



Integrating Resource Management

**DA Report / Nutrient and Irrigation
Management Plan:
Lots on McLarty Rd x Pinjarra Williams Rd,
Meelon WA 6208**

**Kelliher Bros
469 Fourteen Mile Brook Road
PO Box 6, Wandering WA 6308
Western Australia
September 2020**

**Nutrient and Irrigation Management Plan**

Lots on McLarty Rd x Pinjarra Williams Rd, Meelon WA 6208

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Issue	Date	Author	Reviewer	Approved
1	06/07/2020	D. Alanoix	P. Keating	P. Keating
2	03/09/2020	D. Alanoix	P. Keating	P. Keating



Contents

Response to Issue 1 Comments	5
Preamble	9
1 Summary of the Land Use Proposal.....	11
2 Project Setting.....	12
3 Land Use, Staff and Livestock.....	12
3.1 Land Use	12
3.2 Staff and Livestock.....	12
4 Local Rainfall, Evaporation and Interception.....	13
5 Soils and Landform Description.....	13
5.1 Land Contours	13
5.2 Soil Type.....	13
5.2.1 Geological Context	13
5.2.2 Surface Soil Type	14
5.3 Phosphorous Retention Index.....	14
5.4 Acid Sulfate Soil.....	15
5.5 Proposed Earthwork Details.....	15
5.6 Imported Soil Amendments.....	15
6 Water Resources Description and Use.....	15
6.1 Sensitive Water Resources.....	15
6.1.1 Wetlands.....	15
6.1.2 Groundwater Users.....	16
6.1.3 Surface Water.....	16
6.2 Seasonal or Occasional Flooding.....	16
6.3 Groundwater Description	17
6.3.1 Aquifer Description.....	17
6.3.2 Groundwater Flow, Discharge and recharge.....	17
6.3.3 Groundwater Level	18
6.3.4 Groundwater Quality	18
6.4 Source of Irrigated Water	19
6.5 PDWSA	20
7 Site Management	20
7.1 Irrigation System.....	20
7.2 Crops.....	21
7.3 Nutrient Application.....	21



8	Drainage and Nutrient Leaching Control.....	23
8.1	Drainage Management	23
8.2	Contaminant Leaching Control.....	23
8.2.1	Fertiliser Use Efficiency	23
8.2.2	Water Use Efficiency.....	23
9	Protection of Natural Water Resources	24
10	Contingency Plan	25
11	Vegetation Management	27
11.1	Clearing.....	27
11.2	Erosion Control.....	27
11.3	Water and Nutrient Application Matching Plant Needs.....	27
12	Pesticide and Storage Use	27
	References	27



Response to Issue 1 Comments

DWER Comments	Response
<p>To adhere to nutrient targets within the preceding documents, the operation would need to be able to demonstrate that fertiliser regimes could achieve either:</p> <ul style="list-style-type: none"> • Application rate of 6.5 kg/ha/year of total phosphorous (TP); and • Application rate of 45kg/ha/year of total nitrogen (TN); or • Export rate of 0.3 kg/ha/year TP; and • Export rate of 2.4 kg/ha/year TN. 	<p>The DWER policy nutrient application rates were derived from SQUARE modelling (WST 33) and based on assumption that granular fertilisers are applied as per previous practice. No granular fertilisers will be used. The project will demonstrate that nutrient export rates are less than DWER target rates. If these are not achieved, the project will be abandoned, and grazing will revert to existing farmer practice.</p>
<p><i>Nutrient application methods</i> – Section 8.2.1 fourth bullet point states “<i>Fertigation used when necessary, not in every irrigation cycle</i>”. Fifth bullet point states “<i>No application of phosphorous or nitrogen through fertigation, but through foliar spray</i>”. Fertigation involves the application of nutrients through irrigation, hence the approach is not clear.</p>	<p>Acknowledged - reworded</p>
<p>The proponent should provide a nutrient balance that demonstrate nutrients imported to site minus the nutrients exported from the site (in produce) are less than 6.5 kg/ha/year.</p>	<p>Agreed, with the caveat that it will take some years before soil organic matter P will reach equilibrium, thereafter, nutrients imported to the site will equal nutrients exported from the site.</p>
<p>Site Preparation – Section 5.5 cites that earthworks will achieve a minimum of 0.6m clearance of sand over clay. It then states the top 0.3m will be rotary hoed to increase PRI, however the aforementioned clearance to clay would prevent the mixing of sand higher PRI material.</p> <p>If higher PRI material is to be added, location and quantity should be specified.</p>	<p>Application revised to include where higher PRI material is added, location and quantity. The high PRI material is not clay. It will calcined spongolite (PRI of 2,000 – 5,000) applied at 125 kg/ha and will be blended into the top 300 mm of soil by rotary hoe prior to seeding.</p> <p>Note that very high PRI materials, by limitations in the PRI metric which quantifies low PRI materials is unrealistic. Accordingly PSI (phosphate sorbence index) is a more appropriate measure and will be used</p>
<p>Fertilisation Method - Section 8.2.1 fourth bullet point states “<i>Fertigation used when necessary, not in every irrigation cycle</i>”. Fifth bullet point states “<i>No application of phosphorous or nitrogen through fertigation, but through foliar spray</i>”.</p> <p>Fertigation involves the application of nutrients with irrigation, hence the approach is not clear;</p>	<p>Application reworded. For simplicity and clarity, all mineral nutrients applied post seeding and crop establishment will be applied as foliar sprays. Irrigation will only apply water, not nutrients.</p>
<p>Monitoring – Section 9 details the proposed monitoring approach. It is recommended the following information is included:</p> <ul style="list-style-type: none"> • Given this section identifies that there is monitoring information currently in existence 	<p>The monitoring information available is from 25 km northwest of the site, and 30 km north of the site and demonstrate the erratic and unpredictable and temporally stochastic nature, whereas the site itself has not demonstrated legacy nutrients in groundwater. However the</p>



<p>west of the site, this information should be used to calculate interim trigger levels;</p> <ul style="list-style-type: none"> Location, quantity and type of lysimeters should be provided; Annual reporting of lysimeter data should include determination of nutrient loads exported from site for comparison and compliance with Peel-Harvey targets. It is recommended any exceedances are reported to the Shire as a matter of process. 	<p>same principle (being 2 standard deviation units above background from the accumulative mean) will still be used as a trigger value.</p> <p>Lysimeters will be portable, and moved as accumulated data demonstrates the most appropriate placements</p>
<p><i>Drainage infrastructure</i> – its recommended conceptual design information is provided for the spoon drain and vegetated capturing structure including cross sections, grade and critical inverts.</p>	<p>Prepared and attached (Figure 7).</p>
<p>Establishment of species – It is understood foliar application is proposed to fertilise crops, however it is not clear whether this method is to be used for establishment.</p>	<p>Pasture will be established using liquid fertilisers supplied into the drill row giving application of 3 kg/ha of elemental P. This is less than half of the policy maximum.</p>
DPIRD Comments	Bioscience Response
<p>Annual soil sampling and testing is required to monitor changes in soil nutrient status across the 40ha pivot and within the soil profile. Recommendations for sampling and analysis are in Attachment 1.</p>	<p>Soil sampling methodology requested is appropriate for a farmer to determine nutritional requirements. The first words in the guidance recommended are 1. Purpose <i>The purpose of this document is to describe farm-based “fit for purpose” soil sampling methods.</i> The purpose of the proposed work is to provide scientifically robust data to demonstrate to regulators that better methods of pasture fertilization are possible by the adoption of more modern technology than the standard custom and practice that DPIRD is familiar with and upon which current policy is based. To this end, it needs to be noted that Bioscience has developed and validated “fit for purpose” scientific sampling and analysis methods in other research projects. These involve collecting far more samples than Fertcare calls for, furthermore, sampling will be far more frequent – likely fortnightly, but at most monthly. Bioscience is happy to demonstrate these internally routine methods to the satisfaction of DPIRD.</p> <p>The soil profile monitoring methodology outlined (4 locations annually) seems contradictory to the previous point. There is no recommendation of appropriate analytes measured to the depths described.</p> <p>The next point suggests a desire to indicate the levels of build-up of nutrients in all pools without specifying how those different pools might be fractionated thus distinguished. Bioscience proposes that for the purpose of scientific rigour, it will use its’ routine methods of fractionating</p>



	<p>soil into organic and inorganic fractions to thereby determine nutrients that are free, organically bound or mineral-bound. We will be again happy to teach DPIRD such routine research methodology.</p> <p>DPIRD prescription of analysis is not in accord with Peel Harvey Policy (WST 33) (i.e. no testing for N as proposed by Bioscience, and a curious method (perhaps misprinted?) 'sulphur (KCl40-S)' possibly referring to Rayment and Lyons method 10D1 "Empirical extraction at 40° followed by measurement by ICPAES.? We use modern methods (Leco induction furnace for Total S – more selective, accurate, faster, more sensitive.</p> <p>DPIRD calls for testing in a NATA-accredited laboratory. This is contrary to DPIRD's latest guidance "Soil sampling high rainfall pasture in WA (June 2020)" which recommends using ASPAC laboratories. Bioscience is an ASPAC-accredited soil testing laboratory, and an AusIndustry registered Research Service Provider.</p>
More information is needed on the procedure for flushing salts from the soil profile, which may accumulate from irrigation and fertigation.	The nearest BOM rainfall data to Meelon (station #9891 – Pinjarra refinery) shows a mean rainfall of 550 mm from May to August that is in excess of evaporation. Thus rainfall will flush any accumulated salt to below the root zone. Until a production bore is drilled, we cannot confirm the salinity of bore water, however the nearest bore Bioscience had drilled (in 2009) had 245 ppm TDS, so we do not anticipate salinity, nor flushing salt will be an issue for irrigation. However, it also needs to be noted that pasture grasses are generally quite salt tolerant.
It is unclear from the NIMP whether soil amendments will be used across the 40ha centre pivot area. Section 5.6 on page 11, indicates the untrialled area <u>will not</u> be subject to soil amendment. This contradicts the proposed measures to reduce leaching on page 18, which include soil amendments.	Bioscience maintains that the crop nutrition system to be used will not exceed export rate targets, but it cannot demonstrate this unless and until development approval is obtained. The requirement for having PRI amended soil over the entire pivot can be accommodated, but for the purpose of generating robust scientific data, an area of 0.5 ha will be left unamended to test the hypothesis that it makes a difference to phosphate egress.
The following statement is made on page 18 <i>"The maximum phosphorous (6.5 kg/ha/yr) and nitrogen (45 kg/ha/yr) input rates recommended by the Department of Water and Environmental Regulation will not be exceeded unless mass balance calculations demonstrate that at least 90% of these values have been exported from</i>	There will be virtually no fertiliser applied directly to soil once plants achieve a LAI (leaf area index) of 1. Any mineral nutrients entering soil will be as plant root exudates. Thus, the rhizosphere will become enriched, and soil organic carbon will increase. This will mean the nutrient dynamic will be biologically driven and



