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Integrating Resource Management

Nutrient Management Plan:
121 King Road, Oakford WA 6121

Kieu LP Family Pty Ltd
74 Gladstone Road Rivervale 6103
Western Australia
July, 2016

Nutrient Management Plan
121 King Road, Oakford WA 6121

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Document Control

Issue	Date	Author	Reviewer	Approved
1	08/09/2015	D. Alanoix	P. Keating	P. Keating
2	19/11/2015	D. Alanoix	P. Keating	P. Keating
3	06/01/2016	D. Alanoix	P. Keating	P. Keating
4	07/07/2016	D. Alanoix	P. Keating	P. Keating

Contents

Introduction

This Nutrient and Irrigation Management Plan (NIMP) was prepared by Bioscience Pty Ltd, as per the guidelines of WQPN 33, on behalf of Kieu LP Family Pty Ltd. This NIMP follows the guidance information of WQPN 25 and was written in conjunction with advice and recommendations found in WQPN 17.

Kieu LP Family Pty Ltd has recently purchased Lot 14 (121) King Road Oakford. The proponent is seeking to develop the property as a vegetable farm, growing cucumbers under 25 tunnel houses. The property is 4.05 ha, of which 1 ha will be used for the production.

The property is within a Priority 2 (P2) area of the Jandakot Mound Public Drinking Water Source Area (PDWSA). The proponent understands the *risk minimisation* principle of P2 areas and in the non-commercial areas of the property, commits to not over-water, avoid excessive or poorly timed use of fertilisers or pesticides, and to avoid inappropriate storage of chemicals and disposal of wastes that can leach contaminants.

A closed system, recirculating fertigation will be used for commercial operations on the site.

1 Summary of the Land Use Proposal

Proponent's name:	Kieu LP Family Pty Ltd of 74 Gladstone rd, Rivervale WA 6103
Contact details:	04 1358 8330
Site location:	Lot 4 (121) King Rd, Oakford WA 6121 (Figure 1)
Project description:	The proponent is seeking to develop the property as a vegetable farm, growing cucumbers under 25 tunnel houses. The property is around 4.05 ha, of which 1 ha will be used for the production.
Timetable:	Anticipated start of production is within 8 weeks of acceptance. Operations on site will last over 30 years.

2 Project Setting

A site layout map is presented in Figure 2. As per the shire's requirement, a 10 m and a 20 m setbacks are planned respectively to the north/south and east of the proposed development. The site will also include a 3 m firebreak and a 5 m vegetated screen.

The site is zoned "Rural Groundwater Protection" under the Shire of Serpentine-Jarrahdale's local planning scheme 2, and is surrounded by properties of the same zoning to the south and the north, by Modong Nature Reserve to the west and by rural lots to the east. The boundary of the Groundwater Protection Zone is the Eastern border of Lot 14.

Lot 14 (121) King Rd is thus within a Priority 2 (P2) area of the Jandakot Mound Public Drinking Water Source Area (PDWSA). The property is not within an area currently defined as WHPZ or RPZ or originally proposed as WHPZ's when the GPZ was envisaged in the 1990's.

3 Land Use and Nutrient Application Details

Kieu LP Family Pty Ltd intends to establish a vegetable farm, growing cucumbers under 25 tunnel houses. The tunnel houses will occupy 1 ha of the 4.05 ha property.

Non-commercial (domestic) gardening operations that require negligible irrigation and chemical inputs, as proposed by Kieu LP Family Pty Ltd, is a compatible activity in P2 areas, as long as conditions 6 and 11, as they appear in WQPN 25, are respected. Both conditions are detailed below:

- ***Condition 6.*** Pesticides should be applied in accordance with best management practices (i.e. in accordance with label directions). For more information see the Department of Water's Statewide policy no. 2: *Pesticide use in public drinking water source areas,* WQPN no. 104: *Aerial spraying of crops with pesticides*, WQPN no. 22: *Herbicide use in wetlands, brochure: Liquid chemicals on agricultural land: transport, blending, storage and disposal and the Department of Health's A guide to the use of pesticides in Western Australia and Circular no. PSC88: Use of herbicides in water catchment areas.*

- ***Condition 11.*** Fertilisers should be applied in accordance with best management practices. For information on fertiliser management refer to the activity-specific documents in the *Guidance information* column and our brochures Fertiliser application on pasture or turf near sensitive water resources and Liquid chemicals on agricultural land: transport, blending, storage and disposal.

No livestock will be living on the property. A peak number of 5 people will be working on site.

4 Local Rainfall, Evaporation and Interception

The area has a Mediterranean climate with cool wet winters and warm to hot dry summers. Average rainfall data was obtained from the Bureau of Meteorology records, recorded at the Medina Research Centre situated 9.5 km to the north west of the property. Average monthly rainfall data and annual totals recorded since 1983 are presented in Table 1. The majority of rainfall occurs between April and September whilst the remaining months are characteristically dry and hot, resulting in large evaporation losses.

Evaporation data obtained from Perth Regional Office is also presented in Table 1. Evaporation is likely to be similar to the Perth area which has an annual evaporation of 1716 mm, exceeding annual average rainfall by a factor of 2:1. Monthly rainfall typically only exceeds evaporation during the winter months.

Soil on site consists mostly of coarse to medium textured sand. Infiltration in such soils is in the order of 10-4- 10-5 m sec-1(Look 2007). This translates to the capacity of soil to handle rainfall in excess of 36 – 360 mm per hour. Accordingly, even in the heaviest rainfall events, rain water in the undeveloped parts of the property will infiltrate soils and not lead to runoff.

Table 1: Average annual rainfall and evaporation data

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Average Rainfall (mm)	11.5	18.8	19.3	39.4	98.5	140.8	145.9	112.5	78.2	40.1	31.4	11.4	752.5
Average Evaporation (mm)	257	218	195	120	78	57	71	102	99	148	189	253	1716

5 Soils and Landform Description

5.1 Land Contours

The site has not been surveyed. Discussions of land contours are based on Nearmap observations. The site is generally flat with surface elevations ranging between 23 and 25 mAHD (Figure 3).

5.2 Soil Type

The Geological Survey of WA's Environmental Geology Map (Armadale) describes the site as Qpb/Qpa, i.e. thin Bassendean Sand layer over Guildford Formation (Figure 4).

5.3 Soil Strata

The property is located within the Perth (sedimentary) Basin and is overlain by superficial formations of Quaternary age comprising of Bassendean Sand and the Guildford Formation. Locally the superficial formation unconformably overlies the Leederville Formation consisting of the Pinjar, Wanneroo and Mariginiup Members of Cretaceous age. The Leederville Formation conformably overlies the South Perth Shale.

Superficial formations within the area consist of a variable sequence of fine and medium sand with minor silt and limestone (mainly Bassendean sand) that interfinger with a sequence of clay and clayey sand (Davidson & Yu, 2006).

5.4 PRI

Bassendean sands system is known to have very low PRI, ranging between 2 and 5 mg/L within the vicinity of the site (Safstrom and Short 2012). PRI has not been used as an analytical measure of phosphate sorbance since 1992, but rather phosphate sorbance is in current use, and has been measured at 6.1%, so is considered a low phosphate sorbing capacity.

