Onsite Wastewater Land Capability Assessment

Planning Proposal for a 43 Lot Rural Residential Subdivision Lots 831,832 & 833 DP 847683 Reardon's Lane Swan Bay

HEALTH SCIENCE ENVIROMENTAL EDUCATION
ENVIRONMENTAL AUDITOR

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1. Introduction

Tim Fitzroy & Associates has been engaged by Envirosafe Products Pty Ltd to undertake a Land Capability Assessment for on-site wastewater disposal to accompany for a potential future rural residential subdivision at Lots 831, 832 and 833, DP 847683 Reardons Lane Swan Bay. This report has been prepared to accompany a planning proposal to Richmond Valley Council.

The purpose of the Planning Proposal is to change the town planning provisions applying to Lots 831, 832, 833 DP 847683 to rezone part of the land presently zoned RU1 – Primary Production to R5 – Large Lot Residential in accordance with the provisions of the Richmond Valley Local Environmental Plan 2012. The Planning Proposal also seeks to amend the minimum lot size map to permit the creation of lots with minimum lot sizes of 0.75ha and 1.49ha within the area to be rezoned.

The land to which this Land Capability Assessment relates has an area of approximately 131 hectares and is located on the corner of Reardons Lane and Darke Lane Swan Bay. The bulk of the land is under sugar cane cultivation. A series of cane drains and road crisscross the site. Site improvements include two free standing dwellings and a series of sheds

The planning proposal and subsequent subdivision will result in the development of 43 rural residential allotments ranging in size from 0.75 to 1.49 hectares plus residual land.

The subject lands are adjoined by farmland to the north, east and south and rural residential properties to the west and south east. The two existing dwelling are serviced by a septic tank and absorption trenches.

This report:

- has been prepared in response to a request by Richmond Valley Council to provide a specialised report demonstrating the soil type and structure can support OSMS on smaller lots (< 1ha). RVC advised that it is generally required that OSMS proposed for the site aims to be of a 'low-tech' design to reduce the cost and ongoing difficulties which may be experience with maintaining 'higher-tech' systems.
- details the results of site inspection of the property undertaken by *Tim Fitzroy & Associates* 11 January 2017;
- provides a description of the site and its environs; and
- provides an assessment of the capacity of the proposed smaller lots (< 1ha) at the subject site to assimilate treated on-site site wastewater and
- identifies the pertinent issues to be considered for the installation of on-site wastewater management systems.

Conceptual On site wastewater have been developed in accordance with the Australian / New Zealand Standard™ *On-site Domestic Wastewater Management* (AS/NZS 1547:2012) and in consideration of the Richmond Valley Council's Onsite Sewage and Wastewater Management Strategy 2017. Designs have been prepared based on

either a three bedroom or a four bedroom dwelling house, a series of standard secondary treated wastewater systems for the proposed smaller lots (< 1ha).

2. Site Description

2.1 Site Description

The subject lands are described in Real Property terms as Lots 831, 832 and 833, DP 847683. The property has an area of approximately 131ha. The bulk of the land is under sugar cane cultivation. A series of cane drains and road crisscross the site. Site improvements include two free standing dwellings and a series of sheds.

The land is composed of three ridges with gentle slopes, one along Reardon's Lane, the second running roughly north-east through the centre of the proposed subdivision, and the third on the eastern boundary. An access road exists on this central ridge, from which the land slopes gently to the drainage lines to the east and west. Other than a Reardon's series of pine trees, the remaining land has been cleared and cultivated for growing sugar cane.

A site locality diagram shows the subject site is provided in **Illustration 2.1**. A proposed rural residential subdivision plan is located **Illustration 2.2**, while site photographs can be found in **Appendix A**.

2.2 Topography, Soils and Geology

The relief of the majority of the smaller allotments site varies between 14m and 8m AHD. Slopes on the site are in the range of 6% to 1%.

The site is mostly within the sedimentary landscape (Jurassic Walloon shales and sandstones) while the drainage lines in the north east corner in the lower area reflect Quaternary alluvial soil.

2.3 Groundwater

A search of Natural Resources Atlas of NSW (www.nratlas.nsw.gov.au) reveals that there Bore GW20496 on the subject site. Water bores immediately to the north are shown in **Illustration 2.3**. Bore GW20496 is in the Quaternary Alluvium with shallow groundwater while two other bores are in the sedimentary landscape have standing water at 6 – 8 m below the surface.

Discussions with the property owner Mr Noel Newman (pers. com 30 January 2017) confirmed that Bore GW20496 was decommissioned in 2002. Given the medium to heavy clays in the subsoil, low application of effluent in the surface soil the risk to groundwater contamination is negligible. A surface water storage captures runoff from the western portion of the subdivision and from the areas to the western side of Reardon's Land.

