WIN LAND CAPABILITY ASSESSMENT

Western Water

Property name: Griffiths

NOVEMBER 2020

pinion ADVISORY

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1 Background

Western Water has developed the Western Irrigation Network (WIN) project to meet environmental compliance obligations for managing forecast recycled water volumed from the Bacchus Marsh, Sunbury and Melton recycled water plans until 2050.

The WIN project will connect the Bacchus Marsh, Melton and Sunbury recycled water plants to a new irrigation district in the Parwan-Balliang region to the west of Melbourne (Figure 1). The project involves construction of permanent infrastructure to supply class C recycled water to up to 4500ha of high quality irrigable land.

The Balliang East district is a traditional dryland cropping and pastoral production area which typically annually receives less than 500mm of rainfall. Agricultural productivity of the district is highly constrained due to the prevailing low rainfall conditions. The WIN irrigation development offers the opportunity for landowners to access a high reliability irrigation supply to support the production of various crops and pasture and hence underpin the ongoing viability of agricultural production systems in the district.

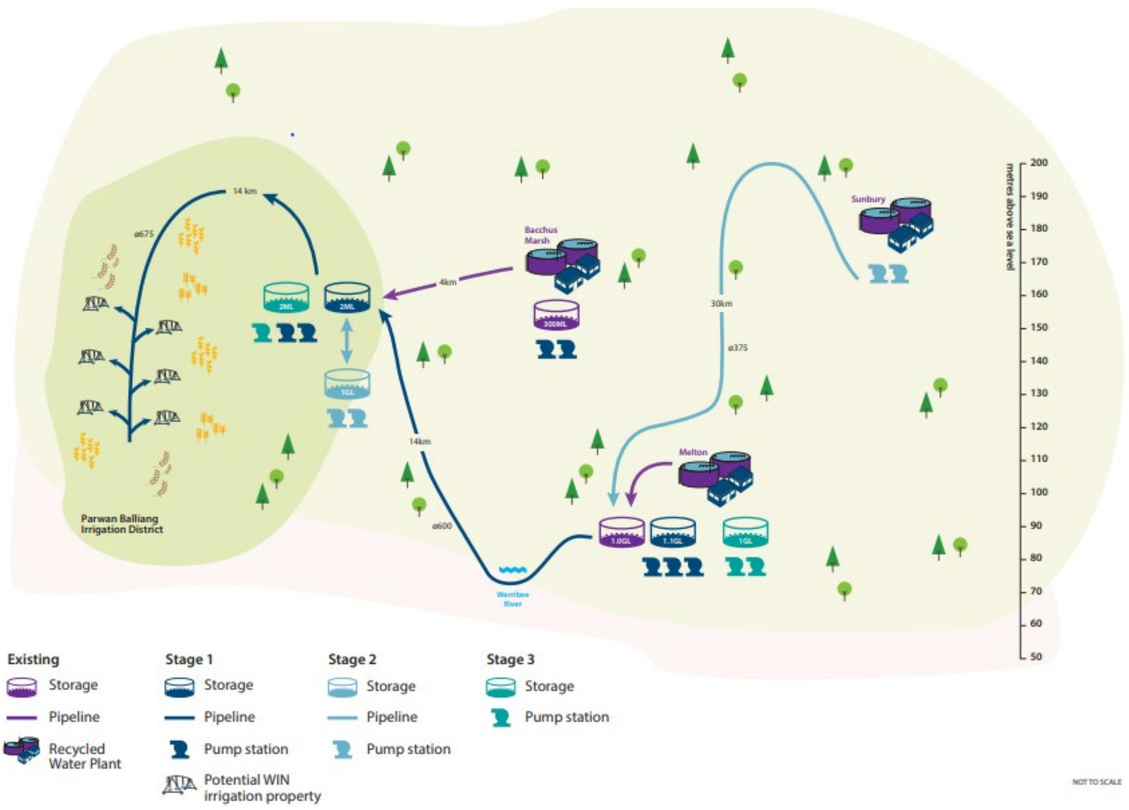

Figure 1 Schematic of the WIN network (supplied by Western Water)

Three foundation properties are central to the initial development of the WIN project (Table 1). Additional connections will be considered by Western Water as the project progresses.

Table 1 WIN stage 1 property details

Property name	Address	Proposed irrigation area (ha)	Recycled water allocation (ML/annum)*
Griffiths	300 Agars Rd, Balliang East 3340	4751ha	750-3500
Parwan Pty Ltd	3922-3684 Geelong-Bacchus Marsh Road, Parwan	307ha	500-2100
Sharkey	315 Sharkey Road, Balliang	397ha	1000-2700

*Approximate range from supply year one to supply year 20

Each property requires a land capability assessment (LCA) to ensure that recycled water irrigation is an appropriate and sustainable activity for the site. Before recycled water irrigation can commence a customer site management plan (CSMP), detailing irrigation protocols and specific recycled water risk management, will also be developed for Environment Protection Authority (EPA) Victoria approval.

1.1 Scope of LCA

This land capability assessment report, specific to the Griffiths property, analyses and documents the following:

- Assessment of current and historic land use.
- Assessment of the landscape capability for use of recycled water.
- Calculation of the 10th, 50th and 90th percentile irrigation requirements and summarise total water demand of the proposed irrigation design.
- Assessment of the nutrient leaching risk associated with recycled water.
- Assessment of the salinity risk associated with the application of recycled water.

This LCA is informed by a site visit (28 August 2018) a water quality review (Stantec, undated) and landowner interview (undertaken by Pinion Advisory Senior Agronomist Jason Lynch, November 2020).