5.5 Acid Sulfate Soil

The ASS Risk Map (Figure 5) defines the area as Class 2 - moderate to low risk of ASS for depths within 3m below natural ground.

5.6 Proposed Earthwork Details

A drainage sump (i.e. a 2,000 L sunken concrete tank lined with waterproof rubber paint) will be installed within the production area.

The installation of the sump will involve minor earthworks and under the threshold volume specified by DER as requiring an Acid Sulfate Assessment and Management Plan. Apart from these, minor earthworks are expected in the property by moving surface soil to make the site level for tunnel houses.

5.7 Imported Soil Amendments

No imported soil amendments will occur within the property. However it is noted that commercial greenhouse plants will be grown in porous soil media contained on sealed drainage channels.

6 Water Resources Description and Use

6.1 Sensitive Water Resources

6.1.1 Wetlands

Five sensitive water resources exist within a 500 m radius of the site (Figures 6 and 7.2), of which:

- Two are Conservation wetlands; UFI 15181 and UFI 7182, located respectively 500 north west and 300 m south east of the proposed operations;
- Two are Resource Enhancement wetlands; UFI 7184 and UFI 7180, located respectively 490 m south and 100 m south east of the operations; and,
- One Multiple use wetland, existing at proximity of the property.

Regional groundwater flow, based on groundwater contours of the Perth Groundwater Atlas, is in a south easterly direction.

Wetlands located down-gradient (with respect to groundwater flow) of the proposed activities might be prone to some risks should the closed system, recirculating fertigation be compromised. Best management practise is expected to prevent such event from happening.

6.1.2 Groundwater Users

Three groundwater users abstracting water from the Superficial aquifer (GWLs 58947, 58776, 101661) are located down gradient of the proposed activities. Best management practice will be used on site to prevent negative impacts on these users.

6.2 Seasonal or Occasional Flooding

Based on the maximum water level recorded within the vicinity of the site (i.e. around 23 mAHD, Perth Groundwater Atlas) and Nearmap observations, the site is not prone to flooding.

6.3 Groundwater Description

The groundwater resources of the central Perth Basin are described in detail by Davidson (*Hydrogeology and Groundwater Resources of the Perth Region Western Australia*) and Davidson & Yu (*Perth Region Aquifer Modelling System*). The following description of the superficial aquifer is drawn from Davidson (1995), Davidson and Yu (2006) and regional monitoring bore data provided by the Department of Water.

6.3.1 Aquifer Description

An unconfined aquifer with an average thickness of 30 m occurs beneath the site and the surrounding area. Regionally, the sediments of the superficial formation are comprised of predominantly Bassendean Sand and with some clayey sediments of the Guildford Formation. The Bassendean Sand represents a highly permeable sandy aquifer with an average horizontal conductivity of 15 m per day. In comparison, the Guildford Clay has a low hydraulic conductivity of less than 0.1 m per day (Davidson, 1995).

Underlying the Superficial aquifer, the Leederville aquifer is a multi-layered aquifer consisting of discontinuous inter-bedded sandstone, siltstone and shale of the Leederville Formation. The thickness of the Leederville aquifer ranges from 0 m at the base of the Darling Scarp and increases towards the West to approximately 150 m thickness below the site.

6.3.2 Groundwater Flow, Discharge and recharge

Groundwater flow within the superficial aquifer is influenced by gravity, with a downward hydraulic gradient and away from the crests of the groundwater mounds. Groundwater flow direction was interpreted from the Perth Groundwater Atlas. The direction of flow is in a south easterly direction (Figure 7.1) and terminates at the discharge boundary formed by major drains within the area.

The superficial aquifer within the Perth region is divided into a number of discrete hydrogeological areas. The site is situated on the south eastern boundary of the Jandakot Mound. Recharge within the Jandakot Groundwater Mound occurs directly by rainfall infiltration and apart from discharge boundaries, are characterised by the absence of surface runoff. Based on Jandakot Mound estimates of groundwater flow in the superficial aquifer (Davidson, 1995), 11% of total rainfall recharges the aquifer of which 1% is downward leakage and 10% net through-flow.

6.3.3 Groundwater Level

Topography, hydraulic conductivity of the sediments and location within the groundwater flow system influence the depth to the watertable. Based on Perth Groundwater Atlas hydrography, the local depth to groundwater is within a range of two to four meters depending on the seasons and surface elevations.

6.3.4 Groundwater Quality

The physical and chemical properties of groundwater within the superficial aquifer vary mainly with geological location and position within the groundwater flow system relative to recharge and discharge points. To the north of the site recharge areas associated with the Jandakot Mound have low groundwater salinity.

Based on the groundwater salinity contour map of the superficial aquifer presented by Davidson (1995), salinity gradually increases in the direction of groundwater flow away from the Jandakot Mound. Underlying the site, groundwater is fresh ranging from 500-1000 mg/L TDS becoming brackish to saline (>1500 mg/L TDS) towards regional discharge areas in the south and increasing prevalence of Guildford Clay within the superficial formation.

Groundwater at the watertable within the Bassendean Sand is generally acidic, with a pH range of 4.0 to 6.5 and becomes neutral towards the base of the aquifer (pH range of 6.5-7.5). Groundwater within the Bassendean Sand is typically sodium chloride-rich.

Water quality observed on site (Appendix A) was deemed to be of an excellent quality and will not require reverse osmosis.

6.4 Source of Irrigated Water

The site lies within the Jandakot Mount 1 subarea of the Serpentine groundwater area. Groundwater resources are administered under the Rights in Water and Irrigation Act (1914, amended 2001) by the Department of Water (formally the Water and Rivers Commission).

The property currently has a groundwater well licence, GWL 165673 allowing abstraction of 10,630 kL/annum. The current allocation is insufficient for the proposed activities; it is therefore Kieu LP Family Pty Ltd's intention to apply to amend the current licence and increase the allocation to 40,000 kL/annum. A Form 3G has been submitted to the Department of Water.

Abstraction will be done on site via the existing production bore (screened in the Superficial aquifer).

7 Site Management

7.1 Irrigation Scheme

7.1.1 Description

A closed system, recirculating fertigation will be used on site. The recirculation fertigation systems used to grow cucumbers delivers a nutrient solution to plants growing in soil conforming to the Australian Standard 4419 contained within a polyethylene plastic membrane over a Styrofoam box section gully which ends in a PVC drainage channel. The gully is set on a 1:50 slope and the drainage channel is set at a 1:100 slope. Drainage water flows from the end of the gully then via the drainage channel to a drainage sump. Water is pumped from the drainage sump to recirculation tanks. Double protection is afforded by all gullies being on waterproof plastic coreflute.

Water from the recirculation tank is blended with fresh water, then fertiliser salts, dissolved in two fertiliser concentrate tanks are added to produce the fertigation solution to a concentration specified by the stage of development of the crop, and automatically controlled by dosing pumps with feedback via the measurement of electrical conductivity. This nutrient solution is pumped into greenhouses, then to irrigate plants via t-tape laid across the top of the soil in the gully. The system is thus hydraulically closed from the external environment, with nutrient solutions separated by a) disposable polyethylene film, b) Permanent polystyrene gullies and c) polyethylene “coreflute” double layered plastic liners.

The reticulation of fertigation solutions uses PN15 grade polyethylene pipes which have a lifetime decades longer than the greenhouse structures.

