Lots 877 & 878 Stakehill Road, Karnup

Structure Plan

May 2025 | 23-325

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Certification Of Approved Structure Plan

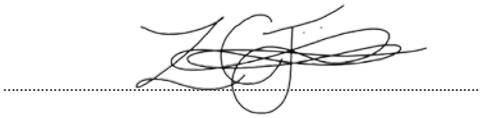
Endorsement Page

This Structure Plan is prepared under the provisions of the City of Rockingham Town Planning Scheme No. 2.

IT IS CERTIFIED THAT THIS STRUCTURE PLAN
WAS APPROVED BY RESOLUTION OF
THE WESTERN AUSTRALIAN PLANNING COMMISSION ON:

19 November 2025

Signed for and on behalf of the Western Australian Planning Commission



An officer of the Commission duly authorised by the Commission pursuant to section 24 of the *Planning and Development Act 2005* for that purpose, in the presence of:

Rhianne Fiander **Witness**

16 December 2025 **Date**

16 December 2035 **Date of Expiry**

We acknowledge the custodians of this land, the Whadjuk Noongar and their Elders past, present and emerging.

We wish to acknowledge and respect their continuing culture and the contribution they make to the life of this city and this region.

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Table of Amendments to Structure Plan

Amendment No.	Description of Amendment	Amendment Type	Date Endorsed by WAPC

Executive Summary

This structure plan has been prepared for Lots 877 & 878 Stakehill Road, Karnup. The subject site is located approximately 52kms south of Perth CBD and 15km south-east of Rockingham Regional Centre. The structure plan area is within the Perth Metropolitan South-West Corridor and is situated within the municipality of the City of Rockingham and the locality of Karnup.

The total area of Lots 877 and 878 is 48.71 hectares. The structure plan provides the rationale, justification and planning framework to guide and facilitate the development of land for urban purposes. It also provides for a negotiated planning solution for the Bush Forever Area 278B.

The structure plan has been prepared in accordance with the provisions of the Planning and Development (Local Planning Schemes) Regulations 2015 Schedule 2 Part 4 'Structure Plans'. The City of Rockingham Town Planning Scheme No. 2 (TPS 2) requires the preparation and approval of a structure plan for land zoned 'Development'.

The structure plan forms part of the future urban development cell in Karnup. A District Structure Plan (DSP) for Karnup is currently in the early stages of preparation, however this structure plan and the planning of the Karnup Phase One Structure Plan immediately to the east, provides advanced planning which will inform the proposed DSP. The following table is a summary of the proposed structure plan.

Executive Summary Table

Item	Data	Structure Plan Reference
Total area covered by Structure Plan	48.715 ha	Section 1.2
Area of each land use proposed: • Residential • Commercial	 19.103 ha 0.349 ha	 Section 4.3
Total estimated lot yield	420	Section 4.3
Estimated number of dwellings	420	Section 4.3
Estimated residential site density	22 dwellings per hectare[1]	Section 4.3
Estimate population (@2.8 persons/dwelling)	1,176 persons	Section 4.3
Estimated Public Open Space: • Bush Forever (inc. Nairn Drive Reserve) • Public Open Space	 8.823 ha 3.49 ha (10.5%)	 Section 4.2.1 Section 4.5

[1] 'Residential Site Hectare' refers to the definition under Element 1 of WAPC's Liveable Neighbourhoods. Calculation excludes roads and public open space.

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PART ONE – IMPLEMENTATION

1. Structure Plan Area

The structure plan is identified as the Lots 877 & 878 Stakehill Road Structure Plan (plan reference 19-338 ST-1 A). This structure plan shall apply to the land contained within the inner edge of the line denoting the structure plan boundary on the Structure Plan Map.

2. Operation

The Structure Plan is in effect from the date it is approved by the Western Australian Planning Commission as stated on the approval page and for a period of 10 years.

3. Staging

3.1 Preliminary Stage – Land Assembly

Overall the structure plan is proposed to be developed in multiple stages due to the size of the development and the outcome of the negotiated planning solution.

A legal agreement has been entered into between the landowner and the WAPC. The agreement requires the landowner to cede to the Crown the area of Bush Forever to be set aside under the negotiated planning solution for the structure plan.

3.2 Stage 1

The landowner's first stage of urban development would be in the north-west portion of the subject site (outside of the poultry odour extent except for commercial development) and progressing southwards. This would include creating the main entry road and public open space park.

Staging of development will rely upon the extension of available services (water and sewer) to the land, the cost of which is to be wholly borne by the landowner/applicant.

3.3 Future Stages

Future staging would generally be from the north to the south, with market conditions dictating the number and extent of staged areas of development. The staging areas indicated in the Part Two section are indicative only and could change.

4. Subdivision and Development Requirements

4.1 Land Use and Permissibility

4.1.1 Zones

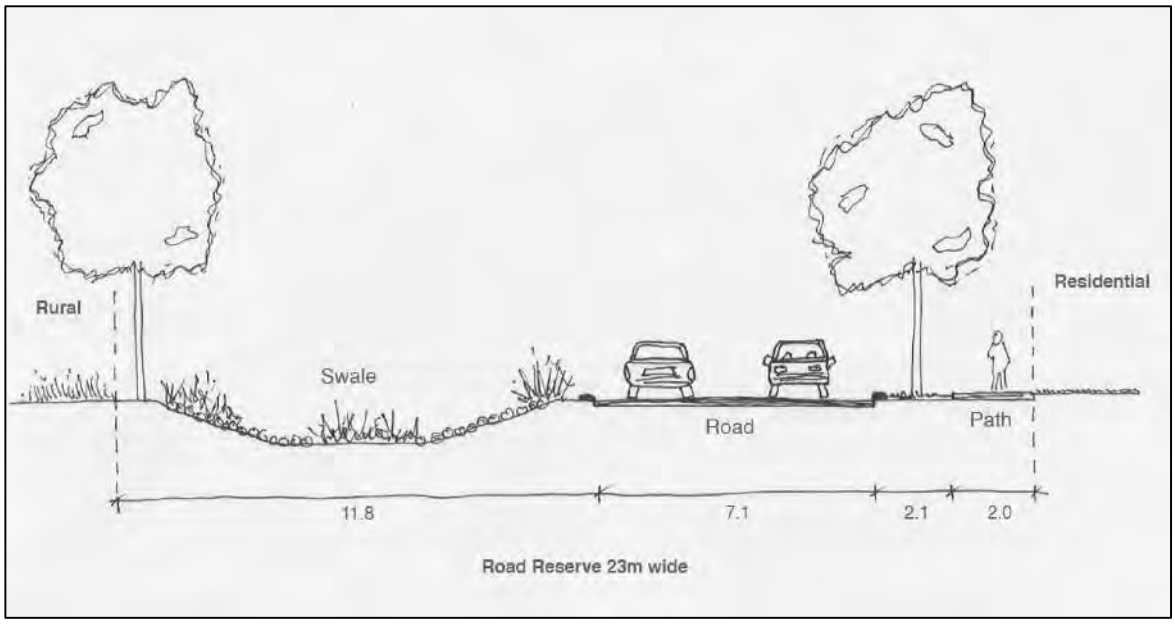
The structure plan outlines the Zones and Reserves applicable within the structure plan area and these will guide future subdivision and development of the land. Land use permissibility within the structure plan area shall generally be in accordance with the corresponding Zone and/or Reserve under the City of Rockingham Town Planning Scheme No. 2 (TPS 2).

4.1.2 Road Reserves

The Structure Plan Map identifies the main internal road network, whereby Neighbourhood Connector roads are proposed to intersect with the existing and planned adjacent road network, to provide key access and egress points for the development. The neighbourhood connector roads will serve as higher order roads in the structure plan road hierarchy. Access Streets and Laneways shall make up the lower order roads in the road hierarchy. All road reserve widths for neighbourhood connector roads, access streets and laneways shall be consistent with the requirements of Liveable Neighbourhoods.

For emergency access, the structure plan provides for a 10m wide right of carriageway easement corridor connecting Cassia Drive (South) with the southern neighbourhood connector road. The emergency access will extend through the Bush Forever Site 278 along the southern boundary of Lot 877.

A road reserve width of approximately 23m is proposed to be provided for the Neighbourhood Connector and Access Street that extends along the western boundary of the structure plan area. The additional width of this road reserve is intended to accommodate stormwater infrastructure (i.e. drainage swale) along the western boundary.



Indicative cross section of the proposed 23m wide road reserve along the western boundary.

4.1.3 Public Open Space

A minimum of 10% public open space in accordance with WAPC Liveable Neighbourhoods is required at the time of subdivision and/or development. The location for public open space is generally shown in the structure plan map. The final design of the public open space is subject to detailed subdivision design.

Public Open Space Schedule

	Ha	Ha
Total Site Area (ha)		**48.715**
Deductions		
Nairn Drive MRS Other Regional Road	2.507	
Stakehill Road MRS Other Regional Road	0.097	
Planning Control Area No. 155	1.268	
Subject to Future Planning	2.737	
Commercial	0.349	
Local Park North Basin (20% and 63.2% AEP)	0.135	
Local Park South Basin (20% and 63.2% AEP)	0.193	
Bush Forever (Lot 878)	0.713	
Bush Forever (Lot 877)	6.738	
Sewer Pump Station	0.040	
Market Garden Spray Drift Vegetation Buffer	0.699	
Total Deductions		**15.476**
Gross Subdivisible area		**33.239**
Required POS (10%)		**3.324**
Breakdown of POS Provided		
May comprise:		
• minimum 80 per cent unrestricted POS	2.659	
• Maximum 20 per cent restricted use POS	0.665	
Restricted Public Open Space provided		
Neighbourhood Park (adjacent Bush Forever)	0.624	
Total Restricted POS Credited to a maximum of 20%		**0.624**
Unrestricted Public Open Space provided		
Local Park 1 (North)		0.496
Local Park 2 (South)		0.375
Neighbourhood Park (adjacent Bush Forever)		1.995
Total Unrestricted POS		**2.866**
Public open space provision provided		**3.49**
POS Provision as Percentage of Gross Subdivisible Area		**10.5%**

4.1.4 Area Subject to Future Planning Investigation

The Structure Plan does not apply to the area identified as 'Subject to Future Planning' on the Structure Plan Map. This area is subject to a poultry farm odour extent associated with operations on Lot 820 Stakehill Road, restricting development of the land for Urban uses. The Structure Plan may be amended to incorporate land designated as 'Subject to Future Planning' upon the advice that operations on Lot 820 Stakehill Road have ceased and its use rights have been voluntarily extinguished.

4.2 Residential Density

4.2.1 Density and R-Codes

(i) An R-Codes Plan is to be submitted at the time of subdivision for the entire structure plan area. The plan will allocate R-Codes for proposed lots consistent with the rationale and the locational criteria in 4.2.2. Once approved by the WAPC, the R-Codes Plan forms part of the structure plan

(ii) The R-Codes Plan is to include a summary of the proposed dwelling yield of the subdivision.

(iii) Approval of the R-Codes Plan shall be undertaken at the time of the determination of the subdivision application by the Western Australian Planning Commission. The approved R-Codes Plan shall then form part of the structure plan and shall be used for the determination of future development applications.

(iv) Variations to the R-Codes Plan will require approval of the Western Australian Planning Commission, with a revised R-Codes Plan submitted generally consistent with the approved plan of subdivision issued by the Western Australian Planning Commission. The revised R-Codes Plan shall be consistent with the R-code ranges identified in the structure plan and the locational criteria.

(v) A revised R-Codes Plan, consistent with (iv) above will replace, wholly or partially, the previously approved residential density code plan, and shall then form part of the structure plan as outlined in (iii) above.

(vi) An R-Codes Plan is not required if the Western Australian Planning Commission considers that the subdivision is for one or more of the following:-

- the amalgamation of lots;
- consolidation of land for "superlot" purposes to facilitate land assembly for future development;
- the purposes for facilitating the provision of access, services or infrastructure; or
- land which by virtue of its zoning or reservation under the structure plan cannot be developed for residential purposes.

4.2.2 Locational Criteria

The allocation of residential densities on the R-Codes Plan shall be in accordance with the following criteria:

1) A density code of R30 applies to all residential lots, except where identified in Clauses 2 and 3 below.

2) A density code of R12.5 applies to all lots located along the western boundary of the structure plan, as shown on the Structure Plan Map, providing a transition to the rural residential land to the west.

3) Higher density up to R40 coding may apply to the following lots:

   i) Lots with a boundary directly opposite or abutting Public Open Space and/or Bush Forever, or

   ii) Lots with rear access from a laneway, or

   iii) Lots within 400m of commercial land use.

4.3 Notifications on Title

In respect of applications for the subdivision of land the City of Rockingham shall recommend to the Western Australian Planning Commission that a condition be imposed on the grant of subdivision approval for a notification to be placed on the Certificate(s) of Title(s) to advise of the following:

i) Land or lots within a bushfire prone area identified on the Map of Bush Fire Prone Areas and has a Bushfire Attack Level (BAL) rating of 12.5 or above

ii) Lots affected by transport noise in accordance with an acoustic assessment provided at subdivision stage.

iii) Amenity impact of existing poultry farm(s) in the vicinity for all residential lots within 300m of each poultry farm while in operation.

iv) Amenity impact spray drift from existing market gardens for all residential lots within 300m of a market garden land use.

4.4 Poultry Farm Buffer Extent and Timing of Development'

Subdivision and/or development of sensitive land use(s) shall not be permitted on land affected by (within) the poultry farm odour extent as shown in the structure plan, until such time as:

i) On advice of the Department of Water & Environmental Regulation the Western Australian Planning Commission has approved a reduction in the poultry farm odour buffer, whereby subsequently any land outside the modified buffer can be developed for sensitive land use; or

ii) On advice of the Department of Water & Environmental Regulation the Western Australian Planning Commission approves the removal of the poultry farm odour buffer.

iii) an odour dispersion buffer is recommended along the eastern boundary of Lot 877 to a thickness of approximately 2-3 x lines of trees interspersed with medium height shrubs to create a high porosity barrier that will effect mechanical dispersion of an odour plume that traverses the tree buffer; and

iv) the odour dispersion buffer is to be prepared in consultation with the City of Rockingham and to the satisfaction of the DPLH.

4.5 Market Garden Spray Drift Buffer

Subdivision and/or development of sensitive land use(s) shall not be permitted on land within 300 metres of the market garden on Lot 849 Stakehill Road, Karnup in accordance with Department of Health's Guidelines for Separation of Agricultural and Residential Land Uses, until:

i) a minimum 5-metre-wide vegetation buffer and a 2.2-metre-high noise wall is constructed as shown on the structure plan map, to the specifications of the City of Rockingham; or

ii) The market garden ceases operation and its use rights have been voluntarily extinguished.

The 5-metre-wide vegetation buffer shall be installed and maintained in accordance with the Vegetative Buffer Plan at Appendix 15 to the Structure Plan.

5. Local Development Plans

Local Development Plan(s) are required to be prepared and implemented pursuant to the provisions of TPS 2 and the Planning & Development (Local Planning Schemes) Regulations 2015, for lots with the following site attributes:

(i) Lots abutting public open space or commercial use

(ii) Lots accessed via a laneway

(iii) Lots affected by transport noise under WAPC State Planning Policy 5.4 'Road and Rail Noise'.

(iv) Commercial lots (to address matters related to building height, scale, bulk etc.)

6. Other Requirements

6.1 Development Contributions

The structure plan is located within 'Development Contribution Area 2' (DCA 2) which relate to developer contributions towards common infrastructure. TPS 2 requires the developer to make satisfactory arrangements with the City of Rockingham to provide developer contributions towards infrastructure contained in Development Contribution Plan No. 2 (DCP 2). This will be required as a condition of subdivision and/or development approval.

6.2 Additional Details

The following additional details for subdivision/development shall be submitted at later stages of planning.

6.2.1 Information to be submitted with an application:

Additional Information / purpose	Approval stage	Responsible agency (consultation required)
R-Codes Plan	Subdivision	City of Rockingham Western Australian Planning Commission
Bushfire Management Plan	Subdivision	City of Rockingham Department of Fire and Emergency Services
Acoustic Assessment **(Transport Noise)**	Subdivision	City of Rockingham Main Roads WA
Mosquito Management Plan	Subdivision	Department of Health

6.2.2 Studies to be required under condition of subdivision/development approval:

Conditions of subdivision approval	Responsible agency
Bushland Management Plan **(For the public open space adjacent to the Bush Forever Site 278)**	City of Rockingham
Wildlife Protection Management Plan **(For the public open space adjacent to the Bush Forever Site)**	City of Rockingham
Urban Water Management Plan	City of Rockingham Department of Water and Environmental Regulation
Preliminary Site Investigation (PSI) and if required a Sampling Analysis Plan **(To identify and address any potential contamination from historical land uses)**	Department of Water and Environmental Regulation

6.3 Infrastructure Upgrades

6.3.1 Upgrading of Stakehill Road and Nairn Drive

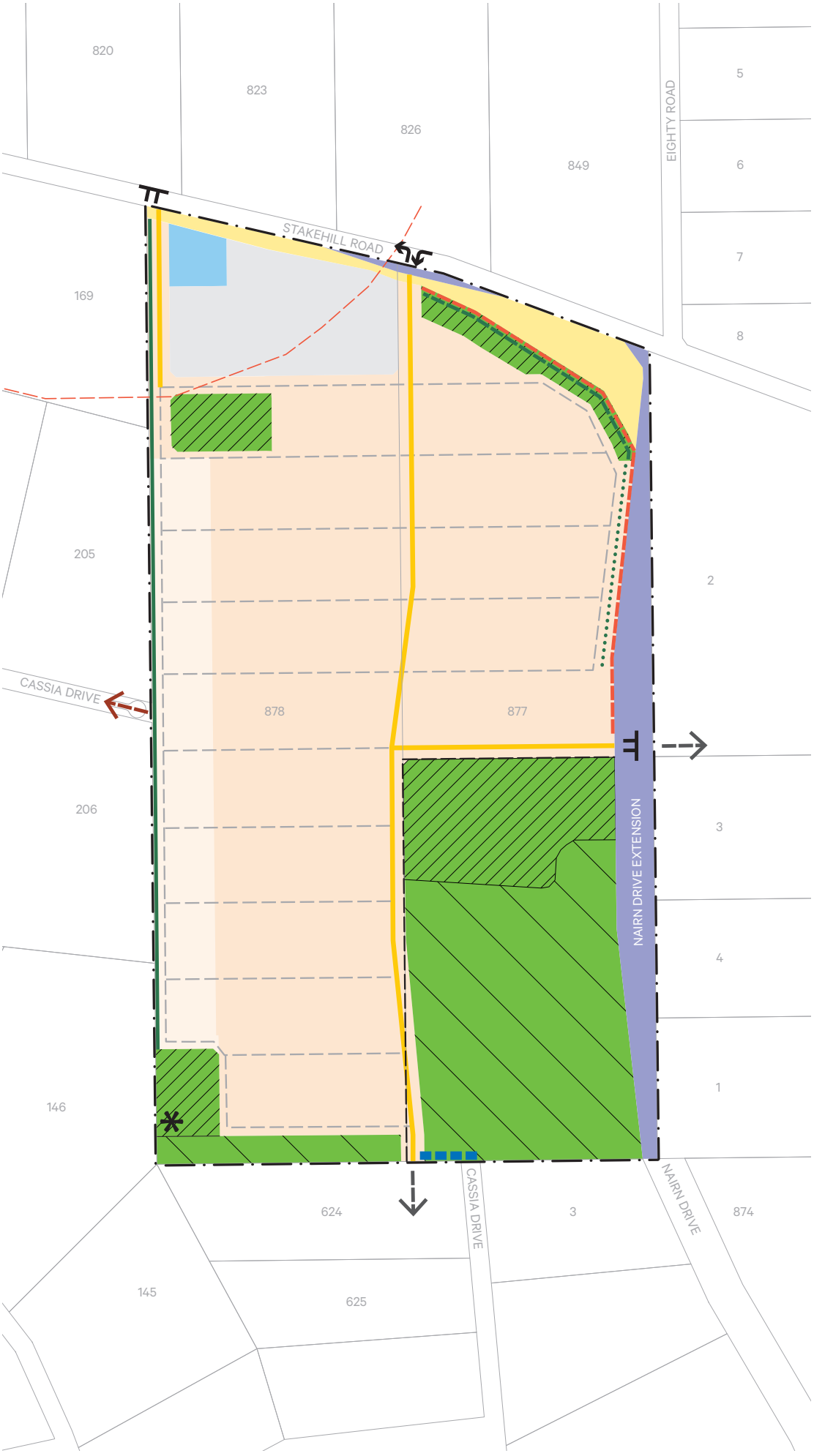
The City of Rockingham shall recommend to the Western Australian Planning Commission that a condition be imposed on the grant of subdivision approval for the:

(i) Upgrading of Stakehill Road abutting the structure plan boundary to a single carriageway urban standard.

(ii) Upgrading of Nairn Drive abutting the structure plan boundary, to a single carriageway urban standard.

6.3.2 Construction of roundabout at intersection of Neighbourhood Connector A road and Stakehill Road

In general, a modified full movement 'T' intersection is sufficient to support full residential development of the structure plan, subject to further transport modelling as part of staged development. As part of development approval of commercial and/or service commercial land uses beyond the extent shown on this Structure Plan, the need for a roundabout shall be determined by further transport modelling to the satisfaction of the City of Rockingham. The specifications for the modified 'T' intersection and/or roundabout construction shall be to the satisfaction of the City of Rockingham.



Legend

- Structure Plan Boundary

Metropolitan Region Scheme Reserves

- Other Regional Road
- Parks and Recreation

Notice of Delegation

- Bush Forever

Local Scheme Reserves

- Public Open Space

Local Scheme Zones

- Residential R12.5-R25
- Residential R30-R40
- Commercial (Maximum 500m² Nett Lettable Area)

Other

- Neighbourhood Connector
- Indicative Future Local Road / Lane
- Potential Future Road Connection
- Emergency Access 10m wide Right-of-Carriageway Easement (Gated)
- Poultry Odour Extent
- Intersection - Left In-Left Out (By others in future)
- Intersection - Full Movement
- Acoustic Wall (2.2m high)
- Vegetation Buffer
- Landscape Buffer to Rural (Roadside Drainage Swale)
- Emergency Access (Gated)
- Bush Forever Original Boundary
- Planning Control Area
- Subject to Future Planning
- Temporary Sewer Pumping Station Type 40
- Indicative Row of Trees (Odour Dispersion)

Lots 877 and 878 Stakehill Road Structure Plan

0 40 80m

Date: 9 Apr 2025 Scale: 1:4000 @ A3 File: **24-174 ST-1 A** Staff: JP GW Checked: JP

element.

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PART TWO – EXPLANATORY SECTION

1. Introduction

This Part Two section of the report provides an explanatory and planning rationale for the structure plan prepared for Lots 877 & 878 Stakehill Road, Karnup (herein referred as the "subject site").

A structure plan is generally required to be prepared and approved prior to subdivision and development of the land in a 'Development' zone under TPS 2. The Lots 877 & 878 Stakehill Road Structure Plan has been prepared pursuant to *Planning and Development (Local Planning Schemes) Regulations 2015* Schedule 2 - Deemed provisions for local planning schemes Part 4 'Structure Plans'.

The report provides a description of the subject site, details of the proposal and planning rationale for the structure plan including an indicative development concept plan. The structure plan has been prepared taking into consideration the relevant planning framework and previous structure planning for future urban development to the east.

Future urbanisation of Karnup is expected to commence in the north and proceed southwards as services become available through extension. The structure plan proposes to bring key services (i.e. sewer) to Karnup by extending these from urban developed areas in southern Baldivis. The proposed structure plan will essentially pioneer urban development in the northern portion of Karnup.

The structure plan will complement the future planned urban area to the east (i.e. Karnup Phase One Structure Plan) by accommodating urban population to support the proposed primary school and commercial centre. The structure plan will also provide opportunity for connections to Cassia Drive to the west and south to assist in bushfire management. Future planning for Nairn Drive (MRS 'Other Regional Road') along the eastern part of the subject site has been considered in the structure plan. The structure plan also provides for a negotiated planning solution for the retention of the majority and best parts of Bush Forever Site No. 278B. The Bush Forever would be contained within future public open space held in a Crown Reserve.

Preliminary discussions have been held with key stakeholders, which is set out in the 'Pre-Lodgement Consultation' section of the report. In addition, various technical investigations have been completed which are attached with the Structure Plan and forms part of the explanatory report and appendices.

Refer to Appendix 1 – Pre-lodgement Consultations

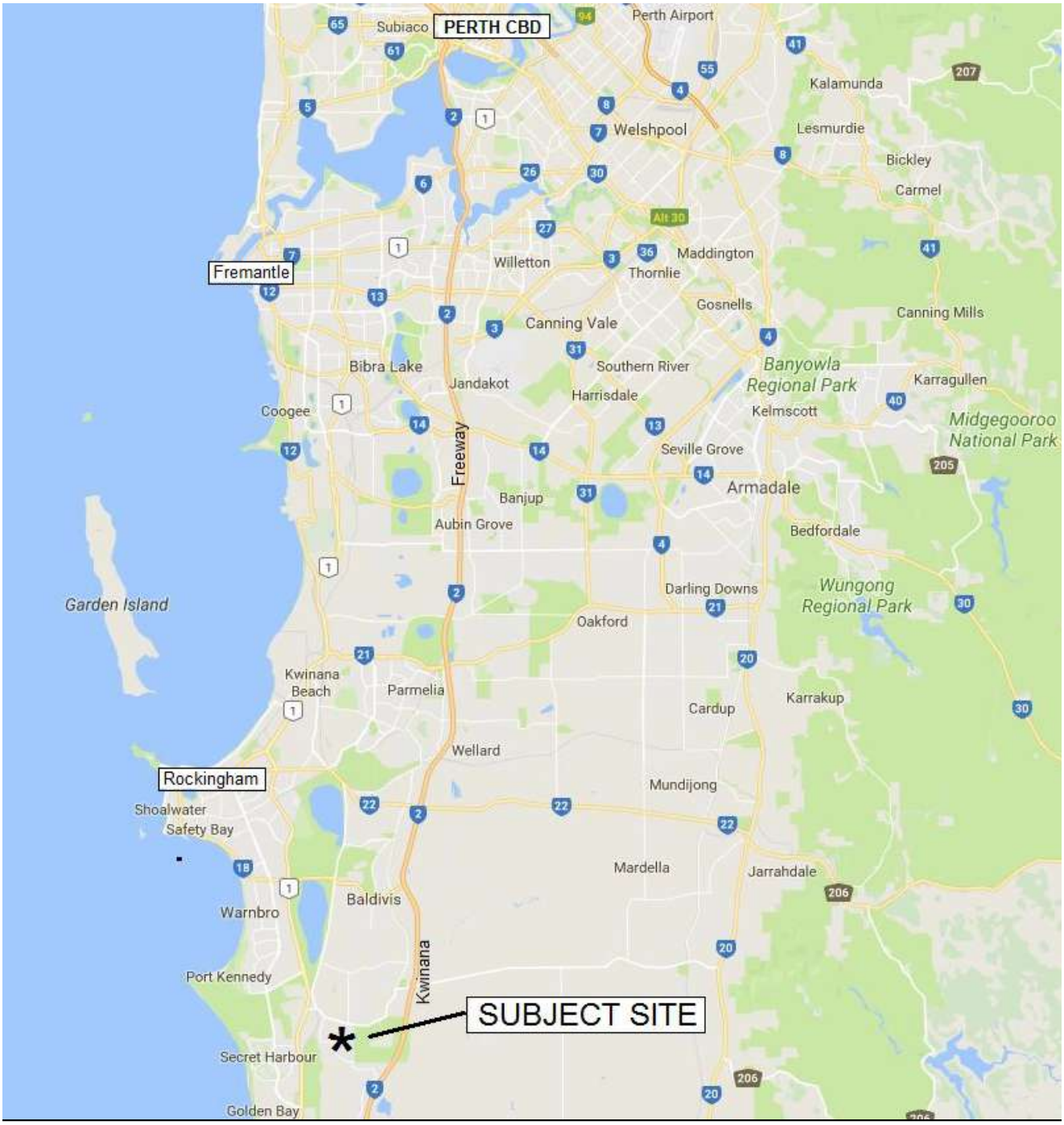
1.1 Location

The subject site is located approximately 39kms south of Perth CBD and 6km east of Rockingham Regional Centre. The coastline of Warnbro Sound and Shoalwater Bay Marine Park is approximately 7km to the west. Kwinana Freeway is accessible within 2kms to the east.

The structure plan area is within the Perth Metropolitan South-West Corridor and is situated within the municipality of the City of Rockingham and the locality of Karnup. Figure 1 shows the location of the subject land in the context of the locality of Karnup and proximity to Rockingham and the Kwinana Freeway. Figure 2 shows the cadastral boundaries, contours and aerial image of the Structure Plan area and neighbouring context.

Refer to Figure 1 – Location plan

Refer to Figure 2 – Cadastral, contours and aerial plan



(Source: Google Maps, 2019)

Figure 1. Location plan



Figure 2. Context Surrounding Land

1.2 Description & Land Ownership

This structure plan is for Lots 877 & 878 Stakehill Road, Karnup on Survey Deposited Plan 202761:

- Lot 877 - Certificate of Title Volume 1293 Folio 787
- Lot 878 - Certificate of Title Volume 1293 Folio 786

The subject lots are in freehold ownership of J Garbin and comprises approximately 48.71 hectares in total area.

1.3 Existing Land Use

The original vegetation on the subject site was extensively cleared over 50 years ago for rural pursuits. This resulted in the establishment of a market garden. Existing development of the subject site generally consists of a single dwelling, sheds and an artificial soak in the north-west corner for irrigation purposes. The subject site has been and is currently being used for a market garden. The intention is for the subject site to now be developed for urban use.

Aerial photography from 1965 shows the subject site having been cleared except for some remnant trees and east-west linear strips of vegetation (windrows) in the Bush Forever area. An environmental assessment report has been prepared which provides historical aerial images showing the cleared site with vegetation regrowth.

Clearing of the site was primarily undertaken to establish a market garden. The south-east portion of the site was excluded from market gardening and remained predominantly parkland cleared. Slowly over time the vegetation was allowed to regrow. Subsequently, aerial photography in 2000 shows the subject site has undergone native vegetation regrowth and has been mapped and identified as Bush Forever Site 278B.

Refer to Appendix 2 – Environmental Assessment Report

1.4. Surrounding Locality Context

The subject site is bound to the north by Stakehill Road with rural land use on the northern side of Stakehill Road. There is an existing poultry farm operating on Lot 820 Stakehill Road immediately to the north-west of Lot 878. There is an existing market garden operating on Lot 849 Stakehill Road immediately north-east of Lot 877.

Lots on the northern side of Stakehill Road generally comprise of parkland cleared rural small holding lots ranging 4 hectares – 8 hectares in area.

To the west and south of the subject site there is a mix of bushland and parkland cleared rural residential lots generally ranging 2 hectares – 5 hectares in area. Lots that contain bushland to the west generally fall within Bush Forever Site No. 278A (Cassia Drive Bushland, Karnup). A portion of Bush Forever Site No. 278B also stretches along a narrow 30m corridor abutting the southern boundary of Lot 878.

Immediately to the east are rural small holding lots 4.5 hectares – 11 hectares in area. There is an operating market garden on Lot 1 Harvey Road abutting the south-east portion of the subject site. Further east is the future urban development area within the Karnup Phase One Structure Plan (Lots 316 & 1340), which lies on the former pine plantation (now a sand quarry) that surrounds the Munitions Depot. The Karnup Phase One Structure Plan (not yet approved) proposes residential densities ranging R25 – R80 to accommodate approximately 1,000 – 1,200 dwellings. The urban development will be serviced by a primary school, a local centre and public open space. A future district centre is proposed at the corner of Stakehill Road and Harvey Road, which is subject to further investigation.

The Holcim Sand Mine operating on Crown Reserve 37090 is located approximately 600m to the east of the site. The sand mining operation is expected to be undertaken in stages over the wider landholding over the long term. The mining operations are regulated and a Construction Environmental Management Plan is required to be implemented to manage and mitigate the impacts of mining operations on the surrounding land, especially in relation to future urban development within the Karnup Phase One Structure Plan area.

To the north-east of the site is an operational poultry farm on Lots 7 & 8 Eighty Road, approximately 250m from Lot 877, however this poultry farm is operating on a temporary basis, is owned by DevelopmentWA.

Refer to Figure 3 – Context Plan

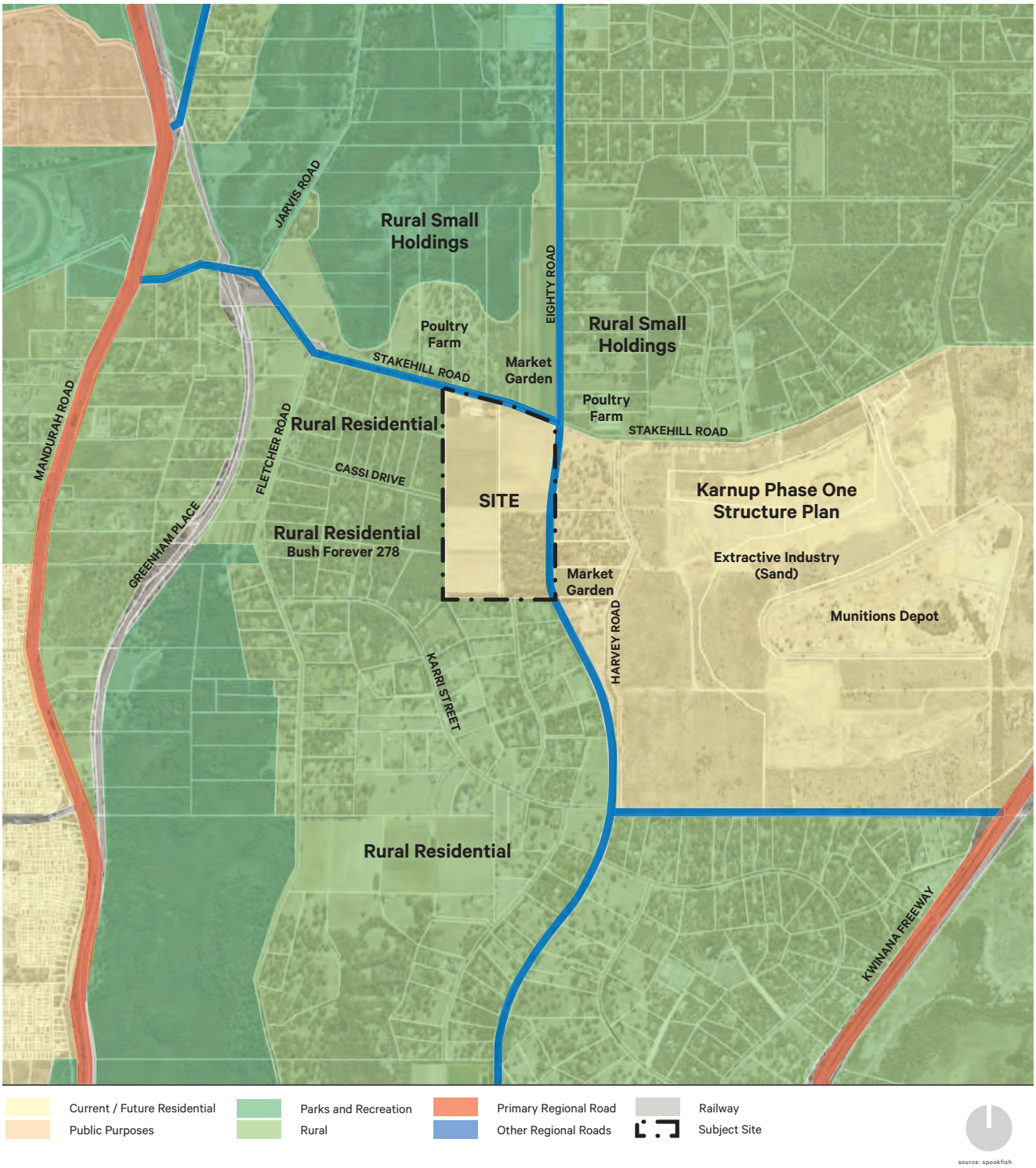


Figure 3. Context Surrounding Land

2. Site Description

The following section is a general description of the site characteristics of the subject land area. This section demonstrates that there are no significant constraints to urban development. A broad opportunities and constraints analysis is provided in Figure 4 (Opportunities and Constraints Plan).

Refer to Figure 4 – Opportunities and Constraints Plan

2.1 Topography & Soils

The topography of the site varies with a high point approximately 18m AHD in the central east portion of Lot 877, then falling generally to 6m AHD at the western boundary and 4m AHD in the north-west corner of Lot 878. From the 18m AHD ridge the site slopes down to approximately 8m AHD – 10m AHD at Stakehill Road and 16m AHD in the south-east corner of Lot 878. Slopes vary throughout the site up to 10%.

A desktop review indicates that the subject site falls within the Spearwood System of the Swan Coastal Plain. The Spearwood System is characteristed by its high relief, consisting of slightly calcareous Aeolian sand.

The main two soil types found on the subject site are:

- Spearwood S2a Phase : Lower slopes (1 – 5% of dune ridge with moderately deep to deep siliceous yellow-brown sands or pale sands with yellow-brown subsoils and minor limestone outcrop.
- Spearwood S4a Phase – Flat to gently undulating sandplain with deep, pale and sometimes bleached, sands with yellow-brown subsoils.

The geology and predominant soil types found on the subject site are suitable for urban development. The predominant soils found on the subject land is very permeable allowing for good infiltration of stormwater on-site. Further detailed geotechnical investigation would be a requirement at the subdivision stage. Accordingly there are no significant topographical or geological constraints that would impact urban development of the subject land.

2.2 Flora and Vegetation

An environmental assessment report has been prepared to inform the structure plan which investigated flora and vegetation characteristics of the subject site.

Existing native vegetation found on the site is limited to the areas within Bush Forever Site No. 278B found on Lot 877 and the 30m strip along the southern boundary of Lot 878. Planning of the Bush Forever area requires a negotiated planning solution, which will be further discussed in this report. The remaining cleared areas of the site (for horticultural use) has limited environmental and ecological value. The flora and vegetation survey thus did not include the cleared areas for horticultural use.

Refer to Appendix 2 – Environmental Assessment Report

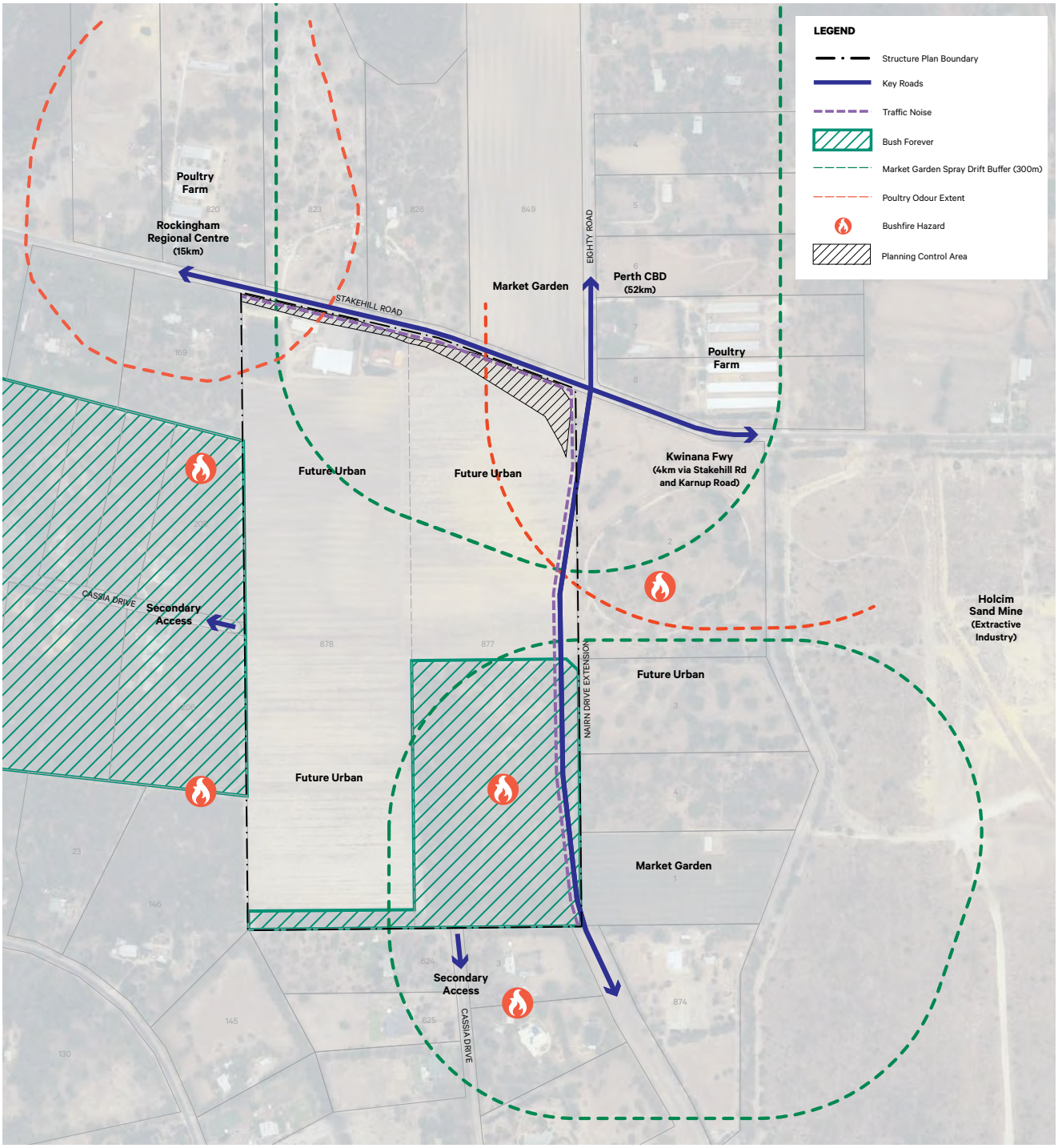


Figure 4. Opportunities and Constraints Plan

2.2.1 Vegetation Condition Within Market Gardening Areas

There are no significant flora or vegetation constraints impacting the proposed urban development over the cleared areas used for market gardening. Vegetation condition within the market garden areas of the structure plan area has been generally assessed based on site inspection against the following criteria (Keighery, 1993):

Classification	Vegetation Condition
Pristine	Pristine or nearly so, no obvious signs of disturbance
Excellent	Vegetation structure intact, disturbance affecting individual species and weds are non-aggressive species
Very Good	Vegetation structure altered, obvious signs of disturbance
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbance. Retains basic vegetation structure or ability to regenerate to it
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management
Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as being 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs

Keighery, B (1994) ***Bushland Plant Survey, Guide to Community Survey for Community***

In classifying the existing vegetation condition using Keighery (1993), the vegetation within the market garden areas of the subject site is classified as being 'Completely Degraded'.

Subsequently there are no significant flora or vegetation constraints impacting the proposed structure plan within areas of the site that are outside of Bush Forever Site No. 278B.

2.2.2 Vegetation Within Bush Forever Site No. 278

The Bush Forever Site No. 278 *(Cassia Drive Bushland, Karnup)* extends over a portion of the subject site and over surrounding rural lots to the west. Site No. 278A covers the semi-rural land uses to the west in Cassia Drive. Site No. 278B extends over the subject site.

A flora and vegetation assessment was undertaken to inform the Bush Forever negotiated planning solution, which investigated flora and vegetation characteristics of the subject site.

Vegetation within the Bush Forever is generally described as an open forest of predominantly Tuart-Jarrah-Marri, with some species of Banksia present. Overall the condition of vegetation ranges from 'Very Good' to 'Completely Degraded' with no areas found to be in 'Excellent' condition. The degraded vegetated areas are mainly located in the northern half of the subject site.

The flora survey recorded no listed and/or Priority Flora occurring within the subject site. The spring survey confirmed there are no threatened species (*Caladenia huegelii* – Grand Spider Orchid) and Priority 3 species (*Jacksonia sericea*) present within the subject site. The spring survey also investigated if any of the vegetation within the subject site is 'Threatened Ecological Community' (TEC), including the recent listing of Tuart Woodland. The results have informed the negotiated planning solution in the structure plan.

2.3 Fauna

The environmental assessment report indicates that, other than the Bush Forever area, due to the subject site being cleared for horticultural use, there is limited existing habitat that is suitable for native fauna. The strip of Bush Forever along the southern end of Lot 878 provides an ecological linkage between the vegetation on Lot 877 and the Bush Forever area to the west. The structure plan proposes the strip of Bush Forever within Lot 878 to be retained.

The *Lot 877 Stakehill Road Flora, Vegetation and Fauna Assessment* indicates that the vegetation community within the subject site Bush Forever is considered to be 'Open Woodland Habitat' for fauna. The condition of the vegetation structure to serve as potential fauna habitat is considered to be 'Good Fauna Habitat', particularly in areas were the vegetation is in 'Good Condition'.

Potentially the Bush Forever provides habitat for some Conservation Significant Fauna Species, including the Southern Brown Bandicoot (Quenda) and Swan Coastal Plain shield-backed trapdoor spider, both of which are Priority 4 species. The Open Woodland may also provide foraging habitat for Carnaby's Black Cockatoo and Forest Red-tailed Black Cockatoo which will be discussed further in this report.

However, the subject site shows signs of pest fauna activity such as rabbits. There is also the likelihood of feral cats, foxes, rats and mice being present which impact native fauna.

2.3.1 Biodiversity Value

Given the subject site has been historically cleared and with the introduction of feral species such as foxes and rabbits, the native ecosystem of the subject site is highly disturbed. Therefore the subject site has limited biodiversity value.

2.3.2 Black Cockatoo Habitat Assessment

The fauna survey records eight native vegetation species being present within the subject site Bush Forever as foraging habitat for Carnaby's Black Cockatoos. Forest Red-tailed Black Cockatoos would only forage on Jarrah and Sheoak trees on the subject site. No evidence of Black Cockatoo foraging (present or recent past) was observed during a survey.

The subject site Bush Forever is not a known roosting or breeding site for Black Cockatoos. No evidence of roosting or breeding was recorded. However some trees were observed to contain hollows or spouts which could be used for breeding in the future.

The limited observations of Black Cockatoo foraging, roosting and breeding evidence found on the subject site correlate with the low density of Banksia trees. Accordingly the subject site Bush Forever is not considered as prime Black Cockatoo habitat. Any clearing of the site (as part of a Bush Forever negotiated planning solution) is unlikely to lead to a significant impact.

2.4 Hydrology

2.4.1 Groundwater

Groundwater generally flows from the east to the west towards the coast. The depth from natural ground level to the groundwater table is approximately 5.0m in the west and 15.0m in the east. Preliminary engineering investigations indicates that the minimum requirement of 1.2m for groundwater clearance would be well exceeded without the need for significant importing of fill.

Accordingly the groundwater level is highly unlikely to be a significant constraint to structure planning of the subject site. Further hydrological investigations associated with urban development and the impact on groundwater would be undertaken at the subdivision approval stage.

2.4.2 Surface Water

There are no permanent surface water bodies within the subject site area. Sheet drainage across the development site is generally from east to west. Sheet drainage is however limited due to the reasonably high soil permeability and infiltration at source. The large soak for irrigation purposes in the north-west corner of the site has been artificially created.

2.4.3 Wetlands

The Department of Environment Regulation (DER) database *Geomorphic Wetlands of the Swan Coastal Plain* shows no mapped wetlands impacting the subject site. No evidence of surface water or wetland features were observed on the site during inspection. Soils are generally free-draining, therefore no ponding or perched water is present on the site.

2.4.4 Stormwater Management

A District Water Management Strategy and a Local Water Management Strategy have been prepared to demonstrate that the subject site can satisfactorily accommodate urban development and address stormwater management in accordance with WAPC *'Better Urban Water Management'*. The Local Water Management Strategy will provide the framework to guide the preparation of an Urban Water Management Plan at subdivision stage.

Refer to Appendix 3 – District Water Management Strategy

Refer to Appendix 4 – Local Water Management Strategy

2.5 Acid Sulfate Soils

A desktop assessment to determine the presence of Acid Sulfate Soils (ASS) indicates very limited possibility of ASS affecting the subject site. The Department of Planning, Lands & Heritage ASS mapping shows the subject site having no risk of ASS occurring within 3 metres of the natural soil surface. This is generally not unexpected due to the limestone substrate under the soil. Accordingly the presence of ASS is highly unlikely to be a significant constraint to urban development of the subject site.

2.6 Site Contamination

The subject site is currently not listed as contaminated in the Department of Water and Environment Regulation Contaminated Sites database. The site is currently used for horticultural purposes and market gardening land use can contain areas that may be classified as contaminated. A Preliminary Site Investigation (and if required a detailed Sampling Analysis Plan) will be undertaken as a condition of development at subdivision approval stage.

2.7 Poultry Farm Odour Extent

EPA Guidance Statement No. 3 : Separation Distances between Industrial and Sensitive Land Uses provides generic buffer separation distances required for different industrial land uses. Residential development is categorised as a sensitive land use and poultry farms, market gardens and extractive industry (sand mining) are considered industrial land use requiring a separation buffer distance from sensitive land use. EPA Guidance Statement No. 3 recommends a generic 300m – 1,000m odour buffer distance from poultry farms to sensitive land uses.

An Odour Model Impact Assessment for the poultry farm to the north-west of the subject site was undertaken in April 2017. The outcomes of the assessment indicated that the modelled odour impacts for the poultry farm to the north-west would extend by 120m from the north-west corner of Lot 878.

Refer to Appendix 2 – Environmental Assessment Report (Technical Appendix 1 – Odour Assessment Report)

The 120m odour extent is considered adequate as the modelling undertaken was (i) conservative, (ii) the poultry farm facility is egg producing which has lower odour impacts (compared with broiler grow-out poultry farms) and (iii) the predominantly prevailing south-easterly and south-westerly winds will blow any odour impacts away from the subject site. Accordingly, the north-west portion of Lot 878 affected by the odour extent is proposed to be utilised for nonsensitive land uses (i.e. public open space and service commercial) as shown in the structure plan.

The existing poultry farm operating on Lots 7 & 8 Eighty Road to the north-east of the site will be removed in the future as DevelopmentWA has now purchased the farm. An Odour Model Impact Assessment has been undertaken and included in the EAR. The outcomes of the assessment indicate that the location, scale and operations of the poultry farm will not present a significant impact on the structure plan. This is due to the location of the poultry farm being upwind from structure plan by the prevailing southerly winds. In addition, the poultry farm has a mechanical ventilation system to mitigate odour impact on neighbouring and surrounding properties. Odour would only generally impact the structure plan when there is a northerly (north-east) wind and especially combined with infrequent cleaning of sheds. The likelihood of these factors combining at any one time is low and would be of short duration. Accordingly, an appropriate odour extent is shown on in the structure plan whereby sensitive land uses would not be permitted until the odour extent is removed or modified. This is considered appropriate to address intermittent potential mild odour impact during shed clean out activities during a northerly wind direction.

2.8 Market Garden Spray Drift Buffer

EPA Guidance Statement No. 3 recommends a generic 300m – 500m buffer (spray drift) separation distance depending on the type and size of the market garden. There is an existing market garden on Lot 849 Stakehill Road directly to the north of Lot 877, used for vegetable production. Pesticide and herbicide spray drift is unlikely to be a significant issue as spraying is conducted predominantly at ground level and under low pressure. The southerly prevailing winds also assist in minimising impact of spray drift on the subject site.

The environmental assessment report has considered the proximity of the market garden to the subject land. A minimum separation buffer of approximately 40m wide would be sufficient to meet the minimum separation requirements set out in the Department of Health guidelines. A Vegetation Buffer Technical Note is provided which outlines the mitigation strategies for addressing potential market garden spray drift. In addition a Planning Technical Note also explains in further detail the planning considerations for addressing market garden spray drift.

Refer to Appendix 12 – Vegetation Buffer Technical Note (PGV)

Refer to Appendix 13 – Planning Technical Note No. 2 'Market Garden Spray Drift Buffer'.

The structure plan provides for a market garden spray drift buffer (refer to Image 1 below), consisting of the Stakehill Road reservation width, the planning control area, acoustic wall and a further vegetation (landscaping buffer) within public open space, which is provided within the site extending along the northern boundary of the site opposite the market garden. With the provision of an appropriate buffer, the existing market garden operation on Lot 849 will not present a significant constraint to the structure plan. The implementation details of the market garden spray drift buffer are included in Appendix 14 – Vegetative Buffer Plan.

There is also a market garden on Lot 1 Harvey Road directly abutting the proposed Bush Forever negotiated planning solution area at the south-east corner of the subject site. A similar 40m separation buffer would be appropriate given spraying would mostly be conducted at ground level and under low pressure. The Nairn Drive regional road reservation (40m wide) will provide a buffer. In addition, areas set aside for public open space and Bush Forever in the structure plan will provide a screen and buffer from the market garden to proposed sensitive land uses. Accordingly, the existing market gardening operation on Lot 1 does not present a significant constraint to the proposed structure plan.

2.9 Extractive Industry Buffer

EPA Guidance Statement No. 3 recommends a generic 300m – 500m (noise and dust) buffer distance depending on the size of the extractive industry use. The extractive industry operation is located approximately 600m to the east of the site and is separated by rural lots, Harvey Road and the future Nairn Drive regional road. Tenement M70/1241 is 560m at its closest point and M70/1046 is 1.2km away at its closest point. These mining tenements do not impact the structure plan. Furthermore, in the consideration of the Karnup Phase One Structure Plan, the Department of Mines and Petroleum supported a separation distance (buffer) of 100m between sand mining operations and proposed development.

The sand mining operations to the east is not a long-term operation. As reported in the environmental assessment report, the continued long-term extractive industry use to the east is highly unlikely to impact urban development of the subject site.

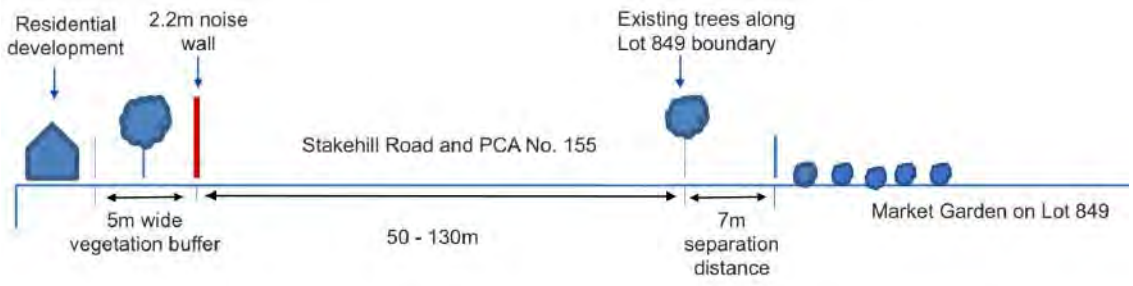


Image 1. Cross section vegetation buffer (market garden spray drift buffer) Source: PGV, 2022

2.10 Transport Noise

The subject site is located adjacent to two major transport regional roads, being Stakehill Road and Nairn Drive (future extension connecting Eighty Road alignment). Both these roads will carry substantial traffic which has the potential to generate transport noise. Acoustic assessments were undertaken to assess the impacts of these roads on the urban development of the subject land.

The acoustic assessment conducted in 2017 investigated potential noise impact from Stakehill Road and Nairn Drive on an earlier draft version of the structure plan. The acoustic assessment undertaken in 2019 investigated noise impacts from Nairn Drive on a pre-lodgement version of the negotiated planning solution structure plan.

Both acoustic assessments conclude that urban development can be accommodated in proximity and/or adjacent to Stakehill Road and Nairn Drive, subject to consideration and management of the impacts of transport noise as recommended in the report. This include provision of an acoustic wall and/or implementation of 'Quiet House Design' to sensitive land uses within the future built form environment.

The requirement for further acoustic assessment at subdivision stage has been included in the structure plan Part One – Implementation at Clause 4.10. Accordingly, there are no significant transport noise constraints impacting urban development and the acoustic assessments confirm that transport noise can be adequately managed at later stages of planning.

Refer to Appendix 5 – Acoustic Assessment (2025)

2.11 Indigenous and European Heritage

A search of the Department of Planning, Lands and Heritage (Aboriginal Heritage Inquiry System) indicates that no Indigenous Heritage sites exist on the land. The subject site is contained within *Heritage Survey 102670(1)*. There are no places or sites of cultural significance within the subject site under the City of Cockburn Municipal Heritage Inventory and State Heritage Register.

2.12 Bushfire Management

The site is affected by the Department of Fire and Emergency Services bushfire prone mapping. The majority of the site within the structure plan boundary has been cleared for rural pursuit. However the site is adjoining areas which have been identified as 'Extreme' and 'Moderate' bushfire hazard level.

A Bushfire Management Plan has been prepared for the structure plan. The bushfire report demonstrates that the subject site is capable of supporting urban development, whereby the threat of bushfire from internal and neighbouring vegetation can be adequately addressed and managed.

The bushfire report demonstrates that potentially, proposed urban development for residential lots could achieve BAL ratings of predominantly BAL-LOW to BAL 12.5, with no residential lots exceeding BAL 29.

There are no issues with provision of secondary emergency access (in a different direction to the primary access) as a secondary emergency access can potentially be provided to Cassia Drive to the south and an additional emergency exit to Cassia Drive to the west. The bushfire report demonstrates that there are no significant bushfire constraints, that cannot be adequately managed, for urban development of the subject site in accordance with the structure plan.

Refer to Appendix 6 – Bushfire Management Plan

2.13 Site Access

The subject land is already serviced by existing sealed roads and this will be further discussed in the report. The engineering investigations indicate that the subject land can be developed with necessary road infrastructure to support urbanisation. Roads will generally be constructed to the satisfaction of the local authority, including provision of pathways, kerbing and piped drainage. The local water management strategy demonstrates that stormwater from proposed roads can be adequately managed within the development.

The subject site therefore has sufficient road access to the existing and planned transport movement network and can support urbanisation. Future planning for provision of roads and connections to existing roads to provide new subdivision roads to service residential lots will be discussed in further detail in this report.

3. Key Planning Framework

REGIONAL & SUB-REGIONAL PLANNING

3.1 Perth and Peel @ 3.5 million

The Perth and Peel @ 3.5 million provides strategic land use planning documents to facilitate accommodation of a forecast population growth of 3.5 million for Perth and Peel regions by 2050. Within the context of this document, the subject site is located within the South Metropolitan Peel Sub-Regional Planning Framework.

The *South Metropolitan Peel Sub-Regional Planning Framework* (SMPSRPF) provides a framework for delivering the objectives of Directions 2031 and Beyond. The subject site (and the large area of DevelopmentWA Karnup Master Plan to the east) is identified in the Framework as 'Urban' thus forming part of the future urban footprint as shown in Figure 5.

Land identified as 'Urban' and 'Urban Deferred' in the Framework is generally given higher priority for short – medium term urban development than 'Urban Expansion' and 'Urban Investigation' areas identified in the Framework. The rural land in Karnup neighbouring and to the south of the subject site is identified in the Framework as 'Urban Expansion'.

Thus the required planning investigations for any potential urbanisation of Karnup rural land, identified as 'Urban Expansion' to the south of the subject site, should not delay structure planning for the subject site, given its established priority as 'Urban' land in the Framework.

It should also be noted that the subject site is included in the City of Rockingham Development Contribution Area No. 2, of which DCA2 contributions have already accounted for developer contributions from the subject site and Karnup Phase One Structure Plan urban areas. This requirement is included in Part One under Clause 4.5.

Refer to Figure 5 – South Metropolitan Peel Sub-Regional Planning Framework

3.1.1 Regional & District Requirements under the SMPSRPF

The Framework does not identify any specific district or regional planning infrastructure for the subject site, except for the future Nairn Drive regional road and Stakehill Road regional road widening. It is noted that the Framework does not identify the future district centre within or adjacent to the subject site. The proposed district centre is shown in the Framework as being well to the south of the subject site, where it will be more centrally located within Karnup.

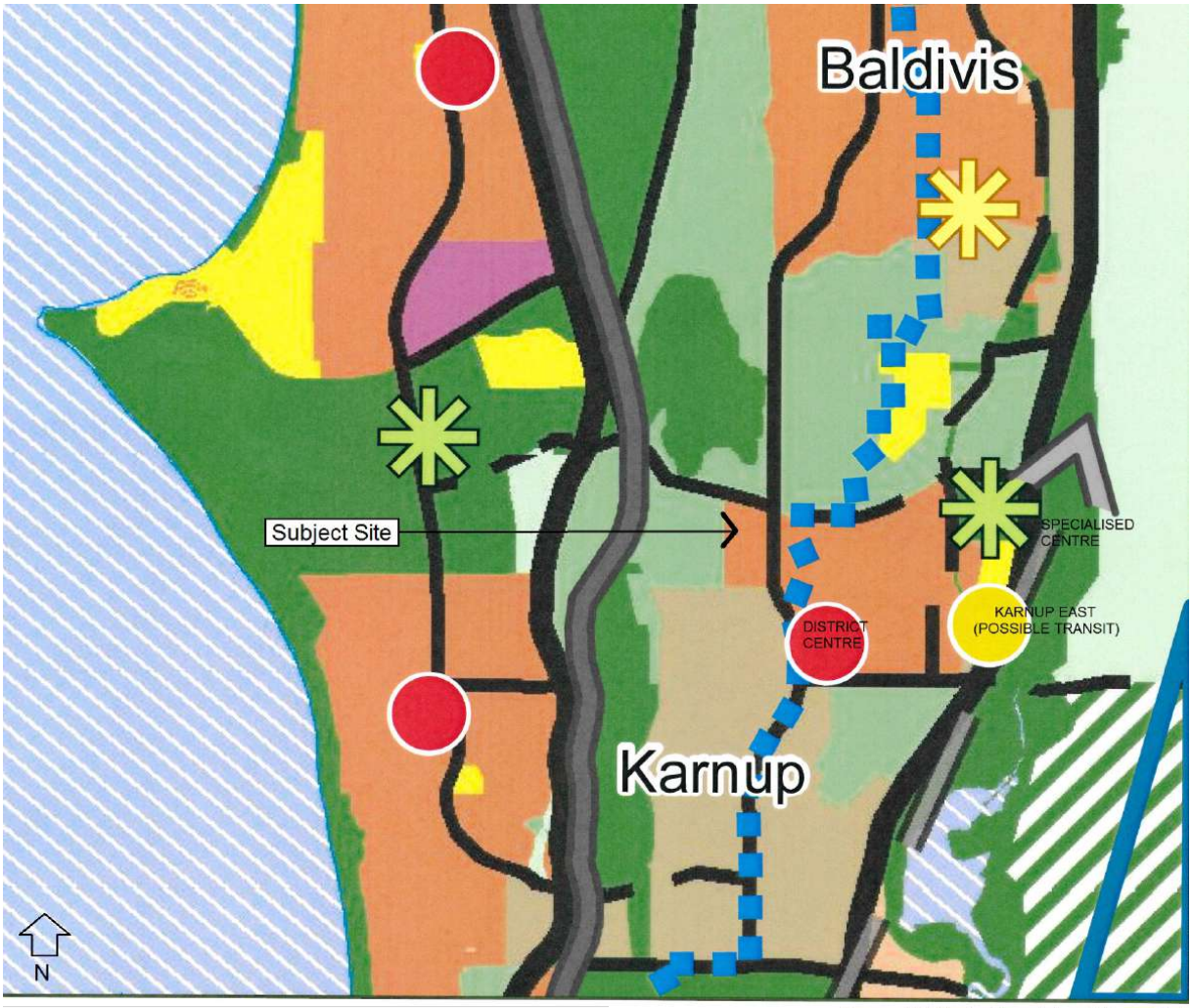
3.1.2 Staging & Implementation under the SMPSRPF

The SMPSRPF identifies the subject site as urban 'medium term (2022-2031). Approval of the structure plan would allow for a 10 year structure plan expiry, which would fall within the forecast 'medium term' timeframe.

Under Section 4.2 of SMPSRPF it states:

"Development within the sub-region will need to be undertaken in a sequential manner as logical extensions to existing development fronts to ensure that an adequate supply of land will be continuously available. The timeframes depicted on the urban staging plan (Plan 10) set out the anticipate timing for commencement of development, aligned with planning service provision and should not be construed as preventing further detailed planning from occurring in the interim."

The MRS amendment and structure plan approval process will take time in the interim as urbanisation in the southern portion of Baldivis matures. The SMPSRPF identifies the northern portion of Karnup as providing available urban land for 2022 - 2031.



(Source: WA Planning Commission, 2015- *modified*)

Legend

Framework Land Uses
- Railway
- Railway Investigation
- Urban
- Urban Deferred
- Urban Expansion
- Urban Investigation
- City Centre
- Industrial
- Industrial Expansion
- Industrial Investigation
- Peel - Harvey Coastal Plain Catchment Area (SPP 2.1)
- Rural Residential
- Rural
- State Forest
- Open Space
- Open Space Investigation
- Waterway
- Public Purposes
- Proposed Public Purposes
- Proposed Open Space - Sport

Regional Roads (MRS/PRS)
- Existing
- Proposed

Rail
- Passenger Rail - Existing
- Passenger Rail - Proposed
- Potential Perth-Bunbury Passenger Rail (conceptual only and subject to further investigation)
- Freight Rail (Post-2031 Investigation)

Activity Centres
- Strategic Metropolitan
- Secondary
- District
- Specialised Centre

Figure 5. Perth and Peel at 3.5million Sub-Regional Planning Framework

The Transport Impact Assessment has modelled full development of the structure plan by 2031, which is consistent with the timeframe for delivery set out in the sub-regional planning framework.

Accordingly, approval of the structure plan would be consistent with the SMPSRPF 'medium term' timeframe for the urbanisation of the subject site.

3.2 Directions 2031 and Beyond

Directions 2031 and beyond: Draft Spatial Policy for Perth and Peel provides strategic direction for the future growth of the Perth and Peel regions. Directions 2031 is a high-level strategic land use planning document for the Perth and Peel for the planning and delivery of housing, infrastructure and services necessary to accommodate growth up until 2031. Directions 2031 has a target density of 15 dwellings per hectare, which is considered a sustainable use of urban zoned land.

The *Draft Outer Metropolitan Perth and Peel Sub-Regional Strategy* within Directions 2031 identifies the structure plan area as part of the "KA1" precinct with an estimated potential for future 4,800+ dwellings. The structure plan area will thus contribute to the overall 'KA1' expected dwelling yield in the metropolitan urban expansion strategy.

Refer to Figure 6 – Draft Outer Metropolitan Perth and Peel Sub-Regional Strategy

3.3 Metropolitan Region Scheme

The majority of the subject site is currently zoned 'Urban' as a result of MRS Amendment 1424-27 which was gazetted on 26 April 2024. MRS Amendment 1424-27 resulted in the transfer of land from the 'Urban Deferred' zone to the 'Urban' zone. The portion of the 'Urban Deferred' zone containing Bush Forever Site 278 in the southern part of Lot 878 and the southern part of Lot 877 was not included in the amendment.

A portion of the site has an MRS 'Notice of Delegation – Bush Forever Area' over a strip of land along the southern boundary of Lot 878 and over the southern half of Lot 877. An area along the eastern boundary of Lot 877 is reserved under the MRS as 'Other Regional Roads' which forms the future extension of Nairn Drive which generally follows the alignment of existing Eighty Road.

Stakehill Road is reserved under the MRS as 'Other Regional Roads' and this is proposed to extend further east to connect with Kwinana Freeway 'Primary Regional Road' reservation. Planning Control Area No. 155 extends along the frontage of the site providing for future road widening requirements for the upgrade of Stakehill Road.

Neighbouring and surrounding land to the west, south and north is currently zoned 'Rural', with portions of land to the west having 'Notice of Delegation – Bush Forever Area', which coincides with Bush Forever Site No. 278. Land to the east on the opposite side of future Nairn Drive MRS 'Other Regional Roads' reservation is zoned MRS 'Urban Deferred' comprising of DevelopmentWA's Karnup Phase One development area.

3.4 State Planning Policy 2.8 'Bushland Policy for the Perth Metropolitan Region'

SPP 2.8 provides a framework for the long term protection and management of significant bushland areas within the Perth Metropolitan Region. As stated in this report, the subject site contains a portion of Bush Forever No. 278, being an area of regionally significant bushland. The structure plan proposes a negotiated planning solution for the areas identified as MRS 'Notice of Delegation - Bush Forever Area'. Further detail on the negotiated planning solution proposal which addresses SPP 2.8 is contained in Section 4.2 of this report.

3.5 State Planning Policy 3.7 'Planning in Bushfire Prone Areas'

The majority of the subject site has been identified and designated by the Fire and Emergency Services Commissioner under the Fire and Emergency Services Act 1998 as a bushfire prone area and as such SPP 3.7, and its accompanying WAPC *Guidelines for Planning in Bushfire Prone Areas,* apply to urbanisation of the subject land.

In accordance with the requirements of SPP 3.7 a Bushfire Management Plan has been prepared and demonstrates there are no significant bushfire constraints that would preclude the subject land from being developed for urban use in accordance with the structure plan. This has been discussed in Section 2.12 of this report.

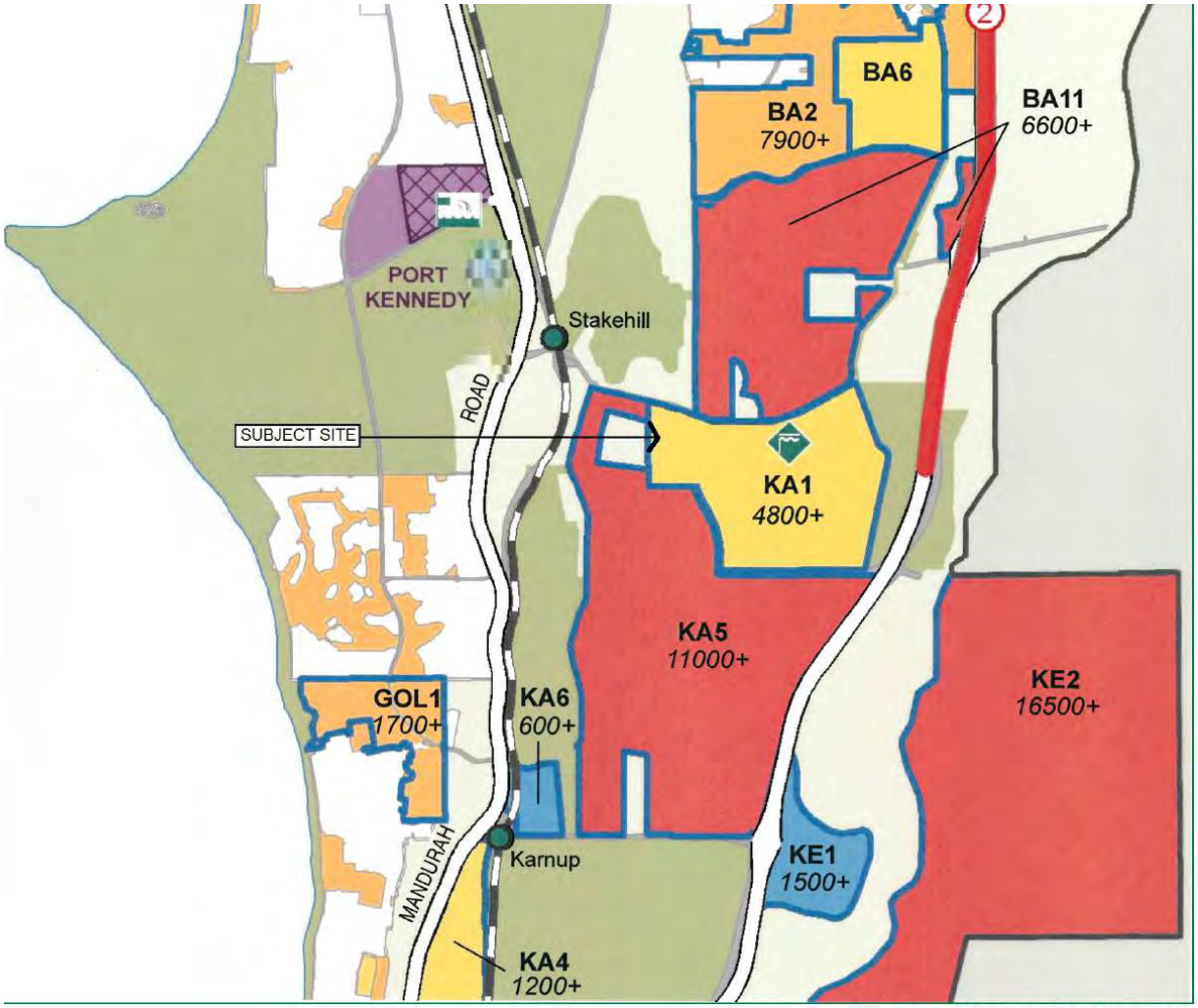


Figure 6. Outer Metropolitan South Sub-Regional Strategy

3.6 State Planning Policy 4.1 'State Industrial Buffer Policy'

SPP 4.1 provides guidance for considering proposals to rezone land for sensitive uses in the vicinity of, amongst other industry types, poultry farm, market garden and extractive industry. The EPA *Guidance Statement No. 3 – Separation Distances Between Industrial Sensitive Landuses* is incorporated into SPP 4.1 as a planning consideration. As previously discussed in section 2.7, 2.8 and 2.9 above, the structure plan adequately addresses the buffer distances in EPA Guidance Statement No. 3.

3.7 State Planning Policy 4.2 'Activity Centres for Perth and Peel'

SPP 4.2 is intended to guide decision making as to land use planning for the location, scale and development outcomes of commercial centres. The Policy provides guidance for centre planning in the preparation of a local commercial strategy and/or activity centre structure planning.

The size and scale of the commercial area and the types of commercial uses proposed in the structure plan are consistent with SPP 4.2 (and the City of Rockingham Local Commercial Strategy) and this is further discussed in Section 4.8 of this report.

3.8 State Planning Policy 5.4 'Road and Rail Noise'

The primary purpose of SPP 5.4 is to minimise the adverse impact of transport noise in land use planning, to ensure where sensitive development is proposed in proximity to transport noise that appropriate mitigation measures are implemented, without adding unreasonable cost to transport infrastructure.

Stakehill Road and the future Nairn Drive extension are proposed MRS 'Other Regional Roads' which will accommodate major transport activity. Accordingly, acoustic assessments have been undertaken to assess and address the impacts of these roads on the urban development of the subject land.

The outcomes of the acoustic assessment conclude that urban development can be accommodated in proximity and/or adjacent to Stakehill Road and Nairn Drive, subject to consideration and management of the impacts of transport noise as recommended in the report. This includes provision of an acoustic wall and/or implementation of 'Quiet House Design' to the built form environment. This has been discussed in Section 2.10 of this report.

3.9 WAPC Liveable Neighbourhoods

Liveable Neighbourhoods (LN) has been prepared to guide the sustainable development of communities. It addresses both strategic and operational aspects of structure planning and subdivision for both 'greenfield' and urban infill sites.

The structure plan has been designed in accordance with the principles of Liveable Neighbourhoods, in particular, the layout of roads and POS. Consistent with LN, the structure plan provides a high level of connectivity with good external linkages to existing and planned road, cycle and pedestrian transport networks.

The road design in the structure plan is legible and reduces car travel distances by creating alternative routes. These aspects are further addressed in the report when referring to the indicative Development Concept Plan for the subject site.

Refer to Figure 7 – Development Concept Plan

LN encourages walkable access to Public Open Space (POS). Within the structure plan, all lots are within 400 metres walking distance from POS areas. This provides residents with opportunities for active lifestyle and recreation within five minutes walking distance from residences. Importantly, the structure plan will establish upfront as part of the single staged development a useable and functional active POS area for existing and future residents.

Consistent with LN, it is important for the structure plan design to respond to site characteristics and site context. The structure plan design has taken into consideration the natural topography, surrounding land uses, solar orientation and existing developments. Proposed lots can achieve an east-west or north-south orientation, which provides good opportunity for solar orientation for dwelling design and outdoor living areas.

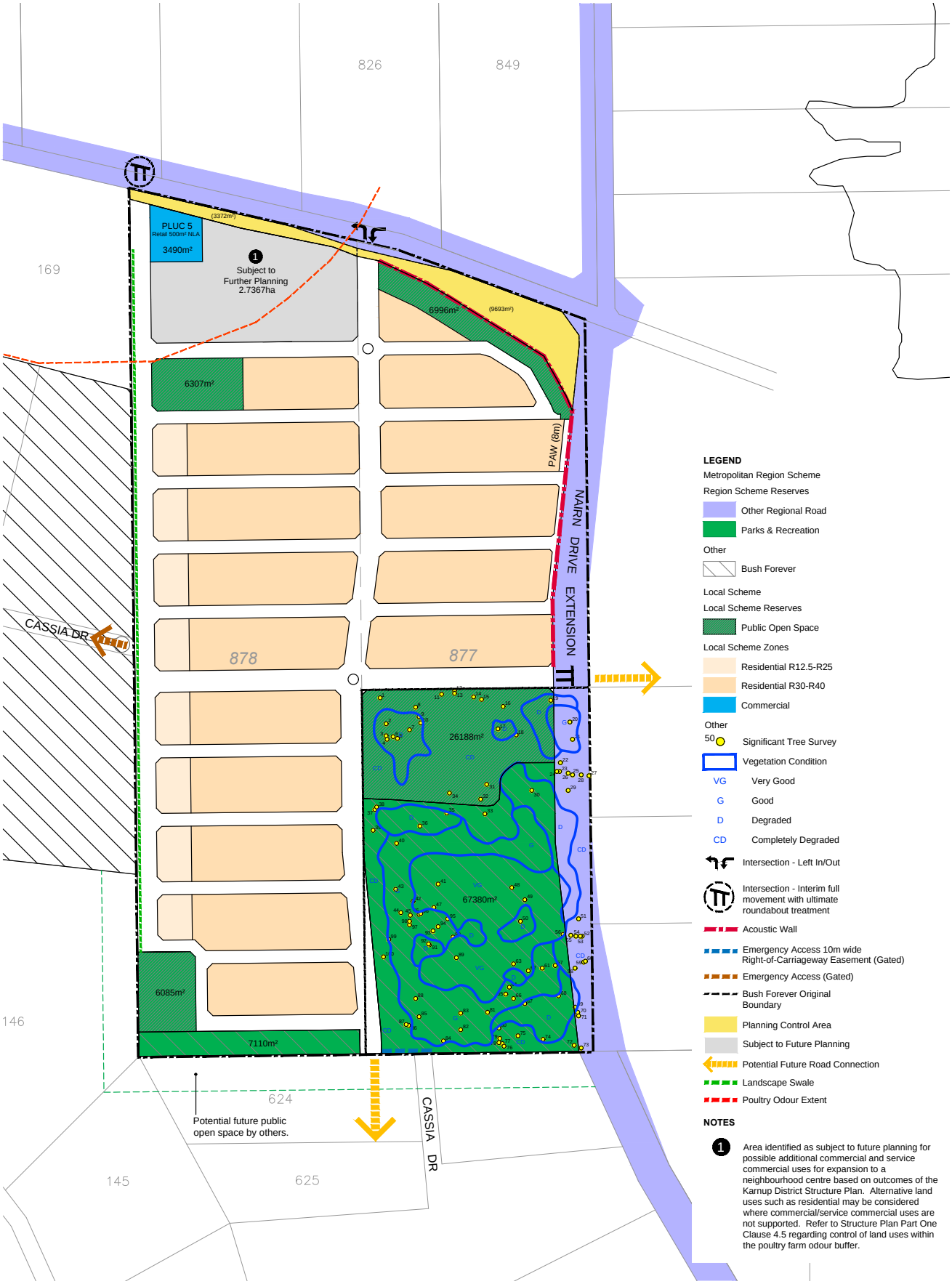


Figure 7. Development Concept Plan

Within the structure plan, lots that face parkland increase opportunity for passive surveillance and interaction with public spaces. Lot shape and proportion of width to depth is considered important and the lots in the structure plan have been designed to be rectangular in shape with a greater depth than width wherever possible. This ensures ability to develop the lots with high quality housing and built form and conformity with the Residential Design Codes of Western Australia.

Other aspects of LN principles, such as local water management and road hierarchy are addressed further in this report. In addition, the proposed commercial uses in the structure plan and the site location for the commercial centre abutting Stakehill Road, at the main entrance to the development, is discussed in further detail under Section 4.8 to demonstrate consistency with the principles of LN.

LOCAL PLANNING

3.10 City of Rockingham Town Planning Scheme No.2

Under the City of Rockingham Town Planning Scheme No. 2 (TPS 2), the subject site is zoned 'Development' zone within 'Development Area No. 36'. The site is also within 'Development Contribution Area No. 2'. Consistent with the MRS the 'Other Regional Roads' reservation is reflected in the TPS 2 for the subject site.

In November 2004, the then Minister for Planning directed the City to zone land which was MRS zoned 'Urban Deferred' to 'Development' zone under TPS 2. Subsequently, the subject site is currently zoned 'Development' zone, notwithstanding those portions of the site that are zoned MRS 'Urban Deferred'. Under the TPS 2 provisions for the 'Development' zone, a structure plan is required to be prepared and approved, prior to any subdivision and/or development commencing.

3.11 City of Rockingham Local Planning Policy 3.1.12 'Local Commercial Strategy'

Planning Policy 3.1.12 (as amended June 2013) provides an overview of the City's retail strategy for existing and planned activity centres. The City's Local Commercial Strategy (LCS) identifies Neighbourhood Centres to generally range from 1,500m^2 – 4,500m^2 net lettable area (nla).

For neighbourhood centres the LCS states:

> *"Recent retail location philosophy suggests that a viable centre needs to be able to harness a substantial 'movement economy' to ensure that its calculated trade is boosted by the passing trade. This means that large neighbourhood centres, if they are to be viable, will want to locate along major roads." (Page 20)*

The subject site is located within LCS 'Precinct 5 – Karnup'. There are no existing retail facilities in Karnup and a District Structure Plan has not been prepared which identifies the location of future centres in Karnup. The LCS does indicatively show possible locations for centres in the LCS map, however, within the Precinct 5 table on the map it states *"The centres modelled were hypothetical. No specific centre locations or sizes are recommended at this time."*

In the interim, whilst the population of Karnup is expected to substantially grow as a result of urbanisation, the Strategy envisages residents in Karnup to be serviced by the established Secret Harbour district centre. However as a minimum for Karnup a neighbourhood centre should be provided for daily convenience products.

The Policy recommends that neighbourhood centres should be provided for within the 'Commercial' zone under TPS 2. A 'Service Commercial' zone offers opportunities for other types of commercial non-retail uses that are compatible with the commercial zone. The structure plan sets aside an area designated as 'Subject to Future Planning' so that the potential for provision of both commercial and service commercial uses can be considered. This will be further discussed in the report in Section 4.8.

3.12 City of Rockingham Structure Plans (Karnup locality)

Currently there are no approved structure plans in Karnup, however there is a draft structure plan that was submitted to the City:

Karnup Phase One Structure Plan, for DevelopmentWA landholdings of Lots 316 & 1340 Stakehill Road.

The Karnup Phase One Structure Plan was advertised to the community and key stakeholders from 19 November 2016 to 18 December 2016. Following advertising, the structure plan was considered by the City of Rockingham at its Meeting held 23 February 2016.

City of Rockingham resolved to support the structure plan subject to a few modifications. Preceding this City of Rockingham correspondence dated 7 January 2016 to WA Planning Commission advised of the City's reconsideration and subsequent support for the lifting of Urban Deferment over the structure plan area, with the exception of the area subject to further investigation for a future District Centre.

The Karnup Phase One Structure Plan is a major greenfield urban development in Karnup. The structure plan generally provides for the following key urban elements:

- Residential development for approximately 1,000 – 1,200 dwellings with density ranging R25 – R80, providing a diverse mix of housing accommodation;
- A new primary school;
- A new Local Centre accommodating 1,500m^2 of retail floor space;
- An extension to Baldivis Road at the intersection of Stakehill Road and an extension and upgrade to Harvey Road; and
- Two new north/south neighbourhood connector roads being provided at the intersection of Ukich Place/ Stakehill Road and Firbank Lane/Stakehill Road and a new east/west neighbourhood connector road between Baldivis Road and Harvey Road.

The Karnup Phase One Structure Plan has been placed on hold by DevelopmentWA at this stage.

Both this structure plan and the Karnup Phase One Structure Plan are beginning to provide guidance towards future urbanisation in Karnup North.

This structure plan and that Karnup Phase One Structure Plan is for the MRS urban deferred area in northern Karnup, identified in the SMPSRPF as 'Urban' use. Both structure plans will inform the future district structure planning over the remaining rural areas in Karnup to the south.

The future district structure planning over Karnup rural land identified in the SMPSRPF as 'Urban Expansion' will require comprehensive technical and land use investigations, that are necessary to confirm the urban footprint boundaries, servicing and infrastructure requirements. These district level comprehensive studies are not necessary for the subject site and Karnup Phase One urban areas, which are already established areas for urbanisation.

3.13 Draft Karnup District Structure Plan

The City of Rockingham is currently preparing the Draft Karnup District Structure Plan over an area of approximately 2000 hectares as shown in Figure x. The district structure plan is a high level strategic plan which will guide future land uses and coordinate the provision of future services and infrastructure to support urban development in Karnup. Preparation of the district structure plan will include extensive consultation with the community and key stakeholders and will incorporate the planning outcomes of this structure plan for Lots 877 and 878. Figure 8 shows the subject site in the context of the Draft Karnup District Structure Plan project area.

Refer Figure 8 - Draft Karnup District Structure Plan Project Area.

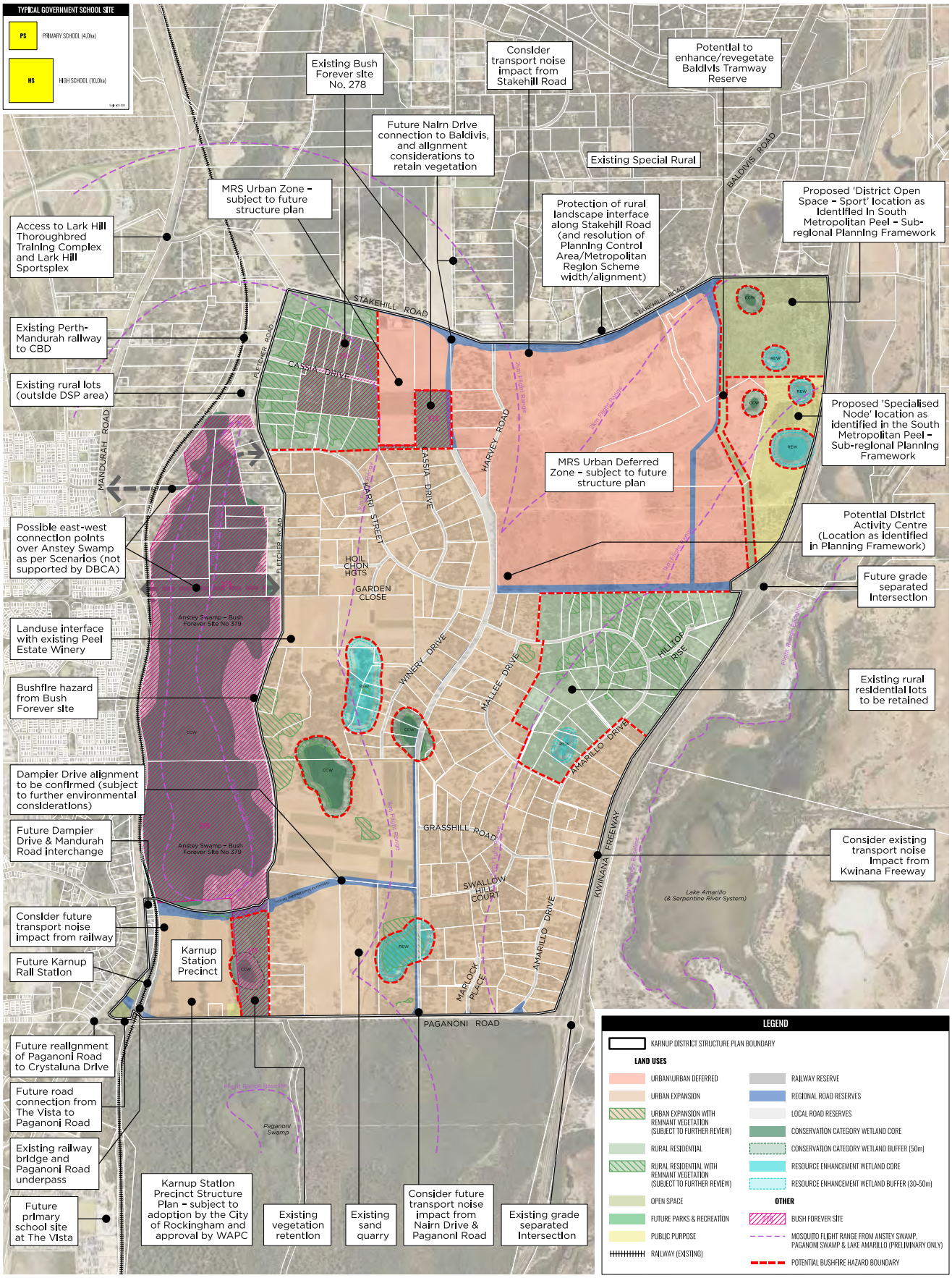


Figure 8. **Draft Karnup District Structure Plan Project Area.** Source: City of Kwinana website August 2024

4. Structure Plan

4.1 Land uses

The structure plan map outlines the Zones and Reserves applicable within the structure plan area which will guide future subdivision and development of the land. Land uses in the structure plan include residential, commercial and regional open space. There is also potential for additional commercial and service commercial in the area designated 'Subject to Future Planning' should there be a need identified. Overall the diversity of these land uses will provide for a vibrant and diverse community.

4.2 Bush Forever Negotiated Planning Solution

The area Bush Forever Site 278B within the subject site is approximately 11.654 hectares and this includes the portion of Nairn Drive regional road reservation inside the Bush Forever area. Bush Forever Site 278B is designated in the State Government of WA Bush Forever Report 2000 as 'Part B: Negotiated Planning Solution'.

Under State Planning Policy 2.8 'Bushland Policy for the Perth Metropolitan Region' where Bush Forever is located within privately owned land, a negotiated planning solution can determine an appropriate outcome for the retention and conservation of Bush Forever. A proposed SPP 2.8 negotiated planning solution (NPS) applies to land earmarked for development through approved planning processes. A NPS involves the development of planning and design solutions in consultation with the landowner to achieve Bush Forever objectives, while still allowing some development to proceed. Solutions can include the use of structure planning which would identify and guide future land use and conservation desired outcomes at the subdivision and/or development approval stage.

At the core of an NPS, any development would be encouraged to develop innovative design solutions

that retain core conservation values and threatened ecological communities and provide an appropriate development and bushland interface. For instance, in the structure plan land within the northern portion of the Bush Forever area is degraded, but contains significant trees. The structure plan proposes retention of these trees within parkland cleared public open space. This provides an appropriate innovative design solution between competing urban use and environmental values.

The subject falls within the expectations and objectives for Bush Forever 'Urban NPS' being:

- To maximise bushland retention for stand-alone Bush Forever Sites through statutory planning processes and environmental approval processes, where applicable, and to seek a balance between the needs of conservation and development and a reasonable outcome.
- Maximising the retention of vegetation will involve some development trade-off.

(Bush Forever Volume 1 – Policies, Principles and Processes, WAPC 2000)

The proposed NPS is outlined in this report below. This process has resulted in a legal agreement between the Proponent landowner and Western Australian Planning Commission. Implementation of the NPS is through the future structure planning and subdivision processes under the direction of the legal agreement. The NPS is for the whole of Bush Forever Site 278B (Lots 877 & 878). The proposed NPS (as shown in Figure 8) focuses on utilising the northern degraded area of the Bush Forever as part of the developer's 10% public open space land contribution. Existing vegetated areas that are in good condition are proposed for retention in balance Bush Forever 'Parks and Recreation' regional reservation (Figure 9).

Refer to Figure 9 - Bush Forever Area

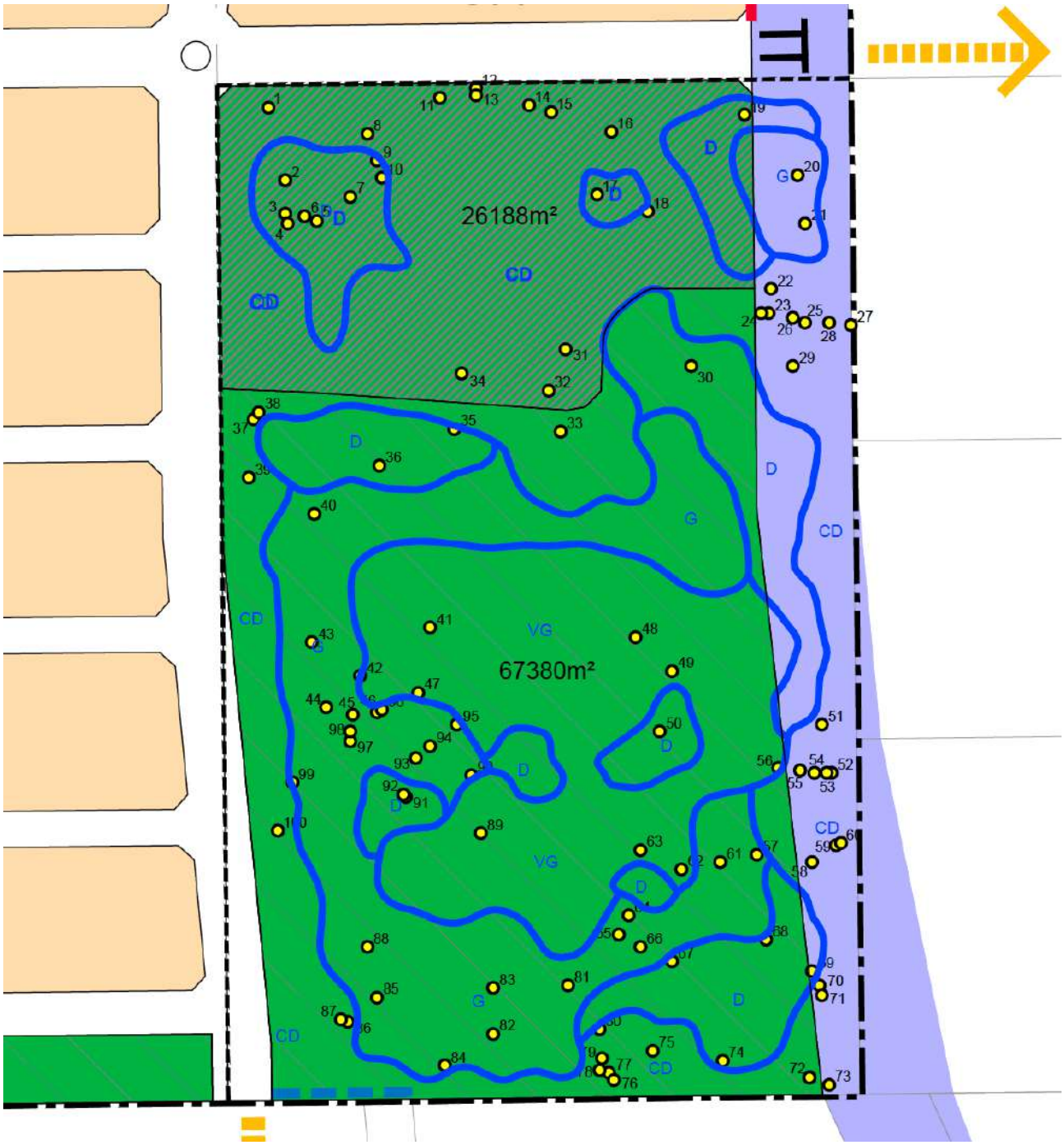


Figure 9. Bush Forever Area

4.2.1 Bush Forever NPS - Conservation of Significant Trees and Vegetation

The existing Bush Forever Site No. 278 on Lot 878 will be retained, except for the area required for the future Neighbourhood Connector road extension to the south. Approximately 76% of the Bush Forever Site No. 278 on Lot 877 will be retained, which includes the area within the Nairn Drive regional road reservation.

Table 1 provides a breakdown of the Bush Forever negotiated planning solution.

Table 1. Bush Forever Negotiated Planning Solution Land Uses

Percentage of Bush Forever No. 278 retained within Lots 877 & 878 Stakehill Road	
Total Area of Bush Forever Site 278 within Lots 877 & 878	11.654 ha
Less Urban Use (Public Open Space)	2.619 ha
Less Urban Use (Neighbourhood Connector Road)	0.2123 ha
Net Area Bush Forever retained (includes Nairn Drive reservation)	8.823 ha
Percentage	**76%**

The southern two thirds of the Bush Forever site on Lot 877 contains the majority of the good and very good condition vegetation, which comprises significant trees and regrowth understorey. Thus the best areas of Bush Forever Site No. 278 will be retained for conservation within a future Crown Reserve and reserved MRS 'Parks and Recreation' regional reservation.

The proposed negotiated planning solution is consistent with the key policy provisions in SPP 2.8. In particular Clause 5.1.2.2(ii) which requires a minimum of 30% of the Bush Forever site being retained for conservation. The proposal will retain 76% of the Bush Forever area, in addition to existing vegetation and trees that will be retained within the public open space use *(refer to Appendix 9 – Landscaping Concept Plan).* The balance of the Bush Forever area will be retained as local Public Open Space, thereby preserving all of the significant tress within the Bush Forever site.

The structure plan retains the existing east-west linkage (linear Bush Forever strip along the southern boundary of Lot 878). This linkage connects the main Bush Forever area on Lot 877 with the Bush Forever area within privately owned semi-rural lots in Cassia Drive to the west. The location of public open space along the western boundary of the subject site reinforces and strengthens this east-west linkage.