<p><i>the site, or are in the form of stable biomass."</i> - The mass balance calculation used to determine applications of P and N should only use the nutrients added and removed from the site and not include the build-up of nutrients in the soil. The maximum application rate of N and P should not be exceeded unless at least 90% of the application rate has been exported</p>	<p>parsimonious. Over time, it is expected to reach an equilibrium, by which time (with increased recycling of mineral nutrition through microbial biomass) it is anticipated that the mass of nutrients applied exclusively as foliar application will be reduced. Thereafter the amount exported (as fodder or cattle biomass) will be the same as the amount applied.</p>
<p>Page 20 section 9 - There are no details regarding lysimeters. The following information is required - type of lysimeters, method of installation, placement and the number to be installed.</p>	<p>Lysimeters will be portable vacuum lysimeters, as previously described in the earlier DA and subsequent proposed trial to the EPA. These will be located throughout the trial areas and be re-located as necessary to the most appropriate areas as demonstrated by data produced. Note that vacuum lysimeters are a more advanced technology than conventional gravity lysimeters previously used. Such standard gravity lysimeters can only collect excess water (i.e. water beyond field capacity) and are very difficult to move without substantial ground disturbance. Given the soil moisture probes guiding irrigation requirements, soils will only exceed field capacity during heavy rainfall events. Unlike a gravity lysimeter, a vacuum lysimeter can recover soil moisture when it is below field capacity, even at wilting point.</p>
<p>Trigger levels mentioned on page 20 do not refer to the Department of Water and Environmental Regulation (DWER) environmental protection guidelines.</p>	<p>DWER guidelines assume standard practice of broadcasting granular fertilisers. The core aim of DWER guidelines is to limit the export of nutrients in groundwater and surface water flows. The nature of any egress of nutrients in groundwater will require understanding of transmissivity and hydraulic gradients. This will be gained from the H3 hydrological test work required to secure a groundwater licence. Routine monitoring of upstream and downstream water N and P will enable precise quantification of potential nutrient egress.</p>
<p>Table 5 on page 22 needs two additional columns to record monitoring intervals and follow-up monitoring intervals if trigger levels are exceeded.</p>	<p>Amended</p>
<p>The spoon drain and the vegetated capturing structure will be lined with high PR/ materials including NUA and calcined spongolite. These areas will not be fertilised beyond the need to establish phreatophyte vegetation." –</p> <p>This drainage plan requires a Notice of Intent to Drain (NOID) to be lodged with the Commissioner of Soil and Land Conservation under Regulation 6 of the Soil and Land Conservation Regulations 1992.</p>	<p>Drainage means to move water with the intent of dewatering land, or to modify drainage such that pre- and post- development flows are altered. SLCR 1992 Reg 6 does not apply. It states "When and owner or occupier.....proposes to drain or pump water from, on or under the land to discharge that water onto other land, into other water or into a watercourse, whether within the area or outside the area....." There is no such intention in this project. If the site becomes seasonally inundated, that seasonal inundation will be managed by directing it to another (adjacent) part of the same property into a nutrient retention basin. The site will still be (temporarily) inundated, but in a different place.</p>



Preamble

This project seeks to develop and demonstrate a new form of agricultural practice which is more productive, efficient and environmentally safe compared to existing practices of cattle grazing in the Peel Harvey catchment.

Kelliher Bros lodged a Development Application with the Shire of Murray to undertake pivot irrigation in order to produce and export pasture for cattle feed at Lots 190, 204, 205, 206, 209, 230, 536, 538 and 542 Ravenswood in 2018. As the proposed activity would be undertaken within the policy area of the *Environmental Protection Peel Inlet- Harvey Estuary Policy (EPP)*, the application was referred by the Shire of Murray to the EPA.

On 2nd May 2019, the EPA has determined under section 40(2)(a) of the *Environmental Protection Act 1986* that additional information is required to finalise the assessment of the proposal. Such additional information was to be provided by undertaking a 1-hectare pilot scale project to run for 12 months and which replicated the proposed growing conditions, nutrient application, foliar spray and irrigation management mechanisms to demonstrate that, when applied to a large scale, nutrient export from irrigated pasture production can meet the targets of the *Environmental Protection Peel Inlet- Harvey Estuary Policy (EPP)*, and *Murray Drainage and Water Management Plan* (DoW, 2011) whilst producing commercially viable crop yields.

Subsequent groundwater monitoring of the initially proposed site in the winter of 2019 demonstrated fundamental problems with using the site as proposed:

- Monthly groundwater monitoring demonstrated legacy nutrient levels of phosphate and nitrate were present in an unpredictable and stochastically noisy pattern in both upstream, downstream and in-site monitoring bores even without any fertiliser applications.
- Drainage flowing onto the site from the east via various drainage channels and passing via a large culvert under the Patterson Rd boundary, and the underestimated maximum groundwater level led to the proposed trial site becoming largely inundated.

A review of the business case for the project reinforced Kelliher Bros view that the proposal was commercially viable.

In order to provide the technical information required by the EPA, Kelliher Bros now propose to undertake the trial work (1 ha) on a different property located in Meelon. This property has available unallocated groundwater, and an exploration licence has been obtained from DWER. Soils on the property have been investigated by Electromagnetic mapping, with ground proofing using a hand auger. Soils are Bassendean sands over Guildford formation clay. Generally the depth of sand is less than Ravenswood, however the existence of prominent sand hills means that with minor earthworks to level the site, a 40 ha pivot will have at least 60 cm of sand over clay.



Preliminary groundwater analysis indicates that unlike Ravenswood, legacy nutrients in groundwater at Meelon are very much lower, with Phosphate below detection limits (0.01 mg/L) and nitrogen salts at typical background (very low) levels. Accordingly, this site will enable the required demonstration to be undertaken with much better statistical rigor.

This document describes the proposed initial development, being the establishment of one 40 ha pivot for pasture production, at the Meelon lots. Although this document briefly describes the 1 ha trial area (included in the 40 ha pivot), which outcome will provide the technical information required by the EPA for the Ravenswood lots, a separate report specifically describing the scope of the 1 ha trial will be provided with input and feedback as necessary by DPIRD, DWER and the EPA. The longer term intention is to operate 2 centre pivots on the site once scientifically robust data is generated to demonstrate that nutrient export targets are met.



1 Summary of the Land Use Proposal

Proponent's name: Shane Kelliher of Kelliher Bros

Contact details: 08 9884 1550

Site location: The proposed development is to cover the lots listed below:

- LOT 100 ON PLAN 3667 - Volume/Folio 2936/889,
- LOT 86 ON PLAN 3667 - Volume/Folio 2936/890,
- LOT 87 ON PLAN 3667 - Volume/Folio 2936/890,
- LOT 88 ON PLAN 3667 - Volume/Folio 2936/890,
- LOT 89 ON PLAN 3667 - Volume/Folio 2936/890,
- LOT 90 ON PLAN 3667 - Volume/Folio 2936/891,
- LOT 91 ON PLAN 3667 - Volume/Folio 2936/898,
- LOT 92 ON PLAN 3667 - Volume/Folio 2936/898,
- LOT 93 ON PLAN 3667 - Volume/Folio 2936/898,
- LOT 94 ON PLAN 3667 - Volume/Folio 2936/898,
- LOT 95 ON PLAN 3667 - Volume/Folio 2936/898,
- LOT 96 ON PLAN 3667 - Volume/Folio 2936/898,
- LOT 97 ON PLAN 3667 - Volume/Folio 2936/898,
- LOT 98 ON PLAN 3667 - Volume/Folio 2936/899,
- LOT 99 ON PLAN 3667 - Volume/Folio 2936/888,
- LOT 550 ON DEPOSITED PLAN 302598

These lots are referred to as “*the site*”, “*the project site*”, “*the project area*” in this document.

Project description: Bioscience has been commissioned by Kelliher Bros to assist in establishing an irrigated pasture operation to expand their existing grass-fed beef production business. Kelliher Bros entered this emerging high value industry some years ago and recognised substantial market opportunities. However, without irrigation, emerging markets can only be addressed for about 6-8 weeks each year and have declined with climate change reducing rainfall. The business objective is to produce grass fed beef for local markets on a year-round basis through the irrigation of 80 ha of pasture via two 40 ha pivot irrigator.

A 150KVA generator which has the ability to power the water pump and two pivots will be used. A small 3m x 4m garden-type shed to protect the generator from the elements, and a small tank stand next to the generator to store fuel will be installed.

It is the applicant's intention to upgrade their energy source from diesel to a more environmentally sustainable, renewable solar power generation unit, using vanadium battery power storage. The use of alternative power still requires the need for diesel generator back-up to reduce risk, so using diesel in the opening phase of the project will enable them to determine precisely how much energy is required to operate the pivots.



Also, as mentioned in the Preamble, within the initial 40 ha of pasture production, 1 ha will be used as a trial area to test soil amendments and provide the technical information required by the EPA for the Ravenswood lots.

Timetable: Groundwork towards production on site will start as soon as development approval is obtained.

2 Project Setting

The site is located approximately 20 km south-east of Mandurah and 5 km south east of Pinjarra, and is zoned "rural" under the Local Planning Scheme.

The project site is owned by Kelliher Bros and covers an area of approximately 178 ha. It is bounded by McLarty Rd to the west, Tuckey Road to the east, Pinjarra-Williams Road to the north and other rural lots to the south (Figure 1).

3 Land Use, Staff and Livestock

3.1 Land Use

The site has been cleared for its current land use, cattle grazing. For the last 40 years cattle on the site have been grazing on deep-rooted perennial pasture such as kikuyu and couch, annual grasses such as ryegrass, and legumes such as Serradella and Balansa. In recent years the site has not received any lime or fertilisers.

3.2 Staff and Livestock

There will be no staff living on the site. Currently livestock is rotationally grazed on the site.

During the operation, no livestock will be involved in the pilot trial, which will be fenced to protect from both cattle and kangaroos. It is envisaged that on the remainder of the pivot, grazing cattle will be trialled using virtual grazing collars. Otherwise pasture will be cut using a forage harvester, baled and exported to other Kelliher farms. Any future decision to directly graze cattle on commercial pivots will be at least in part informed by nutrient mass balance, feed quality and nutrient export data generated from the pilot trial and cattle growth performance on the non-trial parts of the pivot.

Selective grazing by cattle to manage pasture species will be limited to rapid turn-around micrograzing of no more than 3 days per event, with sufficient cattle to remove the anticipated 25 cm of pasture to 5 cm. The remaining 130 ha of the Kelliher property will maintain current cattle production practice.

The sustainable stocking rate will not be exceeded.



4 Local Rainfall, Evaporation and Interception

The climate of the area is characterized by Mediterranean climate of cool wet winters and hot dry summers. There are no weather monitoring stations within the immediate vicinity, therefore the rainfall data has been taken from the Pinjarra Weather Station, (BOM no 9976). Average monthly rainfall between 2001 and 2020 is shown in Table 1. The average yearly rainfall in Pinjarra is 684.9 mm/year. The Medina Research Centre is the closest weather station monitoring evaporation. Evaporation at the site is likely to be similar to Medina which has an annual evaporation of 1725 mm between 1983 and 2017. Average monthly evaporation in Medina is also presented in Table 1.

Evaporation exceeds the annual average rainfall by a factor of 2.5. Monthly rainfall typically only exceeds evaporation during four months from May to August.