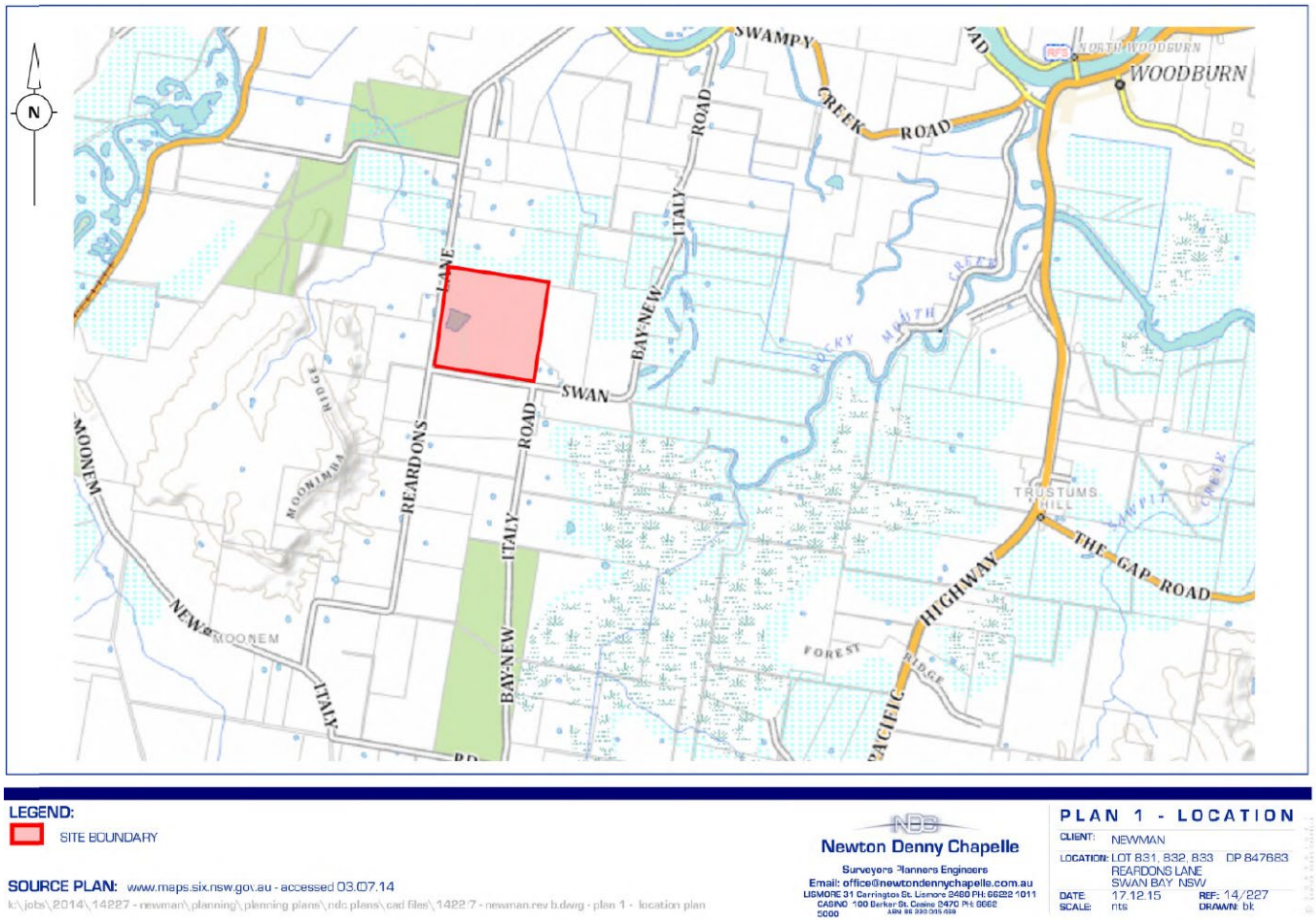
2.4 Environmentally Sensitive Area

The small dam along the western boundary could provide habitat for birds and aquatic species. As the soil around the dam is of a high clay content with exceptionally strong phosphorus sorption capacity, there is almost no risk of phosphorus leaching from the adjoining lots into the water.

Small amounts of nitrogen are not a concern as cyanobacteria have an ability to mobilise atmospheric nitrogen, and natural decomposition of grasses and aquatic plants contribute to nitrogen in the water column. The drainage lines are conduits off-site and setback distances of 10 metres from these channels are recommended. Again, the risk of phosphorus leaching is minute.

Water in the subsoil soils is so slow moving (lateral and vertical permeability) that the risk of pathogen transport is negligible, provided the effluent is discharged into the surface soil (loam).

Illustration 2.1 Site Locality Plan



2.5 Proposed Development

The proposed development would comprise of:

- 43 rural residential allotments (ranging from 0.75 to 1.49 hectares); and
- a residual lot.

The 43 rural residential lots will be Torrens title. A conceptual plan of the proposed sub division plan is provided in **Illustration 2.2**.

Illustration 2.2 Conceptual Subdivision Plan

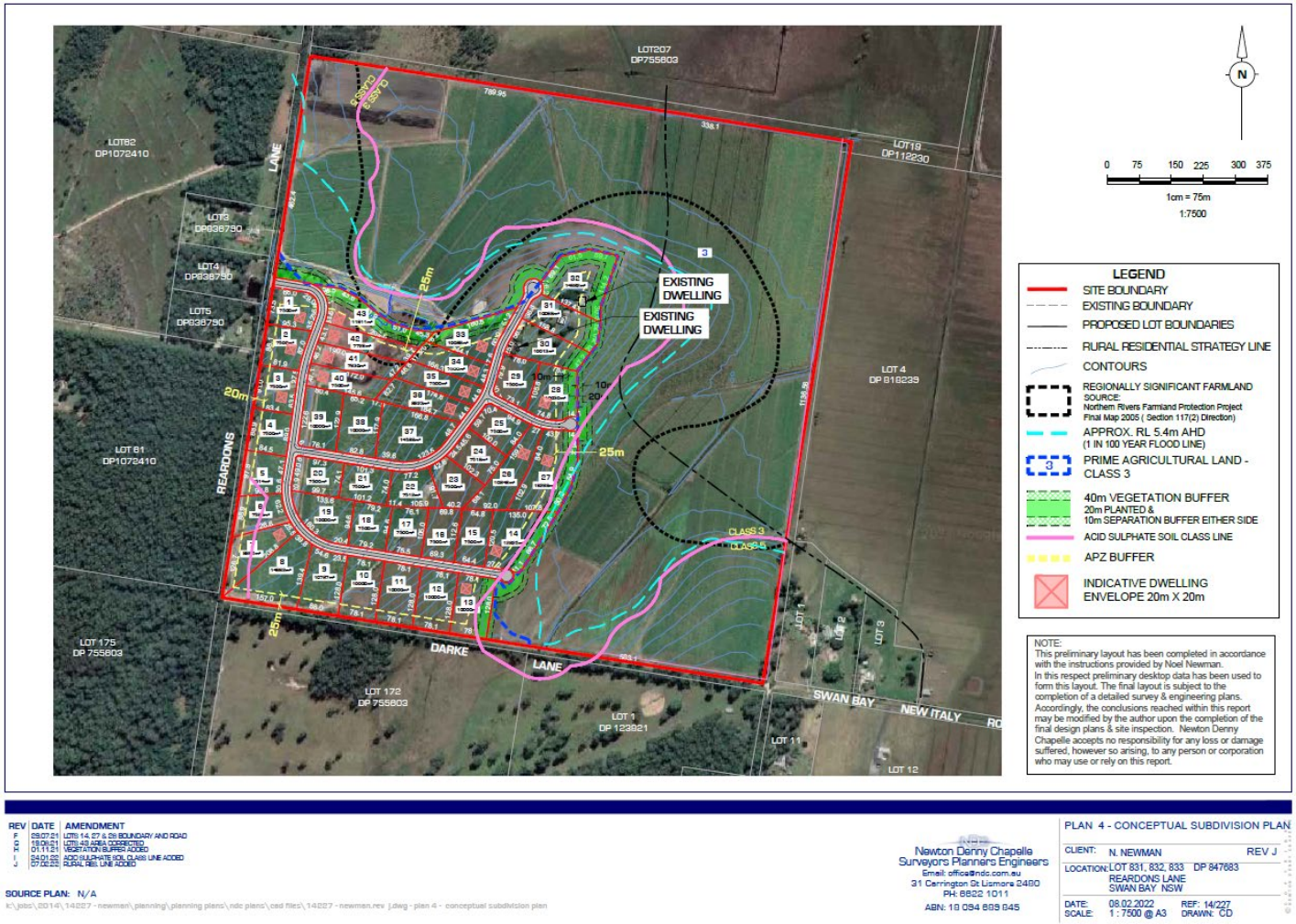


Illustration 2.3 **Groundwater Bores**

3. Site Soil Investigations

3.1 Site Inspection

3.1.1 Site Assessment

A s site assessment of the smaller lots (<1ha) was undertaken on 20 January 2017 by Tim Fitzroy. A site plan detailing the proposed lot layout is provided in **Illustration 2.1.**

A Site Analysis map including drainage features and the locations of surrounding registered groundwater bores is provided in **Appendix B**.