2 Land use review

The proposed recycled water irrigation site is located at 300 Agars Road, Balliang East. Western Water have been in discussion with the landowner regarding potential recycled water supply from thee WIN project for several years. As a result, a concept irrigation design is well developed and attached as appendix A.

The land is currently used for mixed farming which includes dryland broadacre cropping for the produce of cereals (wheat and barley), legumes (lupins and peas), canola, forage brassica crops (rape) and pastoral use to run a self-replacing breeding sheep flock, finishing prime lambs and trading ewes.

The current property owners have owned this land since 1925 and are highly experienced crop and livestock managers. Interviews with the landowners indicates that there are no historical land practices, or contaminants of concern, that might impact the irrigation development area.

The property owners operate a well-managed and organised mixed farming enterprise. They implement modern land management and crop production practices including minimal/no tillage, soil moisture conservation, soil testing, agricultural chemical resistance management and sustainable crop rotations.

Biosolids have been applied across the entire property at a rate of 12.5 T/ha over the last 3-4 years. These biosolid applications are intended to be a once off application on each area, and are not anticipated to be repeated in the future. Biosolids, applied as a dewatered product at the time of sowing crops, were incorporated into the soils by either a separate discing operation or when the crops were drilled. Once incorporated biosolids material is typically not visible on the soil surface.

In order to effectively manage and match nutrient application with crop demand, it is recommended that the application of biosolids cease once the recycled water irrigation scheme commences operation. This has been discussed with the landowner. This might be revisited once recycled water supply commences and accuracy of nutrient budgets is known.

3 Land capability assessment

The land capability assessment identifies the limitations associated with soil and landscape characteristics as relevant to the proposed irrigation development.

A soil reconnaissance and landscape survey was undertaken on 28th August 2018. Due to the uniformity of regional site conditions, only one soil pit on the Griffiths property was developed, analysed and sampled (Table 2). The location is shown on appendix B.

Table 2 Soil pit location

Soil pit ID	Easting	Northing
Griffiths	274437.2	5812382.5

The location of the representative soil pit within the proposed irrigation development area was based on discussion with the property owner, local landscape considerations and review of available satellite imagery. The uniformity of local soil conditions has be confirmed by review of the Assessment of Agricultural Land Capability in Melbourne's Green Wedge and Peri-Urban Areas (Agriculture Victoria, 2018), land suitability analysis of the Shire of Moorabool (DPI Vic, 2006), ASRIS datasets (CSIRO), a broader Balliang East district soil reconnaissance project undertaken on behalf of Western Water in 2018 (Macquarie Franklin), and a geotechnical report commissioned by Western Water as part of the WIN project development (CH2M Beca, 2019). Inspection of pits across each of the three WIN foundation properties (Table 1) also confirmed uniform conditions.

The review of the various available land capability, land suitability, soils, geotechnical and geology indicates this property is consistent covered a single soil type, as per that which was identified in the soil pit. Full description of this soil pit is attached as appendix C, recorded information includes:

- Soil texture, pedality and morphology of the each of the horizons
- Soil colour
- Depth of effective root zone
- Depth and layer of any impeding layer
- Presence of stone and rock
- Soil profile pH and nutrient status
- Profile drainage status
- Presence of any concretions in the soil profile.

Landscape and soil properties were assigned a suitability class based on Table 3. Detailed results are attached as appendix D.

Table 3 Land capability assessment description

Suitability class*	General description	Growth reduction (%)
1	Very few limitations present and easily overcome. Crop growth is expected to be unimpeded with minimal intervention required.	0
2	Minor limitations affecting either productive land use and/or risk of degradation. Limitations overcome by careful management. Crop growth can be marginally impeded by limitations if no intervention is undertaken.	10
3	Moderate limitations significantly affecting productive land use and/or risk of degradation. Careful management and conservation measures required. Crop growth can be significantly impeded if no intervention is undertaken.	30
4	High degree of limitations not easily overcome by standard development techniques and/or resulting in high risk of degradation. Extensive conservation measures and careful ongoing management required. Crop growth is significantly impeded threatening crop survival.	60
5	Severe limitations. Use is usually prohibited in terms of development costs or the associated risk of degradation. Crop survival unlikely and management not feasible.	100

* Adapted from Van Gool D, Tille P & Moore G, 2005 & FAO Soil Bulletin 32 1976 by Stantec (2018).

3.1 Soil and landscape features

The landscape around the property where the proposed irrigation development would occur consists of flat and very gently sloping land (0-3%) and is bisected by the ephemeral Balliang Creek waterway which flows through south western area of the property (appendix A).

The flat to gently sloping nature of the land suggests it is suitable for broadscale irrigation which utilises spray irrigation application technology, as per centre pivot irrigation infrastructure.

All land included within the irrigation development area has been under the current property ownership since 1925 and has had a long history long history of cropping and pastoral use thereafter. Therefore, the land has been significantly modified in terms of an extended history of soil cultivation, de-stoning and the application of fertiliser and soil ameliorants (lime, gypsum and more recently biosolids).

The site inspection indicates the property is consistently covered by red sodosol soils, which features a clay loam A horizon over a clay B Horizon, with rock and stone fragments and calcium carbonate present in the B horizon.

Sodosols are texture contrast soils (duplex) which have lighter textured surface A horizon (e.g. sandy loam or clay loam) overlying a clayey sodic subsoil B horizon, typically an acidic A horizon soil that becomes more alkaline at depth and frequently include calcium carbonate precipitates.

