Land Capability Assessment for Recycled Water Application

Chelsea Gardens Estate, Moss Vale

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SEEC Reference: 20000305

19 October 2020

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Project Reference: 20000305-LC-0A
Date of Assessment: 19/10/2020

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Document Certification

This report has been developed based on agreed requirements as understood by SEEC at the time of investigation. It applies only to a specific task on the nominated lands. Other interpretations should not be made, including changes in scale or application to other projects. The contents of this report are based on a professional appraisal of the conditions that existed at the time of our investigation. Where subsurface investigations have been done the results are only applicable to the specific sampling or testing locations and only to the depth(s) investigated. Because of natural geological variability, and/or because of possible anthropogenic influences, the subsurface conditions reported can change abruptly. Such changes can also occur after the site investigation. The accuracy of the conditions provided in this report is limited by these possible variations and influences and/or is limited by budget constraints imposed by others and/or by adequate accessibility.

Document Issue Table

Version	Date	Author	Reviewer	Notes
Rev A	13/10/20	CB	AM	Issued to JMD for review
Rev 00	15/10/20	CB	AM	Issued as Rev 00
Rev 01	16/10/20	CB	AM	Minor updates. Issued as Rev 01
Rev 02	19/10/20	CB	AM	Minor updates. Issued as Rev 02

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1 INTRODUCTION

1.1 Background

Strategic Environmental and Engineering Consulting (SEEC) Pty Ltd have been commissioned by Prime Moss Vale Pty Limited (the client), to undertake this Land Capability Assessment at the site of Chelsea Gardens Estate, Moss Vale (Figure 1 and 2). It is required to accompany an application to subdivide the land and install a Packaged Wastewater Treatment System (PWTS) to treat domestic household wastewater from up to 385 new allotments from Stages 1 and 2 of the estate.

1.2 Purpose of This Assessment

Following treatment in a PWTS, recycled water (RW) will be disposed of by irrigating it over a dedicated irrigation area located in future Stage 5 of the estate. This treatment and disposal system will remain operational until upgrades to the Moss Vale Sewage Treatment Plant are completed. After that upgrade, all sewerage from the estate will be connected to the municipal sewer system and the PWTS and irrigation field will be decommissioned.

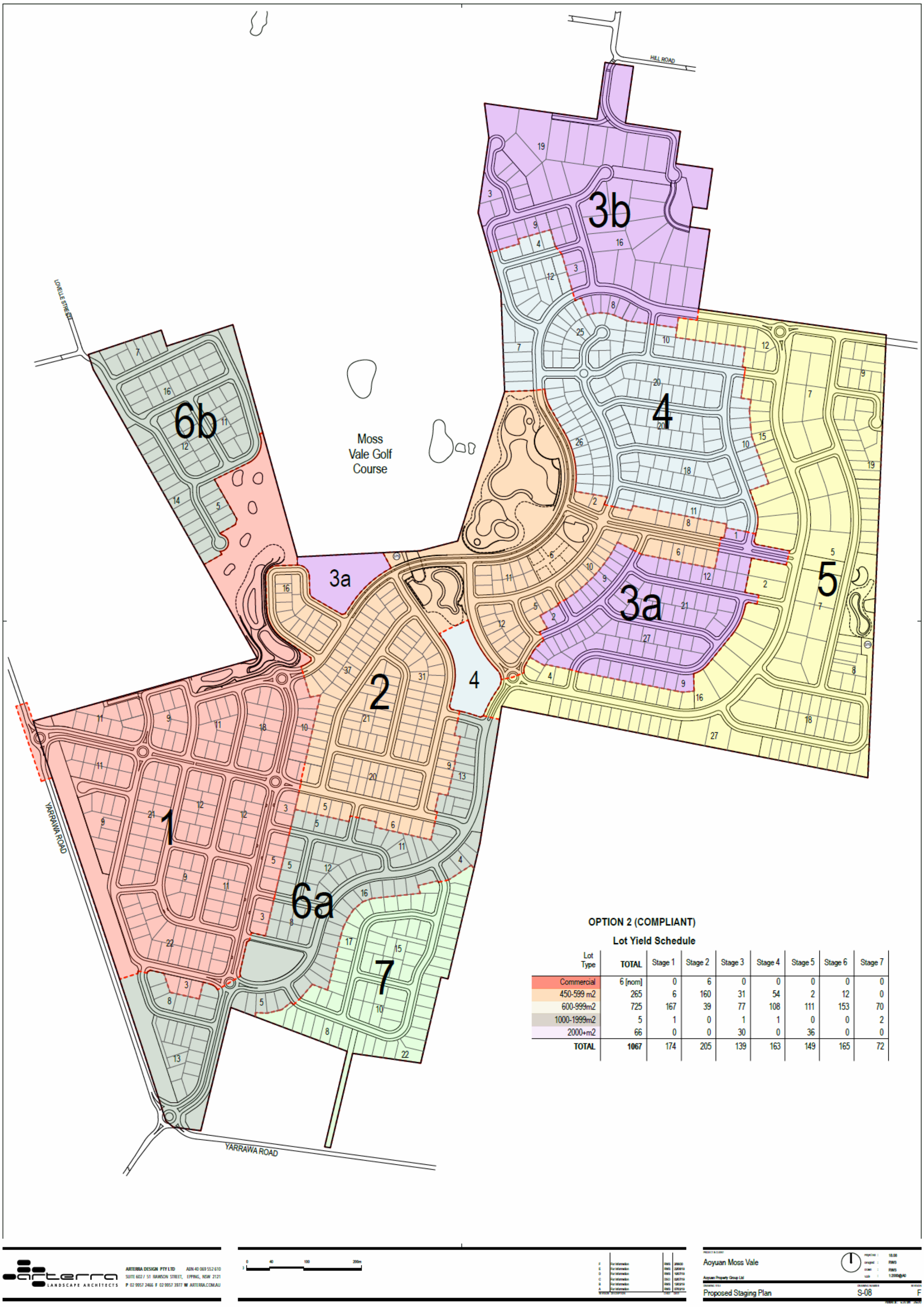
This assessment determines the capability of the lands within future Stage 5 (Figure 2) to be used for irrigating RW.

1.3 Methodology

As part of preparing this report, SEEC undertook the following tasks:

- Undertaking a site inspection and soil survey to assess the suitability of the site and soils for RW application;
- Assessment of soil texture and depth, pH, EC (electrical conductivity), modified Emerson Aggregate Class (dispersion potential) and phosphorus-sorption;
- A review of suitable methods for land application of RW;
- Preparation of a site plan showing suitable RW management areas;
- Details of any special management initiatives required to address inherent site or soil constraints;
- Preparation of this written report.

Figure 1: Chelsea Gardens Estate boundary (Underlying image from Nearmap, 2020).



Lot Type	TOTAL	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Stage 7
Commercial	6 [nom]	0	6	0	0	0	0	0
450-599 m2	265	6	160	31	54	2	12	0
600-999m2	725	167	39	77	108	111	153	70
1000-1999m2	5	1	0	1	1	0	0	2
2000+m2	66	0	0	30	0	36	0	0
TOTAL	**1067**	174	205	139	163	149	165	72

Figure 2: Chelsea Gardens Estate conceptual staging plan. Provided by John M. Daly & Associates Pty Ltd

2 SITE ASSESSMENT

2.1 Introduction

SEEC staff conducted a detailed site investigation on 24 September, 2020. A range of potential site constraints were investigated using both onsite and desktop methods including, but not limited to:

- proximity to permanent watercourses;
- landform, site gradient;
- drainage characteristics;
- aspect and exposure;
- extent of surface rock outcrop;
- soils (refer to Section 3); and
- climate of the area.