7.1.2 Drainage Water Management

Recirculating Nutrient systems are managed on the basis that the applied volume of nutrient solution results in about 30% runoff (i.e. excess of the water holding capacity of the containerised soil.) Thus, for every 100 L applied, about 30 L is recovered as drainage. Further, the salinity of this recovered drainage is 50% higher than what was applied. Growers typically will adjust the irrigation time to ensure the EC of the drainage solution is 150% of the EC of the applied nutrient solution

The collected drainage solution is then blended with fresh water at initially 30% of the total volume, then further nutrient concentrates are added, but at about 70% of the initial rate. The next drainage solution is still 50% more concentrated than the irrigation solution, however the nature of the composition progressively changes, as it becomes relatively depleted in phosphate and trace elements, but relatively concentrated in calcium, sulphate, sodium and chloride. Progressively less drainage water is blended with fresh water, thus drainage water accumulates.

When drainage water has reached a salinity greater than 1,000 parts per million sodium chloride, this drainage water will be used to grow watercress. A permanent bed of watercress will be maintained in the same closed system as used to grow cucumbers, with the exception that it will be completely closed and not drain. The only addition to the drainage water used to grow watercress will be phosphate, added as monopotassium phosphate. Watercress is harvested on a weekly basis. Watercress *Nasturtium officianale* is a very salt tolerant plant, and has been used as a nutrient stripper of brackish water. It is unusual in that it takes up sodium at much higher levels than other related plants belonging to the Brassica family. At present, it is uncertain how long a watercress garden remains productive, however other growers in the Oakford area have maintained systems in a productive state for longer than three years, merely topping up beds with fresh water and fertiliser if they start to dry out because of insufficient drainage water being available.

By the combination of reusing drainage water to grow cucumbers until sodium chloride reaches 1000 ppm, then applying such drainage water to closed water cress production, there will be no discharge of nutrient solution to the environment.

7.1.3 Water Application Rate

Irrigation application rates in closed systems, recirculating fertigation have the advantage over the field systems described in WQPN 22 in that hypothetical water use parameters like evapo-transpiration rates can be directly and continuously measured.

A major part of process optimisation in closed systems, recirculating fertigation is the continuous and automatic measurement and recording of volumes of irrigation and drainage water volumes, pH's and Electrical Conductivity. It is this routine procedure which has made closed systems, recirculating fertigation the most water efficient, fertiliser efficient, and thence, capital efficient plant production systems in the history of agriculture.

The time proven rules for Perth closed systems, recirculating fertigation are:

- Irrigation times are the time it takes until 30% of the applied water is recovered as drainage. (Now measured automatically, with the last irrigation data fed back to the computer).
- Irrigation EC (fertiliser content) is the amount which causes a 50% increase in EC in the 30% applied water recovered.

Modern closed systems, recirculating fertigation use the minimum amount of water and fertilisers to produce the maximum yield that the temperature (whether ambient or controlled) and sunlight (whether ambient or attenuated) allow.

7.1.4 Discharge Water

The discharge water will become unsuitable for further use because of the accumulation of too much calcium sulphate and common salt. However, these levels are not problematic for the irrigation of watercress which is a salt tolerant crop and the nitrate and potassium also present makes the discharge a useful fertiliser.

Lot 121 is immediately neighbouring a cattle farm which is not on the PDWSA. This may elect in the future to use discharge water to irrigate and fertilise this neighbouring farm.

If this eventuates, they would store discharge water in a 18,000 L tank. A pressure pump, connected fixed polyethylene pipes will feed the water to one of 8 knocking sprinklers with a 25 m radius, sequentially turned on by solenoid valves. This type of irrigation is already installed on the farm. Each irrigation event will deliver 7.2 mm of water to spinklers irrigating well established pasture.

This disposal process will commence once DER clear the property to be so irrigated. This is expected to take about a year.

Should the watercress production system prove to be a poor commercial solution, the water, sludge and concentrated salt will be recovered and disposed of in Class 2 landfill.

7.2 Nutrient Application

The amount of nutrient solution applied to grow Lebanese cucumbers depends on the age of the plant and the prevailing climatic conditions. The frequency of application depends on the size of growing channels.

Each grower uses slightly different irrigation regimes according to their preference, however typically mature, fruiting plants in troughs are irrigated every 4 hours during daylight hours in summer, and once per day in winter.

Lebanese cucumbers vines reach full size in about 6 weeks and thereafter they require around 1.5 L of water per day in summer, and around 0.5 L of water per day in winter. Planting density is in the order of 3 plants per square meter, or 1000 plants in a 40 x 9 m tunnel house. Such a house at full production in summer would use about 1500 L of water per day. Across a year growing season (typically 8 months, unless greenhouses are heated), a greenhouse would use 225,000 L

A total of 1440 g of fertiliser is applied in each 1500 L of irrigation water. Of this applied fertiliser about 140 g is contained is the discharged drainage water, giving initially a 90% fertiliser use efficiency for the cucumber crop. Of the fertiliser in the drainage water, about half remains as useful fertiliser in the form of nitrate and potassium, well suited for pasture fertiliser, particularly in P sensitive environments. The remainder is calcium sulphate or gypsum which is a useful soil conditioner, and common salt. Because the drainage solution will be blended with fresh water and re-used, ultimately the fertiliser use efficiency of cucumbers will be 96%. The remaining 4% will be removed as watercress biomass.

7.3 Waste Management

7.3.1 Plant Matter

During the growth cycle, there is a very minor amount of leaf and stem pruning undertaken to train plants. At the completion of the growth cycle, plants are cut from the growing gully and removed. This plant matter will be placed in steel skip bins. When the skip bin is full, it will be transported to a licensed composting facility as below.

7.3.2 Spent Growing Media

Growing media is replaced typically every 3 years. As and when replacement is undertaken, soil will be placed in steel skips. Once filled, skips will be taken to Aussie Organics in Serpentine for incorporation into landscaping mixes. Aussie Organics are a DER licensed composter and soil blender.

8 Drainage and Contaminant Leaching Control

Drainage water reports by gravity from the gullies to a drainage sump which is a 2,000 L sunken concrete tank lined with rubber paint . A float valve-activated sump pump sends this water to the recirculation tank for subsequent reuse. The system is hydraulically closed, and because of the long life and durability of polyethylene tanks, the risk of rupture and spillage is minimal.

9 Protection of Natural Water Resources

Drainage water will be discharge in watercress ponds. Watercress *Nasturtium officianale* is a relatively salt tolerant plant, and has been used as a nutrient stripper of brackish water. These ponds will prevent impacts on the nearby sensitive water resources.

10 Surface Water Protection

No stream banks or damp land vegetation exist within the vicinity of the site.

There is no native vegetation existing within the property.

Crop-growing will not happen on site except as described in completed closed and recirculating systems. There are no steep slopes or rocky terrain on the property.

11 Groundwater Protection

The site is not prone to waterlogging and groundwater separation is higher than two meters in the production area. In addition to these geographical aspects, advanced controls for both irrigation and fertilizer application will be used on site. As such, impacts on groundwater from the proposed activities are deemed to minimal.

12 Vegetation Management

The site is substantially cleared of native vegetation. The proposed development would remove a line of non endemic trees near the central and northern part of the production area (Figure 1). All other existing trees will be retained.

