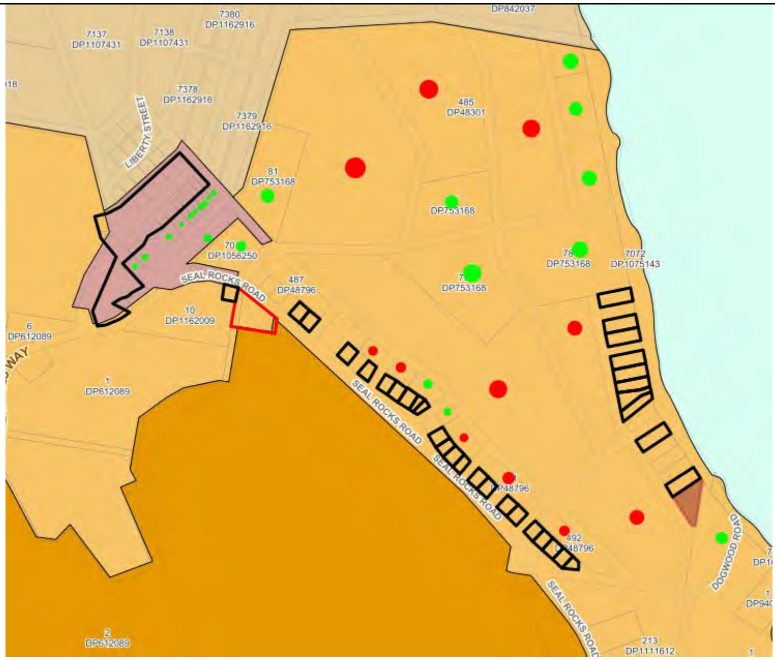
Conference centre at Tahlee – needs to accommodate significant numbers (up to 2000 per event – Gary Mead has more information on this event)



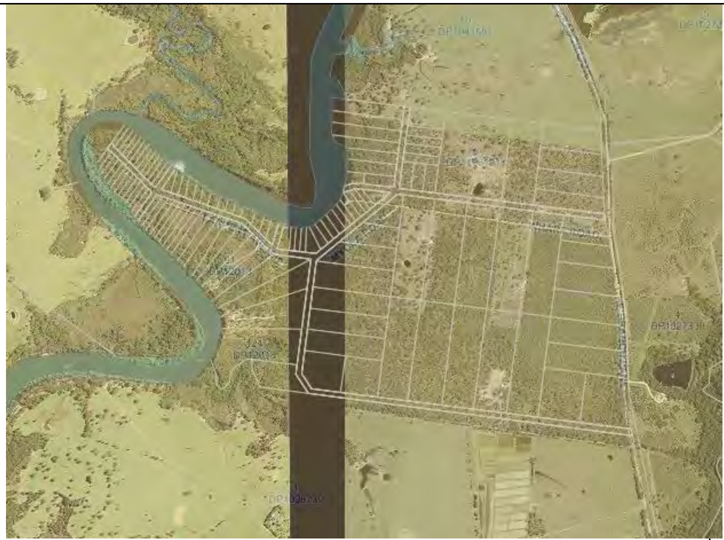
Nerong – lots with existing dwellings in village zone in black outline All lots with existing dwellings are priorities. No further expansion possible – Coastal area, flooding impacts and wetlands. Known OSS issues. Many vacant village zone lots are problematic. Secondary considerations – public toilet facilities If not sewered possible consolidation clause in LEP. if sewered – Est. approx. capacity 60-70+ dwellings		

Seal Rocks – lots capable of containing existing dwellings in village zone (black outline) All lots with existing dwellings, dual occupancies and corner shop within village zone are priorities. No further expansion possible – NPWS. Secondary considerations – public toilet facilities in/adjoining village; caravan park to the west and light house accommodation facilities to the east (red outline highlights location and proximity only) Approx. capacity if sewered – 50-60 dwellings		

Tea Gardens Industrial – industrial lots in black outline Secondary considerations – Council's Tea Gardens landfill offices and amenities	 	
	 	

Bungwahl - lots with existing dwellings only in village zone and existing dwellings in rural zones on Seal Rocks Road and Dogwood Road (black outline). Majority of land by NSW Department of Industry (green circle) and Forster Aboriginal land Council (red circle). Rural Strategy to unlikely expand Village Zone. Possible backzoning of village zone to Environmental Zones. No more dwelling entitlements will be released in rural zones. Bushfire constraints. Secondary considerations – Bungwahl Public School (red outline) and development opportunities for Aboriginal Land Council. Est. approx. capacity if sewered- 30-40 dwellings + public school + land council development.		

Violet Hill All lots are zoned E1 and owned by NSW National Parks and Wildlife Service.		

The Branch Majority of lots do not have dwelling entitlement; are environmentally sensitive and/or in water; and are significantly flood affected (blue shading) - have been transferred back to Council (see green shading).		

Copeland Common (East Copeland) – currently RU1

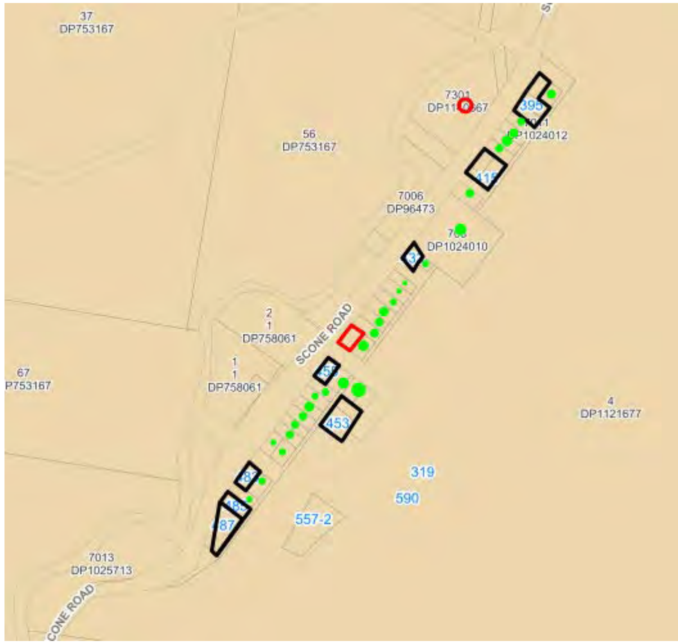
Lots with existing dwellings in (black outline) - 8 dwellings in total