Should the rural properties to the south be zoned for urban development in the future, there would be opportunity to further widen the east-west linkage by the creation of public open space on the neighbouring properties. In addition, there may be a potential planning opportunity in future to enlarge the connection with the Cassia Drive Bush Forever, by acquiring and creating POS along the rear portions of rural properties to the west, to widen the linkage between the Bush Forever sites. This would also provide a buffer to rural properties west of Lot 878 that are not going to be developed for urban.

4.2.2 Bush Forever NPS - Implementation

As part of the structure plan approval, the landowner and WA Planning Commission have entered into an agreement to implement the land subdivision of the Bush Forever area intended to be set aside as Crown Reserve for regional open space as provided for in the structure plan. The subdivision and ceding free of cost of the Bush Forver area in the structure plan as a Crown Reserve will likely form part of the initial stage of development. The MRS notice of delegation 'Bush Forever' mapping over the area intended for local public open space will be rationalised as part of an MRS Omnibus Amendment.

The setting aside of the Bush Forever area to be retained for conservation under SPP 2.8 within a future Crown Reserve (along with its reservation under the MRS as regional open space 'Parks and Recreation') will provide secure tenure. The Bush Forever area will be fenced (i.e. bollards and timber post/wire) and sign-posted to restrict public access to promote rehabilitation and conservation.

4.3 Residential Densities and Yield

The Development Concept Plan in Figure 7 provides one option for the urban development of the subject site, with an estimated 420 dwellings that could be accommodated. The concept plan could provide for a mix of dwellings, predominately single dwellings on 12.5m – 15.0m frontage lots ranging in area from 375m^2 – 450m^2. Medium density R40 could be provided around the commercial centre and high amenity areas such as POS.

The concept plan could accommodate up to approximately 1,176 people, based on an average household of 2.8 persons. The final lot yield and design would be determined as part of detailed subdivision at later stages of planning.

Table 2 provides an overview of development statistics based on the concept plan. Although the concept plan is indicative only at this structure plan level of planning (and not the subject of approval), the structure plan technical reports have been based on the concept plan. The concept plan provides a point of reference to demonstrate the capability of the proposed structure plan design over the subject site.

Table 2 demonstrates that the structure plan design delivers approximately 26 dwellings per site hectare, which meets the Liveable Neighbourhoods density expectations for the site's locational context. At a conservative level, the concept plan delivers 12 dwellings per gross urban hectare, which falls short of the target density of 15 dwellings per gross urban hectare under Directions 2031.

However this is mainly due to extensive areas of Bush Forever, commercial and regional road reservation being set aside and not able to be developed for residential use. The substantial amount of non-residential land use in the structure plan therefore reduces the overall target density per gross urban hectare. But for the areas identified for residential use, the dwelling yield meets the yield expectations per site hectare under Liveable Neighbourhoods (refer to Table 3).

The initial estimated 420 dwellings in Table 2 is based on an average lot size of approximately 450m^2.

Table 2. Development Statistics (based on the Concept Plan)

	Site Outcomes	Target Density
Total Structure Plan Area	487,150m^2	-
Area set aside for local and regional roads	253,255m^2 (approximate)	-
Area set aside for public open space and regional open space	12,008m^2 (approximate)	
Area set aside for commercial and future planning	30,857m^2 (approximate)	
Balance area for residential development	191,030m^2 (approximate)	-
Estimated number of dwellings	420 dwellings	-
Estimated number dwellings per site hectare[1]	22 dwellings per site hectare	Liveable Neighbourhoods 12 – 20 dwellings per site hectare for standard lot layouts; or 20 – 30 dwellings per site hectare for are-as within 400m of neighbourhood centres
Structure Plan target density per gross urban hectare[2]	8.6 dwellings per site hectare[3]	Density target of 15 dwellings per hectare as per Perth and Peel@3.5 million

[1] Liveable Neighbourhoods definition of site hectare is the area available for residential development excluding roads, non-residential uses, public open space and drainage areas.
[2] Directions 2031 definition of gross urban hectare is the total area of the structure plan.
[3] Target dwelling yield is below 15 due to extensive areas of Bush Forever, commercial and regional road reservation being set aside and undevelopable for residential use.

Directions 2031 and Liveable Neighbourhoods prescribe minimum dwelling/lot targets for the purpose of meeting the needs of forecast population growth. Each of the strategic and policy documents set the following targets:

Table 3 Residential Densities and Yield

Directions 2031	15 dwellings per gross urban hectare[1]
Liveable Neighbourhoods	20 dwellings per site hectare[2]

[1] 'Gross Urban Hectare' means the gross area available for urban development.

[2] 'Site Hectare' means the area available for residential development, excluding roads, non-residential uses, public open space, and drainage areas.

The structure plan dwelling yield is below the target density per gross urban hectare of 15 dwellings due to the extensive areas in the structure plan for non-residential development. These non-residential areas contributing to the low yield include the extensive areas set aside for Bush Forever, Planning Control Area No. 155, Nairn Drive regional road reservation and the area designated 'Subject to Future Planning'. When factoring these considerations, the structure plan achieves a good dwelling density of 22 dwellings per site hectare which meets the expectations of the planning framework.

4.4 Proposed Movement Network

A Transport Assessment has been prepared to inform structure planning for the subject site, based on the development concept plan for approximately 420 residential lots and one commercial lot. The area identified for future structure planning will require an updated transport assessment to take into consideration the land uses proposed in future. Based on the concept plan, the transport assessment demonstrates that the proposed structure plan will not have any significant impact on the existing and planned transport movement network.

Refer to Appendix 7 – Transport Assessment

4.4.1 Existing roads

The subject site is currently accessible via Stakehill Road and Cassia Drive to the south and west. A potential future connection from structure plan internal subdivision roads to Nairn Drive is possible, with the details of the intersection design to be determined at later stages of planning.

Stakehill Road is presently constructed as an approximate 8m wide single carriageway, two-lane road with a posted speed limit of 80km/hr. Main Roads WA (MRWA) classifies Stakehill Road as a 'Regional Distributor' road. The current intersection at Stakehill Road/Eighty Road is constructed as a simple priority controlled T-junction with no additional turning lanes or splitter islands. This intersection is likely to be upgraded to a roundabout in due course once the Nairn Drive extension occurs.

Stakehill Road (west of Eighty Road), Eighty Road and the future Nairn Drive extension are all classified as MRS 'Other Regional Roads' and are managed by the City of Rockingham. However, it is likely that as these roads will become major transport routes, ultimate control of these roads will be managed by WAPC and MRWA. Stakehill Road is planned to ultimately be upgraded to dual-carriageway four-lane standard, consistent with its intended future 'Integrator Arterial' road hierarchical function, to accommodate future traffic volumes anticipated as a result of planned long-term urbanisation.

Cassia Drive which abuts the land on the western and southern boundaries are also sealed rural standard roads providing alternative access to the subject site. These roads service the local rural residential lots neighbouring to the west and south. No formal drainage exists on these roads.

The existing and planned regional and local road network provides adequate access to the subject land to accommodate future urban development under the Structure Plan. Any upgrades (and standard of upgrade) to the existing road network to accommodate urbanisation would be considered at subdivision approval.

4.4.2 Proposed Roads

The structure plan proposes two key access points from Stakehill Road. There is also secondary access via a lockable gate (emergency access only) connection to Cassia Drive (on the western boundary). Full development of the structure plan can be accommodated with access to Stakehill Road. However, provision is made for a connection to be provided to the structure plan road network as part of the future (long term) construction of Nairn Drive. The structure plan road layout provides an appropriate responsive design to the existing natural topography and landform to accommodate servicing of lots and stormwater drainage.

The roads within the structure plan are classified in Figure 9 and indicative cross sections are provided in the transport assessment which are consistent with Liveable Neighbourhoods. The proposed neighbourhood connector and local access roads in the structure plan will provide for adequate circulation for traffic and waste services.

The proposed road along the western boundary of the structure plan not only provides an appropriate interface and bushfire hazard separation, but also provides adequate road connection consistent with Liveable Neighbourhoods. For instance, a secondary emergency access can be provided to Cassia Drive (west), but would only be used in emergencies so as to limit urban traffic within a rural environment.

Refer to Figure 10 – Road Hierarchy Plan

4.4.3 Intersections and Traffic Calming Devices

The details and locations for road intersections which are likely to require specific intersection treatments are discussed in the transport assessment. These include the main 'full movement' and 'left-in/left-out' intersections on the interface of the structure plan with Stakehill Road. The type of intersection for the connection of the structure plan road network with Nairn Drive will be determined as part of the future design and construction of Nairn Drive. This will not be the responsibility of the developer.

Internal subdivision road roundabouts are proposed at key road junctions, both as traffic calming and to provide for entry statements. Other intersection treatment types, such as coloured pavement, raised pavement and staggered intersection are proposed to be used throughout the structure plan to create legibility and traffic calming/safety within the structure plan road network.

For example, the road connections with the road running north-south along the eastern boundary may have specific treatments, such as raised sections, so that the north-south road is not a continuous straight single road for traffic calming. Alternatively, traffic devices such as speed humps may be introduced in certain sections of roads for traffic calming.

4.4.4 Pathways

There are no existing pathways within the roads abutting the subject site. The structure plan design allows for provision of pathways at detailed subdivision stage on proposed roads within the subject site. The general proposed pedestrian and cyclist pathway strategy for the structure plan is outlined in the transport assessment and is illustrated in Figure 10, which shows indicative pathways.

The exact location of pathways will be determined in liaison with the City at the subdivision stage once a more specific form of development for the subject site is proposed. In general, pathways are proposed to be provided on all streets in accordance with the requirements of Liveable Neighbourhoods.

Refer to Figure 11 – Open Space and Pathways Plan

4.4.5 Public Transport

The Karnup locality has limited public transport service. However, with further urbanisation in the locality and urban development of the subject site, there is the potential for the Karnup Train Station at Paganoni Road, which could be constructed within the next 10 years. It is likely that public transport feeder bus services along Stakehill Road and Nairn Drive would service the future train station.

It is likely that a feeder bus service along Stakehill Road from the future Karnup train station could be introduced, once a patronage threshold is achieved to warrant such service. With a bus stop on Stakehill Road located centrally to the structure plan area (i.e. near the main entry road), it is estimated that approximately 80% of the structure plan area could be serviced within a 400m radius distance from the bus stop.

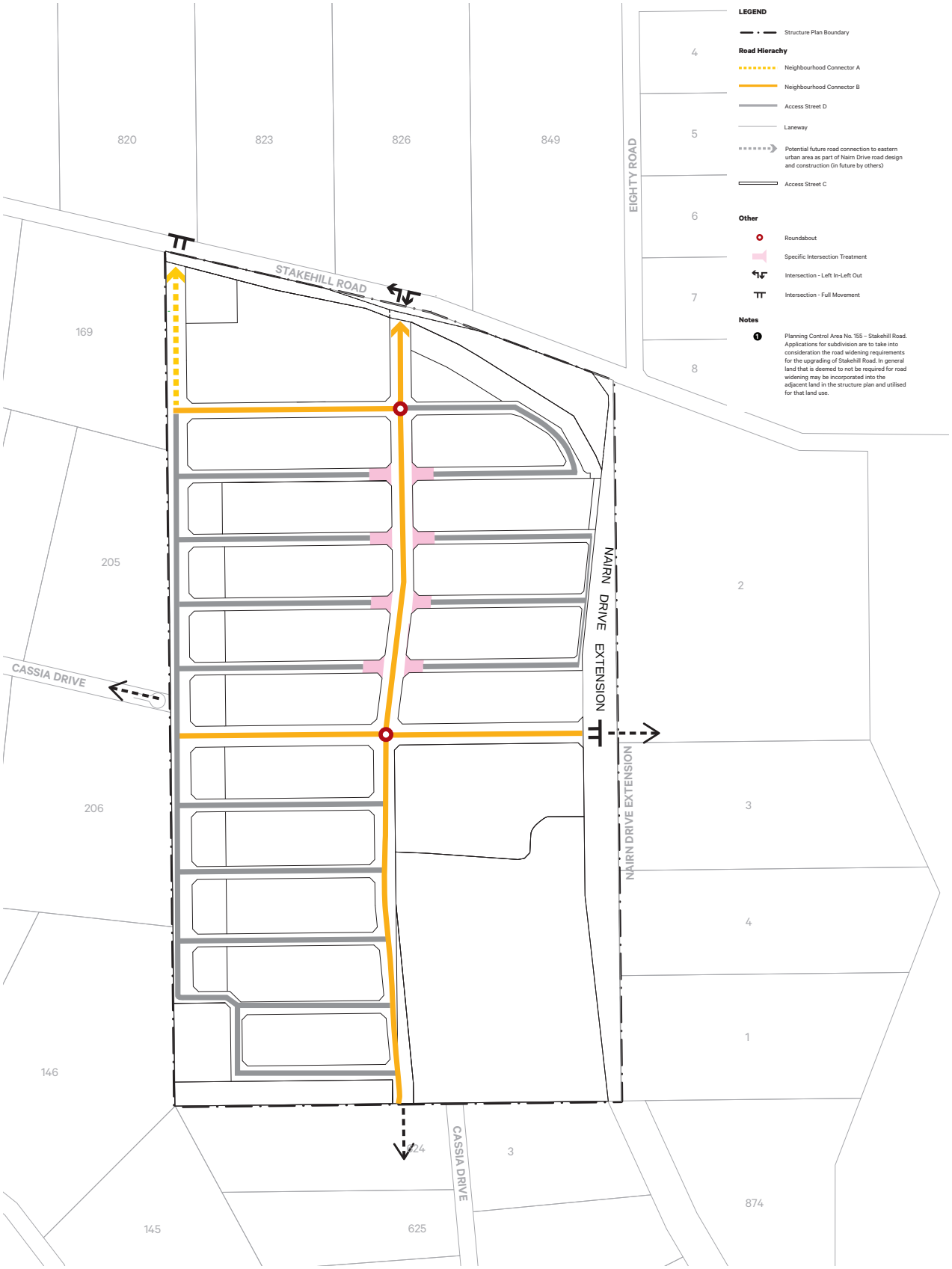


Figure 10. Road Hierarchy

4.5 Public Open Space

The structure plan makes provision for the required minimum 10% Public Open Space (POS) contained within the subject site. Based on the Bush Forever negotiated planning solution, a minimum area of approximately 3.3 hectares is required within the structure plan to meet the 10% POS requirement. The development concept plan (Figure 7) provides for 3.3 hectares which satisfies the 10% POS provision. Land proposed as Bush Forever in the structure plan is not credited as POS, but there is potential for the Bush Forever to be used for passive recreation, for example walk trails and areas for retreat, solitude and contemplation.

Table 4 is a summary of the public open space envisaged for the structure plan and future residents. All public open space will be easily accessible and within walking distance for all residents. Table 5 provides a Public Open Space Schedule for the structure plan.

Table 4. Public Open Space Parks

POS Identifier	Description
Local Park No. 1	This park will provide a multi-use function for active/passive recreation and drainage. The park is located on the estate entry road being highly visible as a focal point and sense of arrival for residents. The park will be landscaped to accommodate an active play area (which will also serve as the 1% AEP stormwater drainage swale during significant storm events. The western portion will contain a retained drainage basin which will be landscaped with wetland species.
Local Park No. 2	This park will provide a similar function as Local Park No. 1, except it is located in the southern area of the structure plan and will contain a temporary sewer pump station. The park is connected to the Bush Forever corridor thus enhancing the east-west ecological corridor between the Bush Forever site neighbouring to the west and the main Bush Forever 278 area in the eastern part of the structure plan.
Neighbourhood Park	The neighbourhood park is co-located with the retained Bush Forever area. Along with the controlled access for the public to the Bush Forever area, the neighbourhood park will provide a significant area for active and passive recreation for residents and the community. Its generous size will be a key amenity feature and centre-piece for the estate, accessible within 400m by over 80% of residents in the structure plan. The park will retain as many existing trees as possible to provide shade and amenity for park users, as well as habitat for fauna. No drainage infrastructure is proposed within this park. A preliminary landscape concept plan for this park is provided in Appendix 9, however final designs will be subject to City of Rockingham approval.

Table 5. Public Open Space Schedule based on Concept Plan

	Ha	Ha
	Total Site Area (ha)	**48.715**
Deductions		
Nairn Drive MRS Other Regional Road	2.507	
Stakehill Road MRS Other Regional Road	0.097	
Planning Control Area No. 155	1.268	
Subject to Future Planning	2.737	
Commercial	0.349	
Local Park North Basin (20% and 63.2% AEP)	0.135	
Local Park South Basin (20% and 63.2% AEP)	0.193	
Bush Forever (Lot 878)	0.713	
Bush Forever (Lot 877)	6.738	
Sewer Pump Station	0.040	
Market Garden Spray Drift Vegetation Buffer	0.699	
	Total Deductions	**15.476**

	Ha	Ha
Gross Subdivisible area		33.239
Required POS (10%)		3.324
Breakdown of POS Provided		
May comprise:		
• minimum 80 per cent unrestricted POS	2.659	
• Maximum 20 per cent restricted use POS	0.665	
Restricted Public Open Space provided		
Neighbourhood Park (adjacent Bush Forever)	0.624	
Total Restricted POS Credited to a maximum of 20%		**0.624**
Unrestricted Public Open Space provided		
Local Park 1 (North)		0.496
Local Park 2 (South)		0.375
Neighbourhood Park (adjacent Bush Forever)		1.995
Total Unrestricted POS		**2.866**
Public open space provision provided		**3.49**
POS Provision as Percentage of Gross Subdivisible Area		**10.5%**[1]

Notes:
[1] Final POS calculations will be subject to WAPC subdivision approval, detailed survey and an approved Urban Water Management Plan. A minimum of 10% POS land contribution is to be provided at Survey Deposited Plan final approval stage.

The proposed POS areas within the structure plan are sufficient for providing regular shaped local and neighbourhood parks, which could be developed for both active and passive recreation. The structure plan POS areas is shown in Figure 11.

The POS areas can incorporate contemporary landscaping and multiple use stormwater design to provide for an attractive high amenity community recreation and meeting place in the neighbourhood. Table 4 is the structure plan POS provision based on the development concept plan. Landscaping concept plans for the POS areas have been prepared and will be finalised at later stages of planning.

Refer to Figure 11 – Public Open Space, Ped-Shed and Pathways Plan

Refer to Appendix 8 – Landscaping Concept Plans

4.6 Employment

The subject site is located in a predominantly existing rural area, with land in Karnup earmarked for future urbanisation. The primary employment areas are within Rockingham Regional Centre approximately 15km to the north-west. Medium to long term employment opportunities will exist in closer proximity to the subject site, including the future Karnup District Centre (potentially within 400 metres of the subject site) and a 'Specialised Centre' (within 2.5km of the subject site) as identified in the *South Metropolitan Peel Sub-Regional Planning Framework – Towards Perth and Peel @ 3.5 Million.*

As stated in the Framework (p.27):

> *"The Karnup [east] specialised activity node will be centred on a regional health facility and other public facilities. Karnup is centrally located in the urban system between Rockingham – Kwinana and Mandurah-Pinjarra and the activity node will be adjacent to a rail and/or transit station."*

The subject site is therefore in a good location having opportunities to existing and planned employment nodes. In addition, the structure plan makes provision for commercial and potential future service commercial land uses abutting Stakehill Road, which will provide short term walkable (400m) distance for local residents to self-sufficient employment opportunities.



Figure 11. Open Space and Pathways Plan

4.7 Education and Community Purpose Uses

Under the existing planning framework there is no identified requirement for any regional educational establishments, regional public utilities and/or community uses within the subject land. A public primary school is proposed in the draft *Karnup Phase One Structure Plan* to the east.

The subject site is estimated to potentially yield approximately 420 dwellings, which is below the threshold requirement for one primary school for every 1,500 dwellings. The primary demand for a primary school will be generated from urban development to the east, where the location for a future primary school is logical. In the interim, residents will be serviced by the existing primary school catchment areas for Karnup.

4.8 Commercial Uses

This section refers to the structure plan commercial land use and the area set aside as 'Subject to Future Planning'. The intent of this section is to outline potential uses for the 'Subject to Future Planning' area, given its location on Stakehill Road. The planning concepts and rationale introduced for potential future commercial and service commercial uses are indicative only and do not form part of the approval of the structure plan. This section provides an overview of investigations undertaken by the Proponent which may be considered in future. The area designated 'Subject to Future Planning' will require a structure plan amendment for the designation of future land uses and any development controls as deemed necessary. Once completed and approved, the Karnup District Structure Plan will also guide the future land uses within the 'Subject to Future Planning' area.

The commercial use in the structure plan at the estate entry road is proposed to provide residents with access to convenience goods. The initial commercial development is likely to be a service station/ convenience store, which can take advantage of exposure to passing traffic along Stakehill Road as well as being accessible to residents in the structure plan.

4.8.1 Preliminary Commercial and Service Commercial Investigations

A local centre abutting Stakehill Road could be located between the estate main entry road and internal spinal road. A Retail Sustainability Assessment has been prepared which demonstrates that proposed commercial land uses could be considered in future. Potential uses for a local centre at this location is outlined in Table 6. Final uses would be subject to the Karnup District Structure Plan, market demand and population growth in the locality.

Refer to Appendix 10 - Retail Sustainability Assessment

Table 6. Example only of potential Local Centre Land Uses and Estimated Floor Area

Land Use	Estimated Total Floor Area (nla)	Estimated Retail PLUC 5 (nla)	Structure Plan Zone	Potential Employment
Medical Centre/Pharmacy	1,100m^2	200m^2 (Pharmacy Shop)	Commercial	17
Service Station/ Convenience Store	350m^2	300m^2	Commercial	3
Liquor Store (Possible Liquor Outlet)	600m^2 (2,000m^2)[1]	600m^2	Commercial	3
Child Care Centre	600m^2	-	Service Commercial	11
Fast Food Outlets (x3)	750m^2 (250m^2 each)	600m^2	Commercial	21
Hardware Store	800m^2	800m^2	Commercial	4
Veterinary Clinic/Hospital	350m^2	-	Service Commercial	4
Learning & Wellbeing Health Studio Dance Studio	800m^2	-	Service Commercial	8
Total Area[1]	**5,550m^2**	**2,500m^2**		**71 (Employed staff)**

[1] Under WAPC SPP 4.2 *'Activity Centres for Perth and Peel'* a Retail Sustainability Assessment (RSA) generally required where the total PLUC 5 shop/retail floorspace of an activity centre exceeds 6,000m^2 nla.

4.9 Servicing

An engineering servicing report has been prepared that demonstrates the site can be developed for urban development through provision of the necessary servicing. There are no significant servicing constraints impacting the structure plan that cannot be adequately managed. Subdivision and/or development for urban use would be subject to consultation with service providers and the necessary upgrades to existing infrastructure to support development. Extension of services is to be borne solely at the cost of the landowner/applicant to facilitate subdivision and development of land.

Refer to Appendix 9 – Engineering Servicing Report

4.9.1 Reticulated Sewer

The site is not currently connected to reticulated sewer. Sewer planning for this area was completed by the Water Corporation in 1995 and updated in 2010. Sewer planning indicates the subject site can be serviced with reticulated sewer via a major trunk sewer to be extended south from their main Waste Water Pumping Station (WWPS) located in the "Rivergums" development some 10km to the north of the site on Stakehill Rd. This trunk sewer is to be extended along Baldivis Rd to Stakehill Rd as a Water Corporation CIP item.

Prior to connection to the site via trunk sewer, a small WWPS will be constructed within the site to collect wastewater generated from urban development. These will discharge to the trunk sewer. Sites for such WWPS will need to be provided by the developers, and the WWPS will be constructed by the developers, with pre-funding repaid by the Corporation under their Funding Agreements, which are to be negotiated. The interim servicing of this site will require the installation of a temporary WWPS at the south west corner of the site, in line with Water Corporation gravity sewer planning, which will pump to an existing discharge point at the corner of Sixty Eight Rd and Baldivis Rd, some 6km from the proposed WWPS site. This WWPS will be at the cost of the developer. The whole of the subject site can be serviced from this proposed temporary WWPS.

4.9.2 Reticulated Water Supply

The Water Corporation has advised there is sufficient capacity to supply the initial development of the subject site, likely from an extension from the Tamworth Reservoir, which is situated some 9.5 km north of the site in Baldivis. It is likely that a trunk supply main will need to be extended from Baldivis south along Eighty Rd to the site to enable development to proceed.

There are no height restrictions for servicing as the highest point of the land is at approximately 18m – 19m AHD. The Corporation has advised that funding of trunk services to the area is not on their current program, and that some funding arrangement with the developer may be required.

4.9.3 Power & Gas

Sufficient power supply exists in the area to supply the urban development of the subject site. High and low voltage aerial power lines are located along the northern verge of Stakehill Road, and a transmission line is located along the southern verge adjacent to the site. The existing aerial power lines located on Stakehill Rd are likely to remain in place, but any private power lines within the site will be removed as part of urban development.

Typically all new internal infrastructure to the development will be relocated underground in line with current development guidelines. In addition, all internal power reticulation lines and transformer installations will be constructed at the cost of the developer. Transformer sites will be determined at the detailed subdivision design stage. A power sub-station site may need to be provided for the urban development.

Gas is not available at present to the site, but may be extended to the site in consultation with the service company ATCO.

4.9.4 Telecommunications

The existing area is serviced from Baldivis Exchange to the north and via a multiplexer on Baldivis Road, near the corner of Sixty Eight Road. Urbanisation of the subject site can be adequately serviced with telecommunications. There are no communications constraints and the site can be adequately serviced to support urban development.

4.10 Local & Urban Water Management

A local water management strategy has been prepared for the structure plan, which demonstrates that stormwater generated by proposed urban development can be adequately treated and managed within the Structure Plan area. The strategy will guide the preparation and approval of an Urban Water Management Plan at subdivision stage.

Stormwater for the structure plan development will be managed via the following measures generally outlined in Table 7:

Table 7. 1yr & 5yr & 100yr ARI stormwater management

ARI Event	Stormwater Water Management Principles
1 Year (62.3% AEP)	Accommodated in piped drainage design directed to drainage detention infrastructure in POS areas; and Stormwater contained within each lot prior to discharge/infiltration to groundwater via conventional methods, such as soakwells.
5 Year (20% AEP)	Accommodated in piped drainage design directed to drainage detention infrastructure in POS areas.
100 Year (1% AEP)	Swale basins constructed within POS areas designed for maximum infiltration; Finished lot levels will be a minimum of 0.5m above the top of 100yr drainage basin infrastructure; and Major storm 100yr stormwater directed away from lots and into POS detention areas.

4.11 Earthworks

Preliminary civil engineering investigations indicate that the subject land can accommodate urban development without the need for excessive earthworks. Earthworks on-site will involve localised cut and fill and removal of topsoil to create the necessary levels for servicing.

Site works will be required to create level, free draining lots for dwelling construction and provision of roads and services. Level sites that are terraced reflect the ideal building site to reduce housing cost and create more affordable housing.

The future urban development of the subject site will likely require earthworks to provide level, free draining building blocks. Retaining walls will be used to provide terraced lots and absorb level differences. Wherever possible, the height of retaining walls will be kept to a minimum and may vary due to natural ground level differences.

Extensive low height (<1.0m) retaining walls will likely be required given the sloping natural topography of the site. All retaining walls will be constructed to the City's satisfaction.

Substantial fill is unlikely to be required as there is considered to be more than sufficient separation distance between envisaged finished lot levels and the highest groundwater level. Subsequently the required minimum 1.2 metre separation distance between finished lot levels and the groundwater table height can be adequately achieved. Accordingly there are no significant earthwork constraints for the urbanisation of the subject site.

4.12 Staging of Development

The Transport Impact Assessment has modelled full development of the structure plan by 2031, which is consistent with the timeframe for delivery set out in the sub-regional planning framework. The structure plan is proposed to be developed in multiple stages due to the size of the development and the outcome of the negotiated planning solution.

Refer to Figure 12 – Staging Plan

Stage 1 would be the landowner's first stage of urban development in the northern portion of the subject site to create the main entry road and first residential lots.

Further staging is expected to be undertaken progressively from the Stage 1 residential boundary most likely commencing from the north moving south. The overall staging of development to completion could take in the order of approximately 6 stages over up to 10 years, depending on market conditions.

Initially as part of Stage 1 the section of Stakehill Road abutting the subdivision staging area would be upgraded from rural road standard to a single carriageway urban standard, in consultation with City of Rockingham.

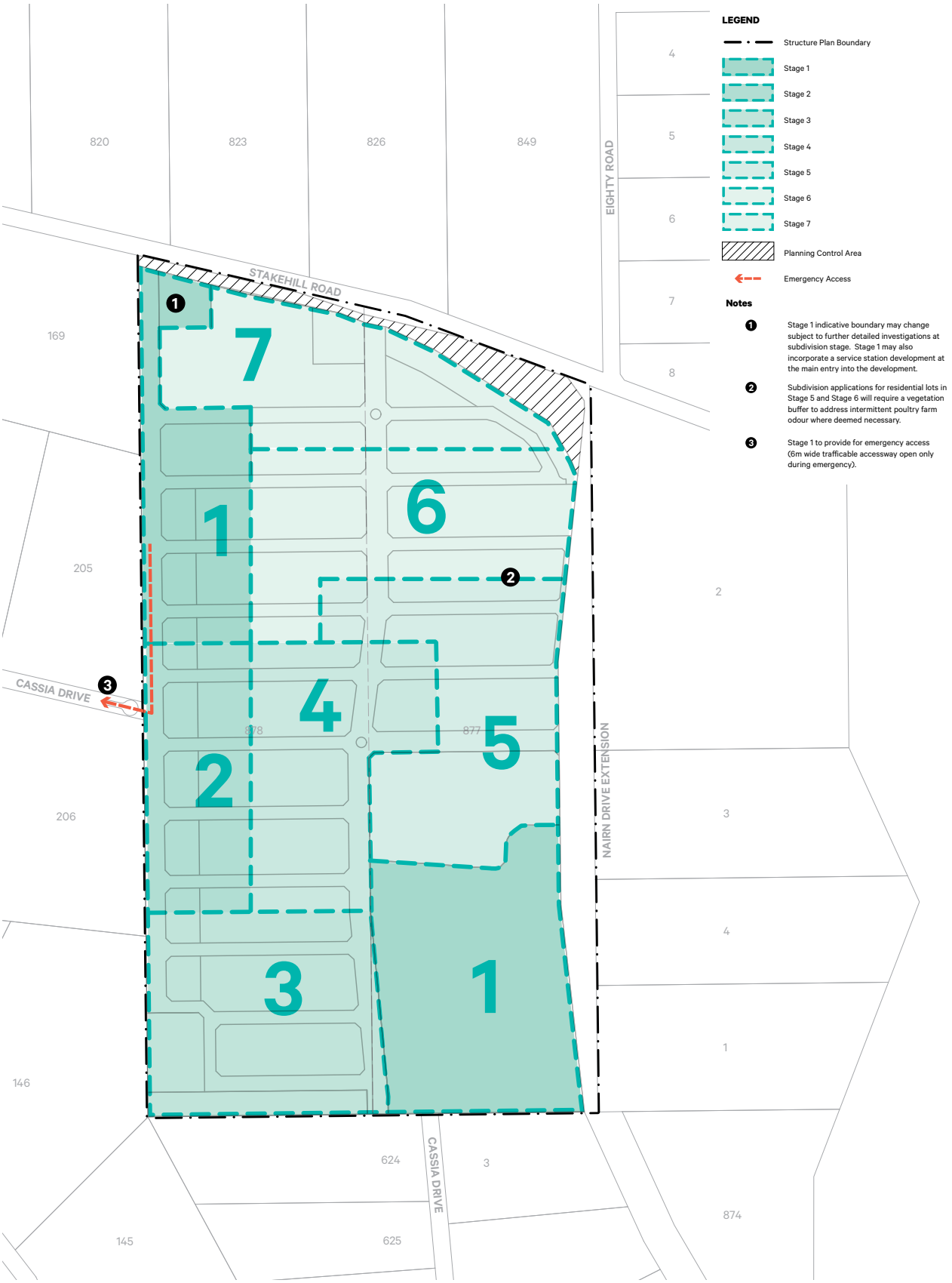


Figure 12. Staging Plan

Appendices

Appendix 1

Chronology of Structure Planning

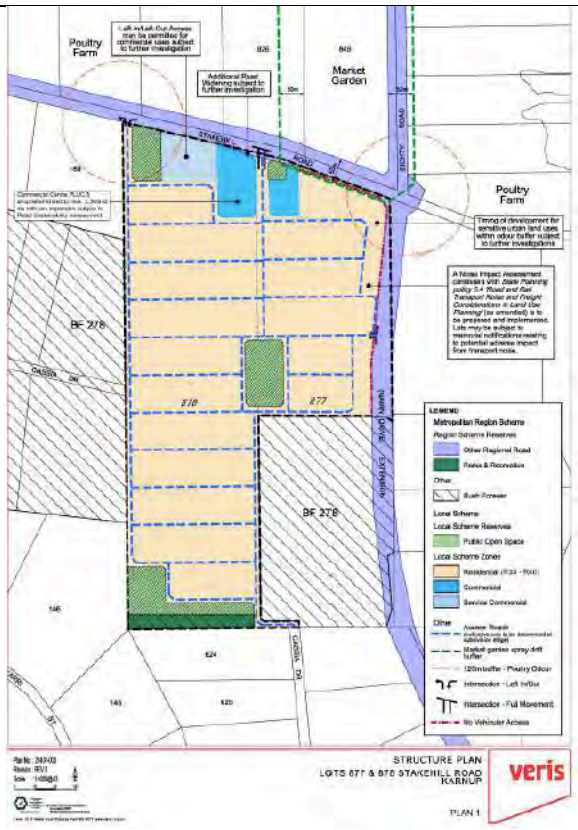
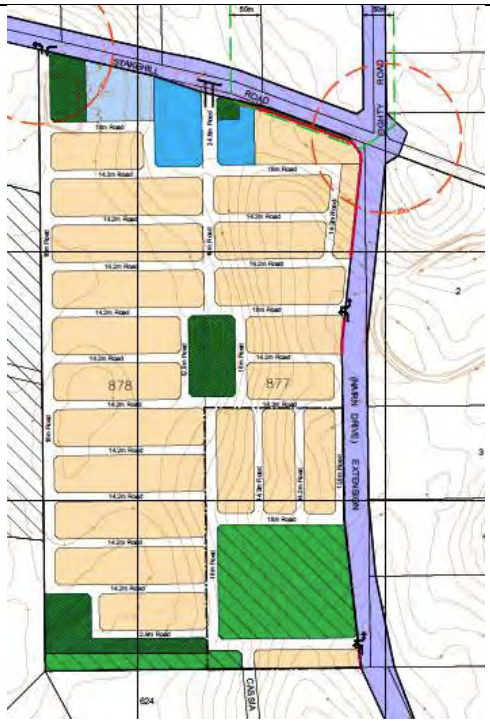
RE-LODGEMENT CONSULTATIONS

Agency	Date Of Consultation	Method Of Consultation	Summary Of Outcome
City of Rockingham	July 2017 – August 2017	Meeting Telephone Emails	Karnup district level planning is yet to commence, so there is no DSP to guide MRS & LSP applications. Proponent to justify servicing (i.e. sewer & water) requirements demonstrating subject site is 'stand-alone' to LandCorp's Karnup Master Plan. LandCorp LSP to the east is yet to be determined by WAPC. Identification of the future District Centre in Karnup most likely to be determined as part of City's DSP, which is delayed pending approval of the Sub-Regional Framework.
Department Planning, Lands & Heritage	February 2017	Meeting	LSP application should: • exclude Bush Forever Site 278 on Lot 877; • perhaps be lodged following outcome of pre-referral consultations for the MRS Amendment; • address environmental constraints including market garden, poultry farm odour buffer and sand mining to the east; and • demonstrate adequate essential servicing to support urban development.
Western Power	July 2017 - August 2017	Telephone/ Emails	Western Power indicates servicing requirements can be provided to support urbanisation of the subject site.
Water Corporation	May 2017 - August 2017	Telephone/ Emails	Water Corporation indicates servicing requirements can be provided to support urbanisation of the subject site, with details pending further investigation in addition to working out Funding Agreement(s) for developer trunk main extensions.
Department of Planning, Lands & Heritage (Region Scheme Amendments Team & Bush Forever)	August 2019	Meeting	Lifting of Urban Deferment proposal for 'Main Estate' Lots 877 & 878: • Lifting request to be accompanied by a technical investigations based on preliminary draft Structure Plan map; Lifting of Urban Deferment proposal for 'Bush Forever' (which will be the subject of a separate MRS Amendment and not part of this Amendment proposal), the following is therefore for noting purposes only: • Proponent and DPLH officers discussed potential for a negotiated planning solution (NPS); • Updated Spring Flora Survey 2019 required; • EPBC referral required over NPS; • Detail of design subject to further assessment including extent of bush forever to be retained; • MRS lifting urban deferred cannot remove the 'Bush Forever' notice of delegation. This would need to be done later on as part of MRS Omnibus Amd, following the NPS; • Legal Agreement likely between Proponent and WAPC for delivery of the bush forever area to be retained and subsequent MRS Omnibus Amd action to rationalise the bush forever notice area. • Proponent to lodge the lifting urban deferred application to trigger commencement of NPS discussions and assessment with DWER & DPLH

Agency	Date Of Consultation	Method Of Consultation	Summary Of Outcome
City of Rockingham	August 2019	Meeting	Proponent informed City officers of intention to lodge concurrent applications for a structure plan and MRS Amendment and advised outcomes of pre-lodgement discussions with DPLH. City officers noted the information.
Department Planning, Lands & Heritage City of Rockingham (City's views obtained by DPLH and conveyed at meeting)	10 September 2019	Meeting	Bush Forever Negotiated Planning Solution: • Min. 4ha square site preferred for NPS; • Connectivity to east Bush Forever 278A area in private rural land to try and be achieved to NPS site; • CoR prefer central POS to be relocated to NW area of BFE to retain trees; • CoR prefer to remove connection of spinal road with Cassia Drive (south) in lieu of providing larger bush site with 6m emergency access along southern boundary; • Client to provide Spring Survey (orchids and Tuart TEC) info for DWER/DBCA further comment; • Next action: Workshop with DPLH, DWER, DBCA, CoR to work towards agreed round table NPS design; and • Structure plan could be lodged concurrent with MRS amendment (lifting urban deferment).
Department of Planning, Lands & Heritage	December 2019	Meeting	DPLH officers advised Proponent of potential further road widening requirements for Stakehill Road, including likelihood of an additional MRS 'Other Regional Road' reservation amendment.
	January - February 2020	Emails	DPLH officers confirmed exact road widening requirements and MRS ORR land area for Stakehill Road unknown at this stage. This can be further explored as part of formal assessment and referrals to key stakeholders. Any modifications to the proposal can be made at the WAPC determination stage. Refer to series of draft plans in **Chronology of Structure Planning Lots 877 & 878 Stakehill Road Structure Plan**

CHRONOLOGY OF STRUCTURE PLANNING

LOTS 877 & 878 STAKEHILL ROAD, KARNUP

LOTS 877 & 878 STAKEHILL ROAD Excluding Bush Forever on Lot 877 **AUGUST 2017**	
LOTS 877 & 878 STAKEHILL ROAD **JULY 2019**	

LOTS 877 & 878 STAKEHILL ROAD **SEPTEMBER 2019**	
LOTS 877 & 878 STAKEHILL ROAD **OCTOBER 2019**	

LOTS 877 & 878 STAKEHILL ROAD

DECEMBER 2019 - current


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Appendix 2

EAR December 2020. Updated for LSP March 2021

LOTS 877 AND LOT 878 STAKEHILL ROAD, KARNUP

ENVIRONMENTAL ASSSESSMENT

Prepared for:	Terranovis
Report Date:	22 December 2020
Version:	5
Report No.	2017-317

pgv ENVIRONMENTAL

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Appendix 2: Flora, Vegetation and Fauna Survey

Appendix 3: Draft Concept Plan

1 INTRODUCTION

1.1 Background

The landowners of Lots 877 and 878 Stakehill Road, Karnup (the site) are preparing to lift the 'Urban Deferred' zoning over their landholding to 'Urban'. The site is approximately 57km south of the Perth Central Business District and 16km south of the City of Rockingham (Figure 1). The site is in the City of Rockingham and is bound by Stake hill Road to the north, Rural landholdings to the west and south and future urban development to the east (Figure 2). The southern portion of Lot 877 includes BushForever Site No. 278 – Cassia Drive Bushland, Karnup (BF278). The site is 48.715ha in size.

The BF278 on Lot 877 is approximately 11.665ha of which 9.6ha contains native vegetation. The BF278 also contains the road reserve for Nairn Road and 'Other Regional Road' which occupies 1.391ha. The area of Lot 877 that is included within BF278 is identified as Part B: Negotiated Planning Solution within the Bush Forever documentation (Government of Western Australia, 2000). A proposed Negotiated Planning Solution will be addressed as part of the lifting of Urban Deferment.

1.2 Purpose and Scope

This environmental assessment provides environmental information to facilitate the proposal to lift the zoning from 'Urban Deferred' to 'Urban'. The assessment provides the following:

- Details the environmental attributes on the site,
- Lists the surrounding land uses;
- Lists any opportunities and constraints;
- Provides an assessment of the separation distances between the site and land uses that currently exist near the site; and
- Recommends any future environmental investigations.

The environmental assessment has been undertaken in accordance with the Western Australian Planning Commission (WAPC) *Guidelines for the lifting of Urban Deferment*. Under the guidelines, the information requirements for the natural environment include the following:

- An accurate description of the land including the natural environment;
- Description of the physical conditions of the land;
- Identification of how natural features (such as foreshores, wetlands, remnant vegetation) will be protected; and
- Identification of any environmental issues which may impact on future development (such as noise, water catchment, contaminated land, and air pollution).

2 EXISTING ENVIRONMENT

2.1 Historical Land Use

The earliest available on-line historical aerial photography from 1965 indicates that the site was parkland cleared over 50 years ago. Plate 1 below shows the vegetation remaining on the site in 1965 (Landgate, 2017a).

Plate 1: Historical Aerial Photography from 1965 (Landgate, 2017a)



The native vegetation regenerated over the next 15 years and poultry farms were established to the north west and north east in the late 1970s (Plate 2). Pines have been planted to the east of the site.

Plate 2: Historical Aerial Photography from 1979 (Landgate, 2017a)



The 1983 aerial photograph shows that the northern portion of the site was cleared for horticultural purposes (Plate 3). A market garden has been established north of Lot 877.

Plate 3: Historical Aerial Photography from 1983 (Landgate, 2017a)



The 2002 aerial photograph shows most of the vegetation has been cleared for market gardens and buildings. Regrowth native vegetation is retained on the southern half of Lot 877 (Bush Forever Site No. 278) and a 30m strip of native vegetation is retained along the southern boundary of Lot 878.

Plate 4: Historical Aerial Photography from 2002 (Landgate, 2017a)



The site is currently used for market gardening (Plate 5). The area to the west has been subdivided into semi-rural lots, the poultry farms to the north west and north east continue to operate and the market gardens to the north of Lot 877 and to the east of Lot 877 continue to operate. The pine plantation to the east of the site has been cleared and a sand extraction operation established which will be followed by future urban development.

Plate 5: Historical Aerial Photography from 2016 (Landgate, 2017a)



2.2 Surrounding Land Use

2.2.1 Poultry Farms

Poultry Farm 162 Stakehill Road

An egg producing poultry farm is located approximately 200m to the north-west of the site on 162 Stakehill Road. Based on sales information the current population of birds is 15,000, however there is capacity for up to 25,000 birds. It is recognised that egg laying poultry farms have lower odour emissions than broiler grow-out poultry farms (TOU, 2010; Jiang and Sands, 1998).

Environmental & Air Quality Consulting Pty Ltd (EAQ) undertook an Odour Field Assessment (OFA) for the poultry farms (Appendix 1). Odours from the north east farm were found to be negligible even in worse case conditions. The north west farm posed no issues for observable and/or problematic odours.

The recommendations from the report are as follows:

- A “tree buffer” is recommended along the eastern boundary of Lot 877 to a thickness of approximately 2-3 x lines of trees interspersed with medium height shrubs to create a high

porosity barrier that will effect mechanical dispersion of an odour plume that traverses the tree buffer; and

- Memorial on Titles for those lots closest to the eastern boundary of Lot 877 is recommended to inform occupants of the possibility of an odour nuisance during shed cleanout events.

2.2.2 Market Gardens

A market garden is located on Lot 849 Stakehill Road approximately 30m from the northern boundary of Lot 877. The market garden is north of Stakehill Road and a narrow buffer planted with WA Peppermint Trees separates the market garden from the Stakehill Road Reserve.

A planning control area (PCA) has been placed on Stakehill Road to allow for the future duplication of the road. The PCA impacts on Lot 877 and provides further separation from the market garden to the north of Lot 877. The proposed 40m buffer to the market garden is now entirely in the PCA.

A market garden operates on Lot 1 Harvey Road to the east of Lot 877. The market garden is east of the BF278. The BF278 provides a 130m vegetated buffer to the proposed development on Lot 877 and a 250m vegetated buffer to Lot 878.

Potential mitigation measures may be required if the market garden and horticultural activities are operational at the time of subdivision. It is recommended that a vegetated buffer is placed adjacent to the PCA on Lot 877 to mitigate any potential impacts from the market garden.

Further information relating to adjacent market garden and horticultural land uses and management requirements in relation to the Proposal area are provided in Section 5.2.2.

2.2.3 Holcim Sand Mine

The Holcim Sand Mine is on Crown Reserve 37090 which is located approximately 600m to the east of the site. Sand mining activities are currently undertaken within the Karnup landholding by Holcim, secured by mining tenements M70/1046 and M70/1241. The land will be converted into freehold title to enable future development of the site once the mining leases or portions of the mining leases M70/1046 and M70/1241 are relinquished on a progressive basis.

The sand mine is unlikely to have any impact on the site due to the 600m separation distance and the separation of the site from the sand mine by rural landholdings.

2.3 Topography

The site is undulating with the topography varying from 5m AHD in the west rising to 18m AHD in the east. (Figure 2).

2.4 Geology and Soils

2.4.1 Geology

The site is mapped as part of the Spearwood System which has the highest relief of the dune systems on the Swan Coastal Plain (Bolland, 1998). The Spearwood system consists of slightly calcareous Aeolian sand remnant from leaching of the underlying Pleistocene Tamala limestone (Davidson, 1995).

2.4.2 Soils

The Department of Agriculture and Food soil landscape mapping over the site identifies the following two soil types (National Map, 2017):

- Spearwood S2a Phase - Lower slopes (1-5%) of dune ridge with moderately deep to deep siliceous yellow-brown sands or pale sands with yellow-brown subsoils and minor limestone outcrop.
- Spearwood S4a Phase - Flat to gently undulating sandplain with deep, pale and sometimes bleached, sands with yellow-brown subsoils.

2.5 Acid Sulphate Soils

Acid sulphate soils (ASS) are wetland soils and unconsolidated sediments that contain iron sulphides which, when exposed to atmospheric oxygen in the presence of water, form sulphuric acid. ASS form in protected low energy environments such as barrier estuaries and coastal lakes and commonly occurs in low-lying coastal lands such as Holocene marine muds and sands. When disturbed, these soils are prone to produce sulphuric acid and mobilise iron, aluminium, manganese and other heavy metals. The release of these reaction products can be detrimental to biota, human health and built infrastructure (WAPC, 2009).

The Acid Sulphate Soil (ASS) risk mapping shows the site has no risk of ASS is which is accurate due to the limestone substrate under the soil (Bolland, 1998). ASS is not a risk to development.

2.6 Hydrology

2.6.1 Groundwater

The depth from ground level to the water table is 5.0m in the west and 15m in the east (DoW, 2017).

Groundwater quality and quantity will be managed in accordance with the Local Water Management Strategy (LWMS) that will be submitted with the Structure Plan and subsequent Urban Water Management Plans (UWMP) as per *Better Urban Water Management* (WAPC, 2008).

2.6.2 Surface Water

There are no natural surface water features on the site.

There is a constructed dam in the north-west corner of Lot 878.

2.7 Wetlands

There are no wetlands on the site mapped in the *Geomorphic wetlands of the Swan Coastal Plain* Dataset (National Map, 2017b) and no evidence of any natural surface water features on the site. The soils are free draining and therefore no ponding or perched water is on the site.

2.8 Prevailing Winds

The prevailing wind conditions from the 1 April 1983 to 24 September 2013 from the Bureau of Meteorology (BOM) Medina Research Station (BOM Site No. 009194) (BOM, 2017) are shown in Plates 6-8 below.

The average wind speeds at 9am peak in the months September to April at speeds ranging from 12 to 16 km/hr (Plate 4). The prevailing wind direction is from the north east, east, and south east (Plate 5).

The average wind speeds at 3pm peak in the months October to March with average speeds ranging from 17 to 21km/hr (Plate 4). The prevailing wind direction is from the south west (Plate 6).

Plate 6: Monthly Average Wind Speeds at 9am and 3pm at Medina Research Centre (BOM, 2017)

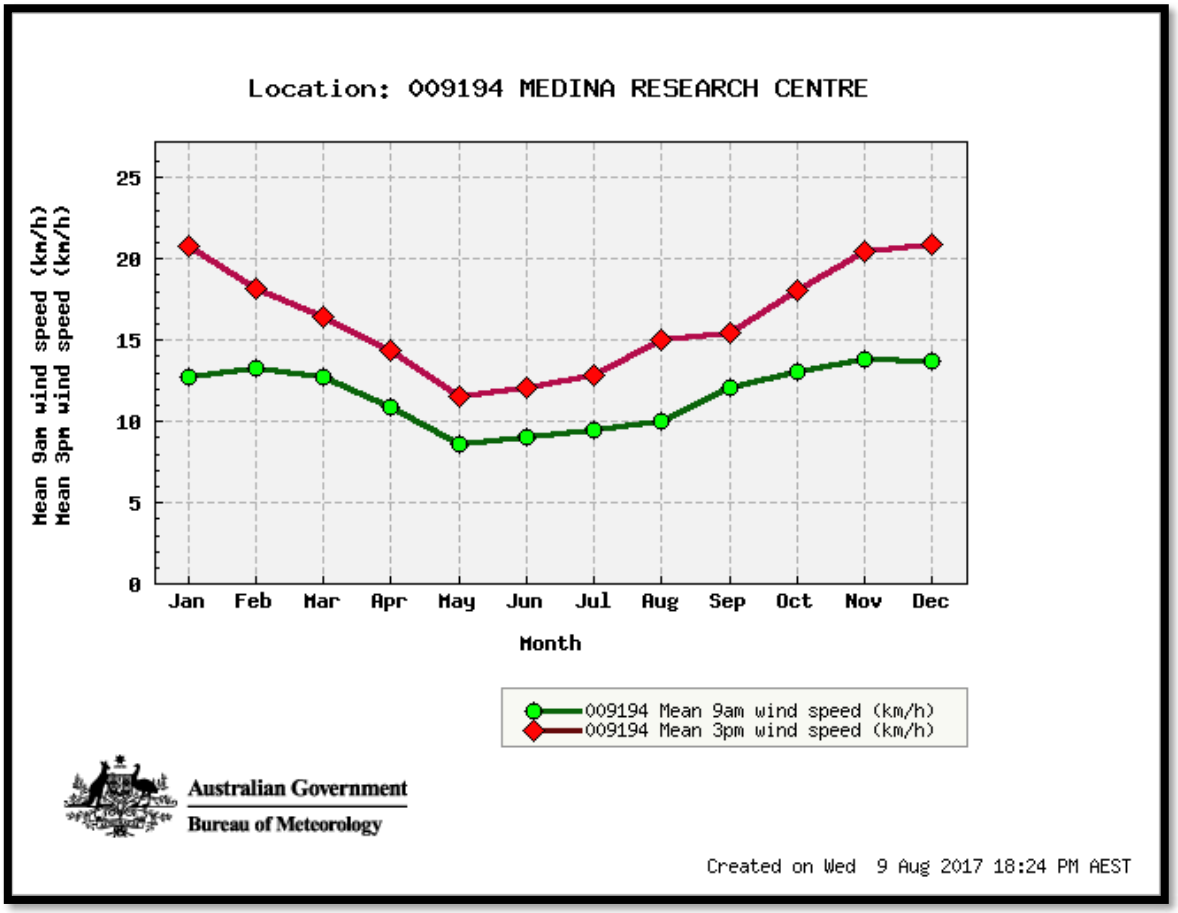


Plate 7: 9am Average Wind Speed and Direction at Medina Research Centre (BOM, 2017)

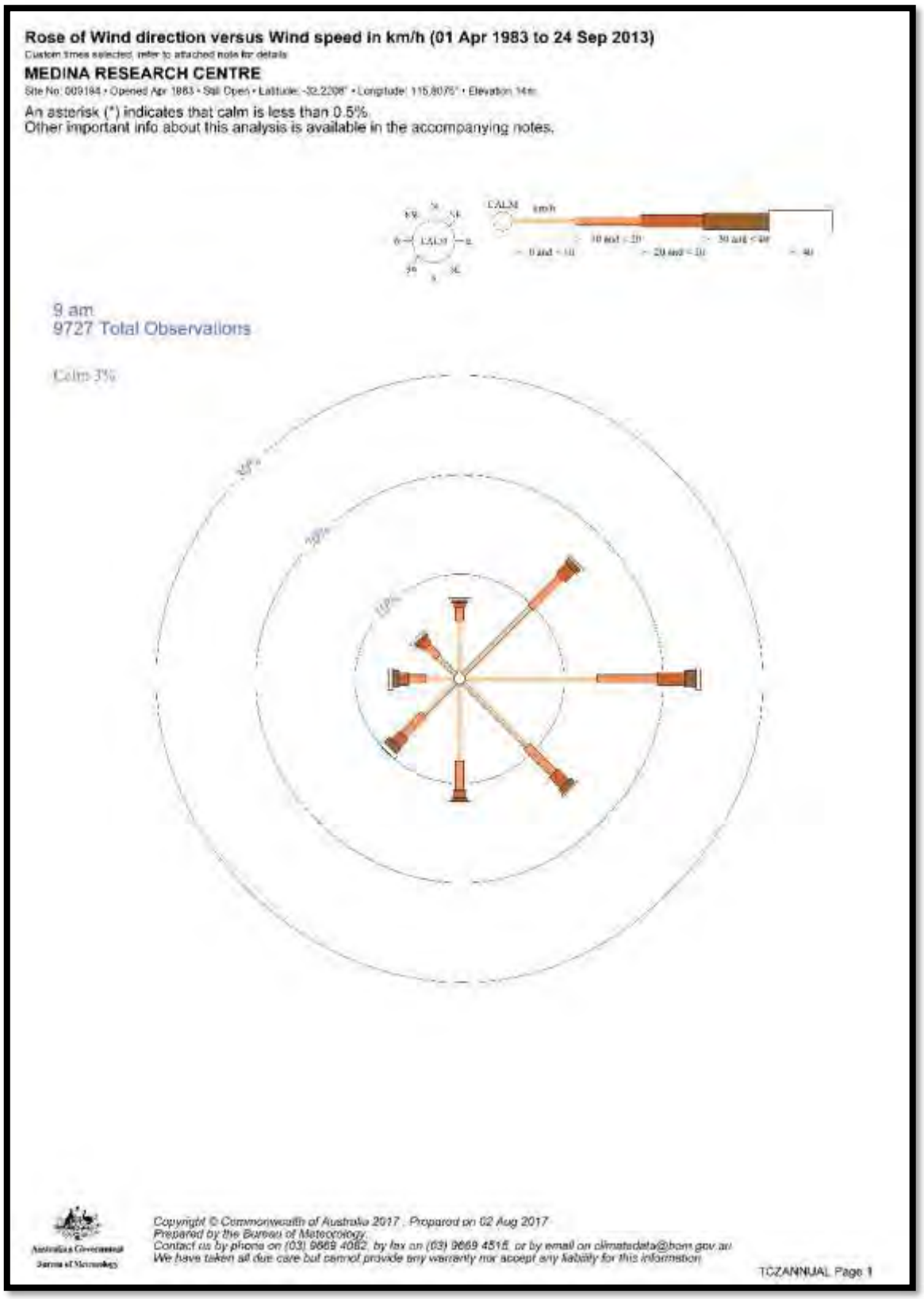
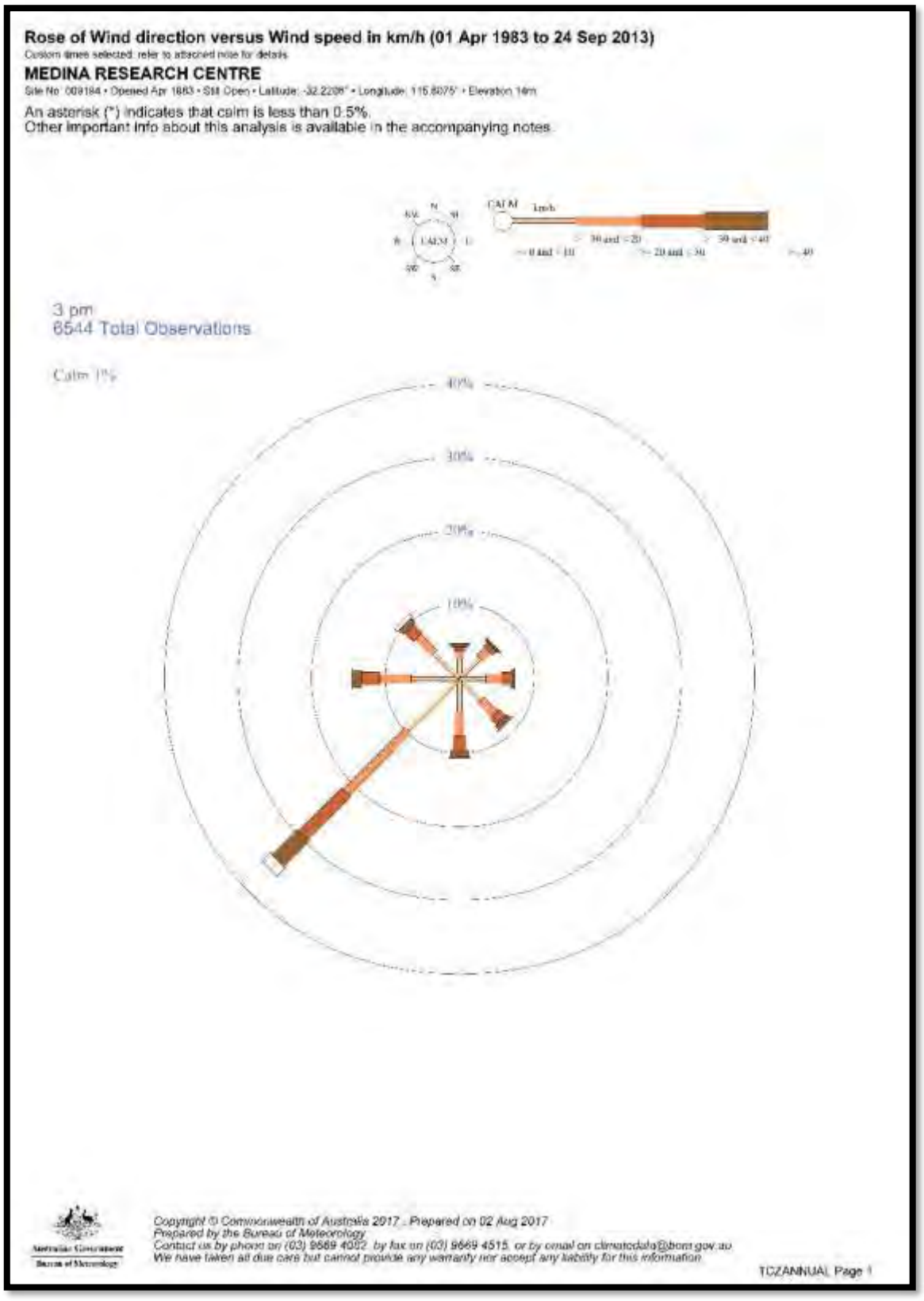


Plate 8: 3pm Average Wind Speed and Direction at Medina Research Centre (BOM, 2017)



The prevailing morning winds during the summer months are towards the site from the north east, east and south east. The neighbouring horticultural and poultry farms to the east, north and north east have some potential for dust and odour impacts on the site, however the north-east prevailing

wind on average blows from 10 -20km/hr for approximately 7% of the time and below 10km/hr for 10% of the time.

The prevailing afternoon winds are from the south west. The neighbouring horticultural and poultry farms to the east, north and north east are not expected to have impacts on the site as the prevailing wind will take any dust or odour impacts away from the site.

2.9 Vegetation and Flora

2.9.1 Methodology

A Detailed Flora and Vegetation Survey was undertaken in accordance with *EPA Technical Guidance Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA, 2016a). The survey included an initial reconnaissance survey of the site in March 2019 followed by a detailed spring survey of the BF278 on 17 September 2019. Native vegetation is restricted to the BF278 with the balance of the site being cleared of native vegetation and subsequently was not surveyed in Spring.

Prior to the site surveys, desktop studies were undertaken to identify potential threatened species and communities that may occur on the site. The site reconnaissance and detailed spring survey were conducted by Dr Paul van der Moezel from PGV Environmental. The survey included walking through the survey area to record vegetation types and species presence by sampling five 10m x 10m quadrats and a thorough site walkover.

In order to assess the potential presence of the Banksia Woodland of the Swan Coastal Plain Threatened Ecological Community, Banksia tree density was recorded in 10m wide belt transects orientated west-east across the site and spaced 50m apart.

2.9.2 Desktop Studies

A search of the DBCA Threatened Flora Databases: the WA Herbarium database (WAHerb and the Threatened (Declared Rare) and Priority Flora Species List (TFPL) (Appendix 2), Naturemap (Appendix 3) (DBCA, 2019) and the EPBC Act Protected Matters Search Tool (Appendix 2) (DoEE, 2019a) indicates that a number of species that are listed as Endangered, Threatened or Priority are identified as potentially being located the site. The results from these database searches are shown in Table 1.

Table 1: Conservation Significant Flora known to occur near the Site

Scientific Name	Common Name	Conservation Status (WA)	Status under EPBC Act
Caladenia huegelii	King Spider-orchid, Grand Spider-orchid, Rusty Spider-orchid	Schedule 1	Endangered
Drakaea elastica	Glossy-leafed Hammer Orchid	Schedule 1	Endangered
Synaphea sp. Fairbridge Farm (D Papenfus 696)	Selena's Synaphea	Schedule 1	Critically Endangered
Synaphea sp. Serpentine (G.R Brand 103)		Schedule 1	Critically Endangered
Diuris micrantha	Dwarf Bee-orchid	Schedule 2	Vulnerable
Diuris purdiei	Purdie's Donkey-orchid	Schedule 2	Endangered
Lepidosperma rostratum	Beaked Lepidosperma	Schedule 2	Endangered
Andersonia gracilis	Slender Andersonia	Schedule 3	Endangered
Diuris drummondii	Tall Donkey Orchid	Schedule 3	Vulnerable
Drakaea micrantha	Dwarf Hammer-orchid	Schedule 3	Vulnerable

Scientific Name	Common Name	Conservation Status (WA)	Status under EPBC Act
Acacia benthamii		Priority 2	
Cardamine paucijuga		Priority 2	
Beyeria cinerea subsp. *cinerea*		Priority 3	
Calandrinia oraria		Priority 3	
Dillwynia dillwynioides		Priority 3	
Lasiopetalum membranaceum		Priority 3	
Pimelea calcicola		Priority 3	
Schoenus capillifolius		Priority 3	
Sphaerolobium calcicola		Priority 3	
Conostylis pauciflora subsp. *pauciflora*		Priority 4	
Jacksonia sericea	Waldjumi	Priority 4	
Parsonsia diaphanophleba		Priority 4	
Stylidium longitubum	Jumping Jacks	Priority 4	

Definitions of the Conservation Codes are in Appendix 2.

Based on the site reconnaissance survey in April 2019 the likelihood of Threatened and Priority flora occurring in the survey area is shown in Table 2.

Table 2: Likelihood of Identified Significant Flora Species Occurring on the Site

Scientific Name	Common Name	Habitat*	Likelihood to occur on the site
Caladenia huegelii	King Spider-orchid, Grand Spider-orchid, Rusty Spider-orchid	The Grand Spider-orchid prefers sand or clay loam. This species generally does not survive in disturbed areas.	Possible - This species may occur in the areas of better condition vegetation
Drakaea elastica	Glossy-leafed Hammer Orchid	The Glossy-leafed Hammer Orchid prefers low-lying situations adjoining winter-wet swamps. This species does not survive in disturbed areas.	Highly Unlikely – there are no low-lying areas on the site
Synaphea sp. Fairbridge Farm (D Papenfus 696)	Selena's Synaphea	Selena's Synaphea occurs in sandy with lateritic pebbles near winter-wet flats, in low woodland with weedy grasses.	Highly Unlikely – there are no low-lying areas on the site.
Synaphea sp. Serpentine (G.R Brand 103)		*Synaphea* sp. Serpentine occurs in brown sandy clay.	Highly Unlikely – soils on the site are not the preferred habitat of this species.

Scientific Name	Common Name	Habitat*	Likelihood to occur on the site
Diuris micrantha	Dwarf Bee-orchid	The Dwarf Bee-orchid is usually found on cleared firebreaks or open sandy patches that have been disturbed with in Jarrah Banksia woodland or thickets of Spearwood (*Kunzea ericifolia/glabrescens*) (Williams *et al*., 2001).	Highly Unlikely – the site does not contain the preferred habitat of this species.
Diuris purdiei	Purdie's Donkey-orchid	Purdie's Donkey Orchid occurs in grey-black sand in moist winter-wet swamps.	Highly Unlikely – The site is not low-lying habitat.
Lepidosperma rostratum	Beaked Lepidosperma	Beaked Lepidosperma is found in peaty sand, clay.	Highly Unlikely – there are no low-lying areas on the site
Andersonia gracilis	Slender Andersonia	Slender Andersonia occurs in white/grey sand, sandy clay, gravelly loam in winter-wet areas, near swamps.	Highly Unlikely – there are no low-lying areas on the site
Diuris drummondii	Tall Donkey Orchid	The Tall Donkey Orchid grows in low-lying depressions, swamps.	Highly Unlikely – The site is not low-lying habitat
Drakaea micrantha	Dwarf Hammer-orchid	Dwarf Hammer-orchid occurs in grey sands over dark, grey to blackish, sandy clay-loam substrates in winter wet depressions or swamps.	Highly Unlikely – The site is not low-lying habitat
Acacia benthamii		*Acacia benthamii* grows on sand, typically on limestone breakaways	Highly Unlikely – There is no limestone on the site.
Cardamine paucijuga		*Cardamine paucijuga* is found on moist flats in calcareous clay over limestone.	Highly Unlikely – The site is not low-lying habitat.
Beyeria cinerea subsp. cinerea		*Beyeria cinerea* subsp. *cinerea* grows in sand over limestone on road verges, gullies	Highly Unlikely – There is no limestone habitat on the site.
Calandrinia oraria		*Calandrinia oraria* grows in restricted to coastal habitats in low coastal heath on white sand dunes (Obbens, 2014)	Highly Unlikely – the site is not coastal dunes
Dillwynia dillwynioides		*Dillwynia dillwynioides* occurs in sandy soils in winter-wet depressions.	Highly Unlikely – The site is not low-lying habitat.
Lasiopetalum membranaceum		*Lasiopetalum membranaceum* grows in sand over limestone.	Highly Unlikely – There is no limestone on the site.

Scientific Name	Common Name	Habitat*	Likelihood to occur on the site
Pimelea calcicola		*Pimelea calcicola* occurs in sand on coastal limestone ridges.	Highly Unlikely – There is no limestone habitat on the site.
Schoenus capillifolius		*Schoenus capillifolius* grows in brown mud on claypans.	Highly Unlikely – The site is not low-lying habitat
Sphaerolobium calcicola		*Sphaerolobium calcicola* grows in white-grey-brown sand, sandy clay over limestone, black peaty sandy clay on tall dunes, winter-wet flats, interdunal swamps, low-lying areas.	Highly Unlikely – The site is not low-lying habitat.
Conostylis pauciflora subsp. *pauciflora*		*Conostylis pauciflora* subsp. *pauciflora* occurs in grey sand, limestone on hillslopes, consolidated dunes.	Highly Unlikely – There is no limestone on the site.
Jacksonia sericea	Waldjumi	Waldjumi grows in calcareous and sandy soils.	Possible – The site contains sandy calcareous soils
Parsonsia diaphanophleba		*Parsonsia diaphanophleba* occurs in alluvial soils along rivers.	Highly Unlikely – The site does not contain habitat for this species.
Stylidium longitubum	Jumping Jacks	Jumping Jacks prefer sandy clay, clay in seasonal wetlands.	Highly Unlikely – The site is not low-lying habitat.

* sourced from Florabase, DBCA database searches and SPRAT (DoEE, 2018) unless otherwise denoted

TEC/PEC Database Searches

A search of DBCA's Threatened (TEC) and Priority Ecological Communities (PEC) database was conducted within a radius of 5km around the site (11-0419EC) (Appendix 2). Eight conservation significant Ecological Communities were identified (Table 3).

Table 3: TEC and PECs identified in database searches within 5km of the site

Number	Description	Conservation Status in WA	Status under the EPBC Act
SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered (as FCT 19)
SCP19b	Woodlands over sedgelands in Holocene dune swales of the southern Swan Coastal Plain (original description; Gibson *et al.* (1994).	Critically Endangered	Endangered (as FCT 19)
SCP08	Herb rich shrublands in clay pans	Vulnerable	Critically Endangered
Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered

Number	Description	Conservation Status in WA	Status under the EPBC Act
Walyungup Microbial	Microbial community of a coastal saline lake (Lake Walyungup)	Priority 1	
SCP24	Northern Spearwood shrublands and woodlands	Priority 3	
SCP25	Southern *Eucalyptus gomphocephala-Agonis flexuosa* woodlands	Priority 3	
SCP29b	Acacia shrublands on taller dunes	Priority 3	

2.9.3 Flora

A total of 130 flora species were recorded during the survey of BF278. The total included 83 native and 47 introduced species (Appendix 2). The relatively high percentage of introduced species (36%) reflected the degraded condition of the vegetation in much of the northern half of the site as well as around the edges of the site which are surrounded by market gardens and cleared rural properties that contain weeds. Many of the introduced species were grasses but several woody weeds were also present such as Maritime Pine (*Pinus maritima*), Olive Tree (*Olea europaea*) and Victorian Teatree (*Leptospermum laevigatum*).

The plant Families with the highest representation of species on the site were the Fabaceae (Wattles and Pea family – 17 species including 10 native and 7 introduced), Poaceae (Grass family – 10 species, 1 native and 9 introduced), Asteraceae (Daisy family – 10 species, 3 native and 7 introduced), Asparagaceae (Lily family – 9 species, all native) and the Proteaceae (Banksia family – 8 species, all native).

None of the species recorded were Threatened or Priority Flora species at State or Commonwealth level.

No Threatened or Priority flora have been recorded on the site according to NatureMap (accessed 30 April 2020).

2.9.4 Vegetation Complex

Vegetation Complexes are a broad unit for mapping vegetation in Western Australia based on the underlying landform and soil type.

The vegetation on the site is part of the Karrakatta - Central and South vegetation complex which is describe as “an open forest of Tuart-Jarrah-Marri, with Jarrah and Marri replacing Tuart while progressing eastwards. *Banksia attenuata, B. menziesii, B. grandis* and *Allocasuarina fraseriana* are also common tree species. (Heddle *et al.,* 1980).

The vegetation on the site meets the general description of this vegetation complex.

2.9.5 Vegetation Type

Vegetation Types are a finer unit of mapping vegetation at the local scale and is based on the structure and composition of the main strata of vegetation.

One vegetation type is considered to occur on the site (Figure 3) as follows:

- EgEmAf - Eucalyptus gomphocephala (Tuart)/E. marginata (Jarrah)/Allocasuarina fraseriana (Sheoak) Woodland to Open Forest over Hibbertia hypericoides/Xanthorrhoea brunonis/Desmocladus flexuosus Low Open Heath (Plate 9).

Tuart is the dominant tree species 10-12m tall with Jarrah and Sheoak in lesser abundance and 4-5m high. *Banksia attenuata* and to a lesser extent *B. menziesii* were scattered trees to 4m on the site. The native Woody Pear (*Xylomelum occidentale*) was also common up to 4m in the central western part of the site.

The understorey, where present, was dominated by *Hibbertia hypericoides* to 1m with *Xanthorrhoea brunonis, Acacia pulchella, Mesomelaena pseudostygia, Desmocladus flexuosus, Acanthocarpus preissii* and *Rhagodia baccata* also common species.

Plate 9: *Eucalyptus gomphocephala* (Tuart)/*E. marginata* (Jarrah)/*Allocasuarina fraseriana* (Sheoak) Woodland



2.9.6 Floristic Community Type

Floristic Community Types (FCT) are a description of the vegetation using the full composition of the flora, rather than the dominant species in each of the main strata. FCTs on the southern Swan Coastal Plain were initially determined by Gibson *et al.* (1994) using computer analysis of over 500 quadrats.

The quadrat data from the vegetation in Very Good condition was assessed against Table 12 of Gibson *et al.* (1994) to determine the most likely FCT for the vegetation on the site. The analysis gave a very high (100%) match for the following FCTs:

- FCT 28 ‘’Spearwood Banksia attenuata or Banksia attenuata – Eucalyptus woodlands”; and
- FCT 21a “Central Banksia attenuata – Eucalyptus marginata woodlands”.

There was also a high match for FCT 25 “Southern *Eucalyptus gomphocephala-Agonis flexuosa* woodlands”.

All three FCTs occur on Spearwood soils. The location of the site is within the boundaries of all three FCTs. While FCT 25 appears the most logical of the FCTs based on the presence of Tuart on the site and in the description of the FCT, all three FCTs can contain Tuart. Therefore, on the basis of the 100% match with FCT28 this report concludes that the vegetation on the site is most likely representative of FCT28.

2.9.7 Vegetation Condition

The condition of the vegetation was assessed according to the system devised by Keighery and described in Bush Forever (Government of Western Australia, 2000) (Table 4).

Table 4: Vegetation Condition Rating Scale.

Condition	Description
Pristine	Pristine or nearly so, no obvious signs of disturbance.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good	Vegetation structure altered, obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbance. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
Completely Degraded	The structure of the vegetation is no longer intact, and the area is completely or almost completely without native species. These are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

Source: Government of Western Australia, 2000.

The condition of the vegetation ranged from Very Good to Completely Degraded (Figure 4). No areas of Excellent vegetation were recorded. The Degraded vegetation occurs mainly in the northern part of the site (Appendix 2).

2.9.8 Conservation Significance of Flora and Vegetation

Flora

Of the 23 species identified in the database search there was potential for one Threatened species (*Caladenia huegelii* – Grand Spider Orchid) and one Priority 3 species (*Jacksonia sericea*) to occur on the site. The Detailed site survey did not record any of these species on the site. The survey was undertaken at an appropriate time of year for the identification of these species.

PGV Environmental concludes there are no Threatened or Priority flora species on the site (Appendix 2).

Vegetation Complex

The vegetation on the site is part of the Karrakatta Complex Central and South. There is approximately 29.5% of the Karrakatta Complex Central and South remaining on the southern Swan Coastal Plain based on the pre-European extent with 2.5% in secure tenure (EPA 2006). More recently the Perth Biodiversity Project (WALGA, 2013) estimated that 23.91% of Karrakatta Complex Central and South remains compared to its pre-European extent (WALGA, 2013).

Floristic Community Type

PGV Environmental considers the vegetation on the site is likely to represent FCT 28 on the basis that the quadrat data for all species, i.e. trees, shrubs and sub-shrubs had a 100% match with the species in Table 12 of Gibson *et al.* (1994). FCT28 is not a Threatened or Priority Ecological Community.

Banksia Woodland TEC Assessment

The Banksia Woodlands of the Swan Coastal Plain Ecological Community was listed as Endangered under the Commonwealth EPBC Act on 16 September 2016. A description of the Banksia Woodland TEC is available through the EPBC Act listing and more specifically the *Approved Conservation Advice (incorporating listing advice) for the Banksia Woodlands of the Swan Coastal Plain ecological community* released by the Commonwealth Government. The Banksia vegetation on site was assessed against the Banksia Woodland TEC criteria.

The density of Banksia trees was measured on the site to assess whether the vegetation could be considered the Banksia Woodland of the Swan Coastal Plain Threatened Ecological Community (TEC) which is listed under the Commonwealth EPBC Act. The dominance of Tuart, Jarrah and Sheoak trees and the low density of Banksia trees on the site, PGV Environmental concludes that the Banksia Woodland of the Swan Coastal Plain TEC does not occur on the site (Appendix 2).

Tuart Woodland TEC Assessment

The Tuart Woodlands and Forests of the Swan Coastal Plain was listed as a Threatened Ecological Community (TEC) under the Commonwealth EPBC Act on 4 July 2019. A description of the Tuart Woodland TEC is available through the EPBC Act listing and more specifically the *Approved Conservation Advice (incorporating listing advice) for the Tuart (Eucalyptus gomphocephala) woodlands and forests of the Swan Coastal Plain ecological community* released by the Commonwealth Government. The Tuart vegetation on the site was assessed against the Tuart Woodlands TEC criteria. The results of the Tuart TEC assessment are provided in Appendix 2 and summarised below.

The Tuart vegetation in the BF278 was assessed as being one 'patch' of Tuart woodland and, because of the size of the patch (around 9ha) and overall High to Very High condition category using the system in the Conservation Advice, all the vegetation on the site is considered to be the Tuart Woodland TEC (Appendix 2).

Ecological Linkage

The site is linked to native vegetation on large private landholdings to the west through a narrow vegetated corridor located at the southern end of Lot 878 Stakehill Road. Small birds and ground-

dwelling fauna would be able to move from BF278 to the vegetated areas further west through this corridor.

2.10 Fauna

2.10.1 Methodology

The only fauna habitat on the site is associated with BF278 and the strip of vegetation along the southern boundary of Lot 878. The remainder of the site is cleared of native vegetation and used for horticulture (Figure 3). A Level 1 Fauna survey was undertaken in accordance with EPA Technical Guidance *Fauna Surveys for Environmental Impact Assessment* (EPA, 2016b). Desktop studies were undertaken to identify habitats and potential threatened species that may occur in the native vegetation on the site. A site reconnaissance was conducted by PGV Environmental on 27 March 2019. The inspection included traversing native vegetation on the site on foot.

2.10.2 Desktop Studies

Desktop studies were undertaken to identify conservation significant species potentially present on the site. A search of the DBCA Database (Appendix 2), Naturemap database (Appendix 2) and the EPBC Act Protected Matters Search Tool (Appendix 2) identified threatened species of fauna listed as potentially occurring within a 5km radius of the site (Table 5).

Table 5: List of Fauna Species Identified from Fauna Database Searches

Scientific Name	Common Name	Conservation Status, WA	Status under EPBC Act
Bettongia penicillata ogilbyi	Woylie, Brush-tailed Bettong	Schedule 1 - CR	Endangered
Calidris ferruginea	Curlew Sandpiper	Schedule 1 - CR	Critically Endangered
Limosa lapponica menzbieri	Bar-tailed Godwit (northern Siberian)	Schedule 1 - CR	Marine/ Migratory
Numenius madagascariensis	Eastern Curlew	Schedule 1 - CR	Critically Endangered
Pseudocheirus occidentalis	Western Ringtail Possum, Ngwayir	Schedule 1 - CR	Critically Endangered
Botaurus poiciloptilus	Australasian bittern	Schedule 2 - EN	Endangered
Calidris canutus	Red Knot	Schedule 2 - EN	Marine/ Migratory
Calyptorhynchus baudinii	Baudin's Black Cockatoo	Schedule 2 - EN	Endangered
Calyptorhynchus latirostris	Carnaby's Black Cockatoo	Schedule 2 - EN	Endangered
Rostratula australis (Rostratula benghalensis australis)	Australian Painted Snipe	Schedule 2 - EN	Endangered Marine/ Migratory
Calyptorhynchus banksii naso	Forest Red-tailed Black-Cockatoo	Schedule 3 - VU	Vulnerable
Dasyurus geoffroii	Chuditch, Western Quoll	Schedule 3 - VU	Vulnerable
Leipoa ocellata	Mallee Fowl	Schedule 3 - VU	Vulnerable

Scientific Name	Common Name	Conservation Status, WA	Status under EPBC Act
Limosa lapponica baueri	Bar-tailed Godwit (western Alaskan)	Schedule 3 - VU	Marine/ Migratory
Westralunio carteri	Carter's Freshwater Mussel	Schedule 3 - VU	Vulnerable
Ardenna carneipes (Puffinus carneipes)	Flesh-footed Shearwater, Fleshy-footed Shearwater	Schedule 3 - VU Schedule 5 - IA	Marine/ Migratory
Actitis hypoleucos (Tringa hypoleucos)	Common Sandpiper	Schedule 5 - IA	Marine/ Migratory
Apus pacificus	Fork-tailed Swift	Schedule 5 - IA	Marine/Migratory
Calidris melanotos	Pectoral Sandpiper	Schedule 5 - IA	Marine/ Migratory
Calidris ruficollis	Red-necked Stint	Schedule 5 - IA	Marine/ Migratory
Hydroprogne caspia (Sterna caspia)	Caspian Tern	Schedule 5 - IA	Marine/ Migratory
Motacilla cinerea	Grey Wagtail	Schedule 5 - IA	Migratory/ Marine
Pandion cristatus (Pandion haliaetus)	Osprey	Schedule 5 - IA	Marine/ Migratory
Pluvialis squatarola	Grey Plover	Schedule 5 - IA	Marine/ Migratory
Sterna dougallii	Roseate Tern	Schedule 5 - IA	Marine/ Migratory
Thalasseus bergii (Sterna bergii)	Crested Tern	Schedule 5 - IA	Marine/ Migratory
Tringa nebularia	Common Greenshank	Schedule 5 - IA	Marine/ Migratory
Phascogale tapoatafa wambenger	South-western Brush-tailed Phascogale, Wambenger	Schedule 6 - CD	
Ardea alba (Ardea modesta)	Great Egret, White Egret		Marine
Ardea ibis	Cattle Egret		Marine
Haliaeetus leucogaster	White-bellied Sea-eagle		Marine
Merops ornatus	Rainbow Bee-eater		Marine
Pachyptila turtur	Fairy Prion		Marine
Ctenotus gemmula (Swan Coastal Plain pop	Jewelled South-west Ctenotus	Priority 3	
Lerista lineata	Perth Slider, Lined Skink	Priority 3	
Idiosoma sigillatum	Swan Coastal Plain shield-backed trapdoor spider	Priority 4	
Isoodon fusciventer	Southern Brown Bandicoot, Quenda	Priority 4	
Synemon gratiosa	Graceful Sun-moth	Priority 4	
Thinornis rubricollis (Charadrius rubricollis)	Hooded Plover	Priority 4	Marine
Bettongia penicillata ogilbyi	Woylie, Brush-tailed Bettong	Schedule 1 - CR	Endangered

Fauna are classified under five different Priority codes and rare and endangered fauna are classified under the *Wildlife Conservation (Specially Protected Fauna) Notice 2014* into five schedules of taxa. These are outlined in Appendix 2.

2.10.3 Fauna Habitat

One fauna habitat was considered present on the site which was an Open Woodland Habitat (Plate 10).

Plate 10: Open Woodland Fauna Habitat



Fauna habitat can be assessed using several factors including, the size of the habitat, the level of habitat connectivity, availability of specific resources (e.g. tree hollows) and overall vegetation quality. The habitat was assessed according to the following categories:

High Quality Fauna Habitat – These areas closely approximate the vegetation mix and quality that would have been in the area prior to any disturbance. The habitat has connectivity with other habitats and is likely to contain the most natural vertebrate fauna assemblage.

Very Good Fauna Habitat - These areas show minimal signs of disturbance (e.g. grazing, clearing, fragmentation, weeds) and generally retain many of the characteristics of the habitat if it had not been disturbed. The habitat has connectivity with other habitats and fauna assemblages in these areas are likely to be minimally affected by disturbance.

Good Fauna Habitat – These areas showed signs of disturbance (e.g. grazing, clearing, fragmentation, weeds) but generally retain many of the characteristics of the habitat if it had not been disturbed. The habitat has connectivity with other habitats and fauna assemblages in these areas are likely to be affected by disturbance.

Disturbed Fauna Habitat – These areas showed signs of significant disturbance. Many of the trees, shrubs and undergrowth are cleared. These areas may be in the early succession and regeneration stages. Areas may show signs of significant grazing, contain weeds or have been damaged by vehicle or machinery. Habitats are fragmented or have limited connectivity with other fauna habitats. Fauna assemblages in these areas are likely to differ significantly from what might be expected in the area had the disturbance not occurred.

Highly Degraded Fauna Habitat – These areas often have a significant loss of vegetation, an abundance of weeds, and a large number of vehicle tracks or are completely cleared. Limited or no fauna habitat connectivity. Faunal assemblages in these areas are likely to be significantly different to what might have been in the area pre-disturbance. (Coffey Environments, 2009).

The Open Woodland Habitat has vegetation in Degraded to Very Good condition with the structure of the vegetation impacted in areas. The vegetation has some linkage to other areas of bushland therefore the habitat is considered to be Good Fauna Habitat.

2.10.4 Conservation Significant Species

Outlined below in Table 6 is a short description of the preferred habitat for each of the species that were identified in the DBCA Database Search (Appendix 2) and the EPBC Protected Matters Search Tool (Appendix 2) in Table 5. The preferred habitat has been compared to the habitats on the site described above and the likelihood of each species to be present was determined.

Table 6: Preferred Habitat of Conservation Significant Fauna Species

Scientific Name	Common Name	Habitat*	Likelihood of occurring on the site
Bettongia penicillata ogilbyi	Woylie, Brush-tailed Bettong	The Woylie habitat types ranged from forest to grassland, coastal and inland. During the day the Woylie shelters under patches of dense undergrowth, logs and rock-cavities and occasionally in burrows.	Highly Unlikey – the site is too disturbed
Calidris ferruginea	Curlew Sandpiper	Curlew Sandpipers mainly occur on intertidal mudflats in sheltered coastal areas, such as estuaries, bays, inlets and lagoons, and also around non-tidal swamps, lakes and lagoons near the coast, and ponds in saltworks and sewage farms.	No – not coastal habitat
Limosa lapponica menzbieri	Bar-tailed Godwit (northern Siberian)	The Bar-tailed Godwit is found mainly in coastal habitats such as large intertidal sandflats, banks, mudflats, estuaries, inlets, harbours, coastal lagoons and bays. It is found often around beds of seagrass and, sometimes, in nearby saltmarsh.	No – not coastal habitat
Numenius madagascariensis	Eastern Curlew	The Eastern Curlew is most commonly associated with sheltered coasts, especially estuaries, bays, harbours, inlets and coastal lagoons, with large intertidal mudflats or sandflats, often with beds of seagrass. Occasionally, the species occurs on ocean beaches (often near estuaries), and coral reefs, rock platforms, or rocky islets.	No – not coastal habitat
Pseudocheirus occidentalis	Western Ringtail Possum, Ngwayir	The Western Ringtail Possum is a medium sized nocturnal marsupial. This species occurs in and near coastal Peppermint Tree (*Agonis flexuosa*) forest and Tuart (*Eucalyptus gomphocephala*) dominated forest with a Peppermint Tree understorey.	No – no suitable habitat on the site

Scientific Name	Common Name	Habitat*	Likelihood of occurring on the site
Botaurus poiciloptilus	Australasian bittern	The Australasian Bittern occurs mainly in densely vegetated freshwater wetlands and, rarely, in estuaries or tidal wetlands.	No – not wetland habitat
Calidris canutus	Red Knot	In Australasia the Red Knot mainly inhabit intertidal mudflats, sandflats and sandy beaches of sheltered coasts, in estuaries, bays, inlets, lagoons and harbours; sometimes on sandy ocean beaches or shallow pools on exposed wave-cut rock platforms or coral reefs.	No – not coastal habitat
Calyptorhynchus baudinii	Baudin's Black Cockatoo	Baudin's Black-Cockatoo mainly occurs in eucalypt forests, especially Jarrah (E. marginata), Marri (Corymbia calophylla), also Karri (E. diversicolor) forest, often feeding in the understorey on proteaceous trees and shrubs, especially banksias (SEWPaC, 2012).	Unlikely – outside of modelled distribution
Calyptorhynchus latirostris	Carnaby's Black Cockatoo	Carnaby's Cockatoo is found in the south-west of Australia from Kalbarri through to Ravensthorpe. It has a preference for feeding on the seeds of Banksia, Dryandra, Hakea, Eucalyptus, Grevillea, Pinus and Allocasuarina spp. It is nomadic often moving toward the coast after breeding. It breeds in tree hollows that are 2.5 - 12m above the ground and have an entrance 23-30cm with a depth of 1-2.5m. Nesting mostly occurs in smooth-barked trees (e.g. Salmon Gum, Wandoo, Red Morrell) (SEWPaC, 2012)	Potentially occurs intermittently on the site
Rostratula australis (Rostratula benghalensis australis)	Australian Painted Snipe	The Australian Painted Snipe has been recorded at wetlands in all states of Australia but is most common in eastern Australia. It generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans. It also uses inundated or waterlogged grassland or saltmarsh, dams, rice crops, sewage farms and bore drains. Typical sites include a cover of vegetation, including grasses.	No – not wetland habitat
Calyptorhynchus banksii naso	Forest Red-tailed Black-Cockatoo	Forest Red-tailed Black Cockatoos frequent the humid to sub-humid south-west of Western Australia from Gingin in the north, to Albany in the south and west to Cape Leeuwin and Bunbury (SEWPaC, 2012). It nests in tree hollows with a depth of 1-5m, that are predominately Marri (Corymbia calophylla), Jarrah (Eucalyptus marginata) and Karri (E. diversicolor) and it feeds primarily on the seeds of Marri.	Potentially occurs intermittently on the site

Scientific Name	Common Name	Habitat*	Likelihood of occurring on the site
Dasyurus geoffroii	Chuditch, Western Quoll	The Chuditch have been known to occupy a wide range of habitats including woodlands, dry sclerophyll forests, riparian vegetation, beaches and deserts. They are opportunistic feeders, and forage on the ground at night, feeding on invertebrates, small mammals, birds and reptiles.	Highly Unlikely due to surrounding clearing and likely domestic predators
Leipoa ocellata	Mallee Fowl	Mallee fowl have been found in mallee regions of southern Australia from approximately the 26th parallel of latitude southwards in mallee bushland.	No – Not mallee habitat
Limosa lapponica baueri	Bar-tailed Godwit (western Alaskan)	The Bar-tailed Godwit is found mainly in coastal habitats such as large intertidal sandflats, banks, mudflats, estuaries, inlets, harbours, coastal lagoons and bays. It is found often around beds of seagrass and, sometimes, in nearby saltmarsh.	No – not coastal habitat
Westralunio carteri	Carter's Freshwater Mussel	Carter's Feshwater Mussel is South-West Western Australia's only freshwater mussel (Murdoch University & SERCUL, 2012). Carter's Freshwater Mussel occurs in freshwater streams, rivers, reservoirs and lakes (ICUN, 2015a) and is intolerant to dehydration for more than three days and salinity (Murdoch University & SERCUL, 2012).	No - no permanent water on the site
Ardenna carneipes (Puffinus carneipes)	Flesh-footed Shearwater, Fleshy-footed Shearwater	The Flesh-footed Shearwater mainly occurs in the subtropics over continental shelves and slopes and occasionally inshore waters. Burrows are situated in areas that provide a clear flight-path for birds to enter and exit their colonies.	No – not wetland habitat
Actitis hypoleucos (Tringa hypoleucos)	Common Sandpiper	The Common Sandpiper is mostly found around muddy margins or rocky shores. Generally the species forages in shallow water and on bare soft mud at the edges of wetlands.	No – not wetland habitat
Apus pacificus	Fork-tailed Swift	The Fork-tailed Swift is almost exclusively aerial and is not known to breed in Australia. They are seen in inland plains but sometimes above foothills or in coastal areas. They often occur over cliffs and beaches and also over islands and sometimes well out to sea. They also occur over settled areas, including towns, urban areas and cities. *Apus pacificus* subsp. *pacificus* is the only subspecies to migrate to Australia.	No – this species is aerial and is unklikely to land on the site
Calidris melanotos	Pectoral Sandpiper	The Pectoral Sandpiper prefers shallow fresh to saline wetlands and is found at coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains and artificial wetlands.	No – not wetland habitat

Scientific Name	Common Name	Habitat*	Likelihood of occurring on the site
Calidris ruficollis	Red-necked Stint	The Red-necked Stint is mostly found in coastal areas, including in sheltered inlets, bays, lagoons and estuaries with intertidal mudflats, often near spits, islets and banks and, sometimes, on protected sandy or coralline shores.	No – not coastal habitat
Hydroprogne caspia (Sterna caspia)	Caspian Tern	The Caspian Tern is mostly found in sheltered coastal embayments (harbours, lagoons, inlets, bays, estuaries and river deltas) and those with sandy or muddy margins are preferred.	No – not coastal habitat
Motacilla cinerea	Grey Wagtail	The Grey Wagtail is mostly recorded in coastal areas in Western Australia (ALA, 2015) however is widespread. There is non-breeding habitat only in Australia and the species has a strong association with water, particularly rocky substrates along water courses but also lakes and marshes.	No – not coastal habitat
Pandion cristatus (Pandion haliaetus)	Osprey	Ospreys occur in littoral and coastal habitats and terrestrial wetlands of tropical and temperate Australia and offshore islands. They feed on fish, especially mullet where available, and rarely take molluscs, crustaceans, insects, reptiles, birds and mammals.	No – not coastal habitat
Pluvialis squatarola	Grey Plover	Grey Plovers occur almost entirely in coastal areas, where they usually inhabit sheltered embayments, estuaries and lagoons with mudflats and sandflats, and occasionally on rocky coasts with wave-cut platforms or reef-flats, or on reefs within muddy lagoons.	No – not coastal habitat
Sterna dougallii	Roseate Tern	The Roseate Tern is a migratory coastal seabird that feeds by plunge diving. This species breeds in sites surrounded by walls and rocks or in the shelter of vegetation (in temperate regions) (Birdlife International, 2014a).	No – not coastal habitat
Thalasseus bergii (Sterna bergii)	Crested Tern	The Crested Tern occurs in coastal Areas (Birdlife Australia, 2018).	No – not coastal habitat
Tringa nebularia	Common Greenshank	The Common Greenshank is a wader and does not breed in Australia. This species can be found in many types of wetlands and has the widest distribution of any shorebird in Australia. This species typically feeds on molluscs, crustaceans, insects, and occasionally fish and frogs.	No – not wetland habitat
Phascogale tapoatafa wambenger	South-western Brush-tailed Phascogale, Wambenger	Southern Brush-tailed Phascogales are arboreal marsupials which require tree hollows in suitable woodland or forest and rely on abundant invertebrate prey to sustain populations (Pescott, 2012).	Highly Unlikely due to surrounding clearing and likely domestic predators

Scientific Name	Common Name	Habitat*	Likelihood of occurring on the site
Ardea alba (Ardea modesta)	Great Egret, White Egret	The Eastern Great Egret has been reported in a wide range of wetland habitats and usually frequents shallow waters. This species feeds on fish, insects, crustaceans, molluscs, frogs, lizards, snakes and small birds and mammals.	No – not wetland habitat
Ardea ibis	Cattle Egret	The Cattle Egret occurs in tropical and temperate grasslands, wooded lands and terrestrial wetlands with breeding in Western Australia recorded in the far north in Wyndham in colonies in wooded swamps such as mangrove forest. This species forages away from water on low lying grasslands, improved pastures and croplands generally in areas that have livestock eating insects, frog, lizards and small mammals.	No – not the preferred habitats for this species
Haliaeetus leucogaster	White-bellied Sea-eagle	The White-bellied Sea-Eagle is found in coastal habitats with large areas of open water, especially those close to the sea-shore. This species feeds opportunistically on a variety of fish, birds, reptiles, mammals and crustaceans, and on carrion and offal.	No – not coastal habitat
Merops ornatus	Rainbow Bee-eater	Populations of the Rainbow Bee-eater that breed in northern Australia are considered to be resident, and in many northern localities the Rainbow Bee-eater is present throughout the year. The Rainbow Bee-eater nests in a burrow dug in the ground. It is found across the better-watered parts of WA including islands preferring lightly wooded, sandy country near water.	Potentially an intermittent visitor to the site
Pachyptila turtur	Fairy Prion	The Fairy Prion occurs over oceans and coastal breeding islands (ALA, 2015a).	No – not coastal habitat
Ctenotus gemmula (Swan Coastal Plain pop	Jewelled South-west Ctenotus	The Jewelled south-west Ctenotus inhabits sand plains with heaths. It is also found in Banksia or Mallee woodlands (ICUN, 2015b).	Unlikely – not the preferred habitat of this species
Lerista lineata	Perth Slider, Lined Skink	The Lined Skink is a burrowing species that occurs in pale sandy soils with coastal heath and shrubland areas in isolated populations in the south-west and mid-west coast of Western Australia. It feeds on termites and other small insects (AROD, 2014).	Unlikely – not the preferred habitat of this species
Idiosoma sigillatum	Swan Coastal Plain shield-backed trapdoor spider	The Swan Coastal Plain Shield-backed Trapdoor Spider arranges fallen twigs from the sheoak tree around the rim of its burrow entrance, enabling it to feel the vibrations of unsuspecting prey that wander by (Curtin, 2018).	Possible as sheoak habitat occurs on the site

Scientific Name	Common Name	Habitat*	Likelihood of occurring on the site
Isoodon fusciventer	Southern Brown Bandicoot, Quenda	Southern Brown Bandicoots are small grey marsupials that prefer dense scrub (up to one metre high). Their diet includes invertebrates (including earthworms, adult beetles and their larvae), underground fungi, subterranean plant material, and very occasionally, small vertebrates (DEC, 2012).	Possibly present on the site
Synemon gratiosa	Graceful Sun-moth	The Graceful Sun-moth is a diurnal moth with dull coloured brown to black forewings and brightly coloured orange hind wings. The larvae burrow into the rhizomes of Lomandra maritima and Lomandra hermaphrodita exclusively and therefore require the presence of one or both of these species to be present in an area (Bishop *et al*., 2011).	Unlikely – *Lomandra maritima* did not occur at densities that provide habitat for this species
Thinornis rubricollis (Charadrius rubricollis)	Hooded Plover	The Hooded Plover primarily inhabits sandy, ocean beaches, with the highest densities on beaches with large amounts of beach-washed seaweed that are backed by extensive open dunes. In Western Australia the species also inhabits inland and coastal salt lakes (Birdlife International 2014)	No – not coastal or wetland habitat

* Habitat descriptions from DoEE (2016) SPRAT Database unless otherwise denoted

The Open Woodland Habitat may provide some foraging habitat Carnaby's Black Cockatoos (*Calyptorhynchus latirostris*) and Forest Red-tailed Black-Cockatoo (*Calyptorhynchus banksii naso*) as it has some tree species that are recognised foraging habitat (Valentine and Stock, 2008; Groom, 2011). The site also contains potential breeding habitat.