The subject land is characterised by gently sloping lands with slopes between 3% and 7 %, draining from higher landscape along the road easement towards the east. The land is primarily cultivated cane land, that has been extensively cleared and cultivated for many decades. There are no rocks or rocky outcrops visible on the subject land.

Drainage lines are predominantly surface drainage ditches – constructed for cane cultivation and designed to reduce the potential for the soils to remain saturated for long periods. There are no areas within the proposed subdivision that require protection for environmental values and future use as rural-residential will ultimately see increased tree and shrub cover from its current status.

A preliminary desktop study of the subject land incorporated an investigation of existing data on geology, groundwater, topography, aerial photography and climate data. A series of 7 boreholes were established with a small excavator site as typifying the topographical position in relation to soil profiles within the locations of the proposed smaller lots (<1ha) for the purpose of discharge of domestic wastewater by an appropriate means. The soil profiles were examined and samples taken for laboratory analysis. The locations of the pits are shown in **Illustration 3.1.**

Soil samples were:

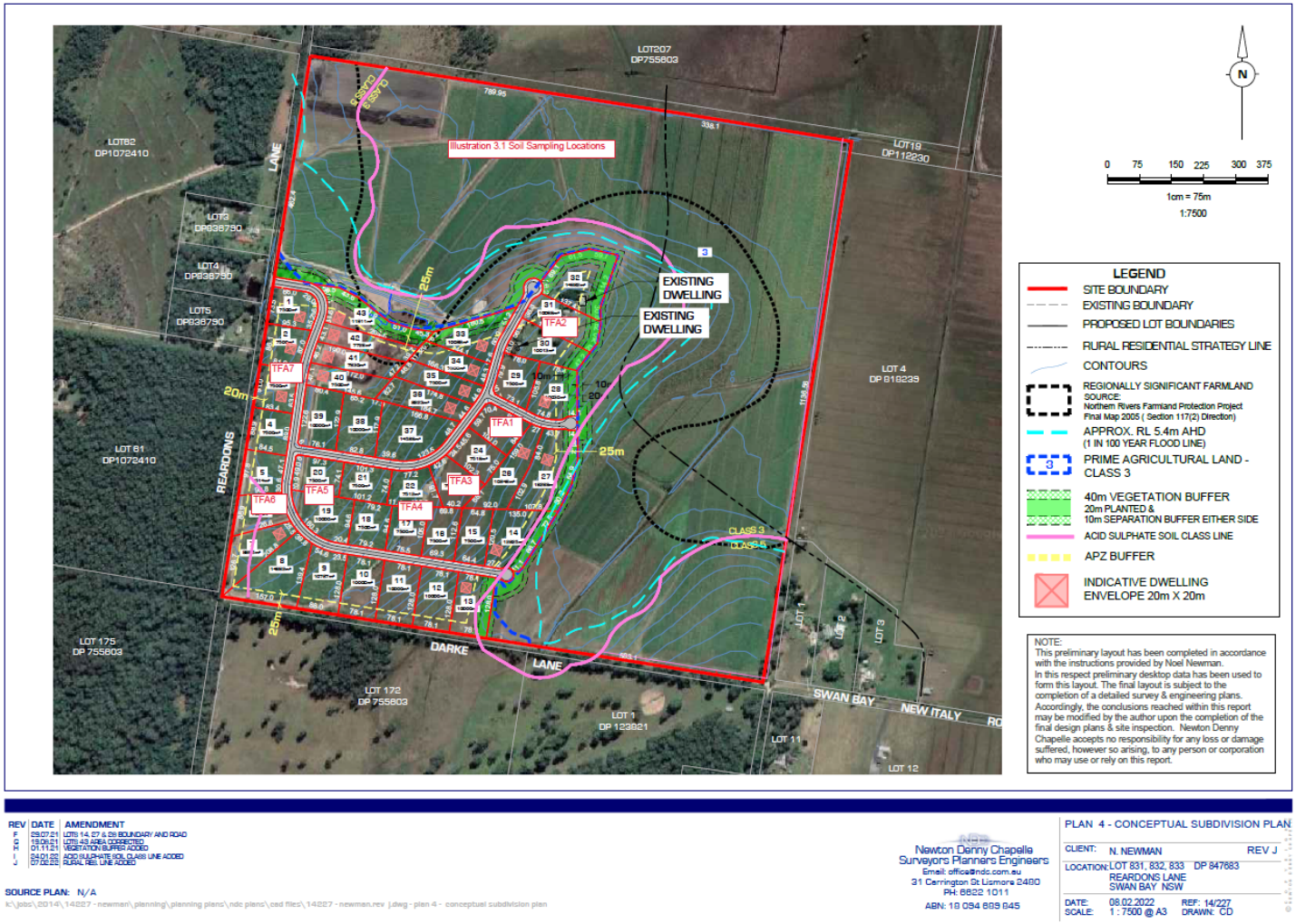
- collected from the A and B horizons to a depth of 1.2m below ground level; and
- analysed at the Environmental Analysis Laboratory Lismore for the following parameters:
    - moisture, pH(CaCl2), EC, Total Dissolved Salts (TDS) (calculation); Exchangeable Sodium, Potassium, Calcium, Magnesium, Aluminium, Hydrogen, Exchangeable Sodium Percentage, Cation Exchange Capacity; Phosphorus Sorption Capacity; Modified Emerson Aggregate Test (MEAT); Texture Full, bulk density and Sodicity

Table 3.1 details the site features assessed and the likely limitations for on-site wastewater disposal. There are no significant site limitations as detailed below.