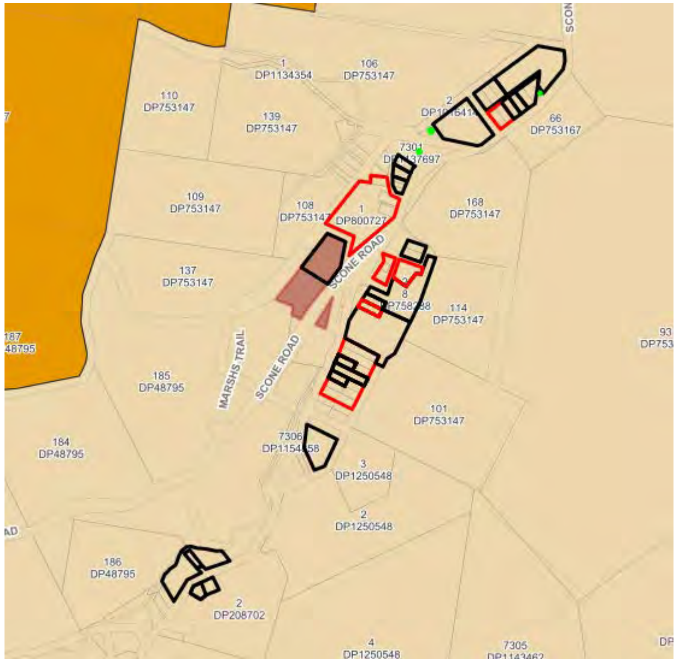
Majority is Council or Crown owned (green).

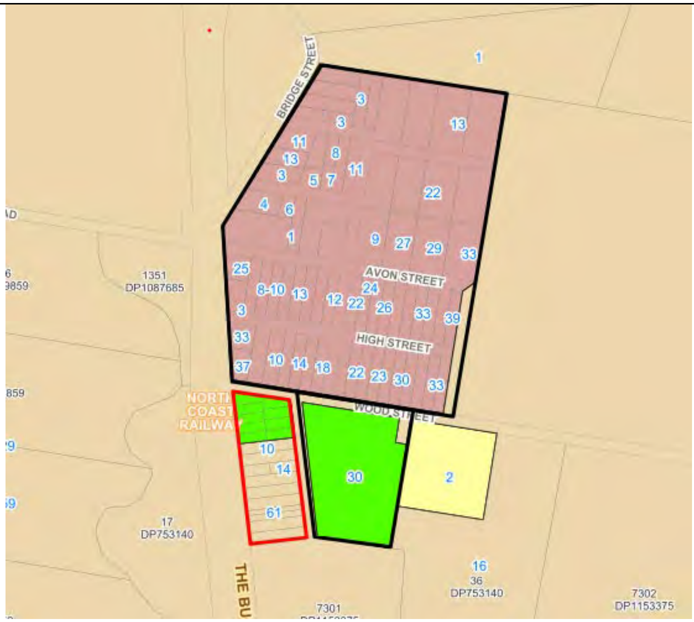
Historical context is important – Copeland is a historical gold mining village of over 1,000 people, essentially all previous lots contained buildings.

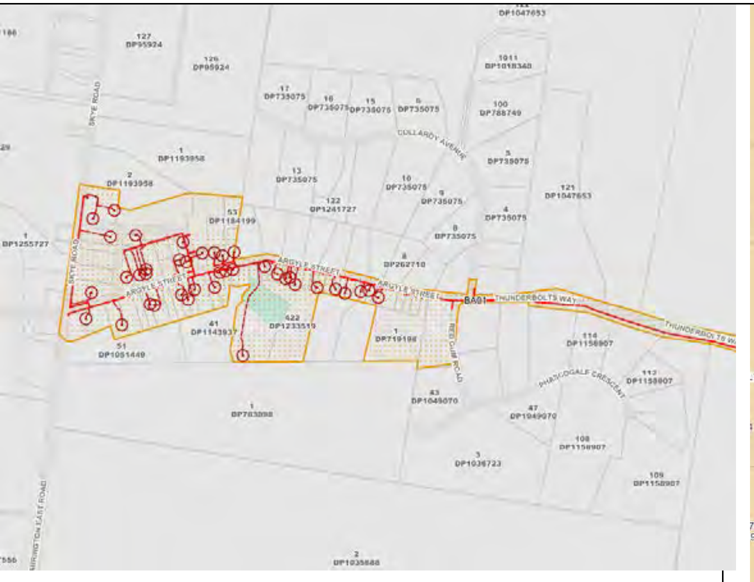
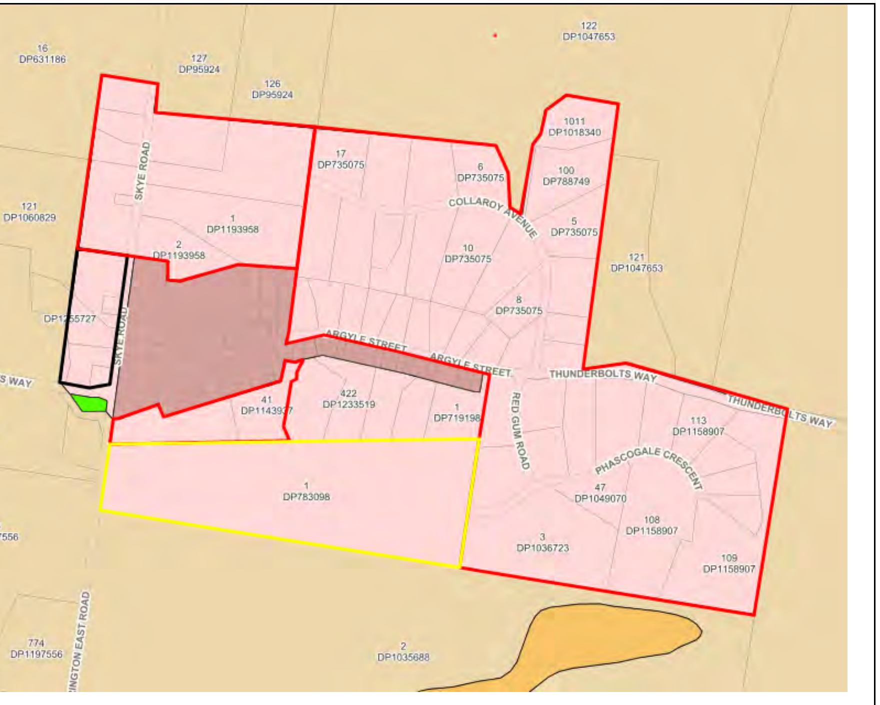
Rezoning as part of Rural Strategy unlikely given all entitlements taken up and Council and Crown ownership./ Fractured development pattern.