The nutrient status of the soils indicates they have a moderate level of fertility, with the highlights being:

- High phosphorus levels in the A horizon (110 mg/kg) with very low levels in the B1 and B2 horizon (<12 mg/kg).
- Very high sulphur levels in the A, B1 and B2 horizons (99, 62 and 110 mg/kg respectively).
- Weakly acidic pH in the A horizon (5.6) and alkaline soil pH in the B1 and B2 horizon (8.3 and 9.6).
- Elevated exchangeable sodium percentage in the A horizon (9.8%) and high in the B1 and B2 horizon (26% and 33%).
- Slightly saline soil with an electrical conductivity in the A horizon (0.29 dS/m), moderately saline in the B1 horizon (0.52 dS/m) and strongly saline in the B2 horizon (1.16 dS/m).
- Low soil organic carbon levels in the A, B1 and B2 horizons (1.5, 0.61 and <0.15%).
- Moderate phosphorus buffer index (PBI) value in the A1 horizon (190) which increases to high in the B2 horizon (430) and moderate in the B2 horizon (290).
- Marginally high aluminium levels in the A horizon (43 mg/kg) and very low in the B1 and B2 horizons (<9.0 mg/kg).
- Below threshold levels for all heavy metals with the exception of an elevated chromium level in the A horizon (143 mg/kg).

Nutrient levels present in the soil would not be anticipated to negatively impact crop and/or pasture growth.

The chromium levels present in the A horizon are likely to be related to the geological parent material, and elevated levels (>100 mg/kg) have also be identified on similar red sodosol soils during a wider Balliang East 2018 soil survey.

The A horizon of these red sodosols are moderately well drained and the permeability of these soils is estimated to be approximately 15-20 mm/day (or 0.6-0.8mm/h). The clay nature of the B horizon would constrain the drainage capacity of the soil at depth, and this is evidenced by presence of slight cutans and orange/brown B horizon subsoil mottling.

The accumulation of sodium in the soil A horizon of the profile could result in impairment of the soil's drainage capacity, and therefore the application of gypsum must be considered to mitigate the potential for soil sodicity.

Excessive, inappropriate irrigation and/or the application of recycled irrigation with an elevated sodium content could result in degradation of the soil's drainage capacity and lead to soil water logging.

3.2 Outcome of land capability assessment

A single soil group was identified, being the red sodosol which can be characterised as moderately well drained.

The various characteristics and features of the landscape and red sodosol soil were assigned a rating and the property is assessed as having a suitability score of 1.9. The land capability assigned is therefore Class 2 (appendix D) with generally minor limitations for recycled water irrigation.

It is noted that due to elevated sodium content of these soils sodicity must be carefully monitored and proactively managed. The application of gypsum will be required to positively manage the soil's permeability and overall drainage capacity.

4 Irrigation water balance

The assessment of irrigation application rates uses a water balance model which includes inputs from climate, crop water usage and elements of the land capability assessment. The outcome is an analysis of the variation in irrigation requirements based on variable annual rainfall.

4.1 Rainfall and evaporation

Rainfall and evaporation data (Table 4) has been generated by a combination of using the available rainfall records from Balliang East Bureau of Meteorology weather station #087008 (1970-2020) and evaporation modelling data generated using SILO modelling.

East Balliang receives a median annual rainfall of 464mm and has an expected annual pan evaporation of 1298mm. Median monthly rainfall does not exceed the pan evaporation rate at any time of year. The annual 10th, 50th, 90th percentiles and minimum and maximum median rainfall, pan evaporation and evapotranspiration values are shown in Table 5.

Table 4 Annual rainfall, evaporation and evapotranspiration statistics

	Minimum	10th percentile	50th percentile	90th percentile	Maximum
Rainfall (mm)	225	328	464	615	797
Pan evaporation (mm)	1062	1166	1298	1440	1540
Evapotranspiration (mm)	1062	979	1090	1210	1540

Table 5 Median rainfall, evaporation and evapotranspiration by month

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall (mm)	32.4	40.1	33.9	37.7	36	32.4	33.7	36.8	44.7	48.8	44.5	43.1
Pan evaporation (mm)	196.8	165.5	133.4	85.3	52.8	38.1	44.8	60.1	83.9	119.6	143.4	179.1
Evapotranspiration (mm)	165.3	139.0	112.1	71.7	44.4	32.0	37.6	50.5	70.5	100.5	120.5	150.4

Crop demand, determined using crop coefficients and potential evapotranspiration, for lucerne and winter wheat are outlined in Table 6. Lucerne and wheat represent the highest and lowest irrigation demand of the likely crop options, however a rotation of crops might include including barley, canola, lupins, peas and soybeans.

Table 6 Lucerne and winter wheat crop coefficients

	Monthly crop coefficient											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Lucerne	1.14	1.08	1.02	0.96	0.84	0.66	0.66	0.78	0.9	1.02	1.14	1.2
Winter wheat	0	0	0.7	0.8	1	1.15	1.15	1.15	1.15	0.8	0.4	0.2

The water balance indicates that in a median rainfall year a lucerne pasture would require 7.8 ML/ha of irrigation, whilst a winter wheat crop would require 2.5 ML/ha of irrigation. The complete irrigation requirements for lucerne and winter wheat crops are summarised in Table 7.

Lucerne and wheat represent the highest and lowest irrigation demand of the likely crop options, however a rotation of crops might include including barley, canola, lupins, peas and soybeans.

Table 7 Total annual irrigation requirements for lucerne and winter wheat

	Minimum rainfall	10^{th} %ile rainfall	50^{th} %ile rainfall	90^{th} %ile rainfall	Maximum rainfall
Lucerne	11.1	10	7.8	7	2.2
Winter wheat	4.6	4.1	2.5	1.3	0

5 Irrigation concept design and demand

The irrigation concept design is attached as appendix A. The detail of the proposed irrigation plan is outlined in Table 8 which summarises potential water use of each pivot area.