Table 3.1 Site Assessment

Site Feature	Condition/Comments	Limitation
Climate	*Summer temperatures:* 17 – 29 °C *Winter temperatures:* 8 – 21 °C	none none
Slope Angle	Slopes on the site are in range of 3% to 9%.	none
Slope Shape	The slope shapes are generally concave.	none
Aspect	Varies from East to North to West	none
Exposure	Wind exposure will generally be good.	none
Boulders / Floaters / Rock Outcrops	Floaters or rock outcrops were not evident	none
Buffer Distances	*Permanent watercourses*: >100m *Intermittent watercourses:* >40m *Groundwater wells:* >250m (approx. 50m*) *Property boundaries, driveways and buildings:* >6m up-gradient and >12m down-gradient to existing infrastructure. *** Groundwater well was decommissioned in 2002 but remains on Office of Water data base**	none minor moderate pathogen die off calculation conducted none
Run-on and Upslope Seepage	run-on or seepage will not significantly impact the irrigation areas.	Minor ensure stormwater diversion provided above proposed dispersal areas
Flooding Potential	Flooding is not considered an issue due to the elevation of the smaller lots (<1ha).	none
Site Drainage	No visible signs of poor drainage were observed. The soil texture analysis indicates poor permeability	major
Vegetation indicating Waterlogging	No evidence in Land Application Areas	none
Fill	No evidence of fill onsite	none
Is there sufficient land area available for:	*Application systems (including buffer distances):* sufficient area is available for the proposed land application. *Reserve application system (including buffer distances):* sufficient area is available for a reserve application area.	none none
Erosion / Mass Movement	No evidence of mass movement or significant erosion was evident.	none

Illustration 3.1 Soil Sampling Locations



3.1.2 Soil Assessment

A total of 14 soil samples were obtained from test holes in the vicinity of the proposed small allotments (ranging from 0.75 to 1ha) at various locations across the subject site. Soils were obtained at various depths to approximately 1.2m deep for qualitative analysis.

The soils of the site are described as the Jurassic Walloon Coal Measures consisting of Shales, sandstones and coal. These soils are medium, silty and heavy clays.

Table 2 Soil Assessment

Soil Feature	Comments	Limitation
Soil structure	Strong to moderately structured	refer to features below
Soil texture	**TFA 1A – TFA 4A & TFA7A** Horizon A - Medium Clay **TFA 1B – TFA 4B & TFA7B** Horizon B – Heavy Clay **TFA5A & 5B** Horizon A - Heavy Clay Horizon B – Silty Clay **TFA6A & 6B** Horizon A - Heavy Clay Horizon B – Heavy Clay	refer to features below
Soil Colour	Dark brown topsoil and subsoil Yellow speckled	not applicable
Depth to bedrock or hardpan (m)	Estimated >1.2 metres	minor
Depth to high soil water table (m)	Estimated >5.0 metres	minor
Permeability category	Indicative permeability (K_{sat}) of 0.06-0.5m/day (Based on Table 5.1 in AS/NZS 1547:2012 for strongly structured medium to heavy clay soils)	major
Dispersiveness	Meat Emerson Aggregate Test Class 3 Non dispersive (see **Appendix C**)	minor
Hydraulic loading recommended for soil absorption system	15 mm/week DIR (based on Table 4.2A4 in AS/NZS 1547:2012 for strongly structured medium to heavy clay soils)	moderate
Coarse fragments (%)	Less than 10%,	minor

The soils are typically duplex in nature, that is predominately a medium clay horizon over a medium to heavy clay B horizon. The heavy clay texture of the B horizon makes the soil unsuitable for traditional trenches as the permeability is extremely low and effective drain fields would be in excess of 120 m making even distribution very difficult; consuming large areas of each lot for effluent disposal; and negating any potential for reuse of the effluent.

Fourteen soil horizons were sampled for chemical and physical properties and phosphorus sorption capacity. The results of those tests are tabled in **Appendix C**. Two examples of the soil profiles are given in **Appendix A.**

The soils are low in calcium, and generally slightly low in exchangeable sodium percentage (ESP) being below the ideal value of 6% in all but 2 samples. It should not be construed that because the ESP is in the main <6% that the soils are unsuitable for domestic effluent application since the levels of sodium are generally low and there is no dispersion in the soils. ESP in the surface soil is acceptable.

The surface soils are water stable (do not slake in water), and the subsoils slake slightly which is simply a reflection of the low organic matter at depth. Increasing the calcium in the soil by dressing with lime will not only add essential calcium to the soil but elevate the pH to more desirable levels around pH ca 6. The effluent irrigation area will need to be dressed with lime at the rate of about 0.5 kg/m2 at least every two years.

None of the soil horizons is saline and unlikely to lead to any detrimental increase in salinity because of the high clay content of the soil. It is expected that sufficient rainfall will leach salts from the root zone. Typical surface soil was a water stable medium clay, about 300 to 400 mm deep overlying medium/heavy clay subsoils. There was no well-defined A2 horizon in the soil profiles, although in places a shallow non-bleached A2 may have existed but its influence was considered negligible.

The subsoil was poorly structured to massive and expected permeability was very low. There was no indication of long term saturation in any horizon. Soil permeability was assessed from the field texture in accordance with AS/NZS 1547:2012. The soils were dried and sieved to minus 2 mm prior to testing.

The soil profiles were assessed as suitable only for surface or subsurface irrigation of effluent.

The phosphorus sorption capacity of the soil is extremely high. conservatively adopting a figure of 12,000kg/ha for P sorption and effluent produced at the rate of 1000 litres per day and a 15 mg/L phosphorus concentration over an area of 480 m2, the soil would take about 105 years to meet the soil's sorption capacity for that area. Thus, the potential loss of phosphorus from any of the lots is negligible.

The nitrogen loading from a septic tank + reedbed is about 20 mg/L. At the loading rates identified in eth model for a 3,4 and 5 bedroom dwelling over a 5,000m2 nitrogen is readily absorbed and is not a limiting factor for effluent dispersal

3.1.3 Flood Potential

The smaller allotments are to be located between 16 and 8 m AHD. All the smaller allotments are located above the 1:100 flood level.

3.1.4 Local Metrology

The average annual rainfall recorded at Ballina Weather Station is 1,742.2mm, with the highest rainfall falling in February to March, while the driest months are from August to October. Temperatures range from a lowest average minimum14.2 C to a highest average maximum of 24.4 C.

4. Wastewater Management

4.1 Wastewater Management

4.1.1 Overview

A conceptual onsite wastewater management system* has been prepared for each of the following future development scenarios at the subject site:

- A three bedroom dwelling;
- A four bedroom dwelling; and
- A five bedroom dwelling

*It is noted that allotments will be serviced by roof water supply. Onsite waste water hydraulic loadings are based on 120 litres per person per day which equates to roof water supply with standard water saving devices installed.

The conceptual onsite wastewater management system has been designed to achieve the following general objectives:

1. Protection of public health: applied effluent is to be assimilated in the soil profile and remain beneath the soil surface. No effluent resurfacing is to occur.
2. Ecologically Sustainable Beneficial Reuse: design is to maximise assimilation of nutrients and pathogens within the land applications areas.
3. Neutral or Beneficial Impact Test: design is to produce a sustainable net beneficial of neutral impact over the long term.