12.1 Vegetated Screen

A substantial vegetated screen consisting of *E. camaldulensis* already exist on the property. Where gaps exist within the screen, tree and shrub species will be planted as per the brochure "Keeping it Local" produced by the Serpentine Jarrahdale Community Landcare Centre. Vegetation species that have a low nutrient-demand will be selected and branches hanging over the proposed tunnel houses will be routinely cut.

12.2 Production Area

Ground cover outside greenhouses will not be removed; as such erosion protection measures are not necessary. Areas between greenhouses will be mowed.

Water and nutrient will be applied to match the growth cycle plant's needs. Slight changes will be made as crops develop and mature. Fine tuning will be based on leaf tissue analyses and by the growers' many years of experience. The fertigation system is closed so will not discharge water or nutrient to the external environment.

13 Pesticide and Storage Use

The use of pesticides in Australian agriculture is regulated through the Australian Pesticides and Veterinary Medicines Authority. The increasing trend in registration of products is to restrict the use of insecticides, fungicides and fumigants which have half lives of more than a few days. Environmentally persistent pesticides have been progressively deregistered and removed over the last 20 years. Advanced closed systems, recirculating fertigation in tunnel houses is increasingly using chemical-free systems based on the use of natural predators to control pests, and climatic control to manage fungal diseases.

The proponent will adopt chemical free integrated pest management (IPM) systems wherever possible. Relative to the open environment, passive and IMP methods are usually sufficient in tunnel houses. However, if pests and diseases pose significant economic threats, they reserve the right to use chemical pesticides provided and will:

- Follow regulations set by the Australian Pesticides and Veterinary Medicines Authority governing the use, storage, and disposal of pesticides and fungicides and training of applicators and pest control advisors.
- Follow manufacturers' recommendations and label directions.
- Use pesticides only if there is an actual pest problem (not on a regular preventative schedule) and use the minimum amount of chemical needed for the job.
- Do not mix and prepare pesticides within 30m of any well, stream or pond.
- Do not get rid of unused pesticides by washing them down drains.
- Employ techniques to minimize off-target application (e.g. spray drift) of pesticides, including consideration of alternative application techniques.
- Clean pavement and sidewalk if chemicals are spilled on these surfaces.

All chemicals will be stored in a locked area (concrete floor). All applications of chemicals will be entered into a log book.

All remaining mixtures will be disposed of according to label instructions. All equipment used for pesticide preparations will be triple rinsed both inside and out to minimize pesticide residues.

14 Site Monitoring and Reporting

The scale of operation, both in terms of water use and level of activity, is quite modest. A groundwater licence of only 40,000 kL usually does not have any monitoring or reporting requirements.

The technical service Bioscience provides to horticultural operations involves routine monitoring of recirculating nutrient solutions and leaf tissue analysis of growing plants. Combined with ongoing computer recording of all production parameters, this enables a complete record of water and fertiliser use, and enables the progressive optimisation of production operations towards maximum yield and quality.

15 Contingency Plans

The following section discusses actions planned to minimize loss of chemicals to water resources during wildfire or major storm events or via spillage and leakage of chemicals.

The minimum necessary amount of chemicals will be stored on site. All chemicals will be stored in allocated sheds (with concrete floors) that will be located at least 10 m away from the nearest tree.

References

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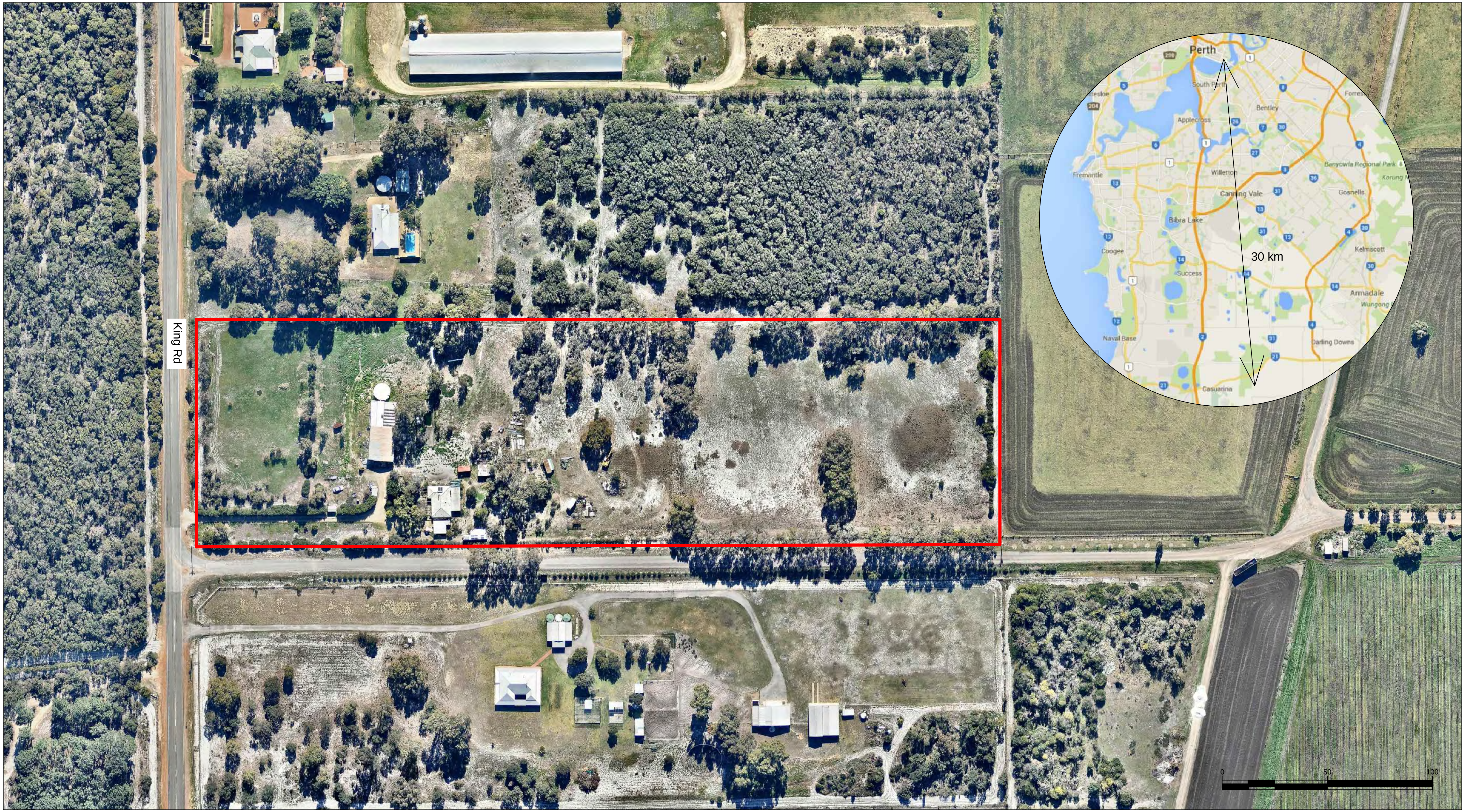
Figures



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Legend:

Site Boundary

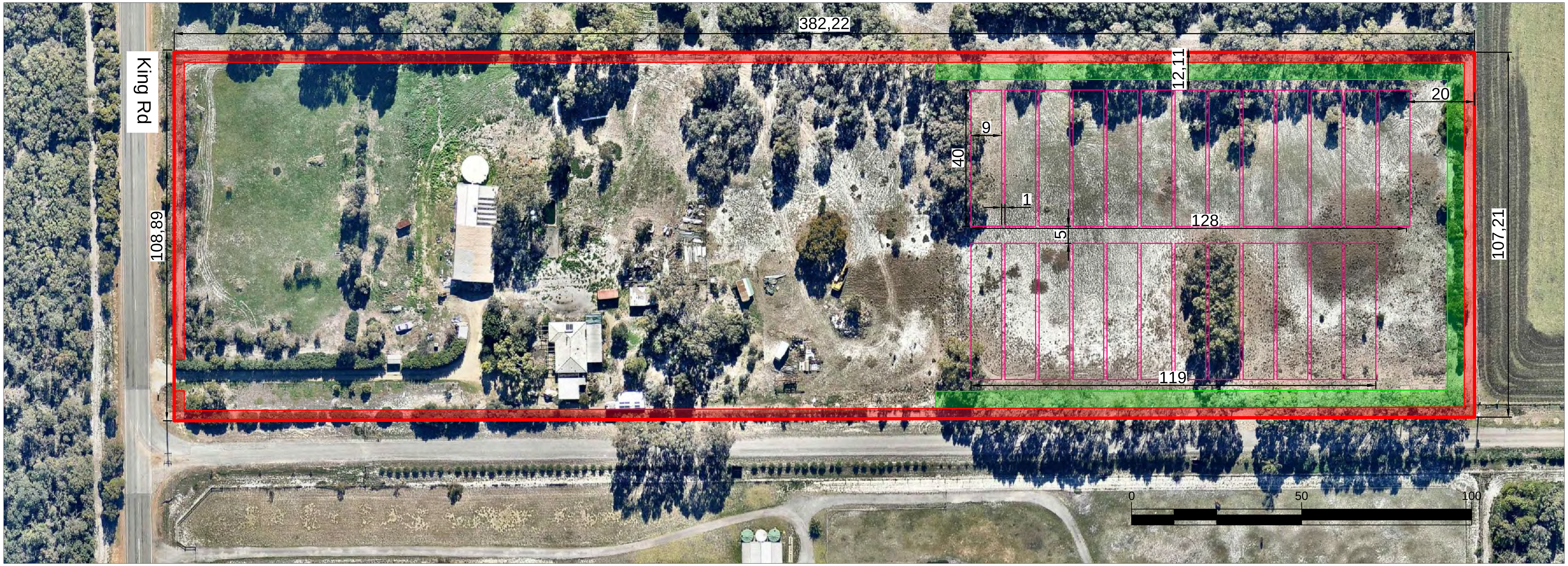
Dimensions in m

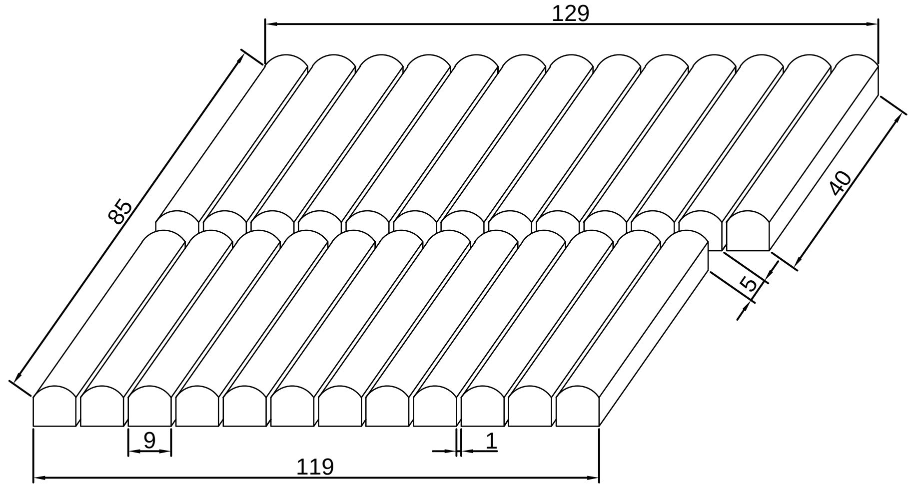
Data Source: Nearmap & Google Maps

Project Title: 121 King Rd, Oakford, WA
Location: Oakford, Perth, WA
Client: Kieu
Date: 02/09/2015

Drawn: AO
Checked: PK

Figure 1: Location Plan





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Legend:

- Site Boundary
- Proposesd Tunnelhouses
- Firebreak (3 m)
- Vegetated Border (5 m)

Dimensions in m

Data Source: Nearmap, Bioscience &The Glasshouse Company (www.ghco.com.au)

N

Project Title: 121 King Rd, Oakford, WA
Location: Oakford, Perth, WA
Client: Kieu
Date: 02/09/2015

Drawn: AO
Checked: PK

Figure 2: Site Plan - Proposed Tunnelhouses

OCM176.3/09/16

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Site Location

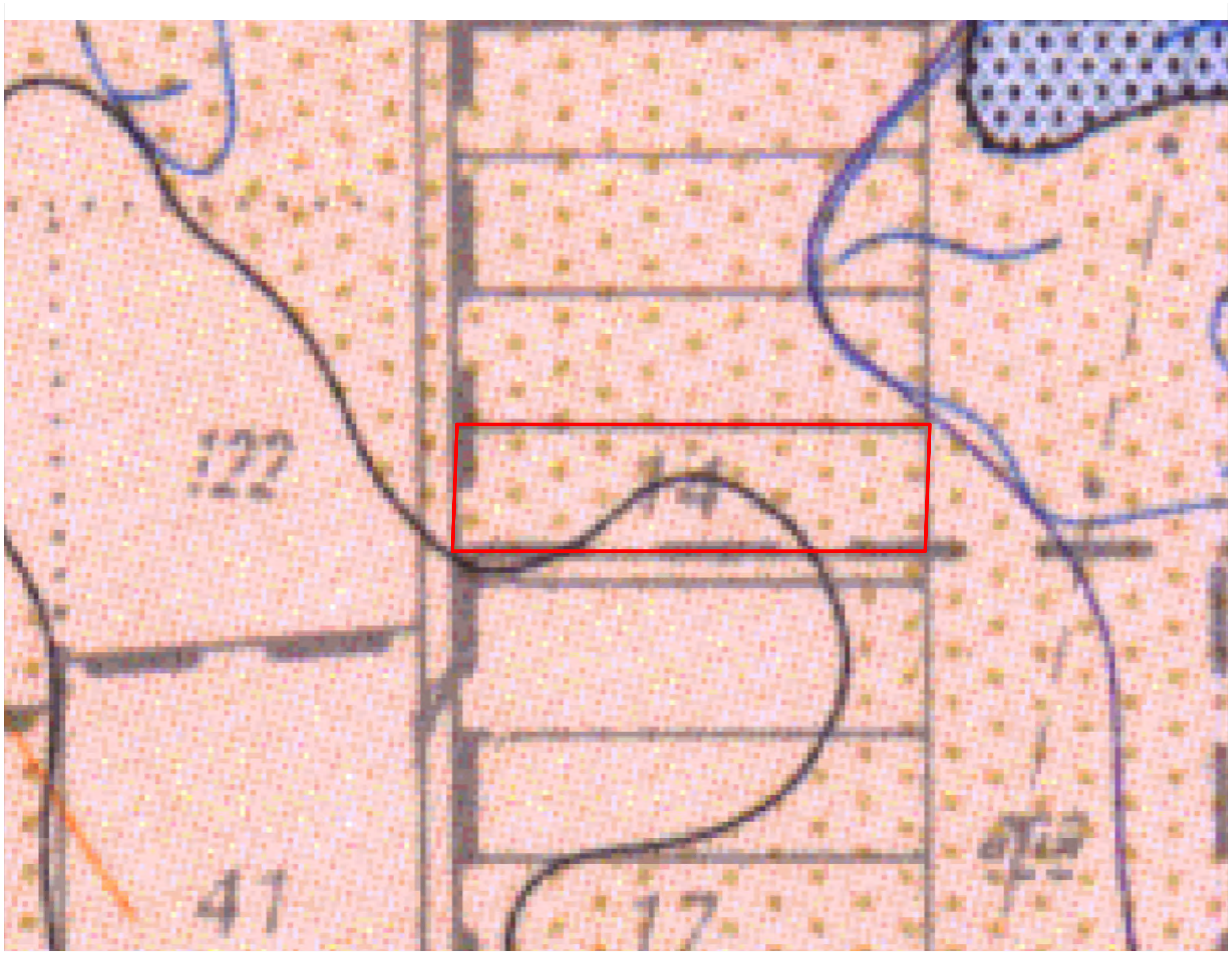
1 m Contours (mAHD)

