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On-site Wastewater Management Report for Preliminary Planning Proposal at 127 High Street, Wallalong NSW

Whitehead & Associates Environmental Consultants Pty Ltd ("W&A") was engaged by Perception Planning Pty Ltd (PP) to prepare an On-site Wastewater Management Report (WMR) for a preliminary planning proposal at 127 High Street, Wallalong NSW (the "Site"). The Site is currently zoned RU1 'Primary Production' under the Port Stephens Local Environmental Plan (LEP, 2013).

We understand PP is working with a Client to prepare a preliminary planning proposal for the rezoning of the Site for the long-term development of an independent ("seniors") living community. The first stage of the planning proposal involves a submission of a Site Compatibility Certificate for support under the NSW SEPP (Housing for Seniors or People with a Disability) 2004, ultimately proceeding to a Development Application submission to Port Stephens Council ("PSC" or "Council"). Perception Planning submitted a Site Compatibility Certificate, dated May 2020, for the Site; and we understand Council have provided comment on the proposal and identified wastewater servicing as a matter for further consideration.

The Site is identified as Lot 91 DP 1167540 (accessed from High Street) and is approximately 10.22ha in area. The property is largely cleared for pasture/grazing, with scattered trees throughout. The Site presently contains an existing dwelling, shed and other improvements. The Site contains, or is adjacent to, several dams and intermittent drainage features and is identified as bushfire prone land. The development would be serviced by reticulated water supply and no sewer service is available at present.

A preliminary Site Layout plan is provided in the Site Compatibility Certificate (Perception Planning, May 2020), which includes 180 single storey self-contained units. The development will also include the following communal facilities: community hall, barbeque and outdoor communal areas, swimming pool, tennis court and parking.

With regard to sanitary wastewater servicing, Council has adopted a comprehensive Development Assessment Framework (DAF) for Onsite Sewage Management (OSSM), which sets out required standards for investigation, acceptable solutions and minimum standards for sewage management in unsewered areas of Port Stephens. Council have advised that the Site is considered a ‘high hazard’ allotment for non-domestic development with an average-dry-weather-flow (ADWF) 10-100kL/day.

The following table presents the minimum standards required by Section 3.2 (and Table 3.7) PSC DAF (2015) for a ‘high hazard’ allotment WMR.

DAF Minimum Standards for WMR (non-domestic system ADWF 10-100kL/day)		
Report Element	**Minimum Standard**	**Completed**
Introduction and Background	• Name, contact details and qualifications of author(s).	✓
	• Site location and owner.	✓
	• Allotment size (m² or ha).	✓
	• Proposed / existing water supply.	✓
	• Description of proposed facility (including equivalent persons).	✓
	• Availability of sewer.	✓
Site and Soil Assessment	• Broad overview of locality and landscape characteristics.	✓
	• Details of the date and time of assessment in addition to statements confirming the methods used to complete the assessment.	✓
	• Site assessment that considers all parameters listed in Table 6-1 of the DAF in accordance with *AS/NZS 1547:2012*.	✓
	• Detailed review of available published soils information for the Site.	✓
	• Soil assessment that considers all parameters listed in Table 6-1 of the DAF in accordance with *AS/NZS 1547:2012*.	✓
	• Where multiple soil facets are present the site plan should show the approximate boundary between facets.	✓
	• Detailed explanation of the implications of observed site and soil features for system design and performance.	✓
	• Assessment of the existing condition of the receiving environment and sensitivity to on-site system impacts.	✓
System Selection	• Summarise potential treatment and land application systems considered including advantages and limitations.	✓
	• Preliminary design calculations for a minimum of 2-4 options.	✓
	• Brief statement justifying selection of potential treatment and land application systems.	✓
Design	• Detailed wastewater characterisation (quality and quantity) including temporal variation using existing data for the subject site or similar facilities	✓
	• Establishment of clear, site specific design criteria based on typical or published performance	Preliminary work completed
	• Process design in accordance with Tchobanoglous and Burton (2003) or Crites and Tchobanoglous (1997) detailing the rationale, assumed performance and capacity to manage design flows and loads. Process performance should be supported by published data or information that demonstrates the suitability of the process to the site and development.	To be completed at DA stage
	• Daily water, nutrient and pathogen modelling to size any land application areas.	Preliminary work completed
	• Hydraulic design of collection, treatment and land application components to demonstrate the viability of the process.	To be completed at DA stage

DAF Minimum Standards for WMR (non-domestic system ADWF 10-100kL/day)		
Report Element	**Minimum Standard**	**Completed**
	• Design drawings and specifications for all system components	To be completed at DA stage
Site Plan	• Survey Plan. • Proposed allotment boundaries, dimensions and area; • Location of existing buildings, swimming pools, paths, groundwater bores, dams and waterways; • Location of exclusion zones (e.g. setback distances and unsuitable site and soil conditions); • Location of EMAs capable of containing LAAs and reserves (where applicable); • Half metre elevation contours; and • Location of existing and proposed drainage pipework (centreline).	✓ (STC) ✓ ✓ (STC) ✓ To be completed at DA stage
Cumulative Impacts (Where required)	• Summary of approach taken and confirmation of compliance with the Minimum Standards documented in Section 2.7. • Methodology documenting the basis and source of input data including reference to site specific data, published information or the *Technical Manual* to justify use. • Results demonstrating compliance with local water quality objectives and adequate management of health risk as defined and demonstrated in Section 10.1.1 of the *Technical Manual*. • Brief discussion of long-term risks to health and environment and recommended management measures to address impacts.	To be completed at DA stage
Appendices	• Soil bore logs for all test pits. • Raw laboratory results for soil analysis. • All design calculations and assumptions including screenshots of cumulative impact spreadsheets/models.	✓ ✓ Preliminary work completed

1 Author Statement

This WMR was prepared by Jasmin Kable who is an experienced Environmental Consultant with W&A (>7 years), holding a Bachelor of Science (Class 1 Honours) from the University of Newcastle (2012). Jasmin has completed the On-Site Wastewater Management professional short-course with the Centre for Environmental Training (CET) and has prepared WMR's for many residential Sites across the Hunter, Central Coast, Port Stephens and Mid North Coast regions.

2 Introduction

This assessment has been undertaken in reference to the assessment and design principles of:

- AS/NZS 1547:2012 On-site Domestic Wastewater Management (Standards Australia / Standards New Zealand, 2012);
- Environment & Health Protection Guidelines: On-site Sewage Management for Single Households (Department of Local Government, 1998);

- Port Stephens Council (2015) On-site Sewage Development Assessment Framework (DAF). Revision 4, dated 24 March 2015; and
- Port Stephens Council (2015) On-site Sewage Management Technical Manual. Revision 3, dated 31 March 2015.

The following table presents information on the property investigated.

Feature	Description
Site Address	127 High Street, Wallalong
Lot / DP	Lot 91 DP 1167540
Local Government Area	Port Stephens Council
Land Zoning	RU1 Primary Production
Lot Size (ha)	10
Sewer Connection Available	Presently unavailable but Wallalong township considered part of a ~5 year sewer extension plan.
Potable Water Supply	Reticulated (town) water supply available.

3 Site and Soil Assessment

The Site investigation was undertaken by Jasmin Kable and Lucinda O'Sullivan of W&A on the 21st May 2020. The following tables present the results of our site and soil investigation for the property.

A description of the Site physical constraints and the degree of limitation they pose to on-site sewage management (OSSM) is provided in the Table below. Reference is made to the rating scale in NSW DLG (1998) and, where appropriate, the PSC DAF (2015).

SITE ASSESSMENT			
Parameter	**Data / Observation**	**Reference**	**Classification / Outcome**
Climate	Temperate climate with median annual rainfall of 925mm; monthly minimum 30.1mm (August) and maximum 105.1mm (March). Rainfall exceeds potential evaporation only 1 month of the year. Mean annual evaporation is 1,552mm.	Paterson (Tocal AWS) (BoM 061250) – Table 8-2 DSC Technical Manual (2015)	Minor limitation
Hydraulic balance (monthly) attached:	Yes	per PSC DAF (2015) procedure	
Nutrient balance (annual) attached:	Yes		
Land application area sizing attached:	Yes		
Wet weather storage requirement:	No	N/A	
Flooding Land application area above 1:20 ARI flood level:	Yes	PSC Flood Prone Mapping LEP 2013	Moderate limitation
Land application area above 1:100 ARI flood level:	Yes		
Electrical components above 1:100 ARI flood level:	Yes		
The north-eastern portion of the Site adjacent to the dam is identified as 'minimal risk' flood prone			

land 'subject to further investigation' by PSC Flood mapping. Refer to Section 2.1.3 of Site Compatibility Certificate.		
Aspect & Exposure	The Site is generally cleared of vegetation with scattered stands of mature trees. Predominantly north-easterly aspect. Good exposure to sun and prevailing wind.	Minor limitation
Slope	Site slopes range from ~3-12%.	Minor limitation
Landform	The landform of the Site is generally convergent slope towards the dam located in the north-eastern corner of the Site.	Minor limitation
Vegetation	Grass groundcover within paddock with some established stands of mature eucalypt trees throughout.	Minor limitation
Run-on and Seepage	Subsurface run-on/ seepage were observed within the TPs (TP2 and 3) adjacent to the gullies on the lower slopes. Stormwater from upslope areas, including internal roads and roof run-off, must be directed away from the EMA. Mitigation measures are presented in Section 8.3.	Moderate limitation
Erosion Potential	No erosion evident within EMA with generally good vegetation cover; however, minor erosion evident within dry gullies and along internal gravel access roads Address using erosion and sediment controls during construction and revegetation of the LAAs using turf.	Minor limitation
Site Drainage	Moderately well drained. Some surface water ponding in areas throughout the Site; typically associated with surface outcrops. Some mottling and gleying was observed in the subsoil horizons, indicating imperfect drainage at times during the climate cycle. Note that there was constant rainfall during the Site inspection.	Moderate limitation
Fill	None observed or apparent.	Minor limitation
Groundwater	Shallow groundwater encountered during soil survey within TP3 only at a depth of 300mm. It is assumed that subsoil water moves along the weathered bedrock surface at this depth. Site as adjacent to the dry gullies. NSW Office of Water groundwater bore registry indicates no bores are located within 500m of the Site. The NSW DLG (1998) recommended 250m buffer distance to domestic groundwater bores can therefore be achieved within the EMA.	Moderate limitation

Buffers achievable Permanent rivers and creeks (100m):	NA	
Intermittent creeks and drainages (40m):	Yes	Achievable (shown on Site Plan), including swale drain at front of the Site.
Domestic groundwater wells and bores (250m):	N/A	

Other sensitive receptors:	N/A	
Lot boundaries (3m if EMA downslope-6m if EMA upslope):	Yes	Achievable (shown on Site Plan); 6m applied.
Buildings, driveways and swimming pools (3m if EMA downslope-6m if EMA upslope):	Yes	Appropriate buffers will need to be applied to the individual units and internal roads once final building plans are developed.
Limiting horizon (groundwater, bedrock etc.) (0.6m):	Limited	Weathered parent material encountered at ~600-1,000mm depth within some TP locations. Shallow subsoil seepage identified within TP3 at 300mm. Rock floaters also present within TPs. Mitigation recommended (see Section 8.1.1).
Surface Rock / Outcrop	Surface rock and rock outcrops were observed during the Site investigation.	Moderate limitation
Effluent Management Area (EMA)	Approximately 8.1ha of useable EMA at the Site exclusive of the proposed development. Approximately 9,495m^2 of available EMA identified at the Site based on the preliminary development plan.	Major limitation
Concluding Remarks The Site is constrained by localised subsoil run-on from upslope catchment, surface rock outcrops, and minimal available EMA; however, these identified limitations can be mitigated or avoided through appropriate LAA site selection and design.		

SOIL ASSESSMENT (physical)			
Parameter	**Data / Observation**	**Reference**	**Classification / Outcome**
Soil Depth	~150/300mm-1,000mm; typically 400-600mm. Refusal in test pits due to subsoil run-on, weathered parent material and rock floaters.	Moderate to Major limitation	
Soil Profile	The presence and depth of topsoil varies throughout the Site. Typically the soil profile is comprised of moderately structured light clay to sandy clay overlying moderately structured medium- heavy clay subsoil.	Major limitation	
Depth to Water Table	Shallow (episodic) water table encountered in TP3 at 300mm depth within the medium clay horizon. Mottling and gleying observed in subsoil horizons, indicating restricted vertical drainage within Site soils during periods of high rainfall or extended wet weather.	Moderate limitation	
Coarse Fragments (%)	The proportion of coarse fragments within the Site soils was typically 2-20%. Subsoil within TP2 and TP8 contained approximately 20-50% coarse fragments and TP5 was terminated due to weathered bedrock at the surface.	Moderate limitation	
Soil Permeability	<0.06m/day (inferred)	Based on moderately structured heavy clay	Major limitation

		(Cat 6)	
Modified Emerson Aggregate Class (EAT)	Typically low to moderate EAT (5, 7, 2(1) and 2(2)). Subsoil within TP1/3 exhibited a high EAT of 2(3).	Minor limitation	
Soil Landscape	The Site is located on the Wallalong (wg) soil landscape. Topography consists of undulating hills on sediments of Permian Dalwood Group in East Maitland Hills Region. Long side slopes with local relief up to 30m. Extensively cleared tall open forest. Limitations include high water erosion hazard, foundation hazard, high run-on (localised) seasonal waterlogging (localised), shallow soils (localised) with high acidity and very low fertility.	Soil Landscapes of the Newcastle 1: 100 000 Sheet (Matthei, 1995)	

Concluding Remarks

Site soils are characterised by shallow profile comprised of moderately structured sandy clay to light clay; overlying moderately structured medium to heavy clay subsoil. Test pits were terminated at varying depths (typically 400-600mm) due to the presence of weathered parent material, large rock floaters of bedrock, or subsoil seepage. This description is consistent with the Wallalong soil landscape series.