Table 1: Rainfall at Pinjarra and Evaporation at Medina Research Centre (Bureau of Meteorology)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Average Rainfall (mm)	13.5	9.2	12.6	32.7	98.9	119.8	124.2	107.8	74.9	35.8	24.3	12.8	684.9
Average Evaporation (mm)	260	224	195	114	71	54	53	71	96	146	195	245	1725

5 Soils and Landform Description

5.1 Land Contours

Overall the project site gently slopes down towards the north-west with a 0.3% gradient, from an average elevation of 20 mAHD in the eastern section of the site to 14 mAHD in the north-west corner. Sandhills and sandplains are also present (Figure 2).

5.2 Soil Type

5.2.1 Geological Context

The site is located in the Perth (sedimentary) Basin and is underlain by approximately 15 m to 20 m of superficial formations (Quaternary and Tertiary age), comprising of Bassendean Sands, the Guildford Formation (Guildford Clay Member) and the Yoganup Formation in deeper layer. These formations unconformably overlie about 126 m of the Leederville Formation of Cretaceous age. Only the Marignup Member of the Leederville Formation underlies the project area whereas the Wanneroo Member is present to the north/east of the site. The Leederville formation unconformably overlies the Cattamarra Coal Measures

The Yoganup Formation unconformably overlies the Leederville Formation and it is unconformably overlain by the Guildford Clay. According to Deeney (1989) the Yoganup



Formation extends 7 to 10km west of the Darling Scarp and ranges in thickness from 1 to 25m.

The Leederville Formation consists of interbedded sandstone, siltstone and shale. Near the Darling Scarp, sandstone accounts for approximately 40% of the formation with individual sandstone beds of about 6m in thickness. The percent of sandstone and thickness of the formation generally increases to the west. The Mariginup Member of the Leederville Formation consists of thinly interbedded and discontinuous grey to black siltstone and shale with minor, very thin beds of mostly fine-grained sandstone.

Stratigraphic logs of surrounding exploratory and monitoring bores suggest that the locally the Leederville Formation unconformably overlies the Cattamarra Coal at depths ranging from approximately 100 m to 200 m below ground level. Near the unconformity there appears to be a weathered zone where mottled red-brown to yellow colours are common (Commander, 1975).

5.2.2 Surface Soil Type

According to the GSWA mapping (Figure 3), the surface geology of the grounding consists of:

- Qpb, Bassendan Sand;
- Qpa, Guildford Formation; and,
- Qbp/Qpa, Thin layer of Bassendean Sand of top of Guildford clay.

This description can be related to the NRinfo mapping system of the Department of Primary Industries and regional Development (Figure 4), where the project area is mapped as:

- Pinjarra P1a Phase for most of the area; i.e. flat to very gently undulating plain with deep acidic mottled yellow duplex (or effective duplex) soils. Shallow pale sand to sandy loam over clay; imperfect to poorly drained and generally not susceptible to salinity;
- Pinjarra P1b Phase for the southern section of the area; i.e. flat to very gently undulating plain with deep acidic mottled yellow duplex (or effective duplex) soils. Moderately deep pale sand to loamy sand over clay: imperfectly drained and moderately susceptible to salinity in limited areas.
- Pinjarra B1 Phase for the sandhills; i.e. extremely low to very low relief dunes, undulating and discrete sand rises with deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at depths generally greater than 2 m; banksia dominant; and,
- Pinjarra B2 Phase for the sandplains; i.e. flat to very gently undulating sandplain with well to moderately well drained deep bleached grey sands with a pale yellow B horizon or a weak iron-organic hardpan 1-2 m.

5.3 Phosphorous Retention Index

The Phosphorous Retention Index (PRI) describes the ability of the soil to retain phosphorous. Soil within the Peel Harvey catchment area is known for its low Phosphate



binding, showing PRIs of 2-5 or even lower (EPA 2008). Bassendean Sand, as found on the site, is a typical surface formation of the Peel-Harvey catchment with very low PRI.

5.4 Acid Sulfate Soil

The Acid Sulfate Soil (ASS) Risk Map provided by the Department of Water and Environmental Regulation (DWER) defines the area as Class 2 - moderate to low risk of ASS for depths within 3m below natural ground (Figure 5).

5.5 Proposed Earthwork Details

Ground levelling is proposed on the site. The pivot area is to have at least 0.6 m of sand overlying the clay formation to reduce the effect of waterlogging from perched groundwater.

In order to minimise any prospects of uncontrolled runoff in the event of heavy rainfall, soil will be raised at the centre of the pivot relative to the outer western edge, thereby directing runoff in a 1 in 500 gradient to a perimeter gutter of soil amended to a PRI of over 25 (Figure 7). Calcined spongolite (PRI of 4,000 – 5,000) will be applied at 250 kg/ha and will be blended into the top 300 mm of soil (pivot footprint) by rotary hoe prior to seeding. This will simultaneously flatten minor depressions and hillocks on the site and increase efficiency of pivot irrigation.

5.6 Imported Soil Amendments

A 0.5 ha portion of the pivot area will not be subject to soil amendments. However, the 1 ha trial area will test different amendment rates. This is further described in the Pilot Project Scope Report (to be provided in due course, and upon the agreement of regulatory authorities that the trial is scientifically robust).

6 Water Resources Description and Use

6.1 Sensitive Water Resources

6.1.1 Wetlands

The site and its surroundings consist of Multiple Use Category Wetlands (Figure 8):

- UFI 5642 – Multiple Use Wetland, on site
- UFI 5644 – Multiple Use Wetland, on site
- UFI 5827 – Multiple Use Wetland, on site
- UFI 5645 – Multiple Use Wetland, on site
- UFI 5646 – Multiple Use Wetland, on site
- UFI 5755 – Multiple Use Wetland, on site

No other wetland is located on the lot, the following wetlands are in the immediate vicinity of the lot:



- UFI 5643 – Multiple Use Wetland, located 600 m south of southern boundary
- UFI 5752 – Multiple Use Wetland, located 1000 m south-west of southern boundary
- UFI 14632 – Conservation Wetland, located 600 m west of western boundary
- UFI 15802 – Conservation Wetland, located 300 m west of western boundary

6.1.2 Groundwater Users

The locations of groundwater users within the vicinity of the project site are listed in Table 2.

Existing groundwater users in the area were assessed through the Department of Water's Water Register database. Four groundwater users are abstracting water from the Superficial Aquifer and the Leederville Aquifer within a 3 km radius of the northern site boundary.

Table 2: Groundwater Users Abstracting Water within the Superficial Aquifer

Groundwater Use	Licence No.	Allocation (kL/yr)	Aquifer	Approx. Distance from the Project Site
Leedale Holdings Pty Ltd	163695	19,600 kL	Superficial	2 km west
McLarty Family Trust	108176	1,500 kL	Lower Leederville	3 km south west
Lillyvale Dairy	166816	42,460 kL	Lower Leederville	2 km south east
Alcoa	150586	400,000 kL	Superficial	3 km north

6.1.3 Surface Water

As seen on Figure 9, drainage lines were established on site to reduce the effect of perched groundwater during winter months.

6.2 Seasonal or Occasional Flooding

The site is not within the floodplain and is therefore not subject to inundation from 1% AEPs (Figure 10). However, given the presence of the Guildford Formation at relatively shallow depths in areas described as Pinjarra Phase 1, it is believed that perched groundwater occurs within these areas. Some waterlogging can be observed in historical aerial photography. As such, to prevent waterlogging within the pivot area, as discussed in Section 5.5 of the report, it is proposed to have a separation distance of a minimum of 0.6 m from the clay layer.

In addition, probes will be placed on the site to continuously monitor soil moisture and soil salinity. Since irrigation will be scheduled based on the data retrieved from the probes, irrigation will be managed to avoid saturation of soil within the root zone. All fertiliser will be exclusively applied via foliar application of dilute solutions using a boom spray. Hence, if no irrigation is required due to water availability nutrient leaching via drainage can be prevented. Irrigation and foliar spray is of much lower intensity during the winter months due to higher rainfall as presented in Table 1 and lower temperature, solar irradiance and evapotranspiration. However, irrigation cannot be completely precluded in winter months due to seasonality of rainfall, wind and sunshine.



6.3 Groundwater Description

6.3.1 Aquifer Description

6.3.1.1 Superficial Aquifer

The site lies within the southern part of the Serpentine flow system described by Deeney (1989). The Serpentine flow system is bounded by the Serpentine River in the west, Murray River in the south and the Darling Scarp in the east. The superficial formations, which consist predominantly of clay and sand forms a regional extensive unconfined aquifer. In the southern part of the Serpentine flow system the clay member of the Guildford Formation is prevalent and forms an aquitard in the upper part of the aquifer.

The transmissivity within the superficial aquifer generally increases from east to west, varies locally and ranges from 50 to 1150 m²/day. The wide variation in values obtained reflects the variation in lithology and to a lesser extent the saturated thickness of the aquifer (Deeney, 1988).

6.3.1.2 Leederville Aquifer

The Leederville aquifer consists entirely of the Leederville Formation and is described as a multilayered groundwater flow system consisting of discontinuous interbedded sandstone, siltstone and shales. The presence of a green clay marker in the north-west of the Pinjarra subarea separates the aquifer into two principle aquifer zones, described as 'upper' and 'lower' Leederville aquifers. The green clay marker was not identified in lithological logs from nearby production bores or surrounding bores therefore the area is assumed to consist of only the lower Leederville aquifer.

Estimates of local aquifer parameters were obtained from an aquifer pumping test performed in lower Leederville bore Alcoa 0-10 (WIN Site 20015461), screen between 185-193m below ground level. Pumped at 730 m³/day for 3.5 hours and 550 m³/day for 4.5 hours the drawdown response fit closely to the non-leaky artesian type curve yielding a transmissivity of 72 m²/day. Aquifer thickness derived from the bore lithological log was 190 m, therefore the resulting hydraulic conductivity was 0.4 m²/day.

The horizontal hydraulic conductivity of sandstone beds in the Leederville aquifer may locally reach 10 m/day, and that of the siltstone and shale is about 1x10⁻⁶ m/day (WRC, 1998).

6.3.2 Groundwater Flow, Discharge and recharge

6.3.2.1 Superficial Aquifer

Groundwater in the southern part of the Serpentine flow system flows in a westerly direction (Figure 11) from the Darling Scarp to the Murray River, where discharge occurs. Discharge to underlying Leederville aquifer by downward leakage occurs locally in the presence of a downward hydraulic gradient and in the absence of confining beds.

Recharge to the superficial aquifer is by direct infiltration of rainfall with lesser amounts from runoff. Recharge rates vary across the coastal plain as a result of the variation in lithology, depth to groundwater table and topographic gradient. Generally, recharge rates are likely to be lower in the eastern region of the coastal plain due to the greater portion of clay sediments and low topographic gradient.



Within the Pinjarra Subarea the average saturated thickness of the superficial sediments is approximately 20m, although it decreases towards the Scarp. The Murray River to the west of the site has completely eroded the Guildford Clay to expose the Yoganup Formation and groundwater discharges directly into the river from the Serpentine flow system. Groundwater losses also result from evapotranspiration from wetlands and areas where the watertable is at shallow depth. Groundwater discharge from the Guildford clay is mainly by evapotranspiration.

6.3.2.2 Leederville Aquifer

Recharge to the Leederville aquifer, due to direct infiltration from the overlying superficial formation, occurs mainly along the central and eastern margins of the Swan Coastal Plain where downward hydraulic heads prevail. Based on the prevalence of clay in the surface geology, estimates of recharge within the Leederville aquifer are 0.5% of annual rainfall.