The site also potentially has habitat for the Swan Coastal Plain shield-backed trapdoor spider (*Idiosoma sigillatum*) and Southern Brown Bandicoot, Quenda (*Isoodon fusciventer*). Both species are Priority 4.

The Rainbow Bee-eater (*Merops ornatus*), listed Marine under the EPBC Act, may potentially utilise some sections of the site as part of a much larger home range although this species is only likely to occur infrequently.

2.10.5 Black Cockatoo Habitat Assessment

PGV Environmental undertook a Black Cockatoo Habitat Assessment in accordance with the EPBC Act referral guidelines for three threatened Black Cockatoo species: Carnaby's cockatoo (endangered) *Calyptorhynchus latirostris* Baudin's cockatoo (vulnerable) *Calyptorhynchus baudinii* Forest red-tailed Black Cockatoo (vulnerable) *Calyptorhynchus banksii naso* (SEWPaC, 2012) (Black Cockatoo Referral Guidelines) and the methodology that is outlined in the SPRAT Database for each of the Black Cockatoo species for Black Cockatoo Habitat Assessments.

The field work for the assessment was undertaken by PGV Environmental on 27 March 2019. The site was traversed on foot and information on Black Cockatoo foraging, roosting, and breeding habitat was assessed.

The results of the Black Cockatoo Habitat Assessment are provided in Appendix 2 and summarised below.

Foraging

The site contains eight native plant species that are recognised as foraging habitat for Carnaby's Black Cockatoos (Table 7). Forest Red-tailed Black Cockatoos would only forage on Jarrah and Sheoak on the site.

Table 7: Foraging Species for Carnaby's Black Cockatoos Recorded on the Site

Species	Common Name
Allocasuarina fraseriana	Sheoak
Banksia attenuata	Candlestick Banksia
Banksia grandis	Bull Banksia
Banksia menziesii	Firewood Banksia
Eucalyptus gomphocephala	Tuart
Eucalyptus marginata	Jarrah
Pinus maritima	Maritime Pine
Xanthorrhoea brunonis	Grass Tree
Xanthorrhoea preissii	Balga

No evidence of Black Cockatoos having foraged on the site recently or in the past was observed during the assessment. The dominant tree species on the site is Tuarts. Carnaby's Black Cockatoos are only recorded feeding on the flowers of this species. Given the low density of Banksia trees, the foraging habitat on the site is not considered to be high quality.

Roosting

The site is not a known roosting site for Carnaby's Black Cockatoos or Forest Red-tailed Black Cockatoos. The nearest roosting site for Carnaby's Black Cockatoos is approximately 1.4km to the east (DoP, 2011). No evidence of the site being utilised as roosting habitat by Black Cockatoos was observed during the site assessment.

Breeding

The site is not known as a breeding site for Carnaby's Black Cockatoos (DoP, 2011). The Black Cockatoo Referral Guidelines define trees of certain species with a DBH of 500mm or greater as breeding habitat regardless of the presence or not of hollows. PGV Environmental recorded 90 Tuart (*Eucalyptus gomphocephala*), 4 Jarrah (*Eucalyptus marginata*) and 6 Standing Dead Trees (SDT) as potential breeding habitat. One Jarrah and one of the Standing Dead Trees recorded had hollows or spouts and three Tuarts had potential hollows. There was no evidence of the hollows being used for breeding recently or in previous years.

Significance of Impact

There are two guidelines that can be used to assess the significance of an impact on Black Cockatoos. The first is the statutory document *EPBC Act Significant Impact Guidelines 1.1* which can be used for

any matter listed under the EPBC Act. The second is the more specific *Black Cockatoo Referral Guidelines* that were prepared specifically to address impacts on the three listed Black Cockatoo species from South-West Western Australia.

The conclusion of this assessment in accordance with the criteria set out in the *Significant Impact Guidelines 1.1* is that development on the site will not have a significant impact on Carnaby's Black Cockatoos or Forest Red-tailed Black Cockatoos (see Appendix 2 for detailed assessment).

The DCP proposes to retain 9.552ha of Black Cockatoo habitat including 63 potential nesting trees.

The conclusion of the assessment against the Black Cockatoo Referral Guidelines assuming that 2.61ha of vegetation and 16 potential breeding trees are cleared is that the impact is not a significant risk to the species.

The Decision Making flowchart in Figure 1 of the Black Cockatoo Referral Guidelines was applied to the site without consideration of mitigation strategies and is shown in sequence below:

1 Could the impacts of your action occur within the modelled distribution of the black cockatoos? – YES
2 Could the impacts of your action affect any black cockatoo habitat or individuals? - YES
3 Have you surveyed for black cockatoo habitat using the recommended methods? – YES
4 Could your action have an impact on black cockatoos or their habitat? – YES
5 Is your impact mitigation best practice so that it may reduce the significance of your impacts on black cockatoos? Prioritise impact avoidance over impact minimisation - Yes

RESULT – Referral Recommended: Risk of resulting in a small impact.

The amount of foraging habitat to be cleared would need to be less than 1ha and virtually no clearing of potential breeding habitat trees.

2.10.6 Pest Fauna

The site shows signs of use by rabbits. Feral cats, foxes, rats and mice are also likely to be present.

2.10.7 Biodiversity Value

The EPA's (2002) *Terrestrial Biological Surveys as an Element of Biodiversity Protection Position Statement No. 3* indicated an ecological assessment of a site must consider its biodiversity value at the genetic, species and ecosystem levels; and its ecological functional value at the ecosystem level. The ecosystem on the site has been disturbed and the fauna assemblage would be modified. There is likely to be a high percentage of introduced feral species such as foxes and rabbits and increased domestic predators such as cats.

2.11 Heritage

There are no listed heritage sites in the Aboriginal Heritage Inquiry System associated with the site (DAA, 2017).

There are no listed sites in the Heritage Council WA – State Register associated with the site (National Map, 2017).

2.12 Contamination

The site is currently used for horticultural purposes.

Market gardens can have areas of soils that may be classified as contaminated as per *Potentially Contaminating Activities, Industries and Land Uses* (DoE, 2004). A Preliminary Site Investigation (PSI) and if required a Sampling Analysis Plan (SAP) should be undertaken and prepared prior to subdivision once design details are known.

3 Draft Development Concept Plan

3.1 Proposed Negotiated Planning Solution

The Draft Development Concept Plan (DCP) has been prepared by Veris (Appendix 3). The DCP for the site has been prepared based on the proposed Negotiated Planning Solution (NPS) for BF278.

The proposed NPS is based on the policy framework and the findings of the flora, vegetation, and fauna surveys for the site. The proposed NPS involves the retention of 3.095ha of bushland which is approximately 50 percent of the vegetation included within Area B of the BF278 outside of the Nairn Road Reserve (Table 8). The area is regular in shape and contains the majority of the Good to Very Good condition vegetation as well as retaining an ecological link to bushland on Lot 146 to the west. The proposed NPS site includes the retention of 33 Jarrah and Tuart trees identified as potential future breeding habitat for Black Cockatoos (Strategen, 2019).

Table 12: Percentage of Bush Forever No. 278 (B) Retained

Land Use	**Area (ha)**
Total Area Bush Forever (Lots 878 and 877)	11.654
Less Deductions	
Urban Use (residential)	2.6000
Public Open Space	1.322
Nairn Drive regional road reservation	1.372
Net Area retained (including Nairn Drive Area)	**6.360**
Percentage	54.7%

3.2 Draft Concept Plan

The draft Concept Plan for the site includes residential, conservation area, public open space and drainage, service commercial and commercial. The land use breakdown is provided in Table 9 below.

Table 9: Land Use Breakdown

Land Use	**Area (ha)**
Total Site Area	**48.715**
Less Deductions	
Nairn Drive MRS Regional Road Reservation	**2.703**
Stakehill Road MRS Road Reservation	0.095
Service Commercial	1.136
Commercial	1.749
Local Park No. 1	0.087
Local Park No. 6	0.146
Western boundary north south linear drainage swale	0.322
Sewer Pump Station	0.041
Market Garden Spray Drift Buffer and Landscaping Strip	0.114
BushForever (to be retained in NPS)	6.360
Total Deductions	1.753
Gross Subdividable Area	**35.962**

The service/commercial and commercial land use is located along Stakehill Road and will not include sensitive receptors such as childcare centre to minimise any potential odour impacts from the nearby market garden. The residential land use along Stakehill Road in the east will contain a vegetated buffer on the north and east to assist with odour and spray drift mitigation from the nearby market garden.

4 SEPARATION DISTANCE ASSESSMENT

The surrounding land uses need to be considered in the planning for urban development on the site. The following provides an assessment of the separation distances required for the market garden, poultry farms and Holcim Sand Mine which are in the vicinity of the site.

4.1 Policies and Guidelines

4.1.1 Separation Distances between Industrial and Sensitive Land Uses

EPA Guidance Statement No. 3: *Separation Distances between Industrial and Sensitive Land Uses* (2005) was withdrawn following a review by the EPA of its policies and guidelines in 2018. Guidance Statement No. 3 therefore is no longer pertinent to the determination of industrial buffers.

4.1.2 Draft DER Separation Distances between Industrial and Sensitive Land Uses

The Draft Assessment Guideline for *Separation distances between industrial and sensitive land uses* (DER, 2015) was withdrawn and is no longer pertinent to the determination of industrial buffers.

4.1.3 EPA Environmental Factor Guideline – Social Surroundings

The EPA's Environmental Factor Guideline: Social Surroundings describes the EPA's position in relation to how emissions of noise, odour and dust should be considered in the context of sensitive land uses. The guideline does not include any generic separation distances between emission sources and sensitive land uses and states that "*The EPA expects proponents or, in the case of a scheme, planning authorities, to consider and/ or design proposals with appropriate distances in mind, informed by recognised published separation distance guidelines to ensure human health and wellbeing, local amenity and aesthetic enjoyment continue*". The EPA, however, does not have recognised published separation distance guidelines.

4.1.4 State Planning Policy 2.5: Rural Planning

SPP 2.5 is the Western Australian Planning Commission's policy on rural land assets and is applied to land that may be impacted by rural land uses. SPP repealed *State Planning Policy 4.3: Poultry Farms Policy 1998.*

In terms of separation distances between rural land and sensitive land uses SPP 2.5 refers to the EPA's Guidance Statement 3.

The repealed SPP 4.3: Poultry Farms is the only WAPC policy that mentioned any particular separation distance to poultry farms as follows: "*proposal for the zoning, subdivision and development of land for residential purposes (closer that 500m to any existing or approved poultry sheds) and rural-residential purposes (closer than 300m to any existing or approved poultry shed). The Commission and/or local government may require an assessment to show that the operation of the poultry farm will not adversely affect the amenity of the new residents in the proposed residential and rural-residential area*".

4.1.5 Draft State Planning Policy 4.1 Industrial Interface 2017

The objectives of Draft SPP 4.1 are to:

> (a) protect existing and proposed industry, and infrastructure facilities from encroachment by incompatible land uses that would adversely affect efficient operations;
>
> (b) avoid land use conflict between existing and proposed industry/ infrastructure facilities and sensitive land uses; and
>
> (c) promote compatible land uses in areas impacted by existing and proposed industry and infrastructure facilities.

The Draft SPP 4.1 outlines how statutory buffers should be applied and outlines how statutory buffers should be determined. The SPP states that the size/extent of a buffer should consider (1) technical environmental reports on the nature and extent of potential off-site impacts, and (2) technical advice from the relevant State Government agency including DWER, DMIRS and/or Department of Health. No generic buffer distances are prescribed in Draft SPP 4.1.

4.1.6 Guidelines for the Separation of Agricultural and Residential Land Uses

The Guidelines for the Separation of Agricultural and Residential Land Uses (DoH, 2012) was developed to consolidate the Department of Health (DoH) position for the establishment of buffer areas in new residential subdivisions. The Guidelines state that they should be used in conjunction with Draft SPP 4.1 and EPA Guidance Statement 3 (which has since been revoked).

The objective of this guideline is to avoid conflicts arising from proposed residential developments and other sensitive land use near existing agricultural land. The guideline provides recommendations on the minimum separation distance required between agricultural land use and residential land use based on current scientific knowledge and industry practice. This guideline will assist in minimising health and nuisance impacts from chemical use and dust.

Under the guideline the following minimum requirements will be considered suitable by the DoH:

- A separation distance of 300m for to control spray drift, dust, smoke, and ash;
- Alternatively, a 40m separation distance can be used where a vegetative buffer has been adequately designed, implemented, and maintained in accordance with these guidelines; and
- Vegetative buffers will not be operational until trees reach the minimum effective height to control spray drift. Residential areas should not be developed within 300m until this time.

The guideline provides specific criteria for creating vegetated buffers.

4.2 Separation Distance Assessment

The approximate distance between the site and nearby land uses that have a potential to impact on the future development are as follows:

- 150m to the poultry farm to the north west;
- 30m to the market garden to the north;
- 80-250m to the market garden to the south east; and
- 500m to the sand mining operation in the east.

4.2.1 Poultry Farms

A technical report has been undertaken on odour levels from the poultry farm to the north-west by the proponent (Appendix 1).

The EAQ (2020) OFA assessment indicated that the odour impacts from the poultry farm are negligible during worst case conditions.

The draft DCP has considered the potential impact from odour sourced from the poultry farm to the north west and has not included sensitive land uses within the 120m contour. The land use within the 120m contour area will be Public Open Space (drainage) and non-sensitive commercial uses. The reduced separation area is considered adequate based on the outcomes of the EAQ assessment and that poultry facility is egg producing which has lower odour impacts and that the prevailing winds are away from the site.

4.2.2 Market Garden

The generic buffer under the Department of Health guidelines between market gardens and sensitive land use is 300m. A minimum separation distance of 40m could apply if the separation area is vegetated in accordance with the specific criteria set out in the guidelines. The 40m can be made up of a road or firebreak with 20m vegetation.

The market garden is located on the northern side of Stakehill Road approximately 30m north of the site and is used for vegetable production. The main emissions from the market garden is likely to be dust. Pesticide spray drift is unlikely to be an issue as spraying is done at ground level and under low pressure. An existing narrow stand of *Agonis flexuosa* is planted along the northern boundary of the market garden. The prevailing winds in the morning are largely from the east and in the afternoon from the south-west which is away from the site.

A second market garden is situated to the east of the site and is separated from the development by the future Nairn Road and the NPS for BF278. Pesticide spray drift is unlikely to be an issue as spraying is done at ground level and under low pressure. The afternoon prevailing winds are from the south west and will take pesticide spray drift away from the site. The morning winds are from the east and spray drift is separated from the site by native vegetation.

Spray Drift has been defined by the Co-ordinating Committee on Agricultural Chemicals (CCAC) *Review of Agricultural Chemical Spray Drift* (1993) as:

> *Drift is the airborne movement of agricultural chemicals onto a non-target area with the potential for risk of injury or damage to humans, plants, animals, environment, or property.*

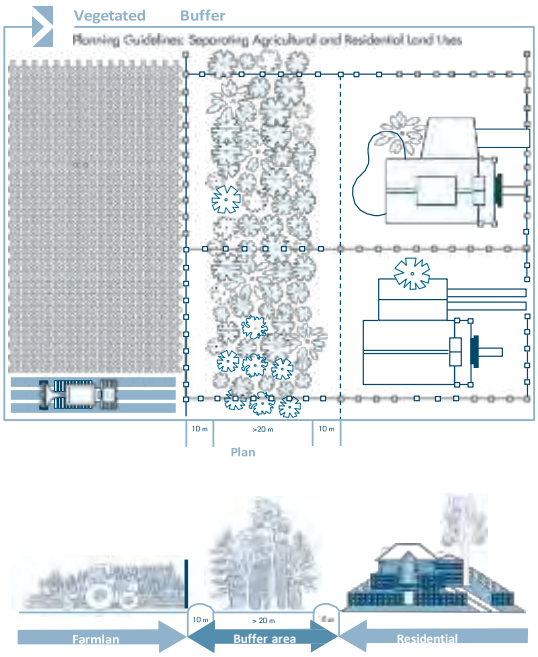
Management of the vegetation and landscaping design of the interface between the rural and residential areas is integral to the mitigation of any risk of conflict between the land uses. Landscaping and vegetation management, in accordance with the DoH Guidelines should include:

To be effective barriers to spray drift, the vegetated buffers need to meet the following criteria (Plate 10):

1. Be located as close as practicable to the point of release of the spray.
2. A minimum total width of 40m made up of 10m cleared fire break area either side of a 20 m wide planted area.

3. Contain random plantings of a variety of tree and shrub species of differing growth habitats, at spacings of 4-5m.
4. Include species with long, thin (needle-like) and rough (furry/hairy) foliage which facilitates the more efficient capture of spray droplets and which are fast growing and hardy;
5. Foliage should be from the base to the crown; mixed plantings of trees may be required to ensure there are no gaps in the lower canopy.
6. Provide a permeable barrier which allows air to pass through the buffer. A porosity of 0.5 is acceptable (that is, approximately 50% of the screen should be air space).
7. Have a mature tree height twice the height of the spray release height.
8. Have mature height and width dimensions which do not detrimentally impact upon adjacent crop land.

Plate 11: Diagram below shows buffer design (Department of Natural Resources, 1997).



The DCP includes a PCA which includes the 50m buffer to the market garden north of Stakehill Road which meets the minimum requirements set out in the DoH guidelines.

It is recommended that a vegetated buffer (5m) is planted along the southern PCA boundary to provide a barrier to any potential air quality issues from adjacent land uses. The vegetated buffer will also provide a noise attenuation barrier to Stakehill Road.

4.2.3 Holcim Sand Mine

The Holcim Sand Mine is located 600m to the east of the site and is separated by rural lots and Harvey Road and is therefore unlikely to impact on the development of the site.

4.3 Memorial on Title

If the market garden and poultry farm are still in production when development occurs, it is recommended that purchasers/owners of lots within 40m of the market garden and 120m from the Poultry Farm should be made aware of the adjacent market garden and poultry farm activity with a memorial on the title.

5 ENVIRONMENTAL ASSESSMENT

The following table provides a summary of the environmental factors, constraints to development, suggested management measures and recommendations for any additional investigations to inform future planning for the site.

The only remaining native vegetation on the site is within a Bush Forever Site which is retained in the concept design. The remainder of the site has been cleared of native vegetation.

Factor	Potential Constraint to Development	Justification	Management and Additional Investigations
Landform and Topography	No	The site gradually increases in height from west to east and there is no requirement for fill to be brought into the site. Existing levels adjacent to the Bush Forever Site will be retained.	N/A
Soils and Geology	No	Soils and geology are highly unlikely to constrain the development of the site. There are no known ASS issues associated with the site and is therefore not a constraint to the development of the site.	N/A
Hydrology	No	There are no surface water features or wetlands associated with the site. The depth from ground level to the watertable is 5.0m in the west and 15m in the east. A Local Water Management Strategy (LWMS) has been prepared for the site.	Groundwater level monitoring program to be undertaken to inform LWMS and UWMP.

Factor	Potential Constraint to Development	Justification	Management and Additional Investigations
Vegetation and Flora	Yes	The northern portion of the BF278 (5.294ha), which has a mostly Degraded understorey will be developed in accordance with the Negotiated Planning Solution (Strategen, 2019). Some of the vegetation (1.17ha) and potential breeding trees will be retained in Public Open Space. Existing ground levels will be retained adjacent to the percentage of BF278 retained (6.940ha including 63 potential nesting trees) to protect the Black Cockatoo habitat/Tuart Woodland TEC. Weeds are present in the understorey of the BF278. A road interface has been included adjacent to all Bush Forever sites adjoining the development area. The remainder of the site has been cleared of native vegetation.	The vegetation to be retained in the development area will need to be managed during construction. A management plan (MP) for the southern part of BF278 can be prepared to manage the Tuart Woodland TEC. The MP will address vegetation conservation, construction management, weed control and rehabilitation requirements.

Factor	Potential Constraint to Development	Justification	Management and Additional Investigations
Fauna	Yes	The northern portion of the BF278 (5.71ha and 16 habitat trees) which has a mostly Degraded understorey will be developed in accordance with the Negotiated Planning Solution (Strategen, 2019). The removal of vegetation from this area will likely displace some fauna. Fauna in the BF278 area will need to be protected during construction. Approximately 6.390ha and 63 habitat trees have been retained for conservation. The remainder of the site has been cleared of native vegetation and is unlikely to provide fauna habitat.	A fauna management plan for the southern Bush Forever Site can be prepared during subdivision to address fauna movement between the western and eastern areas of bushland and to relocate fauna from native vegetation that will be cleared
Heritage	No	There are no Heritage sites mapped on the site, therefore it is not a constraint tot development.	N/A
Poultry Farm	No	The odour impact assessment for Lot 877 found that there would be negligible odour impacts even on worst case days. Non-sensitive land uses have been proposed in the draft DCP plan within the 120m odour impact zone.	A five-metre vegetated corridor will be planted along the PCA southern boundary to mitigate any odour issues.

Factor	Potential Constraint to Development	Justification	Management and Additional Investigations
Market Garden	No	The market garden to the north of the site will have a future separation area of approximately 50m, which meets the minimum separation distance in the DoH Guidelines. A vegetated buffer will be created along the northern boundary of the site to meet the criteria set out in the DoH guidelines. The market garden to the south-east will be between 80 and 250m away from future houses and separated by Nairn Road and the vegetation in the Bush Forever site NPS.	A five-metre vegetated corridor will be planted along the PCA southern boundary to mitigate any potential air quality issues. Memorials on titles are recommended for lots within the generic 50m of the market garden.
Contamination	No	The site is currently used for horticultural purposes. Market gardens can have areas of soils that may be classified as contaminated as per *Potentially Contaminating Activities, Industries and Land Uses* (DoE, 2004). A Preliminary Site Investigation (PSI) and if required a Sampling Analysis Plan (SAP) should be undertaken and prepared prior to subdivision once design details are known.	Undertake PSI and if required a SAP before subdivision.

6 SUMMARY AND CONCLUSION

6.1 Environmental Features

The Environmental Statement concludes the following:

- The site was largely cleared during the early 1980s for the purposes of market gardening. During this time, there were sheds and a dwelling established;
- The BF278 is located on the southern end of Lot 877 and is connected through a vegetation corridor on the southern end of Lot 878 to native vegetation to the west. The BF278 interface with development will require management during construction.
- The northern portion of the BF278 is proposed to be developed in accordance with the Negotiated Planning Solution (Strategen, 2019). An area of 1.17ha Black Cockatoo Habita/Tuart Woodland ecological community has been retained in public Open Space and will not be used for drainage.
- The southern part of the Bush Forever site (6.940ha) has been retained in the DCP for conservation purposes.
- Market gardens are listed as a potential source of contamination and a PSI and if required SAP should be prepared once detailed design is determined and prior to subdivision;
- The soils are part of the Spearwood dune system that has underlying limestone which means the risk of Acid Sulphate Soils is low;
- The soils are characteristically highly permeable;
- The site rises from 5m AHD in the west to 18m AHD in the east;
- The depth from ground level to the water table is 5.0m in the west and 15m in the east and will be managed in accordance with the Local Water Management Strategy and subsequent Urban Water Management Plans as per *Better Urban Water Management* (WAPC, 2008);
- There are no natural surface water features or wetlands on the site, a constructed dam is located in the north-west corner of Lot 878 and will be de-commissioned; and
- There are no known heritage sites mapped within the site.

6.2 Separation Distance Assessment

6.2.1 Poultry Farm

The site is located to the south-west of a poultry farm. There is no generic separation distance provided in State government environmental or planning policies anymore. However, a generic separation distance 500m was used in SPP 4.3.

The odour impact assessment (Appendix 1) for the poultry farm to the north-west indicated that emissions will be negligible on Lot 877 even on worst case scenario days. To minimise risk of odour impacts on sensitive receptors, the draft DCP proposes to have Public Open Space and commercial development within the 120m odour impact contour.

6.2.2 Market Garden

The market gardens to the north and south-east of the site have a generic separation distance of 300m depending on the size of the operation and the type of horticulture. The DoH guideline indicates that

a minimum separation area that will be considered is 40m. The separation area is required to be vegetated in accordance with the specific criteria set out in the guidelines.

The draft DCP proposes a separation distance of 50m to the northern market garden which includes the existing vegetation buffer to the north of Stakehill Road, the PCA for Stakehill Road and a 5m vegetated buffer along the northern boundary of the PCA. The vegetated Public Open Space will be planted in accordance with the criteria set out in the DoH guidelines. The market garden to the south-east will be between 80 and 250m away from future houses and separated by Nairn Road and the vegetation in the Bush Forever site NPS.

6.3 Conclusion

The environmental assessment supports the lifting of Urban Deferment from the site and concludes that development undertaken in the form of the draft Development Concept Plan (DCP) can be done in an environmentally sensitive manner.

Soils, groundwater, surface water, topography, vegetation, and fauna are not environmental constraints to the development of Lot 878 and part lot 877 Stakehill Road, Karnup. The previous use of the site as a market garden can be managed by investigating and, if required, managing any areas of contamination prior to subdivision.

The draft DCP has retained 6.940ha (73% of existing vegetation) of Black Cockatoo Habitat/Tuart Woodland TEC which includes 63 potential future nesting trees.

The draft DCP is within the generic separation distances for poultry farms and market gardens. The separation distances are developed to minimise the risk of conflict between land uses and identifies the factors that could be the cause of conflicts. In the case of poultry farm and market gardens consideration has been given to odour, spray drift and dust.

Memorials on Title and information at point of sale should be used for lots within the generic recommended separation distance of the poultry farm and market garden to ensure future residents are aware of the potential for dust and odour impacts.

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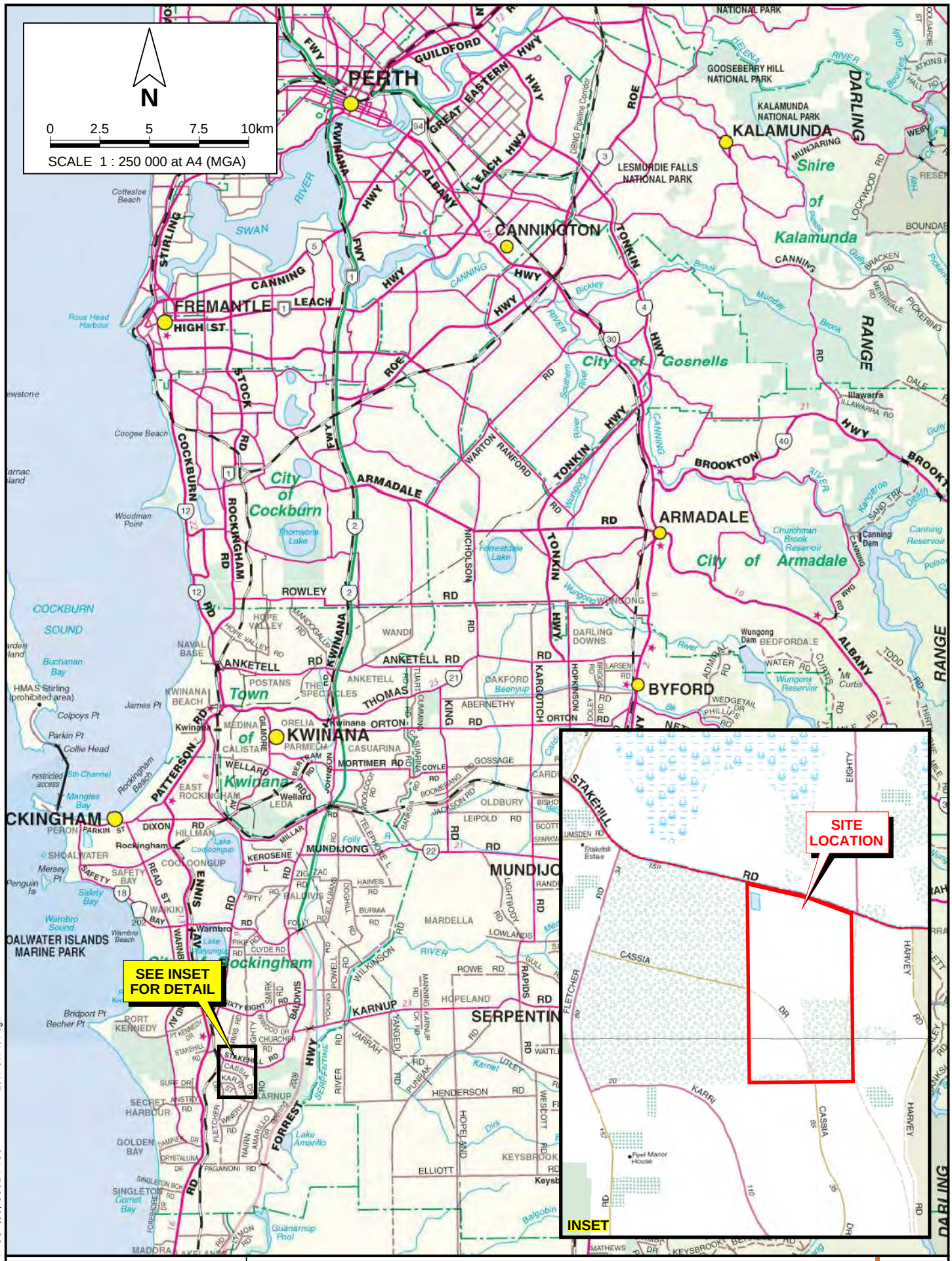
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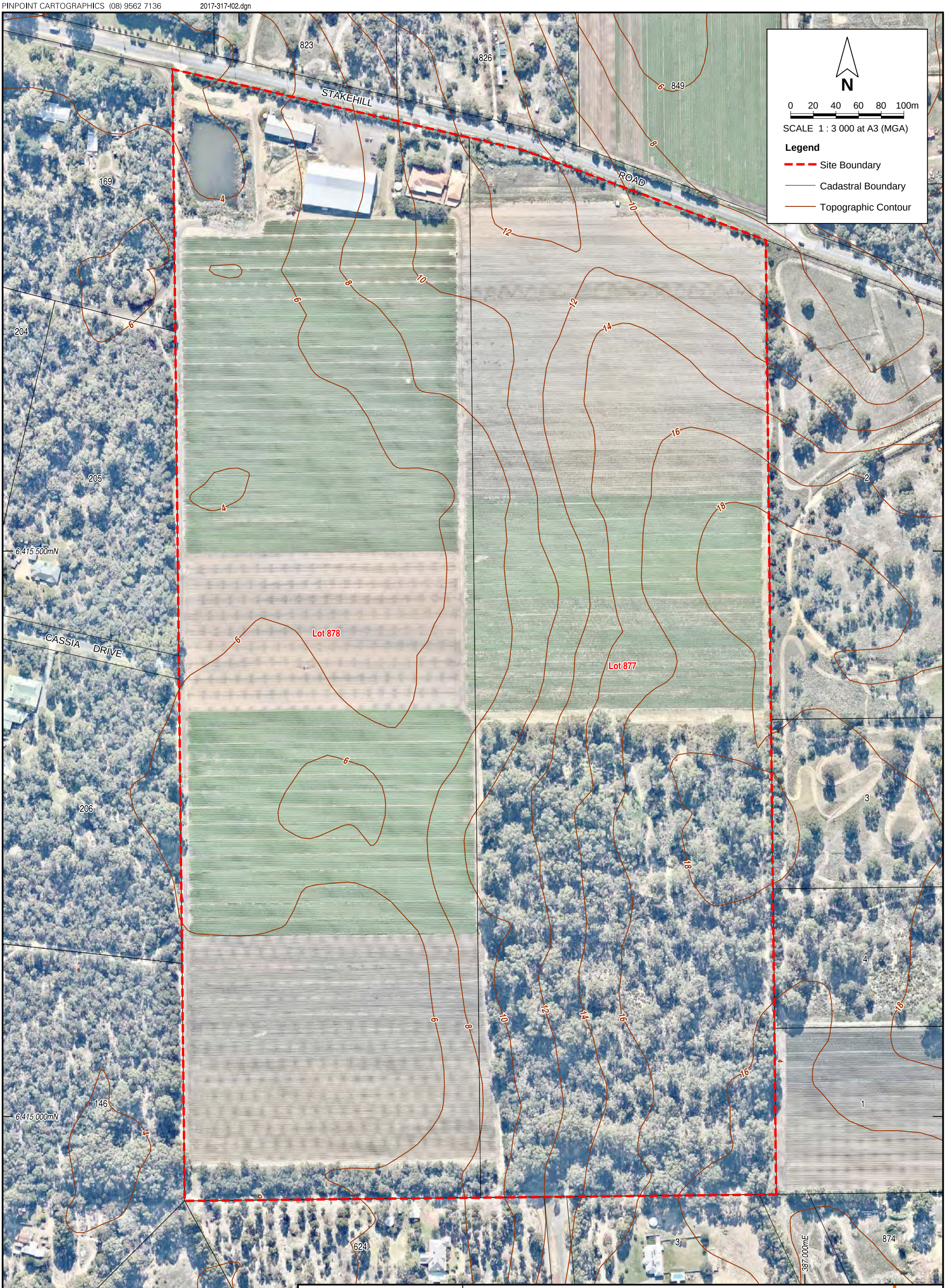
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FIGURES


N
0 2.5 5 7.5 10km
SCALE 1 : 250 000 at A4 (MGA)
PERTH
FREMANTLE
CANNINGTON
KALAMUNDA
ARMADALE
BYFORD
KWINANA
ROCKINGHAM
MUNDIJONG
SERPENTINE
KARNUP
SEE INSET FOR DETAIL
SITE LOCATION
INSET
STAKEHILL RD
CASSIA
KARRI
HARVEY
FLETCHER
Peel Manor House
Lake Amarillo
Guanarnup Pool
Bargobin
Lake Coogoongup
Lake Yangungup
Thomsons Lake
Forrestdale Lake
Canning Dam
Wungong Dam
Churchman Brook Reservoir
Canning Reservoir
Wungong Reservoir
Mt Curtis
Mt Cuthbert
Mt Brown
Mt Vincent
Mt Richon
Mt Wilson
Mt Dale
Mt Cooke
Mt Lesueur
Mt Lennard
Mt Lawley
Mt Hawthorn
Mt Flora
Mt Eliza
Mt Claremont
Mt Pleasant
Mt Henry
Mt Nasura
Mt Helena
Mt Gunderbooka
Mt Gunderbooka
Mt Gunderbooka

PINPOINT CARTOGRAPHICS (08) 9562 7136 2017-317-f02.dgn



CADASTRAL SOURCE: Landgate, August 2017.
CONTOUR SOURCE: Department of Agriculture, 2000.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown June 2017.

pgv ENVIRONMENTAL

Terranovis
ENVIRONMENTAL ASSESSMENT
LOT 877 AND LOT 878 STAKEHILL ROAD, KARNUP

Drawn: B. Heath | Date: 19 Aug 2020
Job: 10281 Rpt: 2017-317 | Revision: A

SITE BOUNDARY AND TOPOGRAPHY

Figure 2

PINPOINT CARTOGRAPHICS (08) 9562 7136 2017-317-f03.dgn

Legend

- Site Boundary
- Cadastral Boundary
- Quadrat Location
- Vegetation Type Boundary
- EgEm Vegetation Type

Potential Breeding Habitat Tree

- Dead
- Jarrah (*Eucalyptus marginata*)
- Tuart (*Eucalyptus gomphocephala*)
- 30 Tree Number

N

0 20 40 60 80 100m

SCALE 1 : 3 000 at A3 (MGA)

STAKEHILL ROAD

CASSIA DRIVE

Lot 878

Lot 877

EgEmAf

SR1 SR2 SR3 SR4 SR5

C

6 415 500mN

6 415 000mN

387 000mE

Vegetation Types

EgEmAf
Eucalyptus gomphocephala (Tuart)/*E. marginata* (Jarrah)/ *Allocasuarina fraseriana* (Sheoak) Woodland to Open Forest over *Hibbertia hypericoides*/*Xanthorrhoea brunonis*/ *Desmocladus flexuosus* Low Open Heath

C
Cleared

CADASTRAL SOURCE: Landgate, August 2017.
CONTOUR SOURCE: Department of Agriculture, 2000.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown June 2017.

pgv ENVIRONMENTAL

Drawn: B. Heath | Date: 19 Aug 2020
Job: 10281 Rpt: 2017-317 | Revision: A

Terranovis
ENVIRONMENTAL ASSESSMENT
LOT 877 AND LOT 878 STAKEHILL ROAD, KARNUP

VEGETATION TYPES AND SIGNIFICANT TREES

Figure 3

PINPOINT CARTOGRAPHICS (08) 9562 7136 2017-317-f04.dgn



pgv ENVIRONMENTAL

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ENVIRONMENTAL ASSESSMENT
LOT 877 AND LOT 878 STAKEHILL ROAD, KARNUP

Drawn: B. Heath	Date: 19 Aug 2020
Job: 10281 Rpt: 2017-317	Revision: A

VEGETATION CONDITION

Figure 4

N

0 50 100 150 200m

SCALE 1 : 5 000 at A3 (MGA)

Legend

- Site Boundary
- Cadastral Boundary
- Proposed Subdivision
- Proposed Parks & Recreation
- Proposed POS
- 120m Odour Line from Poultry Farm
- 40m Buffer from Horticultural Lots
- Bush Forever Site
- PCA 155

STAKEHILL ROAD

CASSIA DRIVE

KARRI STREET

HARVEY ROAD

Lot 878

Lot 877

120m

278

75

Holcim Sand mine

6 416 000mN

6 415 500mN

6 415 000mN

386 000mE

386 500mE

387 000mE

387 500mE

BUSH FOREVER SOURCE: DoP, April 2016.
CADASTRAL SOURCE: Landgate, August 2017.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown June 2017.

PINPOINT CARTOGRAPHICS (08) 9562 7136

2017-317-105.dgn

pgv ENVIRONMENTAL

Terranovis
ENVIRONMENTAL ASSESSMENT
LOT 877 AND LOT 878 STAKEHILL ROAD, KARNUP

Drawn: B. Heath | Date: 22 Dec 2020
Job: 10281 Rpt: 2017-317 | Revision: A

OPPORTUNITIES AND CONSTRAINTS

Figure 5

APPENDIX 1

Odour Assessment Report

EAQ Consulting

ODOUR IMPACT ASSESSMENT OF POULTRY FARMS – STAKEHILL ROAD, KARNUP

TERRANOVIS PTY LTD

Terranovis Pty Ltd

Prepared for: Terranovis Pty Ltd (Licenced Real Estate Agent)

Project Ref: EAQ-20024

December 2020

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Signature



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1 Background to Assessment

Environmental & Air Quality Consulting Pty Ltd (EAQ) was engaged by Terranovis Pty Ltd (Terranovis) to undertake an Odour Impact Assessment (the Assessment) of two (2) Poultry Farms (the Farms) along Stakehill Road, Karnup Western Australia.

The Assessment was commissioned to determine if the Farms had odorous emissions that would impact a proposed land re-zoning and development that resides directly south of the two farms along Stakehill Road (the Site).

The Farms' comprise of a bird rearing facility (Farm A) and an egg layer facility (Farm B).

Farm A is owned by Mr. John White of White Ladybirds Pty Ltd. Mr. White informed EAQ that Farm A is a bird hatchery that is currently leased and operated by Steggles Ltd, where adult birds brood and rear hatchlings that are grown to chicks ready to be delivered to commercial meat grower farms. Farm A is not a production meat bird (broiler) farm.

Farm B is understood to be an egg layer farm. In 2017 an odour modelling assessment was undertaken on Farm B by Envall. Within the Envall Report it was determined that egg layer stocking densities were determined from recent sales information, however; updated sales information cannot be found for the farm. The farm has previously been advertised for sale and may have changed hands over the past few years. Notwithstanding, EAQ inspected the farm from the boundaries and found the farm to be notably small with respect to other egg layer facilities. It is likely that Farm B may be utilised as a barn layer and/or hatchery facility which would account for the negligible activity observed during the Assessment.

Located in the City of Rockingham (CoR), the Site is within, and adjacent to the CoR's Planning Policy No.3.1.1 – Rural Land Strategy (July 2020). The Planning Policy notes Farm A as a poultry farm within Precinct 1C - Baldivis (South), and Farm B within Precinct 1A – Rural Wedge (South).

The Assessment was undertaken to determine the likelihood and consequence of odour impacts at the Site from Farms A and B.

1.1 Legislative Context

The Western Australian (WA) Environmental Protection Authority (EPA) document "Guidance for the Assessment of Environmental Factors: Separation Distances between Industrial and Sensitive Land Uses No.3: June 2005" advises of an odour buffer distance for intensive poultry farming of between 300m – 1,000m depending on size.

The WA Department of Water and Environmental Regulation (DWER) offer no guidance within a formal document as to an appropriate odour buffer for poultry farms. The DWER does however have an Odour Emissions Guideline (2019) that sets out the methods to be used to investigate the risk of an odour impact from those premises undertaking activities that are regulated under the Environmental Protection Act (1986) and/or Environmental Protection Regulations 1987.

Poultry farms in Western Australia are designed, approved and managed in accordance with (among others) the Environmental Code of Practice for Poultry Farms in Western Australia, and more specifically, the Western Australia Planning Commission (WAPC) State Planning Policy (SPP) 2.5 for Rural Planning (2016).

In accordance with State Planning Policy 2.5; *"A range of rural land uses are not 'Prescribed Premises' under the Environmental Protection Regulations 1987, though they may still generate environmental impacts. This includes poultry farms, crushing and screening components of basic raw material extraction and composting under certain thresholds. These land uses and their impacts are regulated entirely by planning processes, and therefore require special consideration by planning decision-makers", and; "Many animal premises are subject to environmental regulation, but others, most notably poultry farms, are not. Where animal premises are not subject to environmental regulation, planning decision-makers may need to consider a broader range of environmental factors and resolve potential land use conflict".*

2 Assessment Methodology

The Assessment was undertaken using two methods, the first being a meteorological (met) analysis of the five (5) years of met data from the nearest Bureau of Meteorology (BoM) Automatic Weather Station (AWS), and the second a series of field-based odour intensity investigations to record the observable presence, frequency and intensity (strength) of odours from the Farms.

2.1 Meteorological Analysis

The met analysis reviewed 5 years of met from the Mandurah BoM AWS, specifically the wind direction and speed (velocity).

The met analysis determined the frequency of winds originating from the wind vector range of 315^0 – 90^0 inclusive (i.e. NNW – E). This range was chosen to represent all winds that would push odours from both Farms onto the Site.

Additionally, the hours of day expressed as a percentage of time was also investigated within the wind vector range to determine what times of day would be problematic with respect to odours being pushed over the Site.

A single representative year was derived (refer Appendix A) using the *chi*-squared (vector) and Mann-Whitney (scalar) statistical relationships. The representative was 2017, derived from 2015 – 2019 inclusive.

2.2 Odour Field Assessments

Odour Field Assessments (OFAs) are a field-based technique that records the presence (observation), intensity (strength) and frequency of observations of odours, downwind of the odour source.

OFAs were undertaken in reference to a methodology that attempts to determine the extent of the odour plume emitted, and its perceived impact from the odour source using field methods based on the most recent European Methodology (BS EN 16841-Parts 1 & 2:2016) *"Ambient air – Determination of odour in ambient air by using field inspection"* which determines the downwind plume width and length, and the standard known as *"Measurement of Odour Impact by Field Inspection*" defined by the German Standard VDI 3940 (Part 3), where the system by which those observed odours are ranked is done according to the strength (intensity) of the odour, sensation experienced and in the case of hedonic tone, the quality of the odour impression for each detection interval within each measurement cycle.

OFAs 'ground-truth' detectable odours from a pre-defined odour source(s) to assess the plume length and width, the odour intensity of an observed odour, and the frequency of observation of those intensities.

Field odours are detected by a panel of field technicians (assessors) that have been calibrated for their olfactory sensitivity according to the Australian/New Zealand Standard AS/NZS4323.3:2001; *Stationary source emissions: Determination of odour concentration by dynamic olfactometry.*

2.2.1 Odour Field Assessment Method

For the purpose of this Assessment, the Plume Measurement method was chosen to determine the plume extent downwind of the Farms and in consideration of those measurement points most aligned with a *line-of-sight* to both Farms' odour sources.

The European Standard EN 16841-2:2016 describes the plume method for determining the extent of recognisable odours from a specific source using direct observation in the field by human panel members (assessors) under specific meteorological conditions.

The plume method involves the determination of the presence or absence (YES/NO) of recognisable odours in and around the plume originating from a specific odorant emission source, for a specific emission situation and under specific meteorological conditions (specific wind direction, wind speed and boundary layer turbulence). The unit of measurement is the presence or absence of recognisable odours at a particular location downwind of an odour source.

The extent of the plume is assessed as the transition of absence to presence of recognisable odour. The results are typically used to determine a plausible extent of potential exposure to recognisable odours.

Further assessment of the plume's odour impact was undertaken by reference to the VDI Standard where the intensity and frequency of odour observations was determined within, and at the plume extents (length and width). This provided further insight as to the plume's potential for odour decay as assessors move further away from the odour source.

Additionally, the measure of odour intensity within the plume allows a determination of *Risk* (existing and future) for odour impacts.

2.2.1.1 Determination of Plume Extents (EN 16841-2:2016)

Calibrated assessors are used to determine the presence or absence of the specific odour under investigation at different measurement points downwind of an odour source, and often under pre-defined meteorological conditions. These conditions are chosen to ensure that the extent of the plume is sufficiently defined and can be observed within locales that are relatively free of obstructions such as dense forest, scrub, high density housing etc.

The meteorological conditions during the field observations are live tracked using the nearest BoM AWS data which informs each assessor of the typical meteorological conditions across the site.

- Importantly, the local meteorological information isn't always specifically aligned with the nearest BoM AWS if that station is sufficiently far away from the odour source, or influenced by coastal or terrain effects, where;
    - To assure that local meteorology is appropriately recorded and observed, EAQ deploys a mobile weather station (Kestrel) which is situated adjacent to the odour source and free of obstructions.

Typically, measurements are repeated to reduce uncertainty to an acceptable level. In this way variability due to random variations in meteorological conditions, assessor performance and odorant emission(s) is averaged out. There are two versions of observation methods for plume extent measurement; stationary plume measurement, and dynamic plume measurement.

Using the dynamic method, the assessors cross the plume, while conducting single measurements at frequent intervals (stationary during a single measurement). By successively entering and exiting the plume and in this way determining the transition between absence and presence of recognisable odour, the extent of the plume is defined.

The plume direction is crossed at different distances from the source. This includes often crossings at distances where no recognisable odour is detected. The maximum plume reach estimate is defined as the distance along the plume direction between the source and the point halfway from the furthest intersection line or crossing where odour presence points were recorded, and the first intersection line or crossing where only odour absence points were recorded.

2.2.1.2 Determination of Odour Intensity (VDI 3940 Part 3)

Following the determination of the Plume extent, the assessor(s) then refer to the VDI standard for determining odour intensity at transition points and incremental plume extents downwind of the odour source.

With this method:

- Calibrated and experienced assessors conduct a single measurement(s) at discrete measurement points within the downwind odour plume offsite of the upwind odour source;
- Each measurement cycle comprises 60 grab measurements every 10 seconds for a single measurement cycle of 10 minutes. Each grab measurement results in a single odour sample. The Assessment/Grid/Plume Measurement Area typically represents a specific, preferential wind condition;
- An OFA survey comprises the total individual discrete measurement points, and the total single measurement(s) undertaken within the assessment/grid/plume measurement area on the measurement day;
- The survey period is often reflective of worst-case meteorological conditions when it is sub-annual, or all wind conditions when it is annual. A survey may be undertaken at any interval during the survey period (i.e. daily, weekly etc). The result of each OFA derives the impact range within that assessment/grid/plume measurement area for each survey;
- For every single measurement, the assessors determine the presence, character and intensity of any observed odours. Each OFA is designed to collect a multitude of single measurements per measurement day and often in duplicate; and
- The category scale for judging odour intensity in the field is a quantitative reference scale where assessors award one of the attributes in **Table 2-1** to their odour impression.

Table 2-1: VDI 3940 (Part 3) Odour Intensity Categories

Odour Strength	Intensity	Interpretation
Not detectable	**0**	No odour detected
Very Weak	**1**	Odour recognised and assigned to the odour source/facility (recognition)
Weak	**2**	Odour is weak but not yet distinct
Distinct	**3**	Odour is clearly distinct
Strong	**4**	Strong odour detectable
Very Strong	**5**	If offensive, observer may consider moving from the area
Extremely Strong	**6**	Odour is sufficiently over-powering that assessor moves from area

In general, the objective of an OFA is to determine the impact of odours observed and subsequent odour 'decay' observed downwind of the odour source/s, thus further defining the impact range.

2.2.2 Odour Impact Criterion

The odour impact criterion is based on determining if future sensitive receivers within the Site would be at risk of an amenity impact due to odour nuisance from the Farms.

The risk can be further understood by considering the frequency of those odour observations by defining the odour frequency, or percentage odour time, at each measurement point.

At each single measurement point the percentage odour time is calculated by the ratio of times/intervals/ where recognisable odours are recorded over the 10-minute measurement cycle. The ratio "percentage odour time" is then compared to a previously defined percentage (typically 10%) to determine if the percentage is exceeded.

An exceedance of the percentage criterion therefore implies a positive resultant odour impact at that single measurement point. Determination of the maximum distance to which the clearly recognisable odour (recognition threshold) is considered problematic can be refined not only by the determination of percentage odour time, but also by applying additional criteria to the results; for example, assigning a level of odour intensity considered problematic for a given odour source/facility, which would be considered equal to or greater than a nuisance odour intensity.

3 Locality

The Farms and Site are located in the Perth Metropolitan locality of Karnup which is within the City of Rockingham. The Site is approximately 5.5 kilometres east of the coastline.

Both Farms are located north of Stakehill Road, whilst the Site is south of Stakehill Road.

Immediately east and south of the Site are rural properties.

The Site is currently operational as a market gardening facility.

The Farms are primary sources of odour in the locality, although Farm B is far less likely to pose a nuisance for observable malodours given its size and location with respect to annual prevailing winds.

Farm A, which is directly north-east of the Sites' central location is the main source of poultry odour within the Sites' locality, where;

i. Farm A is a hatchery/rearing facility with six (6) tunnel ventilated sheds in operation;
ii. Importantly, the tunnel ventilation exhausts the air horizontally and in an easterly direction (i.e. away from the Site);
iii. The access doorways into each of the 6 tunnel ventilated sheds are at the eastern end of each shed (i.e. farthest point from the Site); and
iv. The odour emissions under normal operations (tunnel ventilated mode) and during upset conditions where the sheds are being cleaned out are at the eastern most extent of each shed and therefore the ***nearest odour source to the Site*** is not the corner of the closest shed, rather it ***is the eastern corner of the closest poultry shed to the Site*** and/or odour observation location.

The Locality of the Farms and Site is presented in **Figure 3-1**.

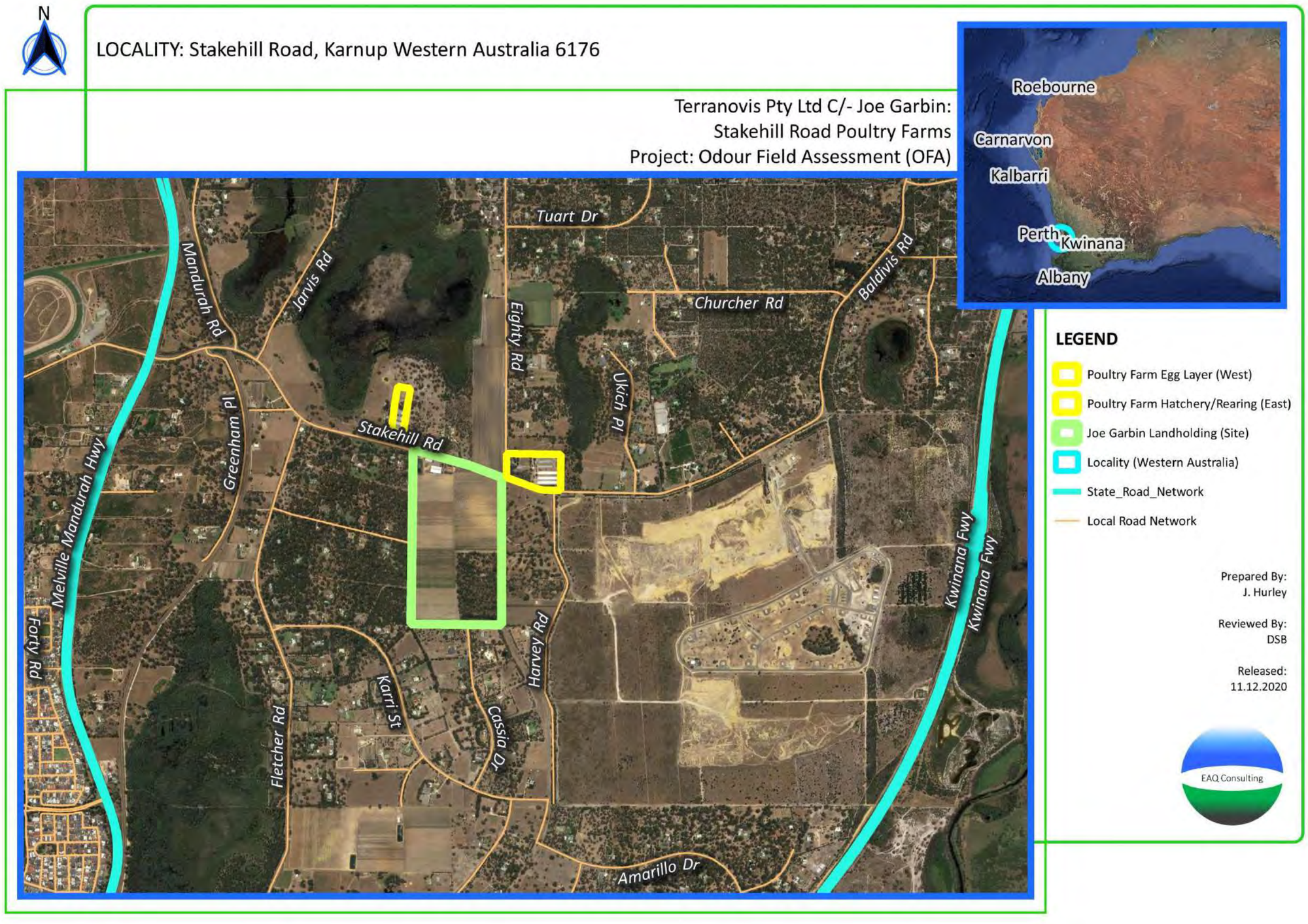


Figure 3-1: Locality Map of Poultry Farms and Site (Stakehill Road, Western Australia)

4 Meteorological Analysis

The 2017 meteorological dataset was derived as the representative year from a 5-year trend analysis.

There were 138 counts (hours) of missing data from the entire dataset with respect to wind direction and speed. The dataset recovery was therefore >99% and of a high quality.

When considering the Site, winds from 315^0 – 90^0 inclusive are directionally problematic as these winds push airflow across both Farms and toward the Site. There were 1,685 data points for wind direction within this vector. This represents 19.2% annually.

Within this 19.2% annually, the timeframe of problematic odour impacts would in general be from 5AM – 10PM daily representing "at-home" household activities. There are 1,254 counts within these times and within the 315^0 – 90^0 vector. This represents 14.3% annually.

In terms of wind speeds that would more likely cause an odour impact, those winds of a moderate breeze or less (< 8 m/s or < 28km/hr) are more conducive to causing odour nuisance. At higher wind speeds the mechanical mixing is elevated and dispersion is prominent.

At wind speeds < 8 m/s, there are 1,128 counts representing 12.9% annually.

Table 4-1 lists the Frequency Distribution of winds for both direction and wind speed classes over the meteorological analysis period with the wind vector of interest ***highlighted in grey***.

An analysis of each daily hour within this wind vector range, with respect to the percentage of time daily that these winds prevail, is presented in **Table 4-2**. Highlighted grey rows in Table 4-2 represent those times of day considered more problematic with respect to human habitation.

Table 4-3 presents the analysis of each month and the number of days, per month, where winds are originating from the wind vector range. Table 4-3 shows May – August are shown to be the more problematic months with respect to occurrences of problematic daily winds per month.

Figure 4-1 presents the Windrose of Wind Direction and Wind Speed over the entire dataset of met analysed.

Table 4-1: Frequency Distribution of Wind Direction and Wind Speed Classes

Directions	Wind Classes (m/s)						
	0.50 - 2.00	2.00 - 4.00	4.00 - 6.00	6.00 - 8.00	8.00 - 10.00	>= 10.00	Total (%)
355 - 5	0.08	0.46	0.45	0.35	0.22	0.14	1.69
5 - 15	0.17	0.34	0.37	0.34	0.17	0.01	1.40
15 - 25	0.13	0.39	0.58	0.24	0.02	0.02	1.38
25 - 35	0.40	0.67	0.37	0.10	0.00	0.00	1.54
35 - 45	0.29	0.64	0.18	0.14	0.00	0.01	1.26
45 - 55	0.42	0.61	0.38	0.07	0.00	0.00	1.47
55 - 65	0.41	1.02	0.38	0.01	0.00	0.00	1.82
65 - 75	0.55	0.74	0.23	0.05	0.00	0.00	1.56
75 - 85	0.43	0.70	0.17	0.03	0.00	0.00	1.34
85 - 95	0.56	1.10	0.61	0.09	0.00	0.00	2.35
95 - 105	0.68	1.62	0.53	0.06	0.00	0.00	2.89
105 - 115	0.87	1.46	0.95	0.09	0.01	0.00	3.38
115 - 125	0.98	1.93	1.18	0.10	0.00	0.00	4.19
125 - 135	1.22	1.89	0.89	0.14	0.00	0.00	4.14
135 - 145	0.84	2.80	0.92	0.21	0.00	0.00	4.77
145 - 155	0.72	3.41	1.30	0.22	0.00	0.00	5.65
155 - 165	0.81	4.00	1.21	0.08	0.00	0.00	6.10
165 - 175	0.64	3.63	1.94	0.35	0.03	0.01	6.61
175 - 185	0.65	1.79	1.58	0.43	0.06	0.00	4.51
185 - 195	0.41	1.35	1.48	0.26	0.02	0.00	3.53
195 - 205	0.30	1.35	2.21	0.65	0.06	0.00	4.57
205 - 215	0.45	0.97	1.74	0.81	0.08	0.00	4.04
215 - 225	0.40	0.74	1.07	0.54	0.05	0.00	2.80
225 - 235	0.32	0.72	1.39	0.97	0.10	0.03	3.54
235 - 245	0.17	1.02	2.31	1.05	0.13	0.00	4.67
245 - 255	0.11	0.95	1.16	0.38	0.21	0.01	2.82
255 - 265	0.08	0.50	0.65	0.25	0.13	0.05	1.66
265 - 275	0.09	0.50	0.54	0.22	0.21	0.07	1.62
275 - 285	0.08	0.49	0.33	0.34	0.22	0.39	1.85
285 - 295	0.11	0.32	0.26	0.19	0.31	0.32	1.52
295 - 305	0.15	0.38	0.26	0.19	0.34	0.41	1.74
305 - 315	0.08	0.27	0.17	0.26	0.30	0.42	1.51
315 - 325	0.16	0.23	0.13	0.35	0.17	0.39	1.43
325 - 335	0.29	0.29	0.16	0.15	0.08	0.49	1.45
335 - 345	0.09	0.21	0.07	0.11	0.02	0.09	0.59
345 - 355	0.16	0.27	0.30	0.14	0.08	0.11	1.06
Sub-Total	14.30	39.74	28.42	9.98	3.00	2.98	98.42
						Calms	1.55
						Missing/Incomplete	1.58
						Total	100.00

Table 4-2: Hourly Analysis of Wind Direction

Hour of Day	Hour Count (Total Dataset)	% of Total Dataset
0	51	0.59%
1	54	0.63%
2	63	0.73%
3	61	0.71%
4	65	0.75%
5	72	0.84%
6	73	0.85%
7	84	0.97%
8	101	1.17%
9	114	1.32%
10	126	1.46%
11	126	1.46%
12	105	1.22%
13	91	1.06%
14	69	0.80%
15	62	0.72%
16	56	0.65%
17	53	0.61%
18	47	0.55%
19	37	0.43%
20	38	0.44%
21	42	0.49%
22	47	0.55%
23	48	0.56%

Table 4-3: Monthly Analysis of Wind Direction

Month	Hour Count (Annual)	# Days per Month (Annual)
Jan	50	2.1
Feb	72	3.0
Mar	70	2.9
April	46	1.9
May	270	11.3
June	330	13.8
July	243	10.1
Aug	222	9.3
Sept	132	5.5
Oct	91	3.8
Nov	102	4.3
Dec	57	2.4

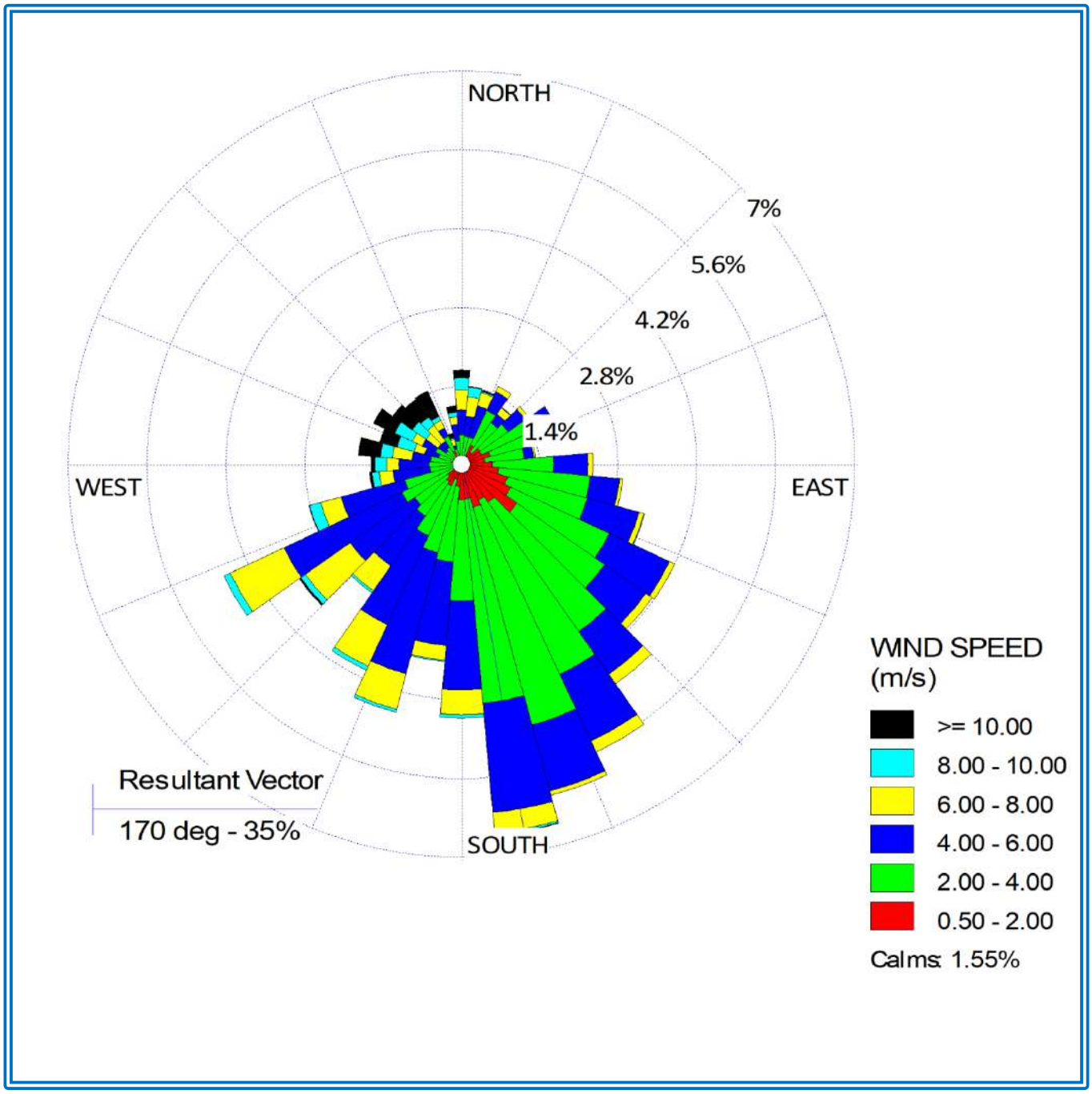


Figure 4-1: Windrose of Meteorological Dataset

The meteorological analysis shows that the frequency of problematic winds originating from the wind vector range 315^0 – 90^0 inclusive represents an averaged total of 71 days per year. These winds have prominence in the cooler, winter months.

Furthermore, the dominant wind vector originated from the south which pushes odours away from the Site.

5 Odour Field Assessment (OFA) Results

Ten (10) OFAs were undertaken using three (3) calibrated odour assessors.

For each assessment day EAQ observed the presence of odour at ground level (YES/NO), the estimated plume extent, odour frequency and intensity (strength).

The precise locations for each single measurement are illustrated in **Figure 5-1**.

The observed maximum frequency of odours (intensity) for each measurement point and on each assessment day is presented in the Odour Impact Maps of **Figures 5-2 to 5-12,** where;

- **Figure 5-8** investigates the findings in more detail for OFA # 6 where winds are from the north.

The maximum frequency of results has been presented to avoid duplication of results at each measurement point and therefore demonstrate a worst-case assessment for ground level odour impacts on each assessment day.

The full list of Observations at each measurement point, their odour intensities and frequencies and chronological time order of observations, and the Wind Direction Meteorological Trends during each single measurement are presented in Appendix B.

Within the odour impact maps are the wind characteristics (origin and velocity) during each OFA presented as wind roses.

The maps are illustrative and do not specifically represent the exact locations down to the nearest metre (+/- 20m), they do however show the relative position of observations and the wind vector within which observations are made, and:

- The pie charts on each odour impact map are enlarged to illustrate the frequency of observations more clearly. In doing this the more precise locations for each single measurement may appear to be further from the actual locations which are presented in **Figure 5-1;**
- White pie charts indicate no odour was detected;
- Pie charts with detection frequencies in varying colours depict the Intensity & Frequency of odour observations at that measurement point, for all discrete measurements taken at each measurement point, and in reference to the VDI 3940 (Part 3) scale;
- Pie charts on the 'edge' of each wind vector (blue hashed polygons) are the extent of odours observable laterally of those single measurement points, and/or where topographical constraints prevent further assessment of odours past that single measurement point; where:
    - At those lateral single measurement points the edge of the plume has been identified; and
- The light blue polygon represents the average wind direction for the duration of each OFA day.

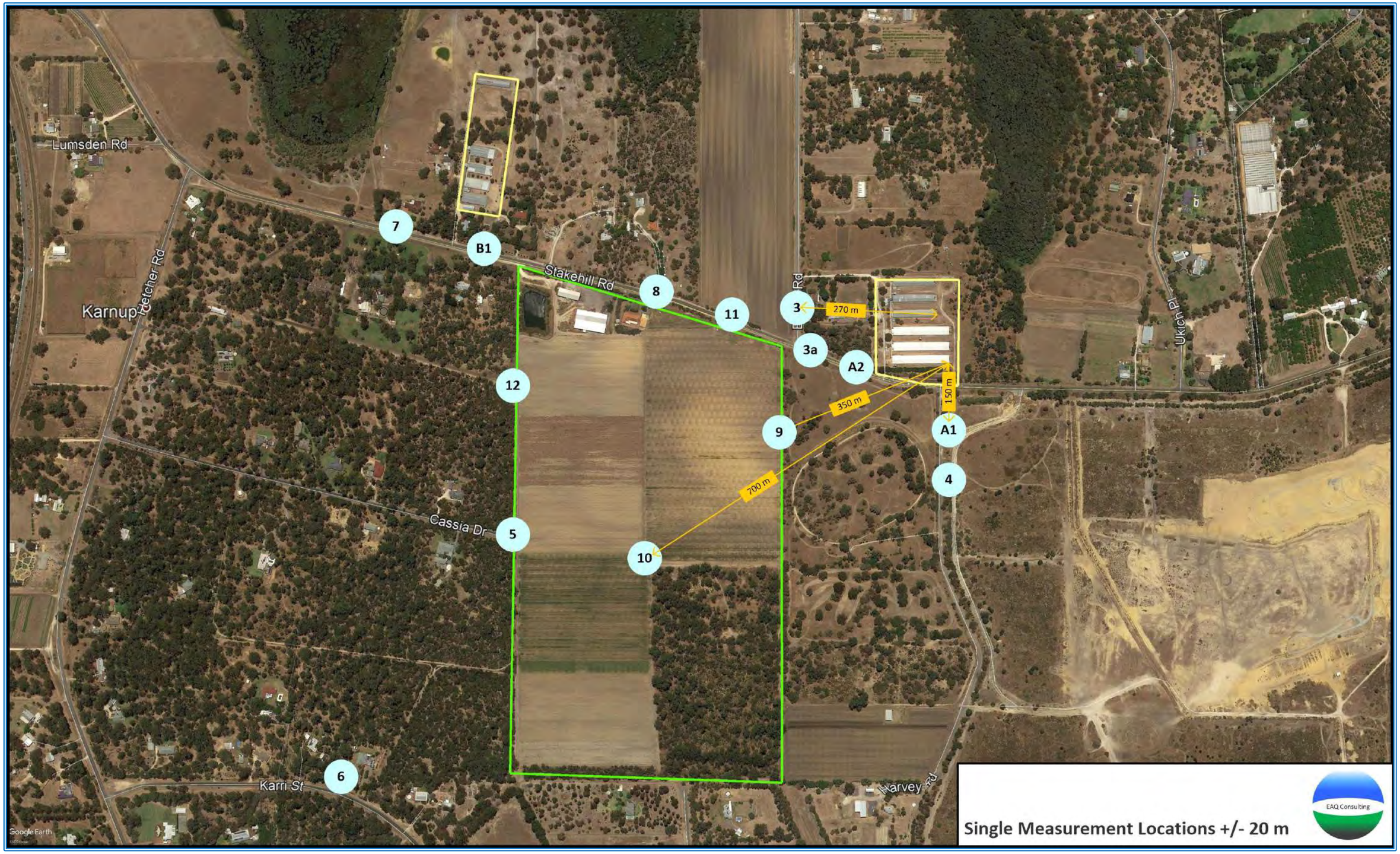


Figure 5-1: Single Measurement Locations

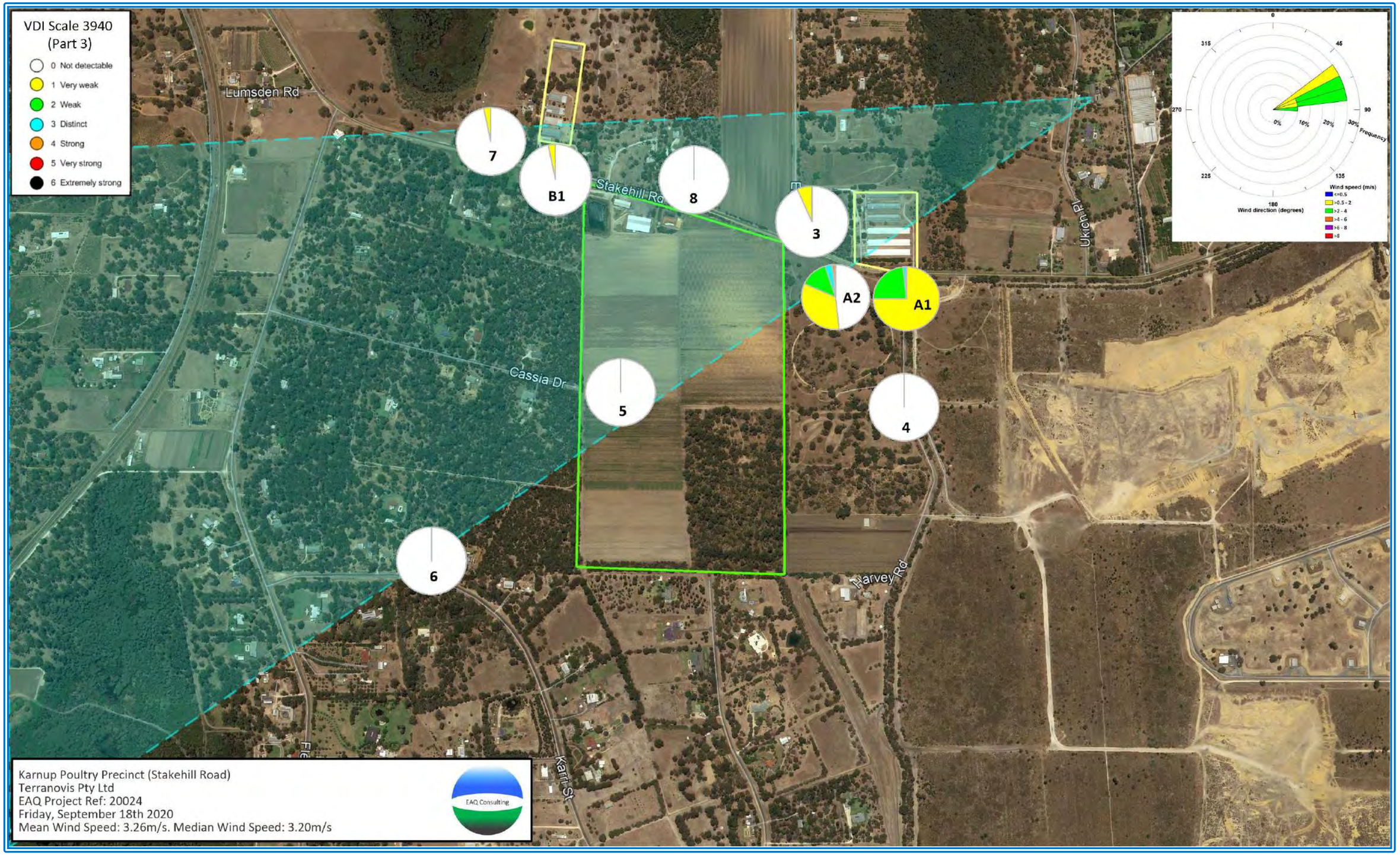


Figure 5-2: OFA #1 (18th September 2020)

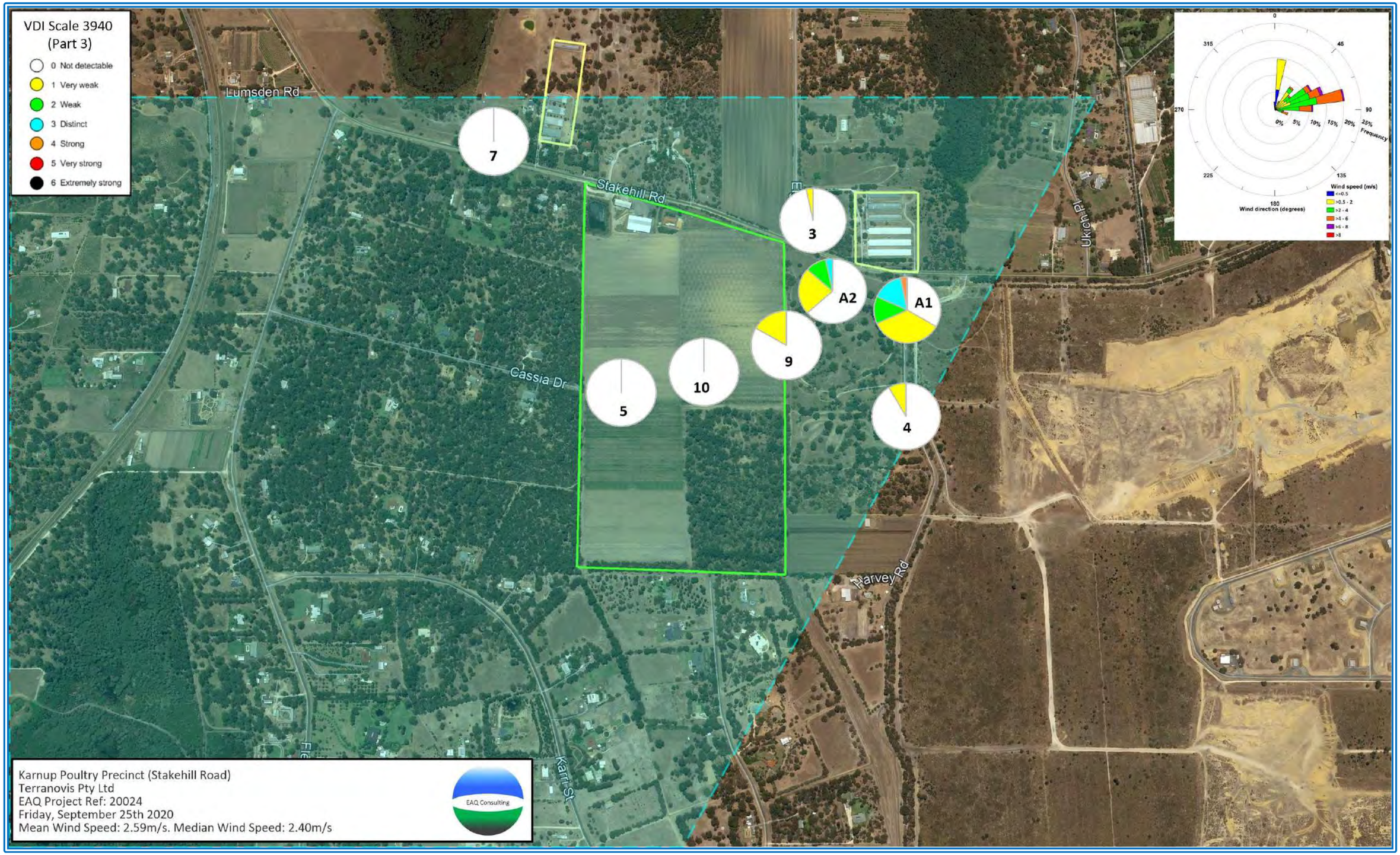


Figure 5-3: OFA #2 (25th September 2020)

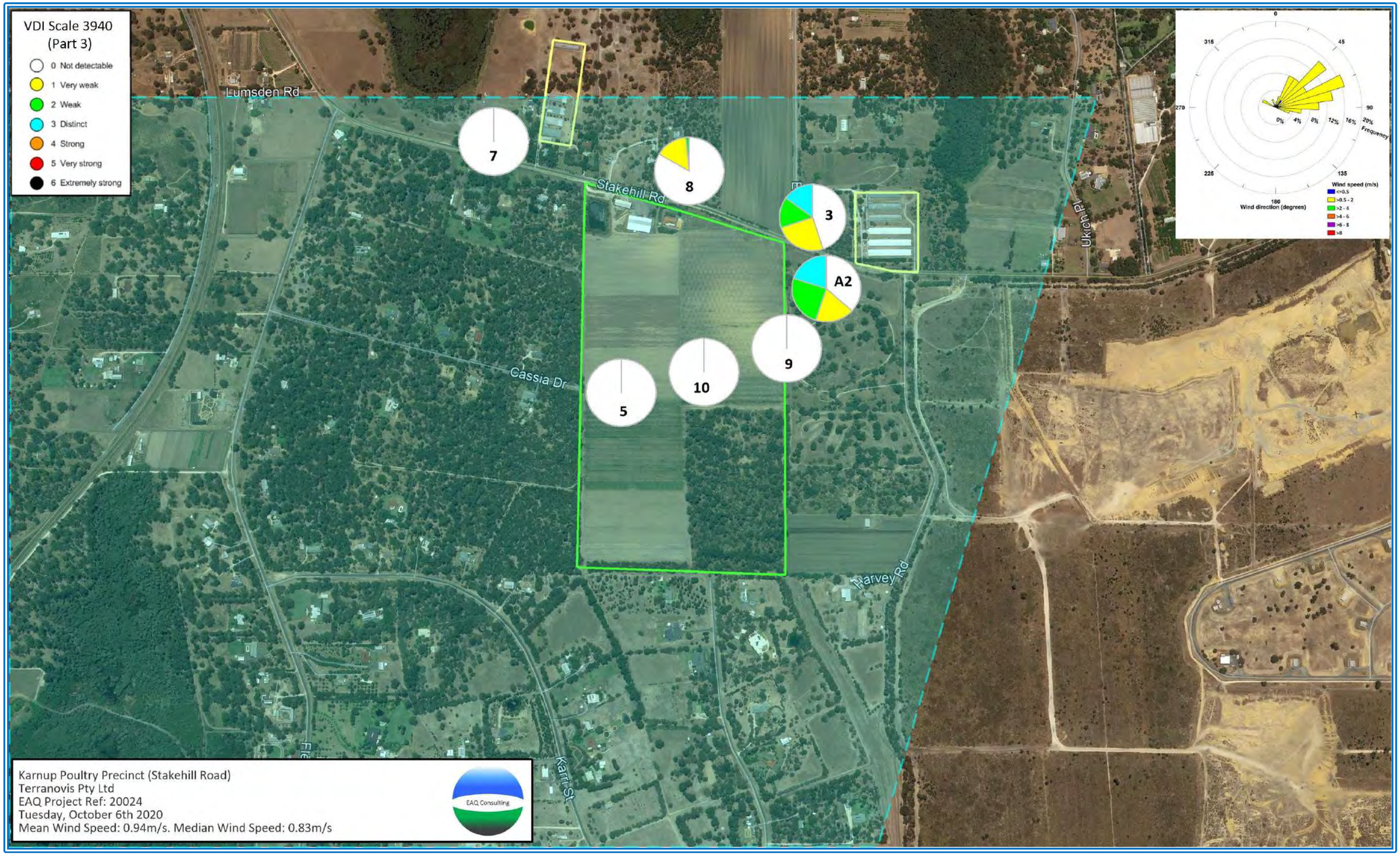


Figure 5-4: OFA #3 (6th October 2020)

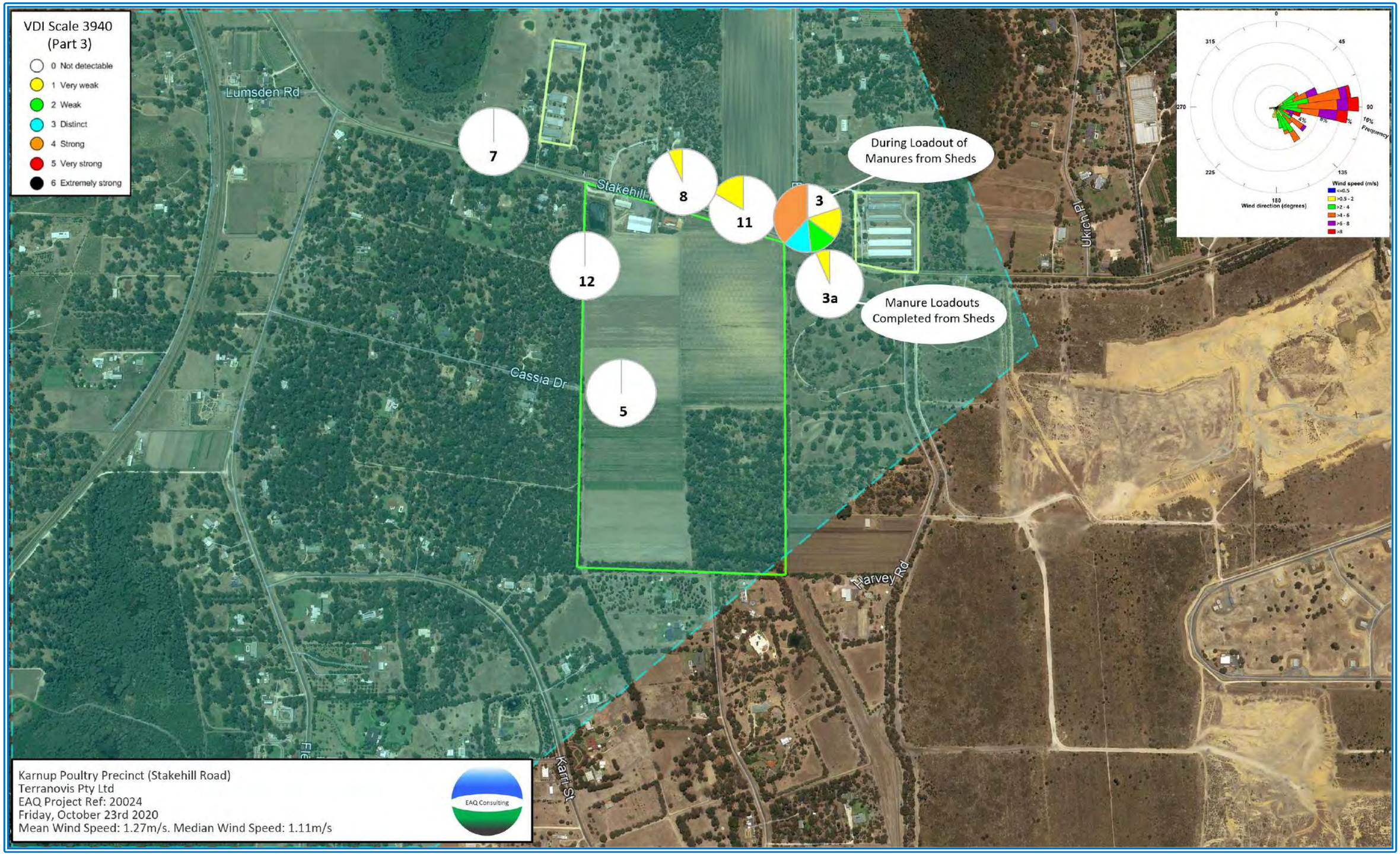


Figure 5-5: OFA #4 (23rd October 2020)

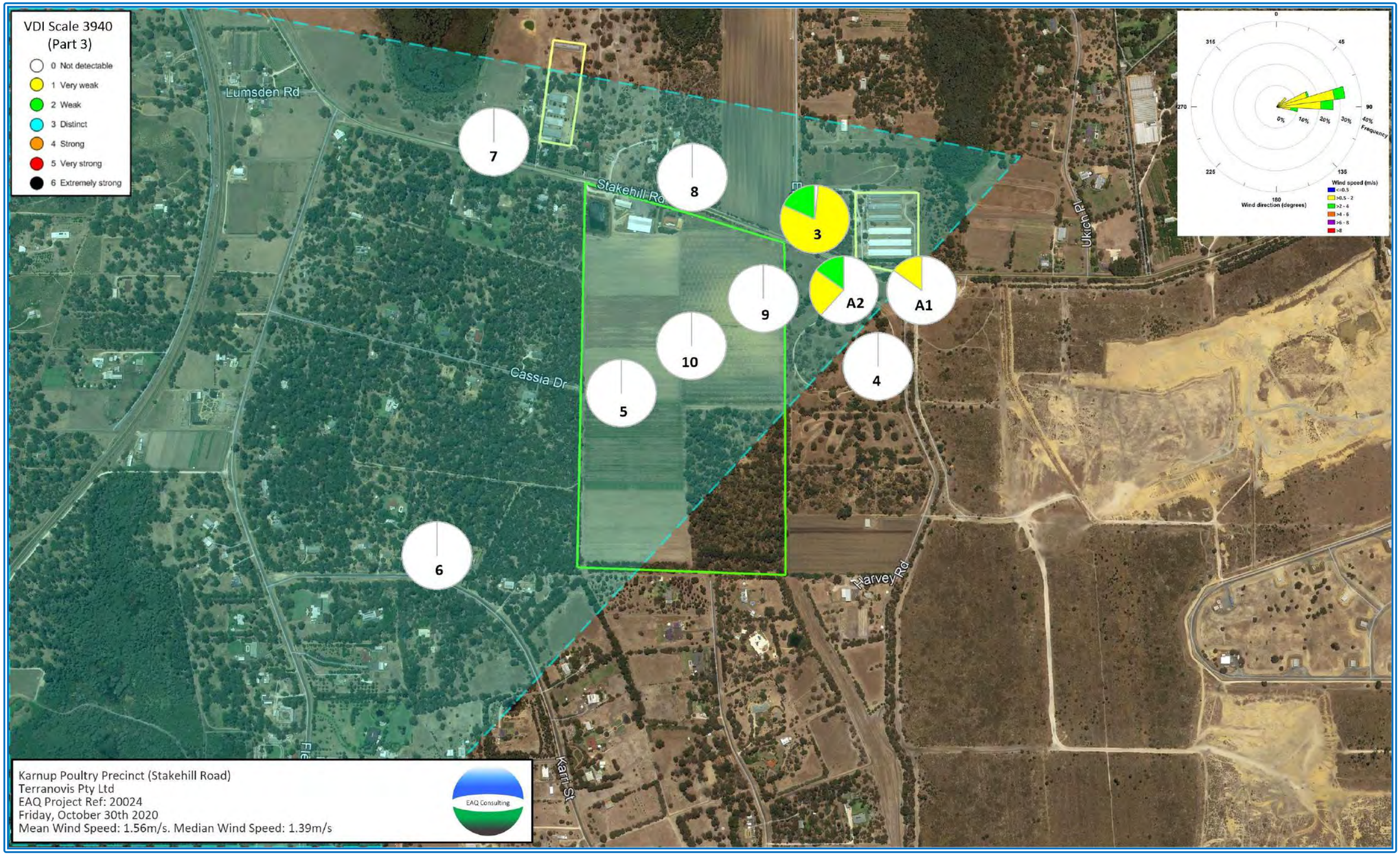


Figure 5-6: OFA #5 (30th October 2020)

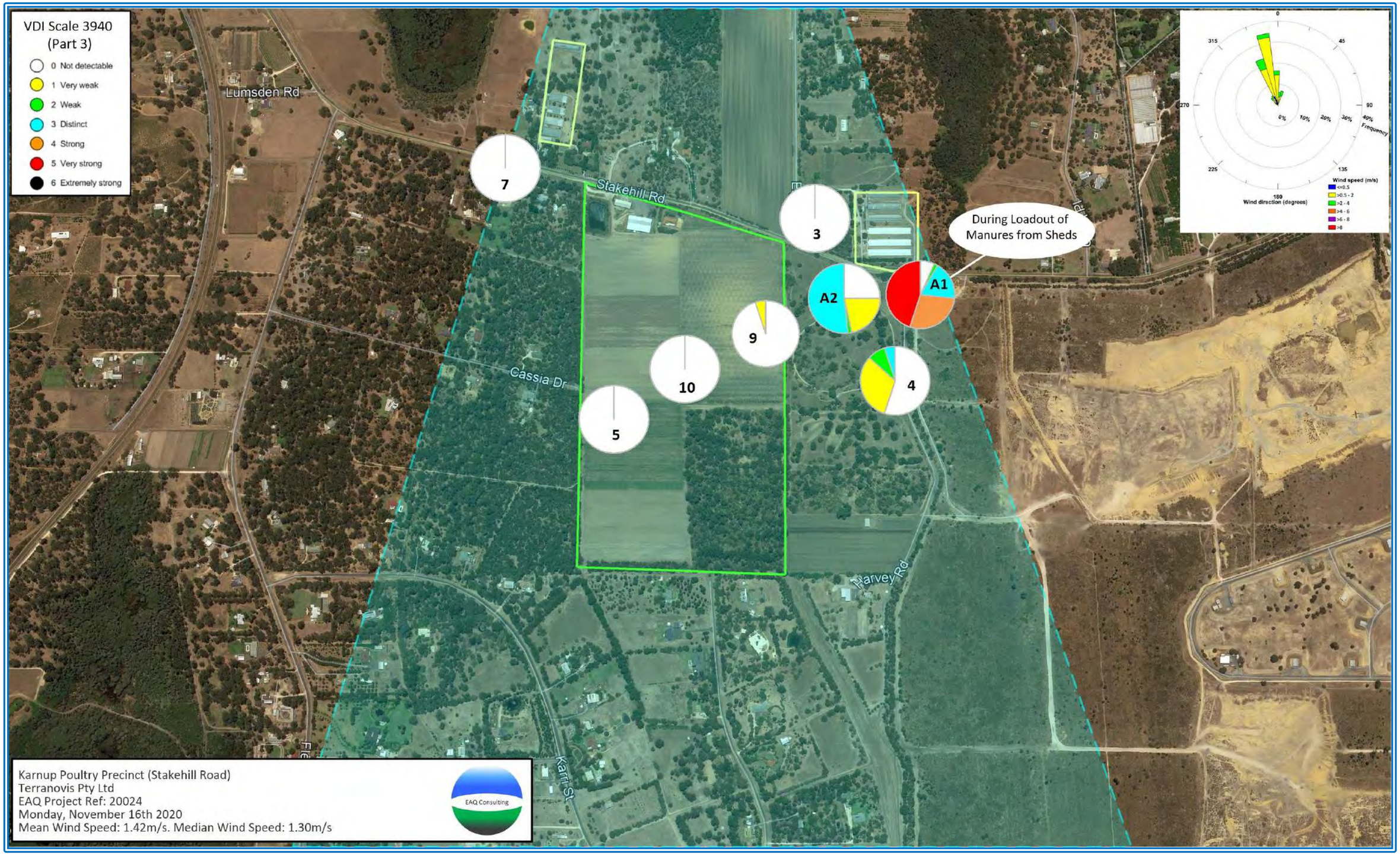


Figure 5-7: OFA #6 (16th November 2020)