The results of that assessment are in the following sections.

2.2 General Conditions

At the time of the site inspection the site was being used as grazing land for cattle (Figure 1). The site was divided into several paddocks and there were a number of dams and drainage depressions located onsite (Figure 4).

2.3 Climate

Moss Vale experiences a warm temperate climate, with warm summers and mild winters. According to the Bureau of Meteorology (BOM), Moss Vale – Hoskins Street (Station No. 068045) receives 933.3 mm of annual average rainfall (Table 1). Evaporation data is also within Table 1, and was obtained from WaterNSW (2019). Rainfall is typically higher during the summer months, while evaporation is significantly greater in summer (Figure 3). Rainfall exceeds evaporation for only two months of the year. This is considered a minor limitation for RW irrigation.

Table 1: Average monthly rainfall (Moss Vale – Hoskins Street 068045) and Evaporation (WaterNSW, 2019 Climate Zone 4).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Rain (mm)	77.7	71.9	72.4	65	48.8	69.3	52.2	38.8	44.6	57.4	64.1	59.8	933.3
Evap (mm)	171	134	116	78	53	38	44	68	94	125	141	173	1234

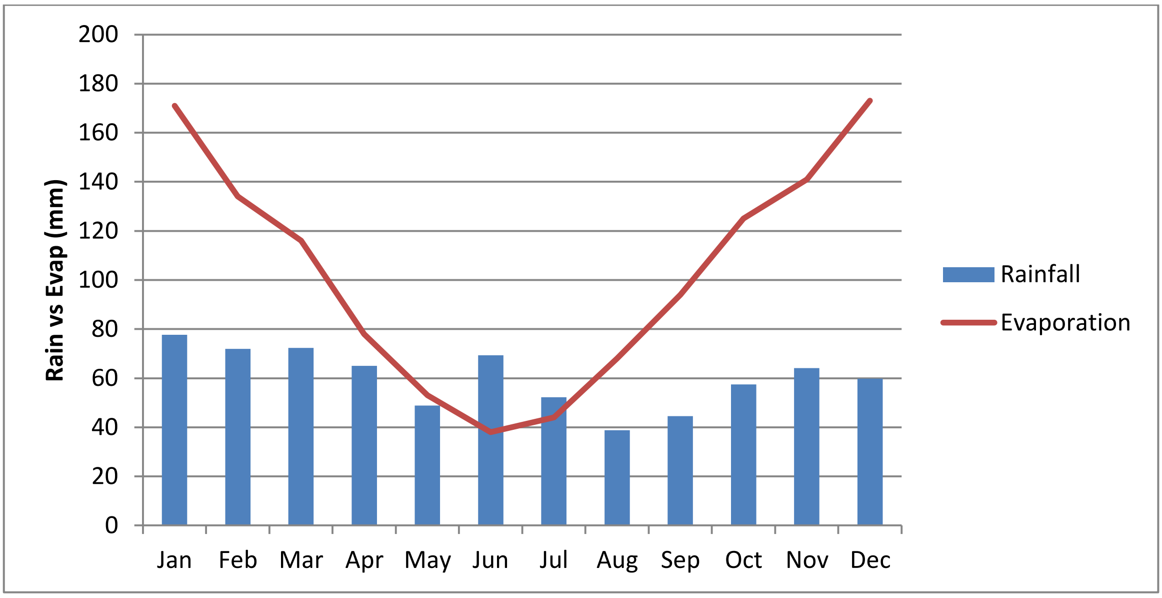


Figure 3: Graph showing Rainfall (Moss Vale – Hoskins Street 068045) and Evaporation (WaterNSW, 2019 Climate Zone 4).

2.4 Proximity to Surface Waters

There are four small farm dams located on the site along with a network of shallow, broad drainage depressions. These depressions are considered first order streams and do not have permanent flow. If runoff of RW occurred, the natural slope of the land would direct it into these localised drainage depressions. To mitigate this risk, there must be no irrigation of RW:

- When the rainfall forecast for the next 24 hours is sufficient to saturate the upper 600 mm of soil. A conservative rainfall forecast of >50% chance of more than 10 mm in 24 hours is recommended; and
- In the 24 hours following a rainfall event of more than 50 mm over the preceding 5 day period; and
- Within 40 m of the natural drainage depressions and farm dams on the property (Figure 6). The area within these buffers must be fully vegetated with pasture grasses and maintained as such.

The above recommendations are included in Section 5.5. After allowing for the 40m buffers to drainage depressions and dams, there is still sufficient room onsite to allow for irrigation of RW and, as such, this is considered a minor limitation for RW irrigation.

2.5 Flood Potential

According to Wingecarribee Shire Council's 'Whites Creek Flood Study' (Wingecarribee Shire Council, 2007) (Appendix 4) there is a low risk of flooding over the areas identified as suitable for RW application. This is a minor limitation for RW irrigation.

2.6 Site Drainage

The site has moderate infiltration capacity due to the strongly pedal topsoil and subsoil (Section 3). A site inspection conducted by SEEC found minor evidence of potential periodic waterlogging in the subsoil in Test Pits 1-5. (i.e. light grey mottling in the soils). The shallowest instance of mottling occurred in Test Pit 1 at a depth of 700 mm. This is not considered to be a limiting factor to RW application via surface or near-surface irrigation.

2.7 Ground Water

A site inspection conducted by SEEC found no evidence of ground water ingress into any of the Test Pits. This is considered a minor limitation for RW irrigation.

2.8 Exposure to Sun and Wind

A site investigation conducted by SEEC has found the proposed RW application area will have good exposure to sun and wind. This is considered a minor limitation for RW irrigation.

2.9 Slope

Slope gradients vary across the site. A site investigation conducted by SEEC identified a significant area within future Stage 5 (Figure 2) that had slopes of 10% or less and which was suitable for irrigation of RW. Under the National Water Quality Management Strategy (2006), surface irrigation is permissible on slopes of less than 10% and, as such, this is considered a minor limitation for RW irrigation.

2.10 Erosion Potential

A site investigation conducted by SEEC has found there were minor signs of erosion within the drainage depressions running south-to-north on the property. To minimise the risk of RW irrigation being impacted by erosion or exacerbating existing erosion RW must not be applied within a 40 m buffer across the natural slope of the land from any drainage depression or waterway (Figure 4).

There was an additional cut in the land located at N. -34.5671 E. 150.3821. Minor erosion of the landscape was occurring at this location. Prior to commissioning the irrigation area this cut must be re-levelled to the natural ground surface (Figure 4). This is noted in the recommendations in Section 5.5.

2.11 Fill

A site investigation conducted by SEEC did not encounter fill within any of the areas that will be receiving RW. This is considered a minor limitation for RW irrigation.

2.12 Surface Rock

A site investigation conducted by SEEC has found no surface rock within any of the areas that will receive RW. This is considered a minor limitation for RW irrigation.

2.13 Vegetation

All areas receiving RW must be vegetated with improved pasture grasses. Improved pasture will respond well to the application of RW and take up much of the nitrogen and phosphorus present in the RW. Vegetation must be periodically slashed to a height of around 100 mm. This is considered a minor limitation for RW irrigation, and this noted in the recommendations in Section 5.5.

2.14 Frost

The site is located in Moss Vale, NSW, which experiences regular frosts during the winter months. Frost can affect irrigation systems. To mitigate this risk and reduce the risk of frost damage, all distribution pipes within the irrigation field will need to be:

- Well buried; or
- If laid on the surface, well insulated and provided with a loose mulch cover.