Free camping facility on Copeland Common (red circle) consideration for sewered amenities.

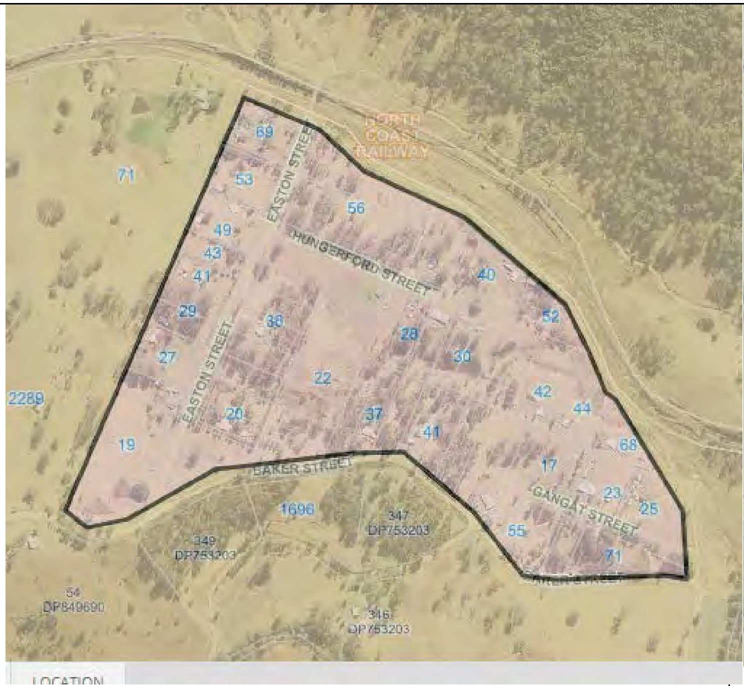


Copeland (west Copeland currently RU1) Lots with existing dwellings (black outline) Rural Strategy – investigation of possible village zone – some lots unsuitable for development due to vegetation and bushfire Forster Aboriginal Land Council own several allotments. Existing on-site sewerage issues relates to boundary uncertainties, reflected in historical mining as mentioned above. If sewered - Est. approx. capacity 30+ lots.		

Stratford Lots with existing dwellings in village zone (black outline) Additional lots outside of village zone (red outline). Also allow for a few additional lots within village area and black outline – some larger lots could subdivide if sewer. Rural Strategy – considered rezoning of rural area in red outline to village. Also consider public toilets in RE1 Zone. Aboriginal Land claims on crown red in red outlined area does not preclude servicing by sewerage If sewered – Est. approx. capacity 40-50 lots.		

Barrington All RU5 sewered in addition to some adjoining R5 Lot highlighted in yellow subject to approval part of which requires sewerage infrastructure R5 lots have land parcels area predominantly over 8,000sq.m – topography issues Sewerage infrastructure may observe more subdivision of R5 lots creating undesirable fragmentation in area highlighted red Rural Strategy – considered extension of village areas to black outline If sewered – additional capacity approx. 10 lots.		

Craven - lots with existing dwellings in RU1 Primary Production zone (black outline). 2 section, 8 dwellings and 7 dwellings. Known OSS issues – flat and subject to local flooding – predominantly aerated systems due to clay soils. Constrained land subject to flooding/drainage issues. No further development encouraged.		

Bundook – R5 zoned area outlined in black Former paper subdivision rezoned to R5 in 2010. Rural Strategy to investigate possible RU5 zone to encourage self-sustaining community i.e. cafes Existing dwellings highlighted in red Individual Lot size ranging from 2,000 to 4,000 square metres Traversed by a watercourse offering a development constraint. If not sewered possible consolidation clause in LEP.		

Appendix D: High Level Options Assessment Criteria

This table provides further information explaining the criteria used for selection of a preferred high-level option for each village.