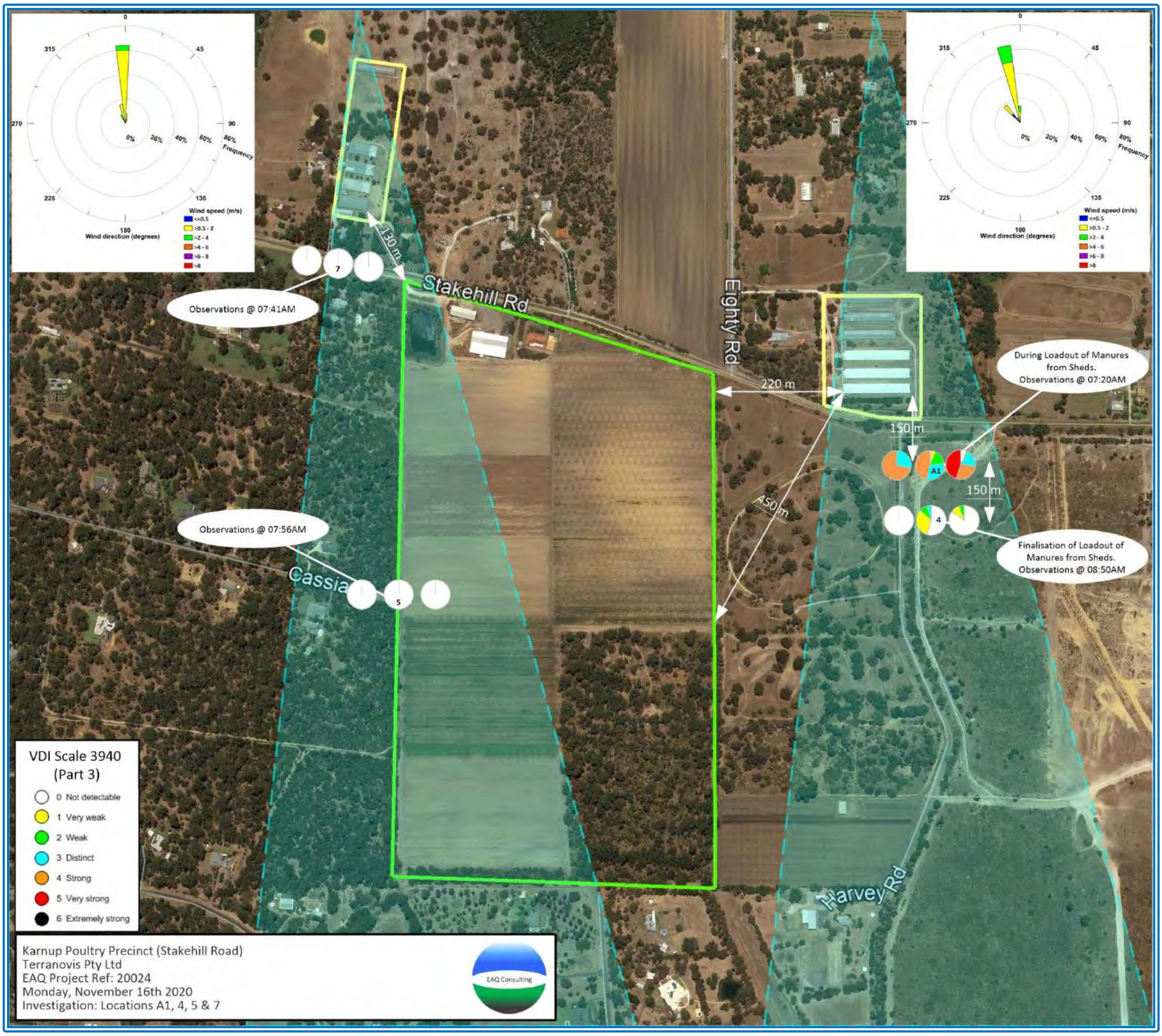


Figure 5-8: OFA #6 (16th November 2020) - <u>Investigation</u>

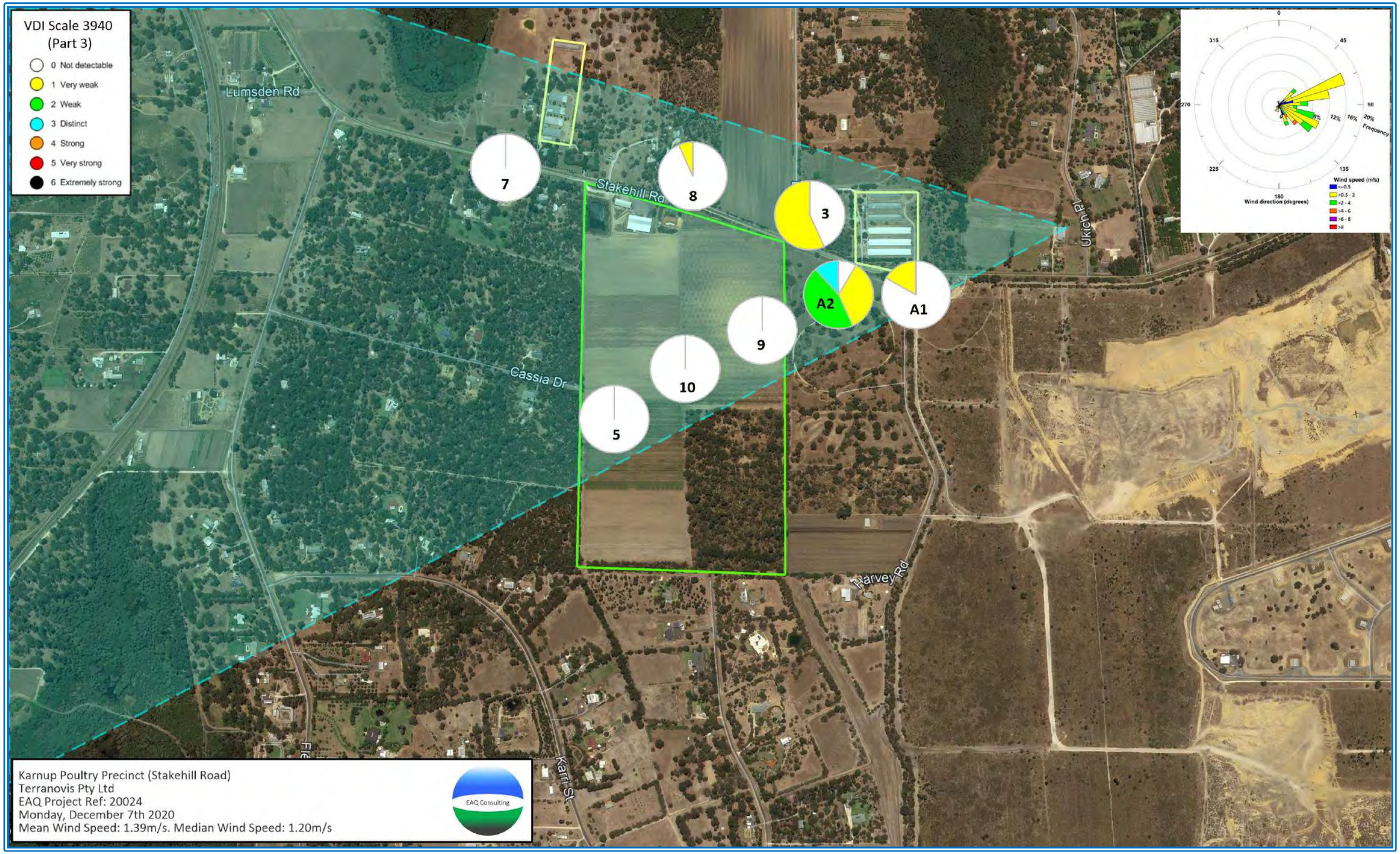


Figure 5-9: OFA #7 (7th December 2020)

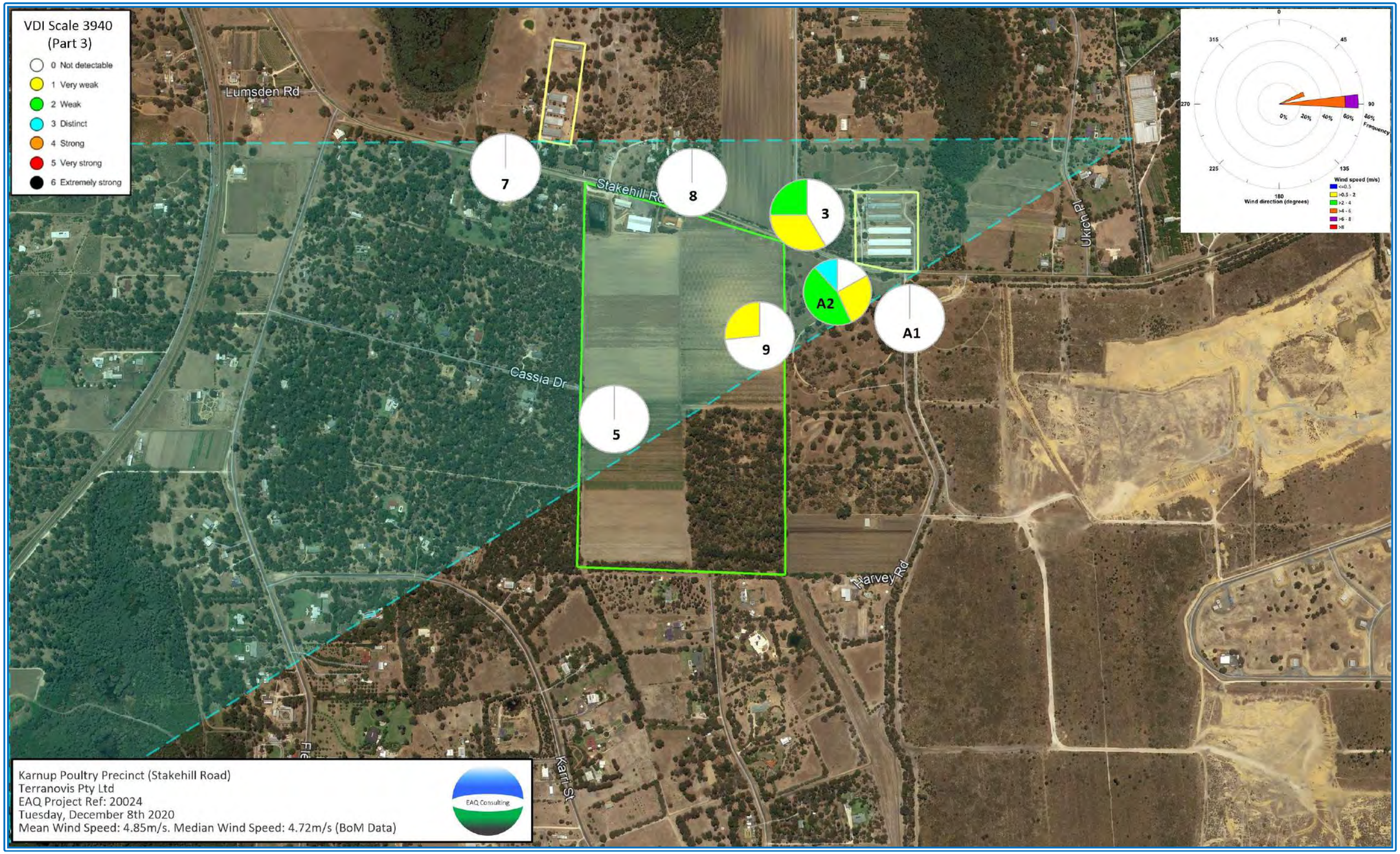


Figure 5-10: OFA #8 (8th December 2020)

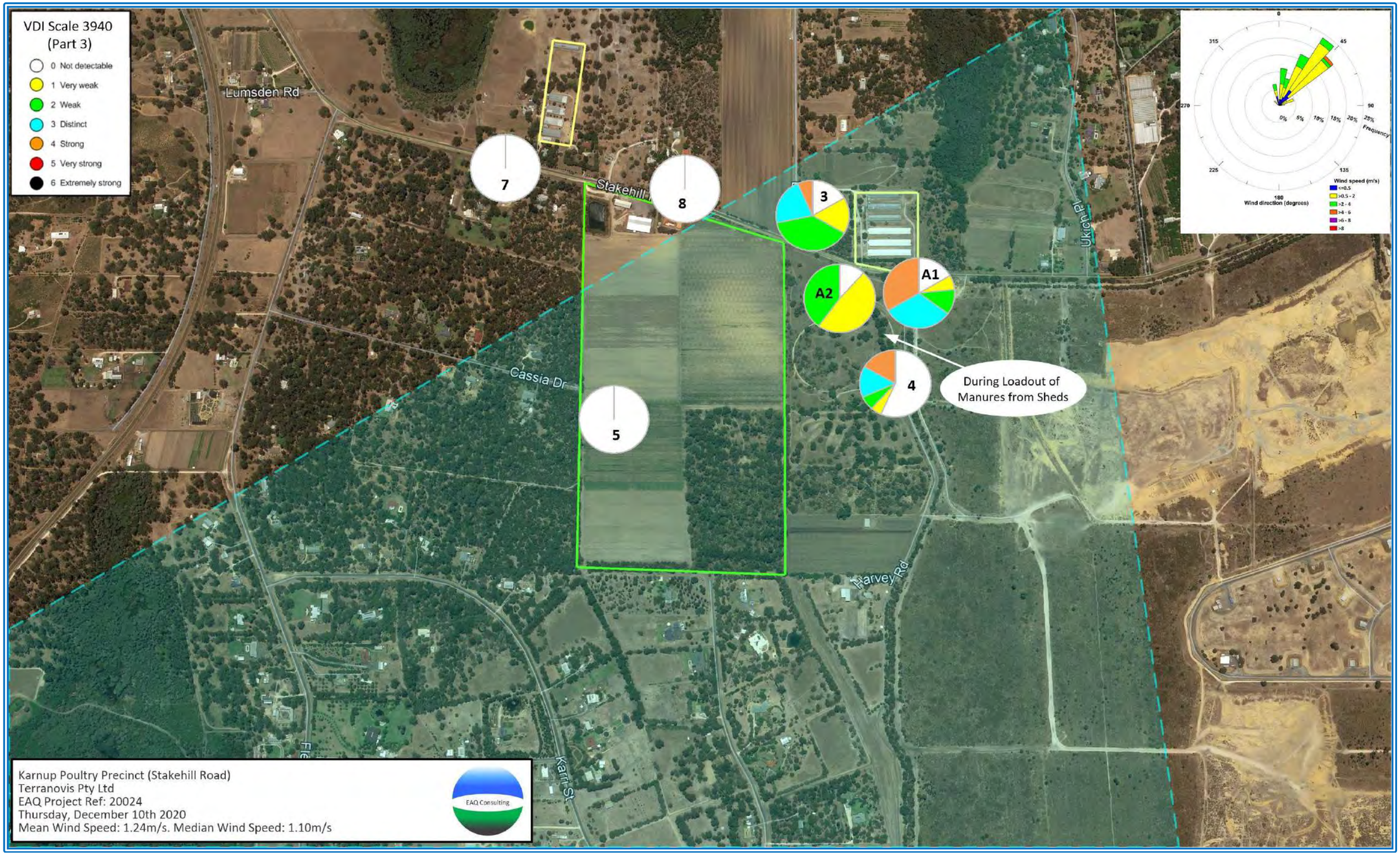


Figure 5-11: OFA #9 (10th December 2020)

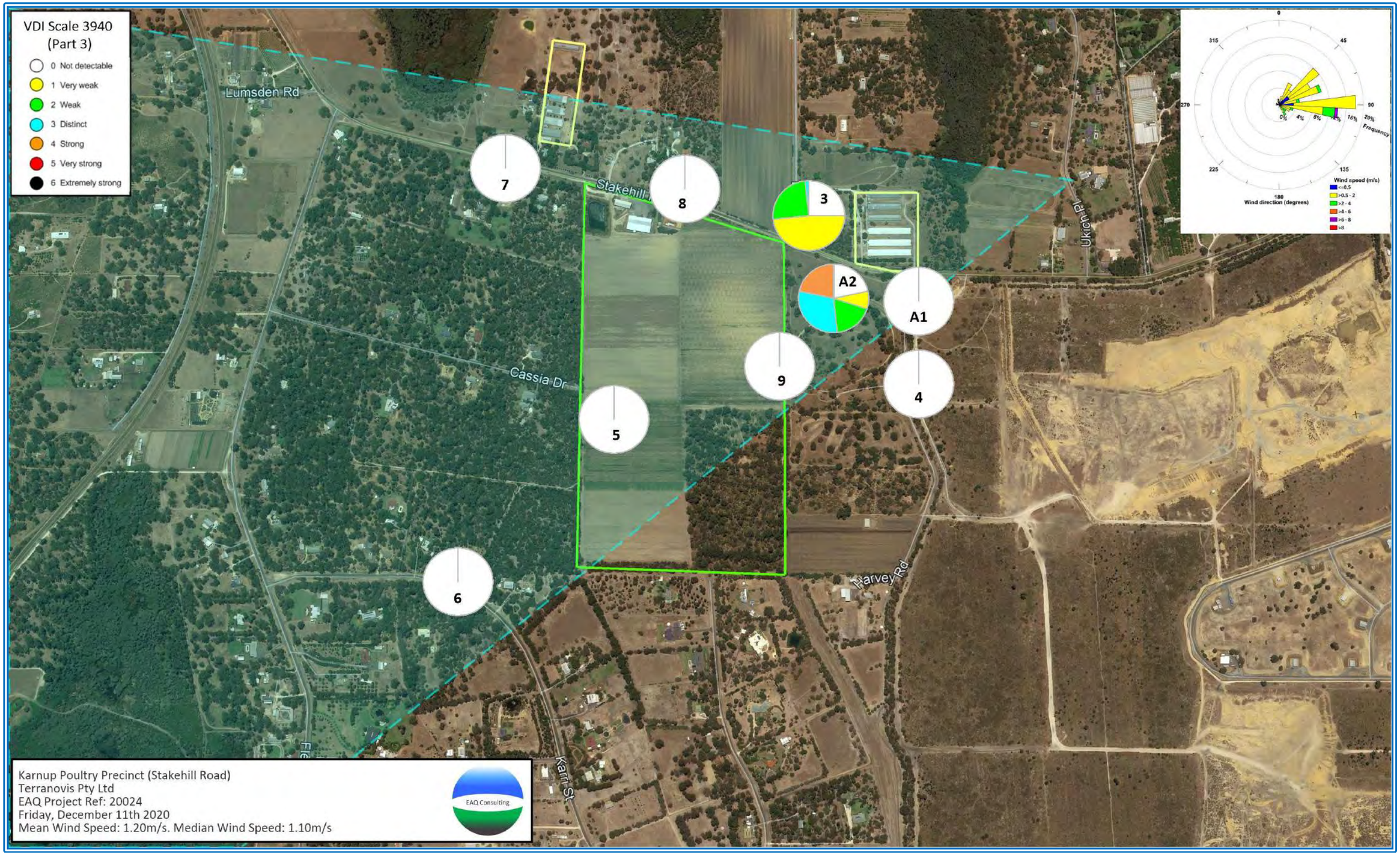


Figure 5-12: OFA #10 (11th December 2020)

6 Discussion of Findings

6.1 Odour Field Assessments

It was found from EAQ's OFA investigations that odours from Farm A (north-east of the Site) are observable at the Sites' boundary up to approximately 350 m south-west from the Farm (single measurement location #9). Observations of odour at this measurement location were sufficiently low in frequency and intensity such that odour nuisance would be unlikely.

Odours within approximately 350 m from the Farms' closest odour source (eastern side of sheds) were notable at times, where;

- there are notably stronger odours when the Farm sheds are being cleared out of wastes; and
- of the ten (10) OFAs undertaken, and based on visual observations, the sheds and activities within Farm A (north-east of the Site) were as per normal for daily observations except when the sheds were being cleaned of wastes **(refer Figures 5-5, 5-7 and 5-11).**

Farm A has tunnel ventilated sheds which eject the extracted odours in a horizontal and easterly direction. The horizontal momentum of these exhausts fans is not trivial. The exhausted airflow moves easterly and is pushed in a south-westerly direction by opposing prevailing winds. The shift in easterly exhaust flows, due to opposing prevailing winds, promotes mechanical friction (mixing) and subsequent dispersion. The affected airstream then moves in a west/south-westerly direction (under an easterly prevailing wind) and "collides" with the Farms' sheds again causing mechanical friction and subsequent dispersion. It is these airflow characteristics that appear to break-up the odour plumes as they move toward the Site.

It was apparent during the OFA program that odours rarely, if at all, were observable within the Site. Those observations of low frequency and intensity odours at location #9 are sufficiently low that during mobilisation from the eastern boundary of the Site, specifically the boundary of Lot 877, toward measurement location #10; assessors did not discern odours from Farm A.

Notwithstanding, it is possible that on occasion and under the worst case conditions that odours may traverse into the Lot 877, albeit at low odour frequency and intensity.

1) **Recommendation # 1:** A portion of the eastern boundary of Lot 877 comprising of a line of 2-3 x tress and interspersed medium height shrubs should be established to provide a dispersion barrier (tree buffer). This barrier would consist of tall trees at the boundary, interspersed with shorter trees/shrubs to increase canopy, followed by another 1-2 lines of trees facing into the Lot 877. Details of the flora architecture can be finalised within the development concept plans.

The Development Concept Plan for Lots 877 and 878 already delineates a potential extension of Nairn Drive which will traverse the eastern boundary of Lot 877 (refer Appendix C). The "tree buffer" would be in addition to this regional road.

The Site is already cleared and free from natural vegetation and bush structures and therefore any future development would not be exposed to increased odours due to clearing within the development.

Farm B, north-west of the Site, posed no issues for observable and/or problematic odours within proximity to the Site. Moreover, any observations of odours from Farm B, when extrapolated, are highly unlikely to affect the Site into the future.

Based on the findings of the OFA program EAQ would support the redevelopment of the Site given that, in EAQ's opinion based on the findings herein, the risk for future odour impacts within the Site is Moderate, where;

- The Consequence to the Environment is Moderate;
  - On-site impacts: mid level,
  - Off-site impacts local scale: low level,
  - Off-site impacts wider scale: minimal,
  - Local scale impacts: mid level impact to amenity,
- The Likelihood of the Risk Event occurring;
  - Unlikely - the risk event will probably not occur in most circumstances.

6.2 Meteorological Analysis

In consideration of the percentage annually where problematic winds occur, the analysis in Section 4 showed that these problematic winds occur 19.2% annually, where 19.2% accounts for all winds that could cause odour nuisance from Farm A, and Farm B ($315^0 – 90^0$ / NNW - E).

It was found that Farm B poses no threat of odour nuisance; subsequently the more problematic winds that would push odours from Farm B onto the Site would originate from the vector of $22.5^0 – 90^0$ (NNE – E).

Under this revised wind vector, the percentage of time annually that winds would prevail that may cause an odour nuisance from Farm A is **10.6%** (927 hours annually).

This 10.6%, and in consideration of the odour observations for frequency and intensity, further supports the risk assessment of a maximum risk of Moderate. In EAQ's opinion based on the findings herein, under normal conditions (i.e. outside of shed cleaning activities) the risk is further reduced.

2) **Recommendation # 2:** Memorial on Land Titles informing owners within Lot 877 of possible odour nuisance during shed cleanout events.

6.3 Conclusion

The findings of the OFA program downwind of the two poultry Farms along Stakehill Road, Karnup has shown that there is observable malodour near to Farm A, in particular during shed cleaning of wastes. This was expected.

The extent of observable odours in the direction of the Site was approximately 350 m or less from the nearest shed odour source at Farm A, which is the eastern end of the sheds where the extraction fans eject to atmosphere.

The incidence of observable odours in proximity to the Farm (Farm A) is normal and expected. Three (3) of the ten (10) individual OFA days' recorded malodours from Farm A during shed cleanout activities, which is considered to be worst-case.

Based on the findings of the daily OFAs, and in consideration of the meteorological analysis:

- EAQ would support the re-zoning of the Site to accommodate future development;
- EAQ does not foresee a risk of odour nuisance within Lot 878;
- EAQ considers that the eastern boundary of Lot 877 may experience odours from time-to-time and in particular during shed cleanout events, where;
    - A "tree buffer" is recommended along the eastern boundary of Lot 877 to a thickness of approximately 2-3 x lines of trees interspersed with medium height shrubs to create a high porosity barrier that will effect mechanical dispersion of an odour plume that traverses the tree buffer; and
    - Memorial on Titles for those lots closest to the eastern boundary of Lot 877 is recommended to inform occupants of the possibility of an odour nuisance during shed cleanout events.
- The design of the development should be cognisant of the potential for occasional odour observations along the eastern boundary of the Lot 877 during exceptional events, such as cleaning out of shed wastes, and consider the appropriate land uses along this boundary where practicable.

Appendix A: Deriving Representative Meteorological Year



Appendix B: Raw Observational Data & Meteorology Trends

Appendix C: Development Concept Plan September 2020

Meteorological Parameters

- When undertaking dispersion modelling for odour, the wind vector (speed and direction) is critical in determining the magnitude of the odour impacts downwind of an odour emission source(s), where;
  - This vector carries the largest weight in terms of a representative year for odour impacts.
- Temperature is also important within odour dispersion modelling for understanding vertical mixing layers, and inversion layers within the domain assessed by the dispersion model; and
- Rainfall has importance empirically when determining odour impacts at ground level;
  - Relative humidity is also a useful parameter within the dispersion modelling assessment when considering the density of the air within the vertical mixing layers.

Method

Five (5) years of the latest annual meteorological (met) data is sourced from the nearest, or multiple, Bureau of Meteorology (BoM) Automatic Weather Station (AWS).

The data is arranged into annual observations and the primary *vector* of wind is sorted into "bins" of wind speed and direction, for example:

2018		CHECK #	8760			
WD↓ WS→	0	2	4	6	>6	TOTAL
0	0	0	0	0	0	0
90	0	407	457	305	136	1305
180	0	822	1560	919	152	3453
270	0	278	848	1243	527	2896
360	0	124	273	222	487	1106
TOTAL	0	1631	3138	2689	1302	8760

The ***chi-squared*** test shows a statistical relationship between two categorical variables. The statistic is a single number that shows how much difference exists between observed counts and the counts expected if there were no relationship at all in the population.

- For determining the representative met year, each of the annual period five year counts, for grouped wind speed and direction, are compared to the averaged dataset of all five years of grouped wind speed and direction, where;
  - A **low value** for chi-square means there is a high correlation between two sets of data. In theory, if the observed and expected values were equal ("no difference") then chi-square would be zero — an event that is unlikely to happen in real life.

The ***Mann-Whitney U-Test*** is another statistical way of determining differences between values. A null hypothesis is tested where there are no significant differences between two values. In this case, the hourly values within one year compared to the long-term average over five years.

- Mann-Whitney U-Test can be used to determine the representative year based on the *scalar* of temperature.

Results

Comparing the annual periods of 2015 – 2019 inclusive for the Mandurah BoM AWS and deriving the representative year based on the ***vector of wind***, the representative year derived using the chi-squared relationship was 2018, followed by 2017, 2016, 2019 and 2015.

Table 1: chi-squared outcomes

Annual Period	chi-squared
2015	96.0
2016	52.4
2017	42.1
2018	39.7
2019	77.2

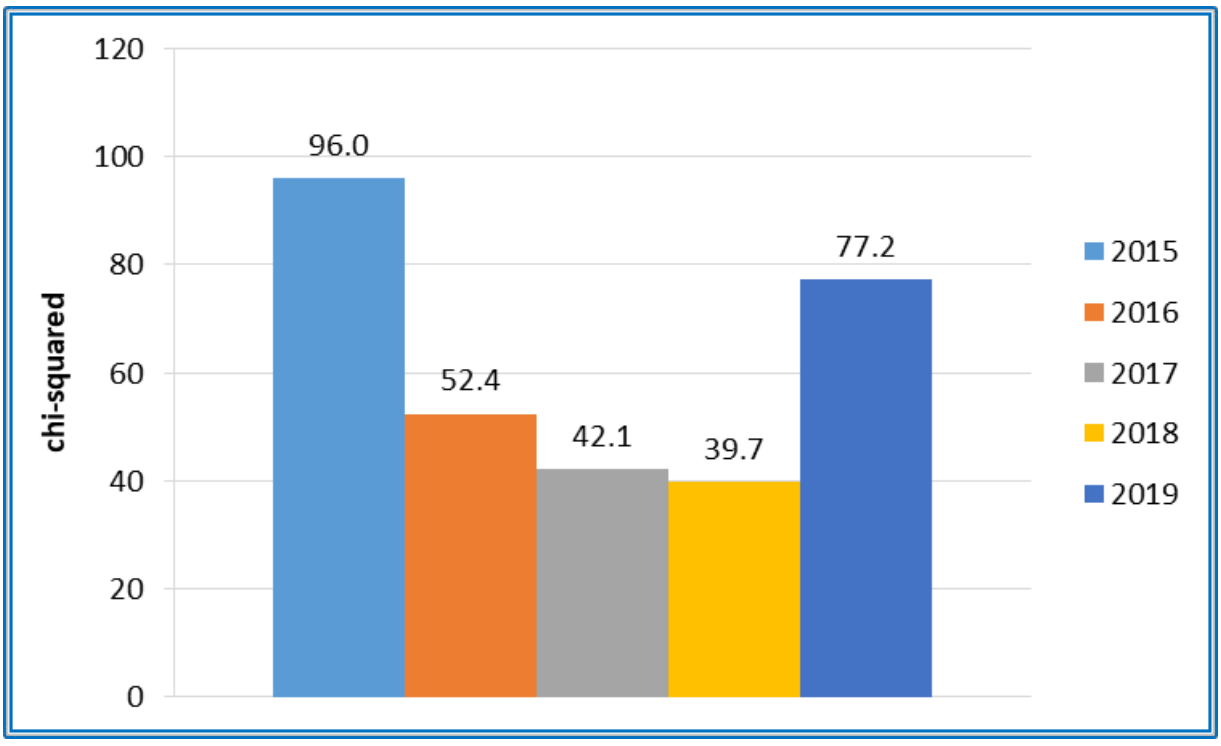


Figure 1: chi-squared outcomes

Comparing the annual periods of 2015 – 2019 inclusive for the Mandurah BoM AWS and deriving the representative year based on the ***scalar of temperature***, the representative year derived using the Mann-Whitney U-Test was 2017, 2015/2018, 2019 and 2016.

Table 2: Percentage of Temperature Observations within Degrees (^{0}C) Bins

^{0}C	2015	2016	2017	2018	2019	5-Year
0 - 5	0.02%	0.05%	0.00%	0.00%	0.00%	0.01%
5 - 10	3.32%	4.25%	1.96%	2.41%	2.47%	2.88%
10 - 15	17.82%	26.68%	21.02%	20.91%	20.79%	21.47%
15 - 20	39.23%	35.52%	41.61%	43.04%	39.13%	39.71%
20 - 25	27.29%	22.13%	24.70%	24.73%	25.44%	24.84%
25 - 30	9.35%	8.46%	8.56%	7.28%	9.30%	8.59%
30 - 35	2.77%	2.39%	2.02%	1.56%	2.67%	2.28%
>35	0.20%	0.53%	0.11%	0.07%	0.21%	0.22%
TOTAL	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

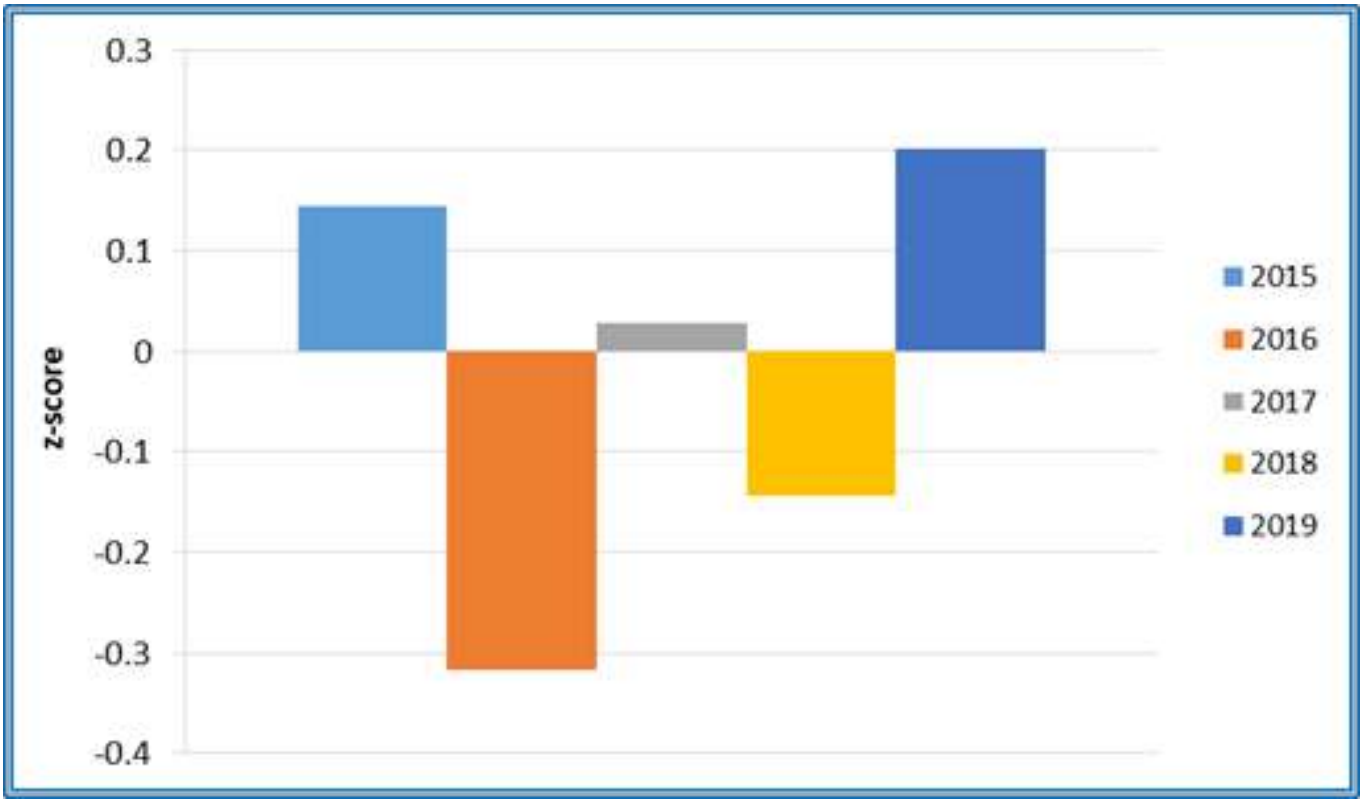
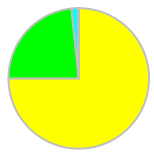
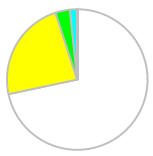
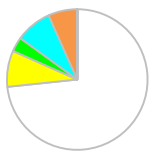
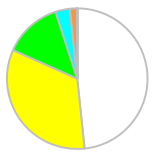
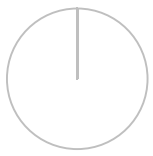


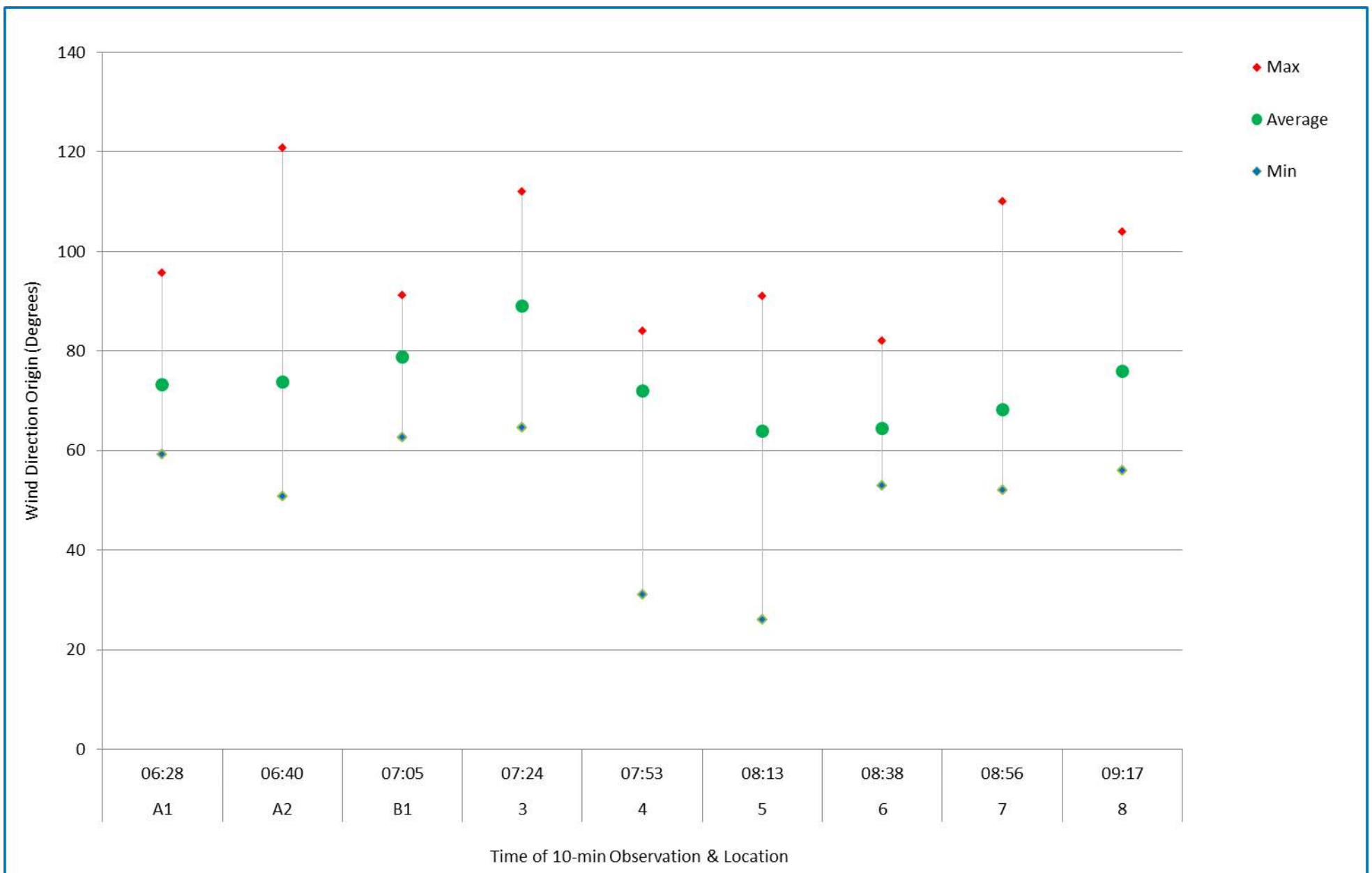
Figure 2: Mann-Whitney U-Test z-score outcomes

OFA # 1 Field Results – 18.09.2020

Survey Location	Time	Intensity Count							>1	Frequency
		0	1	2	3	4	5	6		
A1	06:28	0	45	14	1	0	0	0	100.0%	
	06:28	43	14	2	1	0	0	0	28.3%	
	06:28	60	0	0	0	0	0	0	0.0%	
A2	6:40	44	5	2	5	4	0	0	26.7%	
	6:40	29	20	8	2	1	0	0	51.7%	
	6:40	60	0	0	0	0	0	0	0.0%	
B1	7:05	58	2	0	0	0	0	0	3.3%	
	7:05	60	0	0	0	0	0	0	0.0%	
3	7:24	56	4	0	0	0	0	0	6.7%	
	7:25	58	2	0	0	0	0	0	3.3%	

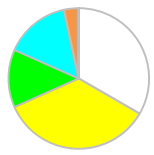
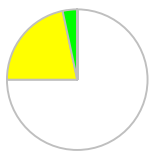
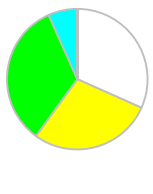
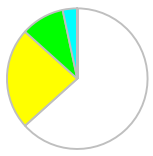
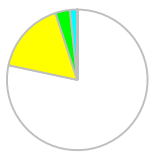
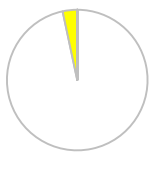
	7:25	60	0	0	0	0	0	0	0.0%	
4	7:53	60	0	0	0	0	0	0	0.0%	
	7:55	60	0	0	0	0	0	0	0.0%	
	7:52	60	0	0	0	0	0	0	0.0%	
	8:13	60	0	0	0	0	0	0	0.0%	
5	8:15	60	0	0	0	0	0	0	0.0%	
	8:13	60	0	0	0	0	0	0	0.0%	
	8:38	60	0	0	0	0	0	0	0.0%	
6	8:38	60	0	0	0	0	0	0	0.0%	
	8:37	60	0	0	0	0	0	0	0.0%	
	8:56	60	0	0	0	0	0	0	0.0%	
7	8:56	60	0	0	0	0	0	0	0.0%	
	8:56	58	2	0	0	0	0	0	3.3%	

	9:17	60	0	0	0	0	0	0	0.0%	
8	9:17	60	0	0	0	0	0	0	0.0%	
	9:16	60	0	0	0	0	0	0	0.0%	

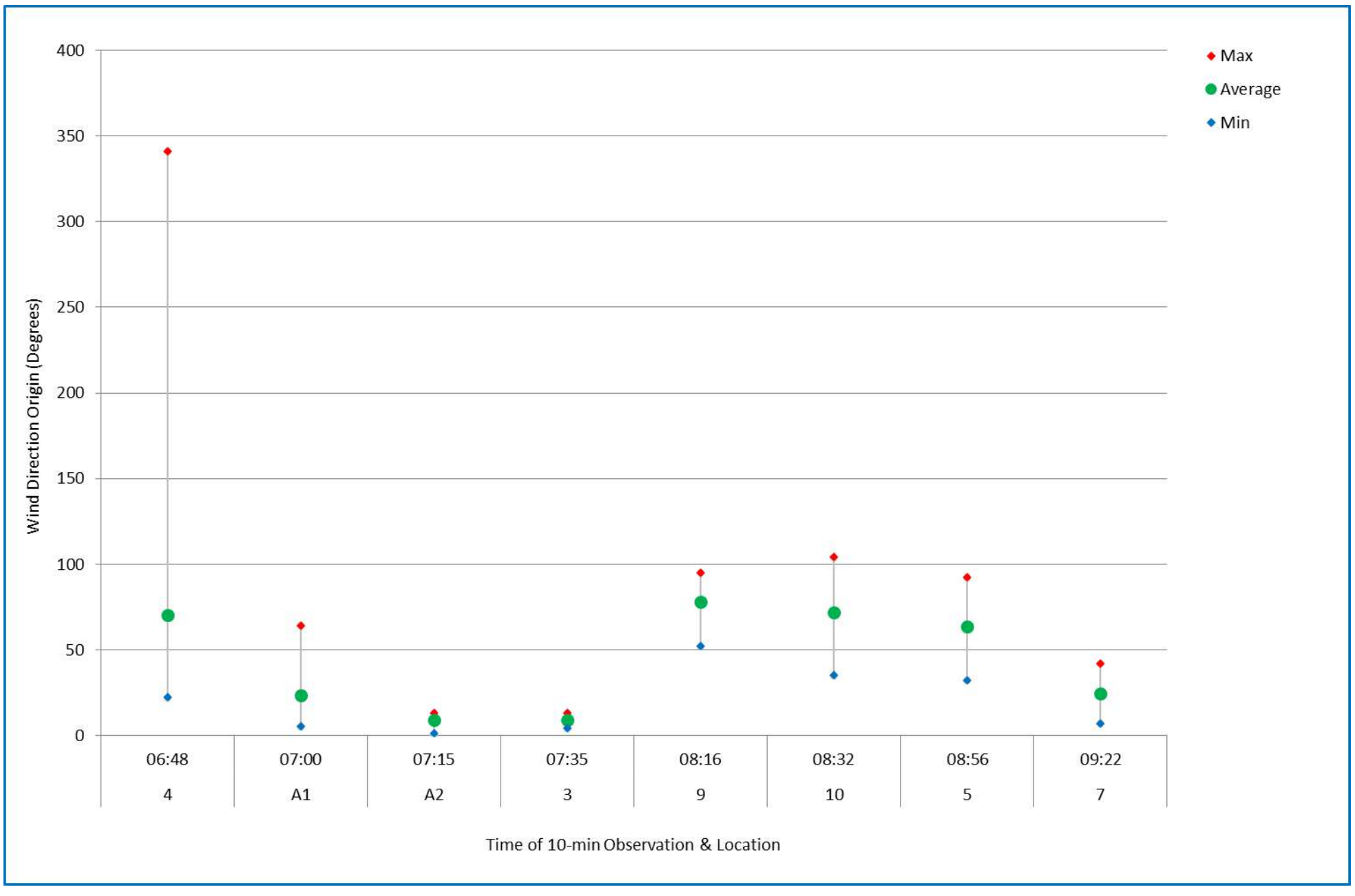


Meteorological Trends for Wind Direction (OFA #1 – 18.09.2020)

OFA #2 Field Results – 25.09.2020

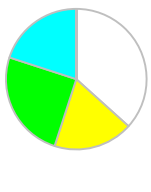
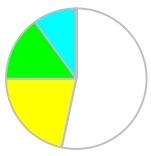
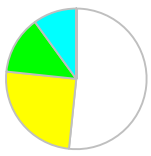
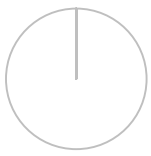
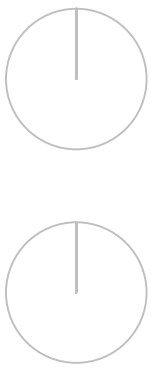
Survey Location	Time	Intensity Count							>1	Frequency
		0	1	2	3	4	5	6		
A1	07:00	20	21	8	9	2	0	0	66.7%	
	07:02	45	13	2	0	0	0	0	25.0%	
	07:00	19	17	20	4	0	0	0	68.3%	
A2	7:15	38	14	6	2	0	0	0	36.7%	
	7:15	47	10	2	1	0	0	0	21.7%	
	7:15	45	15	0	0	0	0	0	25.0%	
3	7:35	59	1	0	0	0	0	0	1.7%	
	7:37	58	2	0	0	0	0	0	3.3%	
4	7:34	60	0	0	0	0	0	0	0.0%	
	6:48	58	2	0	0	0	0	0	3.3%	
	6:49	55	5	0	0	0	0	0	8.3%	

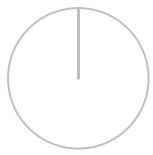
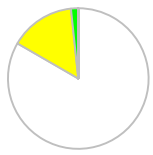
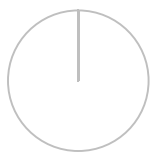
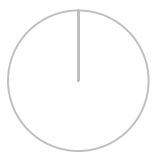
	6:47	59	1	0	0	0	0	0	1.7%	
5	8:56	60	0	0	0	0	0	0	0.0%	
	8:59	60	0	0	0	0	0	0	0.0%	
	8:56	60	0	0	0	0	0	0	0.0%	
	9:22	59	1	0	0	0	0	0	1.7%	
7	9:24	60	0	0	0	0	0	0	0.0%	
	9:23	60	0	0	0	0	0	0	0.0%	
	8:16	50	10	0	0	0	0	0	16.7%	
9	8:18	60	0	0	0	0	0	0	0.0%	
	8:16	60	0	0	0	0	0	0	0.0%	
10	8:32	60	0	0	0	0	0	0	0.0%	
	8:33	60	0	0	0	0	0	0	0.0%	
	8:32	60	0	0	0	0	0	0	0.0%	

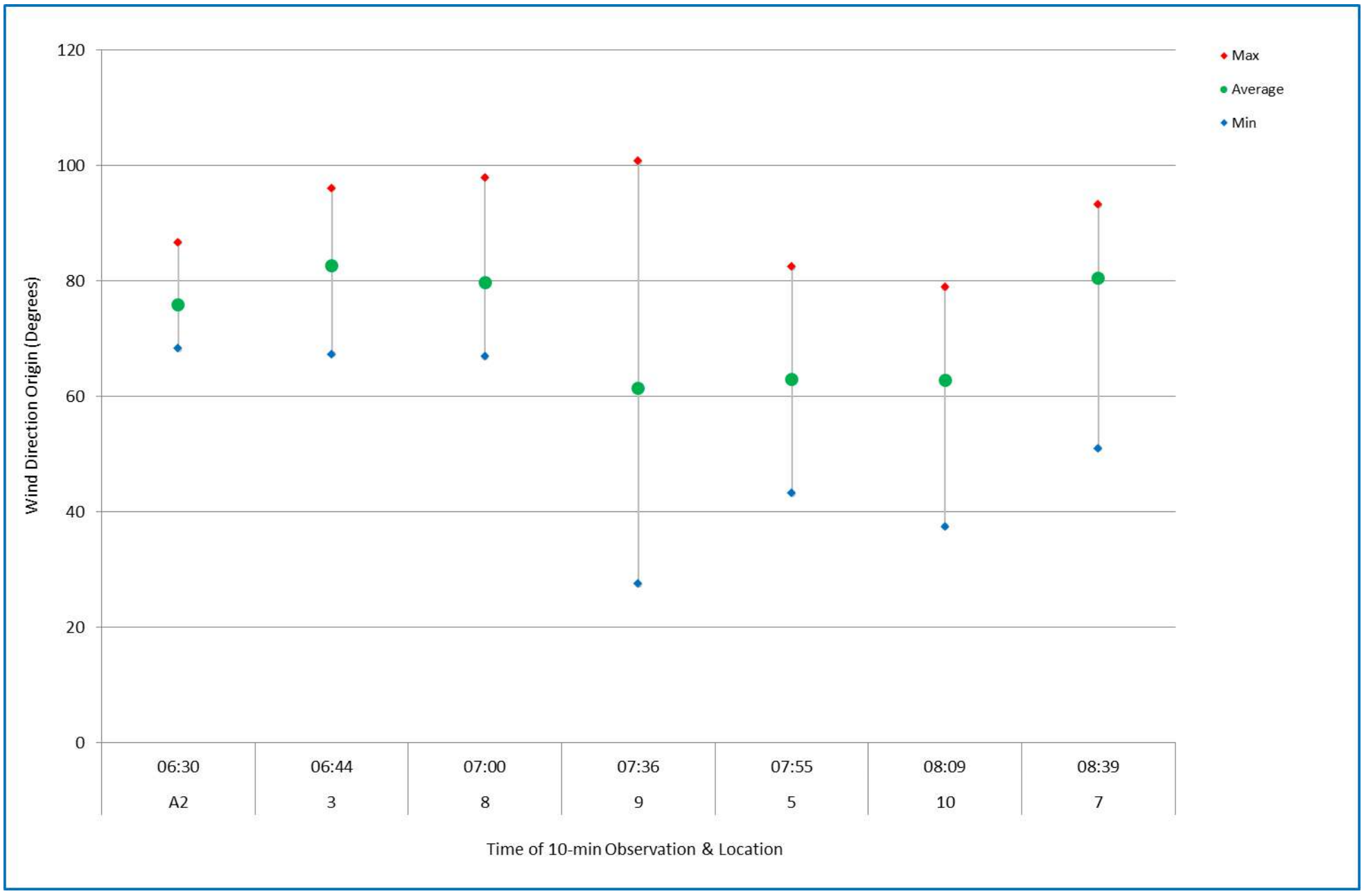


Meteorological Trends for Wind Direction (OFA #2 – 25.09.2020)

OFA #3 Field Results – 06.10.2020

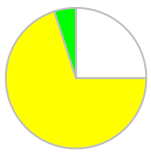
Survey Location	Time	Intensity Count							>1	Frequency
		0	1	2	3	4	5	6		
A2	6:30	18	18	16	8	0	0	0	70.0%	
	6:30	25	10	15	10	0	0	0	58.3%	
	6:30	22	11	15	12	0	0	0	63.3%	
3	6:44	32	13	9	6	0	0	0	46.7%	
	6:45	31	15	8	6	0	0	0	48.3%	
	6:44	27	15	9	9	0	0	0	55.0%	
5	7:55	60	0	0	0	0	0	0	0.0%	
	7:56	60	0	0	0	0	0	0	0.0%	
7	8:39	60	0	0	0	0	0	0	0.0%	
	8:39	60	0	0	0	0	0	0	0.0%	

	8:36	60	0	0	0	0	0	0	0.0%	
8	7:00	50	9	1	0	0	0	0	16.7%	
	7:00	51	9	0	0	0	0	0	15.0%	
	7:00	51	9	0	0	0	0	0	15.0%	
	7:36	60	0	0	0	0	0	0	0.0%	
9	7:36	60	0	0	0	0	0	0	0.0%	
	7:37	60	0	0	0	0	0	0	0.0%	
	8:09	60	0	0	0	0	0	0	0.0%	
10	8:09	60	0	0	0	0	0	0	0.0%	
	8:07	60	0	0	0	0	0	0	0.0%	

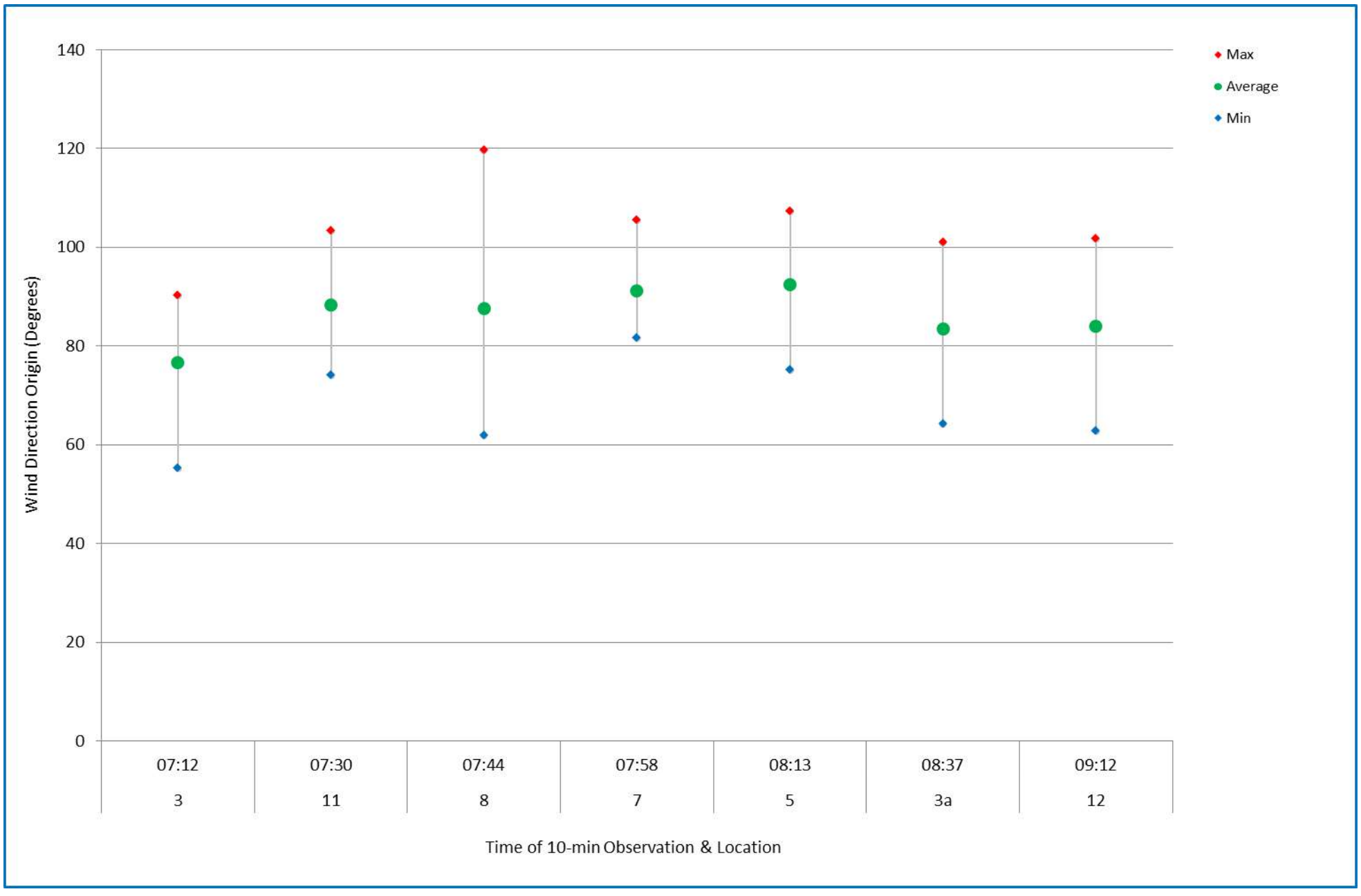


Meteorological Trends for Wind Direction (OFA #3 – 06.10.2020)

OFA #4 Field Results – 23.10.2020

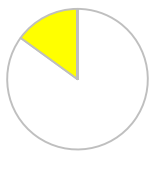
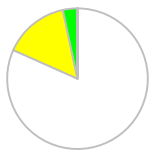
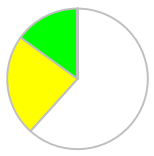
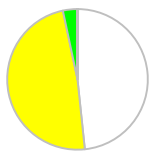
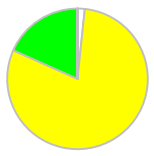
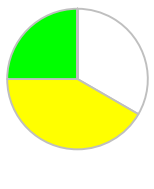
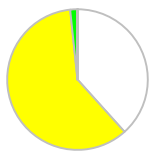
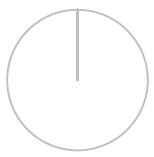
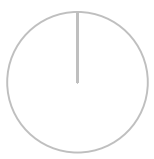
Survey Location	Time	Intensity Count							>1	Frequency
		0	1	2	3	4	5	6		
3	7:12	12	9	8	8	23	0	0	80.0%	
	7:12	16	8	13	17	6	0	0	73.3%	
	7:13	15	42	3	0	0	0	0	75.0%	
3a	8:37	56	4	0	0	0	0	0	6.7%	
	8:37	57	3	0	0	0	0	0	5.0%	
	8:37	60	0	0	0	0	0	0	0.0%	
5	8:13	60	0	0	0	0	0	0	0.0%	
	8:13	60	0	0	0	0	0	0	0.0%	
7	7:58	60	0	0	0	0	0	0	0.0%	
	7:58	60	0	0	0	0	0	0	0.0%	

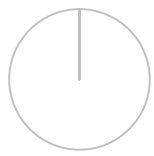
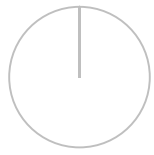
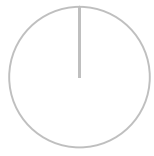
	7:58	59	1	0	0	0	0	0	1.7%	
8	7:44	57	3	0	0	0	0	0	5.0%	
	7:44	56	4	0	0	0	0	0	6.7%	
	7:45	59	1	0	0	0	0	0	1.7%	
11	7:30	58	2	0	0	0	0	0	3.3%	
	7:30	50	10	0	0	0	0	0	16.7%	
	7:30	50	10	0	0	0	0	0	16.7%	



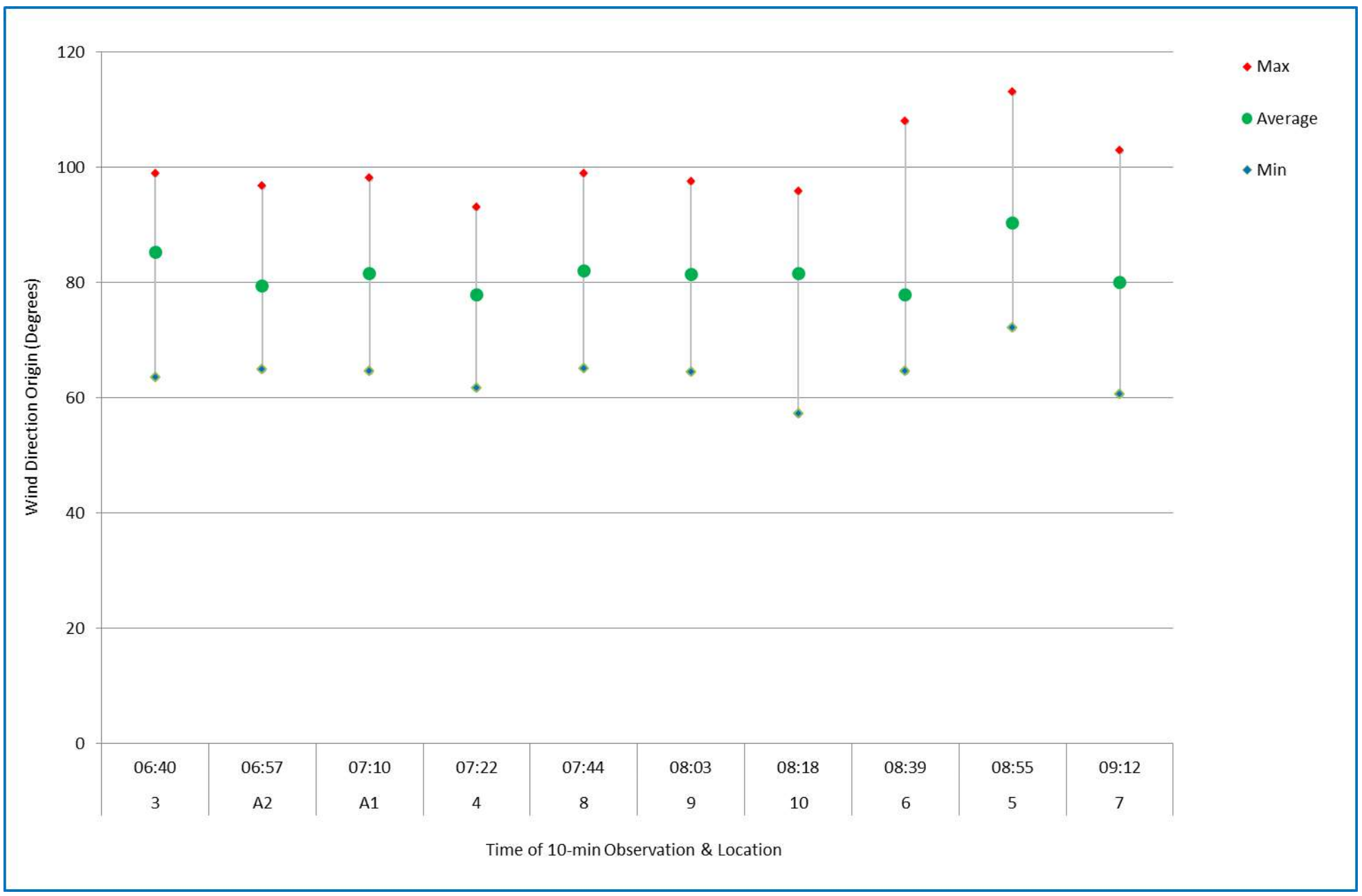
Meteorological Trends for Wind Direction (OFA #4 – 23.10.2020)

OFA #5 Field Results – 30.10.2020

Survey Location	Time	Intensity Count							>1	Frequency
		0	1	2	3	4	5	6		
A1	07:10	55	5	0	0	0	0	0	8.3%	
	07:10	56	4	0	0	0	0	0	6.7%	
	07:10	51	9	0	0	0	0	0	15.0%	
A2	6:57	49	9	2	0	0	0	0	18.3%	
	6:56	37	14	9	0	0	0	0	38.3%	
	6:57	29	29	2	0	0	0	0	51.7%	
3	6:40	1	48	11	0	0	0	0	98.3%	
	6:40	20	25	15	0	0	0	0	66.7%	
	6:41	23	36	1	0	0	0	0	61.7%	
4	7:22	60	0	0	0	0	0	0	0.0%	
	7:24	60	0	0	0	0	0	0	0.0%	

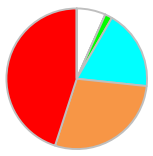
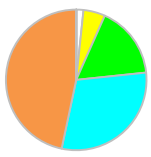
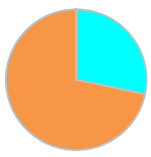
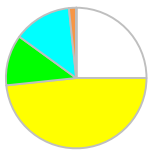
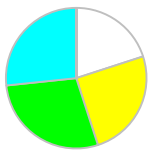
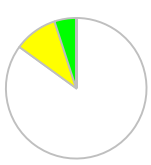
	7:31	60	0	0	0	0	0	0	0.0%	
5	8:55	60	0	0	0	0	0	0	0.0%	
	8:54	60	0	0	0	0	0	0	0.0%	
	8:55	60	0	0	0	0	0	0	0.0%	
	8:39	60	0	0	0	0	0	0	0.0%	
6	8:40	60	0	0	0	0	0	0	0.0%	
	8:40	60	0	0	0	0	0	0	0.0%	
	9:12	60	0	0	0	0	0	0	0.0%	
7	9:11	60	0	0	0	0	0	0	0.0%	
	9:11	60	0	0	0	0	0	0	0.0%	
	7:44	60	0	0	0	0	0	0	0.0%	
8	7:44	60	0	0	0	0	0	0	0.0%	
	7:44	60	0	0	0	0	0	0	0.0%	

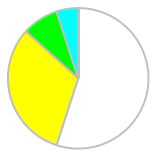
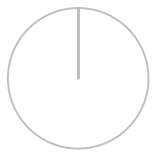
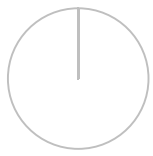
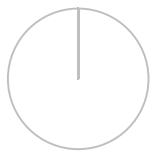
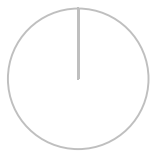
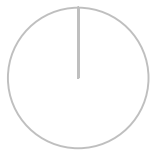
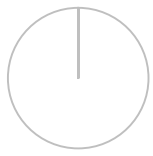
	8:03	60	0	0	0	0	0	0	0.0%	
9	8:02	60	0	0	0	0	0	0	0.0%	
	8:02	60	0	0	0	0	0	0	0.0%	
	8:18	60	0	0	0	0	0	0	0.0%	
10	8:18	60	0	0	0	0	0	0	0.0%	
	8:18	60	0	0	0	0	0	0	0.0%	

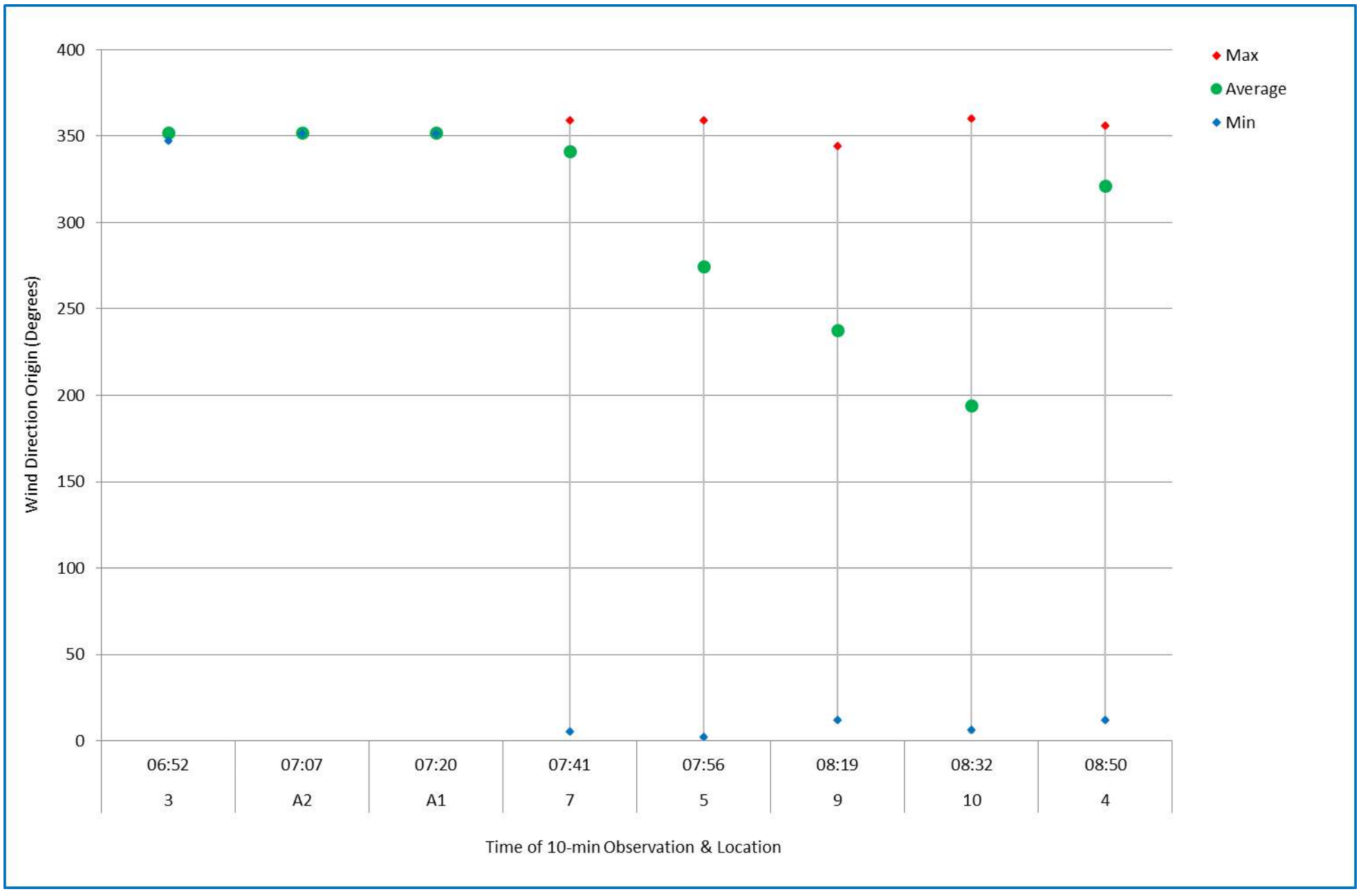


Meteorological Trends for Wind Direction (OFA #5 – 30.10.2020)

OFA #6 Field Results – 16.11.2020

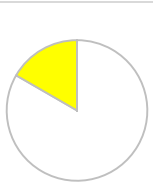
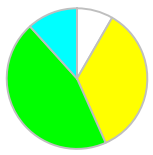
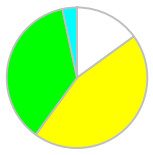
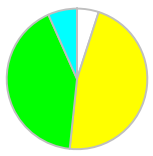
Survey Location	Time	Intensity Count							>1	Frequency
		0	1	2	3	4	5	6		
A1	07:20	4	0	1	11	17	27	0	93.3%	
	07:20	1	3	10	18	28	0	0	98.3%	
	07:20	0	0	0	17	43	0	0	100.0%	
A2	7:07	15	13	1	31	0	0	0	75.0%	
	7:07	15	29	7	8	1	0	0	75.0%	
	7:07	12	15	17	16	0	0	0	80.0%	
3	6:52	60	0	0	0	0	0	0	0.0%	
	6:52	60	0	0	0	0	0	0	0.0%	
4	8:50	60	0	0	0	0	0	0	0.0%	
	8:50	51	6	3	0	0	0	0	15.0%	

	8:50	33	19	5	3	0	0	0	45.0%	
5	7:56	60	0	0	0	0	0	0	0.0%	
	7:56	60	0	0	0	0	0	0	0.0%	
	7:56	60	0	0	0	0	0	0	0.0%	
7	7:41	60	0	0	0	0	0	0	0.0%	
	7:42	60	0	0	0	0	0	0	0.0%	
	7:42	60	0	0	0	0	0	0	0.0%	
9	8:19	57	3	0	0	0	0	0	5.0%	
	8:18	60	0	0	0	0	0	0	0.0%	
10	8:18	58	2	0	0	0	0	0	3.3%	
	8:32	60	0	0	0	0	0	0	0.0%	
	8:32	60	0	0	0	0	0	0	0.0%	
	8:32	60	0	0	0	0	0	0	0.0%	

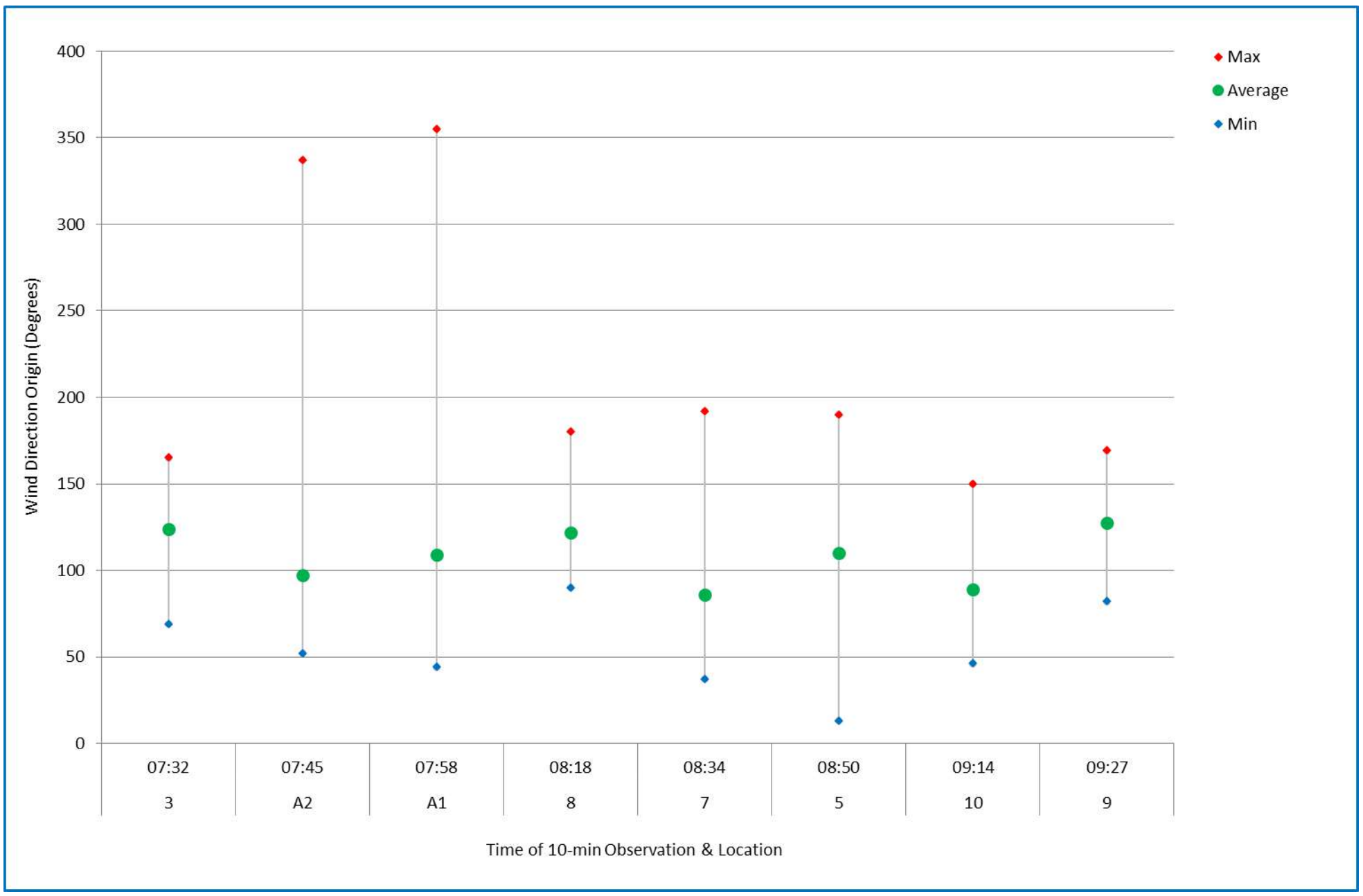


Meteorological Trends for Wind Direction (OFA #6 – 16.11.2020)

OFA #7 Field Results – 07.12.2020

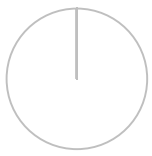
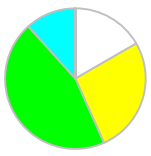
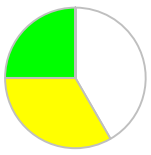
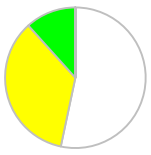
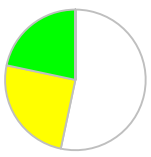
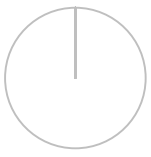
Survey Location	Time	Intensity Count							>1	Frequency
		0	1	2	3	4	5	6		
A1	07:58	56	4	0	0	0	0	0	6.7%	
	07:58	55	5	0	0	0	0	0	8.3%	
	07:58	50	10	0	0	0	0	0	16.7%	
A2	7:45	5	21	27	7	0	0	0	91.7%	
	7:45	9	27	22	2	0	0	0	85.0%	
	7:45	3	28	25	4	0	0	0	95.0%	
3	7:32	26	34	0	0	0	0	0	56.7%	
	7:32	28	32	0	0	0	0	0	53.3%	
	7:32	30	29	1	0	0	0	0	50.0%	
5	8:50	60	0	0	0	0	0	0	0.0%	
	8:49	60	0	0	0	0	0	0	0.0%	

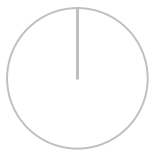
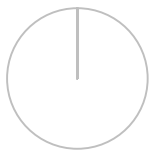
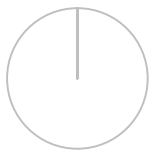
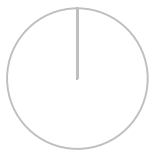
	8:50	60	0	0	0	0	0	0	0.0%	
7	8:34	60	0	0	0	0	0	0	0.0%	
	8:34	60	0	0	0	0	0	0	0.0%	
	8:34	60	0	0	0	0	0	0	0.0%	
	8:18	60	0	0	0	0	0	0	0.0%	
8	8:18	57	3	0	0	0	0	0	5.0%	
	8:18	56	4	0	0	0	0	0	6.7%	
	9:27	60	0	0	0	0	0	0	0.0%	
9	9:27	60	0	0	0	0	0	0	0.0%	
	9:27	60	0	0	0	0	0	0	0.0%	
	9:14	60	0	0	0	0	0	0	0.0%	
10	9:14	60	0	0	0	0	0	0	0.0%	
	9:14	60	0	0	0	0	0	0	0.0%	



Meteorological Trends for Wind Direction (OFA #7 – 07.12.2020)

OFA #8 Field Results – 08.12.2020

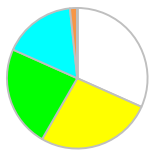
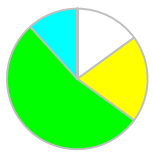
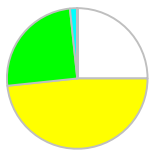
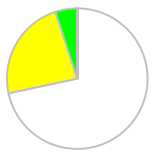
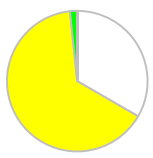
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	08:40	60	0	0	0	0	0	0	0.0%	
	08:40	60	0	0	0	0	0	0	0.0%	
A2	8:12	10	16	27	7	0	0	0	83.3%	
	8:26	15	12	23	10	0	0	0	75.0%	
3	6:23	25	20	15	0	0	0	0	58.3%	
	6:23	32	21	7	0	0	0	0	46.7%	
	6:23	32	15	13	0	0	0	0	46.7%	
5	8:12	60	0	0	0	0	0	0	0.0%	
	8:26	60	0	0	0	0	0	0	0.0%	
7	6:38	60	0	0	0	0	0	0	0.0%	

	6:51	60	0	0	0	0	0	0	0.0%	
	6:38	60	0	0	0	0	0	0	0.0%	
8	6:51	60	0	0	0	0	0	0	0.0%	
	6:38	60	0	0	0	0	0	0	0.0%	
	6:51	60	0	0	0	0	0	0	0.0%	
9	8:26	44	16	0	0	0	0	0	26.7%	
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	8:12	44	16	0	0	0	0	0	26.7%	

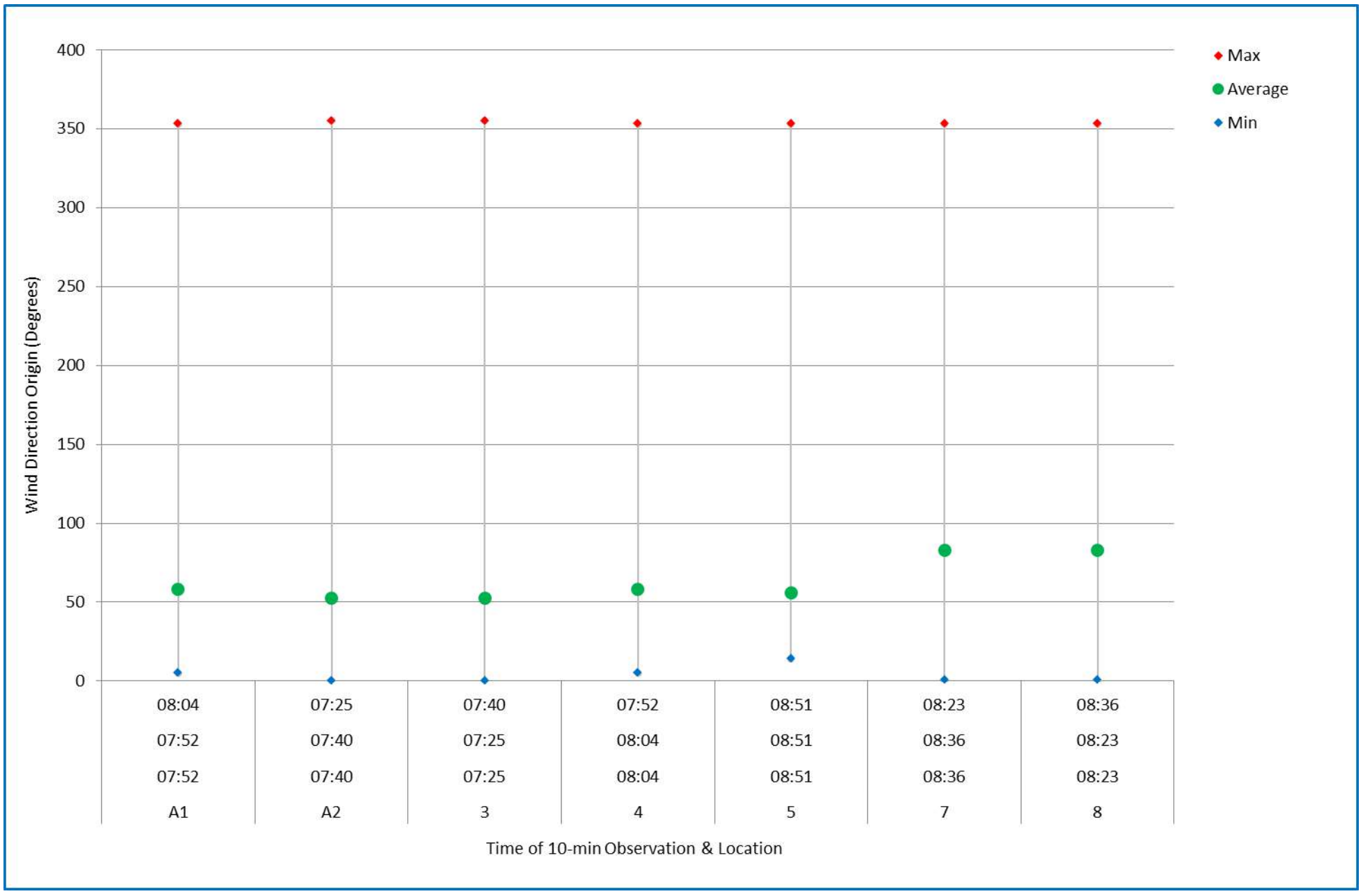
BoM Data used (Kestrel failed during OFA)

OFA #9 Field Results – 10.12.2020

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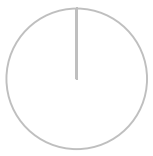
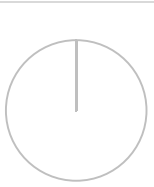
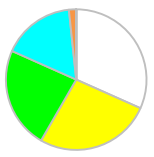
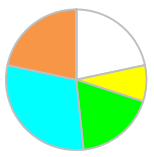
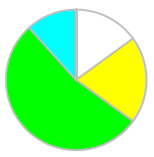
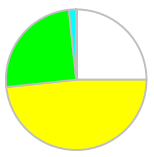
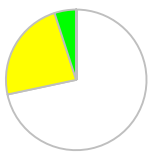
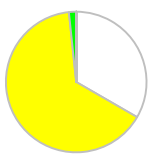
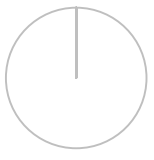
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		0	1	2	3	4	5	6		
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	07:52	21	17	20	2	0	0	0	65.0%	
	08:04	60	0	0	0	0	0	0	0.0%	
A2	7:40	37	16	6	1	0	0	0	38.3%	
	7:40	7	29	24	0	0	0	0	88.3%	
	7:25	19	13	21	7	0	0	0	68.3%	
3	7:25	57	3	0	0	0	0	0	5.0%	
	7:25	60	0	0	0	0	0	0	0.0%	
	7:40	10	10	23	13	4	0	0	83.3%	
4	8:04	34	3	4	9	10	0	0	43.3%	
	8:04	35	18	7	0	0	0	0	41.7%	

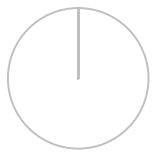
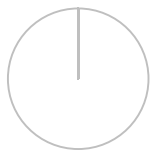
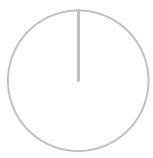
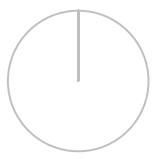
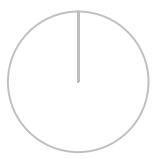
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	8:51	60	0	0	0	0	0	0	0.0%	
7	8:36	60	0	0	0	0	0	0	0.0%	
	8:36	60	0	0	0	0	0	0	0.0%	
	8:23	60	0	0	0	0	0	0	0.0%	
8	8:23	60	0	0	0	0	0	0	0.0%	
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	8:36	60	0	0	0	0	0	0	0.0%	



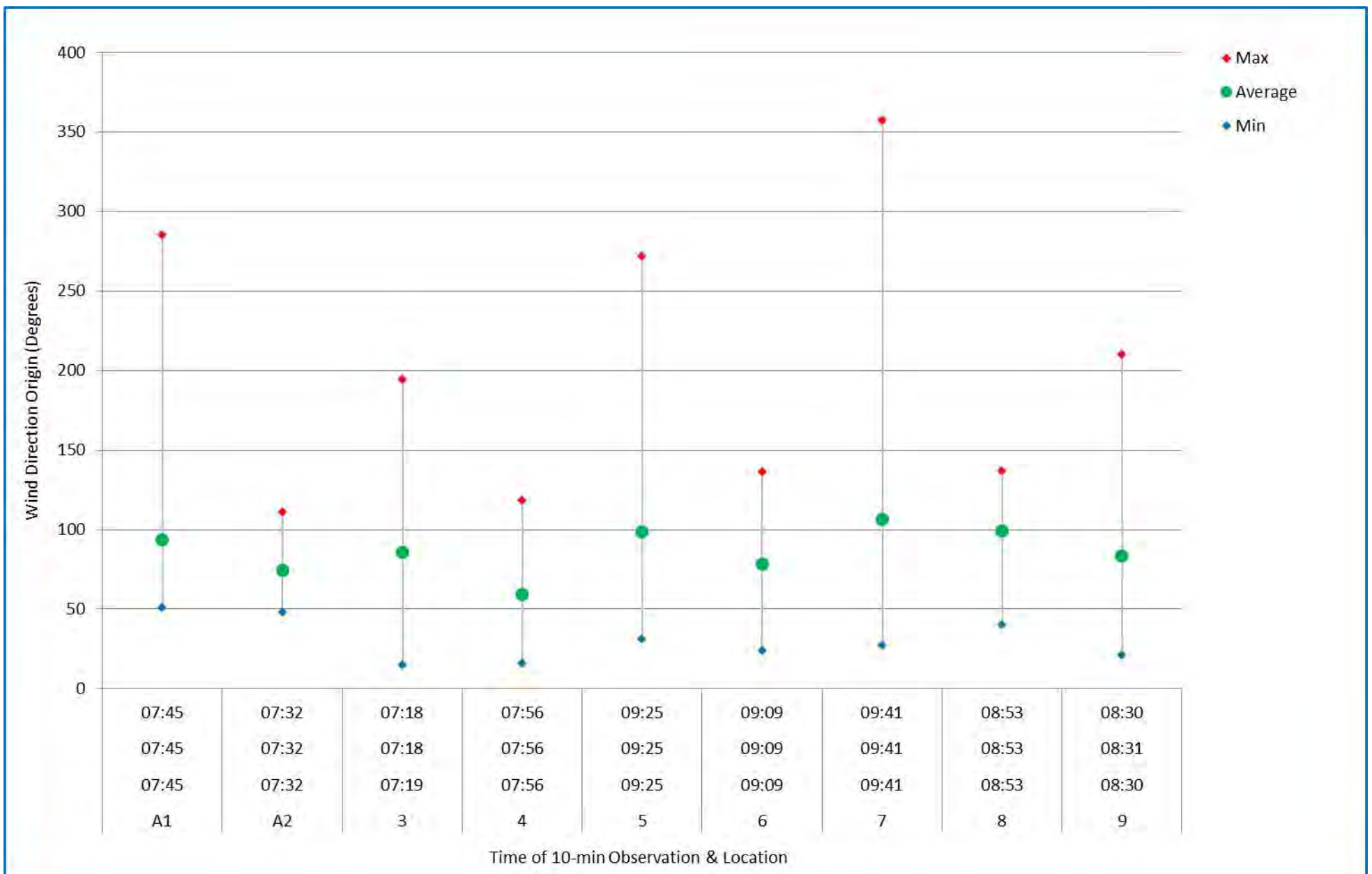
Meteorological Trends for Wind Direction (OFA #9 – 10.12.2020)

OFA #10 Field Results – 11.12.2020

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	07:45	60	0	0	0	0	0	0	0.0%	
	07:45	60	0	0	0	0	0	0	0.0%	
A2	7:32	19	16	14	10	1	0	0	68.3%	
	7:32	13	5	11	18	13	0	0	78.3%	
	7:32	9	12	32	7	0	0	0	85.0%	
3	7:19	15	29	15	1	0	0	0	75.0%	
	7:18	43	14	3	0	0	0	0	28.3%	
	7:18	20	39	1	0	0	0	0	66.7%	
4	7:56	60	0	0	0	0	0	0	0.0%	
	7:56	60	0	0	0	0	0	0	0.0%	

	7:56	60	0	0	0	0	0	0	0.0%	
5	9:25	60	0	0	0	0	0	0	0.0%	
	9:25	60	0	0	0	0	0	0	0.0%	
	9:25	60	0	0	0	0	0	0	0.0%	
6	9:09	60	0	0	0	0	0	0	0.0%	
	9:09	60	0	0	0	0	0	0	0.0%	
	9:09	60	0	0	0	0	0	0	0.0%	
7	9:41	60	0	0	0	0	0	0	0.0%	
	9:41	60	0	0	0	0	0	0	0.0%	
	9:41	60	0	0	0	0	0	0	0.0%	
8	8:53	60	0	0	0	0	0	0	0.0%	
	8:53	60	0	0	0	0	0	0	0.0%	
	8:53	60	0	0	0	0	0	0	0.0%	

	8:30	60	0	0	0	0	0	0	0.0%	
9	8:31	60	0	0	0	0	0	0	0.0%	
	8:30	60	0	0	0	0	0	0	0.0%	



Meteorological Trends for Wind Direction (OFA #10 – 11.12.2020)

826

169

18m Road

(3372m²)

18m Road

24.5m Road

(9693m²)

14.2m Road

18m Road

14.2m Road

23m Road

14.2m Road

18m Road

14.2m Road

14.2m Road

14.2m Road

14.2m Road

SSIA DR

878

877

14.2m Road

(NAIRN DRIVE) EXTENSION

14.2m Road

13.5m Road

2

14.2m Road

13.5m Road

13.5m Road

14.2m Road

14.2m Road

13.5m Road

18m Road

18m Road

3

146

624

Potential future public open space by others.

CASSIA DR

Potential future north extension of Cassia Drive subject to dedication of public road in Bush Forever reserve.

145

625

LEGEND

Metropolitan Region Scheme

Region Scheme Reserves

- Other Regional Road
- Parks & Recreation

Other

- Bush Forever

Local Scheme

Local Scheme Reserves

- Public Open Space

Local Scheme Zones

- Residential (R25-R40)
- Commercial
- Service Commercial

Other

- Poultry Odour Buffer
- Intersection - Left In/Out
- Intersection - Full Movement
- No Vehicular Access
- Emergency Access (6m wide)
- Bush Forever Original Boundary
- Planning Control Area

Development Concept Plan

Lots 877 and 878 Stakehill Road, Karnup

0 80m

Date: 17 Feb 2021 Scale: 1:4000 @ A3 File: **19-338 ST04B** Staff: JP GW Checked: JP

element.

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PREDICTION OF ODOUR LEVELS FROM POULTRY FARM AT 162 STAKEHILL ROAD, BALDIVIS AT LOTS 877 AND 878, STAKEHILL ROAD

Prepared for

J & J Garbin C/- Terranovis Pty Ltd

by

ENVALL

Environmental Alliances Pty Ltd

April 2017

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It is further assumed that normal activities were being undertaken at the site on the day of the site visit(s), unless explicitly stated otherwise. ENVALL has not attempted to fully verify the accuracy or completeness of the written or oral information supplied for the preparation of this report.

While ENVALL has no reason to doubt the information provided, the report is complete and accurate only to the extent that the information provided to ENVALL was itself complete and accurate. This report does not intend to give legal advice, which can only be given by qualified legal advisors. Copying of this report or parts of this report is not permitted without the authorisation of the Client or ENVALL.

Client: J & J Garbin C/- Terranovis Pty Ltd

Job No: L7047	**Version**	**Prepared by**	**Reviewed by**	**Submitted to Client**	
Status				**Copies**	**Date**
Draft Report	1a	DP	KP	*.pdf	23/3/2017
Final Draft Report	1b	DP	-	*.pdf	28/2/2017
Final Report	1c	DP	-	*.pdf	3/4/2017

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1. INTRODUCTION

Environmental Alliances (ENVALL) has been engaged by J & J Garbin C/- Terranovis Pty Ltd (the Client) to predict the odour levels from an existing poultry farm located at 162 Stakehill Road, Baldivis, on Lots 877 and 878. It is understood that a structure plan application is being prepared for lifting the urban deferred zoning of both Lots 877 and 878.

Poultry farms are recognised as having the potential to cause odour annoyance to residents and other odour-sensitive land uses. The comparison of predicted odour levels against criteria for acceptable impacts provides guidance on whether future residents are likely to be exposed to odour annoyance.

2. QUANTITATIVE ODOUR ASSESSMENT

2.1 DISPERSION MODELLING

The approach for quantifying odour impacts follows that for environmental assessments generally - the objective being to define the levels arising from a proposal and compare these to some criterion for an acceptable impact. The procedure recommended by the Department of Environment Regulation (DER) to assess air quality impacts from commercial/industrial operations, is modelling the dispersion of the air emissions as described of "Air Quality Modelling Guidance Notes" (DEP 2006) and comparing the predictions to criteria for acceptable impacts at "sensitive" land uses. "Sensitive land uses" include "residential developments, hospitals, hotels, motels, hostels, caravan parks, schools, nursing homes, child care facilities, shopping centres, playgrounds, and some public buildings. Some commercial, institutional and industrial land uses, which require high levels of amenity or are sensitive to particular emissions, may also be considered "sensitive land uses". Examples include some retail outlets, offices and training centres, and some types of storage and manufacturing facilities" (EPA 2005).

2.2 ODOUR MEASUREMENT

The basis for quantifying odour concentrations is "dynamic olfactometry". Dynamic olfactometry is the term used to describe the measurement of odour by presenting a sample of odorous gas to a panel in a range of dilutions and seeking a response from the panellists on whether they can detect the odour. The correlations between the known dilution ratios and the panellists' responses are used to calculate the number of dilutions of the original sample required to achieve the odour detection threshold.

The odour concentration of the sample is expressed in "odour units" (ou), being the ratio of the volume which the sample would occupy when diluted to the odour threshold, to the volume of the sample. An Australian Standard reflecting these procedures was published in 2001 (Standards Australia 2001).

2.3 ODOUR CRITERIA

The criteria currently used by the DER to assess acceptable odour impacts from new proposals[1] for sources other than wake-free stacks is:

- C99.9,1hr=8ou[2]; and
- C99.5,1hr=2.5ou.

The "Cnn.n" denotes annual percentiles.

"C99.9" is the 99.9th percentile of 1-hour average odour concentrations predictions. The 99.9th percentile is taken to be the 9th highest 1-hourly predicted odour concentration in the year.

"C99.5" is the 99.5th percentile of 1-hour average odour concentrations predictions, taken to be the 44th highest 1-hourly predicted odour concentration in the year.

In practical terms, in order to compare modelling predictions to this criterion, the 8,760 1-hour average concentration values predicted by the model at each grid point are ranked from highest to lowest. The 99.5 percentile is the 44th highest ranked concentration. The predicted 99.5 percentile, 1-hour average concentrations at each gridded receptor, may then be contoured using a computer software package to draw continuous lines of equal concentrations. The software interpolates the concentrations required for the contours as selected by the user between the values predicted at each discrete grid point. The 2.5 ou contour shows the extent from the source within which the EPA's criterion is exceeded. Areas outside the 2.5 ou contour have odour levels less than the criterion.

Similarly, the 99.9 percentile is the 9th highest ranked concentration. Areas outside the 8ou contour have odour levels less than the criterion.

3. DISPERSION MODELLING

3.1 ODOUR EMISSION RATES

3.1.1 Poultry farm capacity

The Client has advised that they endeavoured to obtain estimates of bird numbers on the Stakehill Rd poultry farm from a variety of sources including the owners, however the information requested has been unable to be provided.

For modelling, the bird numbers on the farm have been based on sales information[3]. This states that the current population is 15,000 birds using three sheds, with a maximum capacity of 25,000 birds using all five sheds.

---

[1] D Griffiths *pers com* 19/10/2012.

[2] Also accepted by Environmental Protection Authority (WA) – see ENVIRON, 2014, "Phoenix Energy Kwinana WTE Project – Air Dispersion Modelling Assessment", 23 May 2014.

[3] See http://www.morgansudlow.com.au/for-sale/baldivis/hazelmere-stakehill-road-162/303692.aspx, accessed 15/3/2017.

This is equivalent to an average bird density of 5.6 birds/m^2, which is consistent (i.e. at least as high) as that from previous known densities of other egg-producing poultry farms (see Environmental Alliances 2003, Environmental Alliances 2004). For estimating odour emissions for modelling, it was assumed that the farm was stocked to its maximum capacity of 25,000 birds, with 5,000 birds in each of the five sheds.

It is noteworthy that the Stakehill Rd egg-producing poultry farm is a relatively small poultry farm. Broiler grow-out poultry farms, which are more common, would typically stock some five to ten times this number of birds.

3.1.2 Poultry odour emissions

A study of odour emissions from naturally-ventilated poultry farms in Perth was undertaken in 1997.

The results from broiler grow-out poultry farms were reported in Jiang and Sands (1998). The study found that, from sampling odour emissions from a number of sheds on different poultry farms, the highest odour emissions occurred at around week five of the growth cycle. The average maximum odour emission rate (OER) at this time was 0.205 ou.m^3/s bird.

The results from some limited odour sampling from an egg-producing farm were described in a Supplementary Report (Jiang and Sands 1997[4]). This showed that odour emissions from an egg-laying shed was 0.11 ou.m^3/s bird. This is less than one-half that of broiler grow-out sheds at maximum emissions.

The lower odour emissions from egg-producing farms was confirmed in a more recent study of another egg producing farm in Baldivis (TOU 2010), in which the results from odour dispersion modelling using the broiler emission rate were compared to the results of field odour assessments of the actual odour from the farm. The modelling results indicated "odour impacts well beyond those observations made during the FAOA's"[5] (Field Based Ambient Odour Assessments).

For previous modelling studies of egg-producing farms, the DER has, however, advised that, in lieu of further measurements of odour emissions from egg-producing sheds or site-specific odour sampling, the maximum emission rate for grow-out sheds should be used for odour dispersion modelling of egg-producing farms[6].

This study has therefore used the "per bird" maximum emission rates for broiler grow-out sheds, which will produce a "conservative" estimate of ambient odour levels from the farm (i.e. an over-estimate of odour levels). For 25,000 birds, the total odour emission rate from the farm is, therefore, 5,125 ou/s.

[4] The main report was finalised after the Supplementary Report.

[5] TOU (2010) p 43.

[6] G Sowerbutts pers com, May 1999, and also stated in TOU (2010).

These emission rates have been assumed as constant through the year. Based on odour measurements from broiler poultry farms, this will also be conservative since during cold nights, the sheds are likely to be more closed up[7].

3.2 MODEL

The U.S. Environmental Protection Agency's (US EPA) CALPUFF model was used for the dispersion modelling of odours from the poultry farm. This model has been adopted by the US EPA in its "Guideline of Air Quality Models" as the preferred model for assessing long range transport of pollutants and their impacts on Federal Class I areas and on a case-by-case basis for certain near-field applications involving complex meteorological conditions.

More specifically to this study, the Guideline (amongst other reasons) provides for the use of CALPUFF on a case-by-case basis for air quality estimates involving complex meteorological flow conditions, where steady-state straight-line transport assumptions are inappropriate. Odour dispersion from a constantly-emitting ground level source is lowest and hence downwind odour concentrations highest, during light wind conditions, which alternative gaussian dispersion models such as AUSPLUME handle poorly. Full details are described in the model's documentation (see http://www.src.com/calpuff/calpuff1.htm).