Regardless of whether irrigation pipes are buried or laid on the surface, all irrigation pipes should drain after pumping. The potential for frost damage is considered a moderate limitation for RW irrigation, and the above recommendations are included in Section 5.5.

2.15 Presence of Stock

Stock can cause damage to irrigation systems and must be kept out of the irrigation area by fencing or other physical barrier at all times. Provided the irrigation area is fenced from stock there will be minor risk to the irrigation area. This recommendation is included in Section 5.5.

2.16 Receiving Environment

The site lies wholly within Sydney's Drinking Water Catchment and ultimately drains into Warragamba Dam.

There are two principal catchments on this site separated by a north-south ridge line. Areas identified as suitable for RW application on the eastern side of the ridge drain in a north-easterly direction, eventually joining the Wingecarribee River approximately 4 km downstream of the site boundary.

Areas identified as suitable for RW application on the western side of the ridge drain in a westerly direction, eventually reaching Whites Creek approximately 400 m downstream of the site boundary.

All RW will be applied within the confines of the site. The proposed rate of application of RW is designed to minimise the risk of any runoff being generated from the site, as are the safeguards and limitations of where and when RW can be applied. As such, there is a minor risk of RW running off into the receiving environment.

It is required that all new developments within the Sydney drinking water catchment have a Neutral or Beneficial Effect (NorBE) on water quality. This is assessed using the NorBE assessment tool which includes a Wastewater Effluent Model (WEM). SEEC were unable to undertake a WEM as the development is classed as a "Module 5" development (multi-dwelling housing). This report must be provided to WaterNSW for concurrence.

3 SOIL ASSESSMENT

3.1 Soil Landscape Mapping

Soil Landscape mapping available on the NSW Government eSPADE portal (2020) identifies the areas suitable for RW application as lying on the Moss Vale Soil Landscape (Figure 4).

The Moss Vale Soil Landscape is an erosional soil landscape formed on the Wianamatta Shale of the Moss Vale Tablelands. The dominant topography is hill slopes and the dominant lithology is shale. Soils usually comprise of brown sandy clay loam topsoils over sandy clay/clay subsoils. A site and soil inspection by SEEC staff confirmed the mapping is accurate.

3.2 Site Specific Soil Investigations

Nine test pits were excavated by SEEC staff while on site. All nine test pits revealed relatively consistent soil conditions across the site. A summary of the nine test pits follows:

Test Pit 1

0-350 mm	Strongly pedal, greyish brown, silty clay loam topsoil; 35-40 mm ribbon.
350-1,200+ mm	Strongly pedal, light brown, light/medium clay; 75-80 mm ribbon. Minor mottling from 700 mm.

Test Pit 2

0-100 mm	Strongly pedal, dark brown, silty clay loam topsoil; 35-40 mm ribbon.
100-400	Strongly pedal, greyish brown, silty clay loam topsoil; 35-40 mm ribbon.
400-1,200+ mm	Strongly pedal, light brown, light/medium clay; 75-80 mm ribbon.

Test Pit 3

0-500 mm	Strongly pedal, brown sandy loam to sandy clay loam topsoil;. 25-30 mm ribbon.
500-780 mm	Moderately pedal, fine sandy clay loam; 30-35 mm ribbon. 10% coarse fragments.
780-1,200 mm	Slightly mottled orange brown sandy clay loam; 40-45 mm ribbon.

Test Pit 4

0-300 mm	Strongly pedal, dark brown clay loam topsoil; 40 mm ribbon.
300-600 mm	Strongly pedal, light brown light clay; 50 mm ribbon.
600-1,100+ mm	Moderately pedal, light brown light/medium clay; 70-80 mm ribbon. Minor mottling from 1,000+ mm.

Test Pit 5

0-400 mm	Strongly pedal, dark brown silty clay loam topsoil; 30 mm ribbon.
400-600 mm	Strongly pedal, light brown light clay; 60-65 mm ribbon.
600-1,100	Moderately pedal, slightly mottled medium clay. Refusal at 1,100mm on rock.

Test Pit 6

0-300 mm	Strongly pedal, dark brown clay loam topsoil; 40 mm ribbon.
300-600+ mm	Strongly pedal light brown light/medium clay; 75 mm ribbon.

Test Pit 7

0-300 mm	Strongly pedal dark brown clay loam topsoil; 30 mm ribbon.
300-500 mm	Strongly pedal greyish brown silty clay loam; 35 mm ribbon.
500-1,000	Moderately pedal light brown light clay. Refusal on rock at 1,000mm.

Test Pit 8

0-350 mm	Strongly pedal greyish brown silty clay loam topsoil; 35-40 mm ribbon.
350-1,200+ mm	Strongly pedal light brown light/medium clay; 75-80 mm ribbon. Minor mottling from 700 mm.

Test Pit 9

0-100 mm	Strongly pedal dark brown silty clay loam topsoil; 35-40 mm ribbon.
100-400	Strongly pedal greyish brown silty clay loam topsoil; 35-40 mm ribbon.
400-1,200+ mm	Strongly pedal light brown light/medium clay; 75-80 mm ribbon.

3.3 Laboratory Testing

Six samples (3 x topsoil and 3 x subsoil) were sent to NSW Department of Primary Industries (DPI) Wollongbar Research Laboratory for analysis (Table 2). Topsoil and Subsoil samples from Test Pits 1-2, 4-5, 8-9 were combined into composite samples due to their similarity and to ensure laboratory sampling was representative of conditions across the site.

Table 2: Laboratory test results from the DPI Wollongbar Research Laboratory.

	Units	Topsoil TP-1,2	Topsoil TP-4,5	Topsoil TP-8,9	Subsoil TP-1,2	Subsoil TP-4,5	Subsoil TP-8,9
Electrical Conductivity	dS/m	0.035	0.072	0.046	0.037	0.027	0.22
pH (Water)	pH units	5.5	5.3	5.9	5	5.6	7.3
pH ($CaCl_2$)	pH units	4.8	4.7	5	4	4.5	6.4
Texture	N/A	Light clay	Silty clay loam	Medium clay	Heavy clay	Heavy clay	Heavy clay
Emerson aggregate test	N/A	Class 3 Sub(1)	Class 8	Class 8	Class 5	Class 3 Sub(2)	Class 2 Sub(3)
P Sorption	mg/kg	410	380	260	730	530	580
Aluminium	cmol(+)/kg	0.48	0.5	<0.1	6	1	<0.1
Calcium	cmol(+)/kg	3.8	5.8	3.8	2	2.5	2.3
Potassium	cmol(+)/kg	0.14	0.23	0.11	0.13	0.2	0.15
Magnesium	cmol(+)/kg	0.91	1.7	1.8	1.6	1.1	9.8
Sodium	cmol(+)/kg	0.12	0.11	0.19	0.19	0.12	2.6
CEC $_{\text{(effective)}}$	cmol(+)/kg	5.5	8.3	5.9	9.9	4.9	15
Calcium/ Magnesium	N/A	4.2	3.5	2.1	1.3	2.3	0.23
Percent Aluminium Saturation	% of ECEC	8.9	6	N/A	60	21	N/A
Exchangeable Calcium	% of ECEC	70	70	64	21	51	15
Exchangeable Potassium	% of ECEC	2.6	2.8	1.8	1.3	4	0.99
Exchangeable Magnesium	% of ECEC	17	20	31	16	22	66
Exchangeable Sodium Percentage	% of ECEC	2.2	1.4	3.2	1.9	2.5	18

3.4 Soil Permeability

Soil permeability was not directly measured but can be inferred from the texture and depth. AS/NZS1547 (2012) suggests that:

- Strongly pedal clay loam (topsoil) has a permeability of 20-70 mm/h and a design irrigation rate (DIR) of 25 mm/week.
- Strongly pedal clay has a Ksat of approx. 5-50 mm/h.