To achieve the objectives listed above, the following analyses have been completed:

1. Evaluation of predicted wastewater generation for the nominated scenarios;
2. Conceptual design of system to public health standards (AS/NZS 1547, 2000); NSW EPA (2005) and the Richmond Valley Council's Onsite Sewage and Wastewater Management Strategy;
3. Assessment of local site and soil conditions; and
4. Assessment of nutrient assimilation

4.1.2 Potential Secondary Treatment Systems

As required by RVC (2017) a minimum secondary treatment is required for new on site wastewater systems. RVC advised that it is generally required that OSMS proposed for the site aims to be of a 'low-tech' design to reduce the cost and ongoing difficulties which may be experience with maintaining 'higher-tech' systems.

Given the nature of the subsoil conditions and low tech options the following contemporary secondary treatment option have been included in the scenarios consisting of a:

- Baffled septic tank + outlet filter + reedbed + sub surface irrigation (septic tank sizes shown in Table 4.1)
- Baffled septic tank + outlet filter + sand filter+ sub surface irrigation (SSI)

Table 4.1 Septic Tank Sizes

	House Size		
	3 bedrooms	**4 bedrooms**	**5 bedrooms**
Septic tank size for combined grey/blackwater systems (Litres)	3,000	4,500	5,000

4.1.3 On site wastewater Modelling

Given the smaller lot sizes range from 7,500m^2 to 10,000m^2 a series of assessments of the required LAA's has been undertaken based on secondary treated effluent for two *average* lot sizes:

- 7,500 m^2
- 10,000 m^2

To assess the land capability to assimilate effluent on site each of the *lot size* scenarios have been assessed using Richmond Valley Council's OSMS Design Model (Disposal Area Calculator). The resultant LAA for each *average lot* when utilising one of the potential secondary treatment system and Compost with separate greywater treatment with are provided in **Table 4.2**.

Table 4.2 Wastewater Modelling

Dwelling	**Lot Size (m^2)**	**Treatment**	**LAA (m^2)**
3 bedrooms	7,500	St + rb + ssi	**277**
3 bedrooms	10,000	St + rb + ssi	**277**
3 bedrooms	7,500	CT + ST	**186**
3 bedrooms	10,000	CT + ST	**186**
4 bedrooms	7,500	St + rb + ssi	**369**
4 bedrooms	10,000	St +rb+ ssi	**369**
4 bedrooms	7,500	CT + ST	**247**
4 bedrooms	10,000	CT + ST	**247**
5 bedrooms	7,500	St + rb + ssi	**461**
5 bedrooms	10,000	St + rb + ssi	**461**
5 bedrooms	7,500	CT + ST	**309**
5 bedrooms	10,000	CT + ST	**309**

The results indicate, as expected, that there is sufficient land available on the proposed smaller lots utilising low tech secondary treated effluent to allow wastewater to be effectively assimilated on each of the nominated allotments.

As shown in Table 4.2 Land Application Areas for secondary treated effluent dispersal range for smaller lots (<1ha) range from:

- **277m^2 for a 3 bedroom dwelling; 369m^2 for a 4 bedroom dwelling to 461 m^2 for a 5 bedroom dwelling;**
- **and in the case of failure provides a sufficient reserve area for wastewater dispersal.**

For spilt blackwater/greywater systems utilising compost toilet and septic tanks for greywater treatment on smaller lots (<1ha) dispersal areas range from:

- **186m^2 for a 3 bedroom dwelling; 247m^2 for a 4 bedroom dwelling to 309 m^2 for a 5 bedroom dwelling**

Examples of the model outcomes are provided in **Appendix D**.

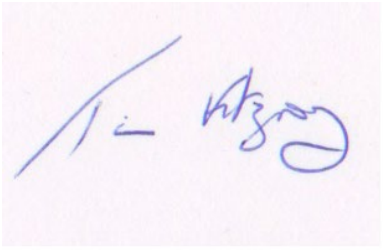
5 Conclusions and Recommendations

Based on the site and soil assessment and in consideration of

- Australian/New Zealand Standard 1547:2012;
- Richmond Valley Council's Onsite Sewage and Wastewater Management Strategy (2017); and
- Environment & Health Protection Guidelines *On-Site Sewage* Management for Single Households (1998)

it is our view that the proposed smaller allotments (7,500m2 to 10,000m2) at the subject site has the capacity to effectively assimilate low tech secondary effluent generated from 3, 4 and 5 bedroom dwellings.

This report has been prepared by Tim Fitzroy of *Tim Fitzroy & Associates.*



Tim Fitzroy
Environmental Health Scientist
Environmental Auditor

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RVC, 2017a. *On-site Sewage Management and Wastewater Management Strategy*. Richmond Valley Council. 2017.

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DLG, 1998. *Environment and Health Protection Guidelines, On-site Sewage Management for Single Households*. Contributions from Department of Local Government, Environment Protection Authority, Department of Health, Department of Land and Water Conservation, and Department of Urban Affairs and Planning. February 1998.