Based on identified soil characteristics a (maximum) design irrigation rate (DIR) of 2mm/day is recommended for irrigation systems with reference to Table M1 in the *AS/NZS 1547:2012* for the limiting Cat 6 subsoil.

The Site is characterised by shallow soils of low permeability. Potential limitations can be mitigated through soil improvement measures (see Section 8.1) and appropriate LAA siting and sizing.

SOIL ASSESSMENT (chemical)				
Parameter	**Data / Observation**		**Reference**	**Classification / Outcome**
pH	5.0-7.4	Very strongly acidic to mildly alkaline	Minor limitation	
EC (EC_e)	0.08-0.66	Non-saline	Minor limitation	
ESP (%)	25.6	Very strongly sodic	From nearby project (2226) at Wallalong on the ‘wg’ soil landscape.	Major limitation
CEC (me/100g)	13.1	Moderate fertility		Moderate limitation
P-sorption (mg/kg)	307	Moderate - High		Minor limitation

Concluding Remarks

Soil chemistry generally poses a minor to moderate constraint to OSSM at the Site; with the exception of sodicity which presents a significant limitation. There was no impact to vegetation growth observed with respects to soil pH or fertility.

Mitigation measures are recommended to maintain the sustainable performance of the proposed LAA (see Section 7).

4 Wastewater Generation

4.1 Wastewater Quantity

Wastewater generated from the proposed independent living community is expected to be from kitchen, bath, laundry and toilet facilities for each individual unit as well as minor usage from the community hall. It is understood that reticulated (town) water supply will be available to the Site.

The preliminary development plan shows 180 permanent residency units with four (4) varying unit plans; with both two (2) and three (3) bedroom layouts and varying footprints:

- 63 Plan A (3-bdr),
- 56 Plan B (3-bdr),
- 41 Plan C (2-bdr), and
- 20 Plan D (2-bdr).

The assumed occupancy for the Site is 479 equivalent persons, equating to one (1) person per bedroom. While this is under the Council's recommended occupancy of 1.6 persons per bedroom for domestic residences (PSC DAF, 2015), W&A consider this to be a representative occupancy for the Site given it is consistent with the primary clientele (seniors) who will typically occupy a residency as a couple or single person, without additional family.

As wastewater generation patterns for the Site are likely to mirror typical residential premises, a design flow allowance of 150L/person/day has been adopted for the units based on reticulated water supply as per Table 6-2 of PSC DAF (2015). Subsequently the 'design' hydraulic load for the proposed development at the Site is presented in the following table

	Value	Description
Number of bedrooms	479	180 units with 2 or 3 bedrooms per unit.
Occupancy rate (persons per bedroom)	1	As per discussion above.
Wastewater generation (L/person/day)	150	Appendix H of AS/NZS 1547:2012 for reticulated (town) water supply and Table 6-2 of PSC DAF (2015).
Design hydraulic load from 2-bedroom unit (L/day)	**300**	2 bedrooms x 1 person per bedroom x 150L/person/day.
Design hydraulic load from 3-bedroom unit (L/day)	**450**	2 bedrooms x 1 person per bedroom x 150L/person/day.
Total hydraulic load (L/day)	**71,850**	479 bedrooms x 1 person per bedroom x 150L/person/day.

4.2 Wastewater Quality

The contaminants in wastewater have the potential to create undesirable public health concerns and pollute waterways unless managed appropriately. As a result, domestic wastewater must be treated to remove the majority of pollutants and enable attenuation of the remaining pollutants through soil processes and plant uptake.

Wastewater generated by each unit at the Site is expected to be of 'typical' domestic nature, with combined wastewater streams; blackwater (toilet) and greywater (kitchen, laundry and shower) wastes.

As such, untreated wastewater is expected to have characteristics similar to that described in the table below; which incorporates information taken from the NSW DLG (1998).

Parameter	Loading	Greywater %	Blackwater %
Daily Flow		65	35
Biochemical Oxygen Demand	200-300mg/L	35	65
Suspended Solids	200-300mg/L	40	60
Total Nitrogen	20-100mg/L	20-40	60-80
Total Phosphorus	10-25mg/L	50-70	30-50
Faecal Coliforms	10^3 – 10^{10}cfu/100ml	Medium – High	High

5 Wastewater Treatment

Given the identified Site and soil constraints, primary treatment systems (i.e. septic tanks) are not recommended as they significantly limit effluent disposal and reuse options and pose a higher risk to human and environmental health compared to secondary or tertiary treatment systems.

5.1 Wastewater Treatment Systems

A **minimum** effluent quality standard of secondary treatment with disinfection is recommended for the Site. Secondary treatment is aimed at the removal of dissolved and suspended organic material by a combination of physical and biological methods, usually incorporating both aerobic and anaerobic phases. Secondary treatment presents a significantly lower risk to human health and the environment, when compared to conventional primary (septic tank) systems.

Suitable options for wastewater treatment systems are discussed in detail in Section 7 of this Report.

5.2 Treated Effluent Quality

Section 6.3.1 of the PSC DAF (2015) describes the minimum effluent quality standards for secondary treatment systems. The nominated treatment system supplier must warrant the selected design by providing a ‘Producer Statement’ that illustrates the system layout and configuration, describes and quantifies the hydraulic design, as well as provides confirmation that the desired effluent standards can be met.

Final system selection is the responsibility of the Owner; however, selection and installation of the system must follow the requirements of Section 6.3 of the PSC DAF (2015).

Secondary treatment systems are expected to achieve the minimum water quality standards for ‘secondary’ effluent, as detailed in Table 6.3.1 of the PSC DAF (2015) and reproduced here.

Parameter	Loading
Biochemical Oxygen Demand	≤20mg/L (90^{th} %ile)
Suspended Solids	≤30mg/L (90^{th} %ile)
Faecal Coliforms	≤30cfu/100mL (90^{th} %ile)
Total Nitrogen	35mg/L
Total Phosphorus	15mg/L

The listed phosphorus and nitrogen concentration values are targets (only) and have been adopted for nutrient balance modelling.

5.3 System Siting

The final positioning of treatment systems will depend on the local gradient and level controls and can be determined in consultation with a licensed plumber and Council prior to obtaining consent for the installation. It is anticipated that the system would be located to the east of the Site if a gravity collection (reticulation) system is employed; alternately, the treatment system can be located anywhere on the Site if primary treated effluent or macerated wastewater is pumped to the centralised treatment system (STEP system).

5.4 System Operation and Management

Successful performance of wastewater treatment systems relies on periodic monitoring and maintenance, which will be the responsibility of the Owner. The selected treatment system should be serviced by a suitably qualified technician at the prescribed intervals.

6 Effluent Management

This section describes the Site's capability for effluent management and provides design details, including sizing of the proposed LAAs. As detailed above, secondary treatment is considered the most appropriate wastewater treatment option for servicing for both on-site and decentralised treatment options.

6.1 On-site Effluent Management Options

W&A have considered the suitability of various land application systems in relation to the identified Site and soil limitations. In determining the suitability of the various options we have assessed the Site constraints and the relative environmental and public health risks associated with each.

The table below provides a summary analysis of the range of effluent land application options considered, and presents recommendation for the preferred approach to be used in conjunction with the minimum secondary treatment systems selected.

Land Application Option	Suitable	Reasoning
Absorption Trenches/Beds	No	Absorption trenches or beds are not supported for Category 6 soils due to (variably) low permeability and the very large trench/bed lengths required (AS/NZS 1547:2012; Table L1).
ETA Beds	No	While possible, ETA beds require large land area and are not preferred due to shallow soils.
Mounds	Possible	Considered suitable with secondary treatment and conservative loading rate; however, large land area requirement and significant capital cost are prohibitive.
Surface Irrigation	Possible	Surface spray irrigation is not permitted for new OSSM systems (PSC DAF, 2015) so would be unsuitable for individual on-site unit application. May be possible with community reticulation option; however, due to restricted EMA, large LAA required and potential contact risks, it is likely considered to be unsuitable except for partial/ complete off-site application options.
Subsurface Irrigation	Yes	Subsurface irrigation is considered most appropriate due to shallow soil profiles as effluent is able to be applied high in the soil profile, maximising

		evapotranspiration and vegetation uptake. Treated effluent **must** be disinfected.

A description of the preferred (and alternate) effluent management method is presented below.

6.1.1 Subsurface Irrigation (SSI)

Subsurface Irrigation

SSI is suitable within lawn and landscaped areas and applies effluent within the root-zone of plants for optimum irrigation efficiency. It is an ideal option for ensuring even, widespread coverage of the proposed irrigation area. SSI installation does not require any bulk materials or heavy machinery and irrigation lines can be simply installed with a small trench digger or "ditch-witch".

Proprietary, pressure-compensating drip irrigation pipe designed for use with treated effluent should be used that will ensure distribution of effluent at uniform, controlled application rates. These products have been specifically designed for use with effluent and allow for the higher BOD, suspended solids, nutrient and biological loads usually present in effluent compared to potable water. They contain specially designed emitters that reduce the risk of blockage, typically incorporating chemicals that provide protection against root intrusion and biofilm development (e.g. Trifluralin). The dripper lines are coloured lilac to clearly identify that they are irrigating treated effluent.

Irrigation pipes (laterals) should be spaced to provide good and even coverage of the area they service. Generally they should be no more than 0.6m apart, roughly parallel and along the contour as close as possible.

An in-line 120μm disc filter may be installed to minimise the amount of solids entering the pipelines and emitters. This must be removed and cleaned regularly (at least at 3-monthly intervals). Alternately, a flush main may be installed to periodically clean-out the irrigation lines to provide effective long term performance. Either manual or automatic flush valves may be installed, with flush water directed back to the treatment system. Air release valves will be installed at the high points in individual irrigation areas to prevent soil particles being sucked into the lines at the end of pump cycles as pipelines depressurise.

Figure 3 (Appendix A) provides a schematic representation of a generic SSI system, courtesy of Netafim Australia. Specialist advice must be obtained for designing and installing the irrigation system.

Current pricing for supply and installation of SSI systems is **~$7-$11 per sq.metre** (depending on supplier). The wider range in capital pricing will also reflect material quality, system performance reliability and controls. Ongoing costs should be included within (quarterly) servicing costs for accredited treatment systems. Additional maintenance costs may be necessary in the event of damage or blockage.

Covered Micro-drip Irrigation

Covered surface micro-drip irrigation could also be utilised within landscaped and mulched garden beds/ hedgerows around the Site where suitable. This would be the recommended option for around the landscaped gardens of the units and smaller communal areas.

6.1.2 Surface Irrigation (SI)

Surface irrigation application method may also be considered as an alternative to SSI for the distribution of treated effluent within a dedicated LAA at the Site. However, SI has the potential to create public health impacts via direct or indirect contact with contaminated surfaces. The NSW DEC (2004) and AGWR (2006) guidelines provide recommendations for irrigation of recycled effluent based on treated effluent quality and the intended end use of the land being irrigated.

SI would only be suitable within a development such as is proposed for this Site if a limited-access irrigation area could be achieved, whether for on-site or off-site reuse. Additional preventative measures include:

- Warnings signs complying with AS 1319 should be erected in at least two (2) places around the boundary of the LAA indicating the use of effluent for irrigation, for example; "*Reclaimed Effluent – Not For Drinking"*.
- No public access during irrigation.
- Prescribed buffers to nearest point of public access.
- Spray-drift controls (sprinkler selection, wind-speed shut-off etc.).
- Excluding grazing animals for >5 days after last irrigation cycle (withholding period).

Implementation of these controls would be sufficient to manage any residual risk associated with the irrigation practice.

A summary of the various surface irrigation methods are discussed below.

Fixed (Pop-up) Sprays

A 'fixed' (pop-up) irrigation system would comprise the installation of a subsurface (buried) distribution manifold beneath the entire irrigation zone to be serviced. The manifold would be constructed PVC pressure pipe or HDPE, with final pipe sizing determined following detailed hydraulic design. For optimal performance the manifold would be divided into manageable units (zones) to reduce pumping requirements and allow for better control of irrigation rates. Hydraulically operated 'pop-up' sprinklers would be fitted at determined locations throughout each zone (depending on distribution radius and coverage requirements) with the ultimate aim of delivering consistent and complete coverage to the area serviced. There are a large number of sprinkler types available on the market suitable to this type of 'agricultural' application.

Surface Irrigation using Fixed (Impact) Sprinklers

The use of fixed impact sprinklers on a raised tripod is a much more traditional method of open space irrigation on sites such as golf courses and public parks. Similar to the pop-up arrangement, the system would comprise the installation of a buried (PVC/HDPE) distribution manifold beneath the entire irrigation zone to be serviced. Because impact sprinklers generally operate at 'relatively' higher pressures and generate a larger throw-radius, the sprinkler intervals would be larger (less sprays), but would still require detailed hydraulic design.