Element	Details	Description
Lot size	Key factor determining area available for effluent management	This has been estimated for each lot based on previous analysis undertaken by DWC for DAF (for minimum lot sizing analysis). This included previous analysis for lots across Greater Taree, Kempsey Shire and Monbulk (Victoria).
Land area required for effluent management	Land Application Area or Reuse Area (LAA)	Initial estimated size of LAA required for sustainable long-term effluent management (either on-property or local cluster reuse facility). **Land Application** Design Loading Rate (DLR) of ~1-2mm/day assumed for conservatism given typical climatic and soil conditions across LGA. **Beneficial Reuse** Initial modelling undertaken to assess potential land application (at a daily timestep) using MEDLI, which is considered a best practice model for simulating effluent irrigation.
Total number of lots	Incorporated into ADWF calculation for each village	Factors into the viability of a local cluster treatment or '*Whole of Town*' solution based on economies of scale and potential value in decentralised management of effluent at dedicated areas Currently assumed ADWF = 525L/day/dwelling
On-site hazard rating (land capability and receiving environment)	Detailed on-site hazard classifications inform the potential for sustainable long-term wastewater management either on-lot or at a designated cluster site.	Given the constrained nature of these identified villages, a large proportion of lots are deemed High Hazard under the DAF. However, can help inform the viability of potential cluster reuse sites.

Appendix E: Village Wastewater Characteristics Summary

This table provides a summary of wastewater servicing characteristics for each village.

Rank	Village	No. of Lots	Approx. Total ADWF (kL/day)	Lot Size (Median)
1	Coomba Park	670	350	560 m^2
2	North Pindimar	91	48	1,310 m^2
	South Pindimar	137	72	1,150 m^2
	North Arm Cove	409	215	1,015 m^2
	Bundabah	125	66	1,215 m^2
	Nerong	168	90	660 m^2
	Seal Rocks	73	38	650 m^2
	Carrington & Tahlee	40 (including church / camp site)	21 (camp site flows will vary)	1,520 m^2
9	Bungwahl	74	40	2,000 m^2 (overall) 4,000m^2 (eastern lots along Dogwood Road)
10	Croki	25 plus 38 caravan park sites	18 Plus caravan flows which will vary seasonally	810 m^2
11	Allworth	92	48	1,010 m^2
	Copeland	116	61	1,055 m^2
13	Tea Gardens (Industrial Estate)	38	TBC (commercial properties)	1,890 m^2
14	Coolongolook	77	40	1,800 m^2
15	Stroud Road	91	48	1,089 m^2
16	Krambach	238	58	1,473 m^2
17	Oxley / Mitchells Island	177 / 47	TBC	>1.4 hectares
	Wards River	64	34	1,013 m^2

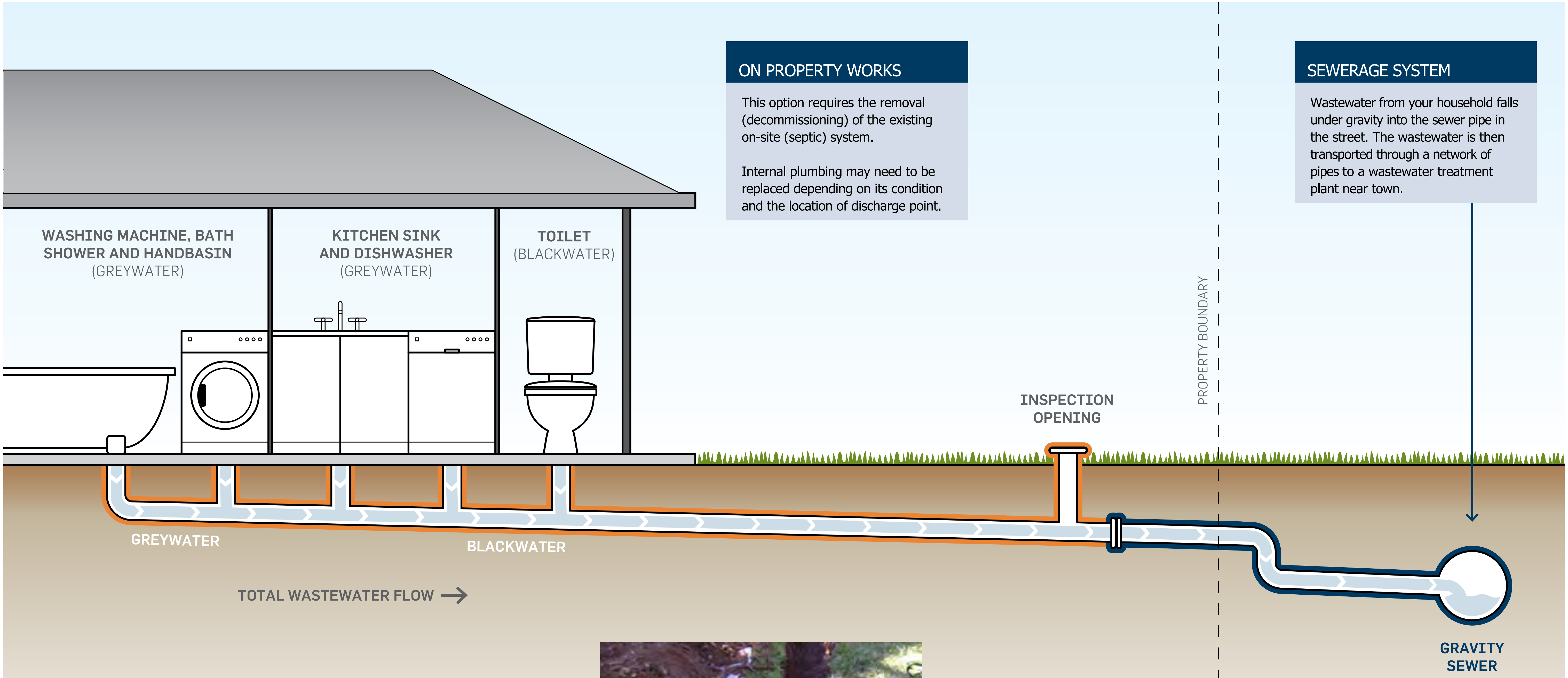
Rank	Village	No. of Lots	Approx. Total ADWF (kL/day)	Lot Size (Median)
19	Mount George	97	51	1,800 m^2
	Elands	62	33	1,492 m^2
21	Johns River	173	91	1,060 m^2
22	East Wingham	65	34	858 m^2
23	Craven	23	12	1,065 m^2
24	Wootton	23	12	3,011 m^2
25	Stratford	100	53	2,022 m^2
26	Limeburners Creek	58	30	1,080 m^2
27	Booral	53	28	2,715 m^2
28	Moorland	120	63	1,295 m^2
29	Barrington	91	48	2 hectares
30	Bundook	79	41	4,055 m^2