Table 8 Irrigation areas and estimated water demand (Lucerne or wheat) under various climate scenarios

Centre pivot	Area (ha)	Crop	Total irrigation demand (ML)		
			10^{th} percentile	50^{th} percentile	90^{th} percentile
CP-A	73.4	Lucerne	734	572	513
		Wheat	399	183	95
CP-B	42.3	Lucerne	423	329	296
		Wheat	173	105	54
CP-C	32.4	Lucerne	324	252	226
		Wheat	132	81	42
CP-D	45.6	Lucerne	456	355	319
		Wheat	186	91	59
CP-E	42.8	Lucerne	428	333	299
		Wheat	175	21	55
CP-F	55.9	Lucerne	559	436	391
		Wheat	229	139	72
CP-G	84.5	Lucerne	845	659	591
		Wheat	346	211	109
CP-H	27.3	Lucerne	273	212	191
		Wheat	111	68	35
CP-I	30.1	Lucerne	301	234	210
		Wheat	123	75	39
CP-J	39	Lucerne	390	304	273
		Wheat	159	97	50

5.1 Buffer zones and offsite risk management

Buffer zones and irrigation controls are necessary to ensure that recycled water remains on the identified property and that sensitive receptors are protected from unintentional irrigation spray drift.

The key risk areas on and adjacent to the property include:

- Several residential dwellings
- Balliang East school,
- Balliang Creek
- Agars Road, School Road and Geelong-Bacchus Marsh Road.

In line with the *Guidelines for Environmental Management: Use of Reclaimed Water (EPA Victoria, 2003*) buffer zones, as identified in appendix A, are summarised in 9.

Table 9 Recycled water irrigation buffer requirements

Receptor	Distance
On farm dwellings and school boundary fence	100m
Balliang Creek	50m
External boundaries*^	50m

*no buffer zone has been identified on the southern boundary as this is shared with one of the two other WIN recycled water irrigation properties (Sharkey).
^buffer zone to School road is 70m. This is to provide a 100m buffer to residential allotments on the Northern side of School road.

In addition to buffer zones, it is recommended that the following practices be implemented to minimise the risk of off-site movement of recycled water:

- Adopt deficit irrigation practices where water is to be applied to crops and pasture such that it will be immediately used by the plants. This limits potential for soil water logging and surface water runoff.
- Implement appropriate irrigation scheduling, such that it is consistent with the soil's permeability. Selection of a suitable centre pivot nozzle pack is important.
- Include anemometer controllers to shut down the centre pivot under a combination of excessive wind speed and specific directions.
- Monitor the soil nutrient levels to minimise the potential excessive sodium accumulation which can impact permeability.

Centre pivots irrigators will be used to apply recycled water. In comparison to other irrigation options, pivot irrigation has low labour requirements, allows high level of control over the volumes and distribution of water, providing ability to closely match irrigation to crop/pasture requirements and soil permeability characteristics. No end guns will be fitted to the centre pivots due to the high risk of irrigation water spray drift and associated unwanted off-site movement of recycled irrigation water.

The principle of operation will be to include Variable Rate Irrigation control (VRI) on area which requirement specific nozzles to be switched off to protect buffer zones in specific areas (current design shows this on pivot areas B, E, D, G and J). This is setup by a GIS map within the irrigator control system, such that it doesn't require manual intervention.

6 Surface water risk management

Balliang Creek, which transects the proposed irrigation areas (between pivots C and E), presents as the key surface water risk (appendix A).

Due to relatively flat topography, the risk of unintentional off site movement of irrigated water is low. However, the following measures are recommended to prevent surface water contamination:

- Utilisation of centre pivot irrigation equipment which allows maximum control of irrigation direction and application rates.
- Adherence to 50m irrigation buffer zones to Balliang Creek which flows through the property. This may require the use of variable rate irrigation (VRI) technology on the irrigation infrastructure to switch off individual nozzles that may encroach on the 50m area.
- Deficit irrigation planning, such that the amount of recycled irrigation water applied is relative to the crop water usage and weather conditions and the potential for soil waterlogging conditions occurring is minimised.
- The centre pivot is to be designed to apply recycled irrigation water at 15mm per application which is commensurate with the soil's permeability.
- Ongoing monitoring of soil sodicity to ensure that the permeability of the soil is not compromised. The requirement for treatment with gypsum will need ongoing review.

With these measure in place, the risk to surface water from the proposed irrigation design is very low.

7 Nutrient leaching and groundwater risk management

7.1 Nutrient management

The intial WIN development will connect Bacchus Marsh and Melton recycled water plants, with Sunbury to be collected in year three of the project (2025). For the purposes of this nutrient budget, supply from Sunbury (which contains comparatively low nutrients and will therefore reduce the WIN nutrient supply once it comes online) has been excluded. The longer term result is that assessment is very conservative.

Average nitrogen of 17.6 mg/L and average total phosphorus of 8.2 mg/L have been adopted to inform the nutrient budget (Stantec, undated) summarised in Table 10.

Table 10 Recycled water nutrient budget summary

	10th percentile irrigation				90th percentile irrigation			
	Lucerne		Wheat		Lucerne		Wheat	
	N	P	N	P	N	P	N	P
Irrigation applied (ML)	7	7	4.1	4.1	10	10	1.3	1.3
Nutrient concentration (mg/ML)	17.6	8.2	17.6	8.2	17.6	8.2	17.6	8.2
Nutrient applied (kg/ha)	123	57	72	34	176	82	23	8
Yield (t DM/ha)	16	16	8	8	16	16	8	8
Nutrient content (kg T DM)	30	3	20	2.5	30	3	20	2.5
Nutrient removed (kg/ha)	480	48	160	20	480	48	160	20
Soil factor P sorption rate (kg P/ha)		14.5		14.5		14.5		14.5
Net balance (kg/ha)	-357	-5	-88	-1	-304	20	-137	-26

The nutrient budget (Table 10) indicates that the application of recycled irrigation water will contribute only a small portion of nitrogen and phosphorus removed during the wheat cropping and lucerne production enterprise. This applies in a 10th percentile rainfall year where recycled water application will be at its highest.