Impact sprinklers typically comprise a one or two nozzle arrangement allowing for both long and short throw coverage. They typically operate in a 360° configuration, but can easily be limited to other arrangements (e.g. 180° or 90°) for edge or corner operations. Even irrigation application is marginally more difficult with impact sprinkler systems and careful irrigation design is required to ensure optimal performance.

Other than controlling coverage, the main issue associated with impact sprinkler systems is spray-drift. Because of the style of discharge, impact sprinkler are prone to generating fine sprays or aerosols which can be readily captured in wind current. This presents a risk for off-site impacts (including unintended contact risk). These risks can be managed by ensuring adequate buffers are maintained between the irrigation area(s) and receptors, or by increasing the droplet size and reducing the throw radius of the individual sprinklers.

A logical alternative would be the use of a low-profile travelling irrigator (spray or drip) system.

Surface Irrigation using 'Travelling' Irrigator

Commercial-scale travelling irrigators are able to reliably irrigate large areas of pasture at controlled soil loading rates to ensure even irrigation distribution and avoid problems with waterlogging or runoff. An electronic control system can be employed and will enable the programing of the irrigator so that correct doses of recycled water are applied. A detailed hydraulic and system design report should be prepared once final approval of the subdivision has been obtained and system selection is being undertaken.

Travelling irrigator systems suitable for large-scale agricultural purposes may include 'centre-pivot' or 'lateral move' designs.

Finally, surface irrigation of treated effluent (recycled water) is not considered appropriate during periods of excessive rainfall; therefore, additional wet-weather storage (nominally >5 days) is required to retain treated effluent during those periods.

6.2 Buffers

Buffer distances from LAAs are recommended to minimise risk to public health, maintain public amenity and protect sensitive environments. Buffer or setback distances are recommended to provide a form of mitigation against unidentified hazards and reduce potential pathways of human and environmental exposure.

The following environmental buffers are required for the proposed land application methods, based on Table 6-10 of the PSC DAF (2015):

- 250m from domestic groundwater bores;
- 100m from permanent watercourses;
- 40m from intermittent watercourses and dams;
- 6m if area up-gradient and 3m if area down-gradient of property boundaries, driveways, swimming pools and buildings; and
- 0.6m vertical separation (from pipework) to hardpan or bedrock.

All of the recommended buffer distances, except for localised vertical separation from bedrock are achievable, as shown on the Site Plan (Figure 2, Appendix A). Section 8.1.1 outlines the mitigation measures to ensure the 0.6m vertical separation to bedrock can be achieved from the base of the LAA.

Additional buffers may be applicable to the Site dependent on the minimum treatment quality of the effluent and the proposed end-use.

6.3 Useable Area

The PSC DAF Technical Manual (2015; Section 6.3) defines 'useable' area for on-site effluent management as the "total allotment area excluding dams, intermittent and permanent watercourses and open stormwater drains and pits, in addition to the relevant buffer distances prescribed in the PSC DAF for those objects".

Section 3.2.4 of the PSC DAF (2015) deems that applications for non-domestic development with an average-dry-weather-flow (ADWF) 10-100kL/day comply from a cumulative impact perspective where they meet the following conditions:

- Scale detailed design drawings (prepared in CAD or similar) shall be provided with the design to demonstrate that sufficient, *useable* land area exists to fit a properly designed and sized system to service the proposed non-domestic facility in the long-term;
- A Standard Cumulative Impact Assessment is completed to demonstrate risks are adequately managed (refer to the PSC On-site Sewage Technical Manual); and
- Land application areas comply with the recommended buffer distances.

Based on the Site investigation and soil assessment, a constraints analysis was prepared (Figure 2a; Site Plan) showing the areas deemed suitable for on-site effluent management and those areas that should be avoided in their present form.

As per the preliminary development plan, approximately **9,495m^2** (0.95ha) of useable EMA is available in 'community' areas of the development, with minor additional area likely available on each individual unit lot. Applicable buffers from internal roads and buildings have not been applied but should be applied to the final development plan to confirm the available EMA.

6.4 LAA Sizing

Section 3.2.3 of the PSC DAF (2015) prescribes the methodology for sizing LAAs for non-domestic development with an average-dry-weather-flow (ADWF) 10-100kL/day on high hazard allotments.

W&A have used the results of the site and soil assessment to undertake preliminary monthly modelling for effluent irrigation at the Site, taking into consideration the PSC DAF (2015) and relevant guidelines. The water and nutrient balance spreadsheets for effluent irrigation are provided in Appendix C.

The PSC DAF (2015) recommends that daily soil water, nutrient and pathogen modelling is used to size the required LAA; however, given the preliminary nature of the investigation and the substantially reduced useable EMA available for the development in its current form, monthly modelling is considered sufficient.

A detailed LAA design should be undertaken when final Site Layout is completed and the rezoning proposal progresses to DA.

6.4.1 Water and Nutrient Modelling

Water and nutrient balance modelling was undertaken to determine the sustainable application rate for Site soils and to estimate the necessary size of the LAA required to manage the proposed hydraulic and nutrient loads from the Site. The procedures for this generally follow the NSW DLG (1998) guidelines.

The water balance used is a monthly model adapted from the "Nominated Area Method" described in the NSW DLG (1998). These calculations determined minimum LAA size for the given effluent load for each month of the year. The water balance can be expressed by the following equation:

Precipitation + Effluent Applied = Evapotranspiration + Percolation + Storage

A conservative (annual) nutrient balance was also undertaken, which calculates the minimum application area requirements to enable nutrients to be assimilated by the soils and vegetation. The nutrient balance used here is based on the simplistic NSW DLG (1998) methodology, but improves this by more accurately accounting for natural nutrient cycles and processes. Annual nutrient modelling requires total nitrogen (TN) to be ≤35mg/L and total phosphorus (TP) to be ≤15mg/L to ensure that the LAA can sustainably assimilate the nutrients within the applied effluent.

Parameter	Units	Value	Comments
Effluent load	L/day	71,850L/day	Expected effluent load for full development 300-450L/day per unit
Precipitation	mm/month	Paterson (Tocal) AWS median monthly	From BoM
Pan Evaporation	mm/month	Paterson (Tocal) AWS mean monthly	From BoM
Retained rainfall	unitless	0.8	Proportion of rainfall that remains on site and infiltrates the soil, allowing for 20% runoff from vegetated site
Crop Factor	unitless	0.5 – 0.8	Typical annual range
Design irrigation rate (DIR)	mm/day	2	Based on the most limiting (Cat 6) soil selected from the DIR values given in Table M1 of AS/NZS 1547:2012
Effluent total nitrogen concentration	mg/L	35	Expected value based on secondary treated (sanitary) effluent
Nitrogen lost to soil processes (denitrification and volatilisation)	annual percentage	20	Patterson (2002)
Effluent total phosphorus concentration	mg/L	15	Expected value based on domestic secondary treated effluent
Soil phosphorus sorption capacity	mg/kg	307	Based on soil laboratory results.
Nitrogen uptake rate by plants	kg/ha/yr	260	A conservative estimate of 50% of published nutrient uptake rates in DECCW (2004), based on grass groundcover.
Phosphorus uptake rate by plants	kg/ha/yr	30	A conservative estimate of 50% of published nutrient uptake rates in DECCW (2004), based on grass groundcover
Design life of system (for nutrient management)	years	50	Reasonable service life for system

6.4.2 Preliminary Assessment

Due to the limited useable EMA at the Site, the preliminary modelling demonstrates that the expected hydraulic load from the development cannot be sustainably accommodated on Site. In its current form, the proposed development requires a minimum 5.5ha (54,792m^2) of useable EMA to achieve a compliant servicing design.

Based on this, W&A have prepared an option's assessment to examine a range of onsite servicing approaches for the development. The results of the preliminary modelling are detailed under the various options listed in Section 7. Preliminary modelling demonstrated that the Site is hydraulically limiting, ensuring that nutrients will be sustainably assimilated on-site within the LAA sized based on the hydraulic load.

7 Options Assessment

As part of the preliminary assessment for the proposed rezoning, a range of options have been evaluated to determine the most practical and economical option for establishing a (senior living) community development on the Site.

The Site is substantially constrained for effluent management due to the proposed development footprint, as well as the requirement to maintain required setbacks from neighbouring development and sensitive features (waterways). The results of the assessment may recommend alteration of the preliminary development plans to accommodate various options.

The selected option will be required to meet the performance requirements for a 'high hazard' non-domestic allotment as per the Port Stephens Council (PSC) On-Site Sewage Management Development Assessment Framework (DAF).

7.1 Connection to Sewer

The option and feasibility of connecting to either a private or Hunter Water Corporation (HWC) reticulated sewage network was investigated.

There are no HWC sewer connection points nearby. A Wastewater Servicing Strategy was undertaken by SMEC (2012) as part of a Planning Proposal for the amendment to the PSC LEP for a Wallalong Urban Release Area in 2013.

The strategy (2012) recommended connecting the proposed Wallalong Urban Release to the Morpeth Wastewater Treatment Works by a rising main and associated pump stations with an initial cost of $6M and a further cost of $10.4M to cater for up to 4,000 tenements.

The Site falls within the considered boundary of the Wallalong Urban Release Area; therefore, plans to sewer the township of Wallalong in the intermediate future should be taken into consideration with the preferred OSSM option.

7.2 Traditional OSSM Option

Individual OSSM involves managing generated wastewater from each unit within individual unit boundaries. Individual treatment and land applications systems would be installed by property owners at the time the units are built upon. Responsibility for obtaining approvals and ongoing operation of these systems would reside with individual property owners.

Council regulate the operation of individual OSSM systems through the Section 68 approval process, with an 'Approval to Install' issued during development consent and an annual 'Approval to Operate' issued for the life of the system.

7.2.1 Domestic Wastewater Treatment Systems

A range of NSW Ministry of Health (NSW Health) accredited domestic secondary treatment systems are available and suitable for use at the Site. These systems are typically accredited up to 10 EP. Appropriate secondary treatment technologies include (but are not limited to) the following:

- Aerated wastewater treatment systems (AWTS); and
- Media / textile filter systems

Disinfection units are typically installed as a standard component of proprietary secondary treatment systems.

A detailed list of NSW Health accredited systems can be found at:

http://www.health.nsw.gov.au/environment/domesticwastewater/Pages/default.aspx

7.2.2 On-Lot Land Application

Under the proposed development plan, each unit lot layout is approximately 300m^2 in area, with a ~200m^2 dwelling footprint.

Preliminary LAA sizing was undertaken for a 'typical' 2-bedroom (300L/day) and 3-bedroom (450L/day) unit, resulting in a minimum LAA requirement of 230m^2 and 343m^2, respectively. This value is >75% of total lot area for each unit, which is not achievable.

7.2.3 Partial On-lot Option

An alternative approach may be to consider partial on-lot and partial community land application. This option would treat generated wastewater at each unit individually using a domestic secondary treatment system (e.g. AWTS) and reuse as much effluent as sustainable for each lot. Based on the current development plan, this would equate to approximately 30m^2-50m^2 (average 40m^2) per lot, capable of reusing up to 80-100L per day of treated effluent to irrigate garden and lawn areas of the property.

Assuming this outcome is possible, approximately 14-18kL of treated effluent could be sustainably reused on-lot, appreciably reducing the volume of treated effluent requiring community land application to <58,000L day.

7.2.4 Preliminary Assessment

Individual OSSM is not considered a suitable option for the Site, unless the available lot area for each unit can be increased to accommodate both the building footprint and required LAA. Preliminary analysis suggests (unit) lot area would need to increase to ~600m^2 to achieve this outcome. It is acknowledged this would result in a substantial reduction in total unit yield for the development.

The partial on-lot solution may be worth considering as treatment would occur at source (individual unit) and to an appropriate standard (secondary) for both on-lot and community reuse options. Capital costs would be shared between the unit owner (on-lot components) and the developer (collection, storage and community land application). The useable EMA requirement for community land application would need to increase from the current 0.95ha to ~4.4ha, which again would result in a sizeable reduction in total unit yield for the development.

7.3 Decentralised OSSM Option

Historically, centralised (conventional) wastewater management has been the only option considered for providing sanitary wastewater (sewage) servicing of developing residential areas. It typically refers to large-scale municipal sewerage systems where individual households are connected to a gravity driven reticulated collection network (sewer) which transfers combined (black and grey) wastewaters to a central treatment facility for processing (or transfer to another network). Disposal/reuse of the treated effluent and other by-products usually occur remote from the point of wastewater origin.

Decentralised, non-conventional wastewater management refers to the collection and treatment of wastewater from individual homes, clusters of homes, isolated communities, industries or institutional facilities and disposal/reuse at or near the point of wastewater generation (Crites and Tchobanoglous, 1998). Apart from the proximity of disposal/reuse, a key point of differentiation between centralised and decentralised wastewater management systems is the frequent use of alternative collection networks and treatment systems. These may include reduced pipe size or grade sewers, pressure or vacuum sewers, waste stream separation and recycled water systems.

Decentralised wastewater servicing solutions may involve partial (primary) treatment of generated wastewater on each unit (or collection of units), or maceration (slurrying), before conveyance of effluent via a reticulated sewer network to a common treatment facility.