Appendix F: Servicing Option Posters

Courtesy Yarra Valley Water

GRAVITY SEWERAGE

A gravity sewer is the traditional way Barwon Water would service a town. Gravity sewerage systems are a known and relatively simple system. However, they can be expensive for small towns that lack the economy of scale of an urban area. They can also require a lot of pump stations in undulating areas.



ON PROPERTY WORKS

This option requires the removal (decommissioning) of the existing on-site (septic) system.

Internal plumbing may need to be replaced depending on its condition and the location of discharge point.

SEWERAGE SYSTEM

Wastewater from your household falls under gravity into the sewer pipe in the street. The wastewater is then transported through a network of pipes to a wastewater treatment plant near town.

AT A GLANCE

PROS

Lower operation cost to pressure sewer (no pump required).

All wastewater managed off-site.

Common / proven option.

CONS

Anticipated high cost due to hilly terrain and small town.

Larger volumes of untreated sewage need management in a central location.

Limited to no potential for reuse on people's properties.

Artwork supplied by Yarra Valley Water

PRESSURE SEWERAGE NETWORK

Pressure sewerage systems can be a cost effective way to provide a full off-site sewerage solution in undulating terrain where gravity sewerage is challenging or expensive. A small pump unit is installed on each property to pump raw macerated sewage into a pressurised sewer network.

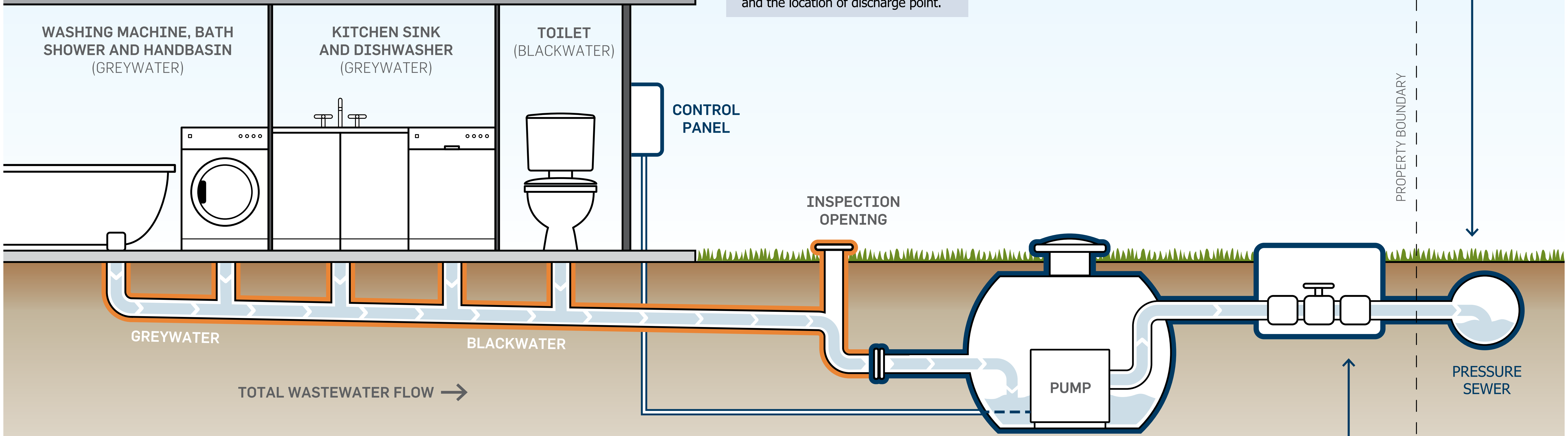
ON PROPERTY WORKS

This option requires the removal (decommissioning) of the existing on-site (septic) system.

Internal plumbing may need to be replaced depending on its condition and the location of discharge point.

SEWER PIPE

Wastewater from your household is pumped into the sewer pipe in the street. The wastewater is then transported through a network of pipes to a wastewater treatment plant near town.



AT A GLANCE

PROS	CONS
All wastewater managed off-site.	Anticipated moderate to higher cost option.
Proven option	Potential issues with seasonal flows.
Can avoid or reduce need for pump stations.	Larger volumes of untreated sewage need management in a central location.
	Limited to no potential for reuse on people's properties.On property infrastructure required.

PUMP UNIT

This tank stores all wastewater and pumps it away to a sewerage network. Unlike septic tanks, this tank will not require sludge to be pumped out of the tank as it will be pumped into the sewer network. This tank is smaller than a septic tank and has sufficient holding capacity to allow for periods of power outage or maintenance of the system.

OFF-SITE PUMPING

A pump and discharge pipeline will be installed to convey wastewater to a central location for treatment and dispersal.