A summary of the key modelling set-ups and assumptions follows:

- Grid resolution of 50 m.
- There is no significant terrain height variation between the poultry farm and Lots 877 and 878 hence flat terrain was assumed. The land along the bearing from the poultry farm to Lots 877 and 878 has a mixture of sparse tall trees and cleared pasture. A roughness length of 0.25 m was considered slightly conservative for this, and for any future residential development on the Lots.
- Poultry farm sheds are appropriately characterised as "volume" sources for modelling. Each poultry shed's dimensions were segmented to better approximate square dimensions, with the initial sigma-y specified as one-quarter of the minimum width of each segment, initial sigma-z specified as one-quarter of the height of the shed, and the release height specified as one-half of the height of the sheds. This is in accordance with general modelling guidance for parameterising volume sources. Furthermore, this implies that no night-time plume buoyancy. A number of studies have shown that cold, night-time emissions from poultry sheds are (weakly) buoyant (PEL 2015), which considerably reduces down-wind ground-level odour concentrations during these conditions.
- For this study, the CALPUFF model was run in "two-dimensional" mode. This permits the use of meteorological data from only a single surface station. In this mode, CALPUFF assumes a spatially uniform meteorological field, however the essential features of a puff model such as

[7] Broiler grow-out poultry sheds are ventilated in order to maintain the internal temperature as close as possible to the optimum for bird growth. This ranges from about 31^{o}C when the chickens are first brought in, to about 22^{o}C at week five of the growth cycle.

During winter, ventilation rates are generally kept very low because heat needs to be retained inside the sheds to keep temperatures above the outside ambient temperature.

Therefore, shed OER also varies in time with ventilation rate and hence ambient temperature.

The relationship between these parameters and OERs was investigated in a report by the University of NSW (Jiang and Sands 2000). That study determined that the OER is about 10% of the maximum OER when the ambient temperature is 15^{o}C or below. This was based on sampling poultry farms in NSW. The use of this relationship was recommended in the report for the purpose of determining appropriate odour buffers from poultry farms.

simulating stagnation during calm wind conditions, and enabling curved trajectories and variable dispersion and stability conditions over multiple hours of transport, are retained.

- Rural wind profile exponents used.
- Dispersion option based on micrometeorological parameters.

3.3 METEOROLOGICAL DATA

For modelling air emissions from sources in the Perth metropolitan area, an important influence on winds is distance from the coast. Average wind speeds across the metropolitan area are higher near the coast where the effects of summertime sea breezes become more dominant, than further inland up to about 5 kms from the base of the Darling Scarp.

The 162 Stakehill Rd poultry farm is located on the Swan Coastal Plain about 6 kms from the coast. The DER has produced meteorological data sets suitable for dispersion modelling in the Perth metropolitan area from measurements at Hope Valley (3 km from the coast) and Caversham (20 km from the coast).

The Hope Valley data set would generally more applicable for modelling in exposed, near-coastal locations, and the latter for more inland locations.

The DER has previously stated its preference for the use of the Caversham data set for modelling air emissions from sources within the Perth Metropolitan Area situated from about 5 kms from the coast to about 5 kms from the base of the Darling Scarp. For locations west of Caversham, this is likely to produce conservative predictions.

Therefore the Caversham data set[8] was used for modelling in this study.

The annual wind rose and matrix based on these data is shown in Appendix 1.

[8] The Caversham data was produced in a format for use with the AUSPLUME dispersion model but can also be used with other models including CALPUFF.

4. MODELLING RESULTS

The predicted criteria odour contours from the poultry farm are shown in Figure 1.

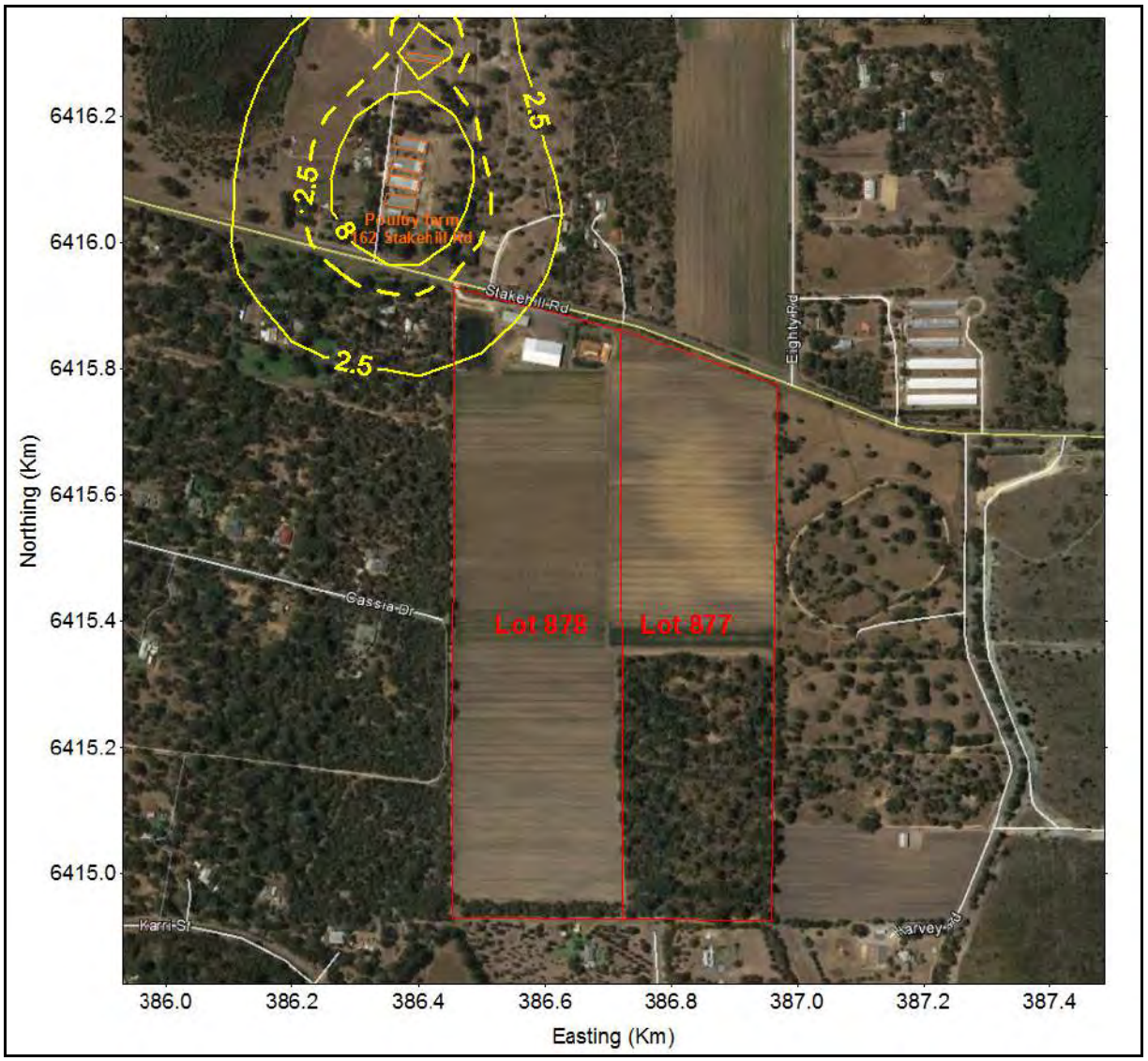


Figure 1 Predicted criteria odour concentrations from 162 Stakehill Rd egg-producing poultry farm

Map reference: Google Earth accessed 14/3/2017.
The "2.5" contour in solid yellow is the C99.5,1hr=2.5ou odour level using the broiler poultry farm emission rate.
The "8" contour in solid yellow is the C99.9,1hr=8ou odour level using the broiler poultry farm emission rate.
The "2.5" contour in dash yellow is the C99.5,1hr=2.5ou odour level using the egg poultry farm emission rate.
Lot boundaries in red are indicative only.

As evident from Figure 1, using the broiler farm odour emission rate of 0.205 ou/s/bird:

- the C99.9,1hr=8ou criteria contour does not encroach Lots 877 and 878; and

- the C99.5,1hr=2.5ou criteria contour encroaches Lot 878 by approximately 120 m from the north-west corner.

There are a number of reasons for the predictions being considerably conservative:

- as previously mentioned, the available information of odours from egg-producing poultry sheds indicates that their odour emissions are about one-half that actually used for the modelling;
- use of the assumption that odour emission rates are constant and the neglect of any plume buoyancy during night-time, which will over-estimate predicted concentrations at night-time which are when the highest concentrations are predicted; and
- the use of the Caversham meteorological data set for the Baldivis region is likely to under-state wind speeds and over-state the frequency of stable night-time conditions, both of which lead to higher predicted concentrations.

In order to illustrate the likely conservatism, Figure 1 also shows the C99.5,1hr=2.5ou criteria contour that would result from using the egg-producing farm odour emission rate of 0.11 ou/s/bird (as described in Section 3.1). The contour does not encroach Lots 877 and 878. It is considered that this contour is likely to be more realistic than the results based on modelling with the broiler farm emission rate. An option to verify this would be to undertake "field odour surveys" which, in brief, involves the use of independent assessors rating odour strength from a source using an accepted methodology. The DER's website states that an odour guideline will be released in April 2017[9]. It is probable that this will describe an accepted methodology for undertaking such field odour assessments.

The odour modelling does not take into account atypical or infrequent situations that may cause odour emissions to be higher than usual. These include litter removal and shed clean-outs. There are, however, a number of industry guidelines for the management of poultry farms to minimise adverse odour impacts from these types of events - for example, "Environmental Guidelines for the Australian Egg Industry - A report for the Australian Egg Corporation Limited, As part of the DAFF EMS Pathways to Sustainable Agriculture Program" (McGahan et al 2008). Poultry farms are typically required to comply with these as a condition of supplier agreements.

[9] See https://www.der.wa.gov.au/our-work/consultation, accessed 28/3/2017.

5. GLOSSARY OF TERMS

"DER", "DEC", "DoE", "DEP" means Department of Environment Regulation (WA), formally Department of Environment and Conservation, formerly Department of Environment, formerly Department of Environmental Protection.

"km" means kilometres.

"m" means metres. "m^2" means square metres.

"^oC" means degrees Celsius.

"OER" means odour emission rate with units of $ou.m^3/s$.

"ou/s" means odour units per second.

"ou" means odour units. An odour unit is a dimensionless ratio defined as the volume which an odorous sample would occupy when diluted to the odour threshold, divided by the volume of the odorous sample.

"PG" means Pasquill Gifford classification of atmospheric stability. This defines six categories of atmospheric stability from "A" class – moderately unstable to "F" class – moderately stable.

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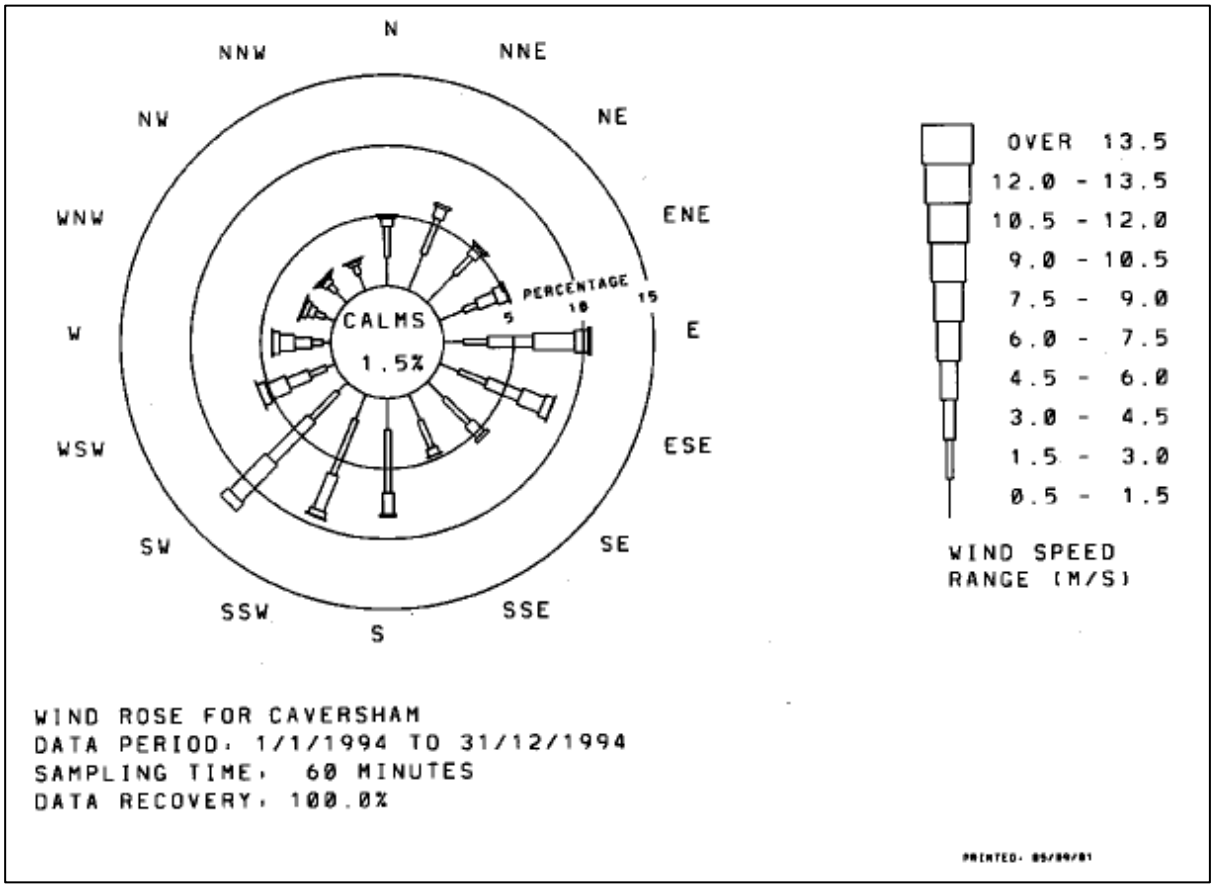
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Appendix 1 Wind speed and direction frequency occurrence rose and matrix and stability distribution for Caversham meteorological data



*** WIND SPEED - WIND DIRECTION PERCENTAGE OCCURRENCE MATRIX ***

DATA PERIOD: 1. 1.94 TO 31.12.94 INCLUSIVE.

WIND SPEED RANGE (M/S)	WIND DIRECTION SECTOR N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	TOTALS
OVER 13.5																	0.0
12.0 - 13.5																	0.0
10.5 - 12.0																	0.0
9.0 - 10.5																	0.0
7.5 - 9.0					0.1												0.3
6.0 - 7.5				0.1	1.0	0.6				0.1	0.7	0.6	0.5	0.1	0.1		3.8
4.5 - 6.0	0.2	0.2	0.2	0.8	3.0	1.7	0.3		0.1	0.5	3.6	1.5	1.1	0.4	0.1	0.1	13.8
3.0 - 4.5	0.6	0.8	0.7	1.4	3.2	2.6	1.2	0.5	1.5	2.7	4.1	1.7	1.2	0.5	0.4	0.3	23.5
1.5 - 3.0	2.2	2.7	1.7	1.0	1.7	2.1	2.5	2.1	4.5	4.2	2.7	1.3	0.8	0.7	0.7	0.7	31.7
0.5 - 1.5	2.0	2.8	2.8	1.9	1.4	1.5	1.7	2.0	2.2	1.9	1.0	0.7	0.6	0.8	1.1	1.2	25.5
TOTALS	5.1	6.5	5.5	5.2	10.5	8.6	5.6	4.7	8.4	9.4	12.1	5.7	4.2	2.5	2.4	2.3	

CALMS (LESS THAN 0.5 M/S): 1.5%
DATA RECOVERY: 100.0%
SAMPLING TIME: 60 MINUTES

Atmospheric turbulence is an important factor in plume dispersion. Turbulence acts to increase the cross-sectional area of the plume due to random motions, thus diluting or diffusing a plume. As turbulence increases, the rate of plume dilution or diffusion increases. Weak turbulence limits plume diffusion and is a critical factor in causing high plume concentrations downwind of a source, particularly when combined with very low wind speeds.

Pasquil (1961) introduced a method whereby mechanical and buoyant turbulence were incorporated into atmospheric stability – categorised by six classes "A' to "F".

Class A is described as highly unstable and occurs in association with strong surface heating and light winds, leading to intense convective turbulence and much enhanced plume dilution. At the other extreme, class F denotes very stable conditions associated with strong temperature inversions and light winds, which commonly occur under clear skies at night and in early mornings. Under these conditions plumes can remain relatively undiluted for considerable distances downwind. Intermediate stability classes grade from moderately unstable (B), through neutral (D) to slightly stable (E). Whilst classes A and F are strongly associated with clear skies, class D is linked to windy and/or cloudy weather, and short periods around sunset and sunrise when surface heating or cooling is small. As a general rule, unstable (or convective) conditions dominate during the daytime and stable flows are dominant at night. This diurnal pattern is most pronounced when there is relatively little cloud cover and light to moderate winds.

A summary of the stability class distributions for the annual meteorological data set used for modelling is shown in Table 4.

Table 1 Stability distributions for meteorological data sets used for annual modelling

Stability Class	Frequency of occurrence (%) Caversham 1994 data
A	3.9
B	8.3
C	27.9
D	21.5
E	13.3
F	24.9

Appendix 2 CALPUFF modelling parameters

Electronic copies of modelling files are available for regulatory review. Please e-mail david.pitt@ea.iinet.net.au and request L7047_ModellingFiles.zip. The following is the CALPUFF input file with extraneous comments removed for brevity:

```
CALPUFF.INP     2.0            File version record
L7047 Lot 162 Stakehill Rd, Baldivis poultry odour


---------------- Run title (3 lines) ------------------------------------------

                     CALPUFF MODEL CONTROL FILE
! PLMDAT =M:\METDATA\CAVERSHM\CA94B.MET   !
! PUFLST =M:\L7047\CAL02\PUF\CALPUFF.LST  !
! CONDAT =M:\L7047\CAL02\PUF\CALPUFF.CON     !
! AUXEXT =AUX     !
! LCFILES = F !
! NMETDOM =  1  !
! NMETDAT =   0   !
! NPTDAT =   0   !
! NARDAT =   0   !
! NVOLDAT =   0   !
!END!
! METRUN =   1  !
! IBYR  =  1994  !
! IBMO  =  0  !
! IBDY  =  0  !
! IBHR  =  0  !
! IBMIN =  0  !
! IBSEC =  0  !
! IEYR  =  0  !
! IEMO  =  0  !
! IEDY  =  0  !
! IEHR  =  0  !
! IEMIN =  0  !
! IESEC =  0  !
! ABTZ= UTC+0800 !
! NSECDT =  3600  !
! NSPEC =  1   !
! NSE =  1   !
! ITEST =  2   !
! MRESTART =  0   !
! NRESPD =  0   !
! METFM =  3   !
! MPRFFM =  1   !
! AVET = 60. !
! PGTIME = 10. !
! IOUTU =  2   !
! IOVERS =  2   !
!END!
! MGAUSS =  1   !
! MCTADJ =  0   !
! MCTSG =  0   !
! MSLUG =  0   !
! MTRANS =  1   !
! MTIP =  1  !
! MRISE =  1  !
! MBDW =   1  !
! MSHEAR =  0  !
! MSPLIT =  0  !
! MCHEM =  0   !
! MAQCHEM =  0   !
! MLWC =  1   !
! MWET =  0   !
! MDRY =  0   !
! MTILT =  0   !
! MDISP =  2   !
! MTURBVW =  3  !
! MDISP2 =  3  !
! MTAULY =  0  !
! MTAUADV =  0  !
! MCTURB =  1  !
```

```
! MROUGH =  0  !
! MPARTL =  1  !
! MPARTLBA =  1  !
! MTINV =  0  !
! MPDF =  0  !
! MSGTIBL = 0  !
! MBCON = 0  !
! MSOURCE = 0  !
! MFOG =  0   !
! MREG =  0   !
!END!
! CSPEC =         ODOR !
!         ODOR  =         1,               1,           0,                 0   !
!END!
! PMAP = UTM  !
! FEAST  = 0.000  !
! FNORTH = 0.000  !
! IUTMZN =  50   !
! UTMHEM = S  !
! RLAT0 = 32S  !
! RLON0 = 116E  !
! XLAT1 = 31S  !
! XLAT2 = 33S  !
! DATUM = WGS-84  !
! NX =  19   !
! NY =  19   !
! NZ =  6   !
! DGRIDKM = .1 !
! ZFACE = .0, 20.0, 60.0, 120.0, 280.0, 720.0, 1280.0 !
! XORIGKM = 385.9 !
! YORIGKM = 6414.8 !
! IBCOMP =  1   !
! JBCOMP =  1   !
! IECOMP =  19   !
! JECOMP =  19   !
! LSAMP = T !
! IBSAMP =  1   !
! JBSAMP =  1   !
! IESAMP =  19   !
! JESAMP =  19   !
! MESHDN =  2  !
!END!
!  ICON =  1   !
!  IDRY =  0   !
!  IWET =  0   !
!  IT2D =  0   !
!  IRHO =  0   !
!  IVIS =  0   !
! LCOMPRS = T !
!  IQAPLOT =  1   !
! IMFLX =  0  !
! IMBAL =  0  !
! INRISE =  0  !
! ICPRT =  1   !
! IDPRT =  0   !
! IWPRT =  0   !
! ICFRQ =  6   !
! IDFRQ =  1   !
! IWFRQ =  1   !
! IPRTU =  5   !
! IMESG =  2   !
!         ODOR =     1,           1,           0,           0,           0,           0,
0   !
! LDEBUG = F !
! IPFDEB =  1  !
! NPFDEB =  1  !
! NN1 =  1   !
! NN2 =  10  !
!END!
! NHILL =  0   !
! NCTREC =  0   !
! MHILL =  2   !
! XHILL2M = 1.0 !
! ZHILL2M = 1.0 !
! XCTDMKM = 0 !
```

```
! YCTDMKM = 0 !
! END !
!END!
!END!
!  RCUTR = 30.0 !
!    RGR = 10.0 !
! REACTR = 8.0 !
!   NINT =  9  !
!   IVEG =  1   !
!END!
!END!
! MOZ =  0   !
!  BCKO3 = 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00
!
! MNH3 =  0   !
! MAVGNH3 =  1   !
!  BCKNH3 = 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00
!
! RNITE1 = .2 !
! RNITE2 = 2.0 !
! RNITE3 = 2.0 !
! MH2O2 =  1   !
!  BCKH2O2 = 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00 !
!  BCKPMF = 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00 !
!  OFRAC  = 0.15, 0.15, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.15 !
!  VCNX   = 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00
!
! NDECAY =  0   !
!END!
! SYTDEP = 5.5E02 !
! MHFTSZ =  0   !
! JSUP =  5   !
! CONK1 = .01 !
! CONK2 = .1 !
! TBD = .5 !
! IURB1 =  10  !
! IURB2 =  19  !
! ILANDUIN =  20  !
! Z0IN = .25 !
! XLAIIN = 1.0 !
! ELEVIN = 5.0 !
! XLATIN = -32.0 !
! XLONIN = -116.0 !
! ANEMHT = 10.0 !
! ISIGMAV =  1  !
! IMIXCTDM =  0  !
! XMXLEN = 1.0 !
! XSAMLEN = 1.0 !
! MXNEW =  99   !
! MXSAM =  99   !
! NCOUNT =  2   !
! SYMIN = 1.0  !
! SZMIN = 1.0  !
! SZCAP_M = 5.0E06 !
! SVMIN = 0.400, 0.400, 0.400, 0.400, 0.400, 0.400, 0.370, 0.370, 0.370, 0.370, 0.370, 0.370!
! SWMIN = 0.200, 0.120, 0.080, 0.060, 0.030, 0.016, 0.200, 0.120, 0.080, 0.060, 0.030, 0.016!
! CDIV = .0, .0 !
! NLUTIBL =  4  !
! WSCALM = .5 !
! XMAXZI = 3000.0 !
! XMINZI = 50.0 !
! WSCAT = 1.54, 3.09, 5.14, 8.23, 10.80 !
! PLX0 = 0.07, 0.07, 0.10, 0.15, 0.35, 0.55 !
! PTG0 = 0.020,   0.035 !
!  PPC = 0.50, 0.50, 0.50, 0.50, 0.35, 0.35 !
! SL2PF = 10.0 !
! NSPLIT =  3  !
!  IRESPLIT = 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0 !
! ZISPLIT = 100.0 !
! ROLDMAX = 0.25 !
! NSPLITH =  5  !
! SYSPLITH = 1.0 !
! SHSPLITH = 2.0 !
! CNSPLITH = 1.0E-07 !
! EPSSLUG = 1.0E-04 !
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! EPSAREA = 1.0E-06 !
! DSRISE = 1.0 !
! HTMINBC = 500.0 !
! RSAMPBC = 10.0 !
! MDEPBC =  1  !
!END!
!  NPT1 =  0  !
!  IPTU =   1  !
!  NSPT1 =  0  !
!  NPT2 =  0  !
!END!
!  NAR1 =  0   !
!  IARU =   1  !
!  NSAR1 =  0  !
!  NAR2 =  0   !
!END!
!  NLN2 =  0   !
! NLINES =  0  !
!  ILNU =   1  !
!  NSLN1 =  0  !
! MXNSEG =  7  !
! NLRISE =  6  !
! XL = .0 !
! HBL = .0 !
! WBL = .0 !
! WML = .0 !
! DXL = .0 !
! FPRIMEL = .0 !
!END!
!  NVL1 =  10   !
!  IVLU =   5  !
!  NSVL1 =  0  !
!  NVL2 =   0   !
!END!
! SRCNAM = SHED1W !
! X =   386.359,  6416.067,     2.0,      5.0,       5.0,       1.0,5.125E02 !
! SRCNAM = SHED2W !
! X =   386.364,  6416.096,     2.0,      5.0,       5.0,       1.0,5.125E02 !
! SRCNAM = SHED3W !
! X =   386.369,  6416.125,     2.0,      5.0,       5.0,       1.0,5.125E02 !
! SRCNAM = SHED4W !
! X =   386.375,  6416.158,     2.0,      5.0,       5.0,       1.0,5.125E02 !
! SRCNAM = SHED5W !
! X =   386.394,  6416.293,     2.0,      5.0,       2.6,       1.0,5.125E02 !
! SRCNAM = SHED1E !
! X =   386.381,  6416.064,     2.0,      5.0,       5.0,       1.0,5.125E02 !
! SRCNAM = SHED2E !
! X =   386.386,  6416.093,     2.0,      5.0,       5.0,       1.0,5.125E02 !
! SRCNAM = SHED3E !
! X =   386.391,  6416.122,     2.0,      5.0,       5.0,       1.0,5.125E02 !
! SRCNAM = SHED4E !
! X =   386.397,  6416.155,     2.0,      5.0,       5.0,       1.0,5.125E02 !
! SRCNAM = SHED5E !
! X =   386.425,  6416.289,     2.0,      5.0,       2.6,       1.0,5.125E02 !
!  NREC =  0   !
!END!
```

APPENDIX 2

Flora, Vegetation and Fauna Report

LOT 877 STAKEHILL ROAD, KARNUP

FLORA, VEGETATION AND FAUNA SURVEY

Prepared for:	J & J Garbin
Report Date:	29 October 2019
Version:	3
Report No.	2019-440

pgv ENVIRONMENTAL

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1 INTRODUCTION

1.1 Background

Lot 877 Stakehill Road, Karnup is approximately 57km south of the Perth Central Business District and 16km south of the City of Rockingham (Figure 1).

The southern part of Lot 877 is within Bush Forever Site 278, 'Cassia Drive Bushland, Karnup' (Figure 2). The Bush Forever component of Lot 877 is approximately 10.8ha in size of which approximately 9.6ha contains native vegetation. The portion of Lot 877 that is within Bush Forever Site 278 is designated as 'Part B: Negotiated Planning Solution' (Government of Western Australia, 2000).

PGV Environmental was commissioned by the owners of Lot 877 to undertake a Flora, Vegetation and Fauna Survey of the Bush Forever component of the lot as part of a Negotiated Planning Solution.

1.2 Scope of Works

The Flora, Vegetation and Fauna Survey report includes a description of the following:

- Physical characteristics including:
  - Landform;
  - Drainage and water bodies; and
  - Geological, hydrogeological and hydrological characteristics;
- A Detailed Flora and Vegetation Survey including:
  - Desktop search and review of the Department of Biodiversity, Conservation and Attractions (DBCA) Naturemap database;
  - A search of the Commonwealth Government's Protected Matters Search Tool to identify species potentially occurring within the area that are protected under the Environment Protection and Biodiversity Conservation (EPBC) Act 1999;
  - Examination of historic and recent aerial photography and contour and soil maps to provisionally identify vegetation types and condition;
  - Field survey using quadrats to record native and introduced species as well as a thorough site walkover of any areas of native vegetation;
  - Recording of any significant plant species using a hand-held GPS;
  - Description and mapping of vegetation types and vegetation condition; and
  - Compilation of a flora list.
- A Level 1 Fauna Survey including:
  - A search of the DBCA Databases and NatureMap for the general area for Threatened and Priority Species;
  - A search of the Commonwealth Government's Protected Matters Search Tool to identify species potentially occurring within the area that are protected under the Environment Protection and Biodiversity Conservation (EPBC) Act 1999 or international migratory bird agreements (JAMBA/CAMBA); and
  - A description of the fauna habitats present on the site from the site walkover; and

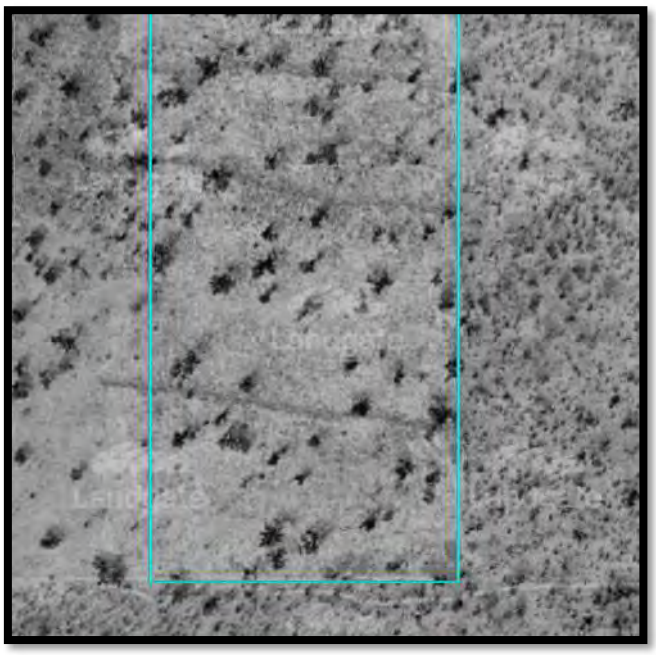
    - An assessment of the significance of the site for conservation significant species in a local and regional context and
- Black Cockatoo Habitat Survey including:
    - Assessment of foraging habitat;
    - Search for any evidence of roosting on site;
    - Measurement of any actual or potential breeding habitat trees.

2 EXISTING ENVIRONMENT

2.1 Land Use

The site has been part of a rural property for many years and as shown in the earliest available on-line aerial photography from 1965 the Bush Forever part of Lot 877 was largely cleared with some trees remaining (Plate 1). Windrows of cleared vegetation appear on the aerial photograph in a west-east direction across the site.

Plate 1: Historical Aerial Photography from 1965 (Landgate, 2019)



By 2000 the cleared parts of the site had regrown with native vegetation. The windrows appear to have a denser regrowth than the remainder of the site (Plate 2).

Plate 2: Historical Aerial Photography from 2000 (Landgate, 2019)



Native vegetation remains over the site and is a combination of regrowth at least 20 years old and remnant trees that were not cleared (Plate 3).

Plate 3: Aerial Photography from 2018 (Landgate, 2019)



2.2 Topography

The site has a gradual slope down from a high of around 19m AHD near the north-east corner down to around 8-10m AHD on the western boundary (Figure 2).

2.3 Geology and Soils

The site is mapped as part of the Spearwood System which has the highest relief of the dune systems on the Swan Coastal Plain (Bolland, 1998). The Spearwood system consists of slightly calcareous Aeolian sand remnant from leaching of the underlying Pleistocene Tamala limestone (Davidson, 1995).

The Department of Primary Industries and Regional Development soil landscape mapping maps Spearwood S2a Phase (211Sp_S2a) which are soils on lower slopes (1-5%) of dune ridges with moderately deep to deep siliceous yellow-brown sands or pale sands with yellow-brown subsoils and minor limestone outcrops.

2.4 Hydrology

Groundwater is at approximately 1mAHD and flows to the west (DWER, 2019). Groundwater is approximately 7 to 18m below ground surface (National Map, 2019).

Surface water on the site is likely to be infiltrated with minimal run-off due to the porosity of the soils. There are no wetlands or surface water features mapped on the site.

3 FLORA AND VEGETATION

3.1 Methodology

A Detailed Flora and Vegetation Survey of the site was undertaken in accordance with EPA Technical Guidance *Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA, 2016a). The survey included an initial reconnaissance survey in March 2019 followed by a detailed spring survey on 17 September 2019.

Prior to the site surveys, desktop studies were undertaken to identify potential threatened species and communities that may occur on the site. The site reconnaissance and detailed spring survey were conducted by Dr Paul van der Moezel from PGV Environmental. The survey included walking through the survey area to record vegetation types and species presence by sampling five 10m x 10m quadrats and a thorough site walkover.

In order to assess the potential presence of the Banksia Woodland of the Swan Coastal Plain Threatened Ecological Community, Banksia tree density was recorded in 10m wide belt transects orientated west-east across the site and spaced 50m apart.

3.2 Desktop Studies

3.2.1 Flora Database Searches

A search of the DBCA Threatened Flora Databases: the WA Herbarium database (WAHerb and the Threatened (Declared Rare) and Priority Flora Species List (TFPL) (Appendix 1), Naturemap (Appendix 2) (DBCA, 2019) and the EPBC Act Protected Matters Search Tool (Appendix 3) (DoEE, 2019a) indicates that a number of species that are listed as Endangered, Threatened or Priority are identified as potentially being located the site. The results from these database searches are shown in Table 1.

Table 1: Conservation Significant Flora known to occur near the Site

Scientific Name	Common Name	Conservation Status (WA)	Status under EPBC Act
Caladenia huegelii	King Spider-orchid, Grand Spider-orchid, Rusty Spider-orchid	Schedule 1	Endangered
Drakaea elastica	Glossy-leafed Hammer Orchid	Schedule 1	Endangered
Synaphea sp. Fairbridge Farm (D Papenfus 696)	Selena's Synaphea	Schedule 1	Critically Endangered
Synaphea sp. Serpentine (G.R Brand 103)		Schedule 1	Critically Endangered
Diuris micrantha	Dwarf Bee-orchid	Schedule 2	Vulnerable
Diuris purdiei	Purdie's Donkey-orchid	Schedule 2	Endangered
Lepidosperma rostratum	Beaked Lepidosperma	Schedule 2	Endangered
Andersonia gracilis	Slender Andersonia	Schedule 3	Endangered
Diuris drummondii	Tall Donkey Orchid	Schedule 3	Vulnerable
Drakaea micrantha	Dwarf Hammer-orchid	Schedule 3	Vulnerable
Acacia benthamii		Priority 2	
Cardamine paucijuga		Priority 2	
Beyeria cinerea subsp. *cinerea*		Priority 3	
Calandrinia oraria		Priority 3	

Scientific Name	Common Name	Conservation Status (WA)	Status under EPBC Act
Dillwynia dillwynioides		Priority 3	
Lasiopetalum membranaceum		Priority 3	
Pimelea calcicola		Priority 3	
Schoenus capillifolius		Priority 3	
Sphaerolobium calcicola		Priority 3	
Conostylis pauciflora subsp. *pauciflora*		Priority 4	
Jacksonia sericea	Waldjumi	Priority 4	
Parsonsia diaphanophleba		Priority 4	
Stylidium longitubum	Jumping Jacks	Priority 4	

Definitions of the Conservation Codes are in Appendix 4.

Based on the site reconnaissance survey in April 2019 the likelihood of Threatened and Priority flora occurring in the survey area is shown in Table 2.

Table 2: Likelihood of Identified Significant Flora Species Occurring on the Site

Scientific Name	Common Name	Habitat*	Likelihood to occur on the site
Caladenia huegelii	King Spider-orchid, Grand Spider-orchid, Rusty Spider-orchid	The Grand Spider-orchid prefers sand or clay loam. This species generally does not survive in disturbed areas.	Possible - This species may occur in the areas of better condition vegetation
Drakaea elastica	Glossy-leafed Hammer Orchid	The Glossy-leafed Hammer Orchid prefers low-lying situations adjoining winter-wet swamps. This species does not survive in disturbed areas.	Highly Unlikely – there are no low-lying areas on the site
Synaphea sp. Fairbridge Farm (D Papenfus 696)	Selena's Synaphea	Selena's Synaphea occurs in sandy with lateritic pebbles near winter-wet flats, in low woodland with weedy grasses.	Highly Unlikely – there are no low-lying areas on the site.
Synaphea sp. Serpentine (G.R Brand 103)		*Synaphea* sp. Serpentine occurs in brown sandy clay.	Highly Unlikely – soils on the site are not the preferred habitat of this species.
Diuris micrantha	Dwarf Bee-orchid	The Dwarf Bee-orchid is usually found on cleared firebreaks or open sandy patches that have been disturbed with in Jarrah Banksia woodland or thickets of Spearwood (*Kunzea ericifolia/glabrescens*) (Williams *et al*., 2001).	Highly Unlikely – the site does not contain the preferred habitat of this species.

Scientific Name	Common Name	Habitat*	Likelihood to occur on the site
Diuris purdiei	Purdie's Donkey-orchid	Purdie's Donkey Orchid occurs in grey-black sand in moist winter-wet swamps.	Highly Unlikely – The site is not low-lying habitat.
Lepidosperma rostratum	Beaked Lepidosperma	Beaked Lepidosperma is found in peaty sand, clay.	Highly Unlikely – there are no low-lying areas on the site
Andersonia gracilis	Slender Andersonia	Slender Andersonia occurs in white/grey sand, sandy clay, gravelly loam in winter-wet areas, near swamps.	Highly Unlikely – there are no low-lying areas on the site
Diuris drummondii	Tall Donkey Orchid	The Tall Donkey Orchid grows in low-lying depressions, swamps.	Highly Unlikely – The site is not low-lying habitat
Drakaea micrantha	Dwarf Hammer-orchid	Dwarf Hammer-orchid occurs in grey sands over dark, grey to blackish, sandy clay-loam substrates in winter wet depressions or swamps.	Highly Unlikely – The site is not low-lying habitat
Acacia benthamii		*Acacia benthamii* grows on sand, typically on limestone breakaways	Highly Unlikely – There is no limestone on the site.
Cardamine paucijuga		*Cardamine paucijuga* is found on moist flats in calcareous clay over limestone.	Highly Unlikely – The site is not low-lying habitat.
Beyeria cinerea subsp. cinerea		*Beyeria cinerea* subsp. *cinerea* grows in sand over limestone on road verges, gullies	Highly Unlikely – There is no limestone habitat on the site.
Calandrinia oraria		*Calandrinia oraria* grows in restricted to coastal habitats in low coastal heath on white sand dunes (Obbens, 2014)	Highly Unlikely – the site is not coastal dunes
Dillwynia dillwynioides		*Dillwynia dillwynioides* occurs in sandy soils in winter-wet depressions.	Highly Unlikely – The site is not low-lying habitat.
Lasiopetalum membranaceum		*Lasiopetalum membranaceum* grows in sand over limestone.	Highly Unlikely – There is no limestone on the site.
Pimelea calcicola		*Pimelea calcicola* occurs in sand on coastal limestone ridges.	Highly Unlikely – There is no limestone habitat on the site.
Schoenus capillifolius		*Schoenus capillifolius* grows in brown mud on claypans.	Highly Unlikely – The site is not low-lying habitat

Scientific Name	Common Name	Habitat*	Likelihood to occur on the site
Sphaerolobium calcicola		*Sphaerolobium calcicola* grows in white-grey-brown sand, sandy clay over limestone, black peaty sandy clay on tall dunes, winter-wet flats, interdunal swamps, low-lying areas.	Highly Unlikely – The site is not low-lying habitat.
Conostylis pauciflora subsp. *pauciflora*		*Conostylis pauciflora* subsp. *pauciflora* occurs in grey sand, limestone on hillslopes, consolidated dunes.	Highly Unlikely – There is no limestone on the site.
Jacksonia sericea	Waldjumi	Waldjumi grows in calcareous and sandy soils.	Possible – The site contains sandy calcareous soils
Parsonsia diaphanophleba		*Parsonsia diaphanophleba* occurs in alluvial soils along rivers.	Highly Unlikely – The site does not contain habitat for this species.
Stylidium longitubum	Jumping Jacks	Jumping Jacks prefer sandy clay, clay in seasonal wetlands.	Highly Unlikely – The site is not low-lying habitat.

* sourced from Florabase, DBCA database searches and SPRAT (DoEE, 2018) unless otherwise denoted

3.2.2 TEC/PEC Database Searches

A search of DBCA's Threatened (TEC) and Priority Ecological Communities (PEC) database was conducted within a radius of 5km around the site (11-0419EC) (Appendix 5). Eight conservation significant Ecological Communities were identified (Table 3).

Table 3: TEC and PECs identified in database searches within 5km of the site

Number	Description	Conservation Status in WA	Status under the EPBC Act
SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered (as FCT 19)
SCP19b	Woodlands over sedgelands in Holocene dune swales of the southern Swan Coastal Plain (original description; Gibson *et al.* (1994).	Critically Endangered	Endangered (as FCT 19)
SCP08	Herb rich shrublands in clay pans	Vulnerable	Critically Endangered
Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered
Walyungup Microbial	Microbial community of a coastal saline lake (Lake Walyungup)	Priority 1	
SCP24	Northern Spearwood shrublands and woodlands	Priority 3	
SCP25	Southern *Eucalyptus gomphocephala-Agonis flexuosa* woodlands	Priority 3	
SCP29b	Acacia shrublands on taller dunes	Priority 3	

3.3 Survey Conditions

The conditions that the survey was undertaken in are presented in Table 4 in order to assess the adequacy of the survey. In summary, there were no constraints to the survey.

Table 4: Statement of Botanical Survey Conditions

Issue	Constraints (Y/N)*	Comment
Competency/experience of the consultant conducting the survey	No	Dr Paul van der Moezel has extensive botanical survey experience in the Perth Metropolitan Region.
Proportion of the flora identified^	No	The timing of the detailed survey on 17 September was optimal to record most of the native species.
Sources of information (historic/recent or new data)	No	The flora of the Perth Metropolitan Region is well documented.
Proportion of the task achieved and further work that may need to be undertaken	No	No follow-up survey required as no Threatened Flora expected to occur in other seasons.
Timing/weather/season/cycle	No	The spring survey was optimal for most flora species.
Disturbances (Fire)	No	The fire age of the vegetation was >5 years.
Intensity of survey (e.g. In retrospect was the intensity adequate)	No	The small site and ease of access made for a full coverage.
Completeness (e.g. was relevant area fully surveyed)	No	
Resources (e.g. degree of expertise available for plant identification)	No	Experienced botanist undertook plant identifications on site.
Remoteness and/or access problems	No	Easily accessible site in the Perth Metropolitan Region.
Availability of contextual (e.g. bioregional) information for the study area.	No	Bush Forever report.

*Constraints have been rated as Significant, Moderate or No constraints

^Fungi and nonvascular flora (e.g. algae, mosses and liverworts) were not specifically surveyed for during the survey.

3.4 Flora

A total of 130 flora species were recorded on the site. The total included 83 native and 47 introduced species (Appendix 6). The relatively high percentage of introduced species (36%) reflected the degraded condition of the vegetation in much of the northern half of the site as well as around the edges of the site which are surrounded by market gardens and cleared rural properties that contain weeds. Many of the introduced species were grasses but several woody weeds were also present such as Maritime Pine (*Pinus maritima*), Olive Tree (*Olea europaea*) and Victorian Teatree (*Leptospermum laevigatum*).

The plant Families with the highest representation of species on the site were the Fabaceae (Wattles and Pea family – 17 species including 10 native and 7 introduced), Poaceae (Grass family – 10 species,

1 native and 9 introduced), Asteraceae (Daisy family – 10 species, 3 native and 7 introduced), Asparagaceae (Lily family – 9 species, all native) and the Proteaceae (Banksia family – 8 species, all native).

None of the species recorded were Threatened or Priority Flora species at State or Commonwealth level.

The number of species recorded in the 10m x 10m quadrats ranged from 18 – 40 (Appendix 7). The number of species varied with the condition of the vegetation. Vegetation in Very Good condition averaged 37.5 species per 100m2, vegetation in Good condition averaged 29.0 and vegetation in Degraded to Completely Degraded condition averaged 18 species, half of which were introduced.

3.5 Vegetation

3.5.1 Vegetation Complex

Vegetation Complexes are a broad unit for mapping vegetation in Western Australia based on the underlying landform and soil type.

The vegetation on the site is part of the Karrakatta - Central and South vegetation complex which is describe as "an open forest of Tuart-Jarrah-Marri, with Jarrah and Marri replacing Tuart while progressing eastwards. *Banksia attenuata, B. menziesii, B. grandis* and *Allocasuarina fraseriana* are also common tree species. (Heddle *et al.,* 1980).

The vegetation on the site meets the general description of this vegetation complex.

3.5.2 Vegetation Type

Vegetation Types are a finer unit of mapping vegetation at the local scale and is based on the structure and composition of the main strata of vegetation.

One vegetation type is considered to occur on the site (Figure 3) as follows:

> EgEmAf - *Eucalyptus gomphocephala* (Tuart)/*E. marginata* (Jarrah)/*Allocasuarina fraseriana* (Sheoak) Woodland to Open Forest over *Hibbertia hypericoides/Xanthorrhoea brunonis/Desmocladus flexuosus* Low Open Heath (Plate 4).
>
> Tuart is the dominant tree species 10-12m tall with Jarrah and Sheoak in lesser abundance and 4-5m high. *Banksia attenuata* and to a lesser extent *B. menziesii* were scattered trees to 4m on the site. The native Woody Pear (*Xylomelum occidentale*) was also common up to 4m in the central western part of the site.
>
> The understorey, where present, was dominated by *Hibbertia hypericoides* to 1m with *Xanthorrhoea brunonis, Acacia pulchella, Mesomelaena pseudostygia, Desmocladus flexuosus, Acanthocarpus preissii* and *Rhagodia baccata* also common species.

Plate 4: *Eucalyptus gomphocephala* (Tuart)/*E. marginata* (Jarrah)/*Allocasuarina fraseriana* (Sheoak) Woodland



3.5.3 Floristic Community Type

Floristic Community Types (FCT) are a description of the vegetation using the full composition of the flora, rather than the dominant species in each of the main strata. FCTs on the southern Swan Coastal Plain were initially determined by Gibson *et al.* (1994) using computer analysis of over 500 quadrats.

The quadrat data from the vegetation in Very Good condition was assessed against Table 12 of Gibson *et al.* (1994) to determine the most likely FCT for the vegetation on the site. The analysis gave a very high (100%) match for the following FCTs:

- FCT 28 ''Spearwood *Banksia attenuata* or *Banksia attenuata – Eucalyptus* woodlands"; and
- FCT 21a "Central *Banksia attenuata – Eucalyptus marginata* woodlands".

There was also a high match for FCT 25 "Southern *Eucalyptus gomphocephala-Agonis flexuosa* woodlands".

All three FCTs occur on Spearwood soils. The location of the site is within the boundaries of all three FCTs. While FCT 25 appears the most logical of the FCTs based on the presence of Tuart on the site and in the description of the FCT, all three FCTs can contain Tuart. Therefore, on the basis of the 100% match with FCT28 this report concludes that the vegetation on the site is most likely representative of FCT28.

3.6 Vegetation Condition

The condition of the vegetation was assessed according to the system devised by Keighery and described in Bush Forever (Government of Western Australia, 2000) (Table 5).

Table 5: Vegetation Condition Rating Scale.

Condition	Description
Pristine	Pristine or nearly so, no obvious signs of disturbance.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good	Vegetation structure altered, obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbance. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

Source: Government of Western Australia, 2000.

The condition of the vegetation ranged from Very Good to Completely Degraded (Figure 4). No areas of Excellent vegetation were recorded. The Degraded vegetation occurs mainly in the northern part of the site (Plate 5).

Plate 5: Vegetation in Completely Degraded Condition



The areas of Good (Plate 6) and Very Good (Plate 7) condition vegetation were mostly located in the southern part of the site.

Plate 6: Vegetation in Good Condition



Plate 7: Vegetation in Very Good Condition



3.7 Conservation Significance of Flora and Vegetation

3.7.1 Flora

Of the 23 species identified in the database search there was potential for one Threatened species (*Caladenia huegelii* – Grand Spider Orchid) and one Priority 3 species (*Jacksonia sericea*) to occur on the site. The Detailed site survey did not record any of these species on the site. The survey was undertaken at an appropriate time of year for the identification of these species. Therefore, there are no Threatened or Priority flora species on the site.

3.7.2 Vegetation

Vegetation Complex

The vegetation on the site is part of the Karrakatta Complex Central and South. There is approximately 29.5% of the Karrakatta Complex Central and South remaining on the southern Swan Coastal Plain based on the pre-European extent with 2.5% in secure tenure (EPA 2006). More recently the Perth Biodiversity Project (WALGA, 2013) estimated that 23.91% of Karrakatta Complex Central and South remains compared to its pre-European extent (WALGA, 2013).

Floristic Community Type

The conservation significance of vegetation types on the southern Swan Coastal Plain is assessed using the Floristic Community Type (FCT) level of vegetation description (Gibson *et al*., 1994).

PGV Environmental considers the vegetation on the site is likely to represent FCT 28 on the basis that the quadrat data for all species, ie. trees, shrubs and sub-shrubs had a 100% match with the species in Table 12 of Gibson *et al.* (1994). FCT28 is not a Threatened or Priority Ecological Community.

Banksia Woodland TEC Assessment

The density of Banksia trees was measured on the site to assess whether the vegetation could be considered the Banksia Woodland of the Swan Coastal Plain Threatened Ecological Community (TEC) which is listed under the Commonwealth EPBC Act.

For an area of bushland to be the Banksia Woodland TEC the area needs to have a distinctive low tree layer of Banksia species. The TEC can include taller trees such as Tuart, Jarrah and Sheoak above the Banksia canopy. The Banksia density measured on the site in the belt transects averaged 31 trees per hectare. This is considered a low density compared to a typical Banksia Low Open Woodland which would have from 100-300 trees per hectare. The Tuart, Jarrah and Sheoak trees dominate the tree canopy, rather than being sometimes present. The Banksia trees do not form a distinctive lower tree layer as is required according to the Conservation Advice for the Banksia Woodland TEC (DoEE, 2016).

As a result of the dominance of Tuart, Jarrah and Sheoak trees and the low density of Banksia trees on the site, PGV Environmental concludes that the Banksia Woodland of the Swan Coastal Plain TEC does not occur on the site.

Tuart Woodland TEC Assessment

The Tuart Woodlands and Forests of the Swan Coastal Plain was listed as a Threatened Ecological Community (TEC) under the Commonwealth EPBC Act on 4 July 2019. A description of the Tuart Woodland TEC is available through the EPBC Act listing and more specifically the *Approved Conservation Advice (incorporating listing advice) for the Tuart (Eucalyptus gomphocephala) woodlands and forests of the Swan Coastal Plain ecological community* released by the Commonwealth Government. According to the Conservation Advice the diagnostic characteristics of the TEC are:

- The ecological community is limited to patches of vegetation (with their associated biota) that meet all of the following key diagnostic characteristics:

- Occurs in the Swan Coastal Plain Bioregion, Western Australia (IBRA v7. Department of the Environment 2012).
- Primarily occurs on the Spearwood and Quindalup dune systems but can also occur on the Bassendean dunes and Pinjarra Plain. It can occur on the banks of rivers and wetlands.
- The primary defining feature is the presence of at least two living established *Eucalyptus gomphocephala* (Tuart) trees in the uppermost canopy layer, although they may co-occur with trees of other species. There is a gap of no more than 60 m between the outer edges of the canopies of adjacent Tuart trees. These trees may occur either as single stemmed trees or as a mallee growth form.
- Most often occurs as a woodland but can occur in other structural forms, For example, forest, open forest, woodland, open woodland, and various mallee forms (NVIS Technical Working Group 2017).
- Other tree species may be present in the canopy or sub-canopy. They commonly include: *Agonis flexuosa* (Peppermint) and *Banksia grandis* (Bull Banksia) (both in the southern part of the range), *Banksia attenuata* (Candlestick Banksia), *Eucalyptus marginata* (Jarrah); and less commonly, *Corymbia calophylla* (Marri), *Banksia menziesii* (Firewood Banksia) and *Banksia prionotes* (Acorn Banksia).
- An understorey of native plants is typically present, which may include grasses, herbs and shrubs, although this is often modified by disturbance.

The Conservation Advice defines a 'Patch' of the ecological community as:

- A patch of the ecological community is a discrete and mostly continuous area of vegetation that meets the key diagnostic characteristics.
- Boundaries for a patch can extend beyond a site or property boundary, or potential area of impact for a proposed action.
- The patch boundary is 30 m beyond the outer canopy of the established Tuart trees (≥15 cm diameter at breast height (DBH)), including dead Tuart trees (stags). See Plate 8.
- Where a dead Tuart tree (stag) is being considered for inclusion in a patch of the ecological community, the vertical projection of its outermost remaining branches is used to define the edge of its canopy. If the species of a stag tree is unclear, if the edge of its canopy is within 60 m of an identified Tuart tree the stag is presumed to be a Tuart.
- Patches of Tuart woodlands and forests may contain areas that vary in structural or biological complexity. One part of a patch may have a larger number of mature trees and more ecological diversity, whereas another part of the same patch may demonstrate fewer mature trees and less groundcover. Areas with soil exposed and/or plant litter can also be expected within this ecological community.
- Variation in quality or condition of vegetation across a patch should not necessarily be considered to be evidence of multiple patches. Patches of the ecological community can be spatially variable and are often characterised by one or more areas within a patch that meet higher condition thresholds amongst areas of lower condition.
- If an area meets the key diagnostic characteristics but the average condition across that area falls below the minimum condition thresholds, the largest area or areas of at least 0.5 ha that meet minimum condition thresholds on average, should be specified as the patch or patches of the nationally listed ecological community. This may result in multiple patches of the

ecological community being identified within the overall area first identified as meeting the key diagnostics.

- A patch may include small areas without understorey vegetation, such as bare ground, as well as waterbodies or hardscape (e.g. roads, paths, car parks, or buildings) that do not significantly alter the overall function of the ecological community. These small areas do not break up a patch, or divide a patch into multiple patches, as long as there are some parts of the canopy within 60 m of the outer edges of the canopies of adjacent Tuart trees (Plate xx). However, existing buildings and other human-made structures and gardens are not part of the nationally protected ecological community and should be excluded from the calculation of patch size and condition. See Plate 9.

Patches of the ecological community extend to 30 m beyond the outermost canopy of the Tuart trees (DoEE, 2019b).

Plate 8: Figure 3 from the Tuart Woodland Listing Advice

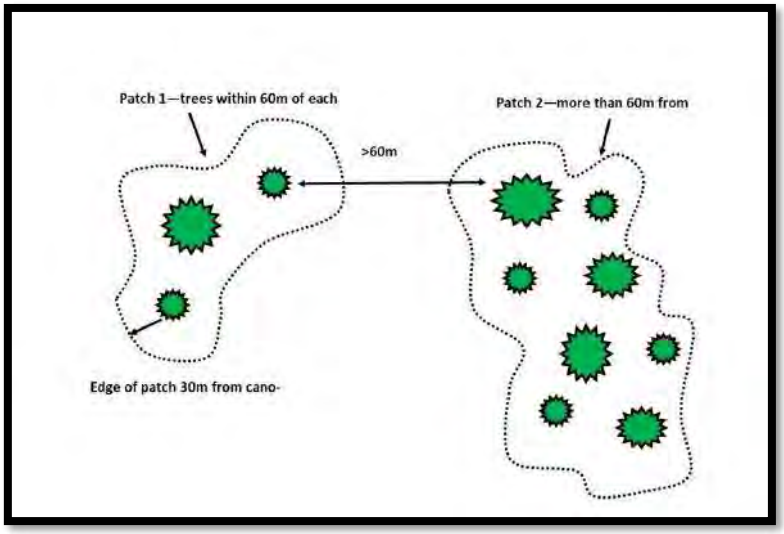
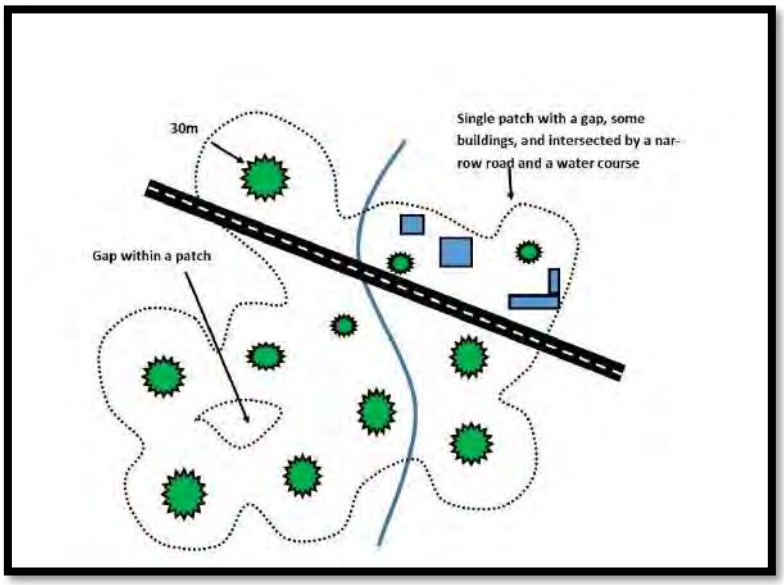


Plate 9: Figure 4 from the Tuart Woodland Listing Advice



For confirmed patches of the ecological community, following the key diagnostic characteristics and patch definition above (Step 1), the following requirements for information on condition need to be assessed to indicate if a patch is part of the TEC:

- If the patch is smaller than 0.5ha it is not part of the nationally protected ecological community.
- If the patch is at least 0.5 ha and up to 5 ha in size, ground surveys are required to determine which condition category applies (Table 6). Patches in this size range are presumed to be part of the nationally protected ecological community unless surveys indicate they do not meet the minimum condition required for national protection. For patches in this size range inclusion in the nationally protected ecological community is determined by surveyed characteristics such as native plant species richness and contribution to cover, habitat values, evidence of regeneration and landscape characteristics.
- All patches of 5 ha or greater that meet the key diagnostic characteristics are part of the nationally protected ecological community.

Table 6: Tuart Woodland TEC Condition Categories and Thresholds

Biotic thresholds	**Patch size**	
	≥2 ha <5 ha	**≥0.5 ha <2 ha**
Very high condition ≥80 % of all understorey^ vegetation cover is native# Or At least 12 native understorey^ species per 0.01 ha (10 m x 10 m plot or equivalent sample unit)	Medium sized patches with very high condition understorey. PART OF THE PROTECTED ECOLOGICAL COMMUNITY	Smaller patches with very high condition understorey. PART OF THE PROTECTED ECOLOGICAL COMMUNITY
High condition ≥60 % of all understorey^ vegetation cover is native# Or At least 8 native understorey^ species per 0.01 ha (10 m x 10 m plot or equivalent sample unit)	Medium sized patches with high condition understorey. PART OF THE PROTECTED ECOLOGICAL COMMUNITY	Smaller patches with high condition understorey. AND That either: have an important landscape role (≤100 m to native vegetation)* OR have a habitat role (≥2 very large trees per 0.5 ha)* OR show regeneration (≥15 seedlings and/or saplings per 0.5 ha)* PART OF THE PROTECTED ECOLOGICAL COMMUNITY
Moderate condition ≥50 % of all understorey^ vegetation cover is native# Or	Medium sized patches with moderate condition understorey. AND That either: have an important landscape role (≤100 m to native vegetation)*	NOT PART OF THE PROTECTED ECOLOGICAL COMMUNITY (but may be a focus for local protection or restoration)

Biotic thresholds	Patch size	
	≥2 ha <5 ha	≥0.5 ha <2 ha
At least 4 native understorey^ species per 0.01 ha (10 m x 10 m plot or equivalent sample unit)	OR have a habitat role (≥2 very large trees per 0.5 ha)* OR show regeneration (≥15 seedlings and/or saplings per 0.5 ha)* PART OF THE PROTECTED ECOLOGICAL COMMUNITY	
Poor Has minimal or no native cover and species richness. That is: <50 % of all understorey^ vegetation cover is native# And Less than 4 native understorey^ species per 0.01 ha (10 m x 10 m plot or equivalent sample unit)	NOT PART OF THE PROTECTED ECOLOGICAL COMMUNITY (but may be a focus for local protection or restoration)	NOT PART OF THE PROTECTED ECOLOGICAL COMMUNITY (but may be a focus for local protection or restoration)

The Tuart vegetation on the site was assessed against the Tuart Woodlands TEC criteria (Table 7).

In summary, the Tuart vegetation on the site was assessed as being one 'patch' of Tuart woodland and, because of the size of the patch (around 9ha) and overall High to Very High condition category using the system in the Conservation Advice, all the vegetation on the site is considered the Tuart Woodland TEC.

Table 7: Tuart Woodlands and Forests TEC Assessment

Key diagnostic characteristics♦	**Information**	**Key diagnostic questions*** (Refer to Section 3.2 of the Approved Conservation Advice for a complete explanation of these diagnostic features – other sections of the Approved Conservation Advice are referenced where relevant)	**Response (yes/no/possibly) and detailed comments.**
Location and physical environment	Bioregion	Is the proposal site within the Swan Coastal Plain IBRA bioregion?	Yes
Soils and Landform	Soil type	Is the soil type consistent with where the Tuart Woodlands and Forests may occur? (see Section 2.2.1♦)	Yes – Spearwood Dunes
	Location in the landscape, topography	Is the topography/physical environment consistent with where the Tuart Woodlands and Forests may occur? Is the site associated with any hydrology (groundwater/surface water)?	Yes - environment consistent with where Tuart woodlands and forests occur. Not associated with any hydrological features
Structure	Presence of Tuart trees	How many Tuart trees are present and are they consistent with the characteristics set out in the Approved Conservation Advice? **Note:** Please present this information in terms of total number of trees (dead, established, seedlings etc.) and trees per hectare of the footprint. Diagrams/maps should also be provided.	Abundant Tuarts (>15cm dbh) throughout the site
	Structural form	What structural form is the vegetation?	Woodland
Composition	Dominant tree species, emergent tree layer, understory	Is the composition of the community consistent with the characteristics set out in the Approved Conservation Advice? What other tree species are present? How many native understorey species are present and what is the number of weedy species/proportion of weeds?	Dominant tree species is Tuart. Jarrah and Sheoak also present. Understorey is a mix of native and introduced species depending on condition of the vegetation. Proportion of weeds throughout the site is 36%.

Key diagnostic characteristics♦	**Information**	**Key diagnostic questions*** (Refer to Section 3.2 of the Approved Conservation Advice for a complete explanation of these diagnostic features – other sections of the Approved Conservation Advice are referenced where relevant)	**Response (yes/no/possibly) and detailed comments.**
Defining a patch of Tuart Woodlands and Forests	Patch definition	What is the extent of the patch? **Note:** Descriptions of patch extent must include analysis of canopy extent and associated understorey vegetation (see Section 3.2.2♦). Patches may extend beyond the project area or include areas of infrastructure (i.e. road, powerline). The referral should make clear how, and how much of the patch will be directly or indirectly impacted.	The patch is considered all of the native vegetation on the site, around 9ha.
Patch condition	Condition thresholds	Using the condition categories in this section, what is the patch condition? (Section 3.3.1♦) What is the quality and size (hectares) of the vegetation community in and around the site where the proposed action will occur? Is the patch expected to improve in condition (e.g. after appropriate fire management) or is there a threatening process underway that will reduce the current size and/or condition? **Note:** Refer to Section 3.4 – Step 3 – Further information to assist in identifying patches of the protected ecological community and avoiding significant adverse impacts If patch quality varies over the site; characterisation of the variation should be provided. Patch condition includes consideration of thresholds for characteristics such as plant species richness, landscape features, Tuart	The vegetation in Good to Very Good condition have more than 20 species per 10m x 10m quadrat which is rated as Very High condition according to Table 2 of the Conservation Advice. The vegetation in Degraded condition have an average of 9 native species per 10m x 10m quadrat which is rated as a High condition according to the Conservation Advice Condition Category criteria. Some of the Completely Degraded areas of vegetation have less than 8 species per quadrat but more than 4 and are rated in Moderate condition.

Key diagnostic characteristics♦	Information	Key diagnostic questions* (Refer to Section 3.2 of the Approved Conservation Advice for a complete explanation of these diagnostic features – other sections of the Approved Conservation Advice are referenced where relevant)	Response (yes/no/possibly) and detailed comments.
		tree age and size and other habitat roles of the vegetation. Other vegetation condition measures (e.g. Keighery scale) do not necessary reflect the condition thresholds and both should be provided, where relevant. Where threats are identified (i.e. those listed in Appendix C of the Approved Conservation Advice) please provide further information on what these are and how they have impacted the condition.	

The complete key diagnostic characteristics are provided in the Approved Conservation Advice

* The Tuart Woodlands and Forests may include restored, planted or revegetated flora. Do not exclude vegetation from being classed as the Tuart Woodlands and Forests because it is a planted, restoration or revegetation site (unless it is a garden).

Comments should include references to appropriate supporting information and data.

Ecological Linkage

The site is linked to native vegetation on large private landholdings to the west through a narrow vegetated corridor located at the southern end of Lot 878 Stakehill Road. Small birds and ground-dwelling fauna would be able to move from the site to the vegetated areas further west through this corridor.

4 FAUNA

4.1 Methodology

The Level 1 Fauna Survey was undertaken in accordance with EPA Technical Guidance *Fauna Surveys for Environmental Impact Assessment* (EPA, 2016b). Desktop studies were undertaken to identify habitats and potential threatened species that may occur on the site. A site reconnaissance was conducted by PGV Environmental on 27 March 2019. The inspection included traversing native vegetation on the site on foot.

4.2 Desktop Studies

Desktop studies were undertaken to identify conservation significant species potentially present on the site. A search of the DBCA Database (Appendix 8), Naturemap database (Appendix 2) and the EPBC Act Protected Matters Search Tool (Appendix 3) identified threatened species of fauna listed as potentially occurring within a 5km radius of the site (Table 8).

Table 8: List of Fauna Species Identified from Fauna Database Searches

Scientific Name	Common Name	Conservation Status, WA	Status under EPBC Act
Bettongia penicillata ogilbyi	Woylie, Brush-tailed Bettong	Schedule 1 - CR	Endangered
Calidris ferruginea	Curlew Sandpiper	Schedule 1 - CR	Critically Endangered
Limosa lapponica menzbieri	Bar-tailed Godwit (northern Siberian)	Schedule 1 - CR	Marine/ Migratory
Numenius madagascariensis	Eastern Curlew	Schedule 1 - CR	Critically Endangered
Pseudocheirus occidentalis	Western Ringtail Possum, Ngwayir	Schedule 1 - CR	Critically Endangered
Botaurus poiciloptilus	Australasian bittern	Schedule 2 - EN	Endangered
Calidris canutus	Red Knot	Schedule 2 - EN	Marine/ Migratory
Calyptorhynchus baudinii	Baudin's Black Cockatoo	Schedule 2 - EN	Endangered
Calyptorhynchus latirostris	Carnaby's Black Cockatoo	Schedule 2 - EN	Endangered
Rostratula australis (Rostratula benghalensis australis)	Australian Painted Snipe	Schedule 2 - EN	Endangered Marine/ Migratory
Calyptorhynchus banksii naso	Forest Red-tailed Black-Cockatoo	Schedule 3 - VU	Vulnerable
Dasyurus geoffroii	Chuditch, Western Quoll	Schedule 3 - VU	Vulnerable
Leipoa ocellata	Mallee Fowl	Schedule 3 - VU	Vulnerable
Limosa lapponica baueri	Bar-tailed Godwit (western Alaskan)	Schedule 3 - VU	Marine/ Migratory
Westralunio carteri	Carter's Freshwater Mussel	Schedule 3 - VU	Vulnerable

Scientific Name	Common Name	Conservation Status, WA	Status under EPBC Act
Ardenna carneipes (Puffinus carneipes)	Flesh-footed Shearwater, Fleshy-footed Shearwater	Schedule 3 - VU Schedule 5 - IA	Marine/ Migratory
Actitis hypoleucos (Tringa hypoleucos)	Common Sandpiper	Schedule 5 - IA	Marine/ Migratory
Apus pacificus	Fork-tailed Swift	Schedule 5 - IA	Marine/Migratory
Calidris melanotos	Pectoral Sandpiper	Schedule 5 - IA	Marine/ Migratory
Calidris ruficollis	Red-necked Stint	Schedule 5 - IA	Marine/ Migratory
Hydroprogne caspia (Sterna caspia)	Caspian Tern	Schedule 5 - IA	Marine/ Migratory
Motacilla cinerea	Grey Wagtail	Schedule 5 - IA	Migratory/ Marine
Pandion cristatus (Pandion haliaetus)	Osprey	Schedule 5 - IA	Marine/ Migratory
Pluvialis squatarola	Grey Plover	Schedule 5 - IA	Marine/ Migratory
Sterna dougallii	Roseate Tern	Schedule 5 - IA	Marine/ Migratory
Thalasseus bergii (Sterna bergii)	Crested Tern	Schedule 5 - IA	Marine/ Migratory
Tringa nebularia	Common Greenshank	Schedule 5 - IA	Marine/ Migratory
Phascogale tapoatafa wambenger	South-western Brush-tailed Phascogale, Wambenger	Schedule 6 - CD	
Ardea alba (Ardea modesta)	Great Egret, White Egret		Marine
Ardea ibis	Cattle Egret		Marine
Haliaeetus leucogaster	White-bellied Sea-eagle		Marine
Merops ornatus	Rainbow Bee-eater		Marine
Pachyptila turtur	Fairy Prion		Marine
Ctenotus gemmula (Swan Coastal Plain pop	Jewelled South-west Ctenotus	Priority 3	
Lerista lineata	Perth Slider, Lined Skink	Priority 3	
Idiosoma sigillatum	Swan Coastal Plain shield-backed trapdoor spider	Priority 4	
Isoodon fusciventer	Southern Brown Bandicoot, Quenda	Priority 4	
Synemon gratiosa	Graceful Sun-moth	Priority 4	
Thinornis rubricollis (Charadrius rubricollis)	Hooded Plover	Priority 4	Marine
Bettongia penicillata ogilbyi	Woylie, Brush-tailed Bettong	Schedule 1 - CR	Endangered

Fauna are classified under five different Priority codes and rare and endangered fauna are classified under the *Wildlife Conservation (Specially Protected Fauna) Notice 2014* into five schedules of taxa. These are outlined in Appendix 4.

4.3 Fauna Habitat

One fauna habitat was considered present on the site which was an Open Woodland Habitat (Plate 10).

Plate 10: Open Woodland Fauna Habitat



Fauna habitat can be assessed using a number of factors including, the size of the habitat, the level of habitat connectivity, availability of specific resources (e.g. tree hollows) and overall vegetation quality. The habitat was assessed according to the following categories:

High Quality Fauna Habitat – These areas closely approximate the vegetation mix and quality that would have been in the area prior to any disturbance. The habitat has connectivity with other habitats and is likely to contain the most natural vertebrate fauna assemblage.

Very Good Fauna Habitat - These areas show minimal signs of disturbance (e.g. grazing, clearing, fragmentation, weeds) and generally retain many of the characteristics of the habitat if it had not been disturbed. The habitat has connectivity with other habitats and fauna assemblages in these areas are likely to be minimally affected by disturbance.

Good Fauna Habitat – These areas showed signs of disturbance (e.g. grazing, clearing, fragmentation, weeds) but generally retain many of the characteristics of the habitat if it had not been disturbed. The habitat has connectivity with other habitats and fauna assemblages in these areas are likely to be affected by disturbance.

Disturbed Fauna Habitat – These areas showed signs of significant disturbance. Many of the trees, shrubs and undergrowth are cleared. These areas may be in the early succession and regeneration stages. Areas may show signs of significant grazing, contain weeds or have been damaged by vehicle or machinery. Habitats are fragmented or have limited connectivity with other fauna habitats. Fauna assemblages in these areas are likely to differ significantly from what might be expected in the area had the disturbance not occurred.

Highly Degraded Fauna Habitat – These areas often have a significant loss of vegetation, an abundance of weeds, and a large number of vehicle tracks or are completely cleared. Limited or no fauna habitat connectivity. Faunal assemblages in these areas are likely to be significantly different to what might have been in the area pre-disturbance. (Coffey Environments, 2009).

The Open Woodland Habitat has vegetation in Degraded to Very Good condition with the structure of the vegetation impacted in areas. The vegetation has some linkage to other areas of bushland therefore the habitat is considered to be Good Fauna Habitat.

4.4 Conservation Significant Species

Outlined below in Table 9 is a short description of the preferred habitat for each of the species that were identified in the DBCA Database Search (Appendix 6), NatureMap Species Report (Appendix 2) and the EPBC Protected Matters Search Tool (Appendix 3) in Table 8. The preferred habitat has been compared to the habitats on the site described above and the likelihood of each species to be present was determined.

Table 9: Preferred Habitat of Conservation Significant Fauna Species

Scientific Name	Common Name	Habitat*	Likelihood of occurring on the site
Bettongia penicillata ogilbyi	Woylie, Brush-tailed Bettong	The Woylie habitat types ranged from forest to grassland, coastal and inland. During the day the Woylie shelters under patches of dense undergrowth, logs and rock-cavities and occasionally in burrows.	Highly Unlikey – the site is too disturbed
Calidris ferruginea	Curlew Sandpiper	Curlew Sandpipers mainly occur on intertidal mudflats in sheltered coastal areas, such as estuaries, bays, inlets and lagoons, and also around non-tidal swamps, lakes and lagoons near the coast, and ponds in saltworks and sewage farms.	No – not coastal habitat
Limosa lapponica menzbieri	Bar-tailed Godwit (northern Siberian)	The Bar-tailed Godwit is found mainly in coastal habitats such as large intertidal sandflats, banks, mudflats, estuaries, inlets, harbours, coastal lagoons and bays. It is found often around beds of seagrass and, sometimes, in nearby saltmarsh.	No – not coastal habitat
Numenius madagascariensis	Eastern Curlew	The Eastern Curlew is most commonly associated with sheltered coasts, especially estuaries, bays, harbours, inlets and coastal lagoons, with large intertidal mudflats or sandflats, often with beds of seagrass. Occasionally, the species occurs on ocean beaches (often near estuaries), and coral reefs, rock platforms, or rocky islets.	No – not coastal habitat

Scientific Name	Common Name	Habitat*	Likelihood of occurring on the site
Pseudocheirus occidentalis	Western Ringtail Possum, Ngwayir	The Western Ringtail Possum is a medium sized nocturnal marsupial. This species occurs in and near coastal Peppermint Tree (*Agonis flexuosa*) forest and Tuart (*Eucalyptus gomphocephala*) dominated forest with a Peppermint Tree understorey.	No – no suitable habitat on the site
Botaurus poiciloptilus	Australasian bittern	The Australasian Bittern occurs mainly in densely vegetated freshwater wetlands and, rarely, in estuaries or tidal wetlands.	No – not wetland habitat
Calidris canutus	Red Knot	In Australasia the Red Knot mainly inhabit intertidal mudflats, sandflats and sandy beaches of sheltered coasts, in estuaries, bays, inlets, lagoons and harbours; sometimes on sandy ocean beaches or shallow pools on exposed wave-cut rock platforms or coral reefs.	No – not coastal habitat
Calyptorhynchus baudinii	Baudin's Black Cockatoo	Baudin's Black-Cockatoo mainly occurs in eucalypt forests, especially Jarrah (E. marginata), Marri (Corymbia calophylla), also Karri (E. diversicolor) forest, often feeding in the understorey on proteaceous trees and shrubs, especially banksias (SEWPaC, 2012).	Unlikely – outside of modelled distribution
Calyptorhynchus latirostris	Carnaby's Black Cockatoo	Carnaby's Cockatoo is found in the south-west of Australia from Kalbarri through to Ravensthorpe. It has a preference for feeding on the seeds of Banksia, Dryandra, Hakea, Eucalyptus, Grevillea, Pinus and Allocasuarina spp. It is nomadic often moving toward the coast after breeding. It breeds in tree hollows that are 2.5 - 12m above the ground and have an entrance 23-30cm with a depth of 1-2.5m. Nesting mostly occurs in smooth-barked trees (e.g. Salmon Gum, Wandoo, Red Morrell) (SEWPaC, 2012)	Potentially occurs intermittently on the site
Rostratula australis (Rostratula benghalensis australis)	Australian Painted Snipe	The Australian Painted Snipe has been recorded at wetlands in all states of Australia but is most common in eastern Australia. It generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans. It also uses inundated or waterlogged grassland or saltmarsh, dams, rice crops, sewage farms and bore drains. Typical sites include a cover of vegetation, including grasses.	No – not wetland habitat

Scientific Name	Common Name	Habitat*	Likelihood of occurring on the site
Calyptorhynchus banksii naso	Forest Red-tailed Black-Cockatoo	Forest Red-tailed Black Cockatoos frequent the humid to sub-humid south-west of Western Australia from Gingin in the north, to Albany in the south and west to Cape Leeuwin and Bunbury (SEWPaC, 2012). It nests in tree hollows with a depth of 1-5m, that are predominately Marri (Corymbia calophylla), Jarrah (Eucalyptus marginata) and Karri (E. diversicolor) and it feeds primarily on the seeds of Marri.	Potentially occurs intermittently on the site
Dasyurus geoffroii	Chuditch, Western Quoll	The Chuditch have been known to occupy a wide range of habitats including woodlands, dry sclerophyll forests, riparian vegetation, beaches and deserts. They are opportunistic feeders, and forage on the ground at night, feeding on invertebrates, small mammals, birds and reptiles.	Highly Unlikely due to surrounding clearing and likely domestic predators
Leipoa ocellata	Mallee Fowl	Mallee fowl have been found in mallee regions of southern Australia from approximately the 26th parallel of latitude southwards in mallee bushland.	No – Not mallee habitat
Limosa lapponica baueri	Bar-tailed Godwit (western Alaskan)	The Bar-tailed Godwit is found mainly in coastal habitats such as large intertidal sandflats, banks, mudflats, estuaries, inlets, harbours, coastal lagoons and bays. It is found often around beds of seagrass and, sometimes, in nearby saltmarsh.	No – not coastal habitat
Westralunio carteri	Carter's Freshwater Mussel	Carter's Feshwater Mussel is South-West Western Australia's only freshwater mussel (Murdoch University & SERCUL, 2012). Carter's Freshwater Mussel occurs in freshwater streams, rivers, reservoirs and lakes (ICUN, 2015a) and is intolerant to dehydration for more than three days and salinity (Murdoch University & SERCUL, 2012).	No - no permanent water on the site
Ardenna carneipes (Puffinus carneipes)	Flesh-footed Shearwater, Fleshy-footed Shearwater	The Flesh-footed Shearwater mainly occurs in the subtropics over continental shelves and slopes and occasionally inshore waters. Burrows are situated in areas that provide a clear flight-path for birds to enter and exit their colonies.	No – not wetland habitat
Actitis hypoleucos (Tringa hypoleucos)	Common Sandpiper	The Common Sandpiper is mostly found around muddy margins or rocky shores. Generally the species forages in shallow water and on bare soft mud at the edges of wetlands.	No – not wetland habitat

Scientific Name	Common Name	Habitat*	Likelihood of occurring on the site
Apus pacificus	Fork-tailed Swift	The Fork-tailed Swift is almost exclusively aerial and is not known to breed in Australia. They are seen in inland plains but sometimes above foothills or in coastal areas. They often occur over cliffs and beaches and also over islands and sometimes well out to sea. They also occur over settled areas, including towns, urban areas and cities. *Apus pacificus* subsp. *pacificus* is the only subspecies to migrate to Australia.	No – this species is aerial and is unklikely to land on the site
Calidris melanotos	Pectoral Sandpiper	The Pectoral Sandpiper prefers shallow fresh to saline wetlands and is found at coastal lagoons, estuaries, bays, swamps, lakes, inundated grasslands, saltmarshes, river pools, creeks, floodplains and artificial wetlands.	No – not wetland habitat
Calidris ruficollis	Red-necked Stint	The Red-necked Stint is mostly found in coastal areas, including in sheltered inlets, bays, lagoons and estuaries with intertidal mudflats, often near spits, islets and banks and, sometimes, on protected sandy or coralline shores.	No – not coastal habitat
Hydroprogne caspia (Sterna caspia)	Caspian Tern	The Caspian Tern is mostly found in sheltered coastal embayments (harbours, lagoons, inlets, bays, estuaries and river deltas) and those with sandy or muddy margins are preferred.	No – not coastal habitat
Motacilla cinerea	Grey Wagtail	The Grey Wagtail is mostly recorded in coastal areas in Western Australia (ALA, 2015) however is widespread. There is non-breeding habitat only in Australia and the species has a strong association with water, particularly rocky substrates along water courses but also lakes and marshes.	No – not coastal habitat
Pandion cristatus (Pandion haliaetus)	Osprey	Ospreys occur in littoral and coastal habitats and terrestrial wetlands of tropical and temperate Australia and offshore islands. They feed on fish, especially mullet where available, and rarely take molluscs, crustaceans, insects, reptiles, birds and mammals.	No – not coastal habitat
Pluvialis squatarola	Grey Plover	Grey Plovers occur almost entirely in coastal areas, where they usually inhabit sheltered embayments, estuaries and lagoons with mudflats and sandflats, and occasionally on rocky coasts with wave-cut platforms or reef-flats, or on reefs within muddy lagoons.	No – not coastal habitat
Sterna dougallii	Roseate Tern	The Roseate Tern is a migratory coastal seabird that feeds by plunge diving. This species breeds in sites surrounded by walls and rocks or in the shelter of vegetation (in temperate regions) (Birdlife International, 2014a).	No – not coastal habitat

Scientific Name	Common Name	Habitat*	Likelihood of occurring on the site
Thalasseus bergii (Sterna bergii)	Crested Tern	The Crested Tern occurs in coastal Areas (Birdlife Australia, 2018).	No – not coastal habitat
Tringa nebularia	Common Greenshank	The Common Greenshank is a wader and does not breed in Australia. This species can be found in many types of wetlands and has the widest distribution of any shorebird in Australia. This species typically feeds on molluscs, crustaceans, insects, and occasionally fish and frogs.	No – not wetland habitat
Phascogale tapoatafa wambenger	South-western Brush-tailed Phascogale, Wambenger	Southern Brush-tailed Phascogales are arboreal marsupials which require tree hollows in suitable woodland or forest and rely on abundant invertebrate prey to sustain populations (Pescott, 2012).	Highly Unlikely due to surrounding clearing and likely domestic predators
Ardea alba (Ardea modesta)	Great Egret, White Egret	The Eastern Great Egret has been reported in a wide range of wetland habitats and usually frequents shallow waters. This species feeds on fish, insects, crustaceans, molluscs, frogs, lizards, snakes and small birds and mammals.	No – not wetland habitat
Ardea ibis	Cattle Egret	The Cattle Egret occurs in tropical and temperate grasslands, wooded lands and terrestrial wetlands with breeding in Western Australia recorded in the far north in Wyndham in colonies in wooded swamps such as mangrove forest. This species forages away from water on low lying grasslands, improved pastures and croplands generally in areas that have livestock eating insects, frog, lizards and small mammals.	No – not the preferred habitats for this species
Haliaeetus leucogaster	White-bellied Sea-eagle	The White-bellied Sea-Eagle is found in coastal habitats with large areas of open water, especially those close to the sea-shore. This species feeds opportunistically on a variety of fish, birds, reptiles, mammals and crustaceans, and on carrion and offal.	No – not coastal habitat
Merops ornatus	Rainbow Bee-eater	Populations of the Rainbow Bee-eater that breed in northern Australia are considered to be resident, and in many northern localities the Rainbow Bee-eater is present throughout the year. The Rainbow Bee-eater nests in a burrow dug in the ground. It is found across the better-watered parts of WA including islands preferring lightly wooded, sandy country near water.	Potentially an intermittent visitor to the site
Pachyptila turtur	Fairy Prion	The Fairy Prion occurs over oceans and coastal breeding islands (ALA, 2015a).	No – not coastal habitat

Scientific Name	Common Name	Habitat*	Likelihood of occurring on the site
Ctenotus gemmula (Swan Coastal Plain pop	Jewelled South-west Ctenotus	The Jewelled south-west Ctenotus inhabits sand plains with heaths. It is also found in Banksia or Mallee woodlands (ICUN, 2015b).	Unlikely – not the preferred habitat of this species
Lerista lineata	Perth Slider, Lined Skink	The Lined Skink is a burrowing species that occurs in pale sandy soils with coastal heath and shrubland areas in isolated populations in the south-west and mid-west coast of Western Australia. It feeds on termites and other small insects (AROD, 2014).	Unlikely – not the preferred habitat of this species
Idiosoma sigillatum	Swan Coastal Plain shield-backed trapdoor spider	The Swan Coastal Plain Shield-backed Trapdoor Spider arranges fallen twigs from the sheoak tree around the rim of its burrow entrance, enabling it to feel the vibrations of unsuspecting prey that wander by (Curtin, 2018).	Possible as sheoak habitat occurs on the site
Isoodon fusciventer	Southern Brown Bandicoot, Quenda	Southern Brown Bandicoots are small grey marsupials that prefer dense scrub (up to one metre high). Their diet includes invertebrates (including earthworms, adult beetles and their larvae), underground fungi, subterranean plant material, and very occasionally, small vertebrates (DEC, 2012).	Possibly present on the site
Synemon gratiosa	Graceful Sun-moth	The Graceful Sun-moth is a diurnal moth with dull coloured brown to black forewings and brightly coloured orange hind wings. The larvae burrow into the rhizomes of Lomandra maritima and Lomandra hermaphrodita exclusively and therefore require the presence of one or both of these species to be present in an area (Bishop *et al*., 2011).	Unlikely – *Lomandra maritima* did not occur at densities that provide habitat for this species
Thinornis rubricollis (Charadrius rubricollis)	Hooded Plover	The Hooded Plover primarily inhabits sandy, ocean beaches, with the highest densities on beaches with large amounts of beach-washed seaweed that are backed by extensive open dunes. In Western Australia the species also inhabits inland and coastal salt lakes (Birdlife International 2014)	No – not coastal or wetland habitat

* Habitat descriptions from DoEE (2016) SPRAT Database unless otherwise denoted

The Open Woodland Habitat may provide some foraging habitat Carnaby's Black Cockatoos (*Calyptorhynchus latirostris*) and Forest Red-tailed Black-Cockatoo (*Calyptorhynchus banksii naso*) as it has some tree species that are recognised foraging habitat (Valentine and Stock, 2008; Groom, 2011). The site also contains potential breeding habitat. See section 5 for further information on Black Cockatoos.

The site also potentially has habitat for the Swan Coastal Plain shield-backed trapdoor spider (*Idiosoma sigillatum*) and Southern Brown Bandicoot, Quenda (*Isoodon fusciventer*). Both species are Priority 4.

The Rainbow Bee-eater (*Merops ornatus*), listed Marine under the EPBC Act, may potentially utilise some sections of the site as part of a much larger home range although this species is only likely to occur infrequently.

4.5 Pest Fauna

The site shows signs of use by rabbits. Feral cats, foxes, rats and mice are also likely to be present.

4.6 Biodiversity Value

The EPA's (2002) *Terrestrial Biological Surveys as an Element of Biodiversity Protection Position Statement No. 3* indicated an ecological assessment of a site must consider its biodiversity value at the genetic, species and ecosystem levels; and its ecological functional value at the ecosystem level. The ecosystem on the site has been disturbed and the fauna assemblage would be modified. There is likely to be a high percentage of introduced feral species such as foxes and rabbits and increased domestic predators such as cats.

5 BLACK COCKATOO HABITAT ASSESSMENT

5.1 Black Cockatoo Species

5.1.1 Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*)

Carnaby's Black Cockatoo is found in the south-west of Australia from Kalbarri through to Ravensthorpe. It has a preference for feeding on the seeds of *Banksia, Dryandra, Hakea, Eucalyptus, Grevillea, Pinus* and *Allocasuarina* spp. It is nomadic, often moving toward the coast after breeding. It breeds in tree hollows that are 2.5 – 12m above the ground and have an entrance of 23-30cm with a depth of 1-2.5m. Nesting mostly occurs in smooth-barked trees (e.g. Salmon Gum, Wandoo, Red Morrell). Eggs are laid from July to October, with incubation lasting 29 days (DoE, 2014).

The site is within the modelled distribution for this species (SEWPaC, 2012).

5.1.2 Baudin's Black Cockatoo (*Calyptorhynchus baudinii*)

Baudin's Black Cockatoo is most common in the far south-west of Western Australia. It is known to breed from the southern forests north to Collie and east to near Kojonup. Baudin's Black Cockatoo is typically found in vagrant flocks and utilises the taller, more open Jarrah (*Eucalyptus marginata*) and Marri (*Corymbia calophylla*) woodlands where it feeds mainly on Marri seeds and various Proteaceous species (Johnstone and Kirkby, 2011).

The site is outside the 'Species May Occur' modelled distribution for Baudin's Black Cockatoos (SEWPaC, 2012).

5.1.3 Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*)

Forest Red-tailed Black Cockatoos are endemic to the humid to sub-humid south-west of Western Australia (SEWPaC, 2012). The range of Forest Red-tailed Black Cockatoos is bound by Gingin in the north to Mt Helena, Christmas Tree Well, West Dale, North Bannister, Mt Saddleback, Kojonup, Rocky Gully, upper King River and Green Range (east of Albany) (SEWPaC, 2012; DoE, 2014). It nests in tree hollows with a depth of 1-5m, that are predominately Marri, Jarrah and Karri (*E. diversicolor*) and it feeds primarily on the seeds of Marri and Jarrah (Johnstone and Kirkby, 2011).

The site is inside the modelled distribution for this species (SEWPaC, 2012).

5.2 Methodology

PGV Environmental undertook a Black Cockatoo Habitat Assessment in accordance with the *EPBC Act referral guidelines for three threatened Black Cockatoo species: Carnaby's cockatoo (endangered) Calyptorhynchus latirostris Baudin's cockatoo (vulnerable) Calyptorhynchus baudinii Forest red-tailed Black Cockatoo (vulnerable) Calyptorhynchus banksii naso* (SEWPaC, 2012) (Black Cockatoo Referral Guidelines) and the methodology that is outlined in the SPRAT Database for each of the Black Cockatoo species for Black Cockatoo Habitat Assessments.

The field work for the assessment was undertaken by PGV Environmental on 27 March 2019. The site was traversed on foot and information on Black Cockatoo foraging, roosting and breeding habitat was assessed.

The extent, type and quality of the vegetation present, including the presence and extent of plants known to be used by Black Cockatoos, was investigated and the quality of the vegetation was determined in the context of foraging habitat for Black Cockatoos. During the site visit a search for feeding signs or feeding debris such as 'chewed' Marri, Jarrah and Sheoak nuts and Banksia cones was undertaken.

The site was also searched for evidence of roosting including areas of droppings, moulted feathers, feather down or clippings from branches under trees.

Breeding habitat is defined in the Black Cockatoo Referral Guidelines as trees of species known to support breeding within the range of the Black Cockatoo species which either have a suitable nest hollow OR are of a suitable diameter at breast height (DBH) to develop a nest hollow. The relevant species on the site is Tuart (*Eucalyptus gomphocephala*) and Jarrah (*E. marginata*). The minimum DBH for Tuart and Jarrah trees to be considered potential breeding habitat is 500mm.

A survey of potential breeding habitat trees was undertaken on the site and included recording of: the location, species, trunk DBH and any other important descriptive information about each suitable tree such as the presence of hollows or spouts. Any hollows or spouts found were assessed from the ground and therefore those deemed suitable for breeding by Black Cockatoos may not be suitable upon closer inspection. The trees were also photographed.

5.3 Results

5.3.1 Foraging

The site contains eight native plant species that are recognised as foraging habitat for Carnaby's Black Cockatoos (Valentine and Stock, 2008; Groom, 2011). These are listed in Table 10.

Table 10: Foraging Species for Carnaby's Black Cockatoos Recorded on the Site

Species	Common Name
Allocasuarina fraseriana	Sheoak
Banksia attenuata	Candlestick Banksia
Banksia grandis	Bull Banksia
Banksia menziesii	Firewood Banksia
Eucalyptus gomphocephala	Tuart
Eucalyptus marginata	Jarrah
Pinus maritima	Maritime Pine
Xanthorrhoea brunonis	Grass Tree
Xanthorrhoea preissii	Balga

Forest Red-tailed Black Cockatoos would only forage on Jarrah and Sheoak on the site.

No evidence of Black Cockatoos having foraged on the site recently or in the past was observed during the assessment. The dominant tree species on the site are Tuarts. Carnaby's Black Cockatoos are only recorded feeding on the flowers of this species. Given the low density of Banksia trees, the foraging habitat on the site is not considered to be high quality.

5.3.2 Roosting

The site is not a known roosting site for Carnaby's Black Cockatoos or Forest Red-tailed Black Cockatoos. The nearest roosting site for Carnaby's Black Cockatoos is approximately 1.4km to the east (DoP, 2011). No evidence of the site being utilised as roosting habitat by Black Cockatoos was observed during the site assessment.

5.3.3 Breeding

Black Cockatoos are known to breed in hollows of large eucalypts. The site is not known as a breeding site for Carnaby's Black Cockatoos (DoP, 2011). The Black Cockatoo Referral Guidelines define trees of certain species with a DBH of 500mm or greater as breeding habitat regardless of the presence or not of hollows. The theory behind this definition is the concept that while the trees may not currently contain hollows, they are mature enough that in the next 50 years or so a hollow might form and be of use to Black Cockatoos for the purposes of breeding.

PGV Environmental recorded 90 Tuart (*Eucalyptus gomphocephala*), 4 Jarrah (*Eucalyptus marginata*) and 6 Standing Dead Trees (SDT) as potential breeding habitat. One Jarrah and one of the Standing Dead Trees recorded had hollows or spouts and three Tuarts had potential hollows (Table 11).

There was no evidence of the hollows being used for breeding recently or in previous years.

The location of potential breeding trees is shown on Figure 4 and the tree data is contained in Appendix 9.

Table 11: Significant trees recorded on the site

Species	Trees with no hollows/spouts or potential hollows/spouts	Trees with hollows/spouts or potential hollows/spouts	Total
Tuart	87	3	90
Jarrah	3	1	4
Standing Dead Trees	5	1	6
Total	**95**	**5**	**100**

5.4 Regional Context

To assist in determining the significance of any impact on Black Cockatoo habitat on the site an assessment of Black Cockatoo habitat within the vicinity of the site was undertaken.

There are a large number of areas of reserved bushland including Bush Forever, Regional Parks and Conservation Areas that occur within 10km of the site (Figure 5). Some of these areas are outlined in Table 12.

Table 12: Reserves containing habitat within 10km of the site

Identifier	Name	Conservation Status	Approximate habitat area (ha)
BF278	Cassia Drive Bushland, Karnup	Bush Forever	45.6ha
BF379	Anstey Swamp, Karnup	Bush Forever	54ha
BF395	Paganoni Swamp and Adjacent Bushland, Karnup	Bush Forever	597ha
BF372	Lowlands Bushland – Western Block (Hymus Swam) Peel Estate	Bush Forever	19ha
BF376	Baldivis Road Bushland, Baldivis	Bush Forever	90ha
BF356	Lake Coolingup, Lake Walyungup and Adjacent Bushland Hillman to Port Kennedy	Bush Forever	275ha
BF378	Henderson Road Bushland, Peel Estate	Bush Forever	75ha
BF77	Yangedi Swamp, Keysbrook	Bush Forever	301ha

The foraging habitat in reserves exceeds total area of 1,456ha. All eight sites also contain large Tuart, Jarrah and Marri trees that are potential breeding habitat.

5.5 Significance of Impact

The following assessments have been undertaken to determine what level of impact on Black Cockatoo habitat may be considered significant and warrant a referral and assessment under the EPBC Act.

There are two guidelines that can be used to assess the significance of an impact on Black Cockatoos. The first is the statutory document EPBC Act Significant Impact Guidelines 1.1 which can be used for any matter listed under the EPBC Act. The second is the more specific Black Cockatoo Referral Guidelines that were prepared specifically to address impacts on the three listed Black Cockatoo species from South-West Western Australia.

5.5.1 EPBC Act Significant Impact Guidelines 1.1

According to the EPBC Act Significant Impact Guidelines 1.1 (DoE, 2013), the significance of the impact depends on the sensitivity, value and quality of the environment and the intensity, duration, magnitude and geographic extent of the impacts. The category of listing (for example; Endangered, Vulnerable or Migratory) determines the significant impact criteria for listed flora and fauna species and ecological communities.

This Black Cockatoo Habitat Assessment assumes all of the foraging and potential breeding trees on the site would be cleared for a development. Using this assumption, the clearing would result in approximately 9.6ha of vegetation containing low quality foraging habitat for Carnaby's Black Cockatoos and Forest Red-tailed Black Cockatoos and 100 potential breeding trees.

The following assessments are for the Carnaby's Black Cockatoo which is listed as Endangered and the Forest Red-tailed Black Cockatoo which is listed as Vulnerable.