Effluent sewer systems utilise smaller diameter, flexible reticulation pipes that can be laid at shallower depths and without the need for uniform or minimum grades for self-cleansing. This leads to greater ease of installation and substantially reduced construction costs, especially when working with challenging ground conditions (e.g. undulating country, shallow soils, and high watertables). By design, they greatly reduce or even eliminate stormwater inflow and groundwater ingress (I/I) in wet weather. These factors impact heavily on traditional gravity sewer design, resulting in frequent wet weather overflows that pollute the environment, requiring network designers to use much larger pipes and additional storages to manage the increased flows.

7.3.1 Reticulation (Collection)Options

A wide variety of sewer reticulation options are available for a decentralised servicing approach. These differ in terms of their general mode of operation, infrastructure requirements, construction methods, maintenance procedures and frequency. These factors affect the suitability of the different options for different physical and socioeconomic settings, as well as the life cycle costs of installing, operating and maintaining the sewer network.

Aside from conventional gravity sewers (CGS), a number of alternatives are now available. Alternative collection systems have historically been defined as any system other than conventional gravity reticulation (USEPA, 1991) and can be broadly broken down into three (3) categories: pressure sewers (PS); vacuum sewers (VS); and common effluent systems (CES) or effluent sewers. The categories are based on the primary force behind conveyance. However, each type of collection system can utilise different configurations and technologies.

PS and CES are often used in combination rather than isolation, such as in septic tank effluent pump/ septic tank effluent gravity (STEP/STEG) systems.

7.3.2 Community Treatment Systems

Regardless of the reticulation option selected, collected wastewater (either raw or primary) will require additional treatment to achieve a standard suitable for land application (as a minimum) in line with regulatory standards and community expectations.

This presents a number of considerations when selecting an appropriate treatment technology because the quality and consistency of the wastewater stream can have a significant bearing on the size of the wastewater treatment system required, as well as the reliability and performance of the treatment processes employed. Therefore, not all treatment systems are suitable for the range of reticulation options considered.

A commercial Sewage Treatment Plant (STP) capable of consistently producing a minimum secondary quality effluent is required. Commercial STPs are typically modular by design, require a relatively small footprint and are commonly used in wastewater servicing scenarios for similar developments to the Site. A breakdown of the fundamental treatment processes typically employed is as follows:

- anaerobic (septic / primary settling) treatment;
- aeration (suspended growth aeration or textile filter);
- effluent clarification (secondary settling);
- nutrient removal (chemical addition);
- multimedia filtration; and
- disinfection (via chlorine and / or inline UV).

There are many commercial STP's on the market capable of catering for a range of expected flow conditions. To guide selection of a STP, the selected design would be expected to achieve nutrient reductions consistent with those outlined in Section 5.2 of this Report. It is recommended that the selected PTP be able to produce this minimum standard of effluent quality to provide assurance that public amenity is maintained and any potential impacts on the surrounding environment are minimised.

As a general guide, and based on recent W&A experience, secondary treatment costs for commercial STP's range from $10k - $30K per kL of wastewater to be treated.

7.3.3 Effluent Management

<u>Community Land Application</u>

The preferred OSSM option for the Site would be community servicing with a centralised treatment system and application of treated effluent in a dedicated LAA on-site.

The development plan provided by the Client has indicated a preferred effluent management area, predominantly within the north eastern corner of the Site. As detailed in Section 6.3 above, the total useable EMA available at the Site with the current development layout is 9,495m^2 (0.95ha).

Preliminary modelling was undertaken (Section 6.4) to quantify the capacity of the development to accommodate anticipated effluent generated under different scenarios, assuming the proposed development plan.

Results are presented in the following table.

Scenario	Design Load L/day	Required LAA m^2	Equivalent Occupancy
Full development 'buildout'	71,850	54,792	479
Available EMA capacity based on proposed development	12,350	9,495	82
Staged construction and implementation	35,925	27,396	239

As shown, land application of the entire effluent load generated by the full development as proposed ('buildout') would require ~5.5ha of 'useable' EMA to be set aside from development. This requirement for >50% of the Site area would result in a significant reduction in developable area and unit yield.

Similarly, if only the useable EMA identified in the development plan is available for land application, the maximum effluent load capable of being sustainably accommodated is ~12,350L/day or approximately 82 (equivalent) persons. Clearly, neither of these outcomes is desirable or acceptable.

7.3.4 Preliminary Assessment

Consideration may be given to seeking approval for the staged implementation of the preferred OSSM servicing solution concurrently with the proposed development.

In this scenario, unit development and community infrastructure (internal roads, drainage, community facilities etc.) would proceed in a staged manner with generated wastewater directed to a centralised 'community' treatment system. Many commercial STP's are modular and readily scalable making them well suited for this approach.

Following treatment, generated effluent can then be directed to areas of the property earmarked for later development stages. This approach would allow for the proposal to proceed in an orderly manner over a moderated development timeframe while remaining consistent with the sustainable capacity of the available effluent land application areas.

Preliminary analysis suggests approximately 239 persons (bedrooms) could be accommodated within the development using this approach. This represents an approximate 50% yield and, depending on construction timeframes, may provide sufficient time for any future reticulated sewer connection option (refer 7.1) to become available (1-2 years).

Alternately, suitable areas for surplus off-site irrigation would need to be identified. This would require commercial agreement, including establishment of legal easement, to disperse treated effluent off-site (i.e. an adjacent property). There is a potential to utilise privately owned agricultural land located to the north and west of the Site, which appears to be one large rural holding.

7.4 Recycled Water Use

Under certain circumstances, it is possible to utilised recycled wastewater for internal reuse and landscape purposes. On single lots this is only possible using treated greywater; however, with large-scale commercial treatment systems, such as considered here, it is possible to treat the combined (all-waste) wastewater load to a standard acceptable for reuse (both internally and externally) on each of the new units.

This could be achieved by providing a dual reticulation (third-pipe) network to distribute 'recycled water' to households and public open space, whilst any unused recycled water would continue to be irrigated in a dedicated land application (irrigation) area either on or off the Site (as previously discussed).

The greatest impediment to implementation of a third-pipe (recycled water) reticulation scheme to a relatively small development is cost. To introduce such a system would require a significant investment in 'enhanced' treatment capacity (quality) and delivery infrastructure (storage and reticulation) to achieve the desired water quality and reliability of supply to off-set existing potable uses within each unit.

Based on other similar projects W&A have been involved in, the breakeven point for such an investment is >200 dwellings, assuming there are no other drivers for implementation (i.e. environmental constraints etc.). Sufficient available EMA would also need to be identified on the Site to support the irrigation of surplus recycled water.

7.4.1 Regulatory Requirements and Guidelines for Recycle Water Schemes

The Independent Pricing and Regulatory Tribunal (IPART, NSW) regulate the licensing of private water schemes under the Water Industry Competition Act (WICA) 2006. An application for a licence may only be made by or on behalf of a corporation. The construction, operation and service delivery associated with any future Sewerage System will be regulated by IPART under WICA licences.

Under WICA, private providers must obtain a licence to construct, maintain or operate any water industry infrastructure (network operators' licence), or to supply potable or non-potable water, or provide sewerage services by means of any water industry infrastructure (retail suppliers' licence).

WICA is also supported by the Water Industry Competition (General) Regulation (WICR) 2008, which sets out the matters a licence application must address, standard licence conditions, information to be contained on the register of licences and the retailer of last resort provisions. The Regulation also provides for the establishment of a marketing code of conduct, a transfer code of conduct and a water industry code of conduct. Under WICR, network operator licensees for sewerage schemes are required to produce a Sewage Management Plan (SMP) and subsequent audit reports on the SMP before commercial operation of the scheme. The sustainability assessment is an audit of relevant components of the SMP, with the aim of helping to determine whether the proposed infrastructure will provide sewerage services which are sustainable and do not present a risk to the environment.

The licensed network operator must submit to IPART an Infrastructure Operating Plan and a Water Quality Plan which is consistent with the Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (AGWR) 2006 and addressing the Framework for Management of Recycled Water Quality and Use.

7.4.2 Tertiary Treatment

To achieve 'tertiary' recycled water quality it is typical for providers to utilise advanced membrane bioreactor (MBR) processes. MBR systems effectively combine two (2) proven wastewater treatment processes (i.e. microbial digestion and membrane separation) into a single process where suspended solids and microorganisms responsible for biodegradation are separated from the treated water by an ultra-filtration (UF) system. The process typically also includes advanced disinfection technologies, potentially producing a high quality (Class

A) effluent. MBR's are well suited to greenfield development sites where reuse reticulation can be designed into the system rather than brownfield sites where costs of retrofitting are often prohibitively high. MBR systems are modular so they are easily expandable for staged development or to cater for any increased loads if any further development at the Site is desired in the future.

The AGWR (2006) guidelines present water quality targets for different reuse applications according to the level of risk associated with reuse. These targets will need to be taken into consideration with the level of tertiary treatment required for the proposed end-use.

7.4.3 Effluent Management

This option would provide dual reticulation ('third pipe') to distribute a secure recycled water supply to the residential households, whilst any unused recycled water would be irrigated within prescribed areas on-site (or potentially off-site) as previously discussed.

The Department of Water & Energy guidelines for *Greywater Reuse in Sewered, Single Household Residential Premises* (DWE, 2008) provide a breakdown of average daily household water use of "33% bath and shower, 23% taps including kitchen, 20% toilet and 24% washing machine". As such, it is assumed that 32% of 'typical' daily household water usage can be replaced by using recycled water internally in the units for toilet flushing and (cold water only) washing machine supply; with a potential for a dedicated landscape use only external tap.

7.4.4 Preliminary Assessment

Under this option, it is estimated that ~23kL of wastewater generated (of the 71.8kL full hydraulic load) could be utilised via internal reuse after tertiary treatment. This could potentially reduce the useable EMA requirement for community land application to ~3.7ha to allow irrigation of the remaining 48,858L/day of surplus recycled water.

Despite the improvement, this option would again result in a sizeable reduction in total unit yield for the development.

7.5 Summary

Reviewing the preliminary modelling undertaken for the potential OSSM servicing options discussed above, the preferred option would be adoption of a 'staged' development approach as described in Section 7.3.4 of this report.

Generated wastewater from constructed units within the development could be treated to a minimum secondary effluent standard (with disinfection) within a centralised 'community' treatment system, with treated effluent then be directed to areas of the property earmarked for later development stages.

This approach would allow for the proposal to proceed in an orderly manner over a moderated development timeframe while remaining consistent with the sustainable capacity of the available effluent land application areas.

Staged construction of the development would allow maximisation of lot yield while ensuring sustainable OSSM at the Site for the interim period until such time that a future reticulated sewer connection option becomes available along with the Wallalong Township.

8 Mitigation Measures

8.1 Soil Improvement

8.1.1 Soil Depth

Due to the presence of weathered parent material at depths of ~400-600mm, it is recommended to import good quality (sandy clay loam) topsoil to the SSI LAAs to ensure a minimum separation of 600mm between the bottom of the installed LAA and any subsurface limitation.

The achievable separation must be confirmed by the irrigation installer, as rock depths vary throughout the Site. Locally won (e.g. building envelopes) or imported clean topsoil material should be used and blended with the proposed LAAs topsoil.

Prior to irrigation installation the proposed LAAs must first be formalised by removing any foreign objects/ waste material to create a natural ground surface. The existing surface profile should be deep ripped to ~300mm with large rock floaters removed prior to topdressing to create a smooth transition between natural and imported soil materials.

8.1.2 Soil Chemistry

Given that Site soils may be sodic, have a low CEC and exhibit some acidity, they may impact vegetative growth in the LAA. These properties can combine to reduce the soils' capacity to sustainably manage wastewater.

Prolonged application of sodium rich wastewater can exacerbate the situation. Application of calcium mineral is a recognised way of reducing the effects of soil instability. It does this by supplying calcium to the affected soil and thereby elevating calcium concentrations with respect to sodium. Added calcium will improve the soil CEC and Ca/Mg ratio, improving fertility, while reducing the potential for soil structural degradation.

Typically, gypsum would be the preferred soil amendment; however, given the identified acidity concern a 50:50 application of gypsum and lime may be more suitable for the Site. Both gypsum and lime are only slowly soluble in water, so simply broadcasting at the surface can be of limited benefit as it can take a long time for the calcium to penetrate the soil and reach the deeper soil layers.

Therefore, it is recommended to incorporate the amendment into the soil during construction of the land application systems. A suitable gypsum/lime application rate of approximately $0.5kg/m^2$ should be applied.

8.2 Vegetation Establishment

Vegetation that is suited to the application of effluent, preferably with high water and nutrient requirements (such as turf) should be established over the LAAs following construction. A complete vegetation cover is important to reduce the erosion hazard and optimise water and nutrient uptake.

It is recommended to establish and maintain a vegetated buffer around the LAAs. It should be planted with moisture-tolerant vegetation and remain well maintained to maximise moisture uptake. Plants must be selected that will not be so large as to shade the LAAs once fully grown. It is important that the LAAs receive maximum exposure to sun and wind to maximise evapotranspiration.

To maximise assimilation of effluent-borne nutrients within the LAAs, vegetation clippings should be removed from the LAAs and mulched elsewhere on-site for use on other landscaped areas that are not used for wastewater application. Mulching clippings back onto the area from which they were cut is not recommended. An alternative is to dispose clippings in the general waste bin, or green waste bin collection service, if provided.