Additionally the soil has a moderate to very high phosphorus sorption capacity. PBI values range from 190 in the A horizon and 430 and 290 in the B1 and B2 horizon which further positively influence the soil's ability to retain phosphorus (Corangamite Catchment Management Authority, 2013).

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It is reasonable to consider that the land manager will be required to apply additional nitrogen and phosphorus to the soil to optimise lucerne and wheat production. This should be informed by ongoing soil monitoring in irrigated areas.

The nutrient budget in conjunction with the soil phosphorus sorption capacity indicates the proposed application of recycled irrigation water would not be expected to result in nitrogen or phosphorus leaching into the local groundwater.

7.2 Groundwater

The property lies within the Western Port Philip groundwater catchment, defined as an upper basalt aquifer that flows in a southerly direction towards Port Philip Bay. The depth of the upper aquifer at the Griffiths property is expected to be greater than 5m, and the ground water salinity (TDS) ranges from 2000-10000 mg/L (Visualising Victoria's Groundwater, 2020), significanly higher than the proposed recycled water supply.

A number of bores are present on the Griffiths property and nearby land, and range in depth from 43 to 158m. It is understood that none of these bores are currently monitored. Bore locations are marked on appendix B and known data is summarised in appendix E.

These bores have historically been drilled to extract groundwater for stock water and irrigation or assist with the identification and potential utilisation of the brown coal deposit which extends throughout the Balliang East district.

The landowner has advised that bores 139964 and 81996 are currently used to supply stock water. This water soruce is recognised as being saline but suitable for livestock consumption (though no formal/routine water quality testing occurs). These bore are respectively located to the south of proposed pivot F and north of pivot H.

The risk of nutrient leaching into the ground water from recycled water irrigaiton is considered to be of low. This is due to the following:

1. Irrigation planning is designed as deficit irrigation. This practice ensures that the opportunity for soil waterlogging is minimised.
2. The nutrient budget (Table 10) indictes that the nutrient load to be applied from recyeld water is low relative to the nutrient removal of wheat and lucerne pasture.
3. The clay nature of the red sodosols soils are not considered susceptible to leaching. Soil PBIs range from moderate to very high.
4. The basalt geology of the district forms a relatively impermeable layer, protecting groundwater from surface activity.

8 Soil salinity and sodicity risk management

8.1 Salinity risk assessment

The development of saline soil conditions would negatively impact the production of lucerne pastures and crops.

Western Water have advised that the target salinity of the WIN class C recycled water supply is an electrical conductivity of <750µ/cm. Landowners are to be notified if electrical conductivity exceeds 1000µS/cm.

Salinity tolerances of lucerne and wheat (DPI, 2016) are summarised in Table 11.

Table 11 Salinity tolerances of various broadacre crops and lucerne growing in moderate to slow draining soils

	Irrigation Water Salinity (dS/m)		
Crop performance	No reduction	10% reduction	25% reduction
Barley	5.3	6.6	8.6
Canola	4.3	7.3	Not available
Lucerne	1.3	2.2	3.6
Soybeans	3.3	3.6	4.1
Wheat	4	4.9	6.3

Based on these salinity tolerances (Table 11) it is possible to determine the minimum leaching requirement (MLR) in order to maintain target crop performance.

$$MLR = ECWA \div [(7.5 \times ECWY\ \%) - ECWA]$$

Where: MLR is the minimum leaching requirement
ECWA is the EC of the available irrigation water (dS/m)
ECWY % is the salinity level of the irrigation water that results in a specified percentage yield loss.

If the most salt sensitive crop is considered (lucerne) it is calculated that 5.6% additional fresh water (in addition to the irrigation water requirements) is required during the irrigation season (September to April) in order to prevent a reduction in growth. This equates to between 0.4 to 0.56 ML/ha (10^{th} to 90^{th} percentile irrigation seasons) or 43-56mm/ha of rainfall. It should be noted that during the lucerne irrigation season the East Balliang area receives 325mm in median rainfall year. This significantly exceeds the freshwater leaching requirement.

Based on this calculation, and local rainfall data, it is unlikely that the salinity of the WIN recycled water supply would result in a reduction in lucerne crop yield.

8.2 Sodicity risk assessment

The soils currently have an elevated level of sodicity (as measured by exchangeable sodium percentage, ESP) in the A horizon (ESP 9.8%) and it would be appropriate to apply gypsum at 2.5 T/ha prior to the application of the recycled irrigation water.

The potential for increasing sodicity of the soil, and associated impairment in soil permeability and drainage capacity, is a function of the sodium content of the recycled irrigation water, measured as sodium absorption ration (SAR).

The annual average SAR of the WIN recycled water supply is anticipated to be less than 4.6 (Stantec, undated). Irrigation water with an SAR <3 is considered low risk but where the SAR is >6 the risk of soil impact significantly increases (DPI NSW, 2016).

Based on the forecast recycled water salinity and SAR value there is a moderate risk of increasing the sodicity levels of the soil, and based on the ongoing soil analysis data it would be appropriate to apply 2.5 T/ha gypsum to irrigation areas if the ESP is 10%.

In order to manage the risk of rising soil sodicity, and maintain soil permeability and drainage characteristics, it is recommended that annual soil analysis be undertaken and ESP data be used to inform an ongoing gypsum application program.