The above values have been adopted when recommending appropriate irrigation rates (refer to Section 4.4).

3.5 Soil pH

The pH of a soil influences its ability to supply nutrients to vegetation. If the soil is too acidic or too alkaline vegetative growth could be inhibited. As detailed in Table 2, the pH of the topsoil is between 5.5 and 5.9 and the pH of the subsoil is between 5.0 and 7.3. As the topsoil and subsoil are both slightly acidic, areas to be used for irrigation would benefit from an application of lime at 250 grams per square meter (gsm) annually to aid pasture growth. This is considered a moderate limitation for RW irrigation, and the recommendation for lime application is included in Section 5.5.

3.6 Electrical Conductivity and Salinity

The electrical conductivity of the soil indicates potential salinity within the soil. Salinity in soils can inhibit vegetative growth and affect water resources.

Laboratory testing of soil samples collected onsite determined the electrical conductivity of the topsoil is between 0.035 dS/m and 0.072 dS/m (Table 2). When translated to ECe (using a multiplier of 8.6), this gives values of 0.301 dS/m and 0.6192 dS/m respectively. Both of these are classified as non-saline according to Hazelton and Murphy (2016). This is a minor limitation for land application of RW.

The electrical conductivity of the subsoil is between 0.027 dS/m and 0.22 dS/m (Table 2). When translated to ECe (using a multiplier of 8.6), this gives values of 0.2322 dS/m and 1.892 dS/m respectively. Both of these are classified as non-saline according to Hazelton and Murphy (2016). This is a minor limitation for land application of RW.

Effluent irrigation poses a moderate to high risk of causing or exacerbating landscape salinity if it is not effectively managed and if application rates cause excessive recharge of groundwater tables. Providing irrigation rates are limited appropriately during periods of wet weather, the risk of salinity can be minimised, as the majority of water applied would be taken up by vegetation through the process of evapotranspiration. Recommendations to this effect are included in Section 5.5 and, as such, this is considered to be a minor limitation to RW irrigation.

3.7 Cation Exchange Capacity (C.E.C)

The C.E.C is the capacity of the soil to hold and exchange cations. It is a major controlling agent for soil structural stability, fertility and the ability of a soil to retain pollutants.

The measured C.E.C for the topsoil is between 5.5 and 8.9 (Table 2 and present a minor limitation for RW irrigation.

The measured C.E.C for the subsoil is between 4.9 and 15 (Table 2). These are low to moderate values and present a minor to moderate limitation for RW irrigation.

3.8 Emerson Aggregate Test (EAT)

The EAT is a measure of soil structural stability, soil dispersibility and susceptibility to erosion. It assesses the physical changes that occur to a single ped of soil when immersed in water - specifically whether it slakes and falls apart or disperses and clouds the water.

Laboratory results (Table 2) classify the topsoil as Class 3(1) and Class 8 which means that the soils are unlikely to be dispersive. This is a minor limitation for RW irrigation.

Laboratory results (Table 2) classify the subsoil as Class 5, Class 3(2) and Class 2(3). Class 5 and Class 3(2) mean the soils are unlikely to be dispersive, which is a minor limitation for RW irrigation. Class 2(3) indicates the soil shows strong dispersion potential, which is a moderate limitation for RW irrigation.

Application of RW can impact on soil structure where dispersive soils occur and, as such, soils would benefit from a regular application of gypsum of 0.2 tonnes per hectare to help minimise the risk of structural decline. This recommendation is included in Section 5.5.

3.9 Soils Summary

Soil investigations and testing showed the soils at this site:

- Are deep (1,000+ mm). This is a minor limitation for RW irrigation.
- Are moderately well drained; test pits generally revealed strongly pedal clay loam topsoil and strongly pedal light/medium clay subsoils. This is a minor limitation for RW irrigation.
- Have slightly acidic topsoils and subsoils. This is a moderate limitation for RW irrigation.
- Are non-saline in both topsoil and subsoil. This is a minor limitation for RW irrigation.
- Are unlikely to have dispersive topsoils. This is a minor limitation for RW irrigation.
- Have potential dispersion issues in the subsoil. This is a moderate limitation for RW irrigation.

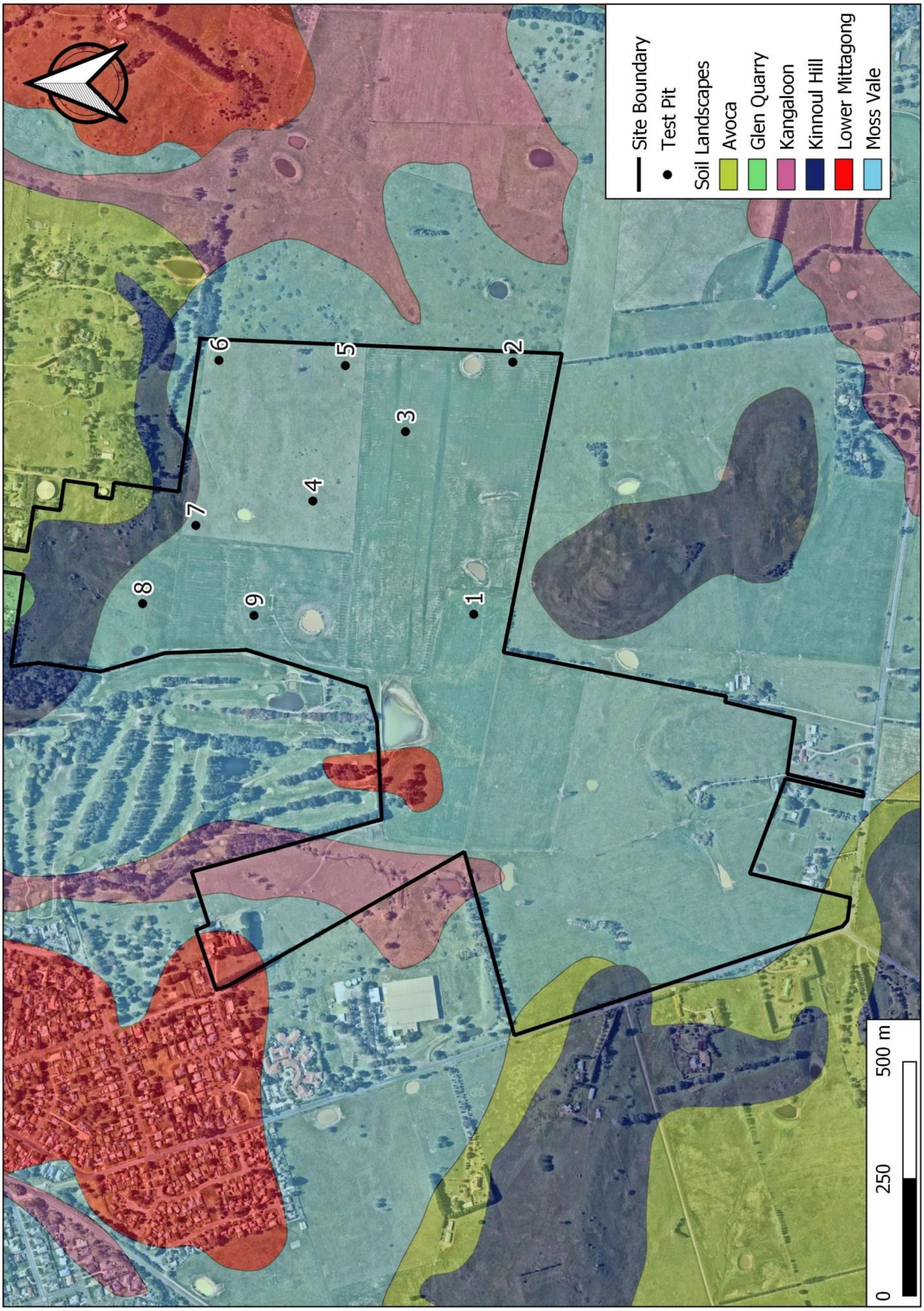


Figure 4: Soil Landscapes and Location of Test Pits.