8.3 Stormwater Management

The performance of LAAs (and potentially treatment systems) can be adversely affected if stormwater is allowed to run onto these areas. Stormwater diversion devices (where required) should be designed and constructed to collect, divert and dissipate collected run-on away from the LAAs. The proposed development would involve extensive stormwater management activities with the construction of internals roads so the final stormwater directions will be considerably different from existing.

The structure(s) should be designed and installed by a suitably qualified professional and be compliant with relevant guidelines and standards. A diagram of a 'typical' stormwater diversion, which would be appropriate for this purpose, is provided in Appendix A, Figure 4. The outlet must be stabilised and must discharge water in a safe location where it will not create an erosion hazard or impact on structures or neighbouring properties.

8.4 Water Saving Measures

To minimise wastewater generation, it is recommended that all domestic water use fixtures in each new dwelling be installed in accordance with BASIX requirements, including installation of 'standard water reduction fittings'.

Standard water reduction fixtures for internal and external water use include:

- Taps – WELS 4-star (or better) rated;
- Toilets – 4.5/3.0 litre dual flush pan and cistern;
- Showers – WELS 3-star (or better) rated; and
- Dishwashers (if used) – AAA rated using as little as 18 litres per wash.

Implementation of these measures is expected to reduce water use, and thereby wastewater generation, by as much as 10-15%.

9 Conclusions and Recommendations

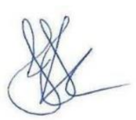
This completes our preliminary planning proposal assessment of the Site's capability for sustainable OSSM in relation to the proposed rezoning of 127 High Street, Wallalong NSW and presents suitable options for OSSM servicing of the Site. Specifically, we recommend the following:

- The preliminary development proposal contains 180 units comprised of both 2-bedroom and 3-bedroom units;
- The assumed occupancy for the Site is 479 equivalent persons, equating to one (1) person per bedroom at 150L/p/day. The total design hydraulic load for the Site is **71,850L/day**;
- Wastewater from the proposed units will be treated to a minimum secondary standard (with disinfection). A minimum of tertiary treatment will be required if internal reuse is desired;
- The selected secondary treatment system must be NSW Health accredited or a commercial packaged treatment plant must meet regulatory standards and

community expectations. It should be installed by an experienced professional, taking into account the expected flows and other recommendations contained within this report;

- Treated effluent will be reused on-site via either pressure-compensating SSI or SI, provided the selected application method is appropriately located, installed and operated;
- An options assessment was undertaken on various wastewater servicing scenario's for the Site; including connection to sewer, traditional OSSM, decentralised OSSM, and recycled water use;
- Importation of good quality topsoil material to ensure there is a minimum 600mm separation between the base of the LAA and the limiting horizon (parent material);
- A suitable lime/ gypsum application rate of approximately 0.5kg/m^2 should be applied at the base of the land application systems prior to installation;
- Vegetation must be established over the LAAs immediately after installation;
- Stormwater run-on must be directed away from the proposed LAAs; and
- Vehicles and grazing animals must be prevented from entering the designated LAAs.

Yours Sincerely,



Jasmin Kable
Environmental Consultant

Appendix A

Figure

Figure 1: Site Locality

2667: 127 High Street, Wallalong - Preliminary Rezoning Proposal OSSM

N

Whitehead & Associates
Environmental Consultants

0 0.5 1 1.5 2 2.5 km
(Approx Scale)

Revision	01
Drawn	JK
Approved	MS

Figure 2a: Site Plan

2667: 127 High Street, Wallalong - Preliminary WMR for Rezoning

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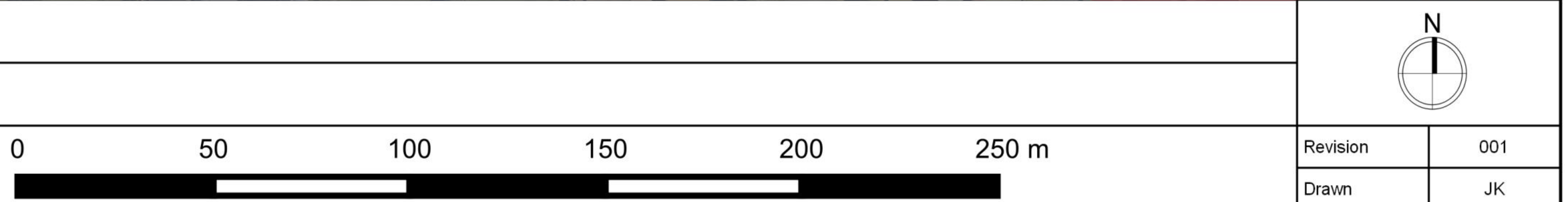
Environmental Consultants

Revision	001
Drawn	JK
Approved	MS

Figure 2b: Site Plan

2667: 127 High Street, Wallalong - Preliminary WMR for Rezoning



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Revision	001
Drawn	JK
Approved	MS

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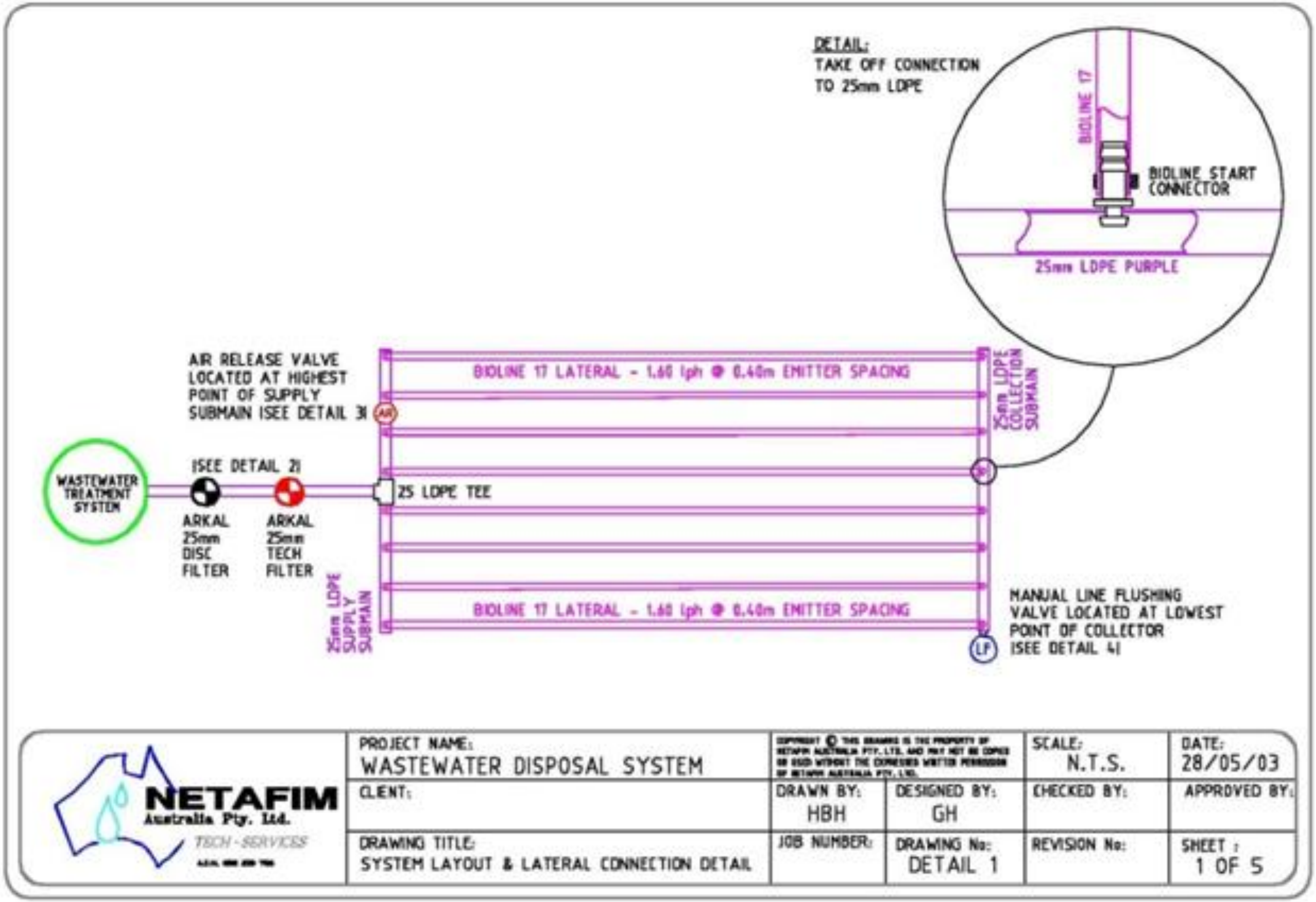
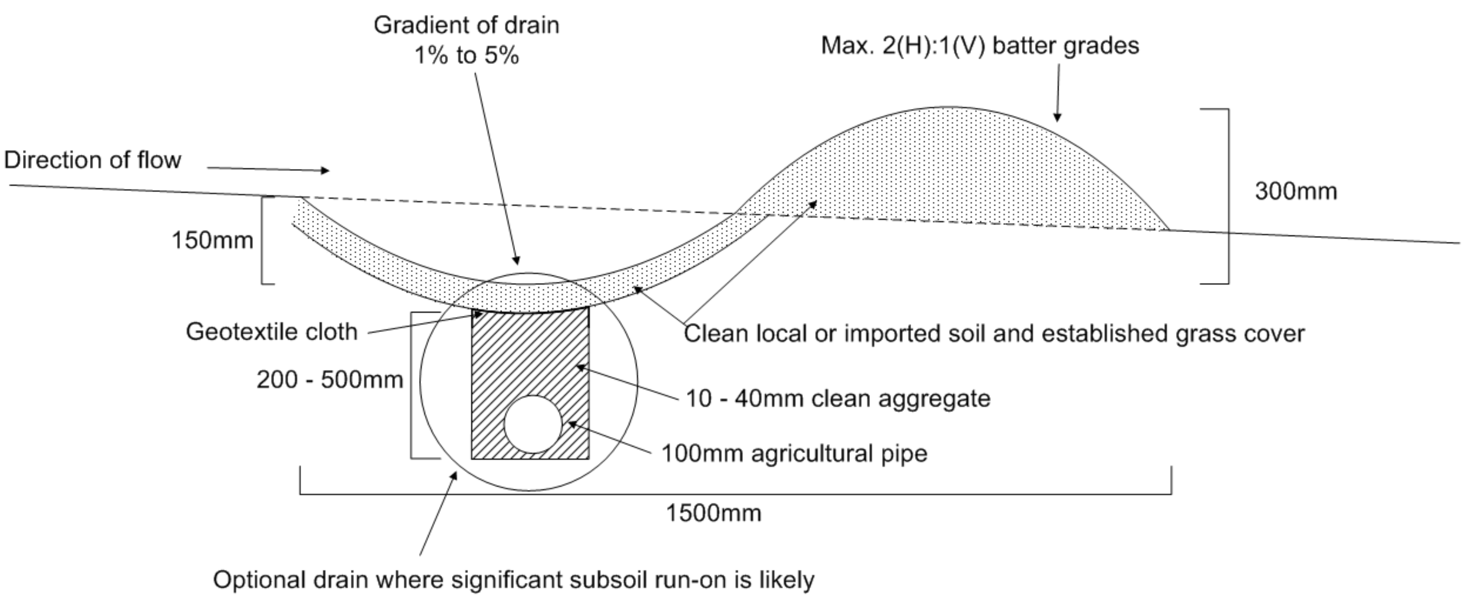


Figure 3: Typical Subsurface Irrigation Detail (courtesy of Netafim Australia)

Cross Section: Upslope Diversion Drain



Whitehead & Associates Environmental Consultants	**Figure 4:** **Standard Drawing:** **Upslope Diversion Drain**	**Project: 2667** **Drawn: JK** **Approved: MS** **Date: 07/07/2020** **Scale: NTS**

Appendix B

Soil Borelogs and Laboratory Results

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Key to Soil Borelogs

Symbols

W	Watertable depth	●	Sample collected
X	Depth of refusal		

Moisture condition

D	Dry
SM	Slightly moist
M	Moist
VM	Very moist
W	Wet / saturated

Graphic Log and Textures

S - Sand
LS - Loamy sand
CS - Clayey sand

CL - Clay loam
SCL - Sandy clay loam
SiCL - Silty clay loam

Gravel (G)

SL - Sandy loam

LC - Light clay
SC - Sandy clay

Parent material (stiff)

L - Loam
LFS - Loam fine sandy
SiL - Silty loam

MC - Medium clay
HC - Heavy clay

Parent material (weathered)

Soil Bore Log

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Environmental Consultants

Client:	Perception Planning	**Test Pit No:**	**TP1**
Site:	2667: 127 High St, Wallalong	Excavated/logged by:	JK & LO
Date:	21 May 2020	Excavation type:	Auger & crowbar
Notes:	- refer to site plan for position of test pit Wallalong SL, grass paddocks, concave convergent slope on eastern side of gully, 12% slope, NEE aspect, great exposure, good surface condition, no erosion, good indicative drainage.		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
		TP1/1	A	LC	Weak	Very dark grey	Nil	2 - 10%	D	
0.1										
0.2		TP1/2	A	LC	Weak	Very dark grey	Nil	2 - 10%	D	
0.3										
0.4		TP1/3	B	HC	Moderate	Dark grey	Gleyed	2 - 10%	D	
0.5										
0.6										
0.7										
0.8										
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										