Artwork supplied by Yarra Valley Water

SEPTIC TANK EFFLUENT PUMP / GRAVITY (STEP/STEG) SYSTEMS

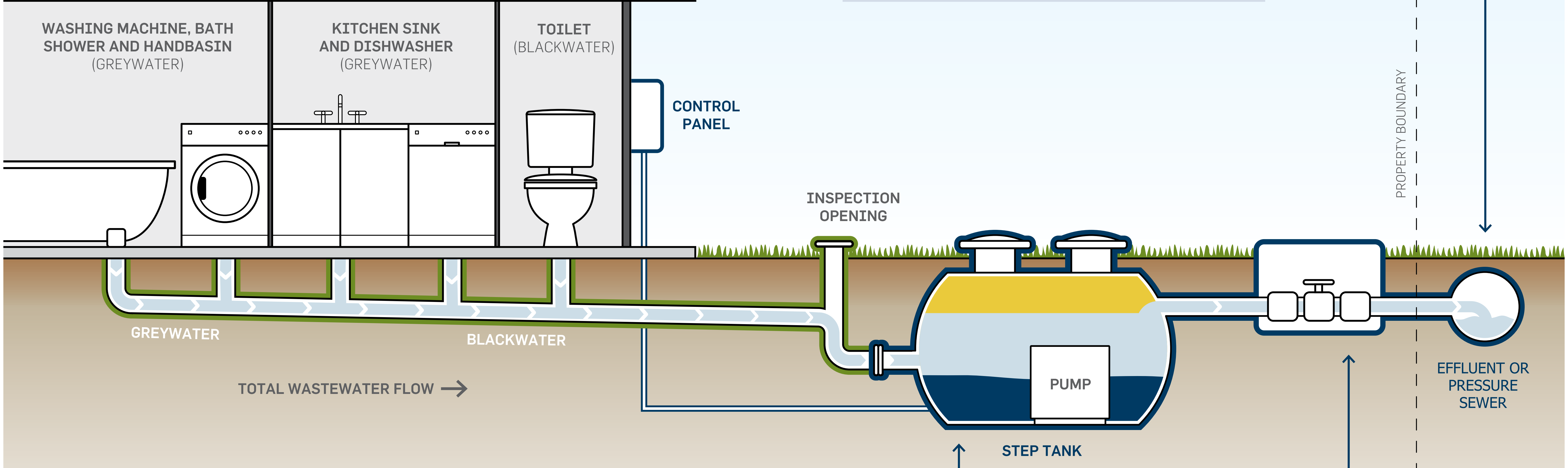
STEP/STEG systems can reduce the size and cost of reticulation and treatment plants by providing primary treatment, biosolids breakdown and flow balancing on each property. This can be important in small towns with lower permanent population and economies of scale for central infrastructure.

COMMUNITY OR CLUSTER MANAGEMENT

Septic tank effluent is pumped or flows by gravity via a sewer to a cluster (e.g. street scale) or a whole town wastewater treatment plant. Here it is treated to enable reuse by irrigation of public open space or use by agricultural or industrial water users. Sometimes it is used to create liveable green spaces that contribute to amenity and recreation in a town.

EFFLUENT SEWER

Wastewater from your household is pumped into the sewer pipe in the street. The wastewater is then transported through a network of pipes to a wastewater treatment plant.



AT A GLANCE

PROS	CONS
Provides partial treatment of effluent on-lot so smaller treatment / recycling plant required for final treatment.	No ability to reuse wastewater for watering on the property.
Better able to manage seasonal flows.	Larger volumes of treated sewage need management in a central location.
No pump stations required.	Requires on property infrastructure.
Lower operational cost than other sewerage options.	Desludging required (approx. every 8-10 years)

STEP / STEG TANK

This tank treats wastewater, stores and digests sludge and pumps away liquid wastewater. Solids in the wastewater are pumped away periodically. In some situations existing septic tanks may be able to be retained and converted into Septic Tanks with Effluent Pumping (STEP) systems.

Septic Tank Effluent Gravity (STEG) units have no pump and operate by gravity fall. They need to be elevated above the sewer.

For properties where the existing septic tank is in poor condition or inadequately sized, it will be replaced with a new STEP/STEG tank system.