The induced recharge for the Leederville aquifer was calculated utilising the same method used in evaluating the rainfall recharge availabilities of the aquifer. The soils within the individual subareas were classified as either sandy or clayey soils, and recharge rates of 3% and 0.5% were applied respectively to the average annual rainfall of 900mm.

Groundwater within the Leederville aquifer flows westwards and is discharge offshore. Discharge to the underlying Cattamarra aquifer also occurs through downward leakage where the South Perth Shale is absent and where a downward hydraulic gradient exists (WRC, 1998).

6.3.3 Groundwater Level

6.3.3.1 Superficial aquifer

If we consider perched groundwater, groundwater levels will be close to the surface in wetter months.

The superficial aquifer, i.e. groundwater within the quaternary formation seems to have a seasonal variation of 3m when analysing hydrographs for DWER bores HS51a and HS52b located respectively 2 km west and 3 km east of the project area.

On average groundwater of the Superficial aquifer seems to be varying between 0.5 m and 5.5 m below ground level depending of the topography.

6.3.3.2 Leederville aquifer

Within the Pinjarra subarea there is limited monitoring data of groundwater levels within the Leederville aquifer. The majority of bore screened within the Leederville aquifer were installed for exploratory purposes and are not included in the Department of Water monitoring program.

6.3.4 Groundwater Quality

6.3.4.1 Superficial Aquifer

Mapping of regional groundwater salinity presented in Deeney (1989) shows that groundwater within the superficial aquifer increases from in a westerly direction away from the base of the Darling Scarp. This trend is common to groundwater salinity both at the



water table and at the base of the superficial aquifer. Salinity ranges from less than 500 mg/L at the base of the Darling Scarp and gradually increases towards the recharge boundary formed by the Murray River to over 1500 mg/L at the watertable and 1000 mg/L at the base of the aquifer.

Department of Water records of in situ total dissolved salts (TDS) measured in the five WIN groundwater sites situated on the site were variable ranging from 900 mg/L to 3300 mg/L.

The groundwater salinity in the Guildford Formation clay member is generally higher than the underlying sediments. Large seasonal variations have been observed in bores screened within the Guildford Formation clay member. This variation has partly been attributed to seasonal changes in the position of the aquifer. The salt content of the soil profile probably varies considerably with depth; therefore, variation in water level would result in the dissolution and deposition of stored salt on a seasonal basis (Deeney, 1989).

The groundwater quality measure in superficial bores WIN Site 4244 and 4245, indicate that locally the superficial aquifer is of sodium-chloride type and slightly acidic with measured pH values ranging from 5.9 to 6.2.

6.3.4.2 Leederville aquifer

Deeney (1989) stated that the salinity in the upper part of the Leederville aquifer ranges between 500 and 2000 mg/L TDS, whilst in the lower part of the aquifer, the salinity is generally less than 3000 mg/L. Salinity at the base of the Leederville aquifer typically increases from east to west from approximately 500mg/L near the scarp to more than 3000 mg/L near the coast.

In situ salinity recorded in Leederville bores within 5km of the site ranged from 548 to 2085 mg/L TDS. These records indicate that salinity within the Leederville aquifer increases with depth and that areas to the south and east of the site more saline, compared to the north and east. This variation in salinity is characteristic of regional groundwater salinity.

The groundwater quality within the Leederville aquifer has been measured in Mandurah Line bore M18 (WIN Site 20015454), situated 1.91 km south-east and M17 (WIN Site 20015453), situated 2.83 km east of the site. Records indicate that the groundwater is predominantly sodium-chloride, with lesser amounts of bicarbonate, sulfate, calcium, magnesium and potassium ions being present. pH was slightly acidic in M18, whilst in M17 values varied from 6.8 to 3.4.

Groundwater quality in the nearest Leederville bore 2 km SE of the site – Table 2, was 260 ppm when Bioscience undertook an H2 study in 2009.

6.4 Source of Irrigated Water

A groundwater application for a licence to construct a well and to take water to draw 1,000,000 kilolitres per annum from the Murray, Pinjarra, Perth – Lower Leederville was submitted on 07/01/2020.



The Department of Water and Environmental Regulation has determined the further additional information required to access the groundwater licence application:

- An H3 level of hydrogeological assessment;
- An operating strategy; and,
- Approval from the local government and the Department of Primary Industries and Regional Development.

These works are yet to be completed. The site does not have an existing production bore. This will be installed prior to the starting the H3 level of hydrogeological assessment.

6.5 PDWSA

The site is not within or near any Public Drinking Water Supply Areas.

7 Site Management

7.1 Irrigation System

Irrigation will use initially one center pivot irrigator with a radius of 355m, 7 spans and cover an area of 40 ha (Figure 6). Irrigation will be scheduled according to soil moisture, weather forecasts and plant needs. The pivot is able to deliver a maximum of 11 mm of irrigation water per day.

Various blends of deep-rooted annual and perennial pasture varieties will be sown. These measures, plus the gradual development of root biomass, soil organic matter and soil microflora, will continuously reduce the potential of leaching of irrigation water into groundwater.

The moisture content of the soil is central for the plant's performance. A moisture content of 10 – 18 % w/w is desirable, because it is well above the wilting point to prevent pasture from drying out and below the drained upper limit to prevent water seeping into the groundwater. Saturation of soil has adverse effects on pasture and will be prevented through irrigation management.

To monitor and maintain optimum soil moisture, 60 cm Sentek TriSCAN probes will continuously measure soil moisture, temperature and salinity up to 60 cm below ground level (BGL) in 10 cm increments. In the Sentek probe system, information is collated and sent through the central Data Transmission Unit via GPRS or NextG transfer to the internet. This way, the information is continuously updated and can be readily downloaded from anywhere with internet access. Through this decision making and management tool, the irrigation system can be adjusted to the current soil conditions. The computer-controlled irrigation management shows the real-time status of the pivot and can start and stop irrigation anytime.

The pivot irrigation system initially used a diesel generator but will eventually be solar powered, backed up by the diesel generator. This means the operation of the pivot irrigator is mostly limited to hours of sunlight. The site will not be irrigated during forecast rain events



or when the soil is approaching saturation. Irrigation is primarily scheduled from spring to autumn, because the winter months usually provide sufficient rainfall; however, winter is not excluded from irrigating. Irrigation can be adjusted to weather forecasts and current soil conditions to maximise water use efficiency.

7.2 Crops

Deep-rooted varieties are preferred to increase nutrient uptake and maintain soil moisture. A range of grasses and legumes will be grown as pasture on the site as described below.

- **Balansa Clover:** self-regenerating annual legume, adapted to most soils, tolerates water logging in winter, provides valuable grazing for livestock (DPIRD 2018)
- **Serradella:** annual legume, grows in autumn, winter and spring, deep rooted and can extract moisture and nutrients from depths up to 2 mBGL (DPI NSW 2018)
- **Lucerne:** perennial legume, main growth in spring, summer and autumn, drought resistant, (DPI NSW 2018)
- **Kikuyu:** perennial grass, drought tolerant, good for stabilizing soil (DPI NSW 2018)
- **Couch:** perennial grass, grows in wide range of soils, good salt tolerance (Agriculture Victoria 2018)
- **Biserrula:** persistent legume, deep rooted system, high level on grazing tolerance, deep-rooted (more than 2 mBGL) (DPIRD 2018)
- **Annual Ryegrass:** Oversown in perennial grass at the beginning of winter, ensures higher net primary productivity of pasture in colder winter months.

Most of the species listed above show great tolerance to different soil types as well as varying soil moisture. Due to the seasonal productivity variations of most pasture crops, a combination of pasture species is preferred to provide year-round feed for cattle. The choice of plants is not limited to the types listed above and will be based on the advice provided by successful irrigated pasture growers in and outside of Western Australia.

7.3 Nutrient Application

Because the land is located within the Peel-Harvey catchment, we recognise there are a number of guidances and policies which must be adhered to before the necessary approvals for such a development can be obtained. However, with the adoption of management techniques including soil amendments, and the continuous monitoring of soil moisture and nutrient levels to adjust irrigation and foliar spray rates, such a project will not exceed the target maximum values for nutrients exported to groundwater or surface drainage specified in current guidelines.

The *Peel-Harvey Environmental Protection Policy (Peel-Harvey EPP)* establishes phosphorous and nitrogen loading targets for the Peel-Harvey Estuary System, which new developments must adhere to. To comply with the nutrient loading targets, new operations within the catchment are required to achieve an export rate for total phosphorous (TP) lower than 0.28 kg/ha/year, as specified within the Department of Water's modeling report (DoW 2011).



The Department's modeling report has also established maximum nutrient input (or application) rates for the Peel Harvey catchment in unamended soils, designed to achieve nutrient export loads within the thresholds mentioned above. Nutrient input rates are calculated, based on past practice of using broadcast granular fertilisers to be less than 6.5 kg/ha/year for TP and less than 45 kg/ha/year for TN. In unamended soils these input rates will result in a maximum export rate of 0.28 kg/ha/year for TP according to the model. For amended soil, the model showed a decrease in total annual phosphorous loading of 68 % in the Nambeelup area. With combined implementation of amended soil and improved fertiliser efficiency, the model indicated an annual phosphorous loading reduction of 79 %. (DoW 2011)

It is anticipated that under foliar fertilising regimes (not more than 3 kg/ha of total elemental nutrients per ha per event), Net Primary Productivity (the production of pasture) will be very high, being potentially in to order of 100 tonnes wet weight or 13 tonnes dry weight per ha per year. The policy target input into non-amended soils is 6.5 kg elemental phosphorous and 45 kg elemental nitrogen per ha. Calculations show that this will produce a maximum dry weight of 2.2 tonnes of pasture. We therefore propose to undertake monitoring of phosphorous and nitrogen content of biomass removed from the site, either as mown or baled pasture. This will be determined by leaf tissue analyses of pasture, and dry mass per square meter. The data so generated will be used to calculate an overall mass balance of above ground TP and TN outputs relative to input.

Further, it is anticipated that deep rooted perennial grasses will lead to the progressive accumulation of carbon in the soil as plant roots, humus and microbial biomass. This total biomass is expected to contain a significant proportion of the applied phosphorous, and therefore will also be sampled and analysed. Below ground biomass will also be measured, to enable an understanding of the complete (above ground and below ground) nutrient mass balance. The maximum phosphorous (6.5 kg/ha/yr) and nitrogen (45 kg/ha/yr) input rates recommended by the Department of Water and Environmental Regulations will not be exceeded unless mass balance calculations demonstrate that at least 90% of these values have been exported from the site, or are in the form of stable biomass.

When this mass balance demonstrates that 90% of the applied P is accounted for by in situ or removed biomass then that same amount of P, being another 5.85 kg/ha of elemental P (90 %) can be applied. By this approach, maximum productivity can be achieved, while meeting the target of minimal or zero nutrient export. Adding phosphorous beyond 6.5 kg/ha/year and nitrogen beyond 45 kg/ha/year will not be allowed if lysimeter and monitoring bore data indicates that P and N is increasing in groundwater.