Soil Bore Log

Whitehead & Associates
Environmental Consultants

Client:	Perception Planning	**Test Pit No:**	**TP2**
Site:	2667: 127 High St, Wallalong	Excavated/logged by:	JK & LO
Date:	21 May 2020	Excavation type:	Auger & crowbar
Notes:	- refer to site plan for position of test pit Wallalong soil landscape, grass paddock, located in between two gullies with adjacent mounded outcrops with surface water ponding of surface water upslope of the outcrops, 10-12% slope, no water present in the gullies, NE aspect, great exposure, no erosion, good indicative drainage		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP2/1	A	LC	Moderate	Very dark grey	Nil	2 - 10%	D	
0.2		TP2/2	B	LC	Moderate	Very dark grey	Orange	20 - 50%	D	Dry, rocky
0.3										
0.4										
0.5		TP2/3	B	HC	Moderate	Dark grey	Orange, white & gleyed	10 - 20%	SM	Weathered bedrock
0.6										
0.7										
0.8										
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										

Soil Bore Log

Whitehead & Associates
Environmental Consultants

Client:	Perception Planning	**Test Pit No:**	**TP3**
Site:	2667: 127 High St, Wallalong	Excavated/logged by:	JK & LO
Date:	21 May 2020	Excavation type:	Auger & crowbar
Notes:	- refer to site plan for position of test pit Wallalong soil landscape, grass paddock, eastern aspect, 7-10% slope, no erosion, linear convergent slope near large tree upslope of the dam, surface water ponding at the surface, runon/ upslope seepage observed at 300mm within TP, great exposure, rock outcrop surrounds, dry soil with upslope seepage.		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP3/1	A	SC	Weak	Dark brown	Nil	2 - 10%	D	
0.2										
0.3		TP3/2	B	MC	Moderate	Dark grey	Nil	10 - 20%	SM	subsoil seepage
0.4										
0.5										
0.6										
0.7										
0.8										
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										

Soil Bore Log

Whitehead & Associates
Environmental Consultants

Client:	Perception Planning	**Test Pit No:**	**TP4**
Site:	2667: 127 High St, Wallalong	Excavated/logged by:	JK & LO
Date:	21 May 2020	Excavation type:	Auger & crowbar

Notes:
- refer to site plan for position of test pit

Wallalong soil landscape, good surface condition, no erosion, good indicative drainage, eastern aspect, great exposure, grass groundcover, 5-7% slope, planar convergent midslope.

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP4/1	A	LC	Moderate	Very dark grey	Nil	2 - 10%	D	
0.2		TP4/2	B	MC	Moderate	Very dark grey	Nil	2 - 10%	D	
0.3										
0.4										
0.5										
0.6		TP4/3	B	HC	Moderate	Dark grey	White & gleyed	2 - 10%	SM	
0.7										
0.8										
0.9										
1.0										
1.1	Terminated on weathered parent material.									
1.2										
1.3										
1.4										
1.5										

Soil Bore Log

Whitehead & Associates
Environmental Consultants

Client:	Perception Planning	**Test Pit No:**	**TP5**
Site:	2667: 127 High St, Wallalong	Excavated/logged by:	JK & LO
Date:	21 May 2020	Excavation type:	Auger & crowbar
Notes:	- refer to site plan for position of test pit Wallalong soil lanscape, good surface condition, top NW corner of the Site near the telecommunications tower, convex convergent slope, northern aspect towards adjacent property dam, great exposure, grass paddock, erosion around gravel access path to tower, 5% slope, good indicative drainage.		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP5/1	A	SC	Weak	Very dark brown	Nil	50 - 90%	D	weathered bedrock at surface
0.2										
0.3										
0.4										
0.5										
0.6										
0.7										
0.8										
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										

Soil Bore Log

Whitehead & Associates
Environmental Consultants

Client:	Perception Planning	**Test Pit No:**	**TP6**
Site:	2667: 127 High St, Wallalong	Excavated/logged by:	JK & LO
Date:	21 May 2020	Excavation type:	Auger & crowbar
Notes:	- refer to site plan for position of test pit Wallalong soil landcape, convex convergent slope, near corner of exisitng house paddock, good surface condition within grassed paddock, no erosion, good drainage, NEE aspect, 3-4% slope, OK exposure adjacent stand of eucalypt trees.		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP6/1	A	SCL	Weak	Black	Nil	2 - 10%	D	Very compacted and friable. Falls out of auger.
0.2		TP6/2	B	HC	Moderate	Very dark greyish brown	Orange	2 - 10%	D	
0.3										
0.4										
0.5										
0.6										
0.7										
0.8										
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										

Soil Bore Log

Whitehead & Associates
Environmental Consultants

Client:	Perception Planning	**Test Pit No:**	**TP7**
Site:	2667: 127 High St, Wallalong	Excavated/logged by:	JK & LO
Date:	21 May 2020	Excavation type:	Auger & crowbar
Notes:	- refer to site plan for position of test pit Wallalong soil landcape, moderate surface condition, linear convergent slope with a large number of surface rock outcrops surrounding TP location, 5-7% slope, grassed paddock, great exposure, NE aspect, good indicative drainage with no erosion.		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP7/1	A	SC	Moderate	Dark brown	Nil	2 - 10%	D	
0.2		TP7/2	B	LC	Moderate	Dark brown	Nil	10 - 20%	D	
0.3										
0.4										
0.5		TP7/3	B	HC	Moderate	Greyish brown	Orange	10 - 20%	D	
0.6										
0.7	Refusal on floater.									
0.8										
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										

Soil Bore Log

Whitehead & Associates
Environmental Consultants

Client:	Perception Planning	**Test Pit No:**	**TP8**
Site:	2667: 127 High St, Wallalong	Excavated/logged by:	JK & LO
Date:	21 May 2020	Excavation type:	Auger & crowbar
Notes:	- refer to site plan for position of test pit Wallalong soil landscape, good surface condition, 10% slope, no erosion, good indicative drainage, convex convergent slope near stand of mature trees, grassed paddock, NE aspect, exposure moderate.		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles	Coarse Fragments	Moisture Condition	Comments
0.1		TP8/1	A	CL	Weak	Black	Nil	2 - 10%	D	
0.2		TP8/2	B	LC	Moderate	Dark brown	Nil	10 - 20%	D	Large sandstone floaters.
0.3										
0.4		TP8/3	B	MC	Moderate	Dark brown	Nil	20 - 50%	D	
0.5										
0.6										
0.7										
0.8										
0.9										
1.0										
1.1										
1.2										
1.3										
1.4										
1.5										

Sheet 1 - Soil Sampling Schedule and Results of pH, EC and Emerson Aggregate Test Analysis												
Site	**Sample Name**	**Sample Depth** (mm)	**Texture Class**	**EAT** [1]	**Rating** [2]	**pH f** [3]	**pH 1:5** [4]	**Rating**	**EC 1:5** (µS/cm)	**ECe** (dS/m) [5]	**Rating**	**Other analysis** [6]
TP1	1/1	50	LC	7	Low	n/a	5.9	Moderately acid	13	0.10	Non-saline	
	1/2	300	LC	7	Low	n/a	5.7	Moderately acid	20	0.26	Non-saline	
	1/3	600	HC	2(3)	High	n/a	5.7	Moderately acid	62	0.18	Non-saline	
TP2	2/1	100	LC	7	Low	n/a	5.6	Moderately acid	19	0.15	Non-saline	
	2/2	450	LC	2(2)	Mod	n/a	5.8	Moderately acid	10	0.08	Non-saline	
	2/3	650	HC	2(1)	Mod	n/a	5.4	Strongly acid	73	0.44	Non-saline	
TP3	3/1	100	LC	5	Low	n/a	5.5	Strongly acid	46	0.37	Non-saline	
	3/2	300	MC	2(2)	Mod	n/a	5.2	Strongly acid	24	0.17	Non-saline	
TP4	4/1	100	LC	5	Low	n/a	7.4	Mildly alkaline	37	0.30	Non-saline	
	4/2	500	MC	2(1)	Mod	n/a	5.8	Moderately acid	63	0.44	Non-saline	
	4/3	1000	HC	2(2)	Mod	n/a	5.0	Very strongly acid	15	0.09	Non-saline	
TP5	5/1	150	LC	2(1)	Mod	n/a	5.8	Moderately acid	28	0.22	Non-saline	
TP6	6/1	100	CL	2(2)	Mod	n/a	5.6	Moderately acid	42	0.38	Non-saline	
	6/2	400	HC	2(1)	Mod	n/a	5.2	Strongly acid	110	0.66	Non-saline	
TP7	7/1	100	LC	7	Low	n/a	6.1	Slightly acid	15	0.12	Non-saline	
	7/2	400	MC	2(2)	Mod	n/a	5.8	Moderately acid	16	0.11	Non-saline	
	7/3	650	HC	2(1)	Mod	n/a	5.6	Moderately acid	66	0.40	Non-saline	
TP8	8/1	100	CL	5	Low	n/a	6.8	Neutral	22	0.20	Non-saline	
	8/2	300	LC	7	Low	n/a	6.2	Slightly acid	18	0.14	Non-saline	
	8/3	400	MC	2(1)	Mod	n/a	5.8	Moderately acid	47	0.33	Non-saline	

Notes:- (also refer Interpretation Sheet 1)

[1] The modified Emerson Aggregate Test (EAT) provides an indication of soil susceptibility to dispersion.

[2] Ratings describe the likely hazard associated with land application of treated wastewater.

[3] pH measured in the field using Raupac Indicator.

[4] pH measured on 1:5 soil:water suspensions using a *Hanna Combo* hand-held pH/EC/temp meter.

[5] Electrical conductivity of the saturated extract (Ece) = $EC_{1:5}$(µS/cm) x MF / 1000. Units are dS/m. MF is a soil texture multiplication factor.

[6] External laboratories used for the following analyses, if indicated:

- CEC (Cation exchange capacity)
- Psorb (Phosphorus sorption capacity)
- Bray Phosphorus
- Organic carbon
- Total nitrogen

Rosebank Drive, Wallalong - Results of External Laboratory Analysis															
Name	**Depth (mm)**	**CEC** (me/100g)	Rating	**Ca** (mg/kg)	Rating	**Mg** (mg/kg)	Rating	**Na** (mg/kg)	Rating	**K** (mg/kg)	Rating	**ESP** (%)	Rating	**P-sorp.** (mg/kg)	Rating
Previous W&A job TP1 - Composite	600	13.1	M	198	VL	925	H	773	VH	72	VL	25.6	VSS	307	MH

Appendix C

Water and Nutrient Balance Modelling

Irrigation Area Water Balance & Storage Calculations

Whitehead & Associates
Environmental Consultants

Site Address: 127 High Street, Wallalong

Scenario: Onsite for two bedroom unit

Design Wastewater Flow	Q	300	L/day	
Design Irrigation Rate	DIR	2.0	mm/day	Litres/m²/day - based on Table M1 AS/NZS 1547:2012 for secondary effluent
Available Land Application Area	L	230	m²	Used for iterative purposes to determine storage requirements for nominated areas
Crop Factor	C	0.5-0.8	unitless	Estimates evapotranspiration as a fraction of pan evaporation; varies with season and crop type
Runoff Coefficient	RC	0.8	unitless	Proportion of rainfall that remains onsite and infiltrates; function of slope/cover, allowing for any runoff
Rainfall Data		Paterson Tocal AWS (061250)		Median Monthly data (1967-2020)
Evaporation Data		Paterson Tocal AWS (061250)		Mean Daily data (1967-2020)

Soil Category (AS1547:2012)	DIR	Units
Gravels and Sands (1)	5	mm/day
Sandy Loams (2)	5	mm/day
Loams (3)	4	mm/day
Clay Loams (4)	3.5	mm/day
Light Clays (5)	3	mm/day
Medium to Heavy Clays (6)	2	mm/day

Parameter	Symbol	Formula	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Days in Month	D		days	31	28	31	30	31	30	31	31	30	31	30	31	31	28	31	30	31	30	
Rainfall	R		mm/month	79.4	81.1	105.1	63.2	55.1	65.2	31.4	30.1	34.6	47.6	69.9	70.3	79.4	81.1	105.1	63.2	55.1	65.2	**733.0**
Evaporation			mm/day	6.2	5.3	4.2	3.2	2.4	2.1	2.4	3.3	4.4	5.2	5.8	6.6	6.2	5.3	4.2	3.2	2.4	2.1	
Evaporation	E		mm/month	192.2	148.4	130.2	96.0	74.4	63.0	74.4	102.3	132.0	161.2	174.0	204.6	192.2	148.4	130.2	96.0	74.4	63.0	**1552.7**
Crop Factor	C			0.80	0.80	0.90	0.70	0.60	0.50	0.70	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.90	0.70	0.60	0.50	
OUTPUTS (LOSSES)																						
Evapotranspiration	ET	ExC	mm/month	153.8	118.7	117.2	67.2	44.6	31.5	52.1	81.8	105.6	129.0	139.2	163.7	153.8	118.7	117.2	67.2	44.6	31.5	**1204.36**
Percolation	B	DIRxD	mm/month	62.0	56	62.0	60.0	62.0	60.0	62.0	62.0	60.0	62.0	60.0	62.0	62.0	56.0	62.0	60.0	62.0	60.0	**730.0**
Outputs		ET+B	mm/month	215.8	174.72	179.2	127.2	106.6	91.5	114.1	143.8	165.6	191.0	199.2	225.7	215.8	174.72	179.2	127.2	106.6	91.5	**1934.4**
INPUTS (GAINS)																						
Retained Rainfall	RR	RxRC	mm/month	63.52	64.88	84.08	50.56	44.08	52.16	25.12	24.08	27.68	38.08	55.92	56.24	63.52	64.88	84.08	50.56	44.08	52.16	**586.4**
Effluent Irrigation	W	(QxD)/L	mm/month	40.4	36.5	40.4	39.1	40.4	39.1	40.4	40.4	39.1	40.4	39.1	40.4	40.4	36.5	40.4	39.1	40.4	39.1	**476.1**
Inputs		RR+W	mm/month	104.0	101.4	124.5	89.7	84.5	91.3	65.6	64.5	66.8	78.5	95.1	96.7	104.0	101.4	124.5	89.7	84.5	91.3	**1062.5**
STORAGE CALCULATION (Δ)																						
Storage Remaining from Previous Month			mm/month	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Storage for the Month	S	(RR+W)-(ET+B)	mm/month	-111.8	-73.3	-54.7	-37.5	-22.1	-0.2	-48.5	-79.3	-98.8	-112.4	-104.1	-129.0	-111.8	-73.3	-54.7	-37.5	-22.1	-0.2	
Cumulative Storage	M		mm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Maximum Storage for Nominated Area	N		mm	0.0																		
Storage Volume required	V	(NxL)/1000	m³	0.0																		
LAND AREA REQUIRED FOR ZERO STORAGE			m²	61	76	98	117	149	229	105	78	65	61	63	55	61	76	98	117	149	229	