Carnaby's Black Cockatoo

The impact on Carnaby's Black Cockatoos from clearing the Black Cockatoo habitat on the site has been assessed against the criteria set out in the Significant Impact Guidelines 1.1 for the impact on an Endangered species and is shown below:

• *Lead to a long-term decrease in the size of a population*

There was no evidence that the site supports breeding or roosting of Carnaby's Black Cockatoos. There are large areas (in excess of 1,450ha) of Bush Forever sites and other formal reserves within 10km consisting of large areas of foraging and potential breeding habitat. Therefore, clearing of the site will not result in this outcome.

• *Reduce the area of occupancy of the species*

Clearing of the site will not result in a reduction of any known breeding and roosting habitat although it will result in a reduction of approximately 9.6ha of low quality foraging habitat. Within 10km of the site, however, there is more than 1,450ha of foraging habitat located in Bush Forever sites and other formal reserves and therefore clearing of the site will not result in this outcome.

• *Fragment an existing population into two or more populations*

Clearing of the site is unlikely to fragment the population of Carnaby's Black Cockatoos in the area into sub-populations due to the Bush Forever sites in the area providing linkages consisting of large areas of Black Cockatoo habitat. Carnaby's Black Cockatoos can fly large distances between foraging areas. Clearing of the site will therefore not result in this outcome.

• *Adversely affect habitat critical to the survival of a species*

There was no evidence of breeding or roosting by Carnaby's Black Cockatoos on the site. The five trees that contained potentially suitable hollows/spouts and the approximately 9.6ha of low quality foraging habitat is not considered to be critical to the survival of the species due to the large amount of foraging and potential breeding habitat within 10km of the site, therefore clearing of the site would not result in this outcome.

• *Disrupt the breeding cycle of a population*

The site contained no evidence of breeding and there were five trees that contained potentially suitable hollows/spouts therefore clearing of the site would not result in this outcome.

• *Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline*

Clearing of the site will not result in this outcome due to the large extent of Black Cockatoo habitat reserved within 10km of the site.

• *Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat*

Clearing of the site will not result in the establishment of an invasive species harmful to Carnaby's Black Cockatoos.

• *Introduce disease that may cause the species to decline*

Clearing of the site will not cause disease to be introduced therefore will not result in this outcome.

• *Interfere with the recovery of the species*

The Carnaby's Black Cockatoos that would utilise the site have access to greater than 1,450ha of habitat within 10km in reserves. Therefore, any clearing of habitat on the site would not interfere substantially with the recovery of the species.

The conclusion of this assessment in accordance with the criteria set out in the Significant Impact Guidelines 1.1 is that development on the site will not have a significant impact on Carnaby's Black Cockatoos.

Forest Red-tailed Black Cockatoo

The impact on Forest Red-tailed Black Cockatoos from clearing the Black Cockatoo habitat on the site has been assessed against the criteria set out in the Significant Impact Guidelines 1.1 for the impact on a Vulnerable species and is shown below:

• *Lead to a long-term decrease in the size of an important population of a species*

In the Significant Impact Guidelines 1.1 an important population is defined as "a population that is necessary for a species' long-term survival and recovery" and may be "key source populations either for breeding or dispersal, populations that are necessary for maintaining genetic diversity, and/or populations that are near the limit of the species' range".

There was no evidence of breeding occurring on the site and the surrounding area contains greater than 1,450ha of reserves providing large areas of foraging and breeding habitat for Cockatoos that utilise the site. Development of the site would therefore not result in this outcome.

• *Reduce the area of occupancy of an important population*

There was no evidence found of Forest Red-tailed Black Cockatoos breeding or roosting on the site. Clearing of the site will reduce the area of foraging available by 9.6ha of vegetation containing foraging habitat, however there is greater than 1,450ha of foraging habitat within 10km of the site in Bush Forever sites therefore clearing of the site would not result in this outcome.

• *Fragment an existing important population into two or more populations*

The large area of reserves containing habitat within 10km of the site that provide foraging and potential breeding habitat. Forest Red-tailed Black Cockatoos can fly large distances between foraging areas. Therefore, clearing of the site would not result in this outcome.

• *Adversely affect habitat critical to the survival of a species*

There was no evidence that Forest Red-tailed Black Cockatoos or Baudin's Black Cockatoos breed on the site and there are large areas of foraging habitat within 10km of the site, as Bush Forever sites, therefore the site is not considered critical to the survival of these species.

• *Disrupt the breeding cycle of an important population*

There was no evidence that Forest Red-tailed Black Cockatoos or Baudin's Black Cockatoos breed on the site. A total of five trees on the site contained potentially suitable hollows/spouts, therefore clearing of the site would not result in this outcome.

• *Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline*

The large areas of foraging and breeding habitat located in reserves within 10km of the site would prevent the population from declining as a result of clearing of the site.

• *Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat*

Clearing the site will not result in invasive species being introduced, therefore would not result in this outcome.

• *Introduce disease that may cause the species to decline*

Clearing the site will not result in disease being introduced, therefore would not result in this outcome.

• *Interfere substantially with the recovery of the species*

The Forest Red-tailed Black Cockatoos that would utilise the site have access to and area greater than 1,450ha of Black Cockatoo habitat within 10km in reserves. Therefore, the clearing of 9.6ha of vegetation containing foraging habitat on the site would not interfere substantially with the recovery of the species.

In accordance with the criteria set out in the Significant Impact Guidelines 1.1 the conclusion of this assessment is that development of the site would not have a significant impact on Carnaby's or Forest Red-tailed Black Cockatoos.

5.5.2 Black Cockatoo Referral Guidelines

The *EPBC Act referral guidelines for three threatened Black Cockatoo species: Carnaby's cockatoo (endangered) Calyptorhynchus latirostris Baudin's cockatoo (vulnerable) Calyptorhynchus baudinii Forest red-tailed Black Cockatoo (vulnerable) Calyptorhynchus banksii naso* (SEWPaC, 2012) (Black Cockatoo Referral Guidelines) contain several steps to determine whether or not a referral is required. These steps are:

1. The definition of habitat (breeding, roosting and foraging – Table 1 in the Black Cockatoo Referral Guidelines);
2. A description of the type of action that may have a high or low risk of being a significant impact and therefore require referral (Table 3 in the Black Cockatoo Referral Guidelines);
3. Formulation of a mitigation strategy to reduce the scale of impact; and

4. A flowchart to assist in decision making on whether or not an action should be referred.

Step 1 Black Cockatoo Habitat

As outlined previously there is approximately 9.6ha of vegetation containing low quality foraging habitat for Black Cockatoos on the site with no evidence of foraging. There are 100 trees that are considered to be potential breeding trees under the definition provided by the Department of the Environment. There is however no recorded breeding or roosting on the site or evidence of such.

Step 2 Level of Impact

Foraging

According to Table 3 in the Black Cockatoo Referral Guidelines the clearing of more than 1ha of quality foraging habitat has a high risk of causing a significant impact. Degradation of more than 1ha of quality habitat by things such as altered hydrology or fire regimes has an uncertain risk. The significance of degradation depends on the type of degradation and the quality of the habitat.

The site contained approximately 9.6ha of vegetation containing low quality foraging habitat and clearing of the site may equate to the loss of more than 1ha of quality foraging habitat and result in a high risk of a significant impact.

Roosting

The Black Cockatoo Referral Guidelines consider the clearing of a known roosting site as a high risk of being a significant impact. The site is not mapped as having a known roosting site by the Department of Planning mapping of January 2011, although there are two known roosting sites in the vicinity. There were no roosting sites recorded during the Significant Tree Survey and the risk of a significant impact on a known roosting site is considered to be low.

Breeding

According to Table 3 in the Black Cockatoo Referral Guidelines the clearing of any known nesting tree has a high risk of being a significant impact. A known nesting tree is defined in the Black Cockatoo Referral Guidelines as any existing tree in which breeding has been recorded or suspected. There are no known nesting trees that occur on the site and therefore there is no risk of a significant impact on known breeding habitat of Black Cockatoos.

The Black Cockatoo Referral Guidelines also consider that the clearing or degradation of any part of a vegetation community known to contain breeding habitat is likely to have a high risk of a significant impact. In Table 1 of the Black Cockatoo Referral Guidelines breeding habitat is defined as woodlands, forests or isolated trees that contain or consist of live or dead trees of certain species with either a DBH of or greater than 500mm or the presence of suitable nest hollows. The site contains 100 trees (live and dead) with a DBH of or greater than 500mm, five of which contained hollows/spouts potentially suitable for Black Cockatoos. According to Table 1 of the Black Cockatoo Referral Guidelines Carnaby's Black Cockatoos may breed in the Marri, Jarrah and Standing Dead trees on the site.

The Black Cockatoo Referral Guidelines state that breeding habitat predominantly applies to those areas within the breeding range of the Black Cockatoo species as shown in the maps attached to the Black Cockatoo Referral Guidelines. The site is within the breeding range of Carnaby's Black Cockatoos. The breeding range of Forest Red-tailed Black Cockatoos is not specified within the map attached to the Black Cockatoo Referral Guidelines, however the site is inside the mapped distribution range.

According to the Black Cockatoo Referral Guidelines the risk of a significant impact on breeding habitat of Black Cockatoos is considered to be high.

Surrounding Habitat

According to the Black Cockatoo Referral Guidelines clearing of vegetation that results in a gap of greater than 4km between patches of Black Cockatoo habitat (foraging, roosting or breeding) has a high risk of having a significant impact. As listed in Table 6 there are greater than 1,450ha of reserves within 10km of the site that provide Black Cockatoo habitat. Therefore, the risk of creating a gap of greater than 4km between areas of Black Cockatoo habitat is considered to be very low.

Step 3 Mitigation

The consideration of a mitigation strategy during the determination of the level of impact and requirement to refer is allowed by the Black Cockatoo Referral Guidelines and setting in place the best practice mitigation strategy may reduce the level of impact and in turn the risk of a significant impact. Mitigation strategies include avoiding impact, managing impact so that there is no net decline in habitat and monitoring the effectiveness of mitigation.

This assessment is based on the entire 9.6ha of vegetation containing foraging habitat and all 100 potential breeding trees being cleared. Putting a mitigation strategy in place during the planning stage may reduce the level of impact on Black Cockatoos from clearing of the site.

Step 4 Referral Advice

The Decision Making flowchart in Figure 1 of the Black Cockatoo Referral Guidelines was applied to the site without consideration of mitigation strategies and is shown in sequence below:

1 Could the impacts of your action occur within the modelled distribution of the black cockatoos? – YES
2 Could the impacts of your action affect any black cockatoo habitat or individuals? - YES
3 Have you surveyed for black cockatoo habitat using the recommended methods? – YES
4 Could your action have an impact on black cockatoos or their habitat? – YES
5 Is your impact mitigation best practice so that it may reduce the significance of your impacts on black cockatoos? Prioritise impact avoidance over impact minimisation - NO

RESULT – Referral Recommended: High risk of resulting in significant impact.

To lower the risk of a significant impact the amount of foraging habitat and number of potential breeding habitat trees proposed to be cleared would need to be greatly reduced. The amount of foraging habitat to be cleared would need to be less than 1ha and the number of virtually no clearing of potential breeding habitat trees.

6 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Flora and Vegetation

The Detailed Flora and Vegetation survey found the following:

- The 10.8ha site is mostly covered with native vegetation;
- One vegetation type was recorded on the site and described as *Eucalyptus gomphocephala* (Tuart)/*E. marginata* (Jarrah)/*Allocasuarina fraseriana* (Sheoak) Woodland to Open Forest over *Hibbertia hypericoides/Xanthorrhoea brunonis/Desmocladus flexuosus* Low Open Heath;
- The native vegetation has been cleared in the past but has partly regenerated. The condition of the vegetation ranges from Good to Completely Degraded in the northern part and Very Good to Completely Degraded to the southern part;
- A total of 23 Threatened (Declared Rare) or Priority Flora species were identified as having been recorded in proximity to the survey area. Of these, one Threatened species (Grand Spider Orchid – *Caladenia huegelii*) and one Priority species (*Jacksonia sericea*) have the potential to occur on the site;
- A detailed survey in September 2019 did not recorded these species on the site and there were no Declared rare or Priority species recorded on the site;
- The vegetation is considered most likely to be representative of the Floristic Community Type FCT28 ''Spearwood *Banksia attenuata* or *Banksia attenuata* – *Eucalyptus* woodlands' although there are strong matches for FCT 21a and 25. FCT 28 is not a Threatened or Priority Ecological Community;
- The vegetation on the site meets the criteria to be considered the Tuart Woodlands TEC;
- The Banksia Woodlands of the Swan Coastal Plain Threatened Ecological Community is assessed as not being present on the site; and
- The site is linked to native vegetation on large private landholdings to the west through a narrow vegetated corridor located at the southern end of Lot 878 Stakehill Road. Small birds and ground-dwelling fauna would be able to move from the site to the vegetated areas further west through this corridor.

6.2 Fauna

The Level 1 Fauna Survey found the following:

- One fauna habitat occurs on the site which is an Open Woodland Habitat;
- The Open Woodland Habitat contains foraging habitat and potential breeding habitat suitable for the following listed species under State and Federal legislation:
  - Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*) (Endangered); and
  - Forest Red-tailed Black-Cockatoo (*Calyptorhynchus banksii naso*) (Vulnerable);
- The site also contains habitat for the Southern Brown Bandicoot, Quenda (*Isoodon fusciventer*) (Priority 4) and the Swan Coastal Plain shield-backed trapdoor spider (*Idiosoma sigillatum*);
- The Listed Marine species under the EPBC Act that may intermittently visit the site is the Rainbow Bee-eater (*Merops ornatus*); and

- Pest fauna likely to occur on the site are rabbits, feral cats, rats, mice and foxes.

6.3 Black Cockatoo Habitat Assessment

The Black Cockatoos Habitat Assessment concludes:

- The 9.6ha of vegetation on the site contains Low quality foraging habitat for Carnaby's Black Cockatoos and to a lesser extent Forest Red-tailed Black Cockatoos. No evidence of foraging was observed on the site;
- The site is not used as a roost site for Black Cockatoos;
- The site contains 100 potential breeding habitat trees (mostly Tuart with some Jarrah and Standing Dead Trees);
- Five trees were recorded that contained potential hollows. No evidence of recent or past breeding was observed in the trees; and
- According to the Black Cockatoo Referral Guidelines the clearing of the site is unlikely to lead to a significant impact however under the Black Cockatoo Referral Guidelines the clearing of more than 1ha of foraging and more than one potential breeding habitat tree is highly likely to have a significant impact and a Referral under the EPBC Act is recommended. To lower the risk of a significant impact, and hence the need for a Referral, the amount of foraging habitat and number of potential breeding habitat trees proposed to be cleared would need to be greatly reduced.

6.4 Conclusion and Recommendations

The vegetation on the Bush Forever part of Lot 877 Stakehill Road is predominantly a Tuart Woodland with a large number of Tuart trees, and some Jarrah and Sheoak trees over a variable understorey. The woodland was partially cleared in the early 1960s and has regrown since then. The understorey in the northern half, and around the edges of the site are in Good to Completely Degraded condition while the understorey in the southern half is mostly in Very Good to Good condition.

The Detailed spring flora survey did not record any conservation significant flora species on the site.

The vegetation was assessed as meeting the requirements of the Tuart Woodlands and Forest of the Swan Coastal Plain Threatened Ecological Community which is listed as Critically Endangered under the Commonwealth EPBC Act and is programmed to be listed under the State *Biodiversity Conservation Act 2016* in the near future..

The fauna habitat on the site has been impacted by past clearing but is considered to be Good Fauna Habitat. The site contains habitat for two conservation significant species of Black Cockatoos and other Priority fauna species may also occur.

Development of the whole site would require a Referral under the Commonwealth EPBC Act for both the Tuart Woodland TEC and the impact on Black Cockatoo foraging and potential breeding habitat.

Clearing of the whole site is unlikely to be supported by the Commonwealth Department of the Environment and Energy due to the impacts on the Tuart woodland PEC (State consideration) and Black Cockatoo habitat (Commonwealth and State consideration).

Some development of the site may be possible under a Negotiated Planning Solution if the following is achieved:

- Retention of all of the Tuart woodland vegetation rated in Very Good condition (approximately 3.5ha);
- Retention of as many potential breeding habitat trees for Black Cockatoos as possible; and
- Retention of the linkage to vegetation at the southern end of Lot 878 to the west of the site.

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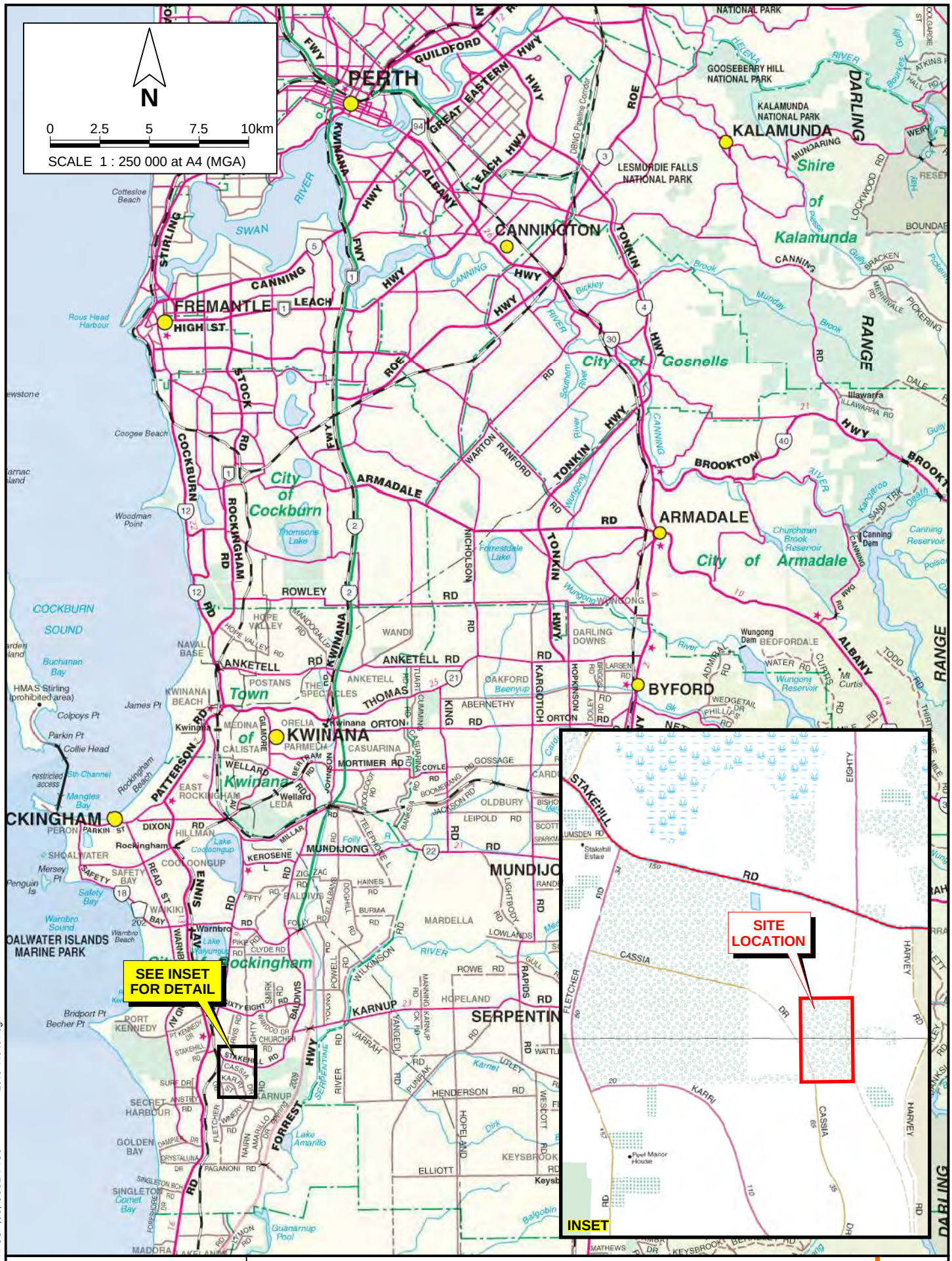
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FIGURES



PINPOINT CARTOGRAPHICS (08) 9562 7136 2019-440-f01.dgn

pgv ENVIRONMENTAL

Terranovis
FLORA, VEGETATION AND FAUNA SURVEY
LOT 877 STAKEHILL ROAD, KARNUP

Drawn: P. van der Moezel | Date: 15 Apr 2019
Job: 10281 Rpt: 2019-440 | Revision: A

SITE LOCATION

Figure 1

386 600mE
386 800mE
387 000mE
6 415 200mN
6 415 000mN
6
8
10
12
14
16
18
878
Lot 877
2
3
4
1
874
624
N
0 20 40 60 80 100m
SCALE 1 : 2 000 at A3 (MGA)

Legend

- Site Boundary
- Cadastral Boundary
- Topographic Contour

CADASTRAL SOURCE: Landgate, April 2019.
CONTOUR SOURCE: Department of Agriculture, 2000.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown February 2019.

pgv ENVIRONMENTAL

Drawn: P. van der Moezel | Date: 15 Apr 2019
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Terranovis
FLORA, VEGETATION AND FAUNA SURVEY
LOT 877 STAKEHILL ROAD, KARNUP

SITE BOUNDARY AND TOPOGRAPHY

Figure 2

2019-440-f02.dgn
PINPOINT CARTOGRAPHICS (08) 9562 7136

386 600mE
386 800mE
387 000mE
6 415 200mN
6 415 000mN
878
Lot 877
874
624
1
2
3
4
C
SR1
SR2
SR3
SR4
SR5
EgEmAf

N

0 20 40 60 80 100m

SCALE 1 : 2 000 at A3 (MGA)

Legend

- Site Boundary
- Cadastral Boundary
- Quadrat Location
- Vegetation Type Boundary
- EgEm Vegetation Type

Vegetation Types

EgEmAf
Eucalyptus gomphocephala (Tuart)/*E. marginata* (Jarrah)/ *Allocasuarina fraseriana* (Sheoak) Woodland to Open Forest over *Hibbertia hypericoides*/*Xanthorrhoea brunonis*/*Desmocladus flexuosus* Low Open Heath

C
Cleared

CADASTRAL SOURCE: Landgate, April 2019.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown February 2019.

2019-440-f03.dgn
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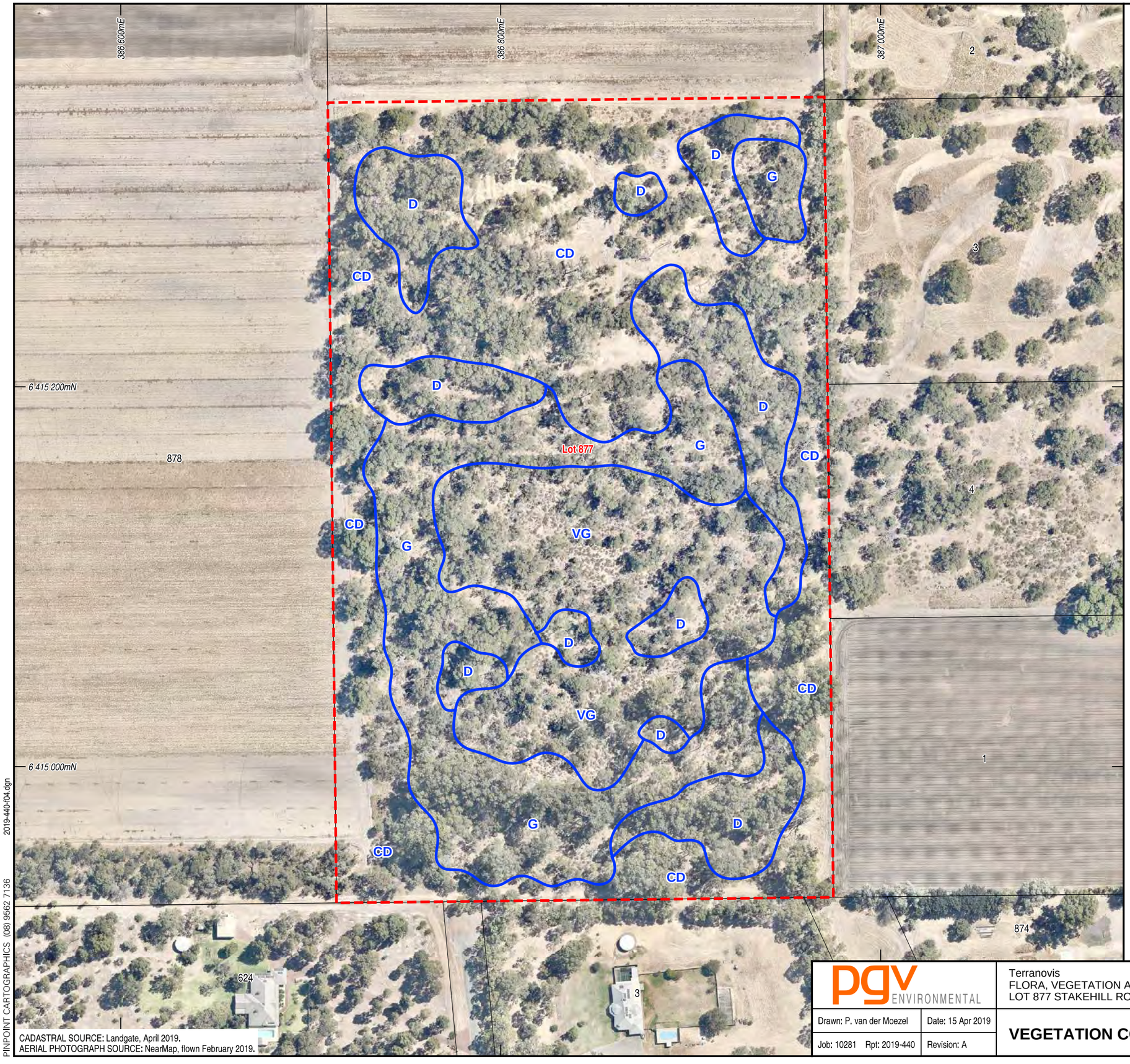
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Terranovis
FLORA, VEGETATION AND FAUNA SURVEY
LOT 877 STAKEHILL ROAD, KARNUP

VEGETATION TYPES

Figure 3



CADASTRAL SOURCE: Landgate, April 2019.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown February 2019.

N

0 20 40 60 80 100m

SCALE 1 : 2 000 at A3 (MGA)

Legend

- Site Boundary
- Cadastral Boundary
- Vegetation Condition Boundary
- VG Vegetation Condition

Vegetation Condition
(SOURCE: Bush Forever, Govt. of W.A., 2000)

P - Pristine
Pristine or nearly so, no obvious signs of disturbance.

Ex - Excellent
Vegetation structure intact, disturbance affecting individual species and weeds are non aggressive species.

VG - Very Good
Vegetation structure altered, obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.

G - Good
Vegetation structure significantly altered by very obvious signs of multiple disturbance. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.

D - Degraded
Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.

CD - Completely Degraded
The structure of the vegetation is no longer intact and the areas is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora composing weed or crop species with isolated native trees or shrubs.

CI - Cleared
No native vegetation remaining.

pgv ENVIRONMENTAL

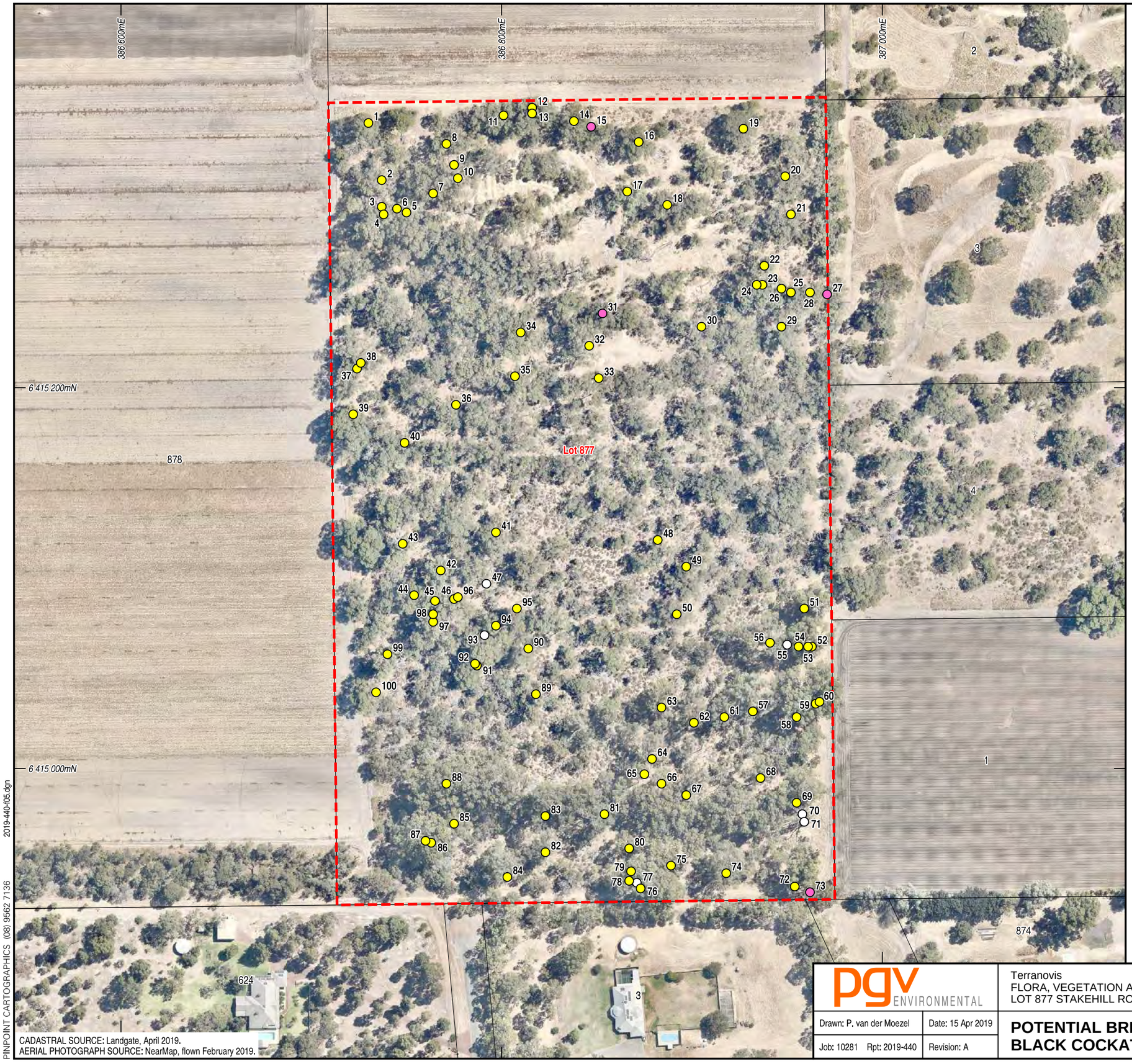
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FLORA, VEGETATION AND FAUNA SURVEY
LOT 877 STAKEHILL ROAD, KARNUP

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VEGETATION CONDITION

Figure 4

PINPOINT CARTOGRAPHICS (08) 9562 7136 2019-440-004.dgn



N

0 20 40 60 80 100m

SCALE 1 : 2 000 at A3 (MGA)

Legend

- Site Boundary
- Cadastral Boundary

Potential Breeding Habitat Tree

- Dead
- Jarrah (*Eucalyptus marginata*)
- Tuart (*Eucalyptus gomphocephala*)
- 30 Tree Number

CADASTRAL SOURCE: Landgate, April 2019.
AERIAL PHOTOGRAPH SOURCE: NearMap, flown February 2019.

2019-440-I05.dgn

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FLORA, VEGETATION AND FAUNA SURVEY
LOT 877 STAKEHILL ROAD, KARNUP

POTENTIAL BREEDING HABITAT TREES FOR BLACK COCKATOOS

Figure 5

APPENDIX 1

DBCA Flora Database Search

FID	Sheet	NameID	Taxon	ConsCode	Plant_Desc	Site	Vegetation	Frequency	Notes	Locality	Geocode_Me	Precision	Date
707	7508492	3237	Acacia benthamii	2					Opportunistic collection.	WSWA Bushland Plant Survey in Paganoni Swamp, Paganoni Road, Karnup	GPS	1	2/10/2004
714	5809150	3237	Acacia benthamii	2	Slender erect shrub 2 m high, 1 m wide.	Grey calcareous sand.	Eucalyptus gomphocephala tall woodland.	uncommon.		Pagononi Block, Lakes Regional Park, Pagononi Road, Baldivis,	MAN	0	22/09/2000
718	6960103	3237	Acacia benthamii	2		Low plain. Grey sand.	Open Jarrah & Tuart woodland. Allocasuarina fraseriana, Banksia attenuata, Kunzea glabrescens, Hibbertia hypericoides.	ca 20 plants.		Lot 203, Stock Road, Stake Hill	GPS	1	31/03/2005
10560	8025630	34236	Beyeria cinerea subsp. cinerea	3	Many stemmed shrub to 30 cm. Male flowers pale yellow.	In sand over limestone.	With low scrub.			The Plains, Mandurah Road	TOPO	4	7/10/1967
10564	8025223	34236	Beyeria cinerea subsp. cinerea	3	Sprawling woody shrub, rootstock. 20 cm high x 40 cm wide. Flowers yellow.	Small limestoneridges. Grey sand over limestone.	Burnt low coastal heath.	scattered.		Madora, Perth to Mandurah	TOPO	3	18/09/1983
10569	5944783	34236	Beyeria cinerea subsp. cinerea	3			Hakea varia Dense Low Heath C over Mixed Dwarf Scrub D.			Site 31, 900 m NW of the intersection of Mulga Road West and Gordon Road, Stakehill,	MAN	3	4/11/1998
10575	7132484	34236	Beyeria cinerea subsp. cinerea	3	Semi-erect shrub 0.2 m high x 0.2 m wide.	Limestone ridge. Brown-orange sand with outcropping limestone. Tamala limestone.	Mixed Low Heath C. Grevillea preissii, Rhagodia baccata.	uncommon.		Lot 4, Mandurah Road (Bushplan Site 395)	AUTO	1	30/06/1999

FID	Sheet	NameID	Taxon	ConsCode	Plant_Desc	Site	Vegetation	Frequency	Notes	Locality	Geocode_Me	Precision	Date
10579	7508891	34236	Beyeria cinerea subsp. cinerea	3		Steeply sloping easterly facing upland site. Surface soil pale brown loamy sand with limestone exposed on <5% of surface. Subsurface limestone present. Well-drained. Litter cover - 50-70% and 5 cm depth; bare ground cover - <2%.	Melaleuca huegelii subsp. huegelii Open Scrub over Templetonia retusa and Trymalium ledifolium var. ledifolium Open Heath, over Acacia lasiocarpa var. lasiocarpa, Phyllanthus calycinus and Gompholobium tomentosum Open Low Heath, over Mixed Very Open Gras			WSWA Bushland Plant Survey Plot PAGL 2 in Paganoni Swamp, Paganoni Road, Karnup	GPS	1	16/10/2005
12574	8336296	44226	Calandrinia oraria	3		Coastal dunes (secondary).	Acacia rostellifera, Spyridium globulosum, Alyxia buxifolia shrubland over Acanthocarpus preissii, Bromus diandrus, Conostylis candicans, forbland/ grassland.			Madora Bay, N of Mandurah	GPS	1	7/09/2011
12580	6019269	44226	Calandrinia oraria	3	Annual herb 30 cm high x 10 cm wide. Pink flowers. Reproductive method: seeds.	Beach ridge plain. Grey sand.	Open heath/grassland. Characteristic species: Melaleuca systena, Lomandra maritima.	over 50 plants in area >1 ha.	<5% weed cover. 4 or more alien species.	PK/1, Port Kennedy Scientific Park	MAN	2	19/10/2001
12582	8765499	44226	Calandrinia oraria	3	Annual herb 10 cm, pink flowers.	Hilly, white sand, dunes.	Corymbia calophylla, Alyxia buxifolia, Conostylis candicans.			Madora beach, c. 1.5 km N of carpark	GPS	1	3/10/2012
13665	6196268	3006	Cardamine paucijuga	2	Decumbent annual. Flowers white, inconspicuous.	Winter wet - damp flats. Calcareous clay over limestone.	Mixed Melaleuca tall shrubland. Melaleuca incana, M. teretifolia, M. viminea, M. rhaphiophylla.	common.		Pagononi Block, Lakes Regional Park, Pagononi road, Baldivis	GPS	1	24/09/2000

FID	Sheet	NameID	Taxon	ConsCode	Plant_Desc	Site	Vegetation	Frequency	Notes	Locality	Geocode_Me	Precision	Date
13670	6330339	3006	Cardamine paucijuga	2	Annual. Flowers white, in late flower.	Swamp, winter wet. Black peaty sand over mud.	Melaleuca rhaphiophylla low forest.	scattered on roots at base of trees.		Pagononi Block, Rockingham Lakes Regional Park, Pagononi Road, Baldivis	GPS	1	24/09/2000
15350	7832923	11657	Conostylis pauciflora subsp. pauciflora	4	Erect herb with yellow flowers.	Brown sand, disturbed soil, mining lease.			Potnetial threat from mining.	Singleton	GPS	1	27/09/2007
18128	4494911	3863	Dillwynia dillwynioides	3	Shrub 1.5m.	Soil: Grey sand. Topography/drainage: Seasonally wet flat. Geomorphology: Alluvial deposits (pinjarra plain).	Vegetation: Pericalymma floribunda, Hakea varia Dense Heath B over Schoenus rodwayanus Low Sedges.			Paganoni block E of Mandurah Rd, 11 km NNE of Mandurah (plot paga-3).	GPS	1	2/10/1992
18140	5943086	3863	Dillwynia dillwynioides	3		Seasonal dampland.	Melaleuca rhaphiophylla Low Forest B over M. rhaphiophylla Low Scrub B over Dense Low Grass and Dense Low Sedges.			Site 8, 1.4 km S of Stakehill Road and the N boundary of Baldivis Pine Plantation, Karnup,	MAN	2	4/11/1998
18141	5943523	3863	Dillwynia dillwynioides	3		Seasonal dampland.	Eucalyptus rudis Low Forest A over Melaleuca rhaphiophylla Open Low Woodland A over Kunzea ericifolia Open Scrub over Dense Low Scrub of mixed grasses, weeds and sedges.			Site 10, 100 m N of S boundary of Baldivis Pine Plantation and 1.8 km E of Karri Street, Karnup,	MAN	2	4/11/1998
18144	7536062	3863	Dillwynia dillwynioides	3		Moist grey loam.	Low Woodland A of Eucalyptus rudis, Melaleuca rhaphiophylla, Banksia littoralis, Lepidosperma longitudinale, Hibbertia stellaris, Kunzea glabrescens, Villarsia albiflora.	>20 plants.	Condition of population: moderate.	Baldivis Ordnance Reserve	GPS	1	15/09/2006

FID	Sheet	NameID	Taxon	ConsCode	Plant_Desc	Site	Vegetation	Frequency	Notes	Locality	Geocode_Me	Precision	Date
18466	8603391	1639	Drakaea elastica	T		Grey sand.	Kunzea glabrescens thickets among Banksia woodland. Banksia attenuata, Kunzea glabrescens, Drakea glyptodon.	1000+ plants, only 50-1000 seen in flower.	Used for pollinator baiting experiments.	Pagononi Reserve, near E boundary, ca 800 m S from the NE	GPS	1	2/10/2007
32930	5437784	4027	Jacksonia sericea	4	Prostrate shrub 10 cm high, 2 m wide; sterile, only a few spiny branchlets.	Limestone ridge, brown orange sand with outcropping limestone over Tamala limestone.	Mixed Low Heath C of Grevillea preissii, Rhagodia baccata and Melaleuca acerosa.	locally abundant.		Lot 4 Mandurah Road, Singleton (Bushplan Site 395)	GPS	1	30/06/1999
32931	5437768	4027	Jacksonia sericea	4	Prostrate shrub 10 cm high, 2 m wide; old fruit; reflexed peduncles, no spiny branchlets; could be considered J. sericea.	Limestone ridge, brown-orange sand with outcropping limestone over Tamala limestone.	Mixed Low Heath C of Grevillea preissii, Rhagodia baccata and Melaleuca acerosa.	locally abundant.		Lot 4 Mandurah Road, Singleton (Bushplan Site 395)	GPS	1	30/06/1999
32937	5962528	4027	Jacksonia sericea	4			Eucalyptus gomphocephala Open Woodland over Mixed Dense Low Heath C over Mixed Low Heath D.			Site 30, 300 m W of the intersection of Mulga Road West and Merrit Road, Stakehill	MAN	3	4/11/1998

FID	Sheet	NameID	Taxon	ConsCode	Plant_Desc	Site	Vegetation	Frequency	Notes	Locality	Geocode_Me	Precision	Date
32940	7508239	4027	Jacksonia sericea	4		Gently sloping easterly facing upland site. Surface soil orange sand with limestone exposed on 1-10% of surface. Sub-surface soil orange sand with subsurface limestone. Well-drained. Litter cover - 2-10% and >5 cm depth; bare ground cover - 10-30%.	Allocasuarina humilis, Melaleuca systena and Hakea prostrata Shrubland over Grevillea preissii subsp. preissii Open Low Shrubland, over Avena barbata Grassland, Conostylis candicans subsp. calcicola Very Open Herbland and Desmocladus flexuosus Open Sedge			WSWA Bushland Plant Survey Plot PAGL 1 in Paganoni Swamp, Paganoni Road, Karnup	GPS	1	16/10/2005
32955	1131257	4027	Jacksonia sericea	4	Bush to ca 1 ft. Flowers orange, standard deeper orange.	Sand over limestone.				The Plains, near Mandurah, ca 31 miles S of Fremantle	MAN	3	10/11/1969
33765	7390025	5038	Lasiopetalum membranaceum	3		Western boundary near firebreak.	Tuart/Banksia/Sheoak woodland.		Opportunistic collection.	WSWA Bushland Plant Survey in Paganoni Swamp, Paganoni Road, Karnup	GPS	1	1/11/2005
38939	1139509	6573	Parsonsia diaphanophleba	4	Twining climber 2.5 m.		In Melaleuca rhaphiophylla fringing vegetation.			64 km S of Perth on the W bank of the Serpentine River, N of Lake Goegerup.	MAN	3	30/06/1983
40054	3409139	5237	Pimelea calcicola	3	Spreading erect multistemmed shrub 30 cm high. Flowers pale pink.	Limestone ridge. Grey sand over limestone.	Coastal limestone heath.		Abundance: common.	Singleton, Perth to Mandurah	AUTO	3	17/09/1983

FID	Sheet	NameID	Taxon	ConsCode	Plant_Desc	Site	Vegetation	Frequency	Notes	Locality	Geocode_Me	Precision	Date
42532	7536070	980	Schoenus capillifolius	3	Reproductive state: vegetative.	Inundated grey clay.	Dense Low Forst of Melaleuca rhaphiophylla. With Baumea articulata, Triglochin linearis, Villarsia albiflora, Callitriche stagnalis, Lemna disperma, Cotula coronopifolia.	large numbers, 40% cover.	Condition of population: healthy.	Baldivis Ordnance Reserve	GPS	1	15/09/2006
43655	6406173	20348	Sphaerolobium calcicola	3	Multistemmed tall shrub, 1-1.5 m high x 50 cm wide. Flowers yellow, w/keel red, eye yellow, in full flower.	Interdunal swamp. Black sandy clay over limestone. Clay.	Melaleuca rhaphiophylla low woodland over Gahnia trifida.	common.		Anstey Swamp; Lakes Regional Park, Baldivis	GPS	1	20/06/1997
43658	7508298	20348	Sphaerolobium calcicola	3		Very gently sloping easterly facing wetland site. Surface soil grey-grey/brown clay loam. Poor drainage, wet in winter/spring. Litter cover - 70% and <1 cm depth; bare ground <10%.	Cassytha sp. Very Open Climber over Melaleuca viminea Open Heath, over Vulpia sp. Open Grassland and Gahnia trifida Open Sedgeland.		Adjacent to quadrat.	WSWA Bushland Plant Survey Plot PAGS 3 in Paganoni Swamp, Paganoni Road, Karnup	GPS	1	16/10/2005

FID	Sheet	NameID	Taxon	ConsCode	Plant_Desc	Site	Vegetation	Frequency	Notes	Locality	Geocode_Me	Precision	Date
44881	4495403	7756	Stylidium longitubum	4	Delicate annual herb.	Soil: Peaty sand. Topography/drainage: Seasonally wet poorly drained flat adjacent to river channel. Geomorphology: Alluvial deposits (pinjarra plain).	Vegetation: Eucalyptus rudis Low Forest A over Hakea varia, Melalueca raphiophylla Thicket over Leptocarpus aff. roycei Tall Sedges.			Paganoni block E of Mandurah Rd, 11 km NNE of Mandurah near Serpentine River (adj. to plot paga-2).	GPS	1	4/11/1992
44882	4555708	7756	Stylidium longitubum	4	Delicate annual herb.	Soil: Brown sand. Topography/drainage: Seasonally wet poorly drained flat. Geomorphology: Swamp deposits - holocene.	Vegetation: Melalueca raphiophylla Low Forest B over exotic Very Open Low Grass over Lotus sauveolens, Stylidium longitubum Herbs over Lepidosperma longitudinale Tall Sedges.			Remnant bushland near Hymus Swamp in SW corner of Lowlands property (M105), 11 km WNW of Serpentine (plot hymus05).	GPS	1	6/11/1993

FID	PopId	Nameid	Taxon	ConsStatus	WARank	PopNumber	SubPopCode	Location	District	Vesting	Purpose1	CountDate	Method	MaturEcoun	JuvenileCo	SeedlingCo	LiveTotal	PlantTypeC	AreaOccupi	inFlower	Population
298	86279	3237	Acacia benthamii	2		5		Pagononi Block, Lakes Regional Park, Pagononi Road, Baldivis. Tenure Unknown - Herbarium record only.	SWAN COASTAL	UNKNOWN	UNKNOWN	22/09/2000 0:00		0			0			N	
301	86282	3237	Acacia benthamii	2		8		Lot 203 Stock Rd. Stakehill	SWAN COASTAL	PRI		31/03/2005 0:00	ESTMT	0			20			N	
5217	86156	3006	Cardamine paucijuga	2		3		Private Lot 809. Pagononi Block, Pagononi Rd, Baldivis.	SWAN COASTAL	PRI		24/09/2000 0:00		0			0			N	
6055	89774	11657	Conostylis pauciflora subsp. pauciflora	4		6		Private Property, Lot 808, [adjacent to Lot 806 & 807]. Singleton. [Ca. 840m S along track from Paganoni Rd]. [Ca. 500m E of Mandurah Rd]. City of Mandurah.	SWAN COASTAL	PRI		27/09/2007 0:00		0			0			Y	
7018	86764	3863	Dillwynia dillwynioides	3		4		Seasonal wetland adjoining Hymus Swamp. Ca 2 km N of Karnup Rd, at approx 1 km W of the junction with Yangetti Rd.	SWAN COASTAL	PRI		15/06/1994 0:00		0			0			N	
7020	86766	3863	Dillwynia dillwynioides	3		6		Wetland in Paganoni block, 11 km ENE of Mandurah. W side of Stock Route Rd, at ca 2.5 km S of Paganoli Rd.	SWAN COASTAL	SPC		15/06/1994 0:00		0			0			N	
7023	86769	3863	Dillwynia dillwynioides	3		9		Baldivis Ordinace Reserve (ID: 37090).	SWAN COASTAL	EXD	OTH	15/09/2006 0:00	ESTMT	20			20			Y	

FID	PopId	Nameid	Taxon	ConsStatus	WARank	PopNumber	SubPopCode	Location	District	Vesting	Purpose1	CountDate	Method	MaturEcoun	JuvenilEco	SeedlingCo	LiveTotal	PlantTypeC	AreaOccupi	inFlower	Population
7035	98820	3863	Dillwynia dillwynioides	3		20	A	Baldivis Ordance Reserve (ID: 37090). Site 8, 1.4km S of Stakehill Rd and the N boundary of Baldivis Pine Plantation, Karnup.	SWAN COASTAL	EXD	TIM	4/11/1998 0:00		0			0			N	
7036	98821	3863	Dillwynia dillwynioides	3		20	B	Baldivis Ordance Reserve (ID: 37090). Site 10, 100m N of S boundary of Baldivis Pine Plantation & 1.8km E of Karri St, Karnup.	SWAN COASTAL	EXD	TIM	4/11/1998 0:00		0			0			N	
7107	89502	10796	Diuris drummondii	T	VU	35		Lot 551, Freehold, Dept of Housing. 4km directly E of Perth-Bunbury Hwy, 1km directly S of Paganoni Road. E of `Paganoni Swamp`, S of lake Amarillo, W of Serpentine River. Access off Vine Road (private). Rockingham.	SWAN COASTAL	PRI		7/12/2008 0:00	ACT_IND	1			1			Y	
7316	85073	1639	Drakaea elastica	T	CR	30		Private property, Lot 2 Lowlands Rd, Mardella (Lowlands Farm). S from Wilkinson Road/Serpentine River junction. Within `Hymus Swamp` along the `Dampier to Bunbury Natural Gas Pipeline Corridor`. Both sides of gas pipeline.	SWAN COASTAL	PRI		29/09/2005 0:00	ACT_IND	54			54			N	

FID	PopId	Nameid	Taxon	ConsStatus	WARank	PopNumber	SubPopCode	Location	District	Vesting	Purpose1	CountDate	Method	MatureCoun	JuvenileCo	SeedlingCo	LiveTotal	PlantTypeC	AreaOccupi	inFlower	Population
7327	97407	1639	Drakaea elastica	T	CR	37	A	Main Roads vested, Lot 212 Lymon Rd, Stake Hill. Between Stock Rd and Paganoni Reserve. Along edge of firebeak on W side of road reserve for future Kwinana Fwy extention. Population has been cleared for freeway extension.	SWAN COASTAL	MRD		1/09/2010 0:00	ACT_IND	0			0			N	
7328	97408	1639	Drakaea elastica	T	CR	37	B	Rockingham Lakes Regional Park, Lot 809 - Paganoni Swamp area. Ca. 1km N of S boundary and 100m W of E boundary. Shire of Rockingham.	SWAN COASTAL	SPC	UNKNOWN	6/08/2010 0:00	ACT_IND	210		1266	0			Y	HEALTHY
7329	97409	1639	Drakaea elastica	T	CR	37	C	Private Property, Lot 519 Stock Rd, Stake Hill. North-eastern boundary of the property. [Adjacent to the west side of the Kwinana Freeway extension].	SWAN COASTAL	PRI		6/09/2010 0:00	ACT_IND	4	30		0	PLANTS	1200	N	MODERATE

FID	PopId	Nameid	Taxon	ConsStatus	WARank	PopNumber	SubPopCode	Location	District	Vesting	Purpose1	CountDate	Method	MatureCoun	JuvenileCo	SeedlingCo	LiveTotal	PlantTypeC	AreaOccupi	inFlower	Population
7330	109312	1639	Drakaea elastica	T	CR	37	D	Rockingham Lakes Regional Park, Lot 180. Known as Paganoni. Access is off Paganoni Rd on the north boudary of the Park through locked gates. Plants are in the NE cnr ~730m S from NE cnr on firebreak, then ~388m W on track to plants closest to track.	SWAN COASTAL	SPC	OTH	19/08/2011 0:00	ACT_IND	3	29		0	PLANTS	5401		HEALTHY
12288	87340	5038	Lasiopetalum membranaceum	3		24		STATE, Lot.809. WSWA Bushland Plant Survery in Paganoni Swamp, Paganoni Rd, Karnup. W boundary near firebreak.	SWAN COASTAL	PRI		1/11/2005 0:00		0			0			N	
14052	88790	6573	Parsonsia diaphanophleba	4		3		Fringing the W bank of Serpentine River. E of Ibis Retreat. Benara Farm, Lot 2 of Pt Lot 42, Cockburn Sound Location 16.	PERTH HILLS	UNKNOWN		15/06/1983 0:00		0			0			N	
15140	84515	980	Schoenus capillifolius	3		12		Baldevis Ordenance Reserve (No.37090), Rockingham	SWAN COASTAL	EXD		15/09/2006 0:00		0			0			N	

FID	PopId	Nameid	Taxon	ConsStatus	WARank	PopNumber	SubPopCode	Location	District	Vesting	Purpose1	CountDate	Method	MaturCoun	JuvenileCo	SeedlingCo	LiveTotal	PlantTypeC	AreaOccupi	inFlower	Population
15629	89293	7756	Stylidium longitubum	4		11		Un-named Reserve (ID: 44986), Paganoni block E of Mandurah Rd, 11km NNE of Mandurah near Serpentine River (adj. to plot paga-2).	SWAN COASTAL	CC	CFF	4/11/1992 0:00		0			0			N	
15632	89296	7756	Stylidium longitubum	4		14		PRI Lot.2. Remnant bushland near Hymus Swamp in SW cnr of lowlands property (M105), 11km WNW of Serpentine (plot hymus05).	SWAN COASTAL	PRI		6/11/1993 0:00		0			0			N	

APPENDIX 2

Naturemap Report

NatureMap Species Report

Created By Guest user on 16/04/2019

Current Names Only Yes
Core Datasets Only Yes
Method 'By Circle'
Centre 115° 47' 50" E,32° 23' 41" S
Buffer 5km
Group By Conservation Status

Conservation Status	Species	Records
Non-conservation taxon	456	1744
Other specially protected fauna	1	6
Priority 2	2	5
Priority 3	6	18
Priority 4	4	28
Protected under international agreement	7	7
Rare or likely to become extinct	4	102
TOTAL	**480**	**1910**

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
Rare or likely to become extinct					
1.	24731	*Calyptorhynchus banksii subsp. naso (Forest Red-tailed Black Cockatoo)*		T	
2.	24734	*Calyptorhynchus latirostris (Carnaby's Cockatoo, White-tailed Short-billed Black Cockatoo)*		T	
3.	48400	*Calyptorhynchus sp. (white-tailed black cockatoo)*		T	
4.	24092	*Dasyurus geoffroii (Chuditch, Western Quoll)*		T	
Protected under international agreement					
5.	41323	*Actitis hypoleucos (Common Sandpiper)*		IA	
6.	24788	*Calidris ruficollis (Red-necked Stint)*		IA	
7.	48587	*Hydroprogne caspia (Caspian Tern)*		IA	
8.	30932	*Limosa lapponica (Bar-tailed Godwit)*		IA	
9.	24383	*Pluvialis squatarola (Grey Plover)*		IA	
10.	48597	*Thalasseus bergii (Crested Tern)*		IA	
11.	24808	*Tringa nebularia (Common Greenshank, greenshank)*		IA	
Other specially protected fauna					
12.	48070	*Phascogale tapoatafa subsp. wambenger (South-western Brush-tailed Phascogale, Wambenger)*		S	
Priority 2					
13.	3237	*Acacia benthamii*		P2	
14.	3006	*Cardamine paucijuga*		P2	
Priority 3					
15.	34236	*Beyeria cinerea subsp. cinerea*		P3	
16.	3863	*Dillwynia dillwynioides*		P3	
17.	48935	*Idiosoma sigillatum (Swan Coastal Plain shield-backed trapdoor spider)*		P3	
18.	25147	*Lerista lineata (Perth Slider, Lined Skink)*		P3	
19.	980	*Schoenus capillifolius*		P3	
20.	20348	*Sphaerolobium calcicola*		P3	
Priority 4					
21.	48588	*Isoodon fusciventer (Quenda, southwestern brown bandicoot)*		P4	
22.	4027	*Jacksonia sericea (Waldjumi)*		P4	
23.	7756	*Stylidium longitubum (Jumping Jacks)*		P4	
24.	33992	*Synemon gratiosa (Graceful Sunmoth)*		P4	
Non-conservation taxon					
25.	15466	*Acacia applanata*			
26.	3262	*Acacia cochlearis (Rigid Wattle)*			
27.	3282	*Acacia cyclops (Coastal Wattle)*			
28.	11611	*Acacia lasiocarpa var. lasiocarpa*			
29.	3502	*Acacia pulchella (Prickly Moses)*			
30.	15481	*Acacia pulchella var. glaberrima*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
31.	3525	*Acacia rostellifera (Summer-scented Wattle)*			
32.	3527	*Acacia saligna (Orange Wattle, Kudjong)*			
33.	30032	*Acacia saligna subsp. saligna*			
34.	3557	*Acacia stenoptera (Narrow Winged Wattle)*			
35.	3602	*Acacia willdenowiana (Grass Wattle)*			
36.	24260	*Acanthiza apicalis (Broad-tailed Thornbill, Inland Thornbill)*			
37.	24261	*Acanthiza chrysorrhoa (Yellow-rumped Thornbill)*			
38.	24262	*Acanthiza inornata (Western Thornbill)*			
39.	24560	*Acanthorhynchus superciliosus (Western Spinebill)*			
40.	25535	*Accipiter cirrocephalus (Collared Sparrowhawk)*			
41.	25536	*Accipiter fasciatus (Brown Goshawk)*			
42.	42368	*Acritoscincus trilineatus (Western Three-lined Skink)*			
43.	25755	*Acrocephalus australis (Australian Reed Warbler)*			
44.	4582	*Adriana quadripartita (Bitter Bush)*			
45.	184	*Aira caryophyllea (Silvery Hairgrass)*	Y		
46.	1728	*Allocasuarina fraseriana (Sheoak, Kondil)*			
47.		*Aname mainae*			
48.	24310	*Anas castanea (Chestnut Teal)*			
49.	24312	*Anas gracilis (Grey Teal)*			
50.	24315	*Anas rhynchotis (Australasian Shoveler)*			
51.	24316	*Anas superciliosa (Pacific Black Duck)*			
52.	47414	*Anhinga novaehollandiae (Australasian Darter)*			
53.	1411	*Anigozanthos manglesii (Mangles Kangaroo Paw, Kurulbrang)*			
54.	44629	*Anilios australis*			
55.	6949	*Anthocercis littorea (Yellow Tailflower)*			
56.	24561	*Anthochaera carunculata (Red Wattlebird)*			
57.	24562	*Anthochaera lunulata (Western Little Wattlebird)*			
58.	202	*Anthoxanthum odoratum (Sweet Vernal Grass)*	Y		
59.	3688	*Aotus gracillima*			
60.	1117	*Aphelia cyperoides*			
61.	6211	*Apium prostratum (Sea Celery)*			
62.	24991	*Aprasia repens (Sand-plain Worm-lizard)*			
63.	24285	*Aquila audax (Wedge-tailed Eagle)*			
64.	41324	*Ardea modesta (great egret, white egret)*			
65.	24340	*Ardea novaehollandiae (White-faced Heron)*			
66.	24341	*Ardea pacifica (White-necked Heron)*			
67.	25566	*Artamus cinereus (Black-faced Woodswallow)*			
68.	24353	*Artamus cyanopterus (Dusky Woodswallow)*			
69.	20350	*Astartea affinis (West-coast Astartea)*			
70.	20283	*Astartea scoparia (Common Astartea)*			
71.	6323	*Astroloma ciliatum (Candle Cranberry)*			
72.	6334	*Astroloma pallidum (Kick Bush)*			
73.	38762	*Auriscalpium barbatum*			
74.	47713	*Austronomus australis (White-striped Free-tailed Bat)*			
75.	17234	*Austrostipa compressa*			
76.	17239	*Austrostipa exilis*			
77.	17240	*Austrostipa flavescens*			
78.	24318	*Aythya australis (Hardhead)*			
79.	1800	*Banksia attenuata (Slender Banksia, Piara)*			
80.	1830	*Banksia littoralis (Swamp Banksia, Pungura)*			
81.	1834	*Banksia menziesii (Firewood Banksia)*			
82.	32202	*Banksia nivea (Honeypot Dryandra, Pudjarn)*			
83.		*Barnardius zonarius*			
84.	741	*Baumea articulata (Jointed Rush)*			
85.	743	*Baumea juncea (Bare Twigrush)*			
86.	748	*Baumea vaginalis (Sheath Twigrush)*			
87.	7046	*Bellardia trixago (Bellardia)*	Y		
88.	48868	*Bellardia viscosa*	Y		
89.	24319	*Biziura lobata (Musk Duck)*			
90.	749	*Bolboschoenus caldwellii (Marsh Club-rush)*			
91.		*Boletus sp.*			
92.	3710	*Bossiaea eriocarpa (Common Brown Pea)*			
93.	6341	*Brachyloma preissii (Globe Heath)*			
94.	8661	*Brachypodium distachyon (False Brome)*	Y		
95.	244	*Briza maxima (Blowfly Grass)*	Y		
96.	245	*Briza minor (Shivery Grass)*	Y		
97.	249	*Bromus diandrus (Great Brome)*	Y		
98.	1383	*Burchardia bairdiae*			
99.	12770	*Burchardia congesta*			
100.	25715	*Cacatua roseicapilla (Galah)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
101.	25716	*Cacatua sanguinea (Little Corella)*			
102.	25598	*Cacomantis flabelliformis (Fan-tailed Cuckoo)*			
103.	1276	*Caesia micrantha (Pale Grass Lily)*			
104.	15330	*Caladenia arenicola*			
105.	1599	*Caladenia latifolia (Pink Fairy Orchid)*			
106.	15361	*Caladenia longicauda subsp. calcigena*			
107.	17589	*Caladenia occidentalis*			
108.	18019	*Caladenia vulgata*			
109.	2848	*Calandrinia corrigioloides (Strap Purslane)*			
110.	2856	*Calandrinia liniflora (Parakeelya)*			
111.	25717	*Calyptorhynchus banksii (Red-tailed Black-Cockatoo)*			
112.	5439	*Calytrix angulata (Yellow Starflower)*			
113.		*Candelariella sp.*			
114.	48920	*Canis familiaris (Dog, Dingo)*	Y		
115.	3005	*Cardamine hirsuta (Common Bittercress)*	Y		
116.	1162	*Cartonema philydroides*			
117.	11799	*Cassytha racemosa forma racemosa*			
118.	6542	*Centaurium tenuiflorum*	Y		
119.	35322	*Centranthus ruber subsp. ruber*	Y		
120.	1121	*Centrolepis aristata (Pointed Centrolepis)*			
121.	24186	*Chalinolobus gouldii (Gould's Wattled Bat)*			
122.	1280	*Chamaescilla corymbosa (Blue Squill)*			
123.	24377	*Charadrius ruficapillus (Red-capped Plover)*			
124.	43380	*Chelodina colliei (South-western Snake-necked Turtle)*			
125.	24321	*Chenonetta jubata (Australian Wood Duck, Wood Duck)*			
126.		*Cherax destructor*			
127.		*Cherax quinquecarinatus*			
128.	763	*Chorizandra enodis (Black Bristlerush)*			
129.		*Chroicocephalus novaehollandiae*			
130.	24288	*Circus approximans (Swamp Harrier)*			
131.	24774	*Cladorhynchus leucocephalus (Banded Stilt)*			
132.	25675	*Colluricincla harmonica (Grey Shrike-thrush)*			
133.	24399	*Columba livia (Domestic Pigeon)*	Y		
134.	4550	*Comesperma calymega (Blue-spike Milkwort)*			
135.	4564	*Comesperma virgatum (Milkwort)*			
136.	1885	*Conospermum triplinervium (Tree Smokebush)*			
137.	6349	*Conostephium preissii*			
138.	1418	*Conostylis aculeata (Prickly Conostylis)*			
139.	11826	*Conostylis aculeata subsp. aculeata*			
140.	12027	*Conostylis candicans subsp. calcicola*			
141.	1436	*Conostylis juncea*			
142.	25568	*Coracina novaehollandiae (Black-faced Cuckoo-shrike)*			
143.	25592	*Corvus coronoides (Australian Raven)*			
144.	1285	*Corynotheca micrantha (Sand Lily)*			
145.	7945	*Cotula coronopifolia (Waterbuttons)*	Y		
146.	25595	*Cracticus tibicen (Australian Magpie)*			
147.	25596	*Cracticus torquatus (Grey Butcherbird)*			
148.	3137	*Crassula colorata (Dense Stonecrop)*			
149.	3140	*Crassula glomerata*	Y		
150.	15706	*Crassula natans var. minus*	Y		
151.	25399	*Crinia glauerti (Clicking Frog)*			
152.	25400	*Crinia insignifera (Squelching Froglet)*			
153.	4802	*Cryptandra mutila*			
154.	30893	*Cryptoblepharus buchananii*			
155.	25027	*Ctenotus australis*			
156.	25039	*Ctenotus fallens*			
157.	768	*Cyathochaeta avenacea*			
158.	24322	*Cygnus atratus (Black Swan)*			
159.	19625	*Cymbalaria muralis subsp. muralis*	Y		
160.	285	*Cynosurus echinatus (Rough Dogstail)*	Y		
161.	783	*Cyperus congestus (Dense Flat-sedge)*	Y		
162.	10916	*Cyrtostylis huegelii*			
163.	30901	*Dacelo novaeguineae (Laughing Kookaburra)*	Y		
164.	7484	*Dampiera trigona (Angled-stem Dampiera)*			
165.	25673	*Daphoenositta chrysoptera (Varied Sittella)*			
166.	6218	*Daucus glochidiatus (Australian Carrot)*			
167.	3832	*Daviesia physodes*			
168.	3845	*Daviesia triflora*			
169.	17663	*Desmocladus asper*			
170.	17691	*Desmocladus fasciculatus*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
171.	16595	*Desmocladus flexuosus*			
172.	299	*Deyeuxia quadriseta (Reed Bentgrass)*			
173.	306	*Dichelachne crinita (Longhair Plumegrass)*			
174.	1287	*Dichopogon capillipes*			
175.	4454	*Diplolaena dampieri (Southern Diplolaena)*			
176.	18541	*Diplopeltis huegelii subsp. huegelii*			
177.	7054	*Dischisma arenarium*	Y		
178.	7055	*Dischisma capitatum (Woolly-headed Dischisma)*	Y		
179.	24470	*Dromaius novaehollandiae (Emu)*			
180.	3095	*Drosera erythrorhiza (Red Ink Sundew)*			
181.	3106	*Drosera macrantha (Bridal Rainbow)*			
182.	3114	*Drosera nitidula (Shining Sundew)*			
183.	3118	*Drosera pallida (Pale Rainbow)*			
184.	3131	*Drosera stolonifera (Leafy Sundew)*			
185.		*Egretta garzetta*			
186.		*Egretta novaehollandiae*			
187.	347	*Ehrharta calycina (Perennial Veldt Grass)*	Y		
188.		*Elanus axillaris*			
189.	47937	*Elseyornis melanops (Black-fronted Dotterel)*			
190.		*Eolophus roseicapillus*			
191.	6131	*Epilobium billardiereanum (Glabrous Willow Herb)*			
192.	14289	*Epilobium tetragonum subsp. tetragonum*	Y		
193.	24567	*Epthianura albifrons (White-fronted Chat)*			
194.	15446	*Eryngium pinnatifidum subsp. pinnatifidum*			
195.	24379	*Erythrogonys cinctus (Red-kneed Dotterel)*			
196.	5649	*Eucalyptus foecunda (Narrow-leaved Red Mallee)*			
197.	5659	*Eucalyptus gomphocephala (Tuart, Duart)*			
198.	20808	*Eucalyptus petiolaris*	Y		
199.	4648	*Euphorbia terracina (Geraldton Carnation Weed)*	Y		
200.	3880	*Eutaxia virgata*			
201.	10765	*Exocarpos sparteus (Broom Ballart, Djuk)*			
202.	25622	*Falco cenchroides (Australian Kestrel, Nankeen Kestrel)*			
203.	25623	*Falco longipennis (Australian Hobby)*			
204.	24041	*Felis catus (Cat)*	Y		
205.	25727	*Fulica atra (Eurasian Coot)*			
206.	24761	*Fulica atra subsp. australis (Eurasian Coot)*			
207.	907	*Gahnia trifida (Coast Saw-sedge)*			
208.	34028	*Galaxias occidentalis (Western Minnow)*			
209.	25729	*Gallinula tenebrosa (Dusky Moorhen)*			
210.	24763	*Gallinula tenebrosa subsp. tenebrosa (Dusky Moorhen)*			
211.	20473	*Gastrolobium ebracteolatum*			
212.	20482	*Gastrolobium nervosum*			
213.	4341	*Geranium solanderi (Native Geranium)*			
214.	25530	*Gerygone fusca (Western Gerygone)*			
215.	1520	*Gladiolus caryophyllaceus (Wild Gladiolus)*	Y		
216.	10909	*Gompholobium confertum*			
217.	3957	*Gompholobium tomentosum (Hairy Yellow Pea)*			
218.	7538	*Goodenia pulchella*			
219.	24443	*Grallina cyanoleuca (Magpie-lark)*			
220.	1982	*Grevillea crithmifolia*			
221.	15839	*Grevillea preissii subsp. preissii*			
222.	12824	*Grevillea vestita subsp. vestita*			
223.		*Gymnopilus allantopus*			
224.	1472	*Haemodorum simplex*			
225.	2197	*Hakea prostrata (Harsh Hakea)*			
226.	24293	*Haliaeetus leucogaster (White-bellied Sea-Eagle)*			
227.	24295	*Haliastur sphenurus (Whistling Kite)*			
228.	3961	*Hardenbergia comptoniana (Native Wisteria)*			
229.	25410	*Heleioporus eyrei (Moaning Frog)*			
230.	3016	*Heliophila pusilla*	Y		
231.	16933	*Hemiandra glabra*			
232.	25119	*Hemiergis quadrilineata*			
233.	5135	*Hibbertia hypericoides (Yellow Buttercups)*			
234.	5162	*Hibbertia racemosa (Stalked Guinea Flower)*			
235.	5172	*Hibbertia stellaris (Orange Stars)*			
236.	47965	*Hieraaetus morphnoides (Little Eagle)*			
237.	25734	*Himantopus himantopus (Black-winged Stilt)*			
238.	24491	*Hirundo neoxena (Welcome Swallow)*			
239.	13758	*Histiopteris incisa*			
240.	445	*Holcus setiger (Annual Fog)*	Y		

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
241.	6222	*Homalosciadium homalocarpum*			
242.	3968	*Hovea trisperma (Common Hovea)*			
243.	12859	*Hovea trisperma var. trisperma*			
244.	5216	*Hybanthus calycinus (Wild Violet)*			
245.	6229	*Hydrocotyle diantha*			
246.	8086	*Hypochaeris glabra (Smooth Catsear)*	Y		
247.	1070	*Hypolaena exsulca*			
248.	17841	*Hypolaena pubescens*			
249.		*Idiommata blackwalli*			
250.	20200	*Isolepis cernua var. setiformis*			
251.	917	*Isolepis marginata (Coarse Club-rush)*			
252.	921	*Isolepis producta*			
253.	3992	*Isotropis cuneifolia (Granny Bonnets)*			
254.	8092	*Ixiolaena viscosa (Sticky Ixiolaena)*			
255.	4012	*Jacksonia furcellata (Grey Stinkwood)*			
256.	20454	*Juncus acutus subsp. acutus*	Y		
257.	1188	*Juncus pallidus (Pale Rush)*			
258.	4044	*Kennedia prostrata (Scarlet Runner)*			
259.	13562	*Lachenalia aloides*	Y		
260.	20019	*Lachnagrostis filiformis*			
261.	25637	*Larus novaehollandiae (Silver Gull)*			
262.	925	*Lepidosperma angustatum*			
263.	932	*Lepidosperma effusum (Spreading Sword-sedge)*			
264.	937	*Lepidosperma longitudinale (Pithy Sword-sedge)*			
265.	940	*Lepidosperma pubisquameum*			
266.		*Lepidosperma sp.*			
267.	945	*Lepidosperma squamatum*			
268.	1078	*Leptocarpus coangustatus*			
269.	1080	*Leptocarpus scariosus*			
270.	1085	*Lepyrodia glauca*			
271.	25133	*Lerista elegans*			
272.	6427	*Leucopogon parviflorus (Coast Beard-heath)*			
273.	6436	*Leucopogon propinquus*			
274.	7677	*Levenhookia stipitata (Common Stylewort)*			
275.	25005	*Lialis burtonis*			
276.	25661	*Lichmera indistincta (Brown Honeyeater)*			
277.	24582	*Lichmera indistincta subsp. indistincta (Brown Honeyeater)*			
278.	25415	*Limnodynastes dorsalis (Western Banjo Frog)*			
279.	7075	*Linaria maroccana*	Y		
280.	36160	*Liparophyllum capitatum*			
281.	36179	*Liparophyllum violifolium*			
282.	25378	*Litoria adelaidensis (Slender Tree Frog)*			
283.	25388	*Litoria moorei (Motorbike Frog)*			
284.	9289	*Lobelia anceps (Angled Lobelia)*			
285.	7408	*Lobelia tenuior (Slender Lobelia)*			
286.	476	*Lolium perenne (Perennial Ryegrass)*	Y		
287.		*Lolium sp.*			
288.	11073	*Lolium x hybridum*	Y		
289.	1223	*Lomandra caespitosa (Tufted Mat Rush)*			
290.	1231	*Lomandra maritima*			
291.	1232	*Lomandra micrantha (Small-flower Mat-rush)*			
292.	14542	*Lomandra micrantha subsp. micrantha*			
293.	1239	*Lomandra preissii*			
294.	1243	*Lomandra sericea (Silky Mat Rush)*			
295.	1246	*Lomandra suaveolens*			
296.		*Lophoictinia isura*			
297.	8564	*Lotus subbiflorus*	Y		
298.	1198	*Luzula meridionalis (Field Woodrush)*			
299.	1097	*Lyginia barbata*			
300.		*Macrolepiota clelandii*			
301.	24132	*Macropus fuliginosus (Western Grey Kangaroo)*			
302.	85	*Macrozamia riedlei (Zamia, Djiridji)*			
303.	24326	*Malacorhynchus membranaceus (Pink-eared Duck)*			
304.	25654	*Malurus splendens (Splendid Fairy-wren)*			
305.	24552	*Malurus splendens subsp. splendens (Splendid Fairy-wren)*			
306.	25758	*Megalurus gramineus (Little Grassbird)*			
307.	34676	*Meionectes brownii (Swamp Raspwort)*			
308.	13273	*Melaleuca incana subsp. incana*			
309.	5926	*Melaleuca lateritia (Robin Redbreast Bush)*			
310.	5952	*Melaleuca preissiana (Moonah)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
311.	5959	*Melaleuca rhaphiophylla (Swamp Paperbark)*			
312.	18598	*Melaleuca systena*			
313.	5978	*Melaleuca teretifolia (Banbar)*			
314.	5987	*Melaleuca viminea (Mohan)*			
315.	25184	*Menetia greyii*			
316.	6886	*Mentha x piperita*	Y		Y
317.	24598	*Merops ornatus (Rainbow Bee-eater)*			
318.	955	*Mesomelaena pseudostygia*			
319.		*Microcarbo melanoleucos*			
320.	485	*Microlaena stipoides (Weeping Grass)*			
321.	15419	*Microtis media subsp. media*			
322.	1660	*Microtis orbicularis (Dark Mignonette Orchid)*			
323.	37440	*Monopsis debilis var. depressa*	Y		
324.	25191	*Morethia lineoocellata*			
325.	48008	*Morus serrator (Australasian Gannet)*			
326.	2412	*Muehlenbeckia adpressa (Climbing Lignum)*			
327.	24223	*Mus musculus (House Mouse)*	Y		
328.	38811	*Mycena clarkeana*			
329.		*Mycena nargan*			
330.	7289	*Myoporum caprarioides (Slender Myoporum)*			
331.		*Nannoperca vittata*			
332.	24738	*Neophema elegans (Elegant Parrot)*			
333.	25252	*Notechis scutatus (Tiger Snake)*			
334.	25564	*Nycticorax caledonicus (Rufous Night Heron)*			
335.	24407	*Ocyphaps lophotes (Crested Pigeon)*			
336.	38816	*Omphalotus nidiformis*			
337.	7348	*Opercularia hispidula (Hispid Stinkweed)*			
338.	4113	*Ornithopus compressus (Yellow Serradella)*	Y		
339.	7122	*Orobanche minor (Lesser Broomrape)*	Y		
340.	24085	*Oryctolagus cuniculus (Rabbit)*	Y		
341.	30375	*Oxalis exilis*			
342.	4355	*Oxalis perennans*			
343.	25680	*Pachycephala rufiventris (Rufous Whistler)*			
344.	25681	*Pardalotus punctatus (Spotted Pardalote)*			
345.	25682	*Pardalotus striatus (Striated Pardalote)*			
346.	1763	*Parietaria judaica (Pellitory)*	Y		
347.	4343	*Pelargonium capitatum (Rose Pelargonium)*	Y		
348.	4346	*Pelargonium littorale*			
349.	24648	*Pelecanus conspicillatus (Australian Pelican)*			
350.	6006	*Pericalymma ellipticum (Swamp Teatree)*			
351.	48061	*Petrochelidon nigricans (Tree Martin)*			
352.	48066	*Petroica boodang (Scarlet Robin)*			
353.	20368	*Petrophile axillaris*			
354.	19825	*Petrorhagia dubia*	Y		
355.	25698	*Phalacrocorax melanoleucos (Little Pied Cormorant)*			
356.	24667	*Phalacrocorax sulcirostris (Little Black Cormorant)*			
357.	24409	*Phaps chalcoptera (Common Bronzewing)*			
358.	18529	*Philotheca spicata (Pepper and Salt)*			
359.	1478	*Phlebocarya ciliata*			
360.	48071	*Phylidonyris niger (White-cheeked Honeyeater)*			
361.	24596	*Phylidonyris novaehollandiae (New Holland Honeyeater)*			
362.	16177	*Phyllangium paradoxum*			
363.		*Phytophthora cinnamomi*			
364.	14370	*Picris angustifolia subsp. angustifolia*			
365.	5252	*Pimelea lanata*			
366.	5261	*Pimelea rosea (Rose Banjine)*			
367.	18117	*Pimelea rosea subsp. rosea*			
368.	24841	*Platalea flavipes (Yellow-billed Spoonbill)*			
369.	24750	*Platycercus zonarius subsp. semitorquatus (Twenty-eight Parrot)*			
370.	38823	*Pleuroflammula praestans*			
371.	573	*Poa drummondiana (Knotted Poa)*			
372.	25704	*Podiceps cristatus (Great Crested Grebe)*			
373.	8175	*Podolepis gracilis (Slender Podolepis)*			
374.	8182	*Podotheca angustifolia (Sticky Longheads)*			
375.	8183	*Podotheca chrysantha (Yellow Podotheca)*			
376.		*Podotheca sp.*			
377.	25510	*Pogona minor (Dwarf Bearded Dragon)*			
378.	24907	*Pogona minor subsp. minor (Dwarf Bearded Dragon)*			
379.	24681	*Poliocephalus poliocephalus (Hoary-headed Grebe)*			
380.	25722	*Polytelis anthopeplus (Regent Parrot)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
381.	25731	*Porphyrio porphyrio (Purple Swamphen)*			
382.	24767	*Porphyrio porphyrio subsp. bellus (Purple Swamphen)*			
383.	1670	*Prasophyllum drummondii (Swamp Leek Orchid)*			
384.	25511	*Pseudonaja affinis (Dugite)*			
385.	25259	*Pseudonaja affinis subsp. affinis (Dugite)*			
386.	48674	*Pterostylis orbiculata*			
387.		*Pterostylis sp.*			
388.	2718	*Ptilotus drummondii (Narrowleaf Mulla Mulla)*			
389.	2751	*Ptilotus polystachyus (Prince of Wales Feather)*			
390.		*Purpureicephalus spurius*			
391.	8195	*Quinetia urvillei*			
392.	2935	*Ranunculus pumilio (Smallflower Buttercup)*			
393.	2938	*Ranunculus trilobus (Buttercup)*	Y		
394.	24245	*Rattus rattus (Black Rat)*	Y		
395.		*Raveniella peckorum*			
396.	24776	*Recurvirostra novaehollandiae (Red-necked Avocet)*			
397.	38832	*Resupinatus cinerascens*			
398.	19183	*Retama raetam*	Y		
399.	11930	*Rhagodia baccata subsp. dioica (Sea Berry Saltbush)*			
400.	48096	*Rhipidura albiscapa (Grey Fantail)*			
401.	25614	*Rhipidura leucophrys (Willie Wagtail)*			
402.	24454	*Rhipidura leucophrys subsp. leucophrys (Willie Wagtail)*			
403.	2440	*Rumex pulcher (Fiddle Dock)*	Y		
404.	6483	*Samolus junceus*			
405.	7603	*Scaevola canescens (Grey Scaevola)*			
406.	7614	*Scaevola globulifera*			
407.	13152	*Scaevola thesioides subsp. thesioides*			
408.	48834	*Schinus terebinthifolia*	Y		
409.	986	*Schoenus efoliatus*			
410.	992	*Schoenus grandiflorus (Large Flowered Bogrush)*			
411.	1018	*Schoenus subfascicularis*			
412.	6033	*Scholtzia involucrata (Spiked Scholtzia)*			
413.	6	*Selaginella gracillima (Tiny Clubmoss)*			
414.	32433	*Sematophyllum homomallum*			
415.	20161	*Senecio pinnatifolius*			
416.	8218	*Senecio ramosissimus (Auricled Groundsel)*			
417.	25534	*Sericornis frontalis (White-browed Scrubwren)*			
418.	2909	*Silene gallica (French Catchfly)*	Y		
419.	8224	*Siloxerus filifolius*			
420.	25266	*Simoselaps bertholdi (Jan's Banded Snake)*			
421.	30948	*Smicrornis brevirostris (Weebill)*			
422.	8230	*Sonchus asper (Rough Sowthistle)*	Y		
423.	9367	*Sonchus hydrophilus (Native Sowthistle)*			
424.	8231	*Sonchus oleraceus (Common Sowthistle)*	Y		
425.	1312	*Sowerbaea laxiflora (Purple Tassels)*			
426.	624	*Spinifex hirsutus (Hairy Spinifex)*			
427.	635	*Sporobolus virginicus (Marine Couch)*			
428.	9069	*Stackhousia huegelii*			
429.	4733	*Stackhousia monogyna*			
430.	2918	*Stellaria media (Chickweed)*	Y		
431.	24554	*Stipiturus malachurus subsp. westernensis (Southern Emu-wren)*			
432.	25597	*Strepera versicolor (Grey Currawong)*			
433.	25590	*Streptopelia senegalensis (Laughing Turtle-Dove)*	Y		
434.	7712	*Stylidium despectum (Dwarf Triggerplant)*			
435.	7717	*Stylidium divaricatum (Daddy-long-legs)*			
436.	7774	*Stylidium piliferum (Common Butterfly Triggerplant)*			
437.	7798	*Stylidium schoenoides (Cow Kicks)*			
438.	2329	*Synaphea spinulosa*			
439.	25705	*Tachybaptus novaehollandiae (Australasian Grebe, Black-throated Grebe)*			
440.	24682	*Tachybaptus novaehollandiae subsp. novaehollandiae (Australasian Grebe, Black-throated Grebe)*			
441.	24331	*Tadorna tadornoides (Australian Shelduck, Mountain Duck)*			
442.	20135	*Taxandria linearifolia*			
443.	4256	*Templetonia retusa (Cockies Tongues)*			
444.	1036	*Tetraria octandra*			
445.	1708	*Thelymitra fuscolutea (Chestnut Sun Orchid)*			
446.	20730	*Thelymitra paludosa*			
447.		*Thelymitra sp.*			
448.	24845	*Threskiornis spinicollis (Straw-necked Ibis)*			
449.	1318	*Thysanotus arbuscula*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
450.	1319	*Thysanotus arenarius*			
451.	1338	*Thysanotus manglesianus (Fringed Lily)*			
452.	1339	*Thysanotus multiflorus (Many-flowered Fringe Lily)*			
453.	1354	*Thysanotus tenellus*			
454.	25203	*Tiliqua occipitalis (Western Bluetongue)*			
455.	25519	*Tiliqua rugosa*			
456.	25207	*Tiliqua rugosa subsp. rugosa*			
457.	25549	*Todiramphus sanctus (Sacred Kingfisher)*			
458.	32445	*Tortula muralis*			
459.	6266	*Trachymene coerulea (Blue Lace Flower)*			
460.	19041	*Trachymene coerulea subsp. coerulea*			
461.	6280	*Trachymene pilosa (Native Parsnip)*			
462.	25723	*Trichoglossus haematodus (Rainbow Lorikeet)*			
463.	25521	*Trichosurus vulpecula (Common Brushtail Possum)*			
464.	1361	*Tricoryne elatior (Yellow Autumn Lily)*			
465.	4292	*Trifolium campestre (Hop Clover)*	Y		
466.	4295	*Trifolium dubium (Suckling Clover)*	Y		
467.	11665	*Trymalium ledifolium var. ledifolium*			
468.	48147	*Turnix varius (Painted Button-quail)*			
469.	8255	*Ursinia anthemoides (Ursinia)*	Y		
470.	24386	*Vanellus tricolor (Banded Lapwing)*			
471.	7107	*Verbascum virgatum (Twiggy Mullein)*	Y		
472.	15725	*Verbesina encelioides*	Y		
473.	24206	*Vespadelus regulus (Southern Forest Bat)*			
474.	24040	*Vulpes vulpes (Red Fox)*	Y		
475.	724	*Vulpia myuros (Rat's Tail Fescue)*	Y		
476.	33101	*Vulpia myuros forma myuros*	Y		
477.	7389	*Wahlenbergia preissii*			
478.	6289	*Xanthosia huegelii*			
479.	25765	*Zosterops lateralis (Grey-breasted White-eye, Silvereye)*			
480.	36218	*Zygodon menziesii*			

Conservation Codes
T - Rare or likely to become extinct
X - Presumed extinct
IA - Protected under international agreement
S - Other specially protected fauna
1 - Priority 1
2 - Priority 2
3 - Priority 3
4 - Priority 4
5 - Priority 5

[1] For NatureMap's purposes, species flagged as endemic are those whose records are wholely contained within the search area. Note that only those records complying with the search criterion are included in the calculation. For example, if you limit records to those from a specific datasource, only records from that datasource are used to determine if a species is restricted to the query area.

APPENDIX 3

Protected Matters Search Tool Report

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

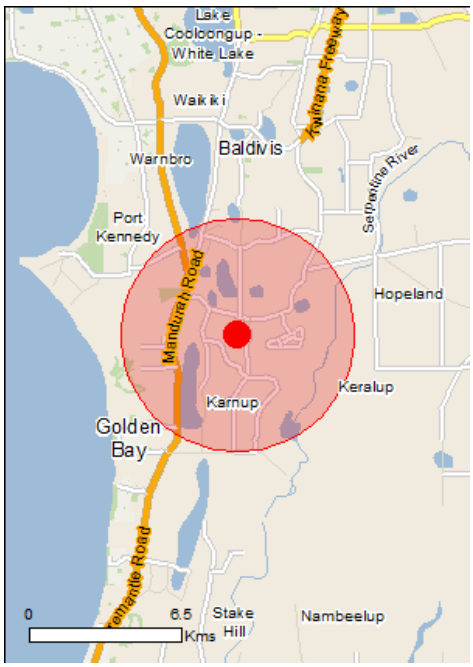
Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

Information is available about Environment Assessments and the EPBC Act including significance guidelines, forms and application process details.

Report created: 16/04/19 17:39:59

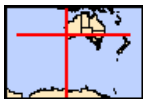
Summary
Details
- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

Caveat
Acknowledgements



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Coordinates
Buffer: 5.0Km



Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance:	2
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	2
Listed Threatened Species:	25
Listed Migratory Species:	13

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Land:	1
Commonwealth Heritage Places:	None
Listed Marine Species:	20
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	1
Regional Forest Agreements:	None
Invasive Species:	33
Nationally Important Wetlands:	None
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Wetlands of International Importance (Ramsar) [Resource Information]

Name	Proximity
Becher point wetlands	Within Ramsar site
Peel-yalgorup system	10 - 20km upstream

Listed Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Banksia Woodlands of the Swan Coastal Plain ecological community	Endangered	Community likely to occur within area
Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Endangered	Community known to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat may occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat likely to occur within area
Calyptorhynchus banksii naso Forest Red-tailed Black-Cockatoo, Karrak [67034]	Vulnerable	Species or species habitat known to occur within area
Calyptorhynchus baudinii Baudin's Cockatoo, Long-billed Black-Cockatoo [769]	Endangered	Species or species habitat likely to occur within area
Calyptorhynchus latirostris Carnaby's Cockatoo, Short-billed Black-Cockatoo [59523]	Endangered	Species or species habitat known to occur within area
Leipoa ocellata Malleefowl [934]	Vulnerable	Species or species habitat likely to occur within area
Limosa lapponica baueri Bar-tailed Godwit (baueri), Western Alaskan Bar-tailed Godwit [86380]	Vulnerable	Species or species habitat known to occur within area
Limosa lapponica menzbieri Northern Siberian Bar-tailed Godwit, Bar-tailed Godwit (menzbieri) [86432]	Critically Endangered	Species or species habitat may occur within area

Name	Status	Type of Presence
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pachyptila turtur subantarctica Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat likely to occur within area
Rostratula australis Australian Painted-snipe, Australian Painted Snipe [77037]	Endangered	Species or species habitat likely to occur within area
Mammals		
Bettongia penicillata ogilbyi Woylie [66844]	Endangered	Species or species habitat known to occur within area
Dasyurus geoffroii Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat known to occur within area
Pseudocheirus occidentalis Western Ringtail Possum, Ngwayir, Womp, Woder, Ngoor, Ngoolangit [25911]	Critically Endangered	Species or species habitat likely to occur within area
Other		
Westralunio carteri Carter's Freshwater Mussel, Freshwater Mussel [86266]	Vulnerable	Species or species habitat known to occur within area
Plants		
Andersonia gracilis Slender Andersonia [14470]	Endangered	Species or species habitat may occur within area
Caladenia huegelii King Spider-orchid, Grand Spider-orchid, Rusty Spider-orchid [7309]	Endangered	Species or species habitat may occur within area
Diuris micrantha Dwarf Bee-orchid [55082]	Vulnerable	Species or species habitat likely to occur within area
Diuris purdiei Purdie's Donkey-orchid [12950]	Endangered	Species or species habitat likely to occur within area
Drakaea elastica Glossy-leafed Hammer Orchid, Glossy-leaved Hammer Orchid, Warty Hammer Orchid [16753]	Endangered	Species or species habitat known to occur within area
Drakaea micrantha Dwarf Hammer-orchid [56755]	Vulnerable	Species or species habitat likely to occur within area
Lepidosperma rostratum Beaked Lepidosperma [14152]	Endangered	Species or species habitat likely to occur within area
Synaphea sp. Fairbridge Farm (D. Papenfus 696) Selena's Synaphea [82881]	Critically Endangered	Species or species habitat likely to occur within area
Synaphea sp. Serpentine (G.R. Brand 103) [86879]	Critically Endangered	Species or species habitat may occur within area

Listed Migratory Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Migratory Marine Birds		

Name	Threatened	Type of Presence
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardenna carneipes		
Flesh-footed Shearwater, Fleshy-footed Shearwater [82404]		Species or species habitat likely to occur within area
Sterna dougallii		
Roseate Tern [817]		Foraging, feeding or related behaviour likely to occur within area
Migratory Terrestrial Species		
Motacilla cinerea		
Grey Wagtail [642]		Species or species habitat may occur within area
Migratory Wetlands Species		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat known to occur within area
Calidris acuminata		
Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus		
Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea		
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat likely to occur within area
Calidris melanotos		
Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Limosa lapponica		
Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Numenius madagascariensis		
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pandion haliaetus		
Osprey [952]		Species or species habitat likely to occur within area
Tringa nebularia		
Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Land [Resource Information]

The Commonwealth area listed below may indicate the presence of Commonwealth land in this vicinity. Due to the unreliability of the data source, all proposals should be checked as to whether it impacts on a Commonwealth area, before making a definitive decision. Contact the State or Territory government land department for further information.

Name
Commonwealth Land -

Listed Marine Species [Resource Information]

* Species is listed under a different scientific name on the EPBC Act - Threatened Species list.

Name	Threatened	Type of Presence
Birds		

Name	Threatened	Type of Presence
Actitis hypoleucos Common Sandpiper [59309]		Species or species habitat known to occur within area
Apus pacificus Fork-tailed Swift [678]		Species or species habitat likely to occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat likely to occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]	Endangered	Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat likely to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Motacilla cinerea Grey Wagtail [642]		Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area
Pachyptila turtur Fairy Prion [1066]		Species or species habitat likely to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat likely to occur within area
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Species or species habitat likely to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat likely to occur within area
Sterna dougallii Roseate Tern [817]		Foraging, feeding or related behaviour likely to occur within area

Name	Threatened	Type of Presence
Thinornis rubricollis		
Hooded Plover [59510]		Species or species habitat likely to occur within area
Tringa nebularia		
Common Greenshank, Greenshank [832]		Species or species habitat likely to occur within area

Extra Information

State and Territory Reserves [Resource Information]

Name	State
Port Kennedy Scientific Park	WA

Invasive Species [Resource Information]

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Birds		
Acridotheres tristis		
Common Myna, Indian Myna [387]		Species or species habitat likely to occur within area
Anas platyrhynchos		
Mallard [974]		Species or species habitat likely to occur within area
Carduelis carduelis		
European Goldfinch [403]		Species or species habitat likely to occur within area
Columba livia		
Rock Pigeon, Rock Dove, Domestic Pigeon [803]		Species or species habitat likely to occur within area
Passer domesticus		
House Sparrow [405]		Species or species habitat likely to occur within area
Passer montanus		
Eurasian Tree Sparrow [406]		Species or species habitat likely to occur within area
Streptopelia chinensis		
Spotted Turtle-Dove [780]		Species or species habitat likely to occur within area
Streptopelia senegalensis		
Laughing Turtle-dove, Laughing Dove [781]		Species or species habitat likely to occur within area
Sturnus vulgaris		
Common Starling [389]		Species or species habitat likely to occur within area
Turdus merula		
Common Blackbird, Eurasian Blackbird [596]		Species or species habitat likely to occur

Name	Status	Type of Presence within area
Mammals		
Bos taurus Domestic Cattle [16]		Species or species habitat likely to occur within area
Canis lupus familiaris Domestic Dog [82654]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Funambulus pennantii Northern Palm Squirrel, Five-striped Palm Squirrel [129]		Species or species habitat likely to occur within area
Mus musculus House Mouse [120]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Rattus norvegicus Brown Rat, Norway Rat [83]		Species or species habitat likely to occur within area
Rattus rattus Black Rat, Ship Rat [84]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Brachiaria mutica Para Grass [5879]		Species or species habitat may occur within area
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat may occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Chrysanthemoides monilifera subsp. monilifera Boneseed [16905]		Species or species habitat likely to occur within area
Genista sp. X Genista monspessulana Broom [67538]		Species or species habitat may occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Olea europaea Olive, Common Olive [9160]		Species or species habitat may occur within area

Name	Status	Type of Presence
Pinus radiata		
Radiata Pine Monterey Pine, Insignis Pine, Wilding Pine [20780]		Species or species habitat may occur within area
Rubus fruticosus aggregate		
Blackberry, European Blackberry [68406]		Species or species habitat likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtii		
Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]		Species or species habitat likely to occur within area
Salvinia molesta		
Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]		Species or species habitat likely to occur within area
Tamarix aphylla		
Athel Pine, Athel Tree, Tamarisk, Athel Tamarisk, Athel Tamarix, Desert Tamarisk, Flowering Cypress, Salt Cedar [16018]		Species or species habitat likely to occur within area
Reptiles		
Hemidactylus frenatus		
Asian House Gecko [1708]		Species or species habitat likely to occur within area

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the Environment Protection and Biodiversity Conservation Act 1999. It holds mapped locations of World and National Heritage properties, Wetlands of International and National Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species distributions have been derived through a variety of methods. Where distributions are well known and if time permits, maps are derived using either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc) together with point locations and described habitat; or environmental modelling (MAXENT or BIOCLIM habitat modelling) using point locations and environmental data layers.

Where very little information is available for species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc). In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More reliable distribution mapping methods are used to update these distributions as time permits.

Only selected species covered by the following provisions of the EPBC Act have been mapped:

- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites
- seals which have only been mapped for breeding sites near the Australian continent

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

-32.39497 115.79699

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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APPENDIX 4

Conservation Codes

Conservation Codes for Western Australian Flora and Fauna

Specially protected fauna or flora are species* which have been adequately searched for and are deemed to be, in the wild, either rare, at risk of extinction, or otherwise in need of special protection, and have been gazetted as such.

Categories of specially protected fauna and flora are:

T Threatened species – Schedules 1-4

Published as Specially Protected under the *Wildlife Conservation Act 1950,* and listed under Schedules 1 to 4 of the Wildlife Conservation (Specially Protected Fauna) Notice for Threatened Fauna and Wildlife Conservation (Rare Flora) Notice for Threatened Flora (which may also be referred to as Declared Rare Flora).

- ***Threatened fauna*** is that subset of 'Specially Protected Fauna' declared to be 'likely to become extinct' pursuant to section 14(4) of the Wildlife Conservation Act.
- ***Threatened flora*** is flora that has been declared to be 'likely to become extinct or is rare, or otherwise in need of special protection', pursuant to section 23F(2) of the Wildlife Conservation Act.

The assessment of the conservation status of these species is based on their national extent and ranked according to their level of threat using IUCN Red List categories and criteria as detailed below.

CR Critically endangered species – Schedule 1

Threatened species considered to be facing an extremely high risk of extinction in the wild. Published as Specially Protected under the *Wildlife Conservation Act 1950,* in Schedule 1 of the Wildlife Conservation (Specially Protected Fauna) Notice for Threatened Fauna and Wildlife Conservation (Rare Flora) Notice for Threatened Flora.

EN Endangered species – Schedule 2

Threatened species considered to be facing a very high risk of extinction in the wild. Published as Specially Protected under the *Wildlife Conservation Act 1950,* in Schedule 2 of the Wildlife Conservation (Specially Protected Fauna) Notice for Threatened Fauna and Wildlife Conservation (Rare Flora) Notice for Threatened Flora.