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A Photographs

Photo 1 Looking east towards TFA6

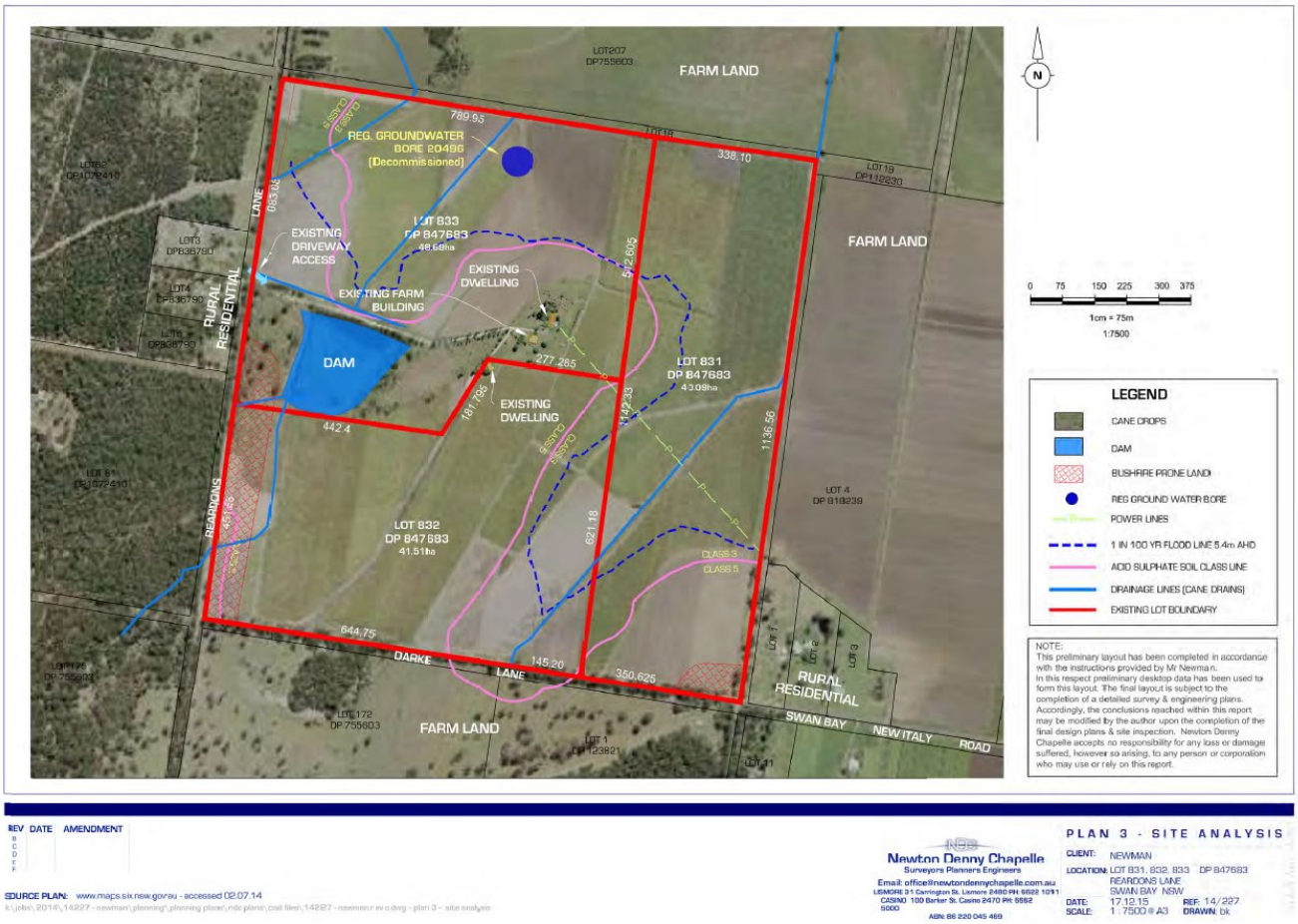
Photo 2 TFA 1 Excavation

Surface: 1-200mm, crumb to small sub-angular blocky, dull brown loam, non-saline, acid pH of low calcium and potassium, water stable aggregates, good permeability
B1 horizon: 200-500 mm, poor structure, no mottles, red clay loam,
B2 horizon: 500 - >1000, poorly structured to massive, brown medium clay of moderate bulk density (1270 kg/m3), , extremely low calcium, some yellow colours from geology, some red and grey mottles, poor permeability
No water in hole

Photo 3 TFA 3 Excavation

Surface: 1-200mm, crumb to small sub-angular blocky, dull brown loam, non-saline, acid pH of low calcium and potassium, water stable aggregates, good permeability
B1 horizon: 200-500 mm, poor structure, no mottles, dull brown, clay loam,
B2 horizon: 500 - >1000, poorly structured to massive, brown medium clay of moderate bulk density (1270 kg/m3), , extremely low calcium, some yellow colours from geology, some red and grey mottles, poor permeability
No water in hole

B Site Analysis Plan



C Laboratory Results

WASTEWATER DISPOSAL SOIL ASSESSMENT

14 samples supplied by Tim Fitzroy & Associates on 11th January, 2017 - Lab Job No. F5991
Analysis requested by Tim Fitzroy. - **Your Project: 70/2016 Newman Swan Bay**
(52 Alston Ave ALSTONVILLE NSW 2477).

	SITE 1 TFA 1A	SITE 2 TFA 1B	SITE 3 TFA 2A	SITE 4 TFA 2B	SITE 5 TFA 3A	SITE 6 TFA 3B	SITE 7 TFA 4A	SITE 8 TFA 4B	SITE 9 TFA 5A	SITE 10 TFA 5B	SITE 11 TFA 6A	SITE 12 TFA 6B	SITE 13 TFA 7A	SITE 14 TFA 7B
Job No.	*F5991/1*	*F5991/2*	*F5991/3*	*F5991/4*	*F5991/5*	*F5991/6*	*F5991/7*	*F5991/8*	*F5991/9*	*F5991/10*	*F5991/11*	*F5991/12*	*F5991/13*	*F5991/14*
Description	Medium Clay	Medium Clay	Medium Clay	Heavy Clay	Medium Clay	Heavy Clay	Medium Clay	Heavy Clay	Heavy Clay	Silty Clay	Heavy Clay	Heavy Clay	Medium Clay	Heavy Clay
Moisture Content (% moisture)	17	20	25	26	21	25	20	22	23	33	22	19	23	21
Lab. Bulk Density (tonne/m3)	1.18	1.08	1.06	1.11	1.14	1.22	1.12	1.33	1.25	0.86	1.40	1.19	1.27	1.39
Modified Emerson Aggregate Test (SAR 5 Solution) note 12	MEAT Class 3 note 12	MEAT Class 3 note 12	MEAT Class 3 note 12	MEAT Class 3 note 12	MEAT Class 3 note 12	MEAT Class 3 note 12	MEAT Class 3 note 12	MEAT Class 3 note 12	MEAT Class 3 note 12	MEAT Class 3 note 12	MEAT Class 3 note 12	MEAT Class 3 note 12	MEAT Class 3 note 12	MEAT Class 3 note 12
Soil pH (1:5 $CaCl_2$)	4.39	4.12	4.71	3.93	4.19	3.87	4.38	3.92	3.90	5.77	4.71	4.72	4.25	3.82
Soil Conductivity (1:5 water dS/m)	0.034	0.030	0.029	0.033	0.026	0.052	0.026	0.046	0.073	0.179	0.669	0.068	0.036	0.042
Soil Conductivity (as EC_e dS/m) note 10	0.292	0.258	0.249	0.284	0.224	0.447	0.224	0.396	0.628	1.539	5.753	0.585	0.310	0.361
Native NaOH Phosphorus (mg/Kg P)	26	5	34	4	18	4	17	2	3	776	3	32	15	6

Residual phosphorus remaining in solution from the initial phosphate phosphorus														
Initial Phosphorus concentration (ppm P)	30	30	30	30	30	30	30	30	30	30	30	30	30	30
72 hour - 3 Day (ppm P)	7.32	11.76	6.58	3.79	4.26	5.60	5.90	7.20	9.84	19.78	13.25	18.76	10.60	12.63
120 hour - 5 Day (ppm P)	6.93	11.19	6.28	3.10	4.00	5.20	5.37	6.64	9.62	19.54	13.21	18.67	10.15	12.01
168 hour - 7 Day (ppm P)	4.38	10.43	5.58	3.22	3.52	4.91	5.33	6.46	9.28	17.87	11.86	18.25	9.69	11.56
Equilibrium Phosphorus (ppm P)	3.23	9.66	5.08	2.61	3.13	4.45	4.82	5.88	8.97	17.13	11.41	18.04	9.13	10.84