MINIMUM AREA REQUIRED FOR ZERO STORAGE: 229 m²

Irrigation Area Water Balance & Storage Calculations

Whitehead & Associates
Environmental Consultants

Site Address: 127 High Street, Wallalong

Scenario: Full proposed Load of 71.85kL/day to determine the maximum LAA required

Design Wastewater Flow	Q	71,850	L/day	
Design Irrigation Rate	DIR	2.0	mm/day	Litres/m²/day - based on Table M1 AS/NZS 1547:2012 for secondary effluent
Available Land Application Area	L	54,792	m²	Used for iterative purposes to determine storage requirements for nominated areas
Crop Factor	C	0.5-0.8	unitless	Estimates evapotranspiration as a fraction of pan evaporation; varies with season and crop type
Runoff Coefficient	RC	0.8	unitless	Proportion of rainfall that remains onsite and infiltrates; function of slope/cover, allowing for any runoff
Rainfall Data	Paterson Tocal AWS (061250)			Median Monthly data (1967-2020)
Evaporation Data	Paterson Tocal AWS (061250)			Mean Daily data (1967-2020)

Soil Category (AS1547:2012)	DIR	Units
Gravels and Sands (1)	5	mm/day
Sandy Loams (2)	5	mm/day
Loams (3)	4	mm/day
Clay Loams (4)	3.5	mm/day
Light Clays (5)	3	mm/day
Medium to Heavy Clays (6)	2	mm/day

Parameter	Symbol	Formula	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Days in Month	D		days	31	28	31	30	31	30	31	31	30	31	30	31	31	28	31	30	31	30	
Rainfall	R		mm/month	79.4	81.1	105.1	63.2	55.1	65.2	31.4	30.1	34.6	47.6	69.9	70.3	79.4	81.1	105.1	63.2	55.1	65.2	**925.4**
Evaporation			mm/day	6.2	5.3	4.2	3.2	2.4	2.1	2.4	3.3	4.4	5.2	5.8	6.6	6.2	5.3	4.2	3.2	2.4	2.1	
Evaporation	E		mm/month	192.2	148.4	130.2	96.0	74.4	63.0	74.4	102.3	132.0	161.2	174.0	204.6	192.2	148.4	130.2	96.0	74.4	63.0	**1552.7**
Crop Factor	C			0.80	0.80	0.90	0.70	0.60	0.50	0.70	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.90	0.70	0.60	0.50	
OUTPUTS (LOSSES)																						
Evapotranspiration	ET	ExC	mm/month	153.8	118.7	117.2	67.2	44.6	31.5	52.1	81.8	105.6	129.0	139.2	163.7	153.8	118.7	117.2	67.2	44.6	31.5	**1204.36**
Percolation	B	DIRxD	mm/month	62.0	56	62.0	60.0	62.0	60.0	62.0	62.0	60.0	62.0	60.0	62.0	62.0	56.0	62.0	60.0	62.0	60.0	**730.0**
Outputs		ET+B	mm/month	215.8	174.72	179.2	127.2	106.6	91.5	114.1	143.8	165.6	191.0	199.2	225.7	215.8	174.72	179.2	127.2	106.6	91.5	**1934.4**
INPUTS (GAINS)																						
Retained Rainfall	RR	RxRC	mm/month	63.52	64.88	84.08	50.56	44.08	52.16	25.12	24.08	27.68	38.08	55.92	56.24	63.52	64.88	84.08	50.56	44.08	52.16	**586.4**
Effluent Irrigation	W	(QxD)/L	mm/month	40.7	36.7	40.7	39.3	40.7	39.3	40.7	40.7	39.3	40.7	39.3	40.7	40.7	36.7	40.7	39.3	40.7	39.3	**478.6**
Inputs		RR+W	mm/month	104.2	101.6	124.7	89.9	84.7	91.5	65.8	64.7	67.0	78.7	95.3	96.9	104.2	101.6	124.7	89.9	84.7	91.5	**1065.0**
STORAGE CALCULATION (Δ)																						
Storage Remaining from Previous Month			mm/month	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Storage for the Month	S	(RR+W)-(ET+B)	mm/month	-111.6	-73.1	-54.4	-37.3	-21.9	0.0	-48.3	-79.1	-98.6	-112.2	-103.9	-128.8	-111.6	-73.1	-54.4	-37.3	-21.9	0.0	
Cumulative Storage	M		mm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Maximum Storage for Nominated Area	N		mm	0.0																		
Storage Volume required	V	(NxL)/1000	m³	0.0																		
LAND AREA REQUIRED FOR ZERO STORAGE			m²	14631	18316	23421	28125	35603	54792	25038	18598	15629	14569	15044	13145	14631	18316	23421	28125	35603	54792	

MINIMUM AREA REQUIRED FOR ZERO STORAGE: 54,792 m²

This value is based on the worst month of the year, so the balance overestimates the area/storage requirements and is therefore conservative for all other months

Irrigation Area Water Balance & Storage Calculations

Whitehead & Associates
Environmental Consultants

Site Address: 127 High Street, Wallalong

Scenario: Existing scenario of determining the wastewater that can be applied to the available area at the Site.

Design Wastewater Flow	Q	12,350	L/day	
Design Irrigation Rate	DIR	2.0	mm/day	Litres/m^2/day - based on Table M1 AS/NZS 1547:2012 for secondary effluent
Available Land Application Area	L	9,445	m^2	Used for iterative purposes to determine storage requirements for nominated areas
Crop Factor	C	0.5-0.8	unitless	Estimates evapotranspiration as a fraction of pan evaporation; varies with season and crop type
Runoff Coefficient	RC	0.8	unitless	Proportion of rainfall that remains onsite and infiltrates; function of slope/cover, allowing for any runoff
Rainfall Data	Paterson Tocal AWS (061250)			Median Monthly data (1967-2020)
Evaporation Data	Paterson Tocal AWS (061250)			Mean Daily data (1967-2020)

Soil Category (AS1547:2012)	DIR	Units
Gravels and Sands (1)	5	mm/day
Sandy Loams (2)	5	mm/day
Loams (3)	4	mm/day
Clay Loams (4)	3.5	mm/day
Light Clays (5)	3	mm/day
Medium to Heavy Clays (6)	2	mm/day

Parameter	Symbol	Formula	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Days in Month	D		days	31	28	31	30	31	30	31	31	30	31	30	31	31	28	31	30	31	30	
Rainfall	R		mm/month	79.4	81.1	105.1	63.2	55.1	65.2	31.4	30.1	34.6	47.6	69.9	70.3	79.4	81.1	105.1	63.2	55.1	65.2	**733.0**
Evaporation			mm/day	6.2	5.3	4.2	3.2	2.4	2.1	2.4	3.3	4.4	5.2	5.8	6.6	6.2	5.3	4.2	3.2	2.4	2.1	
Evaporation	E		mm/month	192.2	148.4	130.2	96.0	74.4	63.0	74.4	102.3	132.0	161.2	174.0	204.6	192.2	148.4	130.2	96.0	74.4	63.0	**1552.7**
Crop Factor	C			0.80	0.80	0.90	0.70	0.60	0.50	0.70	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.90	0.70	0.60	0.50	
OUTPUTS (LOSSES)																						
Evapotranspiration	ET	ExC	mm/month	153.8	118.7	117.2	67.2	44.6	31.5	52.1	81.8	105.6	129.0	139.2	163.7	153.8	118.7	117.2	67.2	44.6	31.5	**1204.36**
Percolation	B	DIRxD	mm/month	62.0	56	62.0	60.0	62.0	60.0	62.0	62.0	60.0	62.0	60.0	62.0	62.0	56.0	62.0	60.0	62.0	60.0	**730.0**
Outputs		ET+B	mm/month	215.8	174.72	179.2	127.2	106.6	91.5	114.1	143.8	165.6	191.0	199.2	225.7	215.8	174.72	179.2	127.2	106.6	91.5	**1934.4**
INPUTS (GAINS)																						
Retained Rainfall	RR	RxRC	mm/month	63.52	64.88	84.08	50.56	44.08	52.16	25.12	24.08	27.68	38.08	55.92	56.24	63.52	64.88	84.08	50.56	44.08	52.16	**586.4**
Effluent Irrigation	W	(QxD)/L	mm/month	40.5	36.6	40.5	39.2	40.5	39.2	40.5	40.5	39.2	40.5	39.2	40.5	40.5	36.6	40.5	39.2	40.5	39.2	**477.3**
Inputs		RR+W	mm/month	104.1	101.5	124.6	89.8	84.6	91.4	65.7	64.6	66.9	78.6	95.1	96.8	104.1	101.5	124.6	89.8	84.6	91.4	**1063.7**
STORAGE CALCULATION (Δ)																						
Storage Remaining from Previous Month			mm/month	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Storage for the Month	S	(RR+W)-(ET+B)	mm/month	-111.7	-73.2	-54.6	-37.4	-22.0	-0.1	-48.4	-79.2	-98.7	-112.3	-104.1	-128.9	-111.7	-73.2	-54.6	-37.4	-22.0	-0.1	
Cumulative Storage	M		mm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Maximum Storage for Nominated Area	N		mm	0.0																		
Storage Volume required	V	(NxL)/1000	m^3	0.0																		
LAND AREA REQUIRED FOR ZERO STORAGE			m^2	2515	3148	4026	4834	6120	9418	4304	3197	2686	2504	2586	2260	2515	3148	4026	4834	6120	9418	

MINIMUM AREA REQUIRED FOR ZERO STORAGE: 9,418 m^2

This value is based on the worst month of the year, so the balance overestimates the area/storage requirements and is therefore conservative for all other months

Irrigation Area Water Balance & Storage Calculations

Whitehead & Associates
Environmental Consultants

Site Address: 127 High Street, Wallalong

Scenario: Half the proposed wastewater generation of 71.85kL/day to determine required LAA.

Design Wastewater Flow	Q	35,925	L/day	
Design Irrigation Rate	DIR	2.0	mm/day	Litres/m^2/day - based on Table M1 AS/NZS 1547:2012 for secondary effluent
Available Land Application Area	L	29,222	m^2	Used for iterative purposes to determine storage requirements for nominated areas
Crop Factor	C	0.5-0.8	unitless	Estimates evapotranspiration as a fraction of pan evaporation; varies with season and crop type
Runoff Coefficient	RC	0.8	unitless	Proportion of rainfall that remains onsite and infiltrates; function of slope/cover, allowing for any runoff
Rainfall Data	Paterson Tocal AWS (061250)			Median Monthly data (1967-2020)
Evaporation Data	Paterson Tocal AWS (061250)			Mean Daily data (1967-2020)

Soil Category (AS1547:2012)	DIR	Units
Gravels and Sands (1)	5	mm/day
Sandy Loams (2)	5	mm/day
Loams (3)	4	mm/day
Clay Loams (4)	3.5	mm/day
Light Clays (5)	3	mm/day
Medium to Heavy Clays (6)	2	mm/day