8.3 Soil monitoring

Prior to commencement of irrigation, representative soil sampling transects are to be established across each of the proposed irrigation areas. Baseline sampling and analysis (prior to commencement of irrigation) is essential. Ongoing monitoring of topsoil (0-10cm) and subsoil (10-30cm) for nutrient status, pH, salinity and sodicity levels will be required.

Standard soil testing analytes are included in appendix C

A nutrient budget reconciliation should form part of the annual soil monitoring program, and this must be based on a review of the nutrient inputs (fertiliser and recycled water) and removal (pasture and crop yields and phosphorus sorption impact) and determine the potential for unnecessary soil nutrient accumulation.

9 Conclusions and recommendations

The land capability assessment has identified the land associated with the proposed recycled water irrigation development can be considered suitable for the intended use.

- The property has been under the same ownership since the 1925 and used for cropping and pasture. As a consequence, the land has undergone significant modification in terms of cultivation, soil fertility, destoning and vegetation cover.
- The landscape and soils have a class 2 suitability rating.
- Red sodosol soils uniformly cover the property and the region. These soils are considered to have a minor restriction to the application of recycled water irrigation.
- Prior to irrigation commencing, soil sampling transects are to be established and soil sampling is to then occur on an annual basis to ensure the soil nutrient, salinity and sodicity levels remain appropriate.
- While soil conditions are not prohibitive to irrigation it is recommended that gypsum applied to irrigation areas at 2.5 T/ha prior to the application of the recycled water. This action will proactively manage the potential for rising soil sodium levels and soil exchangeable sodium percentage. Annual monitoring of soil ESP will inform an ongoing gypsum application program.
- The 50th percentile annual application for Lucerne pasture is anticipated to be 7.8 ML/ha, and for a wheat crop is anticipated to be 2.5 ML/ha.
- The 10th percentile annual application for Lucerne pasture is anticipated to be 10 ML/ha, and for a wheat crop is anticipated to be 4.1 ML/ha.
- Risks associated with soil salinity and nutrient leaching are considered low.
- The proposed recycled water irrigation development covers 475 hectares. Buffer zones to Balliang Creek, adjacent roads (Geelong Bacchus Marsh, Agars and School Roads), dwellings and Balliang East school have been included in the concept design. These must be adhered to as the development progresses.
- Centre pivot irrigators equipped with VRI technology and low drift sprinkler are the preferred irrigation infrastructure for the site.
- The property is well suited to the proposed recycled water irrigation development.

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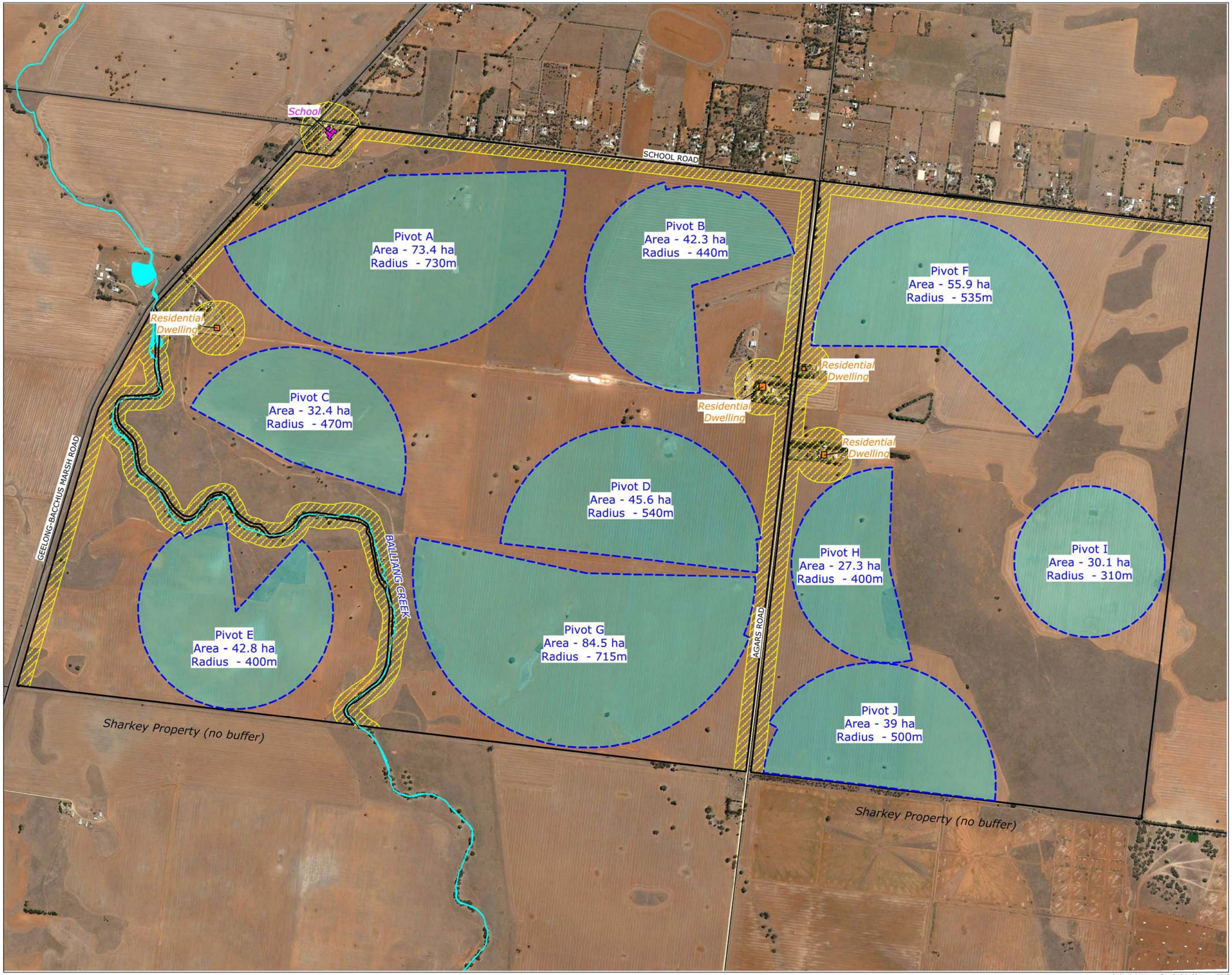
11 Appendices