EXCHANGEABLE CATIONS														
Calcium (cmol+/Kg)	1.65	0.20	3.11	0.31	2.03	0.51	2.32	0.18	0.07	7.63	2.68	2.86	1.14	0.19
kg/ha	739	90	1393	139	909	228	1039	81	31	3418	1201	1281	511	85
mg/kg	330	40	622	62	406	102	464	36	14	1526	536	572	228	38
Magnesium (cmol+/Kg)	1.67	2.58	2.29	2.60	1.91	3.79	1.88	4.37	3.03	5.71	10.56	4.08	1.58	6.43
kg/ha	456	705	626	711	522	1036	514	1194	828	1560	2886	1115	432	1757
mg/kg	204	315	279	317	233	462	229	533	370	697	1288	498	193	784
Potassium (cmol+/Kg)	0.19	0.06	0.13	0.10	0.13	0.18	0.12	0.17	0.11	1.34	0.20	0.24	0.11	0.15
kg/ha	166	52	114	87	114	157	105	149	96	1171	175	210	96	131
mg/kg	74	23	51	39	51	70	47	66	43	523	78	94	43	59
Sodium (cmol+/Kg)	0.17	0.28	0.26	0.67	0.40	1.18	0.28	1.03	1.09	0.49	4.53	0.49	0.35	2.19
kg/ha	88	144	134	345	206	608	144	531	562	252	2334	252	180	1128
mg/kg	39	64	60	154	92	271	64	237	251	113	1042	113	81	504
Aluminium (cmol+/Kg)	1.82	6.81	0.96	9.56	5.40	16.29	3.02	14.94	13.53	0.40	0.91	0.71	3.18	11.54
kg/ha	367	1373	194	1927	1089	3284	609	3012	2728	81	183	143	641	2326
mg/kg	164	613	86	860	486	1466	272	1345	1218	36	82	64	286	1039
Hydrogen (cmol+/Kg)	0.74	3.20	0.21	3.27	0.97	0.00	0.72	0.00	0.00	0.00	1.12	0.43	1.29	8.93
kg/ha	17	72	5	73	22	0	16	0	0	0	25	10	29	200
mg/kg	7	32	2	33	10	0	7	0	0	0	11	4	13	89
ECEC (effective cation exchange capacity)(cmol+/Kg)	6.2	13.1	7.0	16.5	10.8	22.0	8.3	20.7	17.8	15.6	20.0	8.8	7.7	29.4
Exchangeable Calcium %	26.4	1.5	44.7	1.9	18.7	2.3	27.8	0.9	0.4	49.0	13.4	32.5	14.9	0.6
Exchangeable Magnesium %	26.8	19.6	32.9	15.7	17.6	17.3	22.5	21.1	17.0	36.7	52.8	46.3	20.7	21.8
Exchangeable Potassium %	3.0	0.5	1.9	0.6	1.2	0.8	1.4	0.8	0.6	8.6	1.0	2.7	1.4	0.5
Exchangeable Sodium % (ESP)	2.7	2.1	3.7	4.1	3.7	5.4	3.4	5.0	6.1	3.1	22.7	5.6	4.6	7.4
Exchangeable Aluminium %	29.2	51.9	13.8	57.9	49.8	74.2	36.2	72.2	75.9	2.6	4.6	8.1	41.6	39.2
Exchangeable Hydrogen %	11.9	24.4	3.0	19.8	8.9	0.0	8.6	0.0	0.0	0.0	5.6	4.9	16.9	30.3
Calcium/ Magnesium Ratio	0.99	0.08	1.36	0.12	1.06	0.13	1.23	0.04	0.02	1.34	0.25	0.70	0.72	0.03

Notes:
1: ECEC = Effective Cation Exchange Capacity = sum of the exchangeable Mg, Ca, Na, K, H and Al
2: Exchangeable bases determined using standard Ammonium Acetate extract (Method 15D3) with no pretreatment for soluble salts. When Conductivity ≥0.25 dS/m soluble salts are removed (Method 15E2).
3. ppm = mg/Kg dried soil
4. Insitu P determined using 0.1 M NaOH and shaking for 24 hrs before determining phosphate
5. Soils were crushed using a ceramic grinding head and mill; five 1g subsamples of each soil were used to which 40ml of 0.1M NaCl with Xppm phosphorus was added to each. The samples were shaken on an orbital shaker
6. Exchangeable sodium percentage (ESP) is calculated as sodium (cmol+/Kg) divided by ECEC
7. All results as dry weight DW - soils were dried at 60C for 48hrs prior to crushing and analysis.
8. Phosphorus Capacity method from Ryden and Pratt, 1980.
9. Aluminium detection limit is 0.05 cmol+/Kg; Hydrogen detection limit is 0.1 cmol+/Kg.
However for calculation purposes a value of 0 is used.
10. For conductivity 1 dS/m = 1 mS/cm = 1000 µS/cm; EC_e conversions: sand loam 14, loam 9.5; clay loam 8.6; heavy clay 5.8
11. 1 cmol+/Kg = 1 meq/100g
12. MEAT Method from On-site Sewage Management Guidelines using the SAR5 solution. **MEAT Class 1:** Worked bolus material disperses; **Class 2:** Aggregates disperse (cloud solution); **Class 3:** Aggregates slake; **Class 4:** No change to aggregate- non-dispersive.

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checked: .....

D Examples of Modelling Scenarios

	RVC On-site Wastewater Model (Single Rural Households) OSmodel170115.xls *Printed 20-12-2021*	Default	User-defined
Client	Envirosafe		
Address	Reardons Lane Swan Bay		
Site	Block size (m2)		7,500
	Buffer (m) from land application area t stream	>100	
	Water (L/p.d) from Roof water harvesting	120	
	Persons		7.5
	☐ Internal wastewater sources split? ☐ Multiple households? How many?		
Wastewater components/system	Toilet ☑		
	Bathroom ☑		
	Laundry ☑		
	Kitchen ☑		
	Total wastewater flow (L/d) [needs caution if user-defined]	900	
Treatment system	Secondary: Reed bed - BOD 20mg/L		
	Nitrogen removal %	68%	
	Wetted depth of reed bed (m)	0.5	
	Maximum N allowed to go down from system (kg/yr)	15.00	
Land application	Land application type Subsurface drip irrigation		
	Design depth of root zone (mm)	300	
Soil information	Morand code (examples) Duplex Soils= ck		
	Phosphorus sorption (kg/ha.m)	8000	
	Depth to water table or bedrock (for P calcs) (m)		3
	Texture/structure Med. to heavy clays - strong. Structure		
	DIR (mm/d)	3.875	
Area calculations	Hydraulic area (m2) (or override with SSI industry estimate)	460.3	
	Nitrogen area (m2) [allowing export of 13.42 kg/yr]	0.0	
	Phosphorus area (m2)	92.9	
	Required land application area (m2)	**460.3**	
	Reed bed area (m2) and HRT (d)	29.3	6.5
	Reed bed outlet BOD (mg/L and TN% removal	≤20.0	68.0%