To minimize phosphorous and nitrogen export, all nutrients will be applied through foliar spray. The science underlying foliar applications of fertiliser has advanced considerably in the last decade. Foliar spray will be applied when the pasture is established and the Leaf Area Index is high. Using appropriate adjuvants in the foliar spray mix, it is anticipated that more than 90% of the applied phosphorous will be directly taken up by foliage (Peirce et al. 2014). Therefore, application of phosphorous to soil will be significantly lower than existing granular fertiliser practice. Nitrogen will be applied in the form of ammonium nitrate, calcium nitrate and urea in the foliar spray.



Additionally, a range of measures to prevent nutrient leaching such as deep-rooted pastures, irrigation scheduling according to current soil conditions, soil amendments to increase phosphate binding and runoff collection will be implemented, as well as a groundwater and surface water monitoring system. These measures are described further in this report (Chapter 8 and following).

Nutrient formulations will be based on hydroponic principles and include appropriate balances of all 6 major and 6 trace elements. Foliar spray rates will be based on leaf tissue analysis, soil analysis, mass balance, growing season, type of pasture and the stage of development of the plants.

8 Drainage and Nutrient Leaching Control

8.1 Drainage Management

As explained in Chapter 7.1, irrigation will be according to existing soil moisture and plant requirements to prevent soil saturation and runoff. After the proposed earthworks, the soil will have a good draining ability allowing stormwater from most rain events to infiltrate the ground. However, it is understood that the site is located in an environmentally sensitive area and drainage leaving the site should be avoided to prevent nutrient leaching.

It is possible that in late winter, when perched groundwater levels approach maximum, drainage water from heavy rainfall events at the pivot irrigation area could produce runoff. Such runoff will be directed via spoon drainage at the outer perimeter of the pivot to the vegetated, non-irrigated sector south-west of the pivot (Figure 7). The capturing structure will be approximately 4 ha and will be slightly depressed (0.25 m deep). The spoon drain and the vegetated capturing structure will be lined with high PRI calcined spongolite. These areas will not be fertilised beyond the need to establish phreatophyte vegetation.

8.2 Contaminant Leaching Control

8.2.1 Fertiliser Use Efficiency

On site, best management practices will be used to improve fertiliser use efficiency:

- Fertiliser applications will be based on the developmental stage of the plants;
- Fertiliser applications will be recorded to assist future fertiliser management decisions;
- Application of fertiliser via boom spray for uniformity of nutrient input across the site;
- Application rates will be determined by leaf tissue analysis and mass balance.

8.2.2 Water Use Efficiency

On site, water use efficiency will be achieved through the following:

- The decision of when and how much to irrigate will be based on weather forecasts, soil moisture levels and plant requirements;
- Current soil conditions measured by probes will be accessible anytime via internet;



- Remote computer-controlled irrigation system that can be started and stopped anytime;
- High precision and uniformity at low application rates (11 mm per day maximum) will avoid soil saturation, to prevent seepage to groundwater.

9 Protection of Natural Water Resources

The objective of the project is to maximize pasture growth under environmentally responsible practices. The following chapter describes the steps to be undertaken to avoid nutrient leaching.

To confirm exports of nutrients from the proposed activity are minimal and conform to guideline values, monitoring probes, groundwater bores and lysimeters will be installed. Shallow lysimeters and monitoring probes provide locally important data, because they are not influenced by nutrient inputs from off-site.

Lysimeters will be portable vacuum lysimeters. These will be located throughout the trial areas and be re-located as necessary to the most appropriate areas as demonstrated by data produced. Note that vacuum lysimeters are a more advanced technology than conventional gravity lysimeters more commonly used. Such standard gravity lysimeters can only collect excess water (i.e. water beyond field capacity) and are very difficult to move without substantial ground disturbance. Given the soil moisture probes guiding irrigation capacity, soils will only exceed field capacity during heavy rainfall events. A vacuum lysimeter is able to recover soil moisture when it is below field capacity, even at wilting point.

Groundwater nested monitoring bores will also be installed upstream and downstream of the site to measure nutrient levels entering and leaving the site (Figure 12). This will provide an enhanced ability to understand the origins of nutrients.

/\ Note that the 1 ha trial will have its own intense monitoring program. This is further detailed in the Pilot Project Scope Report /

Groundwater will be monitored on a monthly basis. Over many years Bioscience has undertaken groundwater analysis of a number of bores west of the site, which shows that soluble anions phosphate, nitrate and sulphate, and the cation iron, show marked variations (by orders of magnitude) over relatively short time intervals, and independently of each other. At least a year of monthly monitoring data from both upstream and downstream bores is required to understand natural variance and stochastics before meaningful trigger values can be determined.

During the first year an acceptable trigger is when a nutrient concentration exceeds two standard deviations above the accumulated mean. If the trigger is exceeded, the contingency plan described in Chapter 10 becomes effective.

Two monitoring bores (MB1 (Deep & Shallow) and MB2 Deep & Shallow)) will be installed upgradient of the pivot area. Likewise another pair of bores (MB3 Deep & Shallow) and MB4 Deep & Shallow)) will be installed down-gradient.



Monitoring will start upon development approval and will follow the below commitments (Table 3).

Table 3: Monitoring Commitment

Commitment	Location	Frequency
Flow meter reading	Serviced production bores	Monthly
Groundwater level measurements	MB1 D&S, MB2 D&S, MB3 D&S, MB4 D&S	Monthly
Sample and water analysis	MB1 D&S, MB2 D&S, MB3 D&S, MB4 D&S	Monthly
Lysimeters	To be provided	Monthly
Annual report	n/a	Annually

Flow meter readings, groundwater level measurements and sampling will be recorded monthly, at least 20 days apart. Water sampling will be conducted as per AS/NZS 5667.11:1998. Water quality analyses will be carried out by Bioscience and a NATA accredited lab and will test the following:

- pH
- EC
- TDS
- Nitrate N
- Ammonium N
- Total N
- Reactive P
- Total P
- Chloride
- Sulphate
- Cations (calcium, magnesium, potassium, sodium)
- Metals (iron, manganese, zinc, copper)

The rate of aquifer drawdown due to irrigation will be inferred from the water level monitoring and rainfall data and will be assessed once a year.

10 Contingency Plan

The objective of contingency planning is to provide assurance that the *Water quality improvement plan for the rivers and estuary of the Peel-Harvey system - phosphorous management* (EPA 2008) will not be compromised because of the site development.

The attainment of this objective cannot be judged without reference to existing groundwater nutrient values due to past and existing agricultural usage of the site and surrounding land.



Water quality data will be collected from monitoring bores upstream of the site for reference purposes.

Comparing upstream and downstream monitoring bores will provide data about the site's influence on nutrients in groundwater. Therefore, nitrogen and phosphorous concentrations from the upstream and downstream monitoring bores will be compared. Nutrient levels should be the same or lower than upstream levels within a yet unknown lagtime, to show the site is not leaching nutrients. It is noted that within the region (based on data obtained from other premises), nutrient spikes seem to occur randomly without the influence of fertiliser input.

Once a year of upstream monitoring data is collected, a significant increase (two standard deviation units) of nutrient levels from the annual mean will be set as a trigger value. For the first year the mean of collected data will be calculated at each monitoring. If a measured N or P value exceeds the mean by two standard deviation units, monitoring will be repeated within two weeks. If the particular nutrient remains high, the source of nutrient spikes will then be investigated through intensifying of monitoring and comparing data from foliar spray rates to data retrieved from probes, lysimeters and soil analysis that provide direct information about nutrient input and possible leaching.

Table 5 lists the trigger levels and the associated contingency actions. If any water in the shallow lysimeter occurs which is not explained by a rain event, then the irrigation volume will be reduced, the probes recalibrated and the lysimeter re-checked within one week. If lysimeter water shows phosphorous or nitrogen concentrations in excess of 0.1 mg/L the foliar fertilizer rate and irrigation volume will be reduced. If monitoring probes show soil saturation at 50 cm below the surface, the irrigation volume will be reduced. If the total nitrogen or total phosphorous concentrations of the downstream bore are two standard deviation units above the annual mean, the phosphorous and nitrogen input rate will be reduced. If nutrients concentrations exceed the annual mean by more than two standard deviation units at the consecutive monitoring, foliar spray and irrigation will stop until the cause of nutrient spike is determined and rectified. If two successive monitoring events and lysimeters and /or probes indicate nutrient leaching, the fertiliser rate will be reduced. If the water quality does not show improvement over the following monitoring event, foliar spray will stop and the water application rate will be reduced (Table 5).

Table 5: Contingency Actions

Monitoring	Trigger levels	Contingency actions	Monitoring Interval	Follow Up Monitoring Interval
Lysimeters	Any water volume collected in lysimeter which is not explained by rain event	Reduce irrigation volume and recalibrate Sentek probes, recheck lysimeter within 1 week	Monthly	Monitoring interval + 2 weeks
Lysimeters	Consecutive monitoring: Any phosphorous or nitrogen in excess of 0.1 mg/l	Reduce foliar spray and irrigation volume	Monthly	Monitoring interval + 2 weeks
Monitoring Probes	Soil saturated at 50 cm below surface	Reduce irrigation	Daily	Monitoring interval + 2 weeks



Upstream Bores	Data collection only	Data collection only	Monthly	Monitoring interval + 2 weeks
Downstream Bores	Nitrate or phosphate two standard deviations from annual mean	Reduce phosphorous and nitrogen input	Monthly	Monitoring interval + 2 weeks
Downstream Bores	Consecutive monitoring: Nitrate or phosphate two standard deviations from annual mean	Stop foliar spray and irrigation until cause is determined and rectified	Monthly	Monitoring interval + 2 weeks

11 Vegetation Management

11.1 Clearing

The site is substantially cleared of vegetation. Scattered trees might need removal to enable the earthwork and the installation of the pivot irrigation.

11.2 Erosion Control

Deep-rooted pastures improve soil structure and control erosion on the site.

11.3 Water and Nutrient Application Matching Plant Needs

As previously explained in Chapter 7.1, the irrigation intervals and duration will be determined by weather forecasts. The demand for water is greatest during summer months.

12 Pesticide and Storage Use

No pesticides will be stored onsite. Although no pesticides are likely to be used routinely, it is anticipated that insecticides may be required during the establishment phase of lucerne.