Appendix A: Irrigation concept design map



Orthophoto image Google dated January 2019

pinion ADVISORY

Irrigation Management Plan

Griffiths

Western Water WIN

N

0 150 300 metres

1 : 14,000 @ A3

Print Date: 6th October 2020

Datum: GDA94 (Zone 55)

Created by: Mick Lehman
Reference: WesterW

GDA

LEGEND

- Property Boundary
- Residential Dwelling
- School
- Proposed Centre Pivot Irrigator
- Recycled Water Irrigation Area (475 ha)
- Major Watercourse
- Road

Recycled Water Buffer

- 50m - External boundary
- 100m - Residential dwelling, School

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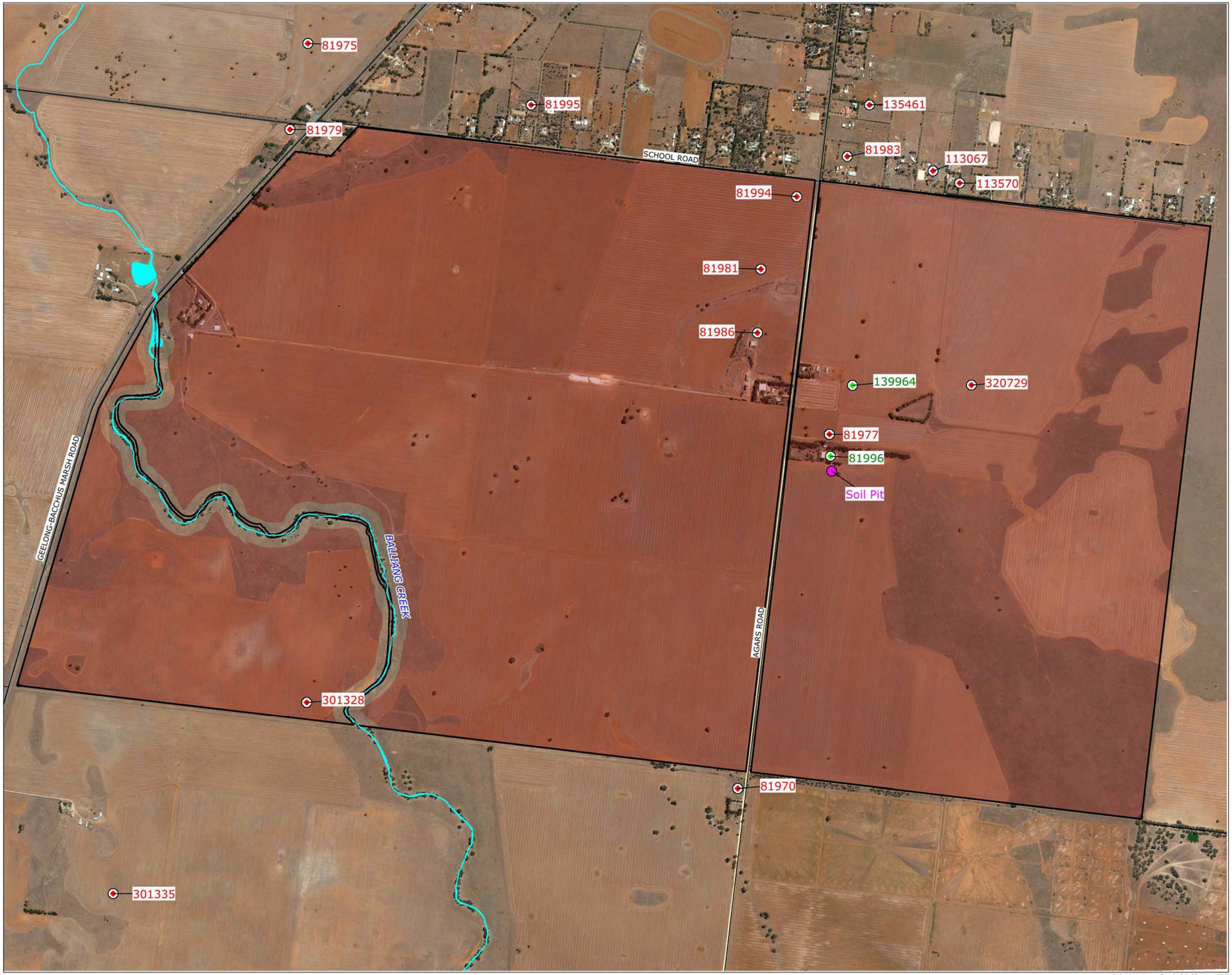
Appendix B: Soil map with groundwater bore identification



Orthophoto image Google dated January 2019

pinion
ADVISORY

Soil Management Plan

Griffiths

Western Water WIN

N

0 150 300
metres

1 : 14,000 @ A3

Print Date: 24th November 2020

Datum: GDA94 (Zone 55)

Created by: Mick Lehman
Reference: WesterW

GDA

LEGEND

- Property Boundary
- Existing Bore
- Bore - Currently in use
- Soil Pit
- Soil Type - Red Sodosol
- Major Watercourse
- Road

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Appendix C: Soil profile assessment