Parameter	Symbol	Formula	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Days in Month	D		days	31	28	31	30	31	30	31	31	30	31	30	31	31	28	31	30	31	30	
Rainfall	R		mm/month	79.4	81.1	105.1	63.2	55.1	65.2	31.4	30.1	34.6	47.6	69.9	70.3	79.4	81.1	105.1	63.2	55.1	65.2	**925.4**
Evaporation			mm/day	6.2	5.3	4.2	3.2	2.4	2.1	2.4	3.3	4.4	5.2	5.8	6.6	6.2	5.3	4.2	3.2	2.4	2.1	
Evaporation	E		mm/month	192.2	148.4	130.2	96.0	74.4	63.0	74.4	102.3	132.0	161.2	174.0	204.6	192.2	148.4	130.2	96.0	74.4	63.0	**1552.7**
Crop Factor	C			0.80	0.80	0.90	0.70	0.60	0.50	0.70	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.90	0.70	0.60	0.50	
OUTPUTS (LOSSES)																						
Evapotranspiration	ET	ExC	mm/month	153.8	118.7	117.2	67.2	44.6	31.5	52.1	81.8	105.6	129.0	139.2	163.7	153.8	118.7	117.2	67.2	44.6	31.5	**1204.36**
Percolation	B	DIRxD	mm/month	62.0	56	62.0	60.0	62.0	60.0	62.0	62.0	60.0	62.0	60.0	62.0	62.0	56.0	62.0	60.0	62.0	60.0	**730.0**
Outputs		ET+B	mm/month	215.8	174.72	179.2	127.2	106.6	91.5	114.1	143.8	165.6	191.0	199.2	225.7	215.8	174.72	179.2	127.2	106.6	91.5	**1934.4**
INPUTS (GAINS)																						
Retained Rainfall	RR	RxRC	mm/month	63.52	64.88	84.08	50.56	44.08	52.16	25.12	24.08	27.68	38.08	55.92	56.24	63.52	64.88	84.08	50.56	44.08	52.16	**586.4**
Effluent Irrigation	W	(QxD)/L	mm/month	38.1	34.4	38.1	36.9	38.1	36.9	38.1	38.1	36.9	38.1	36.9	38.1	38.1	34.4	38.1	36.9	38.1	36.9	**448.7**
Inputs		RR+W	mm/month	101.6	99.3	122.2	87.4	82.2	89.0	63.2	62.2	64.6	76.2	92.8	94.4	101.6	99.3	122.2	87.4	82.2	89.0	**1035.1**
STORAGE CALCULATION (Δ)																						
Storage Remaining from Previous Month			mm/month	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Storage for the Month	S	(RR+W)-(ET+B)	mm/month	-114.1	-75.4	-57.0	-39.8	-24.4	-2.5	-50.8	-81.6	-101.0	-114.8	-106.4	-131.3	-114.1	-75.4	-57.0	-39.8	-24.4	-2.5	
Cumulative Storage	M		mm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Maximum Storage for Nominated Area	N		mm	0.0																		
Storage Volume required	V	(NxL)/1000	m^3	0.0																		
LAND AREA REQUIRED FOR ZERO STORAGE			m^2	7315	9158	11711	14063	17802	27396	12519	9299	7814	7285	7522	6573	7315	9158	11711	14063	17802	27396	

MINIMUM AREA REQUIRED FOR ZERO STORAGE: 27,396 m^2

This value is based on the worst month of the year, so the balance overestimates the area/storage requirements and is therefore conservative for all other months

Irrigation Area Water Balance & Storage Calculations

Site Address: 127 High Street, Wallalong

Whitehead & Associates
Environmental Consultants

Scenario: Internal Reuse Option 68% of total load (32% for reuse)

Design Wastewater Flow	Q	48,858	L/day	
Design Irrigation Rate	DIR	2.0	mm/day	Litres/m²/day - based on Table M1 AS/NZS 1547:2012 for secondary effluent
Available Land Application Area	L	37,258	m²	Used for iterative purposes to determine storage requirements for nominated areas
Crop Factor	C	0.5-0.8	unitless	Estimates evapotranspiration as a fraction of pan evaporation; varies with season and crop type
Runoff Coefficient	RC	0.8	unitless	Proportion of rainfall that remains onsite and infiltrates; function of slope/cover, allowing for any runoff
Rainfall Data		Paterson Tocal AWS (061250)		Median Monthly data (1967-2020)
Evaporation Data		Paterson Tocal AWS (061250)		Mean Daily data (1967-2020)

Soil Category (AS1547:2012)	DIR	Units
Gravels and Sands (1)	5	mm/day
Sandy Loams (2)	5	mm/day
Loams (3)	4	mm/day
Clay Loams (4)	3.5	mm/day
Light Clays (5)	3	mm/day
Medium to Heavy Clays (6)	2	mm/day

Parameter	Symbol	Formula	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Days in Month	D		days	31	28	31	30	31	30	31	31	30	31	30	31	31	28	31	30	31	30	
Rainfall	R		mm/month	79.4	81.1	105.1	63.2	55.1	65.2	31.4	30.1	34.6	47.6	69.9	70.3	79.4	81.1	105.1	63.2	55.1	65.2	**733.0**
Evaporation			mm/day	6.2	5.3	4.2	3.2	2.4	2.1	2.4	3.3	4.4	5.2	5.8	6.6	6.2	5.3	4.2	3.2	2.4	2.1	
Evaporation	E		mm/month	192.2	148.4	130.2	96.0	74.4	63.0	74.4	102.3	132.0	161.2	174.0	204.6	192.2	148.4	130.2	96.0	74.4	63.0	**1552.7**
Crop Factor	C			0.80	0.80	0.90	0.70	0.60	0.50	0.70	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.90	0.70	0.60	0.50	
OUTPUTS (LOSSES)																						
Evapotranspiration	ET	ExC	mm/month	153.8	118.7	117.2	67.2	44.6	31.5	52.1	81.8	105.6	129.0	139.2	163.7	153.8	118.7	117.2	67.2	44.6	31.5	**1204.36**
Percolation	B	DIRxD	mm/month	62.0	56	62.0	60.0	62.0	60.0	62.0	62.0	60.0	62.0	60.0	62.0	62.0	56.0	62.0	60.0	62.0	60.0	**730.0**
Outputs		ET+B	mm/month	215.8	174.72	179.2	127.2	106.6	91.5	114.1	143.8	165.6	191.0	199.2	225.7	215.8	174.72	179.2	127.2	106.6	91.5	**1934.4**
INPUTS (GAINS)																						
Retained Rainfall	RR	RxRC	mm/month	63.52	64.88	84.08	50.56	44.08	52.16	25.12	24.08	27.68	38.08	55.92	56.24	63.52	64.88	84.08	50.56	44.08	52.16	**586.4**
Effluent Irrigation	W	(QxD)/L	mm/month	40.7	36.7	40.7	39.3	40.7	39.3	40.7	40.7	39.3	40.7	39.3	40.7	40.7	36.7	40.7	39.3	40.7	39.3	**478.6**
Inputs		RR+W	mm/month	104.2	101.6	124.7	89.9	84.7	91.5	65.8	64.7	67.0	78.7	95.3	96.9	104.2	101.6	124.7	89.9	84.7	91.5	**1065.0**
STORAGE CALCULATION (Δ)																						
Storage Remaining from Previous Month			mm/month	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Storage for the Month	S	(RR+W)-(ET+B)	mm/month	-111.6	-73.1	-54.4	-37.3	-21.9	0.0	-48.3	-79.1	-98.6	-112.2	-103.9	-128.8	-111.6	-73.1	-54.4	-37.3	-21.9	0.0	
Cumulative Storage	M		mm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Maximum Storage for Nominated Area	N		mm	0.0																		
Storage Volume required	V	(NxL)/1000	m³	0.0																		
LAND AREA REQUIRED FOR ZERO STORAGE			m²	9949	12455	15926	19125	24210	37258	17026	12647	10627	9907	10230	8939	9949	12455	15926	19125	24210	37258	

MINIMUM AREA REQUIRED FOR ZERO STORAGE: 37,258 m²

Nutrient Balance

Whitehead & Associates
Environmental Consultants

Site Address: 127 High Street, Wallalong

Please read the attached notes before using this spreadsheet.

SUMMARY - LAND APPLICATION AREA REQUIRED BASED ON THE MOST LIMITING BALANCE = 49,719 m^2

INPUT DATA [1]

Wastewater Loading			Nutrient Crop Uptake					
Hydraulic Load	71,850	L/day	Crop N Uptake	260	kg/ha/yr	which equals	71.23	mg/m²/day
Effluent N Concentration	35	mg/L	Crop P Uptake	30	kg/ha/yr	which equals	8.22	mg/m²/day
% Lost to Soil Processes (Geary & Gardner 1996)	0.2	Decimal	**Phosphorus Sorption**					
Total N Loss to Soil	502,950	mg/day	P-sorption result	307	mg/kg	which equals	4,912	kg/ha
Remaining N Load after soil loss	2,011,800	mg/day	Bulk Density	1.6	g/cm³			
Effluent P Concentration	15	mg/L	Depth of Soil	1	m			
Design Life of System	50	yrs	% of Predicted P-sorp. [2]	0.5	Decimal			

METHOD 1: NUTRIENT BALANCE BASED ON ANNUAL CROP UPTAKE RATES

Minimum Area required with zero buffer

Nitrogen	28,243	m²
Phosphorus	49,719	m²

Determination of Buffer Zone Size for a Nominated Land Application Area (LAA)

Nominated LAA Size	54,792	m²
Predicted N Export from LAA	-690.29	kg/year
Predicted P Export from LAA	-40.14	kg/year
Phosphorus Longevity for LAA	59	Years
Minimum Buffer Required for excess nutrient	0	m²

PHOSPHORUS BALANCE
STEP 1: Using the nominated LAA Size

Nominated LAA Size	**54,792**	m²			
Daily P Load	1.07775	kg/day	→ Phosphorus generated over life of system	19668.9375	kg
Daily Uptake	0.4503452	kg/day	→ Phosphorus vegetative uptake for life of system	0.150	kg/m²
Measured p-sorption capacity	0.4912	kg/m²			
Assumed p-sorption capacity	0.246	kg/m²	→ Phosphorus adsorbed in 50 years	0.246	kg/m²
Site P-sorption capacity	13456.92	kg	→ Desired Annual P Application Rate	433.514	kg/year
			which equals	1.18771	kg/day
P-load to be sorbed	229.00	kg/year			

NOTES

[1]. Model sensitivity to input parameters will affect the accuracy of the result obtained. Where possible site specific data should be used. Otherwise data should be obtained from a reliable source such as,

- *Environment and Health Protection Guidelines: Onsite Sewage Management for Single Households*
- *Appropriate Peer Reviewed Papers*
- *EPA Guidelines for Effluent Irrigation*
- *USEPA Onsite Systems Manual.*

[2]. A multiplier, normally between 0.25 and 0.75, is used to estimate actual P-sorption under field conditions which is assumed to be less than laboratory estimates.

Appendix D

General Notes

Soil Physical Properties / Chemistry

pH

This test is used to determine the acidity or alkalinity of native soils. pH is measured on a scale of 0 to 14, with 7 being neutral. Results below 7 are considered acid, while those above 7 are alkaline. For land application of effluent, soil with a pH of 4.5 to 8.5 should typically pose no constraints. Soil pH affects the solubility and fixation of some nutrients; this in turn reduces soil fertility and plant growth. By correcting soil pH beneficial plant growth is improved, assisting in the assimilation of nutrient and improving evapotranspiration of effluent. Most Australian soils are naturally acidic.

Electrical Conductivity

Electrical conductivity (EC) is a measure of a soil or soil/water extracts ability to conduct an electrical current. It is used as an indirect measure of a soils accumulation of water soluble salts, mainly of sodium, with minor potassium, calcium and magnesium. High EC within a land application area reflects general soil salinity and is undesirable for vegetation growth. The tolerance of vegetation species to soil salinity varies among plant types. Typically EC readings of <4dS/m pose no constraints. There are a number of measures available to counter high soil EC values for land application of effluent; however, the most important measure relates to the conservative selection of application rates and appropriate application area sizing.

Emerson Aggregate Test

The Emerson Aggregate Test (EAT) is a measure of soil dispersibility and susceptibility to erosion and structural degradation. It assesses the physical changes that occur in a single ped of soil when immersed in water, specifically whether the soil slakes and falls apart or disperses and clouds the water. Dispersive soils pose limitations to on-site sewage management because of the potential loss of soil structure when effluent is applied. Soil pores can become smaller or completely blocked, causing a decrease in soil permeability, which can lead to system failure.

Cation Exchange Capacity

The cation exchange capacity (CEC) is the capacity of the soil to hold and exchange cations (positively charged molecules). Because some soils have a dominant negative charge, they can adsorb cations. Soils bind cations such as calcium, magnesium, potassium and sodium, preventing them from being leached from the soil profile and making them available as plant nutrients. CEC is a major controlling agent for soil structural stability, nutrient availability for plants and the soils' reaction to fertilisers and other ameliorants. A CEC of greater than 15 cmol+/kg or me/100g is recommended for land application systems. Adding organic matter (compost/humus) to soil can greatly increase its CEC.

Exchangeable Sodium Percentage

The exchangeable sodium percentage (ESP) is an important indicator of soil sodicity, which affects soil structural stability and overall susceptibility to dispersion. Sodic soils tend to have a low infiltration capability, low hydraulic conductivity, and a high susceptibility to erosion. When sodium dominates the exchangeable cation complex, soil structural stability declines significantly. Soil ESP is considered acceptable for effluent application areas when it is below 5%, marginal between 5% – 10% and limiting >10%. The ESP of application area soils can be improved by the measured application of calcium (lime/gypsum).

Phosphorus Sorption Capacity

Phosphorus sorption (P-sorption) capacity is a direct measure of a soils ability to adsorb phosphorus. Phosphorus is an important plant nutrient and is the limiting available nutrient in many aquatic environments. Excess phosphorus can increase the production of nuisance vegetative growth such as algae. The P-sorption capacity of the soil in an effluent application area relates to its ability to assimilate the phosphorus in the wastewater for the design life of the application area. P-sorption values greater than 400mg/kg is considered acceptable for land application of effluent, while values below 150mg/kg present a constraint.