4 APPLICATION OF RECYCLED WATER

4.1 Domestic Wastewater Generation

All wastewater will be generated within domestic dwellings of the Chelsea Gardens Estate. SEEC have been informed by the client that only dwellings erected in Stage 1 and Stage 2 of the estate will be connected to the PWTS. This is a total of 385 Equivalent Tenements (ET). Wastewater from these tenements will flow to pump stations and be pumped to the PWTS for treatment. The pump stations and PWTS will be designed and operated by others.

4.2 Domestic Wastewater Volume

The design wastewater flow rate has been calculated using Appendix C of the Water Supply Code (WSC) of Australia. Each ET is assumed to house 3.5 Equivalent Persons (EP). Each EP is given a design wastewater loading rate of 180 L/day. Therefore the assumed total daily wastewater load entering the PWTS is calculated as No. of lots x 3.5 x 180 L/day (Table 3).

Table 3: Daily wastewater load based on total number of lots

No of lots	Total daily wastewater load (L/day)
127	80,010
253	159,390
385	242,550

4.3 Package Wastewater Treatment System

It is proposed to install a PWTS to treat all domestic wastewater generated by all tenements constructed in Stage 1 and Stage 2 of the Chelsea Gardens Estate. SEEC have been informed by the client that the PWTS will be designed and operated by Aerofloat Wastewater Treatment Specialists. A representative from Aeroflot has provided SEEC with the expected effluent quality generated in the PWTS (Table 4).

Dwellings, or similar, on the tenements will not all be constructed at the same time. The result will be a gradual increase in the daily wastewater flow until all tenements are occupied. The installation of the PWTS is to be staged to handle the increasing daily flow rate of wastewater on this site. Installation and staging of the PWTS is to be completed by others.

Table 4: Expected effluent quality generated in the PWTS. Figures provided by Aerofloat Wastewater Treatment Specialists.

Parameter	Unit	Value
BOD	mg/l	5
Turbidity	NTU	5
Suspended Solids	mg/L	10
pH	n/a	6.5-8.5
Free residual chlorine	mg/L	0.2-0.5
Faecal Coliforms	Cfu/100mL	200
Electrical Conductivity	uS/cm	400
Nitrogen	mg/L	15
Phosphorus	mg/L	1.0

4.4 Modelling

A hydraulic and nutrient balance has been undertaken (Appendix 1) to determine the minimum required size of the irrigation area.

Hydraulic modelling has been calculated using a Design Irrigation Rate (DIR) of 3 mm per day based on strongly pedal Category 4 topsoil followed by strongly pedal Category 5-6 subsoil. The results of this modelling are in Table 5, and show that a minimum of 80,850 m^2 of irrigation is required for the maximum load from Stages 1 and 2 (385 lots).

A nutrient balance has been undertaken as per Appendix 6 of the 'Silver Book' (Department of Local Government, 1998). The proposed PWTS features nitrogen and phosphorus removal. The results of the nutrient balance show that nitrogen is the limiting factor (i.e. it generates a larger area requirement than phosphorus). Results of this modelling are in Table 5 and show that a minimum of 47,872 m^2 of irrigation is required for the maximum load from Stages 1 and 2 (385 lots).

When determining and designing the required irrigation area, both the hydraulic modelling and nutrient balance are considered and whichever gives the larger area of these two areas must be adopted (Table 5). Regardless of the number of lots, the hydraulic balance was the limiting factor (i.e. the larger irrigation area), so it must be adopted. For the maximum yield from Stages 1 and 2 of 385 lots, the minimum required irrigation area is 80,850 m^2.

Table 5: Area required for irrigation based on hydraulic and nutrient modelling

No of lots	Total daily wastewater load (L/day)	Area required based on hydraulic modelling (m^2)	Area required based on nutrient balance (m^2)	Nominated area required to satisfy the water balance (m^2)	Required wet weather storage (m^3)
127	80,010	26,670	15,791	31,929	1,346.2
253	159,390	53,130	31,459	63,607	2,681.8
385	242,550	80,850	47,872	96,800	4,079.8

4.5 Available Land Area

Following on from the site and soil assessment in Sections 2 and 3, a total of 96,800 m^2 of suitable irrigation area was identified on this site (Figure 6). The identified irrigation area maintains the following offsets:

- 15 m or more from all property boundaries;
- 15 m or more from the proposed Stage 5 boundary;
- 40 m from drainage depressions along the natural slope of the land;
- 40 m from farm dams;

The identified irrigation areas are all located on lands that slope at 10% or less.

The total area identified as suitable for RW irrigation (96,800 m^2) is greater than the minimum required irrigation area (80,850 m^2) as calculated in Section 4.4.

4.6 Wet Weather Storage

A water balance has been undertaken (Appendix 2) to determine the required amount of wet weather storage based on an irrigation area of 96,800 m^2 and the maximum potential wastewater load from 385 lots. The climate data presented in Table 1 has been adopted when calculating the required wet weather storage.

The result of this water balance is 4,079.8 m^3. This volume can be provided as a holding pond or series of holding tanks, and it is equivalent to approximately 17 days' storage (assuming the wastewater load from 385 lots). The location and design of the storage structure is to be determined by others however if a holding pond is used it must be a 'turkeys nest' structure to minimise the risk of water ingress from upslope runoff.

4.7 Application Rates

The monthly application rate of RW is determined by the water balance (Appendix 2). Figure 5 and Table 6 show the required monthly application rate to satisfy the water balance requirements.

During the months of January-May and August-December a maximum of 3 mm/day of RW can be applied over the irrigation area on those days when irrigation is permissible (refer to Section 4.8). This is the same as the DIR calculated in Section 4.4.

For the month of June a maximum of 1.45 mm/day of RW can be applied over the entire irrigation area on those days when irrigation is permissible (refer to Section 4.8).

For the month of July a maximum of 2.167 mm/day of RW can be applied over the entire irrigation area on those days when irrigation is permissible (refer to Section 4.8). The months of June and July represent the months where the wet weather storage will be required.