Table 12: Griffiths test pit soil profile

Site	Soil description	Image
Soil type: - red sodosol Landscape: - flat and very gently sloping ground with no stone and/or rock fragments on the surface. Effective rooting depth: - 300mm. Drainage: - Moderate to well in the A1 and A2 horizon to poorly drained in the B1 and B2 horizon.	A1: red clay loam to 15cm, moderate crumb structure 3-5mm, abundant canola plant roots, no coarse fragments with a diffused boundary to: A2: red clay loam to 40cm, moderate/coarse crumb structure 5-10mm, limited canola plant roots, no coarse fragments with a clear boundary to: B1: red clay to 70cm, cutans present, blocky structure, common fine roots, occasional large rock fragments (50+mm) with a weakly defined boundary B2: red/brown clay and orange/brown mottling, blocky structure, occasional fine roots (maximum depth to 800mm), frequent large fragments (50+mm), carbonate deposits present	

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Table 13 Griffiths test pit soil nutrient status

Analyte	Limit Ranges		Unit	Horizon		
	Lower	Upper		A (0-30cm)	B1 (30-60cm)	B2 (60-120cm)
Sample ID (Nutrient Advantage)				22033664	22033668	22033660
pH (1:5 water)	6	9		5.6	8.3	9.4
Electrical conductivity (1:5 SE)		4	dS/m	0.29	0.52	1.16
Chloride		100	mg/kg	54	150	640
Nitrate nitrogen	2		mg/kg	19	7.2	6.3
Ammonia nitrogen			mg/kg	2.6	1.3	1.1
Total nitrogen (kjeldahl)			mg/kg	0.1	0.09	<0.04
Phosphorus (Colwell)	40		mg/kg	110	12	<5
Phosphorus buffer index				190	430	290
CEC				9.52	29.6	47.6
Exchangeable sodium percentage	6	15	%	9.8	26	33
Aluminium saturation		1	%	5.0	<1.0	<1.0
Copper DPTA	0.5	2	mg/kg	0.99	1.8	0.74
Iron DPTA	4.5		mg/kg	77	27	8.9
Manganese DPTA	15	30	mg/kg	28	5.6	0.38
Zinc DPTA	0.7	20	mg/kg	0.9	0.21	0.05
Sulphur (KCl40)	10		mg/kg	99	62	110
Organic carbon (Walkley & Black)	1.74	2.62	%	1.5	0.61	<0.15
Aluminium (KCl)			mg/kg	43	<9.00	<9.00
Calcium (Ammonium acetate)	60	80	%	48	18	19
Magnesium (Ammonium acetate)	15	30	%	20	47	41
Potassium (Ammonium acetate)	5	10	%	17	9.8	7.1
Phosphorus environmental risk index		>2		0.58	0.03	0.02
Grass tetany risk index				0.25	0.15	0.12
Sample ID (ALS)	**Metals trigger levels**			**EM1813998004**	**EMI1813998005**	**EMI1813998006**
	HIL	**EIL**				
Arsenic	100	40	mg/kg	10	6	5
Cadmium	20		mg/kg	<1	<1	<1
Chromium	100	130	mg/kg	143	80	70
Cobalt	100		mg/kg	12	15	13
Copper	6000	49	mg/kg	17	29	24
Lead	300	470	mg/kg	19	9	6
Manganese	3800		mg/kg	396	178	284
Nickel	400	37.5	mg/kg	33	77	60
Zinc	7400	66	mg/kg	21	16	16
Mercury	40		mg/kg	<0.1	0.1	<0.1

Above desired level	Below desired level	Potentially a problem/toxic	Condition problematic/toxic

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Appendix D: Land capability score

Table 14 LCA scoring method

	Capability rating				
Score	1	2	3	4	5
Level of restriction to recycled water irrigation	Nil	Minor	Moderate	Major	Severe

Adapted from Van Gool D, Tille P & Moore G, 2005 & FAO Soil Bulletin 32, 1976 by Stantec (2018).

Table 15 Soil and landscape suitability score for the Griffiths property

Landscape properties	Capability Rating
Slope (%)	1
Surface rock (%)	1
Inundation/flooding	1
Depth to regional water table	2
Soil properties	
Surface texture (%clay)	2
Surface ESP (0-40cm) (%)	3
Subsoil ESP (40-100cm) (%)	5
Surface salinity (ECe (0-70cm) (dS/m)	1
Subsoil salinity (ECe (70-100cm) (dS/m)	2
Effective rooting depth (cm)	1
Solum depth (cm)	1
Surface infiltration (mm/h)	1
Profile drainage status	3
AWC within ERZ (mm)	2
Surface pH (field)	2
CEC (40-100cm) (meq/100g)	2
Overall suitability rating	1.9 (Class 2)
Potential development area (ha)	475

Appendix E: Local groundwater bore identification

Data in Table 16 was retrieved from www.vvg.org.au (14 September 2020). Bore locations are identified in Appendix B.

Table 16 Bore identification on and nearby to the Griffith recycled irrigation development site

Bore Identificiation number	Year Constructed	Depth	Use (where known)	Known Monitoring
81970	1925	146.6	Groundwater	No
81975	1926	70.1	Groundwater	No
81977	1926	40.2	Groundwater	No
81981	1970	0	-	No
81983	1973	60.96	-	No
81986	1985	61.56	-	No
81991	1988	66.4	-	No
81994	1988	45.7	-	No
81996	1988	45.7	Livestock – in use	No
81995	1991	50	-	No
113570	1992	53	-	No
139964	1998	43	Livestock – in use	No
301328	1924	124.5	-	No
320729	1981	158	Coal	No
WRK043166	0	0	-	No
WRK071538	2013	124	-	No
WRK975395	2006	46	Groundwater irrigation	No