Data Source: zonums.com

Project Title: 121 King Rd, Oakford, WA
Location: Oakford, Perth, WA
Client: Kieu
Date: 04/09/2015

Drawn: AO
Checked: PK

Figure 3: Topography



Armadale

Geological Survey of Western Australia

BASSENDEAN SAND (Qpb)- white to pale grey at surface, yellow at depth, fine to medium grained, moderately sorted, subangular to subrounded, minor heavy minerals

THIN BASSENDEAN SAND over Guildford Formation (Qpb/ Qpa) - clayey sand of the Guildford Formation, of eolian origin

Swamp deposits (Qrw)- peaty sand, grey to black, fine to medium-grained, moderately sorted quartz sand, slightly peaty, of lacustrine origin

Swamp deposits (Qrw)- peaty sand, grey to black, fine to medium-grained, moderately sorted quartz sand, slightly peaty, of lacustrine origin

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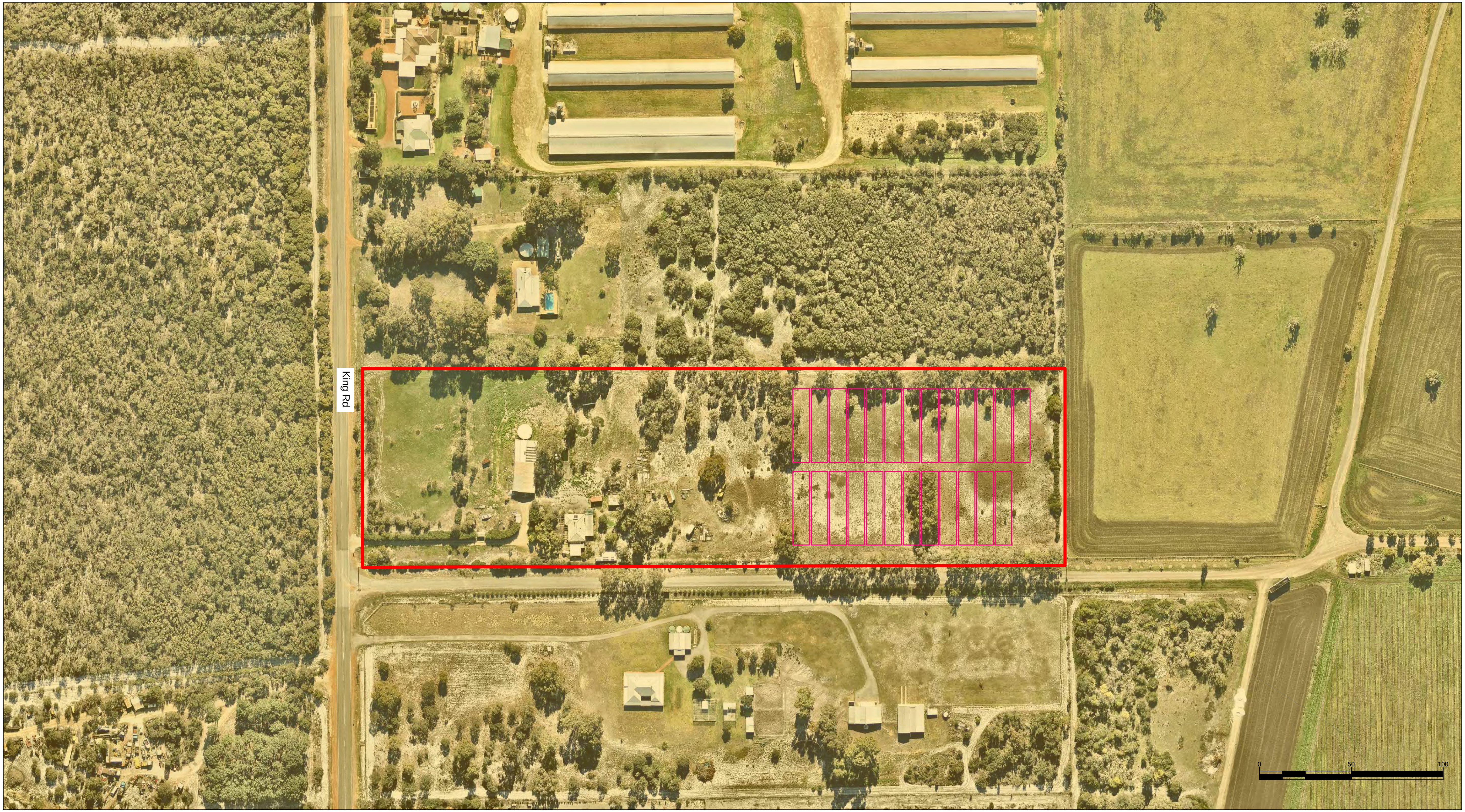
Site Boundary

N

Project Title: 121 King Rd, Oakford, WA
Location: Oakford, Perth, WA
Client: Kieu
Date: 03/09/2015