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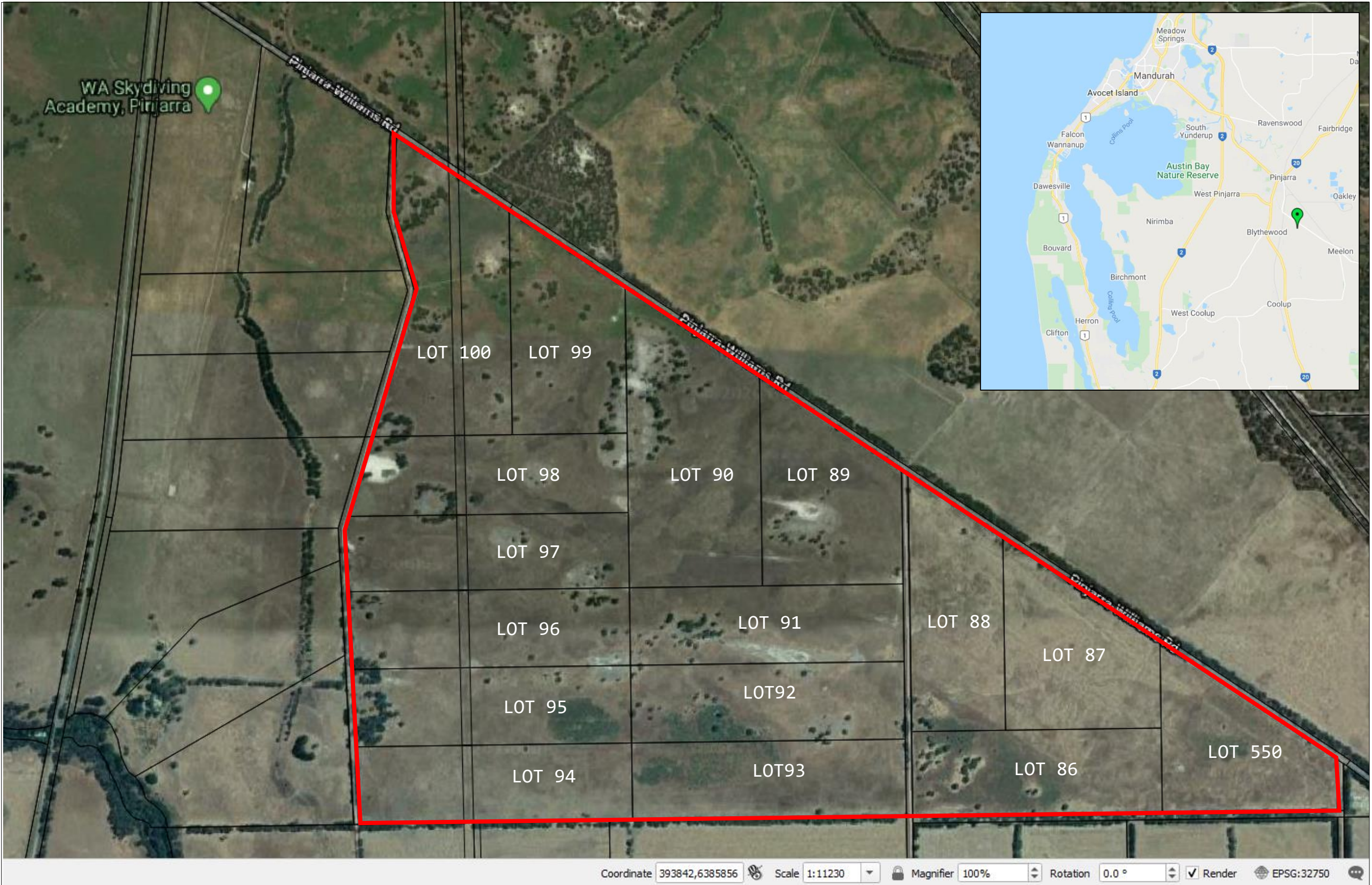


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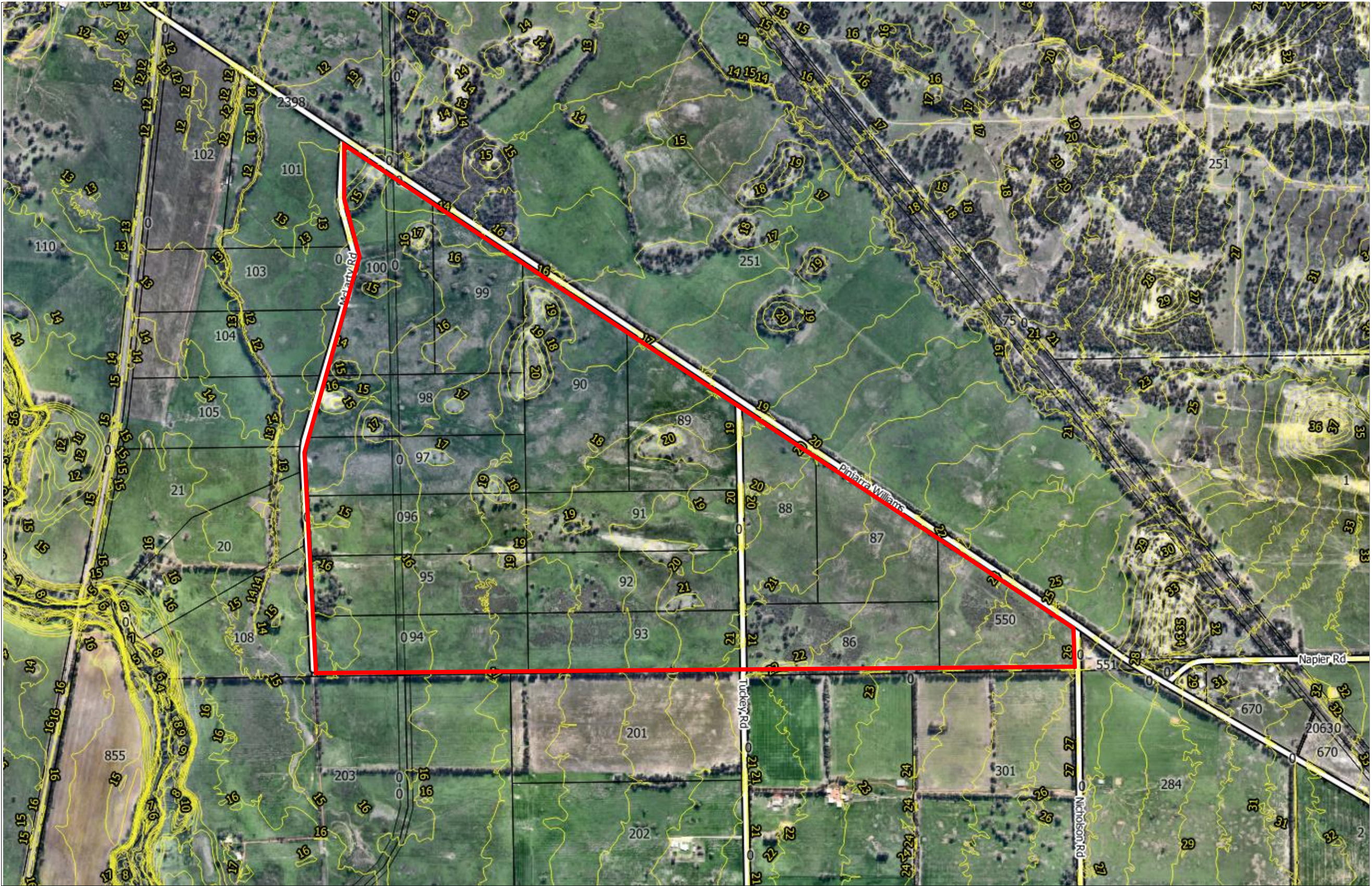


FIGURE 2. LiDAR

Lots on McLarty Rd x Pinjarra Williams Rd, Meelon WA 6208

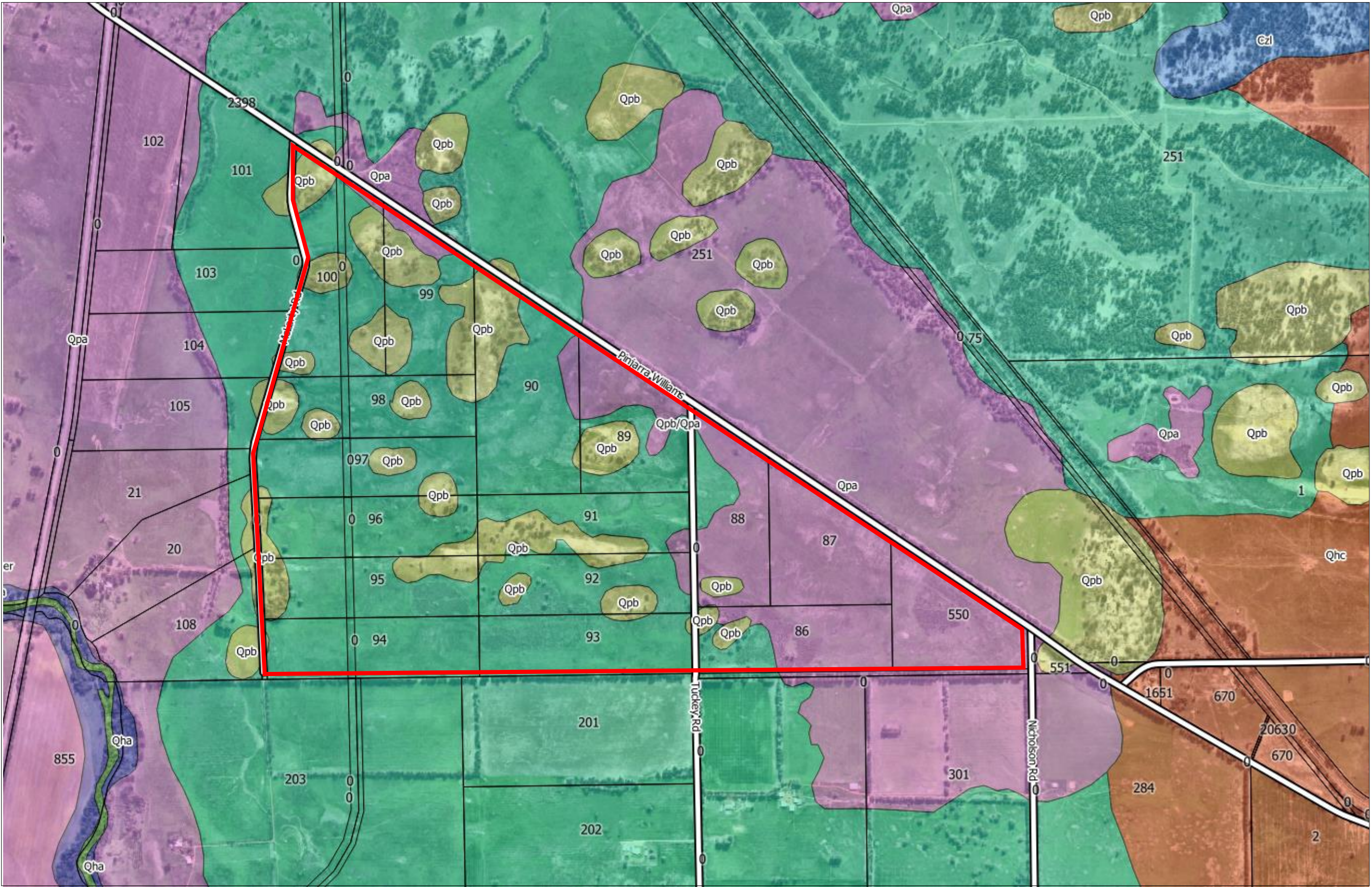
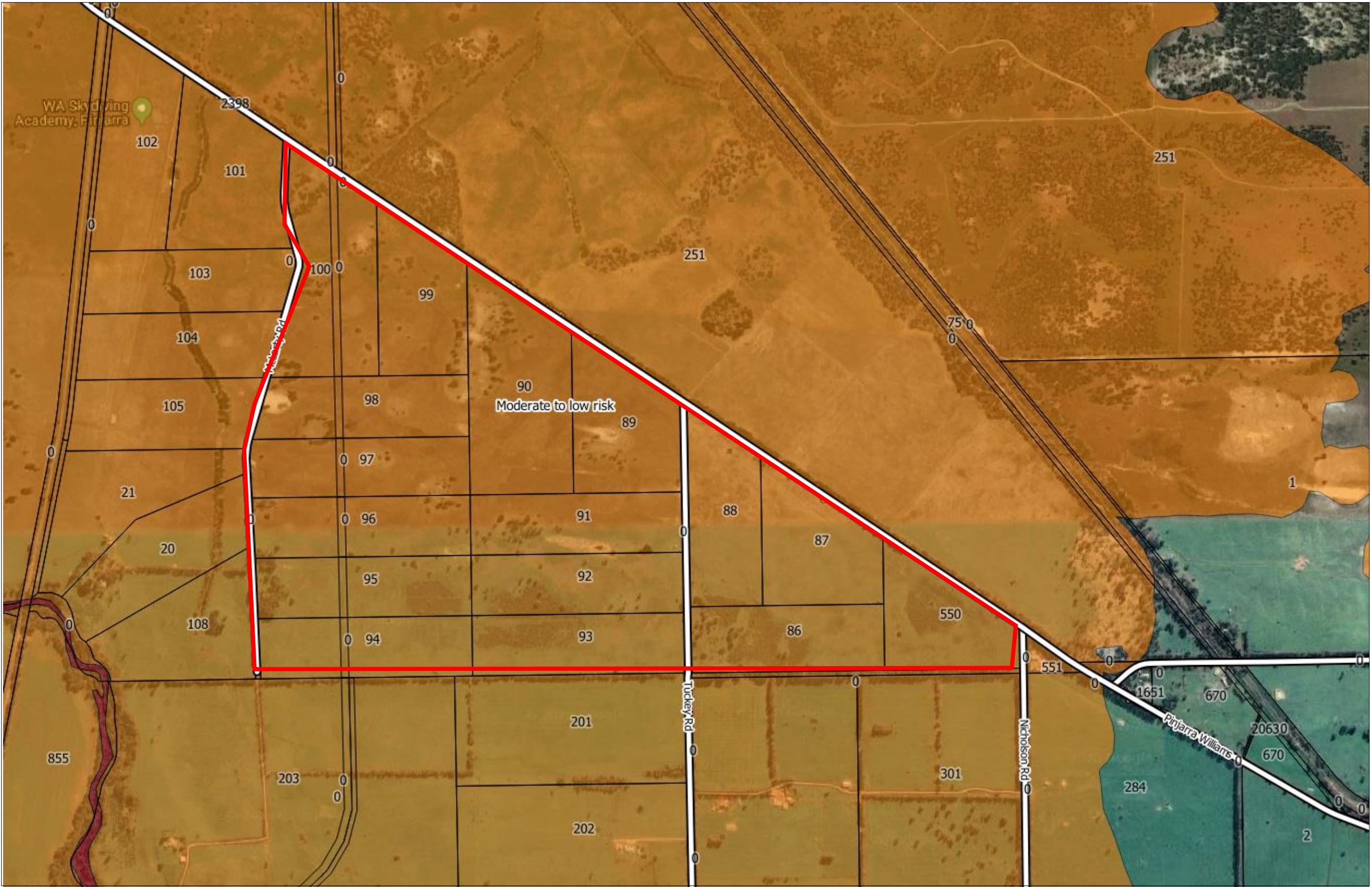