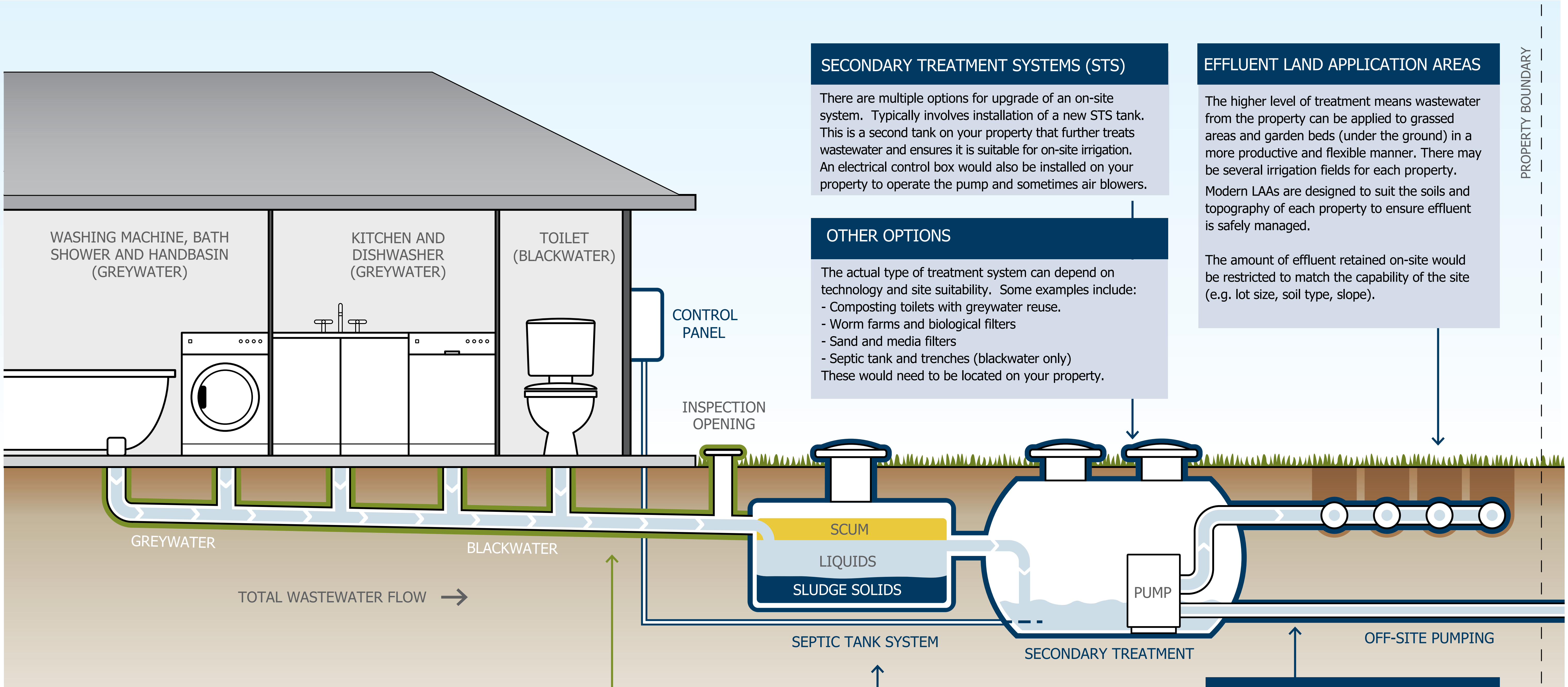
OFF-SITE PUMPING

A pump and discharge pipeline will be installed to convey excess wastewater not able to be irrigated on the property to a central location for treatment and dispersal.

Artwork supplied by Yarra Valley Water

PARTIAL ON-SITE WASTEWATER MANAGEMENT SYSTEMS

Small towns can potentially achieve a cost effective and high quaility outcome by managing a safe amount of wastewater on individual properties and sending excess volumes to a managed off-site solution.



SECONDARY TREATMENT SYSTEMS (STS)

There are multiple options for upgrade of an on-site system. Typically involves installation of a new STS tank. This is a second tank on your property that further treats wastewater and ensures it is suitable for on-site irrigation. An electrical control box would also be installed on your property to operate the pump and sometimes air blowers.

OTHER OPTIONS

The actual type of treatment system can depend on technology and site suitability. Some examples include:

- Composting toilets with greywater reuse.
- Worm farms and biological filters
- Sand and media filters
- Septic tank and trenches (blackwater only)

These would need to be located on your property.

EFFLUENT LAND APPLICATION AREAS

The higher level of treatment means wastewater from the property can be applied to grassed areas and garden beds (under the ground) in a more productive and flexible manner. There may be several irrigation fields for each property.

Modern LAAs are designed to suit the soils and topography of each property to ensure effluent is safely managed.

The amount of effluent retained on-site would be restricted to match the capability of the site (e.g. lot size, soil type, slope).

AT A GLANCE

PROS

Allows the wastewater to be reused for lawn / garden bed watering (reduces water bill).

Provides flexibility in amount of wastewater reused depending on lot size.

Provides greater capacity for permanent residents and temporary visitors.

CONS

On property infrastructure required.

Requires a new management structure.

SEPTIC TANKS

Septic tanks remain a reliable and low cost treatment option but they need to be larger than traditional septic tanks installed in the past. Satisfactory tanks may be retained.

OFF-SITE PUMPING

A pump and discharge pipeline will be installed to convey excess wastewater to a central location for treatment and dispersal.

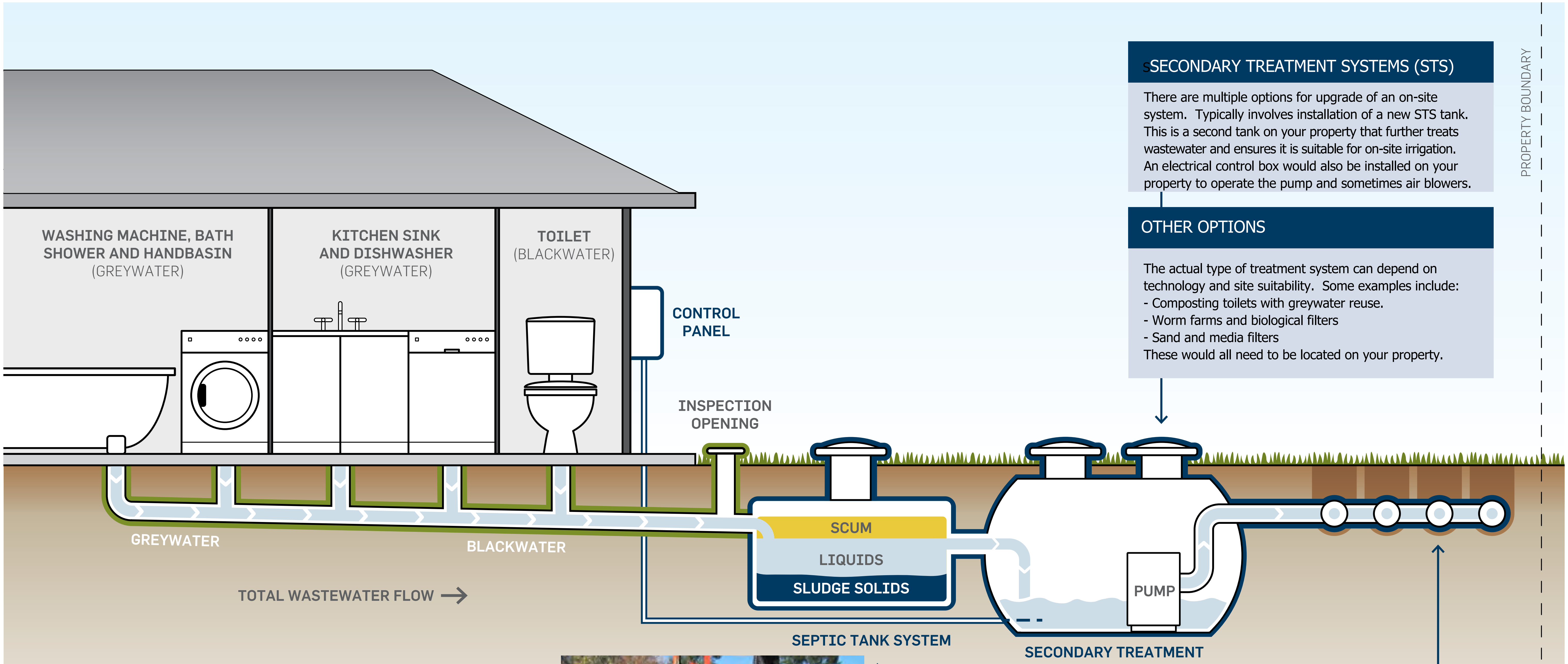
This could be a town water recycling plant or a small cluster reuse system at the end of your street.