Drawn: AO
Checked: PK

Figure 4: Geology



Site Boundary

Moderate to low risk of ASS

Data Source: WA Atlas

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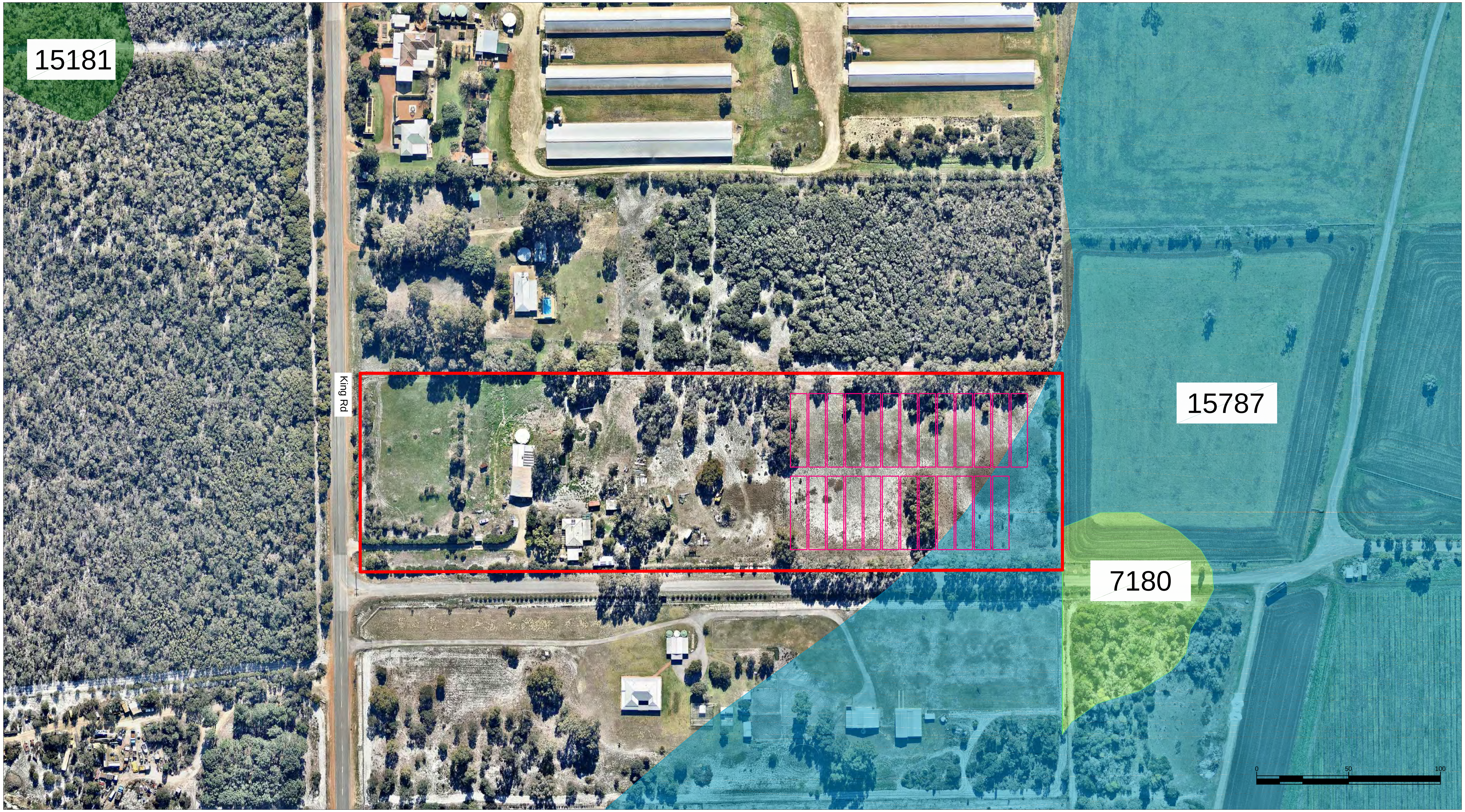
Project Title: 121 King Rd, Oakford, WA
Location: Oakford, Perth, WA
Client: Kieu
Date: 03/09/2015

Drawn: AO
Checked: PK

Figure 5: ASS risk map



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Site Boundary
Multiuse Wetland
Conservation Category Wetland
Resource Enhancement Dampland

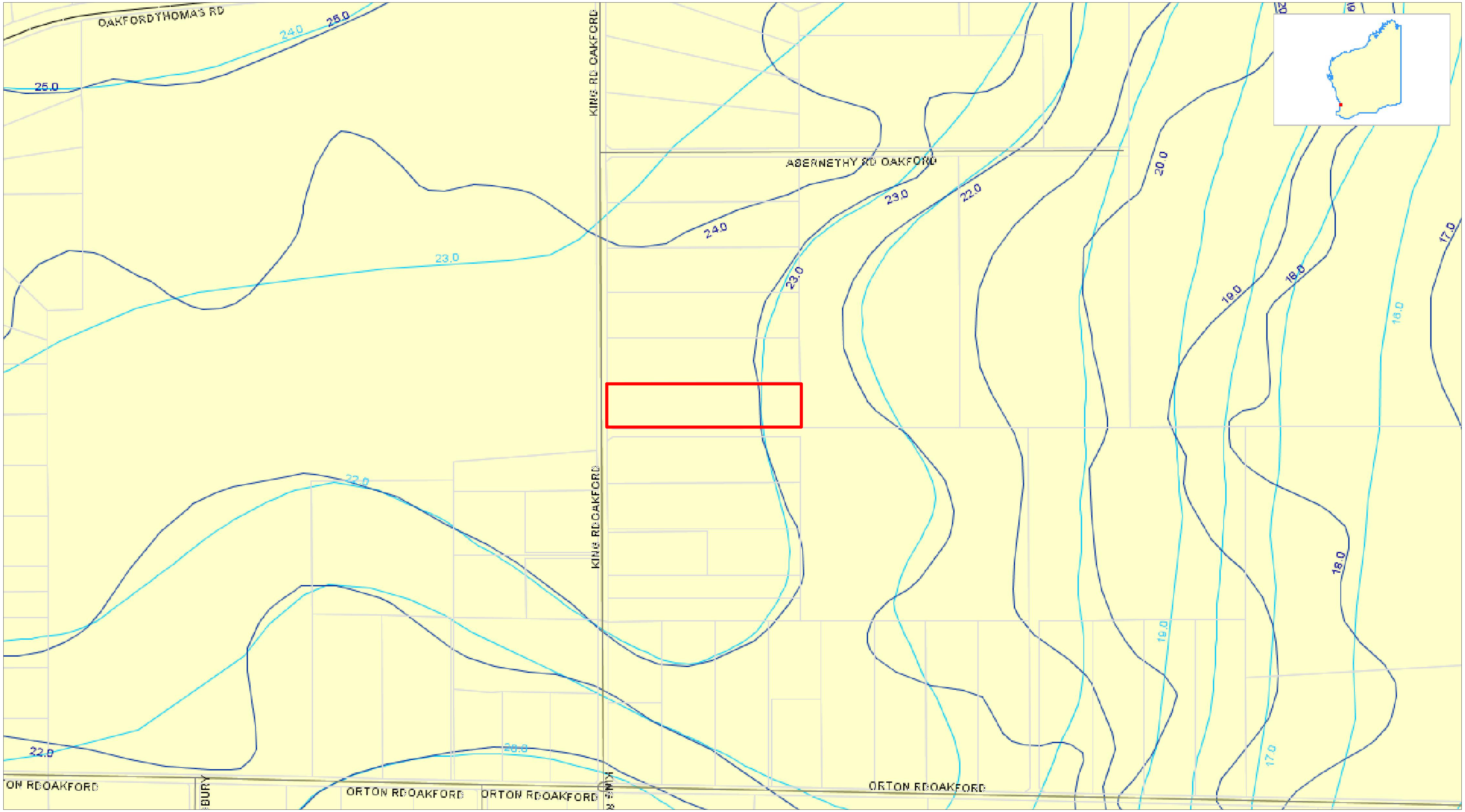
Data Source: WA Atlas

N

Project Title: 121 King Rd, Oakford, WA
Location: Oakford, Perth, WA
Client: Kieu
Date: 03/09/2015