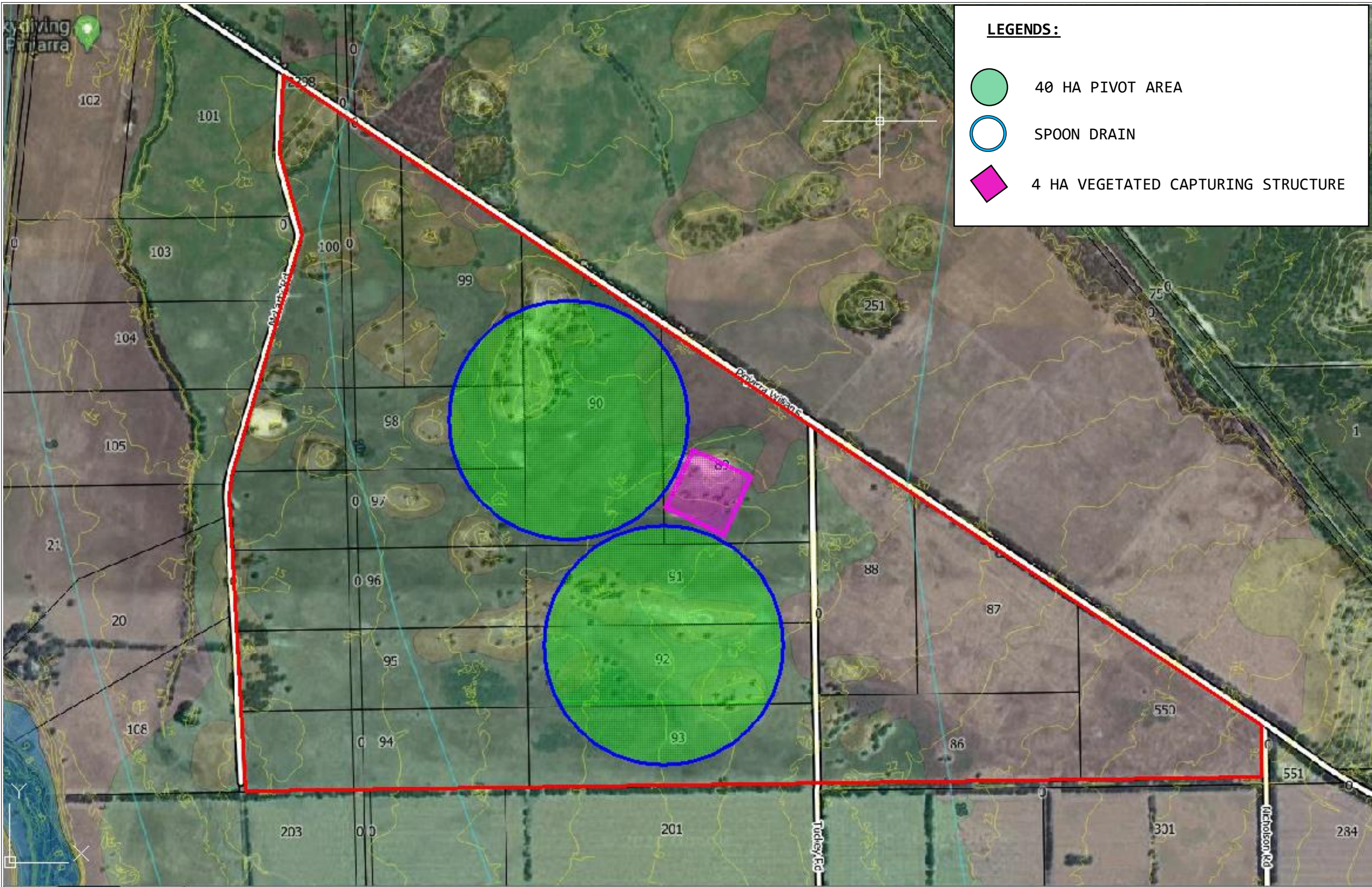


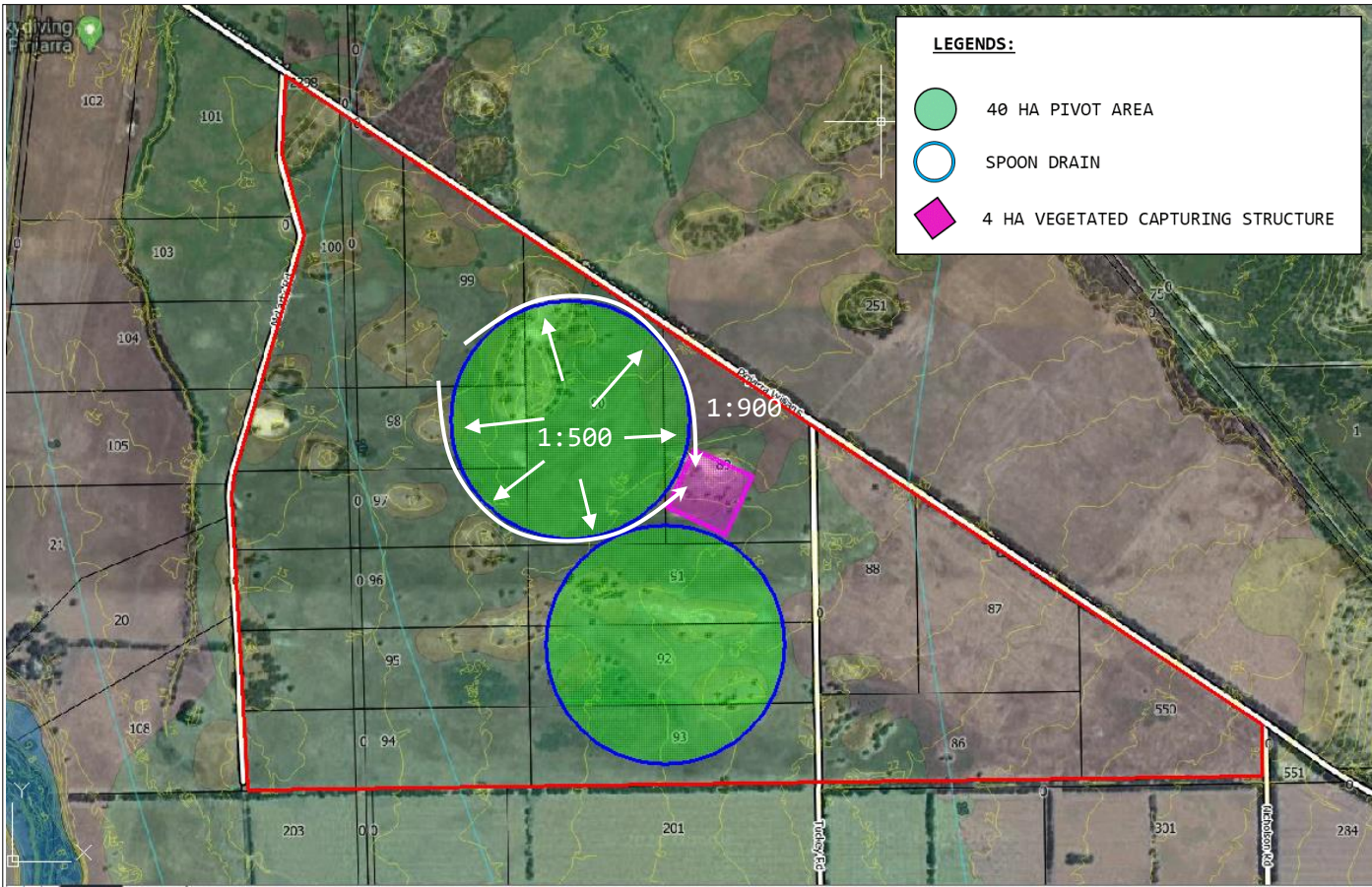
FIGURE 4. NRinfo – Soil Type

Lots on McLarty Rd x Pinjarra Williams Rd, Meelon WA 6208

SOURCE: NRinfo







Description	Value	Unit
Pivot area	40	ha
Radius	355	m
Pivot area gradient	0.002	1: 500
Pivot centre elevation	20	mAHD
Perimeter drop	0.71	m
Perimeter elevation	19.29	mAHD
Spoon drain spill crest lvl at apex pt	19.29	mAHD
Spoon drain depth	0.25	m
Spoon drain invert lvl at apex point	19.04	mAHD
Spoon drain gradient	0.0011	1: 900
Spoon drain length (each)	1114.7	m
Spoon drain drop at discharge loc	1.24	m
Spoon drain spill crest level at discharge loc	18.05	mAHD
Spoon drain invert level at discharge loc	17.80	mAHD
Compensation basin depth	0.25	m
Compensation basin spill crest lvl	17.80	mAHD
Compensation basin invert lvl	17.55	mAHD
Max groundwater level (perched)	17.4	mAHD