This approach means only the effluent not safely managed your property needs to be managed elsewhere and most of the treatment has already occured.

Artwork supplied by Yarra Valley Water

UPGRADES TO EXISTING ON-SITE WASTEWATER MANAGEMENT SYSTEMS

There are some properties in Forrest capable of containing their wastewater on-site subject to an upgraded or new on-site wastewater treatment and land application area.



SECONDARY TREATMENT SYSTEMS (STS)

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OTHER OPTIONS

The actual type of treatment system can depend on technology and site suitability. Some examples include:
- Composting toilets with greywater reuse.
- Worm farms and biological filters
- Sand and media filters

These would all need to be located on your property.

AT A GLANCE

PROS

Allows the wastewater to be reused for lawn / garden bed watering (reduces water bill).

Likely to be lower cost option.

No discharge to rivers.

CONS

On property infrastructure required.

Requires a new management structure.

Some properties in Forrest cannot fully contain their wastewater on site.

SEPTIC TANKS

Septic tanks remain a reliable and low cost treatment option but they need to be larger than traditional septic tanks installed in the past. Satisfactory tanks may be retained.

EFFLUENT LAND APPLICATION AREAS (LAA)

The higher level of treatment means wastewater from the property can be applied to grassed areas and garden beds (under the ground) in a more productive and flexible manner. There may be several irrigation fields for each property.

Modern LAAs are designed to suit the soils and topography of each property to ensure effluent is safely managed.

Artwork supplied by Yarra Valley Water

Innovative options

There are range of innovative systems available for wastewater, greywater and stormwater treatment both on the property and along public areas like streets and parks, these include:

Recirculating sand filter with subsurface irrigation

Reed bed – passively treats the wastewater using natural processes as it moves through vegetation.

Power generation

Greywater onsite treatment

Worm farms

Textile filter system


Precinct plants


Downpipe discharges stormwater to raingarden.
Stormwater gets cleansed by filter sand and plant roots as it percolates through the filter layer.
Drainage layer stops slots in underdrain from blocking with the sandy loam filter media.
Rainwater tank overflow can also enter your raingarden for treatment.
Overflow pipe collects excess water, preventing flooding during heavy rain and allowing flushing if blockage occurs.
Plant roots help to keep filter media porous and contribute to cleansing stormwater.
Slotted underdrain pipe collects filtered water and discharges it to the drainage system.
Raingardens

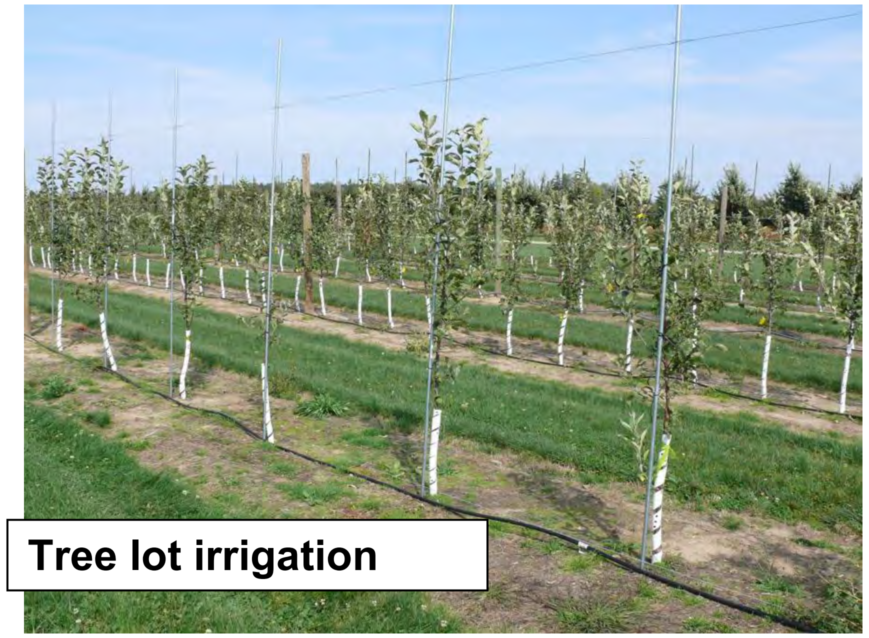

Composting toilets


Potable reuse


Backyard irrigation


Public open space subsurface irrigation


Waste to fertilizer


Tree lot irrigation


Polishing and biodiversity wetland


Irrigation of crops


Water sensitive urban design


Vineyards


Home use


Green roofs







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