Drawn: AO
Checked: PK

Figure 6: Geomorphic Wetlands



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Site Location

Historical Maximum Groundwater Level

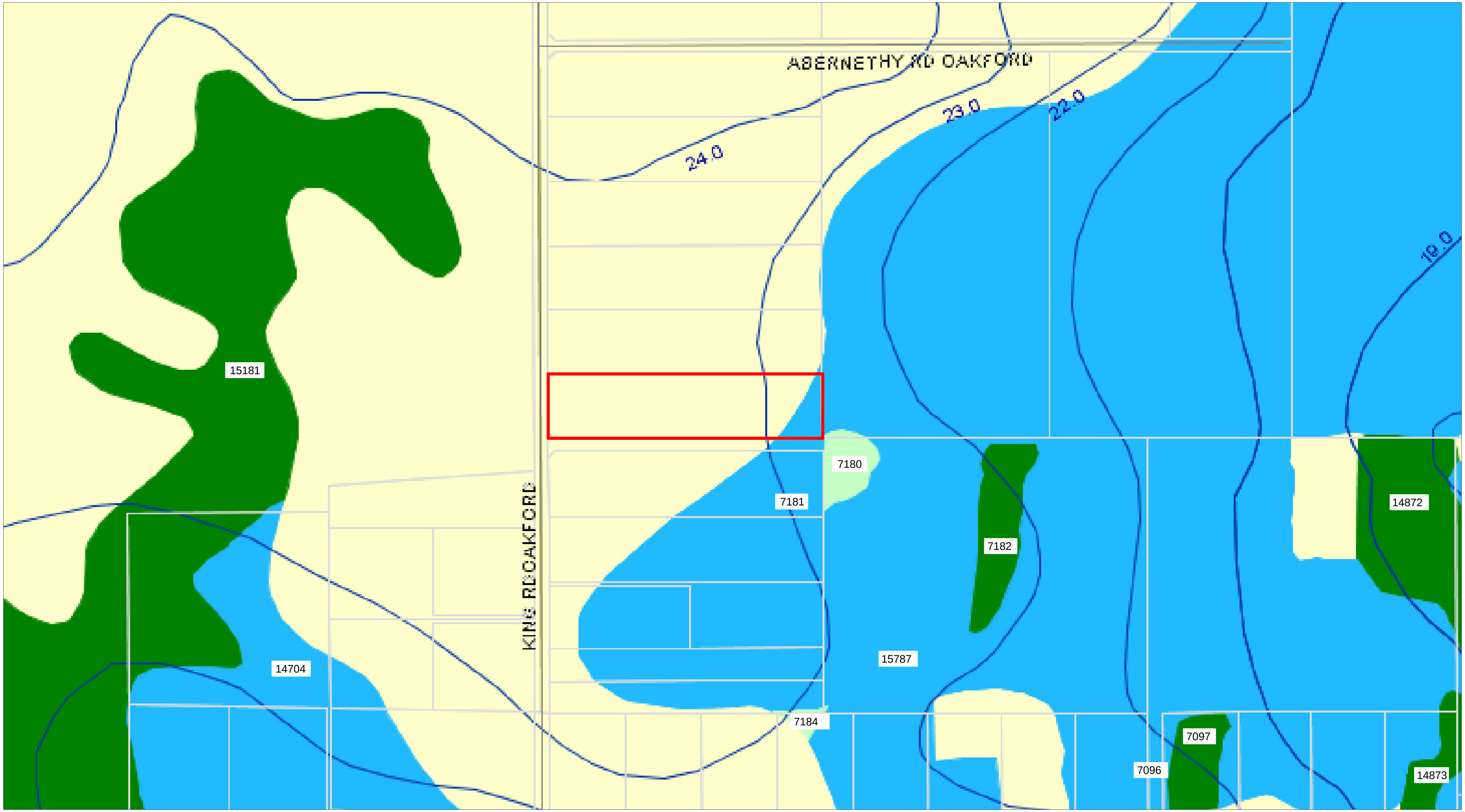
Groundwater Level, May 2003

Data Source: Department of Water

Project Title: 121 King Rd, Oakford, WA
Location: Oakford, Perth, WA
Client: Kieu
Date: 03/09/2015

Drawn: AO
Checked: PK

Figure 7.1: Groundwater Levels



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- Site Boundary
- Multiuse Wetland
- Conservation Category Wetland
- Resource Enhancement Dampland

Data Source: WA Atlas

Project Title: 121 King Rd, Oakford, WA
Location: Oakford, Perth, WA
Client: Kieu
Date: 03/09/2015

Drawn: AO
Checked: PK

Figure 7.2: Sensitive water resources based on groundwater flow

Appendices

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ANALYTICAL REPORT

CLIENT:	Tan Kieu	REPORT NO:	5331_2015
TEST REQUEST:	Standard Potability Suite	LAB SAMPLE ID:	5331
ADDRESS:		DATE RECEIVED:	17/12/2015
CLIENT SAMPLE ID:	121 King Rd Bore	DATE TESTED:	23/12/2015
SAMPLING LOCATION:	Oakford	DATE REPORTED:	4/01/2016

TEST RESULTS

Analytes	Results	Unit	Method / Standard	Potability Standard
Electrical Conductivity (EC)	0.355	mS/cm	EC Sensor	
pH	6.27	-	IJ pH Sensor	6.5-8.5 (2a)
Total Dissolved Salts*	237	mg/L		≤500 (2a), ≤1500 (1)
Ammonium-N	0.22	mg/L	Colorimetric Assay	≤0.4 (2a)
Nitrate-N	0.006	mg/L	Colorimetric Assay	≤11 (1,2h)
Phosphate-P	0.065	mg/L	Colorimetric Assay	
Potassium	1.78	mg/L	Flame AAS	
Calcium	5.49	mg/L	Flame AAS	≤200 (1)
Magnesium	6.91	mg/L	Flame AAS	≤150 (1)
Sodium	42	mg/L	Flame AAS	≤180 (2a)
Chloride	40	mg/L	Precipitation	≤250 (2a)
Sulphate	15.8	mg/L	Turbidity Assay	≤250 (2a)
Iron	2.79	mg/L	Flame AAS	≤0.3 (2a)
Manganese	0.03	mg/L	Flame AAS	≤0.1 (2a), ≤0.5 (2h)
Copper	0.001	mg/L	Flame AAS	≤1 (2a), ≤2 (2h)
Zinc	0.009	mg/L	Flame AAS	≤3 (2a)

These results reflect our findings of the received sample only.

Notes: (1) = World Health Authority; (2) = NHMRC/NRMMC Australian Drinking Water Guidelines 2011, a) aesthetic value, h) health value.
* Estimated from EC
mg/L (milligrams per litre) is equivalent to parts per million (ppm)
"≤": "less than or equal to"
AAS: Atomic Absorption Spectrometry

Tested by: Genevieve Massam Date: 23/12/2015

Approved by: Kylie Macpherson, Laboratory Manager Date: 24/12/2015