VU Vulnerable species - Schedule 3

Threatened species considered to be facing a high risk of extinction in the wild. Published as Specially Protected under the *Wildlife Conservation Act 1950,* in Schedule 3 of the Wildlife Conservation (Specially Protected Fauna) Notice for Threatened Fauna and Wildlife Conservation (Rare Flora) Notice for Threatened Flora.

EX Presumed extinct species - Schedule 4

Species which have been adequately searched for and there is no reasonable doubt that the last individual has died. Published as Specially Protected under the *Wildlife Conservation Act 1950,* in Schedule 4 of the Wildlife Conservation (Specially Protected Fauna) Notice for Presumed Extinct Fauna and Wildlife Conservation (Rare Flora) Notice for Presumed Extinct Flora.

IA Migratory birds protected under an international agreement - Schedule 5

Birds that are subject to an agreement between the government of Australia and the governments of Japan (JAMBA), China (CAMBA) and The Republic of Korea (ROKAMBA), and the Bonn Convention, relating to the protection of migratory birds. Published as Specially Protected under the *Wildlife Conservation Act 1950,* in Schedule 5 of the Wildlife Conservation (Specially Protected Fauna) Notice.

CD Conservation dependent fauna - Schedule 6

Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened. Published as Specially Protected under the *Wildlife Conservation Act 1950,* in Schedule 6 of the Wildlife Conservation (Specially Protected Fauna) Notice.

OS Other specially protected fauna - Schedule 7

Fauna otherwise in need of special protection to ensure their conservation. Published as Specially Protected under the *Wildlife Conservation Act 1950,* in Schedule 7 of the Wildlife Conservation (Specially Protected Fauna) Notice.

P Priority species

Possibly threatened species that do not meet survey criteria, or are otherwise data deficient, are added to the Priority Fauna or Priority Flora Lists under Priorities 1, 2 or 3. These three categories are ranked in order of priority for survey and evaluation of conservation status so that consideration can be given to their declaration as threatened flora or fauna.

Species that are adequately known, are rare but not threatened, or meet criteria for near threatened, or that have been recently removed from the threatened species or other specially protected fauna lists for other than taxonomic reasons, are placed in Priority 4. These species require regular monitoring.

Assessment of Priority codes is based on the Western Australian distribution of the species, unless the distribution in WA is part of a contiguous population extending into adjacent States, as defined by the known spread of locations.

1 Priority 1: Poorly-known species

Species that are known from one or a few locations (generally five or less) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation, e.g. agricultural or pastoral lands, urban areas, road and rail reserves, gravel reserves and active mineral leases; or otherwise under threat of habitat destruction or degradation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under immediate threat from known threatening processes. Such species are in urgent need of further survey.

2 Priority 2: Poorly-known species

Species that are known from one or a few locations (generally five or less), some of which are on lands managed primarily for nature conservation, e.g. national parks, conservation parks, nature reserves and other lands with secure tenure being managed for conservation. Species may be included if they are comparatively well known from one or more locations but do not meet adequacy of survey requirements and appear to be under threat from known threatening processes. Such species are in urgent need of further survey.

3 Priority 3: Poorly-known species

Species that are known from several locations, and the species does not appear to be under imminent threat, or from few but widespread locations with either large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. Species may be included if they are comparatively well known from several locations but do not meet adequacy of survey requirements and known threatening processes exist that could affect them. Such species are in need of further survey.

4 Priority 4: Rare, Near Threatened and other species in need of monitoring

(a) Rare: Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These species are usually represented on conservation lands.

(b) Near Threatened: Species that are considered to have been adequately surveyed and that are close to qualifying for Vulnerable, but are not listed as Conservation Dependent.

(c) Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

*Species includes all taxa (plural of taxon - a classificatory group of any taxonomic rank, e.g. a family, genus, species or any infraspecific category i.e. subspecies or variety, or a distinct population).

A list of the current rankings can be downloaded from the Parks and Wildlife Threatened Species and Communities webpage at http://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities

Commonwealth of Australia Conservation Codes

Threatened fauna and flora may be listed under Section 178 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) in any one of the following six categories:

Extinct

A native species is eligible to be included in the extinct category at a particular time if, at that time, there is no reasonable doubt that the last member of the species has died.

Extinct in the wild

A native species is eligible to be included in the extinct in the wild category at a particular time if, at that time:

a) it is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or
b) it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.

Critically endangered

A taxon is Critically Endangered when the best available evidence indicates that it meets any of the five criteria for the category identified in Part 7.01 of the EPBC Regulations, and it is therefore considered to be facing an extremely high risk of extinction in the wild.

Endangered

A taxon is Endangered when the best available evidence indicates that it meets any of the five criteria for the category identified in Part 7.01 of the EPBC Regulations, and it is therefore considered to be facing a very high risk of extinction in the wild.

Vulnerable

A taxon is Vulnerable when the best available evidence indicates that it meets any of the five criteria for the category identified in Part 7.01 of the EPBC Regulations, and it is therefore considered to be facing a high risk of extinction in the wild.

Conservation dependent

A native species is eligible to be included in the conservation dependent category at a particular time if, at that time:

a) the species is the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered or critically endangered; or
b) the following subparagraphs are satisfied:
    i. the species is a species of fish;

ii. the species is the focus of a plan of management that provides for management actions necessary to stop the decline of, and support the recovery of, the species so that its chances of long term survival in nature are maximised;
iii. the plan of management is in force under a law of the Commonwealth or of a State or Territory;
iv. cessation of the plan of management would adversely affect the conservation status of the species.

The EPBC Act does not provide for listing in a data deficient category. Where sufficient data (evidence) is unavailable to allow assessment by the Threatened Species Scientific Committee against the criteria for listing, the species are found to be ineligible. A recommendation is made to the Minister to not include the species in any category under the EPBC Act. For reasons of transparency and to inform future research, the Threatened Species Scientific Committee publishes the names of those species found to be data deficient. As data deficient is not a listing category under the EPBC Act, this has no statutory implications and the species is not considered to be listed under the EPBC Act.

APPENDIX 5

TEC/PEC Database Search

OCC_UNIQUE	COM_ID	COM_NAME	STATE_CATG	COMM_CATG	S_ID_COUNT	FIRST_S_ID	LAST_S_ID	BUFFER	BDY_ID	ORIG_FID
109028	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03310		200	106027	18231
109034	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03316		200	106033	18237
109037	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03319		200	106036	18240
109041	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03323		200	106040	18244
109054	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03336		200	106053	18257
109118	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03400		200	106117	18321
109126	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03408		200	106125	18329
109127	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03409		200	106126	18330
109138	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03420		200	106137	18341
109139	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03421		200	106138	18342
109140	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03422		200	106139	18343
109141	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03423		200	106140	18344
109207	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03489		200	106206	18410
109333	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03615		200	106332	18536
109406	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03688		200	106405	18609
109416	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03698		200	106415	18619
109419	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03701		200	106418	18622
109420	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03702		200	106419	18623
109421	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03703		200	106420	18624

OCC_UNIQUE	COM_ID	COM_NAME	STATE_CATG	COMM_CATG	S_ID_COUNT	FIRST_S_ID	LAST_S_ID	BUFFER	BDY_ID	ORIG_FID
109422	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03704		200	106421	18625
109423	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03705		200	106422	18626
109424	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03706		200	106423	18627
109425	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03707		200	106424	18628
109426	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03708		200	106425	18629
109427	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03709		200	106426	18630
109432	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03714		200	106431	18635
109433	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03715		200	106432	18636
109434	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03716		200	106433	18637
109435	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03717		200	106434	18638
109439	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03721		200	106438	18642
109440	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03722		200	106439	18643
109441	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03723		200	106440	18644
109442	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03724		200	106441	18645
109447	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03729		200	106446	18650
109448	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03730		200	106447	18651
109449	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03731		200	106448	18652
109452	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03734		200	106451	18655
109567	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld03849		200	106566	18770

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109827	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld04109		200	106826	19030
109828	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld04110		200	106827	19031
116672	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10954		200	113671	25873
116673	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10955		200	113672	25874
116674	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10956		200	113673	25875
116675	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10957		200	113674	25876
116676	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10958		200	113675	25877
116677	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10959		200	113676	25878
116679	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10961		200	113678	25880
116688	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10970		200	113687	25889
116689	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10971		200	113688	25890
116690	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10972		200	113689	25891
116692	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10974		200	113691	25893
116693	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10975		200	113692	25894
116695	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10977		200	113694	25896
116696	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10978		200	113695	25897
116697	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10979		200	113696	25898
116698	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10980		200	113697	25899
116701	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10983		200	113700	25902

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116702	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10984		200	113701	25903
116703	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10985		200	113702	25904
116704	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10986		200	113703	25905
116705	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10987		200	113704	25906
116706	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10988		200	113705	25907
116707	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10989		200	113706	25908
116708	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10990		200	113707	25909
116709	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10991		200	113708	25910
116710	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10992		200	113709	25911
116711	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10993		200	113710	25912
116712	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10994		200	113711	25913
116713	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10995		200	113712	25914
116714	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10996		200	113713	25915
116715	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10997		200	113714	25916
116716	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10998		200	113715	25917
116717	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10999		200	113716	25918
116718	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11000		200	113717	25919
116719	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11001		200	113718	25920
116720	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11002		200	113719	25921

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116723	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11005		200	113722	25924
116724	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11006		200	113723	25925
116728	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11010		200	113727	25929
116735	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11017		200	113734	25936
116737	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11019		200	113736	25938
116738	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11020		200	113737	25939
116739	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11021		200	113738	25940
116740	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11022		200	113739	25941
116743	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11025		200	113742	25944
116751	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11033		200	113750	25952
116752	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11034		200	113751	25953
116753	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11035		200	113752	25954
116754	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11036		200	113753	25955
116755	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11037		200	113754	25956
116756	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11038		200	113755	25957
116757	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11039		200	113756	25958
116758	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11040		200	113757	25959
116759	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11041		200	113758	25960
116760	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11042		200	113759	25961

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116761	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11043		200	113760	25962
116949	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11231		200	113948	26148
116950	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11232		200	113949	26149
116951	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11233		200	113950	26150
116952	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11234		200	113951	26151
116953	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11235		200	113952	26152
116954	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11236		200	113953	26153
116955	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11237		200	113954	26154
116956	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11238		200	113955	26155
116958	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11240		200	113957	26157
116959	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11241		200	113958	26158
116960	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11242		200	113959	26159
116961	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11243		200	113960	26160
116962	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11244		200	113961	26161
116963	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11245		200	113962	26162
116699	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld10981		200	113698	25900
116957	Banksia WL SCP	Banksia Dominated Woodlands of the Swan Coastal Plain IBRA Region	Priority 3	Endangered	1	BanksiaWld11239		200	113956	26156
124846	SCP08	Herb rich shrublands in clay pans	Vulnerable	Critically Endangered	1	Peel01		300	121860	32909
124847	SCP08	Herb rich shrublands in clay pans	Vulnerable	Critically Endangered	1	Peel02		300	121861	32910

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124848	SCP08	Herb rich shrublands in clay pans	Vulnerable	Critically Endangered	1	Peel03		300	121862	32911
124849	SCP08	Herb rich shrublands in clay pans	Vulnerable	Critically Endangered	1	Peel04		300	121863	32912
817	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	Pt Kennedy 94		2000	375	260
820	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	Pt Kennedy 92		2000	376	261
823	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	Pt Kennedy 90		2000	377	262
819	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	Pt Kennedy 91		2000	378	263
617	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	PtKennedy95		2000	380	265
638	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	PtKennedy16		2000	385	270
615	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	Ptkennedy101		2000	387	272
904	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	Pt Kennedy new 01		2000	388	273
636	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	PtKennedy18		2000	389	274
641	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	PtKennedy113		2000	393	278
639	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	PtKennedy49		2000	395	280

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1925	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	PtKennedy115		2000	396	281
643	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	PtKennedy120		2000	399	284
903	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	Pt Kennedy 119		2000	400	285
836	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	Pt Kennedy 116		2000	402	287
887	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	PtBecher38Sc		2000	403	288
637	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	PtKennedy50		2000	405	290
837	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	Pt Kennedy 123		2000	406	291
25	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	PB06		2000	409	293
794	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	PointBecher01		2000	410	294
941	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	MYPoint Becher01		2000	412	296
795	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	PointBecher02		2000	413	297
24	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	3	PB01	PtBecher01SOUTH	2000	414	298
943	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	MYPoint Becher02		2000	415	299

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832	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	PointBecher03		2000	416	300
944	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	MYPoint Becher03		2000	417	301
945	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	MYPoint Becher04		2000	418	302
623	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	LARKHILL22		2000	420	304
624	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	LARKHILL23		2000	421	305
626	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	LARKHILL26		2000	423	307
629	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	SECRETHARBOUR16		2000	426	310
632	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	SECRETHARBOUR42		2000	564	432
634	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	PTKENNEDY23		2000	566	434
947	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	MYPoint Becher06		2000	583	451
616	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	Ptkennedy103		2000	584	452
1922	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	PtKennedy124		2000	585	453
614	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	PtKennedy98		2000	586	454

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824	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	Pt Kennedy 97		2000	587	455
1926	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	PtKennedy125		2000	588	456
946	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	MYPoint Becher05		2000	671	527
799	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	2	MYPoint Becher07	PointBecher35	2000	674	528
621	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	LARKHILL158		2000	849	687
622	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	LARKHILL160		2000	850	688
2028	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	LARKHILL18		2000	852	690
2034	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	LARKHILL21		2000	856	693
2033	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	LARKHILL152		2000	857	694
2035	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	LARKHILL150		2000	858	695
833	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	Pt Kennedy 96		2000	938	770
3422	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	MYGB03		2000	2027	1547
3968	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	MYGB02		2000	2028	1548

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3969	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	MYGB04		2000	2029	1549
3970	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	MYGB05		2000	2030	1550
3971	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	MYGB06		2000	2031	1551
3972	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	MYGB07		2000	2032	1552
3983	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	MYGB01		2000	2033	1553
845	SCP19a	Sedgelands in Holocene dune swales of the southern Swan Coastal Plain	Critically Endangered	Endangered	1	Pt Kennedy 122		2000	407	14573
922	SCP19b	Woodlands over sedgelands in Holocene dune swales of the southern Swan Coastal Plain (original description; Gibson et al. (1994).	Critically Endangered	Endangered	2	Walyungup04	Walyungup05	2000	365	250
618	SCP19b	Woodlands over sedgelands in Holocene dune swales of the southern Swan Coastal Plain (original description; Gibson et al. (1994).	Critically Endangered	Endangered	1	PtKennedy104		2000	392	277
642	SCP19b	Woodlands over sedgelands in Holocene dune swales of the southern Swan Coastal Plain (original description; Gibson et al. (1994).	Critically Endangered	Endangered	1	PtKennedy121		2000	397	282
796	SCP19b	Woodlands over sedgelands in Holocene dune swales of the southern Swan Coastal Plain (original description; Gibson et al. (1994).	Critically Endangered	Endangered	2	PointBecher Plot01	PointBecher07	2000	398	283

OCC_UNIQUE	COM_ID	COM_NAME	STATE_CATG	COMM_CATG	S_ID_COUNT	FIRST_S_ID	LAST_S_ID	BUFFER	BDY_ID	ORIG_FID
902	SCP19b	Woodlands over sedgelands in Holocene dune swales of the southern Swan Coastal Plain (original description; Gibson et al. (1994).	Critically Endangered	Endangered	1	Pt Kennedy 118		2000	401	286
838	SCP19b	Woodlands over sedgelands in Holocene dune swales of the southern Swan Coastal Plain (original description; Gibson et al. (1994).	Critically Endangered	Endangered	1	Pt Kennedy 25		2000	408	292
619	SCP19b	Woodlands over sedgelands in Holocene dune swales of the southern Swan Coastal Plain (original description; Gibson et al. (1994).	Critically Endangered	Endangered	1	PtKennedy28		2000	411	295
620	SCP19b	Woodlands over sedgelands in Holocene dune swales of the southern Swan Coastal Plain (original description; Gibson et al. (1994).	Critically Endangered	Endangered	1	LARKHILL30		2000	419	303
625	SCP19b	Woodlands over sedgelands in Holocene dune swales of the southern Swan Coastal Plain (original description; Gibson et al. (1994).	Critically Endangered	Endangered	1	LARKHILL24		2000	422	306
627	SCP19b	Woodlands over sedgelands in Holocene dune swales of the southern Swan Coastal Plain (original description; Gibson et al. (1994).	Critically Endangered	Endangered	1	LARKHILL27		2000	424	308
628	SCP19b	Woodlands over sedgelands in Holocene dune swales of the southern Swan Coastal Plain (original description; Gibson et al. (1994).	Critically Endangered	Endangered	1	LARKHILL29		2000	425	309

OCC_UNIQUE	COM_ID	COM_NAME	STATE_CATG	COMM_CATG	S_ID_COUNT	FIRST_S_ID	LAST_S_ID	BUFFER	BDY_ID	ORIG_FID
1793	SCP19b	Woodlands over sedgelands in Holocene dune swales of the southern Swan Coastal Plain (original description; Gibson et al. (1994).	Critically Endangered	Endangered	1	Secret Harbour 19		2000	427	311
1795	SCP19b	Woodlands over sedgelands in Holocene dune swales of the southern Swan Coastal Plain (original description; Gibson et al. (1994).	Critically Endangered	Endangered	1	Secret Harbour 169		2000	428	312
631	SCP19b	Woodlands over sedgelands in Holocene dune swales of the southern Swan Coastal Plain (original description; Gibson et al. (1994).	Critically Endangered	Endangered	1	SECRETHARBOUR46		2000	565	433
1914	SCP19b	Woodlands over sedgelands in Holocene dune swales of the southern Swan Coastal Plain (original description; Gibson et al. (1994).	Critically Endangered	Endangered	1	SECRETHARBOUR01		2000	567	435
2027	SCP19b	Woodlands over sedgelands in Holocene dune swales of the southern Swan Coastal Plain (original description; Gibson et al. (1994).	Critically Endangered	Endangered	1	LARKHILL17		2000	851	689
630	SCP19b	Woodlands over sedgelands in Holocene dune swales of the southern Swan Coastal Plain (original description; Gibson et al. (1994).	Critically Endangered	Endangered	3	GOLDENBAY PLOT1	GOLDENBAY01	2000	853	691
2032	SCP19b	Woodlands over sedgelands in Holocene dune swales of the southern Swan Coastal Plain (original description; Gibson et al. (1994).	Critically Endangered	Endangered	1	LARKHILL13		2000	859	696

OCC_UNIQUE	COM_ID	COM_NAME	STATE_CATG	COMM_CATG	S_ID_COUNT	FIRST_S_ID	LAST_S_ID	BUFFER	BDY_ID	ORIG_FID
821	SCP19b	Woodlands over sedgelands in Holocene dune swales of the southern Swan Coastal Plain (original description; Gibson et al. (1994).	Critically Endangered	Endangered	1	Pt Kennedy 100		2000	939	771
4398	SCP19b	Woodlands over sedgelands in Holocene dune swales of the southern Swan Coastal Plain (original description; Gibson et al. (1994).	Critically Endangered	Endangered	1	GOLDENBAY02		2000	2390	1897
2651	SCP24	Northern Spearwood shrublands and woodlands	Priority 3		1	SINGLETON01		500	1489	2061
3120	SCP25	Southern Eucalyptus gomphocephala-Agonis flexuosa woodlands	Priority 3		1	SEW6		200	0	1336
3121	SCP25	Southern Eucalyptus gomphocephala-Agonis flexuosa woodlands	Priority 3		1	SEW7		200	0	1354
3122	SCP25	Southern Eucalyptus gomphocephala-Agonis flexuosa woodlands	Priority 3		1	SEW8		200	0	1355
3132	SCP25	Southern Eucalyptus gomphocephala-Agonis flexuosa woodlands	Priority 3		1	PAGA06		500	0	1492
2079	SCP29b	Acacia shrublands on taller dunes	Priority 3		1	PB04		500	0	781
4332	Walyungup Microbial	Microbial community of a coastal saline lake (Lake Walyungup)	Priority 1		6	Walynugup05	WalyungupSite03	2000	2611	2192

APPENDIX 6

Flora Species List

Lot 877 Stakehill Road BF Site Species List – (March and September 2019)

GYMNOSPERMS

CUPRESSACEAE
**Callitris preissii*

CYCADACEAE
Macrozamia riedlei

PINACEAE
**Pinus maritima*

MONOCOTYLEDONS

ANARTHRIACEAE
Lyginia barbata

ASPHODELACEAE
**Trachyandra divaricata*

ASPARAGACEAE
Acanthocarpus preissii
Chamaescilla corymbosa
Lomandra caespitosa
Lomandra maritima
Lomandra preissii
Sowerbaea laxiflora
Thysanotus dichotomus
Thysanotus patersonii
Thysanotus thyrsoideus

COLCHICACEAE
Burchardia congesta

CYPERACEAE
Lepidosperma pubisquameum
Lepidosperma scabrum
Mesomelaena pseudostygia
Schoenus clandestinus
Schoenus grandiflorus
Tetraria octandra

DASYPOGONACEAE
Dasypogon bromeliifolius

HAEMODORACEAE
Anigozanthos humilis
Conostylis aculeata subsp. *aculeata*
Haemodorum paniculatum

HEMEROCALLIDACEAE
Caesia micrantha
Corynotheca micrantha
Dianella revoluta var. *divaricata*
Tricoryne elatior

IRIDACEAE
**Gladiolus caryophyllaceus*
Patersonia occidentalis
**Romulea rosea*
**Watsonia bulbillifera*

ORCHIDACEAE
Caladenia flava
Caladenia latifolia
Caladenia longicauda subsp. *longicauda*
Diuris magnifica
Pterostylis vittata
Pyrorchis nigricans

POACEAE
Austrostipa flavescens
**Avena fatua*
**Briza maxima*
**Briza minor*
**Cenchrus clandestinus*
**Cynodon dactylon*
**Ehrharta calycina*
**Ehrharta longiflora*
**Lagurus ovatus*
**Lolium perenne*

RESTIONACEAE
Desmocladus flexuosus

XANTHORRHOEACEAE
Xanthorrhoea brunonis
Xanthorrhoea preissii

DICOTYLEDONS

AIZOACEAE
**Carpobrotus edulis*

APIACEAE
Eryngium pinnatifidum
Homalosciadium homalocarpum

APOCYNACEAE
**Gomphocarpus fruticosus*

ARALIACEAE
Trachymene pilosa

ASPHODELACEAE
**Trachyandra divaricata*

ASTERACEAE
**Arctotheca calendula*
**Conyza bonariensis*
**Hypochaeris glabra*
Lagenophora huegelii
**Monoculus monstrosus*
Olearia axillaris
Podolepis gracilis
**Sonchus oleraceus*
**Taraxacum officinale*
**Ursinia anthemoides*

BRASSICACEAE
**Heliophila pusilla*

CARYOPHYLLACEAE
**Petrorhagia dubia*
**Silene gallica*

CASUARINACEAE
Allocasuarina fraseriana

CHENOPODIACEAE
Rhagodia baccata

DILLENIACEAE
Hibbertia hypericoides
Hibbertia racemosa

DROSERACEAE
Drosera erythrorhiza
Drosera macrantha
Drosera stolonifera

ERICACEAE
Astroloma pallidum
Conostephium pendulum
Leucopogon propinquus

EUPHORBIACEAE
**Euphorbia peplus*
**Euphorbia terracina*

FABACEAE
Acacia cyclops
**Acacia iteaphylla*
**Acacia longifolia*
**Acacia podalyriifolia*
Acacia pulchella
Acacia saligna
Daviesia divaricata subsp. *divaricata*
Daviesia triflora
Gompholobium tomentosum
Hardenbergia comptoniana
Hovea trisperma
Isotropis cuneifolia subsp. *cuneifolia*
Jacksonia furcellata
**Lupinus cosentinii*
**Melilotus indicus*
**Trifolium arvense*
**Trifolium campestre*

GOODENIACEAE
Scaevola canescens

MYRTACEAE
Eucalyptus gomphocephala
Eucalyptus marginata
**Leptospermum laevigatum*

OLEACEAE

**Olea europaea*

OROBANCHACEAE
**Orobanche minor*

OXALIDACEAE
**Oxalis corniculata*
**Oxalis pes-caprae*

PAPAVERACEAE
**Fumaria capreolata*

PHYLLANTHACEAE
Phyllanthus calycinus

PHYTOLACCACEAE
**Phytolacca octandra*

POLYGALACEAE
Comesperma confertum

PRIMULACEAE
**Lysimachia arvensis*

PROTEACEAE
Banksia attenuata
Banksia grandis
Banksia dallanneyi
Banksia menziesii
Grevillea crithmifolia
Hakea lissocarpha
Petrophile linearis
Xylomelum occidentale

RANUNCULACEAE
Clematis pubescens

RUBIACEAE
Opercularia vaginata

RUTACEAE
Philotheca spicata

SANTALACEAE
Santalum acuminatum

SOLANACEAE
**Solanum nigrum*
**Solanum linnaeanum*

STYLIDIACEAE
Stylidium piliferum

THYMELEACEAE
Pimelea rosea

VIOLACEAE
Hybanthus calycinus

APPENDIX 7

Quadrat Data

QUADRAT SR1

50 386832 E 6414953 N

Vegetation: *Eucalyptus gomphocephala* (Tuart) Woodland over *Eucalyptus marginata* (Jarrah)*/Allocasuarina fraseriana/Banksia attenuata* Low Open Woodland over *Hibbertia hypericoides* Open Low Heath

Condition: Good

Soil Type: Yellow sand

Landform: Flat



QUADRAT (10 x 10m)

SPECIES	HEIGHT (m)	COVER (%)
Eucalyptus gomphocephala	11	10
Eucalyptus marginata	4	5
Banksia attenuata	3	5
Hakea lissocarpha	1.8	1
**Ehrharta longiflora*	1.1	40
Gompholobium tomentosum	1	1
Daviesia divaricata	1	1
Hibbertia hypericoides	0.7	15
Burchardia congesta	0.6	<1
Xanthorrhoea brunonis	0.5	2
Macrozamia riedlei	0.5	1
**Lolium perenne*	0.4	1
Dianella revoluta var. *divaricata*	0.4	<1
Corynotheca micrantha	0.4	<1
Sowerbaea laxiflora	0.4	<1
Acanthocarpus preissii	0.4	<1
**Briza maxima*	0.3	20
**Lagurus ovatus*	0.3	2
Conostylis aculeata	0.3	<1

SPECIES	HEIGHT (m)	COVER (%)
Eryngium pinnatifidum	0.3	<1
Phyllanthus calycinus	0.3	<1
Petrophile linearis	0.3	<1
**Sonchus oleraceus*	0.3	<1
Thysanotus thyrsoideus	0.2	1
Tetraria octandra	0.2	<1
Scaevola canescens	0.2	<1
**Lysimachia arvensis*	0.2	<1
**Ursinia anthemoides*	0.2	<1
**Arctotheca calendula*	0.2	<1
**Romulea rosea*	0.2	<1
Caladenia flava	0.1	<1
**Briza minor*	0.1	<1
**Trifolium campestre*	0.1	<1
Drosera erythrorhiza	Flat	2
**Hypochaeris glabra*	Flat	<1

* introduced species

QUADRAT SR2

50 386856 E 6415040 N

Vegetation: *Eucalyptus gomphocephala* (Tuart) Woodland over *Eucalyptus marginata* (Jarrah)*/Allocasuarina fraseriana/Banksia attenuata* Low Open Woodland over *Hibbertia hypericoides/Acacia pulchella* Open Low Heath

Condition: Very Good

Soil Type: Orange-brown sand

Landform: Flat



QUADRAT (10 x 10m)

SPECIES	HEIGHT (m)	COVER (%)
Eucalyptus gomphocephala	10	10
Eucalyptus marginata	4	5
Banksia attenuata	4	2
Santalum acuminatum	1.9	1
Acacia pulchella	0.8	1
Daviesia divaricata	0.8	<1
**Ehrharta longifolia*	0.7	5
Xanthorrhoea preissii	0.6	<1
Hibbertia hypericoides	0.5	50
Phyllanthus calycinus	0.5	<1
Burchardia congesta	0.4	<1
Sowerbaea laxiflora	0.4	<1
Gompholobium tomentosum	0.4	<1
**Gladiolus caryophyllaceus*	0.4	<1
Pterostylis vittata	0.4	<1
Dianella revoluta var. *divaricata*	0.4	<1
**Briza maxima*	0.3	10

SPECIES	HEIGHT (m)	COVER (%)
Eryngium pinnatifidum	0.3	<1
Lomandra preissii	0.3	<1
Hybanthus calycinus	0.3	<1
Desmocladus flexuosus	0.2	2
Conostylis aculeata	0.2	<1
**Ursinia anthemoides*	0.2	<1
**Oxalis corniculata*	0.2	<1
Caladenia flava	0.2	<1
Podolepis gracilis	0.2	<1
Astroloma pallidum	0.2	<1
Trachymene pilosa	0.1	<1
**Lysimachia arvensis*	0.1	<1
Homalosciadium homalocarpum	0.1	<1
Scaevola canescens	0.1	<1
Schoenus clandestinus	<0.1	<1
**Hypochaeris glabra*	Flat	2
Drosera erythrorhiza	Flat	<1
Thysanotus patersonii	Climber	<1

* introduced species

QUADRAT SR3

50 386866 E 6415128 N

Vegetation: *Eucalyptus gomphocephala* (Tuart) Woodland over *Allocasuarina fraseriana/Banksia attenuata* Low Open Woodland over *Hibbertia hypericoides/Acacia pulchella* Open Low Heath

Condition: Very Good

Soil Type: Orange brown sand

Landform: Flat



Quadrat (10 x 10m)

SPECIES	HEIGHT (m)	COVER (%)
Eucalyptus gomphocephala	12	5
Allocasuarina fraseriana	4	5
Banksia attenuata	3	5
Acacia pulchella	1.1	2
**Ehrharta calycina*	0.7	<1
**Sonchus oleraceus*	0.6	<1
Hibbertia hypericoides	0.5	50
Phyllanthus calycinus	0.5	2
**Ehrharta longiflora*	0.5	1
Daviesia divaricata	0.5	<1
Lepidosperma scabrum	0.5	<1
Tetraria octandra	0.5	<1
Diuris magnifica	0.4	<1
Burchardia congesta	0.4	<1
Daviesia triflora	0.4	<1
Desmocladus flexuosus	0.3	10
**Briza maxima*	0.3	2
Gompholobium tomentosum	0.3	<1

Eryngium pinnatifidum	0.3	<1
Sowerbaea laxiflora	0.3	<1
Lomandra hermaphrodita	0.3	<1
Lomandra preissii	0.3	<1
**Lagurus ovatus*	0.3	<1
**Petrorhagia dubia*	0.3	<1
Conostylis aculeata	0.2	<1
Leucopogon propinquus	0.2	<1
Podolepis gracilis	0.2	<1
Opercularia vaginata	0.2	<1
**Ursinia anthemoides*	0.2	<1
**Heliophila pusilla*	0.2	<1
Isotropis cuneifolia	0.1	<1
Scaevola canescens	0.1	<1
Trachymene pilosa	0.1	<1
Homalosciadium homalocarpum	0.1	<1
**Trifolium campestre*	0.1	<1
Astroloma pallidum	0.1	<1
Drosera erythrorhiza	Flat	<1
Pyrorchis nigricans	Flat	<1
**Hypochaeris glabra*	Flat	<1
Hardenbergia comptoniana	Climber	<1

* introduced species

QUADRAT SR4

50 386786 E 6415254 N

Vegetation: *Eucalyptus gomphocephala* (Tuart) Woodland over weeds
Condition: Completely Degraded
Soil Type: Orange-brown sand
Landform: Flat



QUADRAT (10 x 10m)

SPECIES	HEIGHT (m)	COVER (%)
Eucalyptus gomphocephala	12	20
**Gomphocarpus fruticosus*	0.8	<1
**Ehrharta calycina*	0.5	60
Burchardia congesta	0.5	<1
Tetraria octandra	0.5	<1
Desmocladus flexuosus	0.4	1
**Lolium perenne*	0.4	1
Sowerbaea laxiflora	0.4	<1
**Olea europaea*	0.4	<1
Macrozamia riedlei	0.4	<1
Eryngium pinnatifidum	0.4	<1
**Lagurus ovatus*	0.4	<1
**Briza maxima*	0.3	20
Conostylis aculeata	0.2	<1
Caladenia flava	0.2	<1
**Romulea rosea*	0.1	5
**Taraxacum officinale*	Flat	<1
Hardenbergia comptoniana	Climber	<1

* introduced species

QUADRAT SR5

50 386920 E 6415322 N

Vegetation: *Eucalyptus gomphocephala* (Tuart) Woodland over *Eucalyptus marginata* (Jarrah)*/Allocasuarina fraseriana/Banksia attenuata* Low Open Woodland over *Hibbertia hypericoides/Acacia pulchella* Open Low Heath

Condition: Good

Soil Type: Orange-brown sand

Landform: Flat



QUADRAT (10 x 10m)

SPECIES	HEIGHT (m)	COVER (%)
Eucalyptus marginata	4	5
Banksia attenuata	4	2
Acacia pulchella	1.2	2
**Ehrharta longifolia*	0.8	40
**Ehrharta calycina*	0.7	2
Hibbertia hypericoides	0.6	30
Daviesia divaricata	0.6	1
Macrozamia riedlei	0.6	1
Burchardia congesta	0.5	<1
Tetraria octandra	0.5	<1
Sowerbaea laxiflora	0.4	<1
**Briza maxima*	0.3	10
Eryngium pinnatifidum	0.3	1
**Ursinia anthemoides*	0.3	1
Conostylis aculeata	0.3	<1
Dianella revoluta var. *divaricata*	0.3	<1
Corynotheca micrantha	0.2	4

SPECIES	HEIGHT (m)	COVER (%)
**Heliophila pusilla*	0.2	1
**Sonchus oleraceus*	0.2	<1
**Lysimachia arvensis*	0.1	<1
**Romulea rosea*	0.1	<1
**Hypochaeris glabra*	Flat	1
Drosera macrantha	Climber	<1

* introduced species

APPENDIX 8

DBCA Fauna Database Search

NAME_SCI	NAME_COM	CLASS	CONS_CODE	Date	SOURCE_ID	SOURCE	CERTAINTY	METHOD	TYPE	COUNT	LOCALITY	SITE	ACCURACY_M	NAME_ID	FAMILY	KINGDOM
Calidris ruficollis	red-necked stint	BIRD	IA	23/07/2002	286592|162	BIRDATLAS 2	Moderately Certain	Observational	Sighting	1	SECRET HARBOUR	Serpentine River reserve	0	24788	Scolopacidae	Animalia
Calidris ruficollis	red-necked stint	BIRD	IA	28/04/2005	456365|162	BIRDATLAS 2	Moderately Certain	Observational	Sighting	1	WARNBRO	lake Walyungup	100	24788	Scolopacidae	Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	2/08/2003	420283|794	BIRDATLAS 2	Moderately Certain	Observational	Sighting	1	BALDIVIS	Karnup NR	100	24734	Cacatuidae	Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	2/08/2003	420285|794	BIRDATLAS 2	Moderately Certain	Observational	Sighting	1	BALDIVIS	Churcher Road	100	24734	Cacatuidae	Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	27/11/2003	218422|794	BIRDATLAS 2	Moderately Certain	Observational	Sighting	1	BALDIVIS	Karnup Nature Reserve and Tramway Reserve	100	24734	Cacatuidae	Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	15/02/2004	218424|794	BIRDATLAS 2	Moderately Certain	Observational	Sighting	1	BALDIVIS	Karnup Nature Reserve and Tramway Reserve	100	24734	Cacatuidae	Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	20/11/2005	218661|794	BIRDATLAS 2	Moderately Certain	Observational	Sighting	1	BALDIVIS	Baldivis Children's Forest	100	24734	Cacatuidae	Animalia
Limosa lapponica	bar-tailed godwit	BIRD	IA	23/07/2002	286592|153	BIRDATLAS 2	Moderately Certain	Observational	Sighting	1	SECRET HARBOUR	Serpentine River reserve	0	30932	Scolopacidae	Animalia
Pluvialis squatarola	grey plover	BIRD	IA	23/07/2002	286592|136	BIRDATLAS 2	Moderately Certain	Observational	Sighting	1	SECRET HARBOUR	Serpentine River reserve	0	24383	Charadriidae	Animalia
Thalasseus bergii	crested tern	BIRD	IA	23/07/2002	286592|115	BIRDATLAS 2	Moderately Certain	Observational	Sighting	1	SECRET HARBOUR	Serpentine River reserve	1000	0	Laridae	Animalia
Tringa nebularia	common greenshank, greenshank	BIRD	IA	28/04/2005	456365|158	BIRDATLAS 2	Moderately Certain	Observational	Sighting	1	WARNBRO	lake Walyungup	100	24808	Scolopacidae	Animalia
Calyptorhynchus banksii naso	forest red-tailed black cockatoo	BIRD	VU	3/06/2011	554483	FAUNASURVEY	Certain	Survey	Unknown	1	PORT KENNEDY	Port Kennedy, Port Kennedy Business Park	3000	24731	Cacatuidae	Animalia
Calyptorhynchus banksii naso	forest red-tailed black cockatoo	BIRD	VU	15/10/2015	1101633	FAUNASURVEY	Certain	Survey	Unknown	3	BALDIVIS	Baldivis, Sixty Eight Rd	100	24731	Cacatuidae	Animalia
Isoodon fusciventer	quenda, southern brown bandicoot	MAMMAL	P4	15/09/2009	73675	FAUNASURVEY	Certain	Survey	Unknown	3	KARNUP	Perth, Anstey Swamp	3000	24153	Peramelidae	Animalia
Isoodon fusciventer	quenda, southern brown bandicoot	MAMMAL	P4	3/06/2011	554503	FAUNASURVEY	Certain	Survey	Unknown	1	PORT KENNEDY	Port Kennedy, Port Kennedy Business Park	3000	24153	Peramelidae	Animalia
Lerista lineata	Perth slider, lined skink	REPTILE	P3	29/11/2013	725484	FAUNASURVEY	Certain	Survey	Unknown	3	BALDIVIS	Baldivis Children's Forest, Site 2	3000	25147	Scincidae	Animalia
Lerista lineata	Perth slider, lined skink	REPTILE	P3	29/11/2013	725485	FAUNASURVEY	Certain	Survey	Unknown	1	BALDIVIS	Baldivis Children's Forest, Site 3	3000	25147	Scincidae	Animalia

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Lerista lineata	Perth slider, lined skink	REPTILE	P3	29/11/2013	725486	FAUNASURVEY	Certain	Survey	Unknown	1	BALDIVIS	Baldivis Children's Forest, Site 6	3000	25147	Scincidae	Animalia
Synemon gratiosa	graceful sunmoth	INVERTEBRATE	P4	9/03/2011	193780	FAUNASURVEY	Certain	Survey	Unknown	1	PORT KENNEDY	Port Kennedy, Port Kennedy	100	33992	Castniidae	Animalia
Synemon gratiosa	graceful sunmoth	INVERTEBRATE	P4	9/03/2011	193781	FAUNASURVEY	Certain	Survey	Unknown	3	PORT KENNEDY	Port Kennedy, Port Kennedy	100	33992	Castniidae	Animalia
Synemon gratiosa	graceful sunmoth	INVERTEBRATE	P4	9/03/2011	193782	FAUNASURVEY	Certain	Survey	Unknown	1	PORT KENNEDY	Port Kennedy, Port Kennedy	100	33992	Castniidae	Animalia
Synemon gratiosa	graceful sunmoth	INVERTEBRATE	P4	9/03/2011	193783	FAUNASURVEY	Certain	Survey	Unknown	1	PORT KENNEDY	Port Kennedy, Port Kennedy	100	33992	Castniidae	Animalia
Synemon gratiosa	graceful sunmoth	INVERTEBRATE	P4	16/03/2011	193784	FAUNASURVEY	Certain	Survey	Unknown	1	PORT KENNEDY	Port Kennedy, Port Kennedy	100	33992	Castniidae	Animalia
Synemon gratiosa	graceful sunmoth	INVERTEBRATE	P4	16/03/2011	193785	FAUNASURVEY	Certain	Survey	Unknown	1	PORT KENNEDY	Port Kennedy, Port Kennedy	100	33992	Castniidae	Animalia
Synemon gratiosa	graceful sunmoth	INVERTEBRATE	P4	5/03/2012	554507	FAUNASURVEY	Certain	Survey	Unknown	1	PORT KENNEDY	Port Kennedy, Lots 14 & 17	100	33992	Castniidae	Animalia
Synemon gratiosa	graceful sunmoth	INVERTEBRATE	P4	5/03/2012	554508	FAUNASURVEY	Certain	Survey	Unknown	1	PORT KENNEDY	Port Kennedy, Lots 14 & 17	100	33992	Castniidae	Animalia
Synemon gratiosa	graceful sunmoth	INVERTEBRATE	P4	5/03/2012	554509	FAUNASURVEY	Certain	Survey	Unknown	1	PORT KENNEDY	Port Kennedy, Lots 14 & 17	100	33992	Castniidae	Animalia
Synemon gratiosa	graceful sunmoth	INVERTEBRATE	P4	5/03/2012	554510	FAUNASURVEY	Certain	Survey	Unknown	1	PORT KENNEDY	Port Kennedy, Lots 14 & 17	100	33992	Castniidae	Animalia
Synemon gratiosa	graceful sunmoth	INVERTEBRATE	P4	5/03/2012	554511	FAUNASURVEY	Certain	Survey	Unknown	1	PORT KENNEDY	Port Kennedy, Lots 14 & 17	100	33992	Castniidae	Animalia
Synemon gratiosa	graceful sunmoth	INVERTEBRATE	P4	5/03/2012	554516	FAUNASURVEY	Certain	Survey	Unknown	1	PORT KENNEDY	Port Kennedy, Port Kennedy Scientific Park	100	33992	Castniidae	Animalia
Synemon gratiosa	graceful sunmoth	INVERTEBRATE	P4	5/03/2012	554517	FAUNASURVEY	Certain	Survey	Unknown	1	PORT KENNEDY	Port Kennedy, Port Kennedy Scientific Park	100	33992	Castniidae	Animalia
Synemon gratiosa	graceful sunmoth	INVERTEBRATE	P4	5/03/2012	554518	FAUNASURVEY	Certain	Survey	Unknown	1	PORT KENNEDY	Port Kennedy, Port Kennedy Scientific Park	100	33992	Castniidae	Animalia
Synemon gratiosa	graceful sunmoth	INVERTEBRATE	P4	5/03/2012	554519	FAUNASURVEY	Certain	Survey	Unknown	1	PORT KENNEDY	Port Kennedy, Port Kennedy Scientific Park	100	33992	Castniidae	Animalia
Synemon gratiosa	graceful sunmoth	INVERTEBRATE	P4	5/03/2012	554520	FAUNASURVEY	Certain	Survey	Unknown	1	PORT KENNEDY	Port Kennedy, Port Kennedy Scientific Park	100	33992	Castniidae	Animalia

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Synemon gratiosa	graceful sunmoth	INVERTEBRATE	P4	12/03/2012	554512	FAUNASURVEY	Certain	Survey	Unknown	1	PORT KENNEDY	Port Kennedy, Lots 14 & 17	100	33992	Castniidae	Animalia
Synemon gratiosa	graceful sunmoth	INVERTEBRATE	P4	12/03/2012	554513	FAUNASURVEY	Certain	Survey	Unknown	1	PORT KENNEDY	Port Kennedy, Lots 14 & 17	100	33992	Castniidae	Animalia
Synemon gratiosa	graceful sunmoth	INVERTEBRATE	P4	12/03/2012	554548	FAUNASURVEY	Certain	Survey	Unknown	1	PORT KENNEDY	Port Kennedy, Port Kennedy Scientific Park	100	33992	Castniidae	Animalia
Synemon gratiosa	graceful sunmoth	INVERTEBRATE	P4	12/03/2012	554549	FAUNASURVEY	Certain	Survey	Unknown	1	PORT KENNEDY	Port Kennedy, Port Kennedy Scientific Park	100	33992	Castniidae	Animalia
Synemon gratiosa	graceful sunmoth	INVERTEBRATE	P4	12/03/2012	554555	FAUNASURVEY	Certain	Survey	Unknown	1	PORT KENNEDY	Port Kennedy, Port Kennedy Offset	100	33992	Castniidae	Animalia
Synemon gratiosa	graceful sunmoth	INVERTEBRATE	P4	12/03/2012	554556	FAUNASURVEY	Certain	Survey	Unknown	1	PORT KENNEDY	Port Kennedy, Port Kennedy Offset	100	33992	Castniidae	Animalia
Calyptorhynchus banksii naso	forest red-tailed black cockatoo	BIRD	VU	12/04/2002	22333	TFAUNA	Certain	Targeted survey	Day sighting	3	Birchmont		1000	0		Animalia
Calyptorhynchus banksii naso	forest red-tailed black cockatoo	BIRD	VU	1/03/2006	23236	TFAUNA	Certain	Survey	Day sighting	0	Warnbro		1000	0		Animalia
Calyptorhynchus banksii naso	forest red-tailed black cockatoo	BIRD	VU	16/03/2006	22559	TFAUNA	Certain	Targeted survey	Day sighting	5	Baldivis		1000	0		Animalia
Calyptorhynchus banksii naso	forest red-tailed black cockatoo	BIRD	VU	25/03/2006	22560	TFAUNA	Certain	Targeted survey	Day sighting	1	Karnup		1000	0		Animalia
Calyptorhynchus banksii naso	forest red-tailed black cockatoo	BIRD	VU	23/05/2010	23237	TFAUNA	Certain	Survey	Day sighting	0	Warnbro		1000	0		Animalia
Calyptorhynchus banksii naso	forest red-tailed black cockatoo	BIRD	VU	29/06/2010	23238	TFAUNA	Certain	Survey	Day sighting	0	Warnbro		1000	0		Animalia
Calyptorhynchus banksii naso	forest red-tailed black cockatoo	BIRD	VU	15/08/2010	23239	TFAUNA	Certain	Survey	Day sighting	0	Warnbro		1000	0		Animalia
Calyptorhynchus banksii naso	forest red-tailed black cockatoo	BIRD	VU	10/10/2010	23240	TFAUNA	Certain	Survey	Day sighting	0	Warnbro		1000	0		Animalia
Calyptorhynchus banksii naso	forest red-tailed black cockatoo	BIRD	VU	21/10/2012	23241	TFAUNA	Certain	Survey	Day sighting	0	Warnbro		1000	0		Animalia
Calyptorhynchus banksii naso	forest red-tailed black cockatoo	BIRD	VU	6/04/2014	80373	TFAUNA	Moderately certain	Community survey	Day sighting	17	Baldivis		1000	0		Animalia
Calyptorhynchus banksii naso	forest red-tailed black cockatoo	BIRD	VU	12/04/2015	80696	TFAUNA	Certain	Community survey	Day sighting	25	Baldivis		1000	0		Animalia
Calyptorhynchus banksii naso	forest red-tailed black cockatoo	BIRD	VU	3/04/2016	84716	TFAUNA	Moderately certain	Community survey	Dusk sighting	24	BALDIVIS		1000	0		Animalia
Calyptorhynchus banksii naso	forest red-tailed black cockatoo	BIRD	VU	9/04/2017	95843	TFAUNA	Moderately certain	Community survey	Sighting	5	KARNUP		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	2/02/2004	26323	TFAUNA	Certain	Survey	Day sighting	50	BALDIVIS		1000	0		Animalia

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Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	2/02/2004	26324	TFAUNA	Certain	Survey	Day sighting	50	BALDIVIS		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	12/02/2004	26321	TFAUNA	Certain	Survey	Day sighting	200	BALDIVIS		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	12/02/2004	26322	TFAUNA	Certain	Survey	Day sighting	200	BALDIVIS		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	24/02/2004	26315	TFAUNA	Certain	Survey	Day sighting	20	KARNUP		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	24/02/2004	26320	TFAUNA	Certain	Survey	Day sighting	20	BALDIVIS		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	10/03/2004	33032	TFAUNA	Certain	Survey	Day sighting	230	BALDIVIS		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	10/03/2004	35869	TFAUNA	Certain	Survey	Day sighting	200	BALDIVIS		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	10/03/2004	35870	TFAUNA	Certain	Survey	Day sighting	200	BALDIVIS		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	5/07/2004	23242	TFAUNA	Certain	Survey	Day sighting	0	Warnbro		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	10/11/2004	26318	TFAUNA	Certain	Survey	Day sighting	10	BALDIVIS		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	10/11/2004	26319	TFAUNA	Certain	Survey	Day sighting	10	BALDIVIS		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	12/11/2004	26316	TFAUNA	Certain	Survey	Day sighting	200	BALDIVIS		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	12/11/2004	26317	TFAUNA	Certain	Survey	Day sighting	200	BALDIVIS		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	21/02/2005	35867	TFAUNA	Certain	Survey	Day sighting	200	BALDIVIS		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	21/02/2005	35868	TFAUNA	Certain	Survey	Day sighting	200	BALDIVIS		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	4/03/2005	26509	TFAUNA	Certain	Survey	Day sighting	200	BALDIVIS		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	2/04/2005	31053	TFAUNA	Certain	Survey	Day sighting	600	KARNUP		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	2/04/2005	31054	TFAUNA	Certain	Survey	Day sighting	600	KARNUP		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	4/04/2005	21381	TFAUNA	Certain	Targeted survey	Day sighting	1200	Karnup		10000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	4/04/2005	31049	TFAUNA	Certain	Survey	Day sighting	1200	KARNUP		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	4/04/2005	31052	TFAUNA	Certain	Survey	Day sighting	1200	KARNUP		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	9/04/2005	31050	TFAUNA	Certain	Survey	Day sighting	574	KARNUP		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	9/04/2005	31051	TFAUNA	Certain	Survey	Day sighting	574	KARNUP		1000	0		Animalia

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Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	4/12/2005	23530	TFAUNA	Certain	Targeted survey	Day sighting	2	Karnup		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	1/02/2006	36241	TFAUNA	Certain	Survey	Day sighting	300	BALDIVIS		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	12/02/2006	23571	TFAUNA	Certain	Targeted survey	Day sighting	53	Baldivis		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	12/02/2006	23578	TFAUNA	Certain	Targeted survey	Day sighting	15	Karnup		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	12/02/2006	23602	TFAUNA	Certain	Targeted survey	Day sighting	600	Karnup		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	12/02/2006	23603	TFAUNA	Certain	Targeted survey	Day sighting	250	Karnup		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	12/02/2006	26325	TFAUNA	Certain	Survey	Day sighting	600	KARNUP		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	12/02/2006	26326	TFAUNA	Certain	Survey	Day sighting	600	KARNUP		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	1/03/2006	21382	TFAUNA	Certain	Targeted survey	Day sighting	300	Armarillo		10000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	1/03/2006	36240	TFAUNA	Certain	Survey	Day sighting	300	KARNUP		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	26/03/2006	23657	TFAUNA	Certain	Targeted survey	Day sighting	300	Baldivis		10000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	26/03/2006	23691	TFAUNA	Certain	Targeted survey	Day sighting	1000	Baldivis		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	26/03/2006	23692	TFAUNA	Certain	Targeted survey	Day sighting	4001	Karnup		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	9/04/2006	21384	TFAUNA	Certain	Targeted survey	Day sighting	574	Karnup		10000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	9/04/2006	31048	TFAUNA	Certain	Survey	Day sighting	574	KARNUP		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	1/05/2006	27246	TFAUNA	Certain	Survey	Day sighting	1	KARNUP		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	1/05/2006	27247	TFAUNA	Certain	Monitoring	Secondary sign	1	KARNUP		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	1/05/2006	27248	TFAUNA	Certain	Monitoring	Secondary sign	1	KARNUP		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	1/05/2006	27249	TFAUNA	Certain	Monitoring	Secondary sign	1	KARNUP		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	1/05/2006	27250	TFAUNA	Certain	Survey	Day sighting	1	KARNUP		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	1/05/2006	27251	TFAUNA	Certain	Monitoring	Secondary sign	1	KARNUP		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	1/05/2006	27252	TFAUNA	Certain	Monitoring	Secondary sign	1	KARNUP		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	9/11/2007	23243	TFAUNA	Certain	Survey	Day sighting	0	Warnbro		1000	0		Animalia

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Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	30/10/2008	33031	TFAUNA	Certain	Monitoring	Secondary sign	1	BALDIVIS		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	24/05/2009	23244	TFAUNA	Certain	Survey	Day sighting	0	Warnbro		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	1/01/2010	35865	TFAUNA	Certain	Survey	Day sighting	1	BALDIVIS		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	1/01/2010	35866	TFAUNA	Certain	Survey	Day sighting	1	KARNUP		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	1/02/2010	35863	TFAUNA	Certain	Survey	Day sighting	1200	BALDIVIS		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	1/02/2010	35864	TFAUNA	Certain	Survey	Day sighting	1200	BALDIVIS		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	8/02/2010	24298	TFAUNA	Certain	Community survey	Day sighting	503	Baldivis		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	11/02/2010	24296	TFAUNA	Certain	Community survey	Day sighting	31	Baldivis		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	18/02/2010	24297	TFAUNA	Certain	Community survey	Day sighting	14	Baldivis		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	1/03/2010	25816	TFAUNA	Certain	Survey	Day sighting	200	BALDIVIS		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	1/03/2010	25817	TFAUNA	Certain	Survey	Day sighting	200	BALDIVIS		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	14/03/2010	24299	TFAUNA	Certain	Community survey	Day sighting	285	Baldivis		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	23/03/2010	24300	TFAUNA	Certain	Community survey	Day sighting	54	Baldivis		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	30/03/2010	24301	TFAUNA	Certain	Community survey	Day sighting	7	Baldivis		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	7/04/2010	20071	TFAUNA	Moderately certain	Community survey	Day sighting	346	Baldivis		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	7/04/2010	24302	TFAUNA	Certain	Community survey	Day sighting	346	Baldivis		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	17/04/2010	24303	TFAUNA	Certain	Community survey	Day sighting	92	Baldivis		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	28/04/2010	24304	TFAUNA	Certain	Community survey	Day sighting	202	Baldivis		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	5/05/2010	24311	TFAUNA	Certain	Community survey	Day sighting	3	Karnup		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	8/05/2010	20126	TFAUNA	Moderately certain	Community survey	Day sighting	3	Karnup		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	10/10/2010	23245	TFAUNA	Certain	Survey	Day sighting	0	Warnbro		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	7/04/2011	24280	TFAUNA	Certain	Community survey	Day sighting	78	Baldivis		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	4/06/2011	24281	TFAUNA	Certain	Community survey	Day sighting	2	Baldivis		1000	0		Animalia

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Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	13/06/2011	24305	TFAUNA	Certain	Community survey	Day sighting	3	Baldivis		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	9/07/2011	24282	TFAUNA	Certain	Community survey	Day sighting	3	Baldivis		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	7/10/2012	24306	TFAUNA	Certain	Community survey	Day sighting	2	Baldivis		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	7/04/2013	24307	TFAUNA	Certain	Community survey	Day sighting	4	Baldivis		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	5/05/2013	24308	TFAUNA	Certain	Community survey	Day sighting	5	Baldivis		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	5/05/2013	24310	TFAUNA	Certain	Community survey	Day sighting	22	Baldivis		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	6/04/2014	80359	TFAUNA	Moderately certain	Community survey	Day sighting	6	Secret Harbour		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	24/04/2015	96213	TFAUNA	Certain	Survey	Day sighting	2	Rockingham		1000	0		Animalia
Ctenotus gemmula (Swan Coastal Plain subpop.)	jewelled southwest Ctenotus (Swan Coastal Plain subpop.)	REPTILE	P3	1/09/2004	16723	TFAUNA	Certain	Survey	Caught or trapped	2	Baldivis		500	0		Animalia
Isoodon fusciventer	quenda, southwestern brown bandicoot	MAMMAL	P4	1/11/2001	6477	TFAUNA	Certain	Survey	Caught or trapped	3	Karnup		1000	0		Animalia
Isoodon fusciventer	quenda, southwestern brown bandicoot	MAMMAL	P4	1/09/2004	16722	TFAUNA	Certain	Survey	Caught or trapped	13	Baldivis		500	0		Animalia
Isoodon fusciventer	quenda, southwestern brown bandicoot	MAMMAL	P4	1/09/2004	23246	TFAUNA	Certain	Survey	Caught or trapped	13	Warnbro		1000	0		Animalia
Isoodon fusciventer	quenda, southwestern brown bandicoot	MAMMAL	P4	14/05/2012	67618	TFAUNA	Moderately certain	Community survey	Day sighting	3	SECRET HARBOUR		1000	0		Animalia
Isoodon fusciventer	quenda, southwestern brown bandicoot	MAMMAL	P4	15/05/2012	67978	TFAUNA	Certain	Community survey	Day sighting	1	KARNUP		1000	0		Animalia
Isoodon fusciventer	quenda, southwestern brown bandicoot	MAMMAL	P4	16/05/2012	68045	TFAUNA	Moderately certain	Community survey	Day sighting	1	PORT KENNEDY		1000	0		Animalia
Isoodon fusciventer	quenda, southwestern brown bandicoot	MAMMAL	P4	1/06/2012	67919	TFAUNA	Moderately certain	Community survey	Day sighting	1	PORT KENNEDY		1000	0		Animalia
Isoodon fusciventer	quenda, southwestern brown bandicoot	MAMMAL	P4	30/09/2013	24874	TFAUNA	Not sure	Opportunistic sighting	Day sighting	1			1000	0		Animalia

NAME_SCI	NAME_COM	CLASS	CONS_CODE	Date	SOURCE_ID	SOURCE	CERTAINTY	METHOD	TYPE	COUNT	LOCALITY	SITE	ACCURACY_M	NAME_ID	FAMILY	KINGDOM
Isoodon fusciventer	quenda, southwestern brown bandicoot	MAMMAL	P4	24/04/2015	96214	TFAUNA	Moderately certain	Survey		0	Rockingham		1000	0		Animalia
Isoodon fusciventer	quenda, southwestern brown bandicoot	MAMMAL	P4	24/06/2016	89654	TFAUNA	Moderately certain	Opportunistic sighting	Caught or trapped	1	Baldivis		10000	0		Animalia
Isoodon fusciventer	quenda, southwestern brown bandicoot	MAMMAL	P4	14/03/2018	96197	TFAUNA	Certain	Survey	Remote camera	3	Rockingham		1000	0		Animalia
Isoodon fusciventer	quenda, southwestern brown bandicoot	MAMMAL	P4	14/03/2018	96198	TFAUNA	Certain	Survey	Remote camera	3	Rockingham		1000	0		Animalia
Isoodon fusciventer	quenda, southwestern brown bandicoot	MAMMAL	P4	14/03/2018	96199	TFAUNA	Certain	Survey	Remote camera	9	Rockingham		1000	0		Animalia
Isoodon fusciventer	quenda, southwestern brown bandicoot	MAMMAL	P4	14/03/2018	96200	TFAUNA	Certain	Survey	Remote camera	1	Rockingham		1000	0		Animalia
Isoodon fusciventer	quenda, southwestern brown bandicoot	MAMMAL	P4	14/03/2018	96201	TFAUNA	Certain	Survey	Remote camera	2			1000	0		Animalia
Isoodon fusciventer	quenda, southwestern brown bandicoot	MAMMAL	P4	14/03/2018	96204	TFAUNA	Certain	Survey	Remote camera	1	Rockingham		1000	0		Animalia
Isoodon fusciventer	quenda, southwestern brown bandicoot	MAMMAL	P4	14/03/2018	96205	TFAUNA	Certain	Survey	Remote camera	6	Rockingham		1000	0		Animalia
Lerista lineata	Perth slider, lined skink	REPTILE	P3	8/11/2001	15083	TFAUNA	Certain	Survey	Caught or trapped	2	Karnup		1000	0		Animalia
Phascogale tapoatafa wambenger	south-western brush-tailed phascogale, wambenger	MAMMAL	CD	12/05/2010	19420	TFAUNA	Certain	Opportunistic sighting	Day sighting	1			1000	0		Animalia
Phascogale tapoatafa wambenger	south-western brush-tailed phascogale, wambenger	MAMMAL	CD	9/03/2017	92709	TFAUNA	Very Certain (photo, specimen, expert)	Survey	Caught or trapped	1	Baldivis		1000	0		Animalia
Calyptorhynchus latirostris	Carnaby's cockatoo	BIRD	EN	25/03/2012	AVIF:38294	WAM_BIRDS	WAM Vouchered	Collection	Specimen	1	KARNUP	Amarillo Drive Karnup	10000	24734	Cacatuidae	Animalia

APPENDIX 9

Significant Tree Data

Map and describe trees greater than 500 mm in diameter (dbh) **Date: 27.3.19** **Observer: PvdM**

Tree Number	Species	Easting MGA zn50	Northing MGA zn50	Height	Diameter	Second Branch	Third Branch	Notes (hollows, bees etc.)
1	Tuart (*Eucalyptus gomphocephala*)	386730	6415339	10	107			
2	Tuart (*Eucalyptus gomphocephala*)	386737	6415309	11	127			
3	Tuart (*Eucalyptus gomphocephala*)	386737	6415295	12	54			
4	Tuart (*Eucalyptus gomphocephala*)	386738	6415291	12	54			
5	Tuart (*Eucalyptus gomphocephala*)	386750	6415292	12	59			
6	Tuart (*Eucalyptus gomphocephala*)	386745	6415294	11	69			
7	Tuart (*Eucalyptus gomphocephala*)	386764	6415302	11	52	56		
8	Tuart (*Eucalyptus gomphocephala*)	386771	6415328	11	63	46		
9	Tuart (*Eucalyptus gomphocephala*)	386775	6415317	12	74			
10	Tuart (*Eucalyptus gomphocephala*)	386777	6415310	10	57	40		
11	Tuart (*Eucalyptus gomphocephala*)	386801	6415343	12	93			
12	Tuart (*Eucalyptus gomphocephala*)	386816	6415347	12	86	40	24	
13	Tuart (*Eucalyptus gomphocephala*)	386816	6415344	11	63			
14	Tuart (*Eucalyptus gomphocephala*)	386838	6415340	12	86			
15	Jarrah (*Eucalyptus marginata*)	386847	6415337	8	79			
16	Tuart (*Eucalyptus gomphocephala*)	386872	6415329	11	71	55	54	
17	Tuart (*Eucalyptus gomphocephala*)	386866	6415303	11	117			
18	Tuart (*Eucalyptus gomphocephala*)	386887	6415296	11	70			
19	Tuart (*Eucalyptus gomphocephala*)	386927	64153336	10	83			
20	Tuart (*Eucalyptus gomphocephala*)	386949	6415311	11	90	21		
21	Tuart (*Eucalyptus gomphocephala*)	386952	6415291	11	54	54	39,22	
22	Tuart (*Eucalyptus gomphocephala*)	386938	6415264	12	53	42	39	
23	Tuart (*Eucalyptus gomphocephala*)	386937	6415254	11	60			
24	Tuart (*Eucalyptus gomphocephala*)	386934	6415254	12	70			
25	Tuart (*Eucalyptus gomphocephala*)	386952	6415250	12	74			
26	Tuart (*Eucalyptus gomphocephala*)	386947	6415252	12	58			
27	Jarrah (*Eucalyptus marginata*)	386971	6415249	10	66			
28	Tuart (*Eucalyptus gomphocephala*)	386962	6415250	10	73			
29	Tuart (*Eucalyptus gomphocephala*)	386947	6415232	9	88			
30	Tuart (*Eucalyptus gomphocephala*)	386905	6415232	10	60	58		
31	Jarrah (*Eucalyptus marginata*)	386853	6415239	12	135			
32	Tuart (*Eucalyptus gomphocephala*)	386846	6415222	10	72			
33	Tuart (*Eucalyptus gomphocephala*)	386851	6415205	11	122			
34	Tuart (*Eucalyptus gomphocephala*)	386810	6415229	11	132	40	35	

Tree Number	Species	Easting MGA zn50	Northing MGA zn50	Height	Diameter	Second Branch	Third Branch	Notes (hollows, bees etc.)
35	Tuart (*Eucalyptus gomphocephala*)	386807	6415206	12	82	81		
36	Tuart (*Eucalyptus gomphocephala*)	386776	6415191	12	109			
37	Tuart (*Eucalyptus gomphocephala*)	386724	6415210	11	101			
38	Tuart (*Eucalyptus gomphocephala*)	386726	6415213	11	115			
39	Tuart (*Eucalyptus gomphocephala*)	386722	6415186	11	56	42		
40	Tuart (*Eucalyptus gomphocephala*)	386749	6415171	11	59			
41	Tuart (*Eucalyptus gomphocephala*)	386797	6415124	12	50	48	27	
42	Tuart (*Eucalyptus gomphocephala*)	386768	6415104	12	74			
43	Tuart (*Eucalyptus gomphocephala*)	386748	6415118	11	148			
44	Tuart (*Eucalyptus gomphocephala*)	386754	6415091	10	58			
45	Tuart (*Eucalyptus gomphocephala*)	386765	6415088	11	59			
46	Tuart (*Eucalyptus gomphocephala*)	386775	6415089	12	83			
47	Standing Dead Tree	386792	6415097	7	67			
48	Tuart (*Eucalyptus gomphocephala*)	386882	6415120	9	60			dead upper branches
49	Tuart (*Eucalyptus gomphocephala*)	386897	6415106	11	51	41		
50	Tuart (*Eucalyptus gomphocephala*)	386892	6415081	12	160			big buttress
51	Tuart (*Eucalyptus gomphocephala*)	386959	6415084	13	122			very healthy specimen
52	Tuart (*Eucalyptus gomphocephala*)	386963	6415064	12	64			
53	Tuart (*Eucalyptus gomphocephala*)	386961	6415064	12	65			
54	Tuart (*Eucalyptus gomphocephala*)	386956	6415064	11	75			
55	Standing Dead Tree	386950	6415065	5	69			
56	Tuart (*Eucalyptus gomphocephala*)	386941	6415066	10	68			
57	Tuart (*Eucalyptus gomphocephala*)	386932	6415030	12	119	68		large spout/hollow 3m up
58	Tuart (*Eucalyptus gomphocephala*)	386955	6415027	13	104			very healthy
59	Tuart (*Eucalyptus gomphocephala*)	386965	6415034	12	74			some termite dust
60	Tuart (*Eucalyptus gomphocephala*)	386967	6415035	13	75			
61	Tuart (*Eucalyptus gomphocephala*)	386917	6415027	10	61			
62	Tuart (*Eucalyptus gomphocephala*)	386901	6415024	10	70			
63	Tuart (*Eucalyptus gomphocephala*)	386884	6415032	12	71			
64	Tuart (*Eucalyptus gomphocephala*)	386879	6415005	11	67			
65	Tuart (*Eucalyptus gomphocephala*)	386875	6414997	12	54			
66	Tuart (*Eucalyptus gomphocephala*)	386884	6414992	12	55			
67	Tuart (*Eucalyptus gomphocephala*)	386897	6414986	11	89			
68	Tuart (*Eucalyptus gomphocephala*)	386936	6414995	12	81			
69	Tuart (*Eucalyptus gomphocephala*)	386955	6414982	13	96			

Tree Number	Species	Easting MGA zn50	Northing MGA zn50	Height	Diameter	Second Branch	Third Branch	Notes (hollows, bees etc.)
70	Standing Dead Tree	386958	6414976	8	53	37		
71	Standing Dead Tree	386959	6414972	8	98			
72	Tuart (*Eucalyptus gomphocephala*)	386954	6414938	12	87	50		
73	Jarrah (*Eucalyptus marginata*)	386962	6414935	7	83			dead branches, broken spout
74	Tuart (*Eucalyptus gomphocephala*)	386918	6414945	11	69			
75	Tuart (*Eucalyptus gomphocephala*)	386889	6414949	10	63	28		
76	Tuart (*Eucalyptus gomphocephala*)	386873	6414937	12	59	59	34	
77	Standing Dead Tree	386871	6414940	5	66			vertical hollow top of dead trunk
78	Tuart (*Eucalyptus gomphocephala*)	386867	6414941	11	81			
79	Tuart (*Eucalyptus gomphocephala*)	386868	6414946	10	64			
80	Tuart (*Eucalyptus gomphocephala*)	386867	6414958	10	52			
81	Tuart (*Eucalyptus gomphocephala*)	386854	6414976	11	94	62		small spouts
82	Tuart (*Eucalyptus gomphocephala*)	386823	6414956	13	109			large hollow up high (photo)
83	Tuart (*Eucalyptus gomphocephala*)	386823	6414975	13	155			large diameter tree
84	Tuart (*Eucalyptus gomphocephala*)	386803	6414943	12	72	67	45	
85	Tuart (*Eucalyptus gomphocephala*)	386775	6414971	11	56			
86	Tuart (*Eucalyptus gomphocephala*)	386763	6414961	10	56	45	44	
87	Tuart (*Eucalyptus gomphocephala*)	386760	6414962	10	75	53	37, 35	
88	Tuart (*Eucalyptus gomphocephala*)	386771	6414992	12	62			
89	Tuart (*Eucalyptus gomphocephala*)	386818	6415039	11	90			
90	Tuart (*Eucalyptus gomphocephala*)	386814	6415063	10	60			
91	Tuart (*Eucalyptus gomphocephala*)	386787	6415054	7	66			
92	Tuart (*Eucalyptus gomphocephala*)	386786	6415055	11	59			
93	Standing Dead Tree	386791	6415070	12	71	54	53	
94	Tuart (*Eucalyptus gomphocephala*)	386797	6415075	10	51	46		
95	Tuart (*Eucalyptus gomphocephala*)	386808	6415084	12	64			
96	Tuart (*Eucalyptus gomphocephala*)	386777	6415090	13	99			
97	Tuart (*Eucalyptus gomphocephala*)	386764	6415077	10	62			
98	Tuart (*Eucalyptus gomphocephala*)	386764	6415081	11	64			
99	Tuart (*Eucalyptus gomphocephala*)	386740	6415060	12	76			some dead small upper branches
100	Tuart (*Eucalyptus gomphocephala*)	386734	6415040	11	88			

APPENDIX 3

Draft Concept Plan

826

169

18m Road

(3372m²)

18m Road

24.5m Road

(9693m²)

14.2m Road

18m Road

14.2m Road

23m Road

14.2m Road

18m Road

14.2m Road

14.2m Road

14.2m Road

14.2m Road

SSIA DR

878

877

14.2m Road

(NAIRN DRIVE) EXTENSION

14.2m Road

13.5m Road

2

14.2m Road

13.5m Road

13.5m Road

14.2m Road

14.2m Road

13.5m Road

18m Road

18m Road

3

146

624

Potential future public open space by others.

CASSIA DR

Potential future north extension of Cassia Drive subject to dedication of public road in Bush Forever reserve.

145

625

LEGEND

Metropolitan Region Scheme

Region Scheme Reserves

- Other Regional Road
- Parks & Recreation

Other

- Bush Forever

Local Scheme

Local Scheme Reserves

- Public Open Space

Local Scheme Zones

- Residential (R25-R40)
- Commercial
- Service Commercial

Other

- Poultry Odour Buffer
- Intersection - Left In/Out
- Intersection - Full Movement
- No Vehicular Access
- Emergency Access (6m wide)
- Bush Forever Original Boundary
- Planning Control Area

Development Concept Plan

Lots 877 and 878 Stakehill Road, Karnup

0 80m

Date: 17 Feb 2021 Scale: 1:4000 @ A3 File: **19-338 ST04B** Staff: JP GW Checked: JP

element.

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Appendix 3

District Water Management Strategy. Rev 3 October 2020 without PCA. Updated for LSP March 2021

DEVELOPMENT
ENGINEERING
CONSULTANTS

DWMS REPORT

J. GARBIN/TERRANOVIS PTY LTD

PROPOSED RESIDENTIAL DEVELOPMENT
LOTS 877 & 878 STAKEHILL ROAD - KARNUP

DISTRICT WATER MANAGEMENT STRATEGY

OCTOBER 2020

Revision History:

Revision	Description	Checked	Approved	Date
0	Original Issue	JPF	RDG	12th September 2017
1	Minor amendments		RDG	15th December 2017
2	Updated to suit revised Plans	SRA	SRA	20th August 2018
3	Updated to suit Amended Strategy and planning	SRA	SRA	13th October 2020

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APPENDIX A – Site Details & Structure Plans
Development Concept Plan
L01 Locality Plan
L02 Aerial Photo with Superimposed Development Layout
City of Rockingham TPS No.2 Map sheet 18 - October 2016
Plan 1 South Metropolitan Peel Sub-Region Structure Plan - April 2015
Plan A Southern Metropolitan Sub-Regional Structure Plan - June 2009

APPENDIX B – Drainage Catchment Plans
L03 Pre-development catchment plan
L04 Post-development catchment plan with indicative basin locations

APPENDIX C – Drainage Calculations
PC Sump Outputs – 63.2%, 20%, 10% & 1% AEP Storm Events
PC Sump Inputs – At Lot calculations to establish Initial and Continuing Loss

APPENDIX D – Groundwater Information
Summary Monitoring Bore Data from lots 877 & 878 (Jun-Dec 2017)
DWER Groundwater levels for Bore Sites 61410049 & 61410060

DEVELOPMENT ENGINEERING CONSULTANTS

Summary of Peak GWLs 1997-2016 for Bore Sites 61410049 & 61410060
Irrigation Water Analysis Report - Nov 2012
GW License over lots 877 & 878 - Oct 2007 to Oct 2017

APPENDIX D – DEC Servicing Report – August 2019 Copy provided in Lots 877 & 878 Stakehill Road Structure Plan report

DEVELOPMENT ENGINEERING CONSULTANTS

Lots 877 & 878 Stakehill Road, Karnup - District Water Management Strategy

DWMS Report Checklist (As based on the guide in Appendix 1 of Guidelines for District Water Management Strategies – DoW Dec 2013)[8]

Applicant:	**TERRANOVIS Pty. Ltd.** Locality: **Karnup**	Version & Date:	**Rev 3** – 27-10-2020
Prepared by:	**Development Engineering Consultants – Steve Allen**	Email:	sallen@deveng.biz
Address:	**Suite 3 / 123A Colin Street WEST PERTH WA 6005**	Phone:	**(08) 9481 1900**

No.	Item Description:	Status	Notes / Comments
	Executive Summary	✓	Description of proposed water management objectives and how the objectives will be met.
1.0	**Planning Background and Previous Studies**		
1.1	Planning Background – site location, details of document the strategy is supporting.	✓	
1.2	Previous drainage / water studies – incl. references to key state &/or local policies, guidelines, strategies and relevance	✓	
2.0	**Design Criteria**		
	- Water management principles, objectives and design criteria - Design objectives from previous water strategies &/or plans	✓ ✓	
3.0	**Pre-development Environment**		
3.1	Site characteristics - provide preliminary desktop assessments and/or field investigations (if required)	✓	
3.2	Climate	✓	
3.3	Topography, Landform and Geotechnical Conditions - describe and map i.e.(Aerial photo; Geotechnical plan, ASS risk map)	✓	
3.4	Existing Land Use	✓	
3.5	Environmental Assets - Identify and describe their significance	✓	
3.6	Social, Cultural and Heritage Considerations	✓	
3.7	Hydrology and Hydrogeology - • surface water • groundwater • water-dependent ecosystems • water resource issues	✓	
3.8	Existing Infrastructure – Drainage and other infrastructure likely to affect management of water resources	✓	
4.0	**Post Development Water Management**		
4.1	Proposed Broad Scale Management Strategies - to address water resource issues, & to meet objectives and design criteria	✓	
4.2	Water Balance - Calculate an indicative water balance	✓	
4.3	Water Resource Impacts - describe the impacts to water resources and/or impacts to proposed change in land use from water issues	✓	
4.4	Surface water - – Estimate land requirements for water management – Identify water quality issues and scope for improvement – Describe proposed strategy for management of small (very frequent), minor (frequent) and major (infrequent) surface flows	✓	
4.5	Groundwater - levels, use, management and maintenance	✓	
4.6	Water-Dependent Ecosystems	✓	
4.7	Contamination - identify issues: high risk acid sulfate soils, contaminated sites or areas with historical high nutrient and/or non-nutrient contaminants	✓	
5.0	**Water Services and Efficiency Initiatives**		
5.1	Potable Water Supply – options incl. details of technical, environmental and regulatory feasibility – regulatory approvals, technical investigations and any obtained written approvals – recommendations for water efficiency and conservation	✓	No options considered. Only standard WC supplied water reticulation service to be used.
5.2	Wastewater Servicing – options including preferred option, location, treatment process, level of treatment, disposal, buffers & infrastructure – approvals and investigations required and any obtained written approvals – recommendations for water efficiency and conservation	✓	No options considered. Only standard WC supplied sewer reticulation service to be used.
5.3	Non-potable Water Supply – Non-potable (fit-for-purpose) water source options. Detail preferred option with consideration of pre & post development water balance – approvals and investigations required and any obtained written approvals – recommendations for water efficiency and conservation	✓	
6.0	**Implementation Framework**		
6.1	Commitments and Obligations - for the next stage of the planning process (e.g. LWMS / UWMP)	✓	
6.2	Identified Issues - that may need specialised investigation and management for the subsequent stage	✓	
6.3	Recommendations - for implementing the DWMS	✓	

Executive Summary

This report has been prepared to support the proposed zoning change over lots 877 & 878 Stakehill Road, Karnup and to help guide the detailed design and construction of the drainage solution for the future subdivision of the land.

The site is currently zoned "Urban Deferred" under the Metropolitan Region Scheme (MRS) and "Development" under the City of Rockingham Town Planning Scheme No. 2. An application for the lifting of the urban deferred zoning is to be lodged with the WAPC.

The site is underlain predominantly by pale yellowish brown, medium to course-grained sand primarily derived from Tamala limestone (Spearwood Sands), which possesses good infiltration characteristics suitable for disposal of storm water by soakage.

The land area to be developed has been fully cleared and currently operates as a market garden. Remaining areas with remnant vegetation are to be retained / protected as a Bush Forever site.

All rainfall will be infiltrated "on-site" for storms up to the 1% AEP (1 in 100yr ARI) event.

Peak groundwater levels are expected to be between RL 2 - 2.25m AHD and will therefore provide a minimum depth to groundwater of ~3.8 m for all proposed post-development finished lot levels.

The proposed development will include:

- public open space designed to have low water use with groundwater used for irrigation
- medium to small lot sizes to help minimise water usage outside of the home
- shallow unfenced basins / swales to treat and infiltrate stormwater close to source
- bulk earthworks managed via on-site cut to fill without the need for groundwater control

Design objectives for water conservation / efficiency and stormwater management will include:

- Targeting water usage to less than 100kl per person per year - with ideally no more than 60kl per person per year of scheme water usage both within and outside of the home
- Ensure that post-development discharge closely matches pre-development conditions
- Protection of all dwellings from flooding during extreme / infrequent storm events
- Improve the overall surface and groundwater quality of the water leaving the site

The proposed approach to achieve each of the above water conservation / efficiency and stormwater management objectives for this development will include:

- Lot purchasers being encouraged to install rain water tanks plumbed into their home; to plant water and nutrient-wise gardens, and to use water efficient devices and appliances
- Lot purchasers will be encouraged to use groundwater for irrigation outside of the home
- All "end-of-line" drainage facilities to be designed to accommodate the 1% AEP storm event via on-site infiltration
- All allotments to be finished a minimum of 0.5m above the 1% AEP flood level
- All surface water will be routed through planted swales or shallow sided unfenced basins
- All swales / basins within the development will be sized to collectively achieve a total surface area equivalent to at least 2% of the total constructed impervious area (CIA)

1 Planning Background and Previous Studies

1.1 Planning Background

This report has been prepared to support a change in zoning over lots 877 & 878 Stakehill Road, Karnup which are located on the south side of Stakehill Road within the City of Rockingham. The report will help guide the detailed design and construction of the drainage solution for the future subdivision of the land.

It is proposed to amend the current zoning of lots 877 & 878 from "Urban Deferred" to "Urban" under the Metropolitan Region Scheme (MRS). Such a proposal requires the preparation and approval of a DWMS prior to an application for the lifting of urban deferred zoning being lodged at the West Australian Planning Commission (WAPC).

A preliminary subdivision layout plan proposed over lots 877 & 878 is included on the locality plan in Appendix A together with copies of associated structure plans covering the Karnup area.

1.2 Previous Drainage / Water Studies

Other than the Department of Water's (DoW), Rockingham-Stakehill Groundwater Management Plan[1] and The City of Rockingham's (CoR) Karnup District Water Management Strategy[10] there are no other known drainage / water studies that have been conducted over the subject land.

Note: Groundwater monitoring bores were installed around the perimeter of the site in May 2017 and a report detailing results obtained from these monitoring bores should be available late 2018.

2 Design Criteria

Storm water drainage designs for developments within the City of Rockingham are governed by specific requirements – several of which are outlined in Table A below:-

Table A – Typical Storm Water Drainage Design Requirements

#	Description	Requirement	Comment
1	Lot storm water quantity	At least the 1 in 1 year - 1 hour ARI storm to be retained on site.	Typical DWER recommendation
2	Storm water quality	Total surface area of installed swales to be min. 2% of total constructed impervious area.	Min. DWER requirement
3	Pipe design	20% AEP (~1 in 5 year ARI)	Typical Council standard
4	"End-of-line" Basin / Swale design	1% AEP (1 in 100 year ARI) without outflow from site.	DWER / Council standard
5	Flow rates	Pre & Post development flows from site to remain unchanged.	DWER / Council standard
6	Min. lot freeboard	0.5m above basin 1% AEP (trapped) flood level. 0.3m above 1% AEP HGL in road / by-pass system.	DWER / Council standard With overland flow along road network during extreme events
7	Side slopes for swales / shallow unfenced basins	Max. 1 in 6 for grassed slopes. Max. 1 in 3 for planted slopes.	Typical Council standard
8	Run-off coefficients	0.70 – residential road reserves. 0.05 – district road reserves (Nairn Drive). 0.11 – Residential Lots 1% AEP 0.25 – Comm. Lots 1% AEP	Typical Council standard Nairn Drive assumes Swales will be installed in medians to allow for infiltration prior to overflow Lot Calculations allow for On site Storage and infiltration prior to overflow
9	Standing Water	All collected storm water to be infiltrated in 96 hours (4 days)	Typical Council standard

#	Description	Requirement	Comment
10	Storm water discharge to receiving environments	No direct discharge permitted All discharges must be treated	DWER / Council standard

The water sensitive principles and design objectives to be used throughout this proposed development are summarised in Table B below:-

Table B – Water Sensitive Principles and Design Objectives

#	Principle	**Objective(s)** - to satisfy principle	**Proposed Approach** - to achieve objective(s)
1	***Potable Water Conservation & Efficiency***	• Target water usage to less than 100kl per person per year • Minimise the use of scheme water outside of the home and to use water as efficiently as possible - both within and outside of the home	• Lot purchasers will be encouraged to install rain water tanks plumbed into their home; to use water efficient devices and appliances, and to plant "Water and Nutrient-wise" gardens • When applicable / appropriate lot purchasers will be encouraged to use groundwater for irrigation
2	***Stormwater Quantity Management***	• Ensure that post-development discharge matches pre-development conditions • Adequately protect dwelling from flooding during extreme events	• All drainage facilities designed so that the 1% AEP storm is satisfactorily disposed on site via infiltration • All allotments to be finished a minimum of 0.5m above the 1% AEP flood level
3	***Stormwater Quality Management***	• To improve the overall surface and groundwater quality of the water leaving the site	• All surface water will be routed through planted swales or shallow sided unfenced basins • All swales / basins installed throughout the development will be sized to collectively achieve a total surface area equivalent to at least 2% of the total constructed impervious area (CIA)

3 Pre-development Environment

3.1 Site Characteristics

The 48ha site is around 80% cleared and currently used for market gardening, with around 11ha of residual bush located in the southern portion of vacant lot 877. Lot 878 contains a residence and sheds along the northern boundary immediately abutting Stakehill Road. Land to the east is semi cleared with a small market garden adjacent to the south east corner.

The site is accessible via Stakehill Road which abuts its northern boundary. Stakehill Road is an 8m wide sealed rural standard road, which acts as a district distributor. Two rural subdivision roads (Cassia Drive west and south) also abuts the land midway along the west and southern boundaries respectively, but are not used to access the site.

An aerial photo underlay and plans showing site contours, and other physical features over the site are shown on various plans contained in Drawing L-02 in Appendix A.

3.2 Climate

The site experiences an average summer temperature of ~32°C and a winter temperature of ~18°C. The majority (~82%) of rain falls between May and October with a total average annual rainfall of ~760mm.

3.3 Topography, Landform and Geotechnical Conditions

A north-south ridge runs along the eastern boundary of lot 877, which basically divides the land into 3 to 4 natural catchments being; the northern portion of lots 877 and 878 which drains west, a small section in the north-eastern corner of lot 877 which drains north and the southern portion

which covers the south of the two lots which drains west and a remaining small portion in the SE corner of Lot 888 which drains south. The highest elevation of the site (ridge on mid-eastern part of lot 877), is ~RL 19m AHD and the land generally falls from this high point in a westerly direction at an overall average grade of ~3% towards two low areas at ~ RL 5m AHD near the western boundary of lot 878.

The Perth Environmental Geology Mapping (Gozzard JR 1983 Rockingham part Sheets 2033 II and 2033 III)[2] indicates that the entire site consists of sand – pale yellowish brown, medium to course-grained, sub-angular to well-rounded quartz, trace of feldspar, shell debris, variably lithified, surface kankar, of "eolian" origin i.e.(from processes pertaining to erosion, transportation & deposition of material by wind). The sand is primarily derived from Tamala limestone which has good infiltration characteristics suitable for disposal of storm water by soakage.

ASS mapping indicates that there is a low to no risk of ASS soils being present over the site. Furthermore, there should not be any requirement for dewatering as all excavations are likely to be well within 3.0m of the finished surface levels. This means there is virtually no risk of the development creating any ASS issues even if ASS were actually present at depth.

3.4 Existing Land Use

The current and historic land use over the site has been horticulture practices with rural/residential lifestyle uses surrounding the site. Two poultry facilities are located around 500m east and west of the common boundary of lots 877 & 878 - both on the north side of Stakehill Road.

3.5 Environmental Assets

Two major "Bush Forever" areas border the proposed development – one covers the southern portion of lot 877 and the other immediately abuts the mid-western boundary of lot 878 (as indicated on the Government of WA Department of Planning and Infrastructure Southern Metropolitan Sub-Regional Structure Plan A – dated 15th June 2009 – Refer Appendix A).

3.6 Social, Cultural and Heritage Considerations

There are no existing / known social, cultural or heritage issues that will be adversely impacted in any significant manner by the proposed development of lots 877 & 878.

3.7 Hydrology and Hydrogeology

Surface water – Due to the sandy nature and high recharge characteristics of the land there is no evidence of any surface water flowing across or emanating from the site.

Groundwater - Lots 877 and 878 are located just outside of the Groundwater Atlas (1997)[4] coverage area. Peak groundwater levels for the site have therefore been estimated by examining the past 20 years of water level records from two surrounding DWER bores (Sites: 61410049 & 61410060) and comparing these levels with readings obtained from recently installed "on-site" monitoring bores – refer Appendix D. Based on initial readings (and taking into account the downwards trend of falling groundwater levels in the area), the current peak groundwater level for site has been estimated to be around RL 2.20m AHD.

The superficial unconfined aquifer beneath the site is ~25m thick, consisting mainly of clayey limestone and sand. Recharge is mainly through infiltration of rainfall. Groundwater flow beneath the site possibly occurs west / south-westerly to the coast as well as east towards the Serpentine River.

Water dependent eco-systems - The site is several hundreds of metres from the Stakehill swamp wetland areas located to the north of Stakehill Road. The nearest wetland that could potentially be

impacted by groundwater leaving the site is the very northern tip of Rockingham Lake Regional Reserve (Anstey Swamp) which is some 1000 metres west / south-west of the site.

Water resource issues – Lots 877 and 878 are within the Churcher East groundwater subarea[1] where groundwater availability has been fully allocated, of which this site has a significant allocation of some 540,000kl/annum. Based on the standard DWER requirement of 7,200 kl/ha/annum for POS irrigation, the required allocation for the POS areas would be around 56,000 kl/annum being significantly less than the current water requirements. Appendix D contains a copy of the current groundwater license (GWL) and irrigation water analysis report for the site.

3.8 Existing Infrastructure

There is no known drainage infrastructure on the site other than a basin / dam in the north–west corner of lot 878 which is being used to extract groundwater for market garden irrigation purposes. Although power and telecommunication services exist in the area, water and wastewater infrastructure extensions will be required in order to fully facilitate the development over the entire site. Additional information on the existing infrastructure and a detailed description of all design constraints are outlined in the Engineering Services Report in Appendix E as prepared by Development Engineering Consultants (DEC) in August 2019.

4 Post-development Water Management

4.1 Proposed Management Strategies

- ***Potable Water Use***

  Standard Water Corporation reticulated sewer and water systems are to be installed within this development. All potable water required by the proposed development will be obtained by extending the Water Corporation water supply network to the site. The design and management of these services will be completed in accordance with Water Corporation design standards and management objectives.

  All lot purchasers will be encouraged to minimise the use of scheme water and to use water as efficiently as possible - both within and outside of the home. They will be encouraged to install rain water tanks plumbed into their home and to use water efficient devices / appliances.

- ***Surface Water***

  All storm water run-off from roadways within this development will be directed into swales / shallow unfenced basins located within and/or adjacent to proposed POS areas.

  All drainage facilities will be designed so that the 1% AEP storm is satisfactorily disposed on site via infiltration.

  All allotments to be finished a minimum of 0.5m above the 1% AEP flood level in the basin and 0.3m above design hydraulic grade line levels for the stormwater drainage system.

- ***Groundwater***

  All swales / basins installed throughout the development will be planted and sized to collectively achieve a total surface area equivalent to at least 2% of the total constructed impervious area (CIA).

  All lot purchasers will also be encouraged to plant Water and Nutrient wise gardens.

4.2 Water Balance

"A Water Balance is an accounting of all water volumes that enter and leave a 3-dimensional space over a specified period of time."[7] Due to the permeability of the soil and limited infrastructure there is likely to be no noticeable water balance change occurring over the site due to current land use activities. Once the estate is fully developed, it is possible that this situation could essentially remain in a similar status provided:-

- All scheme water entering the site leaves via a sewer system and all extracted ground water or captured rainwater is infiltrated back into the site.
    - *Ideally minimal scheme water should be used outside of the home so that all wastewater can then leave the site via the house plumbing system. Also, the majority of all collected rainwater or bore water should also be used outside of the home for irrigation / cleaning purposes etc. so that all such water can then infiltrate back into the ground. Obviously it is unlikely that all residents will totally refrain from using scheme water outside the home meaning some "external water" will enter the site over time. Conversely, if rainwater tanks are used and plumbed into the home to flush toilets or for other internal purposes, then this will mean some internal water will "exit the site" over time.*
- All storm water run-off is fully contained and infiltrated "on-site" close to source.

An estimate of the allocation of water for all types of uses is illustrated below:-

Household scheme / potable water: Target maximum of 60kl per person per year.

Non-potable water: Assume an average of 40kl per person per year throughout the development. This could easily be achieved by installing rainwater tanks &/or bores and would significantly assist towards achieving a target of no more than 60kl/person/year of scheme water usage.

POS water: All POS areas within the estate will be developed in accordance with the DWER and Council requirements for the Karnup area.

Obviously exact requirements for POS ground water usage within this proposed development cannot be established until the final / detailed subdivision plan has been prepared (& after relevant detailed discussions have been held with the Council). Consequently an accurate portion of the existing ground water allocation for this site that can be transferred, traded or cancelled will ultimately be established at a future date. Nonetheless, given the current activities on the site, it is very likely that adequate ground water will be available to support irrigation over some (if not all) POS areas within the proposed development.

4.3 Water Resource Impacts

As the area to be developed is already fully cleared and after the site has been fully subdivided it is quite likely that several hundred trees will eventually be grown in road verges and lots. Over time these planted trees will have a tendency to use / extract more groundwater. On the other hand, with the change in land use, the amount of groundwater extracted could reduce significantly – depending upon the requirements of surrounding users / rural operations; the types of gardens planted within the estate; the amount of scheme water used outside of the home, the number of garden bores installed through-out the estate &/or used to irrigate POS proposed areas; and upon ever-changing state and local government policies etc.

Groundwater yield is influenced by many factors including the extent of rainfall recharge, the amount of water lost through evaporation, the amount taken-up by plants and climate change. Nonetheless the direct impact to the groundwater resource beneath this site is expected to be minimal compared to other external factors and can at least be influenced (internally) to some

degree if / when required. i.e. By encouraging or discouraging the installation / use of garden bores within the estate – for example.

4.4 Surface Water

There is no evidence that any pre-development flow has moved across or ever left the site as all rainfall that falls over the site rapidly infiltrates. Drawing L03 in Appendix B shows the predevelopment sub-catchment boundaries within this site which is also described in Section 3.3 of this document.

The proposed drainage strategy is to infiltrate all storm water on site, as reasonably close to the source as possible, so as to ensure that pre and post development flows essentially remain unchanged – with all post-development surface flows, up to and including the 1% AEP storm event, being fully retained "on-site".

Due to the natural topography of the land and constraints associated with interfacing with existing properties along the western boundary of lot 878, the developed site is expected to be divided into 3 main sub-catchments. Drawing L04 in Appendix B shows the proposed post-development catchment boundaries and the likely locations of all major "end-of-line" infiltration basins. A small portion of the south-eastern corner of site and abutting Nairn Drive will need to be piped under the ridge line in order to be routed to the S1S2 Basin.

Nairn Drive will be designed with a series of swales in the median and roadside which will encourage soakage at source. Based on previous locations, the swales within the Nairn Drive areas alone will not provide sufficient capacity to cater for the full drainage requirements of the road and as a result, a small portion of the south-eastern corner of site and abutting Nairn Drive has been allowed to be piped under the firebreak abutting the southern boundary of the site to be routed into the S1S2 basin.

Given that the site generally falls west then is graded in a northern and southern direction to each of the basins located on the western boundary, it is proposed to install swales on the western side of the western road. The swales are proposed to be constructed with a 1.0m wide base with slopes at 1 in 4 and a maximum depth of 0.5m thereby confining the width to 5.0m. Flow from upper catchments as shown in Drawing L-04 will be directed to the swales. The swales will be graded quite flat but will generally flow towards the basins. All the water not infiltrated will be directed to the end of line basins.

When subdivision layout is finalised and detailed drainage design is further advanced, the logistics of installing some "upper catchment" bio- retention swales will be further examined. This will obviously depend on likely road grades and the availability of areas without services and access such that bio-retention swales can be accommodated. The use of flush kerbing on roads abutting POS areas will also be examined at detailed design stage to maximise opportunities for soakage at source.

All "end-of-line" infiltration basins / swales will typically be constructed within or immediately adjoining POS areas. On the assumption that no "upper catchment" bio retention swales are installed, the maximum areas required to contain all flows from the post development catchments are summarised in Table D below.

The drainage calculations have been undertaken using the shallow water table model PC Sump which has recently been updated by JDA Consultants. Catchment plans and output files for PC Sump are included in Appendices B and C of this document.

Table D – Preliminary Drainage Storage and Area Requirements

Basin / Catchment Name	Impervious Catchment (C_1) Ha	~Storage Required (1%AEP) m^3	~Area Required (1%AEP) m^2	~Storage Required (20%AEP) m^3	~Site Area Required (20%AEP) m^2	~Storage Required (63%AEP) m^3	~Site Area Required (63%AEP) m^2
N	**4.90**	3,743	**4,040**	749	**1,227**	328	**1,069**
S1S2	**6.50**	5,994	**6,597**	1,303	**1,956**	815	**1,659**

Lot owners can retain their surface water run-off "on-site" in rainwater tanks in conjunction with soak wells or overflow into garden beds to infiltrate water and thereby help minimise any outflow to the street drainage system during infrequent / major storm events. All lots should be required to provide on-site storage of ~3.0 cubic metres to at least achieve full retention of the 1 in 1 year 1 hour storm event. This can be provided via:

- Installation of the equivalent of 2 by 1200mm diameter x 1200mm deep soak wells, or alternatively
- An equivalent volume rainwater tanks with an overflow to front garden area

Run-off from roadways for the 1EY storm event will typically be contained within the low area at the base of the basin / swale (or in district distributor verge swales) to help minimise the impact of stormwater run-off during infrequent storm events and to also maximise the opportunity for nutrient up-take.

Non-structural measures can also be employed to reduce the sources of nutrients. These measures involve providing advice to lot purchasers and stakeholders to reduce nutrient sources such as the application of garden fertilisers and eroded particulate matter particularly from the new urban areas during the housing construction phase and initial establishment of gardens.

Minimisation of nutrient loading can obviously be achieved through:

- Education of local residents and Council maintenance personnel; and
- By implementing frequent street and storm water maintenance programs – particularly during the house construction phase.
- By planting and using appropriate local / native species.

All piped drainage systems for public road reserves will be designed to accommodate the 20% AEP event, without inundation of road pavements. All roads within the estate will also be designed to accommodate and direct infrequent / major storm flows (20% AEP events and greater) towards each POS infiltration swale / basin.

All lots adjoining / surrounding each proposed drainage swale / basin will be filled to a minimum of 500mm above the estimated 1% AEP top water level or overflow outlet path. In all cases lot levels will be set to ensure stormwater conveyance, during infrequent events, will safely occur along the roadways in order to help minimise flooding of homes.

POS credit calculations are based upon current Liveable Neighbourhoods[9] policy guidelines – where 100% of the area impacted by the 63% AEP event is not included as POS. Any POS area impacted by the 20% AEP storm is defined as restricted POS and cannot exceed 20% of the total POS allocation.

The DWER's Storm Water Manual also provides guidelines and information on best management practices that may be applied at land development and construction sites to improve storm water management and environmental performance.

Poorly managed land development sites can often be a major source of storm water pollution. Certain construction activities can allow pollutants to be transported (via existing storm water systems or over-land flow) to adjoining receiving water bodies.