RVC On-site Wastewater Model (Single Rural Households) OSmodel170115.xls
Printed 20-12-2021

		Default	User-defined
Client	Envirosafe		
Address	Reardons Lane Swan Bay		
Site	Block size (m2)		7,500
	Buffer (m) from land application area t stream	>100	
	Water (L/p.d) fron Roof water harvesting	120	
	Persons		6
	☐ Internal wastewater sources split? ☐ Multiple households? How many?		
Wastewater components/system	Toilet ☐		
	Bathroom ☑		
	Laundry ☑		
	Kitchen ☑		
	Total wastewater flow (L/d) [needs caution if user-defined]	489.6	
Treatment system	Secondary: Reed bed - BOD 20mg/L		
	Nitrogen removal %	56%	
	Wetted depth of reed bed (m)	0.5	
	Maximum N allowed to go down from system (kg/yr)	15.00	
Land application	Land application type Subsurface drip irrigation		
	Design depth of root zone (mm)	300	
Soil information	Morand code (examples) Duplex Soils= ck		
	Phosphorus sorption (kg/ha.m)	8000	
	Depth to water table or bedrock (for P calcs) (m)		3
	Texture/structure Med. to heavy clays - strong. Structure		
	DIR (mm/d)	3.875	
Area calculations	Hydraulic area (m2) (or override with SSI industry estimate)	246.8	
	Nitrogen area (m2) [allowing export of 13.42 kg/yr]	0.0	
	Phosphorus area (m2)	44.6	
	Required land application area (m2)	**246.8**	
	Reed bed area (m2) and HRT (d)	11.9	4.8
	Reed bed outlet BOD (mg/L and TN% removal	≤20.0	56.2%

	RVC On-site Wastewater Model (Single Rural Households) OSmodel170115.xls *Printed 20-12-2021*	Default	User-defined
Client	Envirosafe		
Address	Reardons Lane Swan Bay		
Site	Block size (m2)		7,500
	Buffer (m) from land application area t stream	>100	
	Water (L/p.d) from Roof water harvesting	120	
	Persons		7.5
	☐ Internal wastewater sources split? ☐ Multiple households? How many?		
Wastewater components/system	Toilet ☐		
	Bathroom ☑		
	Laundry ☑		
	Kitchen ☑		
	Total wastewater flow (L/d) [needs caution if user-defined]	612	
Treatment system	Secondary: Reed bed - BOD 20mg/L		
	Nitrogen removal %	56%	
	Wetted depth of reed bed (m)	0.5	
	Maximum N allowed to go down from system (kg/yr)	15.00	
Land application	Land application type Subsurface drip irrigation		
	Design depth of root zone (mm)	300	
Soil information	Morand code (examples) Duplex Soils= ck		
	Phosphorus sorption (kg/ha.m)	8000	
	Depth to water table or bedrock (for P calcs) (m)		3
	Texture/structure Med. to heavy clays - strong. Structure		
	DIR (mm/d)	3.875	
Area calculations	Hydraulic area (m2) (or override with SSI industry estimate)	308.5	
	Nitrogen area (m2) [allowing export of 13.42 kg/yr]	0.0	
	Phosphorus area (m2)	55.7	
	Required land application area (m2)	**308.5**	
	Reed bed area (m2) and HRT (d)	14.8	4.8
	Reed bed outlet BOD (mg/L and TN% removal	≤20.0	56.2%

	RVC On-site Wastewater Model (Single Rural Households) OSmodel170115.xls *Printed 20-12-2021*	Default	User-defined
Client	Envirosafe		
Address	Reardons Lane Swan Bay		
Site	Block size (m2)		10,000
	Buffer (m) from land application area t stream	>100	
	Water (L/p.d) from Roof water harvesting	120	
	Persons		7.5
	☐ Internal wastewater sources split? ☐ Multiple households? How many?		
Wastewater components/system	Toilet ☑		
	Bathroom ☑		
	Laundry ☑		
	Kitchen ☑		
	Total wastewater flow (L/d) [needs caution if user-defined]	900	
Treatment system	Secondary: Reed bed - BOD 20mg/L		
	Nitrogen removal %	68%	
	Wetted depth of reed bed (m)	0.5	
	Maximum N allowed to go down from system (kg/yr)	15.00	
Land application	Land application type Subsurface drip irrigation		
	Design depth of root zone (mm)	300	
Soil information	Morand code (examples) Duplex Soils= ck		
	Phosphorus sorption (kg/ha.m)	8000	
	Depth to water table or bedrock (for P calcs) (m)		3
	Texture/structure Med. to heavy clays - strong. Structure		
	DIR (mm/d)	3.875	
Area calculations	Hydraulic area (m2) (or override with SSI industry estimate)	460.3	
	Nitrogen area (m2) [allowing export of 14.25 kg/yr]	0.0	
	Phosphorus area (m2)	92.9	
	Required land application area (m2)	**460.3**	
	Reed bed area (m2) and HRT (d)	29.3	6.5
	Reed bed outlet BOD (mg/L and TN% removal	≤20.0	68.0%

	RVC On-site Wastewater Model (Single Rural Households) OSmodel170115.xls *Printed 20-12-2021*	Default	User-defined
Client	Envirosafe		
Address	Reardons Lane Swan Bay		
Site	Block size (m2)		10,000
	Buffer (m) from land application area t stream	>100	
	Water (L/p.d) from Roof water harvesting	120	
	Persons		6
	☐ Internal wastewater sources split? ☐ Multiple households? How many?		
Wastewater components/system	Toilet ☐		
	Bathroom ☑		
	Laundry ☑		
	Kitchen ☑		
	Total wastewater flow (L/d) [needs caution if user-defined]	489.6	
Treatment system	Secondary: Reed bed - BOD 20mg/L		
	Nitrogen removal %	56%	
	Wetted depth of reed bed (m)	0.5	
	Maximum N allowed to go down from system (kg/yr)	15.00	
Land application	Land application type Subsurface drip irrigation		
	Design depth of root zone (mm)	300	
Soil information	Morand code (examples) Duplex Soils= ck		
	Phosphorus sorption (kg/ha.m)	8000	
	Depth to water table or bedrock (for P calcs) (m)		3
	Texture/structure Med. to heavy clays - strong. Structure		
	DIR (mm/d)	3.875	
Area calculations	Hydraulic area (m2) (or override with SSI industry estimate)	185.1	
	Nitrogen area (m2) [allowing export of 14.25 kg/yr]	0.0	

	Phosphorus area (m2)	44.6	
	Required land application area (m2)	**185.1**	
	Reed bed area (m2) and HRT (d)	11.9	4.8
	Reed bed outlet BOD (mg/L and TN% removal	≤20.0	56.2%