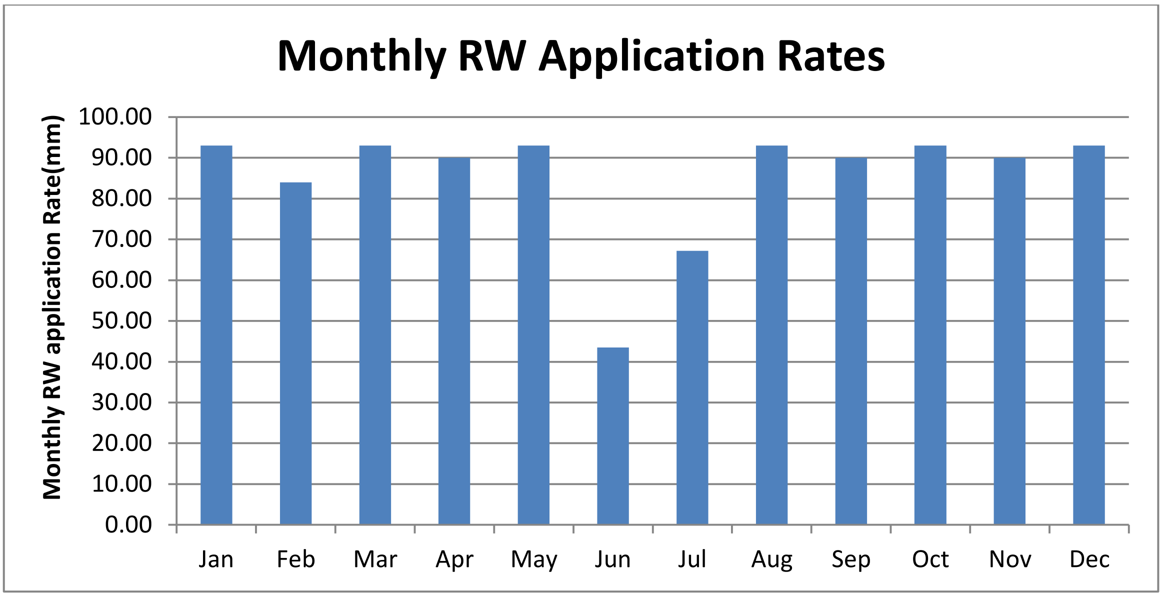


Figure 5: Required monthly RW application rates to satisfy the water balance.

Table 6: Maximum daily and monthly irrigation rates and volumes assuming irrigation over 96,800 m²

	Maximum daily irrigation rate (mm/day)	Maximum Monthly Irrigation Rate (mm/month)	Required daily irrigation rate when storage is empty (mm/day)	Maximum daily irrigation volume (L/day)	Maximum monthly irrigation volume (L/month)
Jan	3	93.00	2.51	290,400	9,002,400
Feb	3	84.00	2.51	290,400	8,131,200
Mar	3	93.00	2.51	290,400	9,002,400
Apr	3	90.00	2.51	290,400	8,712,000
May	3	93.00	2.51	290,400	9,002,400
Jun	1.45	43.50	1.43	140,360	4,210,800
Jul	2.167	67.20	2.167	209,766	6,502,746

Aug	3	93.00	2.51	290,400	9,002,400
Sep	3	90.00	2.51	290,400	8,712,000
Oct	3	93.00	2.51	290,400	9,002,400
Nov	3	90.00	2.51	290,400	8,712,000
Dec	3	93.00	2.51	290,400	9,002,400

4.8 Application Areas

All areas identified as suitable for RW irrigation have slope gradients of 10% or less. Under the National Water Quality Management Strategy (2006), surface irrigation is permissible on such lands. Surface irrigation offers good potential for crops and pasture grasses to take in moisture and any nutrients in the RW. However surface irrigation can increase the risk of RW run-off into the receiving environment, and can increase the risk of excessive recharge of groundwater. As such there must be no irrigation of RW:

- When the rainfall forecast for the next 24 hours is sufficient to saturate the upper 600 mm of soil. A conservative rainfall forecast of >50% chance of more than 10 mm in 24 hours is recommended; and
- In the 24 hours following a rainfall event of more than 50 mm over the preceding 5 day period.

By adopting these recommendations, this will help to minimise the risk of waterlogging within the irrigation field. Waterlogging can cause hypoxia in plants and other organisms. Plants suffering from hypoxia usually have greatly reduced growth rates and become susceptible to root pests and diseases.

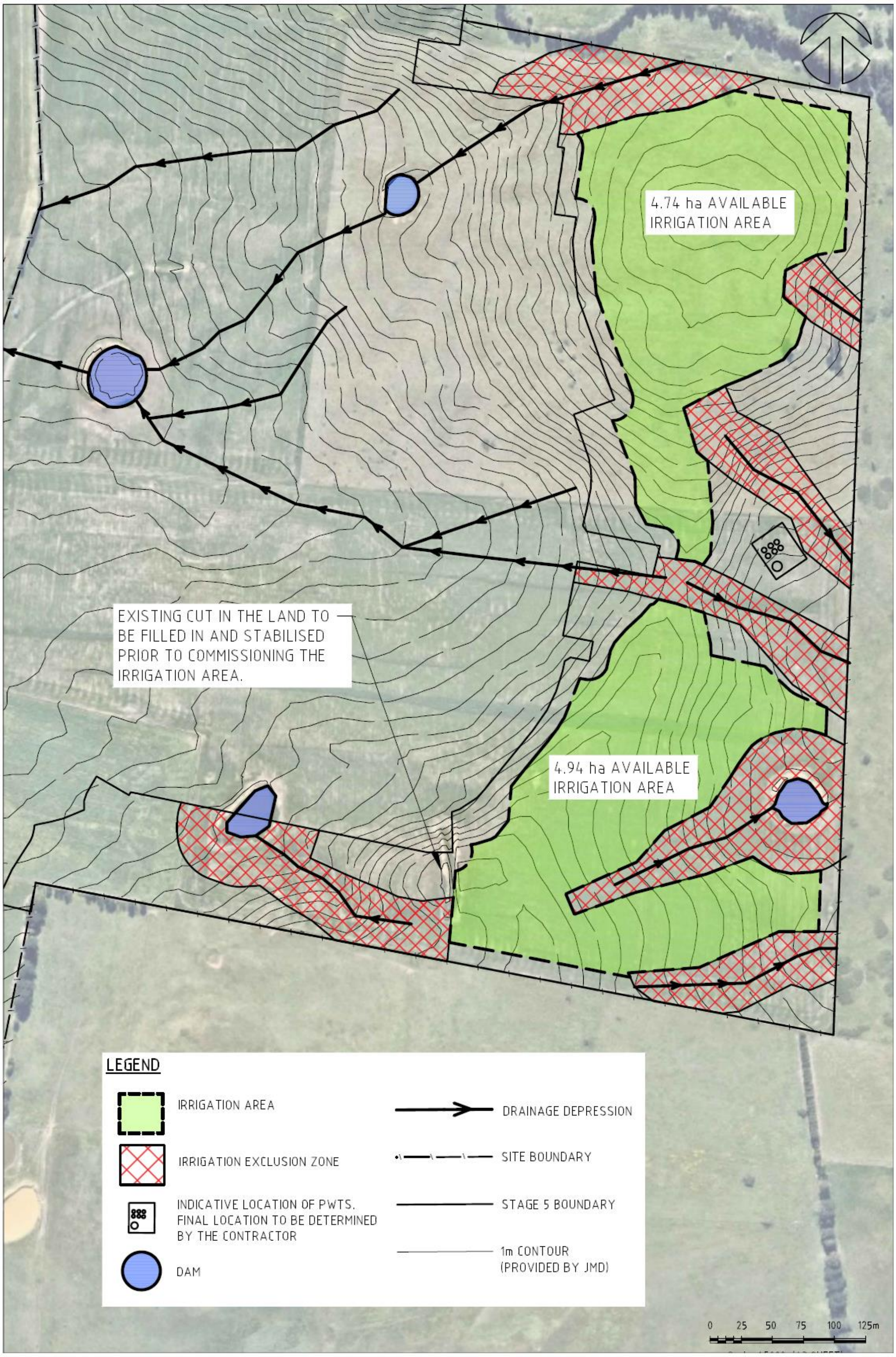


Figure 6: Site plan and RW application areas. This figure must be read in conjunction with the accompanying report by SEEC.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Land Capability

Following on from the site and soil assessment in Sections 2 and 3, and the Calculations in Section 4, we have identified an area of 96,800 m^2 that is suitable for irrigation of RW within future Stage 5 (Figure 2). This area exceeds the minimum calculated area required to manage wastewater from 385 lots (80,850 m^2).