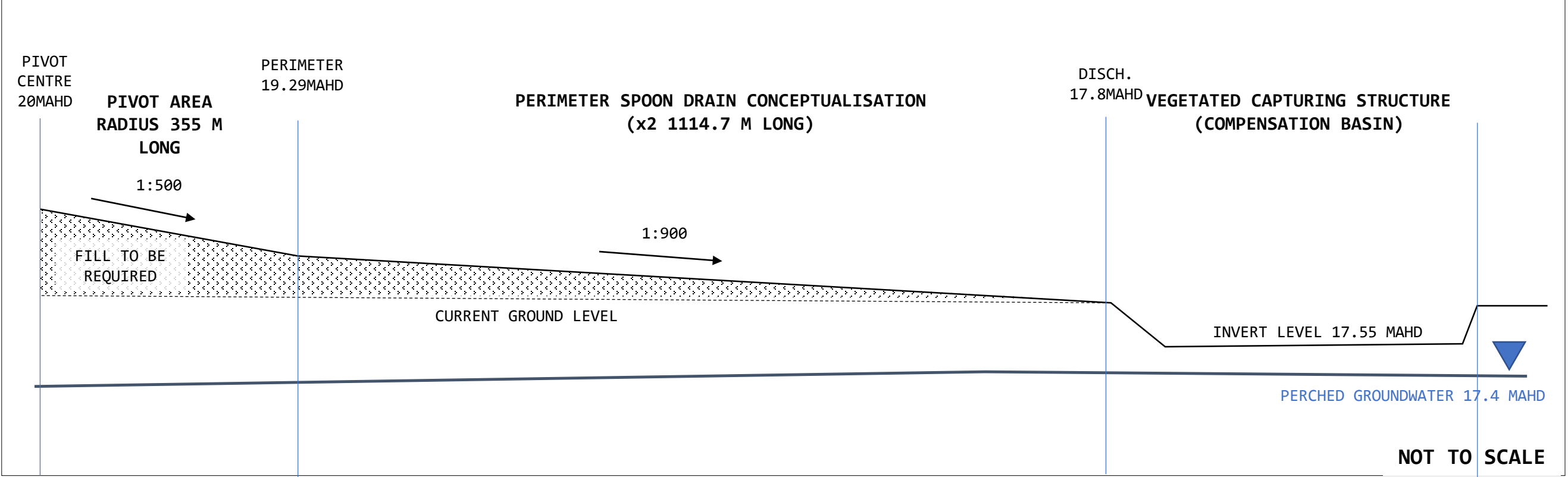




FIGURE 8. Geomorphic Wetlands

Lots on McLarty Rd x Pinjarra Williams Rd, Meelon WA 6208

SOURCE: DBCA database

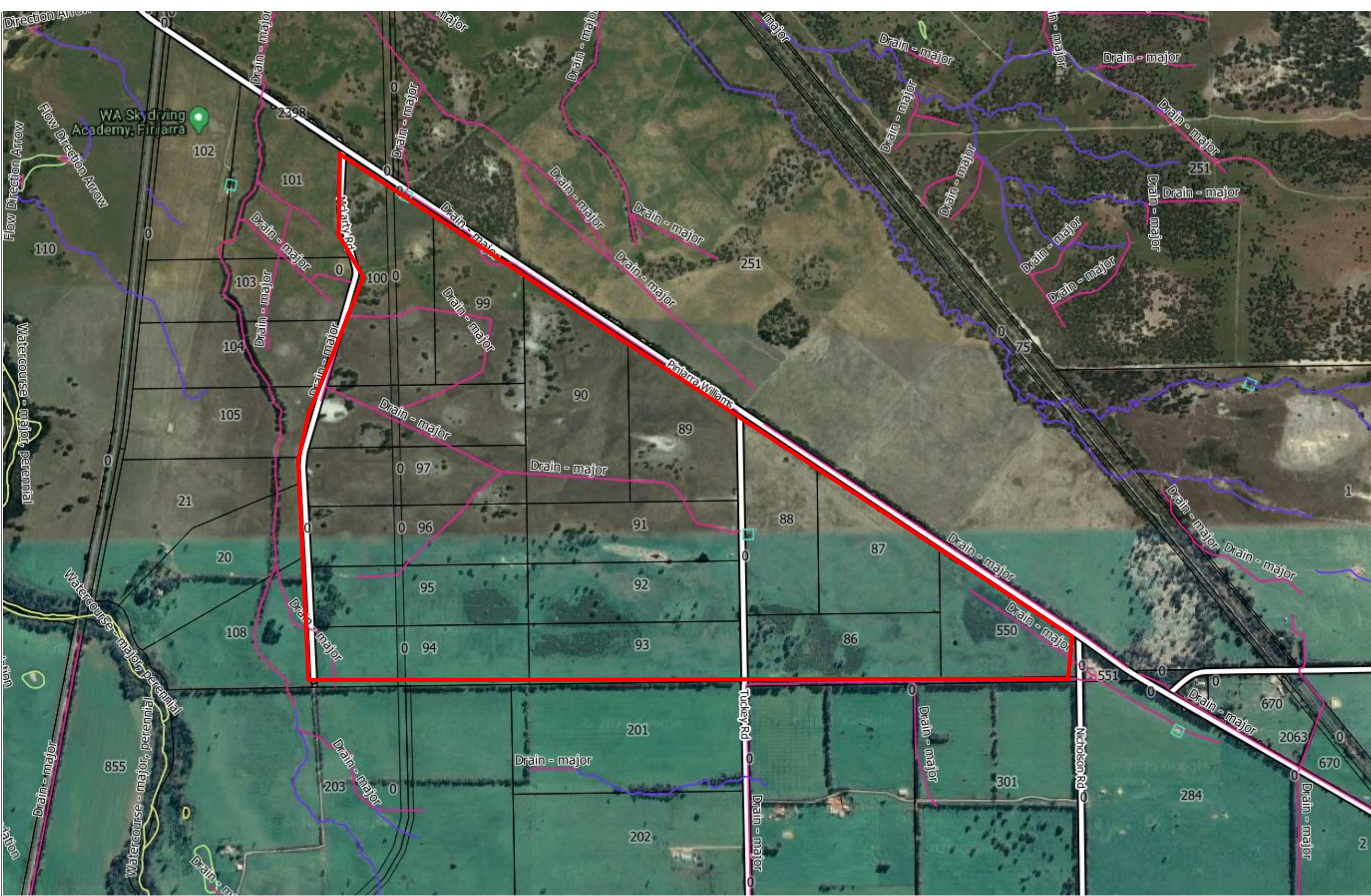
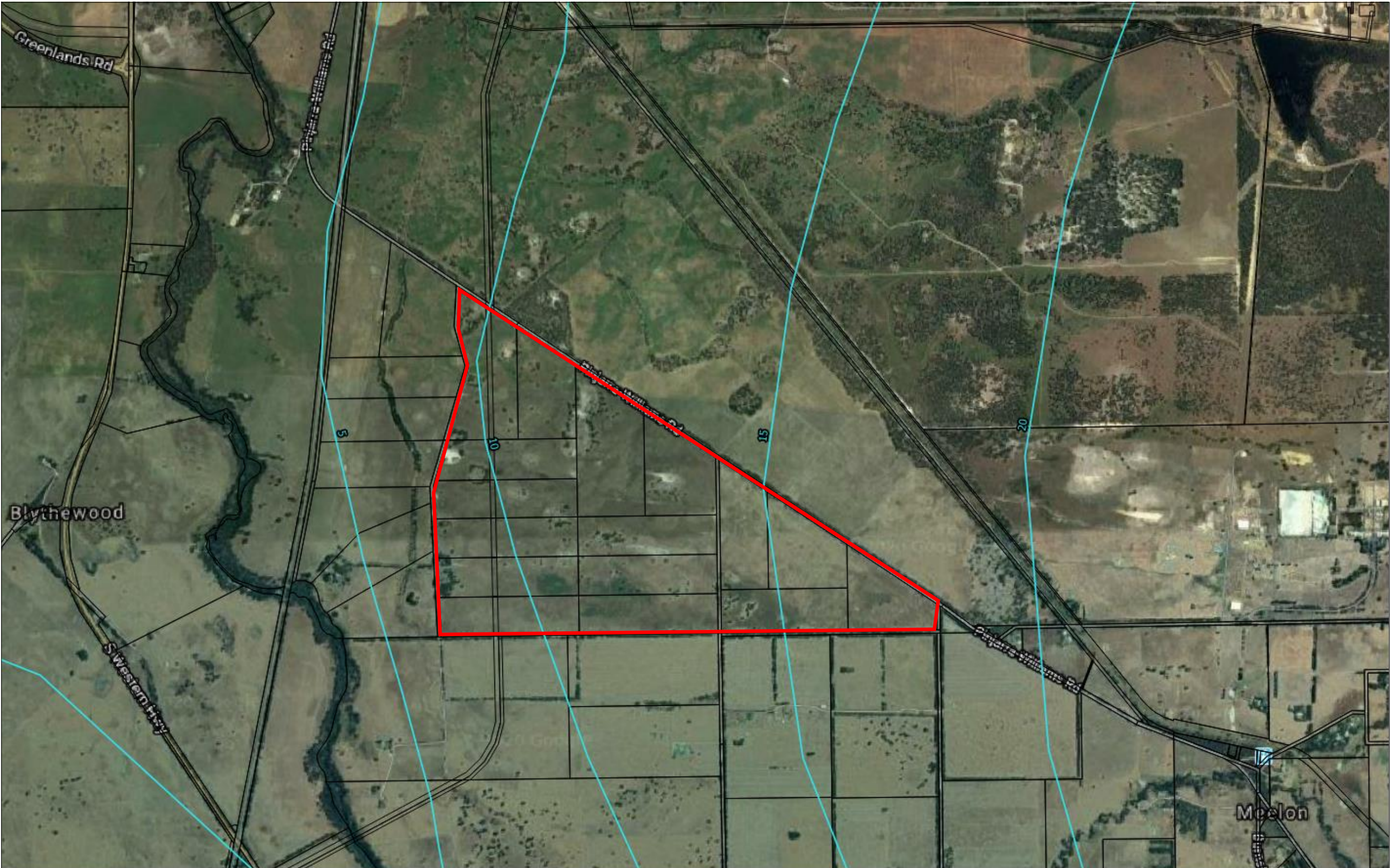


FIGURE 9. Drainage Lines

Lots on McLarty Rd x Pinjarra Williams Rd, Meelon WA 6208

SOURCE: DWER database





Coordinate 392927,6387120 Scale 1:22460 Magnifier 100% Rotation 0.0 ° Render EPSG:32750



FIGURE 11. Groundwater Flow

Lots on McLarty Rd x Pinjarra Williams Rd, Meelon WA 6208

SOURCE: DWER database, Groundwater conours May 2008