The nominated area for irrigation of RW is shown in Figure 6. That area avoids slopes greater than 10% and maintains appropriate buffers to property boundaries, stage boundaries and drainage features.

5.2 Wet Weather Storage

As determined in Section 4.6, 4,079.8 m^3 of wet weather storage is required for when wet weather prevents irrigation of RW. Restrictions on irrigation are detailed in Section 4.8.

This volume can be provided as a holding pond or series of holding tanks, and it is equivalent to approximately 17 days' storage (assuming wastewater load from 385 lots).

The location and design of the storage structure is to be determined by others however if a holding pond is used it must be a 'turkeys nest' structure to minimise the risk of water ingress from upslope runoff.

5.3 Recommendations for Ongoing Monitoring

5.3.1 Weekly Visual Inspections

All sites that could be affected by the use or discharge of RW must be monitored. Monitoring frequency and type depends on the risk the RW scheme poses to the receiving environment. Regular verification monitoring can, in some cases, be as simple as visual assessment (e.g. for yellowing or browning of leaves, or ponding of RW on the surface), with follow-up action if problems are identified. SEEC have identified potential soil hazards that may arise from the application of RW. These include both chemical and physical hazards such as:

- Soil pH change;
- Cause or exacerbate landscape salinity;
- Contamination from excess chloride, chlorine disinfection residuals, nitrogen and phosphorus in RW;
- Degradation of soil structure from the use of RW;
- Increase in soil dispersion and erosion risk.

SEEC recommend a visual inspection of the site be undertaken once per week to monitor conditions and determine if the application of RW has potentially caused any impacts. The inspector should note any pooling of RW on the surface of the site, the operation of the wet-weather storage structure(s), as well as any browning or loss of vegetation across the site and cease RW application in those areas immediately if either is observed.

5.3.2 *Annual Soil Testing*

SEEC have determined that the application of RW on this site poses a moderate risk to the receiving environment. Laboratory testing of the soils has provided baseline data for soils at this site. As such, SEEC recommend that soil physical and chemical properties be tested annually after commencement of RW application. Soil chemical properties that should be tested are detailed in Table 7, along with baseline conditions against which annual testing should be measured.

Table 7: Chemical and physical properties of the soil to be tested annually after the application of RW commences

Property	Units	Baseline Value Topsoil	Baseline Value Subsoil
pH (Water)	pH units	5.3	5
Electrical Conductivity	dS/m	0.035	0.22
CEC	Cmol(+)/kg	5.5	4.9
Soil Structure	-	Strongly Pedal	Moderately Pedal
EAT	-	Class 3 Sub(1)	Class 2 Sub(3)

Full list of Soil Laboratory Results can be found in Appendix 3.

Both topsoil and subsoil samples should be tested. Topsoil can be gathered from the upper 300 mm of the soil profile, while subsoil can be gathered from a depth of between 400 mm and 600 mm. A single composite sample of each soil layer can be sent for testing from within the RW irrigation area.

If soils show no signs of significant (>20% change) physical and/or chemical change from the baseline values in Table 7 for the first three years, testing frequency can be decreased to once every three years instead of annually.

If soil testing identifies potential signs of significant (>20% change) physical or chemical degradation, the application of RW must be halted and an investigation into potential causes and impacts must be initiated.

5.3.3 *Effluent Quality Testing*

A random grab sample of the effluent generated by the PWTS must conform to the values provided in Table 4. If the results show a significant (>20%) difference to the values provided in Table 4 an investigation into the performance of the PWTS must be initiated immediately. Sample frequency is to be monthly and results recorded in a log book available for inspection by Council, NSW Department of Health or WaterNSW.

5.3.4 Exceedance of Design Wastewater Flow

A flow meter must be installed at the inlet(s) to the PWTS. Daily wastewater flows must be monitored and recorded on a monthly basis, and detailed in a log book. If the average daily wastewater flow exceeds the assumed daily wastewater flow stated in Section 4.2 an additional storage component or additional irrigation area must be provided to handle the increased daily flow.

5.4 Recommended Mitigation Measures

5.4.1 Plumbing Fixtures

Plumbing fixtures in new residential homes constructed during Stages 1 and 2 of the Chelsea Gardens Estate development must be a minimum four-star rating to reduce wastewater loads.

5.4.2 Fencing and Signs

The proposed irrigation areas must be fully fenced from the public at all times. Warning sings must be placed along the fences at intervals of 20 m that read:

"WARNING: RECLAIMED EFFLUENT/RECYCLED WATER, DO NOT DRINK, AVOID CONTACT" or similar.

Lettering must be clearly visible from three meters away. Fencing and signs must also be placed around the perimeter of the PWTS and any associated wastewater storage structures.

5.5 Summary of Recommendations

SEEC have determined that RW could feasibly be applied to a 9.68 ha irrigation area positioned within Future Stage 5 of the Chelsea Gardens Estate (Figure 2 and Figure 6), but with a number of mitigation and management measures. These are summarised as follows:

- RW irrigation should only occur within the area nominated in Figure 6;
- No more than 385 Equivalent Tenements (ET) must be serviced by the nominated irrigation area and the PWTS;
- No application of RW is to occur prior to forecast rainfall (>50% chance of 10 mm or more in 24 hours) or during or in the 24 hours after such an event;
- No application of RW is to occur if the total rainfall from the previous 5 days exceeds 50 mm;
- Application of RW must not occur within 40 m of the drainage depressions along the natural slope of the land and 40 m of dams as shown in Figure 6. A vegetation buffer must be provided in these areas as per the *National Guidelines for water recycling: Managing Health and Environmental Risks, November 2006;*
- Existing erosion near N. -34.5671 E. 150.3821 will need to be re-levelled and vegetated if that area is to be used for the application of RW;

- The application of RW must not exceed the maximum monthly applications rates and volumes presented in Table 6 in Section 4.7;
- No RW is to be applied within 15 m of all property boundaries and the Stage 5 boundary;
- Improved pastures are to be retained across all RW irrigation areas and must be periodically slashed to a height of around 100 mm;
- All RW irrigation areas and other wastewater infrastructure must be fenced from the public and stock, and warning sings erected along their fence lines (refer to Section 5.4.2 for details);
- Lime is to be applied to the RW irrigation area at a rate of 250gsm annually.
- Gypsum is to be applied to the RW irrigation area at 0.2 tonnes per hectare annually;
- To reduce the risk of frost damage, all distribution pipes within the RW irrigation field should be well buried or, if laid on the surface, well insulated and loosely covered with mulch;
- To further reduce the risk of frost damage, all irrigation pipes must drain after pumping;
- Weekly visual inspections of the RW irrigation areas are to be carried out to observe if any pooling of RW is occurring at the surface or if any vegetation has begun to brown as a result of RW application, in accordance with the Monitoring Program in Section 5.3.1;
- For at least the first three years of RW application a topsoil and subsoil sample must be sent to the lab for testing annually as detailed in the Monitoring Program in Section 5.3.2;
- To ensure that all plumbing fixtures any new home constructed during Stage 1 and 2 of the development are a minimum four-star rating;
- To provide 4,079.8 m^3 of wet weather storage for when wet weather prevents RW irrigation;

Providing the above mitigation, management and monitoring measures are implemented we consider that there is a reasonably low risk to the receiving environment of RW application at this site.

6 REFERENCES

Department of Local Government (1998). Environment and Health Protection Guidelines: *Onsite Sewage Management for Single Household.*

eSPADE (2020). NSW Office of Environment and Heritage. https://www.environment.nsw.gov.au/eSpade2WebApp

Hazelton, P.A. and Murphy, B.W. (2016). *Interpreting Soil Test Results: What do all the Numbers Mean?* CSIRO Publishing, Collingwood, Victoria.

National Water Quality Management Strategy (2006). National Guidelines for Water Recycling: *Managing Health and Environmental Risks, November 2006.*

Standards Australia / Standards New Zealand (2012). AS/NZS 1547:2012 *On-site Domestic Wastewater Management*.

WaterNSW (2019), *Designing and Installing On-Site Wastewater Systems. A WaterNSW Current Recommended Practice.*

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7 APPENDICES

7.1 Appendix 1 – Hydraulic and Nutrient Balance

Wastewater Volume (Q)		242550	(L/day)	
Vegetation in EMA	Improved Pasture			

Hydaulic Balance

A = DIR/Q

DIR =	3	mm/day
A =	80850	

Nitrogen Balances

A = (C x Q) / Lx

Where:

A = Land Area (m2)

C = Concentration of Nutrient =	15	mg/L
Q = Wastewater Flow =	242550	L/day
Lx = Critical Loading Rate =	76	($mg/m^2/day$)

A = 47872 m^2

Phosphorus Balances

Step 1: P Sorption Calculation Basalt soil: No

Psorb (topsoil)	clay loam	380	mg/kg	Lab Testing
Psorb (subsoil)	clay	530	mg/kg	Lab Testing
Bulk Density (topsoil)	clay loam	1500	kg/m3	WaterNSW, 2019
Thickness (topsoil)		300	mm	
Coarse Frags (topsoil)		0	%	
Bulk Density (subsoil)	clay	1300	kg/m3	WaterNSW, 2019
Thickness (subsoil)		700	mm	
Coarse Frags (subsoil)		5	%	
Calculated Psorb (topsoil)		1710	kg/ha	
Calculated Psorb (subsoil)		4581.85	kg/ha	
Assumed P-sorb		2202.1475	kg/ha	(insitu P-sorb is 35% calculated P-sorb)

Step 2: Determine the required area to sorb phorphorus (50 year design life) :

P absorbed	=	6291.85	x 0.35
	=	2202.1475	kg/ha
	=	0.22021475	kg/m2
P uptake	=	6.5	$mg/m^2/day$

Determine the amount of phosphorus generated over that time:

Concentration of phosphorus =	1	mg/L
Phosphorus generated = Concentration x volume of wastewater =	4426.5375	kg

Area Required:

P generated / (P sorbed + P uptake) = 13064 m^2 of Improved Pasture

7.2 Appendix 2 – Water Balance

Wastewater Site Assessment

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Appendix A

Table 1: Hydraulic Balance

Rainfall Station	Moss Vale	
Evaporation Station	Moss Vale	
Wastewater Load	242550	L/day
Design Irrigation Rate	3	mm/day
Land Area	96,800	sqm
Storage required:	4079.80	cubic m

Month	Days in month	Median Precipitation (mm)	Evaporation (mm)	Crop Factor
Jan	31	77.7	171	0.8
Feb	28	71.9	134	0.8
Mar	31	72.4	116	0.8
Apr	30	65	78	0.8
May	31	48.8	53	0.7
Jun	30	69.3	38	0.6
Jul	31	52.2	44	0.6
Aug	31	38.8	68	0.6
Sep	30	44.6	94	0.7
Oct	31	57.4	125	0.8
Nov	30	64.1	141	0.8
Dec	31	59.8	173	0.8

INPUTS

	Median Precipitation (mm)	Effluent Irrigation (mm)	Inputs (mm)
Jan	77.7	77.68	155.38
Feb	71.9	70.16	142.06
Mar	72.4	77.68	150.08
Apr	65	75.17	140.17
May	48.8	77.68	126.48
Jun	69.3	75.17	144.47
Jul	52.2	77.68	129.88
Aug	38.8	77.68	116.48
Sep	44.6	75.17	119.77
Oct	57.4	77.68	135.08
Nov	64.1	75.17	139.27
Dec	59.8	77.68	137.48

OUTPUTS

	Evapotranspiration (mm)	Percolation (mm)	Outputs (mm)	Storage (mm)
Jan	136.8	93.00	229.80	-74.42
Feb	107.2	84.00	191.20	-49.14
Mar	92.8	93.00	185.80	-35.72
Apr	62.4	90.00	152.40	-12.23
May	37.1	93.00	130.10	-3.62
Jun	22.8	90.00	112.80	31.67
Jul	26.4	93.00	119.40	10.48
Aug	40.8	93.00	133.80	-17.32
Sep	65.8	90.00	155.80	-36.03
Oct	100	93.00	193.00	-57.92
Nov	112.8	90.00	202.80	-63.53

SEEC

20000305 Climate Rain vs Evap for WW

7.3 Appendix 3 – Laboratory Results

Laboratory No. Client's ID	Units	Limit of Reporting	1 20000305 Topsoil 1,2	2 20000305 Topsoil 4,5	3 20000305 Topsoil 8,9	4 20000305 Subsoil 1,2	5 20000305 Subsoil 4,5	6 20000305 Subsoil 8,9
Soil Analysis								
Electrical Conductivity	dS/m	0.0010	0.035	0.072	0.046	0.037	0.027	0.22
pH (Water)	pH units	0.04	5.5	5.3	5.9	5.0	5.6	7.3
pH ($CaCl_2$)	pH units	0.04	4.8	4.7	5.0	4.0	4.5	6.4
Texture			Light clay	Silty clay loam	Medium clay	Heavy clay	Heavy clay	Heavy clay
Emerson aggregate test			Class 3 Sub(1)	Class 8	Class 8	Class 5	Class 3 Sub(2)	Class 2 Sub(3)
P Sorption	mg/kg	25	410	380	260	730	530	580
Exchangeable Cations								
Aluminium	cmol(+)/kg	0.10	0.48	0.50	<0.1	6.0	1.0	<0.1
Calcium	cmol(+)/kg	0.030	3.8	5.8	3.8	2.0	2.5	2.3
Potassium	cmol(+)/kg	0.010	0.14	0.23	0.11	0.13	0.20	0.15
Magnesium	cmol(+)/kg	0.0070	0.91	1.7	1.8	1.6	1.1	9.8
Sodium	cmol(+)/kg	0.030	0.12	0.11	0.19	0.19	0.12	2.6
CEC (effective)	cmol(+)/kg	0.20	5.5	8.3	5.9	9.9	4.9	15
Calcium/Magnesium			4.2	3.5	2.1	1.3	2.3	0.23
Percent Aluminium Saturation	% of ECEC		8.9	6.0	N/A	60	21	N/A
Exchangeable Calcium	% of ECEC		70	70	64	21	51	15
Exchangeable Potassium	% of ECEC		2.6	2.8	1.8	1.3	4.0	0.99
Exchangeable Magnesium	% of ECEC		17	20	31	16	22	66
Exchangeable Sodium Percentage	% of ECEC		2.2	1.4	3.2	1.9	2.5	18

7.4 Appendix 4 – 100 year ARI Flood Level at Whites Creek

Client	Project	Title
WINGECARRIBEE SHIRE COUNCIL	WHITES CREEK FLOOD STUDY	FLOOD EXTENT 100YR FLOOD
URS	Drawn: BH; Approved: DRAFT; Date: 01/11/2007; Job No: 43167391; File No: 43167391.002.wor	Figure: B-5