The major source of pollutants from subdivision construction activities will potentially be from:

- Eroded materials in the interim period between opening up the surface of the site and implementing the drainage management measures.
- Litter and waste storage areas- that allow materials to be blown by wind or washed away by rainfall into existing storm water systems.
- Wash-down areas– poor practices can allow materials to enter storm water systems.
- Placement and storage of delivered products- particularly sand and soil stockpiles where such materials may be tracked by vehicles, or blown, or washed onto roads which then get into existing storm water systems.
- Dewatering activities– which can cause sedimentation of downstream water bodies.

Consequently no construction activities will commence on the site until an appropriate approved Environmental Management Plan (EMP) is prepared by the contractor that fully addresses:

- Litter and waste management practices (non-hazardous and hazardous materials);
- Vehicle and equipment washing-down practices;
- Water conservation practices;
- Product placement and, storage practices;
- Dewatering activities (if applicable); and
- Any other practices that may adversely impact upon receiving water bodies.

The Best Management measures proposed for this site are likely to include:

- Implementation of non-structural measures to reduce applied nutrient loading.
- On site retention of at least the 1 in 1 year 1 hour ARI storm event.
- Use of earth-bunds / bio-retention swales.
- Construction activities only implemented using a pre-approved EMP.

4.5 Groundwater

Peak groundwater levels over the site are expected to be approximately 3.0m below proposed finished lot levels, meaning that no groundwater level control will be needed.

Any proposed landscaping of POS areas will also address the following objectives:

- Minimising irrigation and fertiliser demands via appropriate species selection.
- Managing fertiliser application to minimise impacts on water quality.
- Weed Management and Fauna Protection

The treatment of the POS areas will typically consist of grassed areas with designated areas of native planting and mulching. All areas will be designed to minimise irrigation requirements with predominantly native plantings incorporated into the landscape design and the use of low water requirement grasses.

4.6 Water Dependent Eco-systems

The site is several hundreds of metres from wetland areas located to the north of Stakehill Road. The nearest wetland that could potentially be impacted by groundwater leaving the site is the Rockingham Lake Regional Reserve (Anstey Swap) which is ~1000 metres west/south-west of the site, so it is not anticipated there will be any detectable / noticeable impact given that all stormwater is to be managed by infiltration.

4.7 Contamination

ASS mapping indicates that there is a low to no risk of ASS soils being present over the site. Furthermore, there should not be any requirement for dewatering as all excavations are likely to be well within 3.0m of the finished surface levels. This means there is almost no risk of the development creating any ASS issues even if ASS were actually present at depth.

Furthermore, there is no indication of any historical high nutrient and/or non-nutrient contamination on the site - but further investigations will still need to be carried out as a condition of subdivision approval as per current practices / guidelines.

5 Water Services and Efficiency Initiatives

5.1 Potable Water Supply

The current state government's requirement to increase the efficiency of water use in new developments to a target of around 100kl per person per year is proposed to be implemented within the development.

This can be achieved by:

- Increased water efficiency in the household by encouraging the use of water wise appliances through current state government regulation and financial incentives.
- Use of rainwater tanks and bores etc. for general irrigation, washing and for the flushing of toilets etc. and to help minimise / avoid scheme water usage outside of the home.
- Using low water requirement plants and minimising turf areas in gardens and POS areas.

Note: The above initiatives can be readily provided to each lot purchaser with the purchase contract or in pre-purchase marketing/information handout sheets. The handouts can also outline how each lot owner can install rainwater tanks plumbed into their homes to assist with the capture and re-use of at least the 63% AEP rainfall event.

5.2 Wastewater Servicing

A standard Water Corporation reticulated sewer system is to be used within this development.

5.3 Non-potable Water Supply

As adequately highlighted in the Department of Waters, Rockingham-Stakehill Groundwater Management Plan[1], groundwater yield from an aquifer is impacted by many factors and climate variability has a direct impact on the groundwater available for allocation. "Failure to adapt poses a risk to the sustainability of the groundwater resource and its dependent ecosystems, and the long-term security of groundwater supply for users." So it would be prudent if appropriate educational information is also provided to lot purchasers (and all potential groundwater users) to make them aware that groundwater allocation limits may need to be varied (or even new policies introduced by DWER) in order to influence the way water is allocated and/or used in the future.

6 Implementation Framework

6.1 Commitments and Obligations

The developer is committed to implementing:

1) Physical Outcomes – To be undertaken at the time of construction by:
   - Ensuring that all storm water drainage from the estate is infiltrated on site and as close "to source" as possible.
   - Installing suitably sized basins / swales within the estate to collectively achieve a total surface area equivalent to at least 2% of the total constructed impervious area (CIA).
2) Non-structural solutions – To provide (probably as part of sales documentation) information to encourage all lot purchasers to:
   - Install / use rainwater tanks (plumbed into their homes); and to
   - Install water and nutrient-wise plants and use water efficient devices and appliances throughout their homes.

6.2 Identified Issues

Due to the localised focus of this report and the general suitability of the site for subdivision, there are no obvious drainage / water issues that require special investigation and management other than those typically required to support or achieve subdivision development – *including: Groundwater monitoring* - The presentation of results from monitoring of pre-development and post development groundwater systems.

Geo-technical report – A pre-development geo-technical report will be required to establish specific soil permeability rates as close as possible to where each proposed infiltration basin / swale is to be installed. All infiltration tests should ideally be undertaken at the expected finished base level of each basin and preferably when groundwater levels are at their highest in order to obtain a conservative / worse case effective infiltration rate for detailed drainage design purposes.

Contamination report - Investigations will need to be carried-out to determine the existence (or otherwise) of any contamination resulting from the existing market gardening operations and to advise of any remediation requirements.

6.3 Recommendations

Following the approval of this document, it is recommended that an UWMP be prepared (to report on the outcomes of site monitoring completed over a minimum 18 month period - inclusive of two winter peaks involving water levels, and), to detail the final detailed water management solution for the site.

7 References

1. Rockingham-Stakehill Groundwater Management Plan – Dept. of Water Report No.23 Nov 2008
2. Environmental Geology Mapping- Gozzard JR 1983 Rockingham part Sheets 2033 II & 2033 III
3. Australian Rainfall and Run-off - A Guide to Flood Estimation Vol. 1, Institute of Engineers, 1987
4. Perth Groundwater Atlas, Waters and Rivers Commission, October 1997
5. Perth Groundwater Atlas (2nd Edition), Department of Environment, 2004
6. Better Urban Water Management, WAPC 2008
7. Irrigation Water Balance Fundamentals ITRC Paper 99-001, 1999 http://www.itrc.org/papers/irrwaterbalance/irrwaterbal.pdf
8. Guidelines for District Water Management Strategies – Dept. of Water Dec 2013

9. Liveable Neighbourhoods, WAPC Jan 2009 Update 2
10. Karnup District Water Management Strategy, GHD March 2014

APPENDIX A – SITE DETAILS & STRUCTURE PLANS

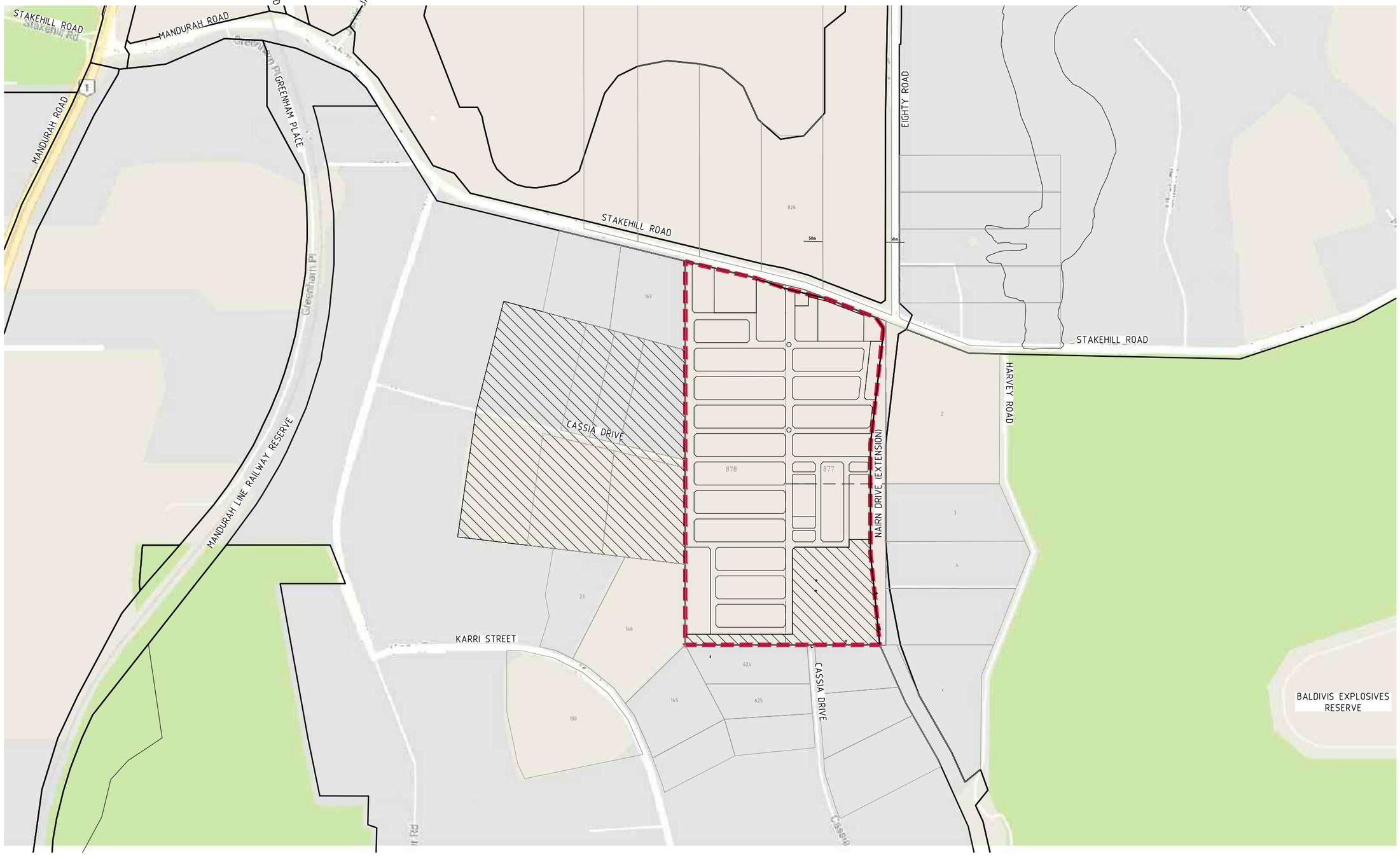
- Development Concept Plan
- L01 Locality Plan
- L02 Aerial Photo with Superimposed Development
- City of Rockingham TPS No.2 Map sheet 18 - October 2016
- Plan 1 South Metropolitan Peel Sub-Region Structure Plan - April 2015
- Plan A Southern Metropolitan Sub-Regional Structure Plan - June 2009

826
169
50m
50m
18m Road
18m Road
24.5m Road
14.2m Road
18m Road
14.2m Road
14.2m Road
14.2

LEGEND

SITE BOUNDARY

BUSH FOREVER



1:5000 (A1)

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No.	DATE	BY	REVISION	
F	18/8/20	JEG	UPDATED LAYOUT	SRA
E	9/3/20	BVS	LAYOUT UPDATED	SRA
D	7/8/19	JEG	LAYOUT AMENDED	SRA
C	13/12/17	JEG	PLAN NAME AMENDED	RDG
B	6/12/17	JEG	PLAN AMENDED	RDG
A	31/8/17	JEG	INITIAL ISSUE	RDG

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PROJECT: **LOTS 877 & 878 STAKEHILL RD BALDIVIS**

W.A.P.C. No. -

DRAWING: **WATER MANAGEMENT STRATEGY LOCALITY PLAN**

CAD DRAWING DO NOT MANUALLY ALTER

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DATE	DESIGNED	APPROVED	
31/8/17	JEG	RDG	

PROJECT NUMBER **PRO1043** DRAWING NUMBER **L01**



LEGEND

SITE BOUNDARY

BUSH FOREVER

1:2000 (A1)

0 20m 40 60 80 100 120 140 160 180 200 220 240 260 280 300

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E	9/3/20	BVS	LAYOUT UPDATED	SRA
D	7/8/19	JEG	LAYOUT AMENDED	SRA
C	13/12/17	JEG	DRAWING NAME CHANGE	RDG
B	6/12/17	JEG	AMENDED PLAN	RDG
A	31/8/17	JEG	INITIAL ISSUE	RDG

CLIENT: **TERRANOVIS**

DEVELOPMENT ENGINEERING CONSULTANTS

SUITE 3, 123A COLIN ST,
WEST PERTH, 6005
WESTERN AUSTRALIA
Ph: (08) 9481 1900
Fax: (08) 9481 1700

PROJECT: **LOTS 877 & 878 STAKEHILL RD BALDIVIS**

W.A.P.C. No. -

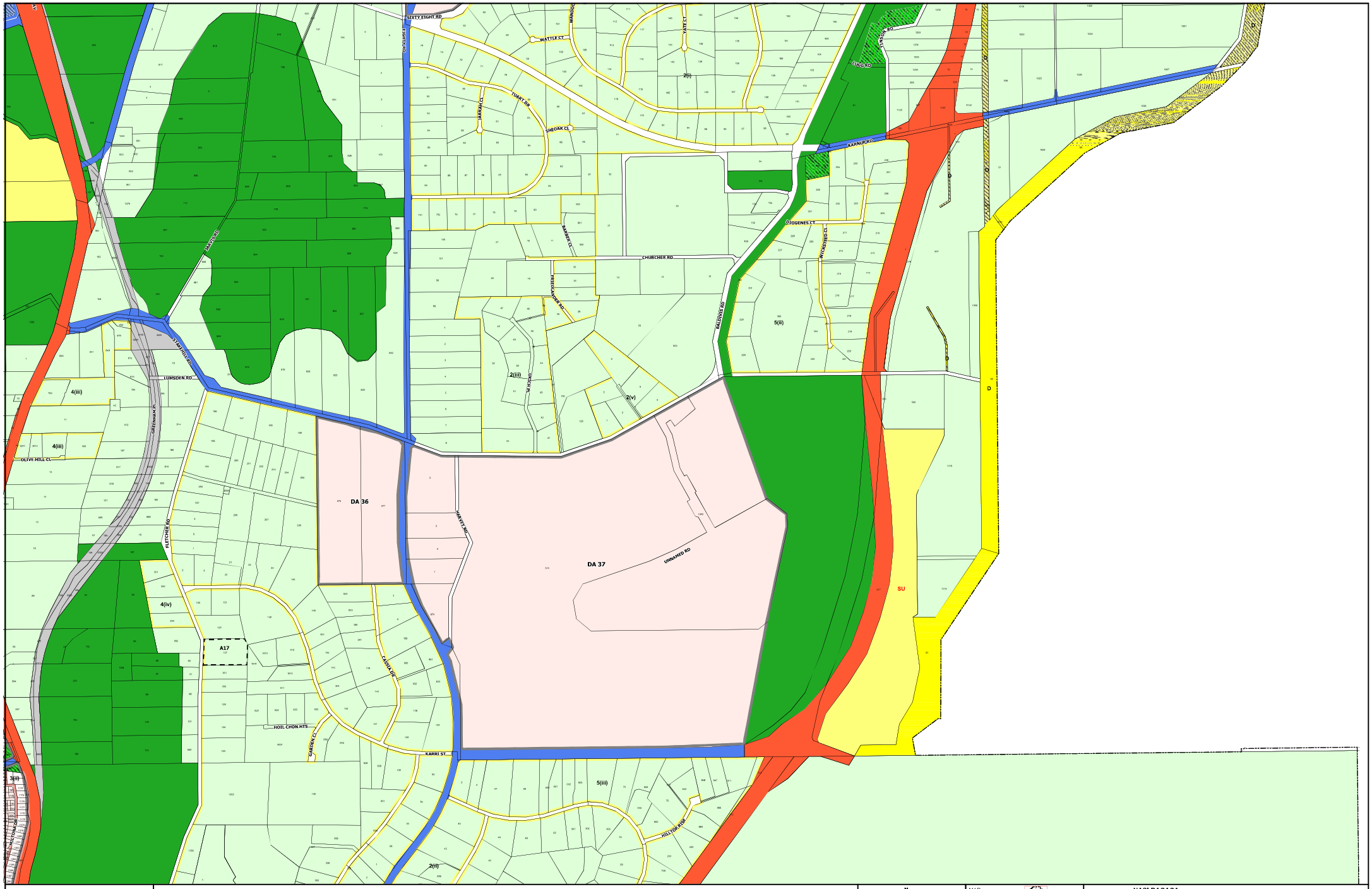
DRAWING: **WATER MANAGEMENT STRATEGY AERIAL PHOTO**

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DATE	DESIGNED	APPROVED	
31/8/17	JEG	RDG	

PROJECT NUMBER **PRO1043** DRAWING NUMBER **L02**



Digital cadastral data supplied by the DLI, Perth, Western Australia.

Whilst all care has been taken to accurately portray the current Scheme provisions, no responsibility will be taken for any omissions or errors in this documentation.

CITY OF ROCKINGHAM

TOWN PLANNING SCHEME No. 2
(DISTRICT ZONING SCHEME)

SCALE 1 : 10000

MAP LEGEND

Authorised NASI RACACA

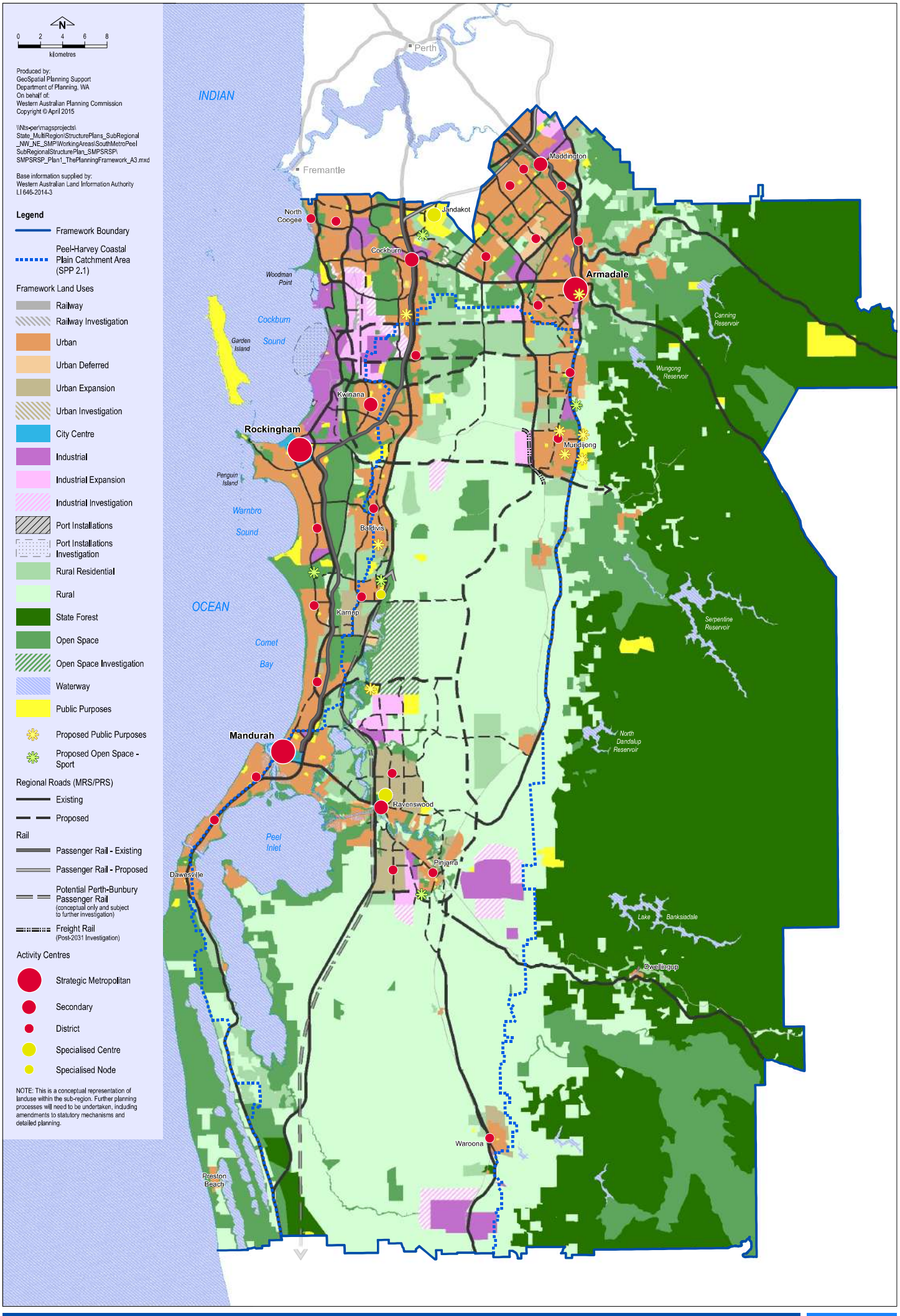
Plot Information : G:\GIS Data\Workspace\GIS_Planning\TPS\Maps\TPS Sheets\Sheet 18 .WOR

Date : OCTOBER 2016

Govt. Gazette : 19th NOVEMBER 2004

TOWN PLANNING SCHEME MAP

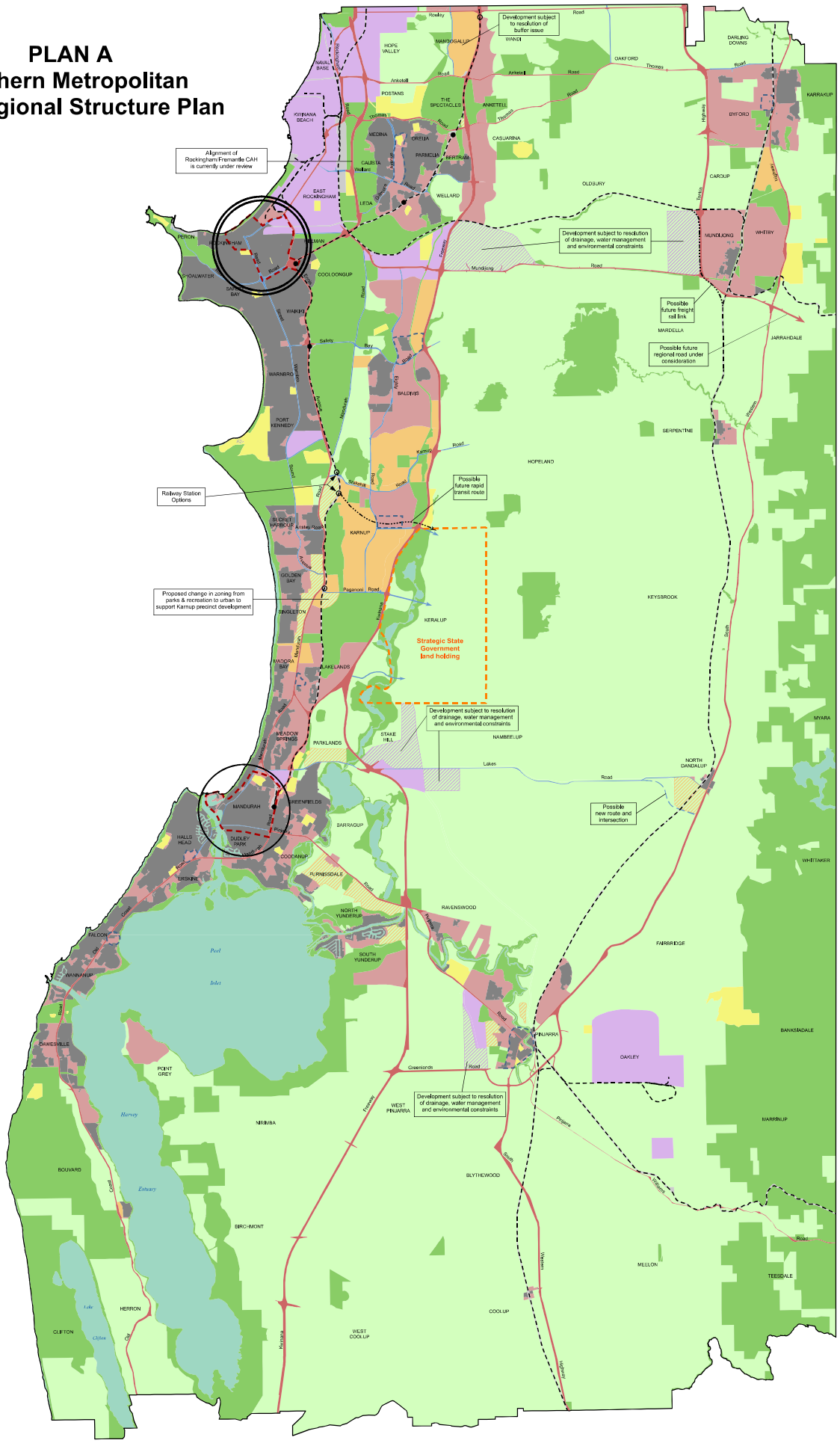
18 of 22



THE PLANNING FRAMEWORK

PLAN 1

PLAN A
Southern Metropolitan Sub-Regional Structure Plan



Legend

- Structure plan boundary
- Developed urban
- Undeveloped urban and urban deferred
- Future urban
- Urban investigation
- Bush forever, parks, open space, recreation and reserves
- Industrial
- Industrial investigation
- Primary regional roads
- Other regional roads
- Public purposes
- Rail reserves and port facilities
- Rural
- Waterways
- Non area
- Primary centre
- Strategic centre
- Indicative primary and strategic city centre precincts
- Indicative regional and district town centre precincts
- Railway line
- Possible future link
- Existing rail station
- Proposed rail station

0 2 4 kilometres

N

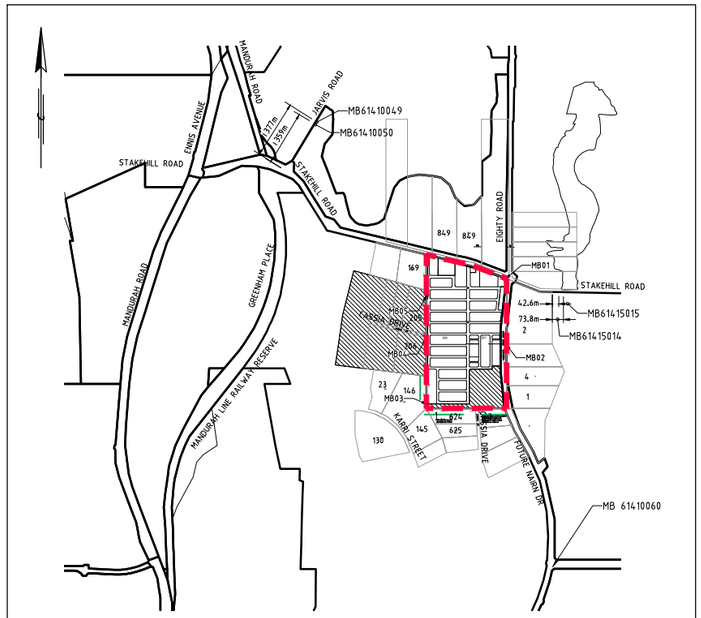
Produced by GIS Analysis and Data Management
Mapping and GeoSpatial Data
Spatial Information and Research Program
Department for Planning and Infrastructure

DATE: 15/06/2009

FILE: \\NTS-PIR\MapGen\Projects\wa_mult\region\South Metropolitan & Peel\Structure Plan\mxd\Report\JUN09\Fig7_SouthMetroSub-RegionalStructurePlan.mxd

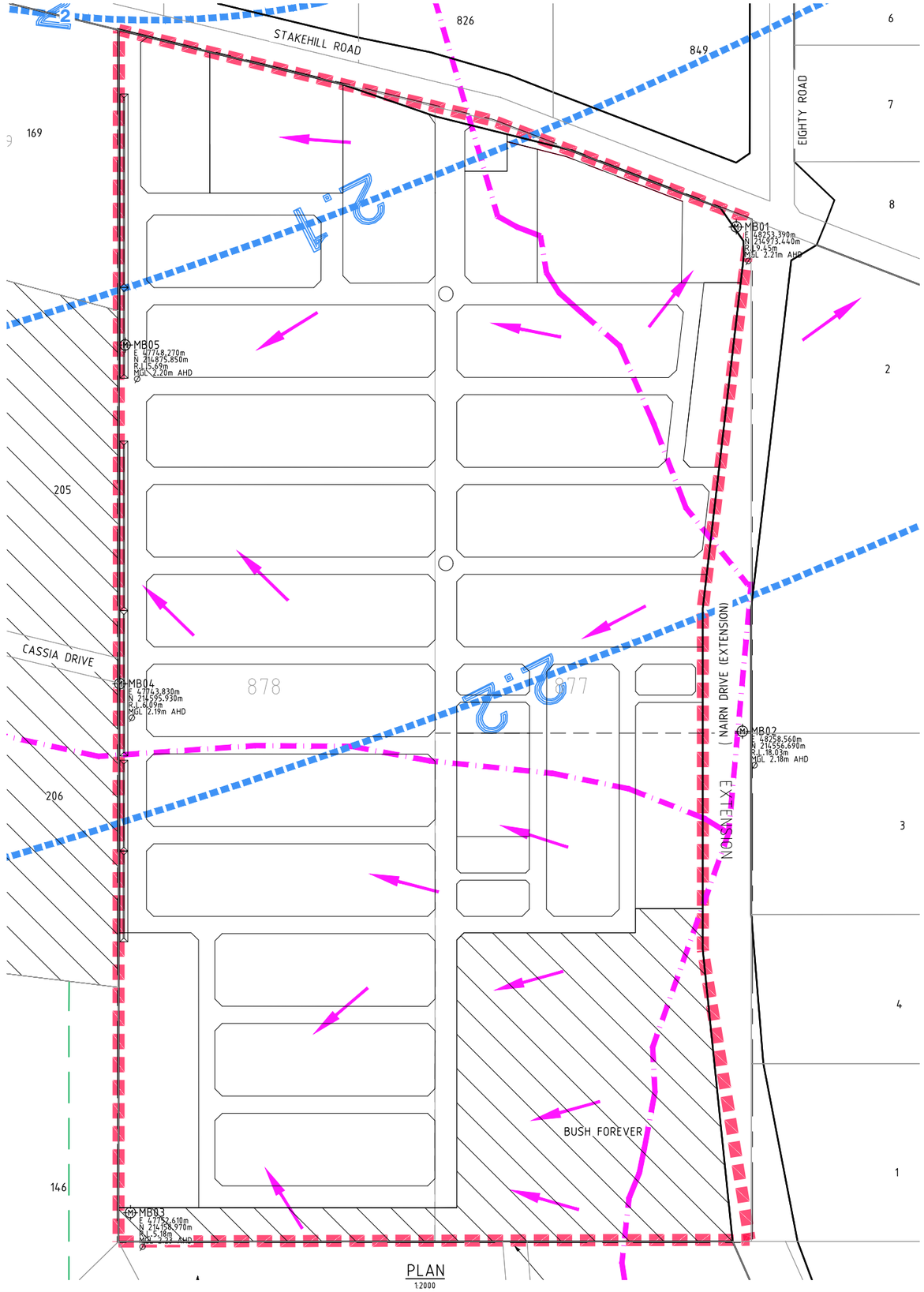
APPENDIX B – DRAINAGE CATCHMENT PLANS

- LW- 03 - Pre-development catchment plan
- LW- 04 - Post development catchment plan



MONITORING BORE LOCALITY PLAN

N.T.S.



PLAN
1:2000

LEGEND

- SUBJECT SITE
- EXISTING SURFACE CONTOURS (23)
- GROUND WATER CONTOURS (MGL) (2)
- IMPLIED NATURAL RIDGE
- SURFACE FLOW ARROW
- MONITORING BORE (MB01 — NAME; E 478.888m, N 496.896m; R.L 0.00m — SURFACE LEVEL; 2.5m — DEPTH; Ø150 — BORE DIAMETER)
- BUSH FOREVER/SPECIAL AREAS

MONITORING BORE LOCATION INFORMATION

BORE NUMBER	EASTING	NORTHING	ROAD NAME
61410049	47028.46	216001.06	JARVIS ROAD
6140050	47018.88	215984.28	JARVIS ROAD
61415015	48606.03	214885.50	STAKEHILL ROAD
61415014	48637.20	214882.13	STAKEHILL ROAD
MB01	48253.39	214973.44	STAKEHILL ROAD
MB02	48258.56	214556.69	NAIN DRIVE (EXTENSION)
MB03	47752.61	214158.97	
MB04	4774383	214595.93	
MB05	47748.270	214875.85	

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D	7/8/19	JEG	LAYOUT AMENDED	SRA
C	13/12/17	JEG	DRAWING NAME CHANGE	RDG
B	6/12/17	JEG	AMENDED PLAN	RDG
A	31/8/17	JEG	INITIAL ISSUE	RDG

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WESTERN AUSTRALIA
Ph: (08) 9481 1900
Fax: (08) 9481 1700

PROJECT: **LOTS 877 & 878 STAKEHILL RD BALDIVIS**

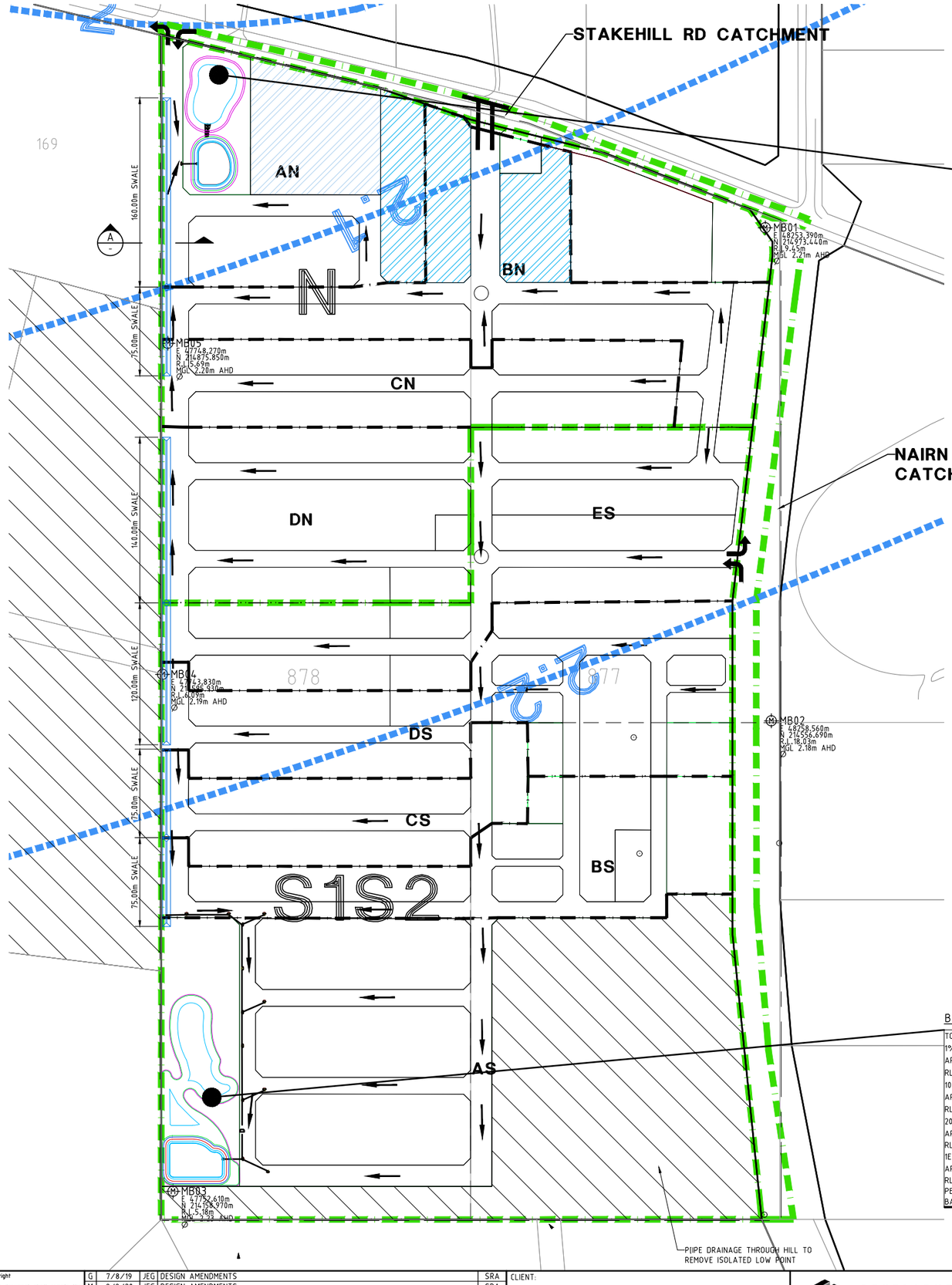
W.A.P.C. No. -

DRAWING: **WATER MANAGEMENT STRATEGY PRE-DEVELOPMENT CATCHMENT PLAN**

CAD DRAWING DO NOT MANUALLY ALTER Z:\Proposals\PRO1043 - Terranovis - Lots 877 & 878 Stakehill Road, Baldivis\Design\Drawings\PRO1043 L03.dwg 18/08/2020

SCALE	DRAWN	CHECK	REV No.
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DATE	DESIGNED	APPROVED	
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PROJECT NUMBER **PRO1043** DRAWING NUMBER **L03**



BASIN DETAILS - CATCHMENT N

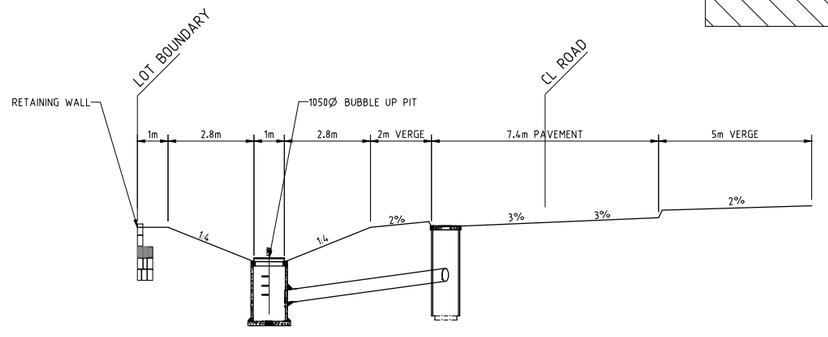
TOTAL IMPERVIOUS AREA (1%)	4.85ha
1% AEP STORAGE REQUIRED	3699m³
AREA AT TWL (1% AEP)	4040m²
RL (TWL) (1% AEP)	4.50m AHD
10% AEP STORAGE REQUIRED	983m³
AREA AT TWL (10% AEP)	1419m²
RL (TWL) (10% AEP)	4.25m AHD
20% AEP STORAGE REQUIRED	705m³
AREA AT TWL (20% AEP)	1235m²
RL (TWL) (20% AEP)	4.04m AHD
1EY STORAGE REQUIRED	284m³
AREA AT TWL (1EY)	812m²
RL (TWL) (1EY)	3.65m AHD
PEAK OUTFLOW (1% AEP)	0 l/s
BASE RL (LWL)	3.30m AHD

BASIN DETAILS - CATCHMENT S1S2

TOTAL IMPERVIOUS AREA (1%)	6.40ha
1% AEP STORAGE REQUIRED	5994m³
AREA AT TWL (1% AEP)	6567m²
RL (TWL) (1% AEP)	5.00m AHD
10% AEP STORAGE REQUIRED	1673m³
AREA AT TWL (10% AEP)	2166m²
RL (TWL) (10% AEP)	4.89m AHD
20% AEP STORAGE REQUIRED	1303m³
AREA AT TWL (20% AEP)	1956m²
RL (TWL) (20% AEP)	4.71m AHD
1EY STORAGE REQUIRED	815m³
AREA AT TWL (1EY)	1659m²
RL (TWL) (1EY)	4.44m AHD
PEAK OUTFLOW (1% AEP)	0 l/s
BASE RL (LWL)	3.80m AHD

LEGEND

- SITE BOUNDARY
- CATCHMENT AREA
- NATURAL SURFACE CONTOURS (23)
- GROUND WATER CONTOURS (2.00)
- DRAINAGE BASIN
- OVERLAND FLOW ARROW
- 1 EY STORAGE
- 20% AEP STORAGE
- 10% AEP STORAGE
- 1% AEP STORAGE
- MB01 — NAME; E 672.299m, N 434.168m, RL 0.00m — SURFACE LEVEL, 2.5m — DEPTH, Ø 150 — BORE DIAMETER — MONITORING BORE
- COMMERCIAL AREA (TYP.)
- BUSH FOREVER SITE / SPECIAL AREAS



TYPICAL DETAIL - SWALE
SECTION A
NOT TO SCALE

CATCHMENT DATA

CATCHMENT	TOTAL AREA m²	LOT AREA m²	COMMERICAL LOT AREA m²	ROAD RESERVE AREA m²	POS AREA m²	BUSH FOREVER AREA m²
N	171121	89206	28860	40852	12203	-
S1S2	288735	134580	-	62198	28162	63795
STAKEHILL ROAD	7620	-	-	7620	-	-
NAIRN DR	18475	-	-	18475	-	-

SUB-CATCHMENT DATA

CATCHMENT	TOTAL AREA m²	LOT AREA m²	COMMERICAL AREA m²	ROAD RESERVE AREA m²	POS AREA m²	BUSH FOREVER AREA m²
AN	56356	19366	17287	8505	11198	-
BN	45166	17790	11572	14799	1005	-
CN	31897	23556	-	8341	-	-
DN	38837	28493	-	10344	-	-
AS	127285	32540	-	15944	15006	63795
BS	35320	17000	-	12804	5516	-
CS	23608	14244	-	6780	2584	-
DS	49166	32256	-	13041	3869	-
ES	53436	38540	-	14896	-	-

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No.	DATE	BY	REVISION	
G	7/8/19	JEG	DESIGN AMENDMENTS	SRA
M	9/9/20	JEG	DESIGN AMENDMENTS	SRA
L	4/9/20	JEG	UPDATED WITH LANDSCAPERS DESIGN	SRA
K	18/8/20	JEG	UPDATED LAYOUT, UPDATED DESIGN	SRA
J	4/8/20	JEG	UPDATED LAYOUT, UPDATED DESIGN	SRA
I	21/2/2020	JEG	UPDATED LAYOUT, UPDATED DESIGN	SRA
H	8/8/19	BVS	UPDATED CATCHMENT S1 AND S2 DETAILS	SRA

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Ph: (08) 9481 1900
Fax: (08) 9481 1700

PROJECT: **LOTS 877 & 878 STAKEHILL RD BALDIVIS**
W.A.P.C. No. -

DRAWING: **WATER MANAGEMENT STRATEGY POST-DEVELOPMENT CATCHMENT PLAN**
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SCALE	DRAWN	CHECK	REV No.
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31/8/17	JEG	RDG	

PROJECT NUMBER: **PRO1043**
DRAWING NUMBER: **L04**

APPENDIX C – DRAINAGE CALCULATIONS

- - PC Sump Outputs – 63.2%, 20%, 10% & 1% AEP Storm Events
- - PC Sump Inputs – At Lot calculations to establish Initial and Continuing Loss

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

Lots 877 and 878 Stakehill Road, Baldivis

Project Description:

Basin N

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	34.2	1%	1.02	4.32	0.18	1,844	3,103	5
	2	1 hour	43.8	1%	1.03	4.33	0.17	1,923	3,145	7
	3	2 hour	57.1	1%	1.12	4.42	0.08	2,971	3,712	3
	4	3 hour	67.3	1%	1.09	4.39	0.11	2,618	3,521	7
	5	6 hour	89.7	1%	1.14	4.44	0.06	3,226	3,850	6
	6	9 hour	105.0	1%	1.19	4.49	0.01	3,742	4,129	1
	7	12 hour	116.0	1%	1.07	4.37	0.13	2,400	3,403	10
	8	24 hour	140.0	1%	1.08	4.38	0.12	2,493	3,453	7
	9	48 hour	155.0	1%	0.98	4.28	0.22	1,430	2,879	2
	10	72 hour	161.0	1%	0.91	4.21	0.29	987	1,390	5
Critical	***6***	***9 hour***	***105.0***	***1%***	***1.19***	***4.49***	***0.01***	***3,742***	***4,129***	***1***

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

Lots 877 and 878 Stakehill Road, Baldivis

Project Description:

Basin N

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	23.4	10%	0.54	3.84	0.66	550	1,085	3
	2	1 hour	29.9	10%	0.65	3.95	0.55	681	1,177	9
	3	2 hour	38.2	10%	0.94	4.24	0.26	1,015	1,410	10
	4	3 hour	44.2	10%	0.94	4.24	0.26	1,014	1,409	4
	5	6 hour	57.0	10%	0.93	4.23	0.27	1,004	1,402	2
	6	9 hour	65.7	10%	0.94	4.24	0.26	1,015	1,409	2
	7	12 hour	72.3	10%	0.78	4.08	0.42	831	1,281	2
	8	24 hour	88.0	10%	0.74	4.04	0.46	787	1,251	8
	9	48 hour	102.0	10%	0.6	3.90	0.60	623	1,136	5
	10	72 hour	111.0	10%	0.45	3.75	0.75	440	1,009	4
Critical	***3***	***2 hour***	***38.2***	***10%***	***0.94***	***4.24***	***0.26***	***1,015***	***1,410***	***10***

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

Lots 877 and 878 Stakehill Road, Baldivis

Project Description:

Basin N

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	20.2	20%	0.36	3.66	0.84	330	932	5
	2	1 hour	25.9	20%	0.45	3.75	0.75	448	1,014	9
	3	2 hour	33.0	20%	0.67	3.97	0.53	706	1,194	4
	4	3 hour	38.1	20%	0.62	3.92	0.58	643	1,150	3
	5	6 hour	48.7	20%	0.66	3.96	0.54	694	1,186	2
	6	9 hour	55.8	20%	0.7	4.00	0.50	742	1,219	6
	7	12 hour	61.2	20%	0.7	4.00	0.50	731	1,212	3
	8	24 hour	74.5	20%	0.59	3.89	0.61	610	1,127	10
	9	48 hour	87.6	20%	0.4	3.70	0.80	379	965	7
	10	72 hour	96.2	20%	0.27	3.57	0.93	251	928	4
Critical	***6***	***9 hour***	***55.8***	***20%***	***0.7***	***4.00***	***0.50***	***742***	***1,219***	***6***

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

PCSump Version 6: Licenced to Development Engineering Consultants

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

Lots 877 and 878 Stakehill Road, Baldivis

Project Description:

Basin N

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	14.2	1 EY	0.13	3.43	1.07	118	928	10
	2	1 hour	18.5	1 EY	0.22	3.52	0.98	202	928	2
	3	2 hour	23.8	1 EY	0.3	3.60	0.90	279	928	4
	4	3 hour	27.4	1 EY	0.29	3.59	0.91	267	928	1
	5	6 hour	34.4	1 EY	0.34	3.64	0.86	314	928	5
	6	9 hour	39.0	1 EY	0.34	3.64	0.86	313	928	7
	7	12 hour	42.5	1 EY	0.33	3.63	0.87	310	928	4
	8	24 hour	51.2	1 EY	0.27	3.57	0.93	247	928	10
	9	48 hour	60.9	1 EY	0.11	3.41	1.09	98	928	7
	10	72 hour	68.1	1 EY	0.05	3.35	1.15	48	928	5
Critical	***5***	***6 hour***	***34.4***	***1 EY***	***0.34***	***3.64***	***0.86***	***314***	***928***	***5***

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

PCSump Version 6

Environmental and Water Resource Software

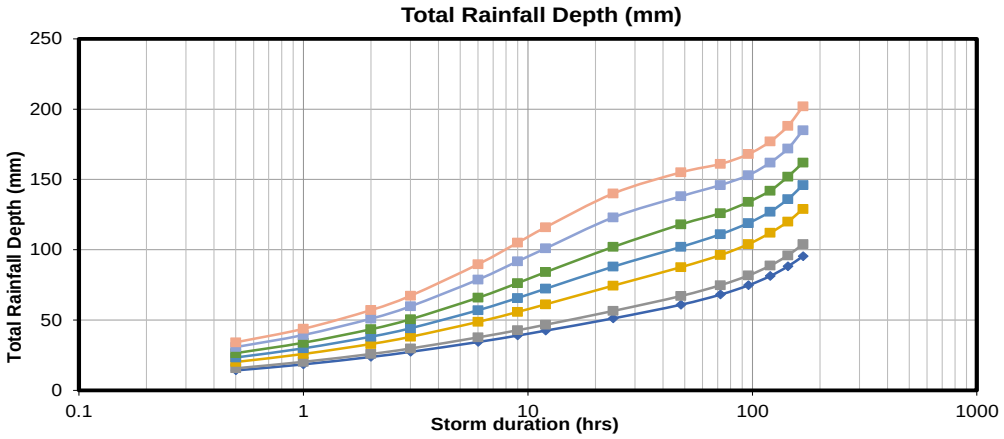
Project Number/Name:	Lots 877 and 878 Stakehill Road, Baldivis
Project Description:	Basin N

Model Selection:	Shallow Water Table Model
Design AEP(EY)/ARI	1% AEP (100 year ARI)
Design Rainfall Region:	Perth Metro
Design Rainfall Location:	Rockingham
Latitude:	-32.28342204
Longitude:	115.7114576
Temporal Pattern:	West Flatlands
Climate Change Selection (Y/N)	N
Effective Service Life	
Consequence of Failure	
Adjustment Applied	

Swale Selection (Y/N)	Y

Total Rainfall Depth (mm)

Duration	EY	Annual Exceedance Probability (AEP)					
	1 EY	50%	20%	10%	5%	2%	1%
30 min	14.2	15.7	20.2	23.4	26.5	30.8	34.2
1 hour	18.5	20.3	25.9	29.9	33.9	39.4	43.8
2 hour	23.8	25.9	33	38.2	43.5	51	57.1
3 hour	27.4	29.8	38.1	44.2	50.6	59.8	67.3
6 hour	34.4	37.7	48.7	57	65.9	78.8	89.7
9 hour	39	42.8	55.8	65.7	76.3	91.8	105
12 hour	42.5	46.7	61.2	72.3	84.1	101	116
24 hour	51.2	56.5	74.5	88	102	123	140
48 hour	60.9	67.1	87.6	102	118	138	155
72 hour	68.1	74.8	96.2	111	126	146	161
96 hour	74.7	81.7	104	119	134	153	168
120 hour	81.3	88.7	112	127	142	162	177
144 hour	88.2	96	120	136	152	172	188
168 hour	95.4	104	129	146	162	185	202



Swale 1:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Roads	0.9944	2		30.0%
Resi Lots	2.9087	13.6	9.7	

Swale 2:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Roads	0.8019	2		30.0%
Resi Lots	2.3856	13.6	9.7	

Swale 3:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Roads	1.4636	2		30.0%
Resi Lots	1.6667	13.6	9.7	

POS				

Comm Lots	1.29	24.4	4.6	
POS	0.1005			100.0%

Swale Geometry:

Swale Length (m)	140.0
Swale Base Width (m)	1.0
Left Batter (1 in X)	4.0
Right Batter (1 in X)	4.0
Ave. Swale Base Elevation (mAHD)	5.92
Maximum Swale Depth (m)	0.50
Swale Slope (m/m)	0.003
Manning's Roughness	0.03

Soil Characteristics:

Saturated Vertical K (m/day)	
Saturated Horizontal K (m/day)	5
Design Groundwater Level	2.1
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	

Swale Geometry:

Swale Length (m)	75
Swale Base Width (m)	1
Left Batter (1 in X)	4
Right Batter (1 in X)	4
Ave. Swale Base Elevation (mAHD)	5.23
Maximum Swale Depth (m)	0.5
Swale Slope (m/m)	0.003
Manning's Roughness	0.025

Soil Characteristics:

Saturated Vertical K (m/day)	
Saturated Horizontal K (m/day)	5
Design Groundwater Level	2.1
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	

Swale Geometry:

Swale Length (m)	160
Swale Base Width (m)	1
Left Batter (1 in X)	4
Right Batter (1 in X)	4
Ave. Swale Base Elevation (mAHD)	4.72
Maximum Swale Depth (m)	0.5
Swale Slope (m/m)	0.003
Manning's Roughness	0.025

Soil Characteristics:

Saturated Vertical K (m/day)	
Saturated Horizontal K (m/day)	5
Design Groundwater Level	2.1
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	

Basin:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Roads	0.8201	2		30.0%
Comm Lots	1.596	24.4	4.6	
Resi Lots	2.0997	13.6	9.7	
POS	1.1198			100.0%
Basin	0.4187			0.0%

Basin Parameters:

Soil Characteristics:	
Saturated Vertical K (m/day)	
Saturated Horizontal K (m/day)	5
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	
Soil Suction (cm)	
Porosity	
Aquifer Storage Coefficient	0.2
Base of Aquifer (mAHD)	-14
Design Groundwater Level (mAHD)	2.1
Initial Conditions:	
Water Depth in Basin (m)	0
Wetting Front Depth (m)	0
Initial Degree of Soil Saturation (%)	0%
Basin Geometry:	
Stage-Area-Volume Relationship Entered (Y/N)	Y
Base Length (m)	32
Base Width (m)	29

Average Slope (1 in X)	20.7
Basin Base Elevation (mAHD)	3.3
Maximum Allowable TWL (mAHD)	4.5

Pipe Outflow:

Entrance Type	
Pipe Diameter (mm)	
Pipe Length (m)	
Upstream Invert Level (mAHD)	
Downstream Invert Level (mAHD)	

Weir Outflow:

Weir Type:	
Weir Coefficient	
Weir Width (m)	
Weir Level (mAHD)	

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

Lots 877 and 878 Stakehill Road, Baldivis

Project Description:

Combined Basin S1 and S2

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	34.2	1%	1.14	4.94	0.06	2,595	3,096	1
	2	1 hour	43.8	1%	1.14	4.94	0.06	3,491	4,059	1
	3	2 hour	57.1	1%	1.14	4.94	0.06	3,236	3,785	1
	4	3 hour	67.3	1%	1.14	4.94	0.06	3,515	4,084	1
	5	6 hour	89.7	1%	1.14	4.94	0.06	4,550	5,196	1
	6	9 hour	105.0	1%	1.19	4.99	0.01	5,966	6,557	8
	7	12 hour	116.0	1%	1.14	4.94	0.06	2,788	3,304	1
	8	24 hour	140.0	1%	1.14	4.94	0.06	3,485	4,052	1
	9	48 hour	155.0	1%	1.14	4.94	0.06	2,768	3,283	1
	10	72 hour	161.0	1%	1.14	4.94	0.06	2,433	2,923	1
Critical	***6***	***9 hour***	***105.0***	***1%***	***1.19***	***4.99***	***0.01***	***5,966***	***6,557***	***8***

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

Lots 877 and 878 Stakehill Road, Baldivis

Project Description:

Combined Basin S1 and S2

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	23.4	10%	0.72	4.52	0.48	1,037	1,767	5
	2	1 hour	29.9	10%	0.77	4.57	0.43	1,118	1,817	5
	3	2 hour	38.2	10%	1.07	4.87	0.13	1,653	2,145	10
	4	3 hour	44.2	10%	1.07	4.87	0.13	1,657	2,147	4
	5	6 hour	57.0	10%	1.06	4.86	0.14	1,645	2,140	2
	6	9 hour	65.7	10%	0.94	4.74	0.26	1,433	2,010	2
	7	12 hour	72.3	10%	0.88	4.68	0.32	1,313	1,936	7
	8	24 hour	88.0	10%	1.01	4.81	0.19	1,543	2,077	3
	9	48 hour	102.0	10%	0.96	4.76	0.24	1,456	2,024	4
	10	72 hour	111.0	10%	1.01	4.81	0.19	1,558	2,087	10
Critical	***3***	***2 hour***	***38.2***	***10%***	***1.07***	***4.87***	***0.13***	***1,653***	***2,145***	***10***

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

Lots 877 and 878 Stakehill Road, Baldivis

Project Description:

Combined Basin S1 and S2

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	20.2	20%	0.5	4.30	0.70	640	1,523	7
	2	1 hour	25.9	20%	0.6	4.40	0.60	824	1,636	9
	3	2 hour	33.0	20%	0.77	4.57	0.43	1,132	1,825	4
	4	3 hour	38.1	20%	0.82	4.62	0.38	1,212	1,874	3
	5	6 hour	48.7	20%	0.82	4.62	0.38	1,208	1,872	2
	6	9 hour	55.8	20%	0.76	4.56	0.44	1,107	1,809	6
	7	12 hour	61.2	20%	0.76	4.56	0.44	1,100	1,805	2
	8	24 hour	74.5	20%	0.83	4.63	0.37	1,240	1,891	10
	9	48 hour	87.6	20%	0.84	4.64	0.36	1,255	1,900	1
	10	72 hour	96.2	20%	0.87	4.67	0.33	1,300	1,928	4
Critical	***10***	***72 hour***	***96.2***	***20%***	***0.87***	***4.67***	***0.33***	***1,300***	***1,928***	***4***

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

Lots 877 and 878 Stakehill Road, Baldivis

Project Description:

Combined Basin S1 and S2

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	14.2	1 EY	0.19	3.99	1.01	203	1,080	7
	2	1 hour	18.5	1 EY	0.32	4.12	0.88	348	1,080	7
	3	2 hour	23.8	1 EY	0.48	4.28	0.72	609	1,504	4
	4	3 hour	27.4	1 EY	0.43	4.23	0.77	527	1,453	1
	5	6 hour	34.4	1 EY	0.46	4.26	0.74	574	1,482	5
	6	9 hour	39.0	1 EY	0.48	4.28	0.72	608	1,503	3
	7	12 hour	42.5	1 EY	0.49	4.29	0.71	633	1,518	3
	8	24 hour	51.2	1 EY	0.56	4.36	0.64	753	1,592	4
	9	48 hour	60.9	1 EY	0.58	4.38	0.62	779	1,608	6
	10	72 hour	68.1	1 EY	0.59	4.39	0.61	813	1,629	2
Critical	***10***	***72 hour***	***68.1***	***1 EY***	***0.59***	***4.39***	***0.61***	***813***	***1,629***	***2***

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

PCSump Version 6

Environmental and Water Resource Software

Project Number/Name: Lots 877 and 878 Stakehill Road, Baldivis

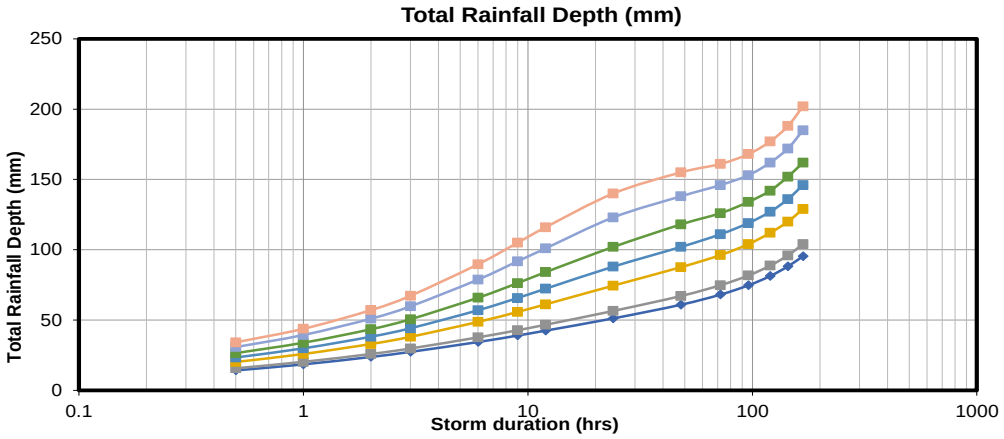
Project Description: Combined Basin S1 and S2

Model Selection:	Shallow Water Table Model
Design AEP(EY)/ARI	1% AEP (100 year ARI)
Design Rainfall Region:	Perth Metro
Design Rainfall Location:	Rockingham
Latitude:	-32.28342204
Longitude:	115.7114576
Temporal Pattern:	West Flatlands
Climate Change Selection (Y/N)	N
Effective Service Life	
Consequence of Failure	
Adjustment Applied	

Swale Selection (Y/N)	Y

Total Rainfall Depth (mm)

Duration	EY	Annual Exceedance Probability (AEP)					
	1 EY	50%	20%	10%	5%	2%	1%
30 min	14.2	15.7	20.2	23.4	26.5	30.8	34.2
1 hour	18.5	20.3	25.9	29.9	33.9	39.4	43.8
2 hour	23.8	25.9	33	38.2	43.5	51	57.1
3 hour	27.4	29.8	38.1	44.2	50.6	59.8	67.3
6 hour	34.4	37.7	48.7	57	65.9	78.8	89.7
9 hour	39	42.8	55.8	65.7	76.3	91.8	105
12 hour	42.5	46.7	61.2	72.3	84.1	101	116
24 hour	51.2	56.5	74.5	88	102	123	140
48 hour	60.9	67.1	87.6	102	118	138	155
72 hour	68.1	74.8	96.2	111	126	146	161
96 hour	74.7	81.7	104	119	134	153	168
120 hour	81.3	88.7	112	127	142	162	177
144 hour	88.2	96	120	136	152	172	188
168 hour	95.4	104	129	146	162	185	202



Swale 1:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Roads	2.8736	2		30.0%
Resi Lots	7.1544	13.6	9.7	

Swale 2:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Roads	0.6532	2		30.0%
Resi Lots	1.4545	13.6	9.7	

Swale 3:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Roads	1.11434	2		30.0%
Resi Lots	1.715	13.6	9.7	

POS	0.2522			100.0%

POS	0.2853			100.0%

POS	0.6703			100.0%

Swale Geometry:

Swale Length (m)	120.0
Swale Base Width (m)	1.0
Left Batter (1 in X)	4.0
Right Batter (1 in X)	4.0
Ave. Swale Base Elevation (mAHD)	6.29
Maximum Swale Depth (m)	0.50
Swale Slope (m/m)	0.003
Manning's Roughness	0.03

Soil Characteristics:

Saturated Vertical K (m/day)	
Saturated Horizontal K (m/day)	5
Design Groundwater Level	2.2
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	

Swale Geometry:

Swale Length (m)	75
Swale Base Width (m)	1
Left Batter (1 in X)	4
Right Batter (1 in X)	4
Ave. Swale Base Elevation (mAHD)	5.95
Maximum Swale Depth (m)	0.5
Swale Slope (m/m)	0.003
Manning's Roughness	0.025

Soil Characteristics:

Saturated Vertical K (m/day)	
Saturated Horizontal K (m/day)	5
Design Groundwater Level	2.2
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	

Swale Geometry:

Swale Length (m)	75
Swale Base Width (m)	1
Left Batter (1 in X)	4
Right Batter (1 in X)	4
Ave. Swale Base Elevation (mAHD)	5.73
Maximum Swale Depth (m)	0.5
Swale Slope (m/m)	0.003
Manning's Roughness	0.025

Soil Characteristics:

Saturated Vertical K (m/day)	
Saturated Horizontal K (m/day)	5
Design Groundwater Level	2.2
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	

Basin:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Roads	1.6138	2		30.0%
Nairn Drive	1.8475			100.0%
Resi Lots	3.0074	13.6	9.7	
POS	8.0986			100.0%
Basin	0.6			0.0%

Basin Parameters:

Soil Characteristics:	
Saturated Vertical K (m/day)	
Saturated Horizontal K (m/day)	5
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	
Soil Suction (cm)	
Porosity	
Aquifer Storage Coefficient	0.2
Base of Aquifer (mAHD)	-14
Design Groundwater Level (mAHD)	2.2
Initial Conditions:	
Water Depth in Basin (m)	0
Wetting Front Depth (m)	0
Initial Degree of Soil Saturation (%)	0%
Basin Geometry:	
Stage-Area-Volume Relationship Entered (Y/N)	Y
Base Length (m)	19
Base Width (m)	58

Average Slope (1 in X)	27
Basin Base Elevation (mAHD)	3.8
Maximum Allowable TWL (mAHD)	5

Pipe Outflow:

Entrance Type	
Pipe Diameter (mm)	
Pipe Length (m)	
Upstream Invert Level (mAHD)	
Downstream Invert Level (mAHD)	

Weir Outflow:

Weir Type:	
Weir Coefficient	
Weir Width (m)	
Weir Level (mAHD)	

Development Engineering Consultants - Drainage Basin Spreadsheet

Project: Lots 877 and 878 Stakehill Road, Baldivis

Client: Garbin

Location: At-lot detention calculations to establish runoff coefficient - commercial-type site

Designer: SRA

Location:	**Stakehill Road, Baldivis**			
Nearest grid cell:	**Latitude**	**32.3125(S)**	**Longitude**	**115.8125(E)**

DEVELOPMENT ENGINEERING CONSULTANTS

Data to be Input

		ARI	v Descriptor v
Rainfall AEP (Percentage)	1	100	Infrequent
1EY Impervious Catchment (Ha)	0.810		
Required Storage (1EY - 1hr) (m^3)	124.740		

Catchment Details	Paved Area	Unpaved area	Total
Lot Area (SQM)			**10000.00**
Proportion Paved	**90%**	**10%**	**100%**
Area Paved (Ha)	**0.900**	**0.100**	**1.000**
Run-Off Co-efficient(C10)	0.90	0.00	
ARI Multiplier	1.00	1.20	
Run-Off Co-efficient(Cy)	0.90	0.00	
Impervious Area(Ha)	**0.810**	**0.000**	**0.810**

Effective C
0.81

AEP	ARI	Effective C	Multiplier
63.2	1	0	-
50	1.44	0	-
20	4.48	0	-
10	9.49	0	-
5	20	0.09	-
2	50	0.21	-
1	100	0.28	-

Volume and Dimensions of Available Storage

Area above ground inundated to 0.03m deep (backyard and front yard) (m^2)	-	0.03	-
Storage provided manholes/pipe (m^3)	-		
Number of Soakwells	40.00		
Diameter of soakwells (m)	1.80		
Depth of each soakwell (m)	2.40		
Storage required soakwells (m^3)	**244.29**		
Strorage provided (m^3)	244.29		
Effective Initial Loss (mm)	**24.43**		
Soakage rate ($l/s/m^2$)	0.020	*1.70 m/day*	

NOTE: All water is retained in soakwells up to and including 10% AEP (1 in 10yr ARI) without surcharge. For greater AEP storms water will surcharge soakwells and enter the road drainage system.

Volume of storage required is $1m^3$ per	**40.93 m^2**	**of total lot area**
Alternatively storage required is $1m^3$ per	**36.84 m^2**	**of paved area**

Development Engineering Consultants - Drainage Basin Spreadsheet

Project: **Lots 877 and 878 Stakehill Road, Baldivis**

Client: **Garbin**

Location: **At-lot detention calculations to establish runoff coefficient - commercial-type site**

Designer: **SRA**

Location:	**Stakehill Road, Baldivis**			
Nearest grid cell:	**Latitude**	**32.3125(S)**	**Longitude**	**115.8125(E)**

DEVELOPMENT

T_C (mins)	T_C (hrs)	I (mm/hr)	Q_{IN} (l/s)	Total V_{IN} (m^3)	Q_{OUT} (soakage) (l/s)	Effective Continuing Loss (mm/hr)	V_{OUT} (soakage) (m^3)	Net storage (after soakage) (m^3)	V_{OUT} required (m^3)	Q_{OUT} (l/s)
10	0.17	131.00	294.8	176.85	12.68	**4.57**	7.61	169.24	0.00	0.00
15	0.25	106.00	238.5	214.65	12.68	**4.57**	11.42	203.23	0.00	0.00
20	0.33	89.10	200.5	240.57	12.68	**4.57**	15.22	225.35	0.00	0.00
30	0.50	69.10	155.5	279.86	12.68	**4.57**	22.83	257.02	12.73	7.08
45	0.75	53.10	119.5	322.58	12.68	**4.57**	34.25	288.34	44.04	16.32
60	1.00	44.10	99.2	357.21	12.68	**4.57**	45.66	311.55	67.26	18.69
90	1.50	34.20	77.0	415.53	12.68	**4.57**	68.49	347.04	102.75	19.03
120	2.00	28.60	64.4	463.32	12.68	**4.57**	91.33	371.99	127.70	17.74
150	2.50	25.00	56.3	506.25	12.68	**4.57**	114.16	392.09	147.80	16.43
180	3.00	22.50	50.6	546.75	12.68	**4.57**	136.99	409.76	165.47	15.32
240	4.00	19.00	42.8	615.60	12.68	**4.57**	182.65	432.95	188.66	13.10
300	5.00	16.70	37.6	676.35	12.68	**4.57**	228.32	448.03	203.74	11.32
360	6.00	15.00	33.8	729.00	12.68	**4.57**	273.98	455.02	210.73	9.76
480	8.00	12.60	28.4	816.48	12.68	**4.57**	365.30	451.18	206.89	7.18
720	12.00	9.76	22.0	948.67	12.68	**4.57**	547.96	400.72	156.43	3.62
960	16.00	8.02	18.0	1039.39	12.68	**4.57**	730.61	308.78	64.49	1.12
1440	24.00	5.95	13.4	1156.68	12.68	**4.57**	1095.91	60.77	0.00	0.00
2880	48.00	3.35	7.5	1302.48	12.68	**4.57**	2191.83	-889.35	0.00	0.00
4320	72.00	2.35	5.3	1370.52	12.68	**4.57**	3287.74	-1917.22	0.00	0.00

Development Engineering Consultants - Drainage Basin Spreadsheet

Project: Lots 877 and 878 Stakehill Road, Baldivis

Client: Garbin

Location: At-lot detention calculations to establish runoff coefficient

Designer: SRA

Location:	**Stakehill Road, Baldivis**			
Nearest grid cell:	**Latitude**	**32.3125(S)**	**Longitude**	**115.8125(E)**

Data to be input

Rainfall AEP (percentage)	1	ARI	**v** Descriptor **v**
1EY impervious catchment (Ha)	0.025	100	Infrequent
Required storage (1EY - 1hr) (m^3)	3.881		

Catchment details	Paved area	Unpaved area	Total
Lot area (m^2)			**400.00**
Proportion paved	**70%**	**30%**	**100%**
Area paved (Ha)	**0.028**	**0.012**	**0.040**
Runoff coefficient (C_{10})	0.90	0.00	
ARI multiplier	1.00	1.20	
Runoff coefficient (C_y)	0.90	0.00	
Impervious area (Ha)	**0.025**	**0.000**	**0.025**

Effective C

0.63

AEP	ARI	Effective C	Multiplier
63.2	1	0	-
50	1.44	0	-
20	4.48	0	-
10	9.49	0	-
5	20	0	-
2	50	0.05	-
1	100	0.11	-

Volume and dimensions of available storage

Area above ground inundated to 0.03m deep (backyard and front yard) (m^2)	40.00	0.03	1.20
Storage provided manholes/pipe (m^3)	-		
Number of soakwells	2.00		
Diameter of soakwells (m)	1.50		
Depth of each soakwell (m)	1.20		
Storage required soakwells (m^3)	**4.24**		
Storage provided (m^3)	5.44		
Effective Initial Loss (mm)	**13.60**		
Soakage rate ($L/s/m^2$)	0.020	*1.70*	*m/day*

NOTE: All water is retained in soakwells up to and including 5% AEP (1 in 20yr ARI) without surcharge. For greater AEP storms water will surcharge soakwells and soak over an area of 40m^2 to a maximum depth of 30mm within the lot, and then enter the road drainage system.

Volume of storage required is 1m^3 per	**59.42 m^2**	**of paved lot area**
Volume of storage required is 1m^3 per	**73.51 m^2**	**of total lot area**

Development Engineering Consultants - Drainage Basin Spreadsheet

Project: **Lots 877 and 878 Stakehill Road, Baldivis**

Client: **Garbin**

Location: **At-lot detention calculations to establish runoff coefficient**

Designer: **SRA**

Location:	**Stakehill Road, Baldivis**			
Nearest grid cell:	**Latitude**	**32.3125(S)**	**Longitude**	**115.8125(E)**

DEVELOPMENT ENGINEERING CONSULTANTS

T_C (min)	T_C (hr)	I (mm/hr)	Q_{IN} (L/s)	Total V_{IN} (m^3)	Q_{OUT} (soakage) (L/s)	Effective Continuing Loss (mm/hr)	V_{OUT} (soakage) (m^3)	Net storage (after soakage) (m^3)	V_{OUT} required (m^3)	Q_{OUT} (L/s)
10	0.17	131.00	9.2	5.50	1.08	**9.71**	0.65	4.85	0.00	0.00
15	0.25	106.00	7.4	6.68	1.08	**9.71**	0.97	5.71	0.27	0.30
20	0.33	89.10	6.2	7.48	1.08	**9.71**	1.29	6.19	0.75	0.62
30	0.50	69.10	4.8	8.71	1.08	**9.71**	1.94	6.76	1.32	0.74
45	0.75	53.10	3.7	10.04	1.08	**9.71**	2.91	7.12	1.68	0.62
60	1.00	44.10	3.1	11.11	1.08	**9.71**	3.88	7.23	1.79	0.50
90	1.50	34.20	2.4	12.93	1.08	**9.71**	5.83	7.10	1.66	0.31
120	2.00	28.60	2.0	14.41	1.08	**9.71**	7.77	6.64	1.20	0.17
150	2.50	25.00	1.8	15.75	1.08	**9.71**	9.71	6.04	0.60	0.07
180	3.00	22.50	1.6	17.01	1.08	**9.71**	11.65	5.36	0.00	0.00
240	4.00	19.00	1.3	19.15	1.08	**9.71**	15.54	3.61	0.00	0.00
300	5.00	16.70	1.2	21.04	1.08	**9.71**	19.42	1.62	0.00	0.00
360	6.00	15.00	1.1	22.68	1.08	**9.71**	23.31	-0.63	0.00	0.00
480	8.00	12.60	0.9	25.40	1.08	**9.71**	31.08	-5.68	0.00	0.00
720	12.00	9.76	0.7	29.51	1.08	**9.71**	46.62	-17.10	0.00	0.00
960	16.00	8.02	0.6	32.34	1.08	**9.71**	62.16	-29.82	0.00	0.00
1440	24.00	5.95	0.4	35.99	1.08	**9.71**	93.23	-57.25	0.00	0.00
2880	48.00	3.35	0.2	40.52	1.08	**9.71**	186.47	-145.95	0.00	0.00
4320	72.00	2.35	0.2	42.64	1.08	**9.71**	279.70	-237.07	0.00	0.00

APPENDIX D – GROUNDWATER INFORMATION

- Summary Monitoring Bore Data from lots 877 & 878
- DWER Groundwater levels for Bore Sites 61410049 & 61410060
- Summary of Peak GWLs 1997-2016 for Bore Sites 61410049 & 61410060
- Irrigation Water Analysis Report - Nov 2012
- GW License over lots 877 & 878 - Oct 2007 to Oct 2019

Bore Details

Bore#	PCG 94 - East	PCG 94 - North	MGA 50 - East	MGA 50 - North	RL of Top of casing	GL (m) base of casing	Height (m) of cap above GL
MB01	48253.39	214973.44	386953.30	6415769.03	10.12	9.45	0.67
MB02	48258.56	214556.69	386963.07	6415352.47	18.70	18.03	0.67
MB03	47752.61	214158.97	386461.67	6414949.27	5.78	5.18	0.60
MB04	47743.83	214595.93	386448.07	6415386.01	6.87	6.09	0.78
MB05	47748.27	214875.85	386449.41	6415665.89	6.28	5.69	0.59

9.00 **SUMMARY OF RESULTS**

	Groundwater Levels	Date of Max. >	27-Sep-18	Date of Max. >	27-Sep-18	Date of Max. >	27-Sep-18	Date of Max. >	27-Sep-18	Date of Max. >	27-Sep-18	
		Max. value >	2.21	Max. value >	2.18	Max. value >	2.23	Max. value >	2.19	Max. value >	2.20	
	Bore No. >>>	**MB01**		**MB02**		**MB03**		**MB04**		**MB05**		
	v Date of Reading v	Depth to GWL from Top of casing	RL GWL (m)	Depth to GWL from Top of casing	RL GWL (m)	Depth to GWL from Top of casing	RL GWL (m)	Depth to GWL from Top of casing	RL GWL (m)	Depth to GWL from Top of casing	RL GWL (m)	
1	29-Jun-17	8.891	1.23	17.595	1.11	4.611	1.17	5.726	1.14	5.145	1.14	
2	30-Aug-17	8.275	1.85	16.871	1.83	3.908	1.87	5.035	1.84	4.426	1.85	
3	03-Oct-17	8.203	1.92	16.821	1.88	3.835	1.95	4.967	1.90	4.384	1.90	< 2017 Max.
4	03-Nov-17	8.267	1.85	16.879	1.82	3.897	1.88	5.029	1.84	4.437	1.84	
5	05-Dec-17	8.426	1.69	17.043	1.66	4.066	1.71	5.185	1.69	4.608	1.67	
6	08-Mar-18	8.759	1.36	17.364	1.34	4.39	1.39	5.505	1.37	4.916	1.36	
7	20-Jun-18	8.644	1.48	17.263	1.44	4.273	1.51	5.407	1.46	4.807	1.47	
8	27-Aug-18	7.995	2.13	16.613	2.09	3.631	2.15	4.752	2.12	4.163	2.12	
9	27-Sep-18	7.915	2.21	16.522	2.18	3.547	2.23	4.677	2.19	4.081	2.20	< 2018 Max.
10	25-Oct-18	7.931	2.19	16.541	2.16	3.568	2.21	4.693	2.18	4.105	2.18	
11	23-Nov-18	8.06	2.06	16.673	2.03	3.699	2.08	4.816	2.05	4.245	2.04	

Government of Western Australia
Department of Water

Site Details Report

Date: 23/08/2017

Site reference (AWRC): 61410049 - LAKE THOMSON - T430 (O) **WIN Site ID: 3011**

Alternative Site References

Numbering System	Reference Code	Context Name	Name
AWRC	61410049	LAKE THOMSON	T430 (O)
GW	PEE0917101B	LAKE THOMSON	T430 (O)
MWB	T430 (OBS)	LAKE THOMSON	T430 (O)
WRC1	T430(O)	LAKE THOMSON	T430 (O)
AQWAB	2033-2-SW-0057	LAKE THOMSON	LAKE THOMPSON 430A

General Details *(Site reference: 61410049 WIN Site ID: 3011)*

Site Type	Ground	**Sub Type**	Bore or Well	**Site Geofeature**	Ground
Northing	6416782.8	**Easting**	385717.37	**Zone**	50
Latitude	-32.380100830	**Longitude**	115.785088520	**Spheroid**	GDA94
Thou250 Map Index	SI5002	**Assessment Method**	GPS	**Geographic Precision(+/- m)**	+/-1m
Local Govt Authority	CITY OF ROCKINGHAM	**Locality**	BALDIVIS	**DOW Region**	Kwinana-Peel
Catchment	_Coastal	**Estuary**		**BOM Rainfall District**	Central Coast
Groundwater Area	Stakehill	**Groundwater Subarea**	Churcher East	**Groundwater Province**	Perth
Surface Water Area	Cockburn/Kwinana Coastal	**Surface Water SubArea**	Cockburn/Kwinana Coastal	**GgStn Catchment Area(km2)**	N/A
Site Purpose	Observation; Groundwater Assessment Network; Monitoring				
Site Comment	Geophysical log supplied. Samples stored. Mwb lab anal. No 81782/77 evap: 1340; cond: 1560; ph: 7.2. Pumping bore td 23.17m with 219mm erw tube-gravel stabilised casing. Steel screen 15m to 20m. Pumped 24 hours at 30987 gph. Swl obs bore 0.07m at start of test and at end of test 0.15m swl. Pumping bore at start of test no record; at end of test 2.55m. Tds 1250 mg/L evap after 3000 gph for 1/4 hr. Swl originally 4.91m. Ahd and sle water levels converted to swl and datums adjusted - completed - 10/01/2005 - BLF23/11/2004; a sampling pump stuck down the bore; dipping or depth tagging should be done very carefully if at all. It will be fine for the normal water level readings.				

Fixed Infrastructure Status *(Site reference: 61410049 WIN Site ID: 3011)*

Start Date	End Date	Status	Comments
11/07/1975		Operational	Groundwater infrequently read, level only. Observation 99.

Stakeholders *(Site reference: 61410049, WIN Site ID 3011)*

Start Date	End Date	Role	Stakeholder
11/07/1975		Establishing authority	Water Authority Metro Operations
11/07/1975		Operating authority	Water and Rivers Commission
11/07/1975	31/01/2008	Owning authority	Water and Rivers Commission
01/02/2008		Owning authority	Department of Water

Depth Reference Points *(Site reference: 61410049 WIN Site ID: 3011)*

Measurement Point	Elevation (m as per Datum Plane)	Measurement Method	Date	Comments
Top of casing	~ 7.18 (mAHD)	Surveyed	11/07/1975 (Unknown)	Growls microfiche
(none)	~ 0 (mNA)	(none)	11/07/1975 (Unknown)	Depth reference point added to cater for historical samples with depth reference point of ()
Top of casing	~ 100 (mSLE)	(none)	11/07/1975 (Unknown)	
Top of cement/concrete block or pad	6.96 (mAHD)	Surveyed	24/06/2015 (Known day)	Surveyed 24/03/2016. Measurement method Spirit Levelled.
Ground level	6.95 (mAHD)	Surveyed	24/06/2015 (Known day)	Surveyed 24/03/2016. Measurement method Spirit Levelled
Top of casing	7.17 (mAHD)	Surveyed	08/1981 (Known month)	New rl; g/w monitoring sheets
Top of casing	100 (mSLE)	(none)	18/08/1981 (Unknown)	Added to datum pair
Ground level	6.76 (mAHD)	(none)	30/06/1975 (Unknown)	Growls microfiche
Measurement Point	7.528 (mAHD)	Surveyed	05/08/2016 (Known day)	Surveyed 24//03/2016; MP refers to TOC (Top of Headworks).
Top of protective headworks	7.528 (mAHD)	Surveyed	24/06/2015 (Known day)	Top of Outer Casing - Lid Open. Surveyed 24/03/2016. Measurement method Spirit Levelled.
Top of inner casing	7.394 (mAHD)	Surveyed	24/06/2015 (Known day)	Originally recorded as Top of Casing. Surveyed 24/03/2016. Measurement method Spirit Levelled.
Top of casing	7.528 (mAHD)	Surveyed	24/06/2015 (Known day)	Originally recorded as Top of Headworks - lid open. Surveyed 24/03/2016. Measurement method Spirit Levelled.

Site Details Report

Date: 23/08/2017

Construction (*Site reference: 61410049 WIN Site ID: 3011)*

Events

Completed Date	1975 (Known year)	**Pump Test Occured**		**Pumping Details**	
Driller	Coffey Drilling Co			**Total Drilled Depth (m)**	37.000
Depth Reference Point	Ground level			**Drill Method**	Cable tool
Construction Method					
Developed By					
Drill Comments					

Elements

From (m)	To (m)	Element	Material	Grain Size	Fill Vol	Min Dia. (mm)	Max Dia. (mm)	Aperture (mm)	Thickness (mm)	Comments
		Unknown	Unknown							76mm PVC. Slotted gravel packed

Aquifers (*Site reference: 61410049 WIN Site ID: 3011)*

Aquifer Name	Type	Comments
Perth-Superficial Swan	Screened DWAID Aquifer	

Log Event - Lithology *(Site reference: 61410049 WIN Site ID: 3011)*

Logged By	Authority Not Known	**Log Date**	1975 (Known year)	**Reference Point**	Ground level
Interpreted By	Non geologist - Unknown Org Type				
Comments					

From (m)	To (m)	Lithological Description
0.000	0.500	Yellow brown sand between hard limestone pinnacles.
0.500	2.500	Calcarenite, light red brown, v/hard, approx equal proportions of fine med indeterminate light grey and yellow brown calcareous grains and coarse v/coarse rounded limonite stained quartz grains in an opaque white lime silt matrix.
2.500	10.500	Limestone, fawn becoming lighter towards base sandy, lightly cemented with some hard layers; fine-med mod-well sorted rounded light grey calcareous grains in white opaque calcareous matrix, frequent unstained and limonite stained quartz grains and rare well rounded v/coarse quartz grains.
10.500	19.000	Calcarenite, fawn lightly cemented to well cemented with some v/hard layers and possible small solution opens v/variable, composed of fine med rounded indeterminate yellow brown and white calcareous grains and coarse-v/coarse rounded to well rounded often limonite stained quartz grains all in a white or buff opaque calcareous matrix; v/rare shell frags and frags of echinoid spines.
19.000	20.000	Sand, fawn; calcareous, v/coarse tending to fine gravel mod sorted, quartz rounded to well rounded often with limonite staining; thin hard layers of calcarenite and fine grained pure limestone. Unconformity.
20.000	26.500	Sand; light green yellow becoming yellower towards base clayey/med v/coarse poor mod sorted quartz ang to sub ang; scattered well rounded v/coarse grains at 26-28m rare dark brown grains of uncertain nature, rare dark brown rounded hard ferruginous pebbles one with glauconite at 26-28m rare green stained grains and frequent limonite stained quartz grains.
26.500	37.000	Sand; yellow brown clayey 15% med coarse mod sorted quartz and to sub ang with dark yellow brown limonitic staining.

Log Event - Summary *(Site reference: 61410049 WIN Site: 3011)*

Logged By	Authority Not Known	**Log Date**	1975 (Known year)	**Reference Point**	Ground level
Interpreted By	Non geologist - Unknown Org Type	**Interpreted Date**	03/01/1997 (Known day)		
Comments					

From (m)	To (m)	Stratigraphy	Lithology1	Lithology2	Lithology3
0.000	20.000	Tamala Limestone	calcarenite	limestone	sand
20.000	37.000	Rockingham Sand	sand		

Advanced Data Summary (*Site reference: 61410049 WIN Site ID: 3011)*

Readings by Project

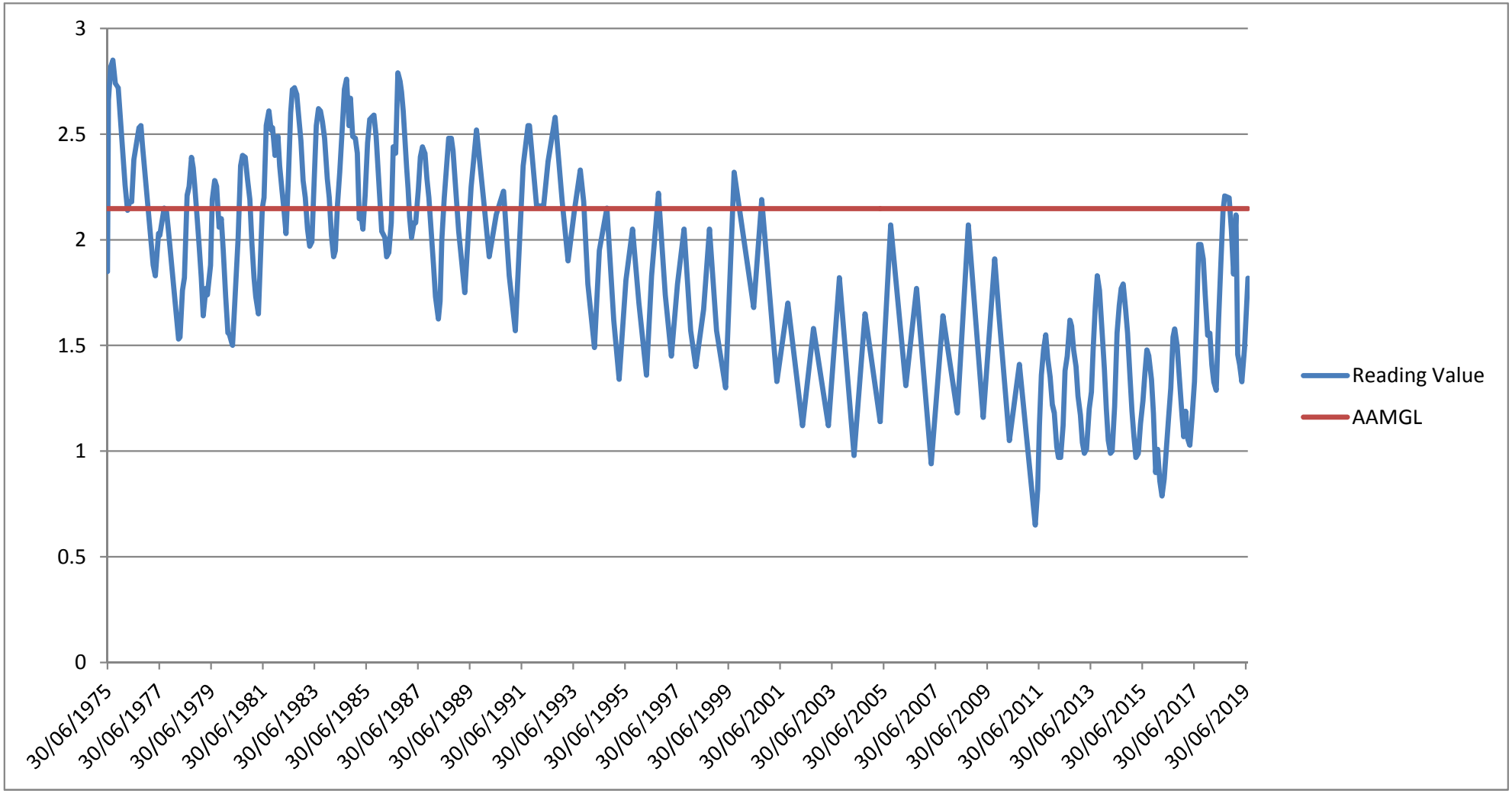
Default Site Reference	Project Code	Project Name	First Measurement	Last Measurement	No of Measurements
61410049	KP-G-GMKP	Groundwater Monitoring - Kwinana Peel Region	29/09/2010	2/06/2017	98
61410049	KP-G-SERPENTINE	Groundwater Resource Review - Serpentine	9/12/2009	9/12/2009	8
61410049	KP-R-DW3	Murray GW bores (Formerly KP-G-DW3)	15/06/2011	10/06/2013	50
61410049	SG-G-GMSG	Groundwater Monitoring Swan Goldfields Region	22/08/2001	12/05/2010	40
61410049	WA-G-<1996AQWADATA	Pre 1996 AQWABase Data Capture	30/06/1975	30/06/1975	2
61410049	WA-G-NONPOINT	South Perth Basin Non-Point Source Baseline Survey	24/11/1993	24/11/1993	23
61410049	WA-S-SWRISHIST	Historical Data from the SWRIS Database	11/07/1975	16/05/2001	447

Readings by Data Category

Default Site Reference	Data Category	First Measurement	Last Measurement	No of Measurements
61410049	Water levels - discrete	30/06/1975	2/06/2017	574
61410049	Water quality indicators - discrete	11/07/1975	19/01/2010	94

Readings By Variable Type

Default Site Reference	Variable Type	First Measurement	Last Measurement	No of Measurements
61410049	Inorganic metals	17/09/1975	12/11/1986	3
61410049	Inorganic non-metals	11/07/1975	24/11/1993	27
61410049	Nutrients	12/11/1986	24/11/1993	10
61410049	Physical	11/07/1975	19/01/2010	54
61410049	Water Level (discrete)	30/06/1975	2/06/2017	574


3
2.5
2
1.5
1
0.5
0
30/06/1975
30/06/1977
30/06/1979
30/06/1981
30/06/1983
30/06/1985
30/06/1987
30/06/1989
30/06/1991
30/06/1993
30/06/1995
30/06/1997
30/06/1999
30/06/2001
30/06/2003
30/06/2005
30/06/2007
30/06/2009
30/06/2011
30/06/2013
30/06/2015
30/06/2017
30/06/2019
Reading Value
AAMGL

Site Details Report

Date: 23/08/2017

Site reference (AWRC): 61410060 - LAKE THOMSON - T490 **WIN Site ID: 3022**

Alternative Site References

Numbering System	Reference Code	Context Name	Name
AWRC	61410060	LAKE THOMSON	T490
GW	PEE1014101B	LAKE THOMSON	T490
MWB	T490 (OBS)	LAKE THOMSON	T490
WRC1	T490	LAKE THOMSON	T490
AQWAB	2033-2-SW-0054	LAKE THOMSON	LAKE THOMPSON 490 A

General Details *(Site reference: 61410060 WIN Site ID: 3022)*

Site Type	Ground	**Sub Type**	Bore or Well	**Site Geofeature**	Ground
Northing	6413902.45	**Easting**	387295.03	**Zone**	50
Latitude	-32.406239980	**Longitude**	115.801513950	**Spheroid**	GDA94
Thou250 Map Index	SI5002	**Assessment Method**	GPS	**Geographic Precision(+/- m)**	+/-1m
Local Govt Authority	CITY OF ROCKINGHAM	**Locality**	KARNUP	**DOW Region**	Kwinana-Peel
Catchment	Peel Estuary_Serpentine River	**Estuary**		**BOM Rainfall District**	Central Coast
Groundwater Area	Stakehill	**Groundwater Subarea**	Churcher East	**Groundwater Province**	Perth
Surface Water Area	Serpentine River Catchment	**Surface Water SubArea**	Lower Serpentine	**GgStn Catchment Area(km2)**	N/A
Site Purpose	Observation; Monitoring; Groundwater Assessment Network				
Site Comment	Geophysical log supplied. Palaeontological report written. Bailed sample 780 mg/L evap. Ahd and sle water levels converted to swl and datums adjusted - completed - 10/01/2005 - BLF				

Fixed Infrastructure Status *(Site reference: 61410060 WIN Site ID: 3022)*

Start Date	End Date	Status	Comments
10/06/1975		Operational	Groundwater infrequently read, level only. Observation 97.

Stakeholders *(Site reference: 61410060, WIN Site ID 3022)*

Start Date	End Date	Role	Stakeholder
10/06/1975		Establishing authority	Water Authority Metro Operations
10/06/1975		Operating authority	Water and Rivers Commission
10/06/1975	31/01/2008	Owning authority	Water and Rivers Commission
01/02/2008		Owning authority	Department of Water

Depth Reference Points *(Site reference: 61410060 WIN Site ID: 3022)*

Measurement Point	Elevation (m as per Datum Plane)	Measurement Method	Date	Comments
Top of casing	~ 15.612 (mAHD)	Surveyed	10/06/1975 (Unknown)	
Top of casing	~ 100 (mSLE)	(none)	10/06/1975 (Unknown)	
(none)	~ 0 (mNA)	(none)	10/06/1975 (Unknown)	Depth reference point added to cater for historical samples with depth reference point of ()
Top of cement/concrete block or pad	15.46 (mAHD)	Surveyed	01/07/2015 (Known day)	Surveyed 23/03/2016. Measurement method Spirit Levelled.
Ground level	15.43 (mAHD)	Surveyed	01/07/2015 (Known day)	Surveyed 23/03/2016. Measurement method Spirit Levelled
Ground level	~ 15.292 (mAHD)	Surveyed	10/06/1975 (Unknown)	
Measurement Point	16.044 (mAHD)	Surveyed	05/08/2016 (Known day)	Surveyed 06//04/2016; MP refers to TOC (Top of Headworks).
Top of protective headworks	16.044 (mAHD)	Surveyed	01/07/2015 (Known day)	Top of Outer Casing - Lid Open. Surveyed 23/03/2016. Measurement method Spirit Levelled.
Top of inner casing	15.905 (mAHD)	Surveyed	01/07/2015 (Known day)	Originally recorded as Top of Casing. Surveyed 23/03/2016. Measurement method Spirit Levelled.
Top of casing	16.044 (mAHD)	Surveyed	01/07/2015 (Known day)	Originally recorded as Top of Headworks - Lid Open. Surveyed 23/03/2016. Measurement method Spirit Levelled.

Construction (*Site reference: 61410060 WIN Site ID: 3022)*

Events

Completed Date	1975 (Known year)	**Pump Test Occured**		**Pumping Details**	
Driller	Galbraith Drilling Co			**Total Drilled Depth (m)**	80.000
Depth Reference Point	Ground level			**Drill Method**	(none)
Construction Method					
Developed By					
Drill Comments	Information imported from gramps.				

Elements

From (m)	To (m)	Element	Material	Grain Size	Fill Vol	Min Dia. (mm)	Max Dia. (mm)	Aperture (mm)	Thickness (mm)	Comments
		Unknown	Unknown							76mm PVC. Slotted gravel packed.
18.000	74.000	Inlet - Screen	Unknown			85.000				

Aquifers (*Site reference: 61410060 WIN Site ID: 3022)*

Aquifer Name	Type	Comments
Perth-Superficial Swan	Screened DWAID Aquifer	

Log Event - Lithology *(Site reference: 61410060 WIN Site ID: 3022)*

Logged By	Authority Not Known	**Log Date**	1975 (Known year)	**Reference Point**	Ground level
Interpreted By	Non geologist - Unknown Org Type				
Comments					

From (m)	To (m)	Lithological Description
0.000	4.500	Sand: orange yellow v/fine coarse, poor to mod sorted qtz sub ang to well rounded, limonitic staining.
4.500	10.000	Sand: light yellow, fine med mod sorted, qtz, limonitic staining.
10.000	14.000	Sand: light yellow, coarse, qtz sub ang to rounded limonitic stained; common heavy mineral grains.
14.000	17.500	Sand: yellow, qtz limonitic stained, common heavy mineral grains.
17.500	21.000	Sand: light yellow, qtz sub ang to well rounded limonite; heavy mineral grains.
21.000	26.000	Sand: dark yellow brown, lighter at base slightly clayey qtz with limonite staining, rare heavy minerals.
26.000	27.500	Calcarenite: fawn, v/coarse qtz grains and fine indeterminate calcareous grains in cemented calcilutite matrix, cemented limestone layers.
27.500	28.000	Sand: light yellow, qtz most grains limonitic staining rare heavy mineral grains. Unconformity.
28.000	35.000	Sand: light yellow at top, yellow brown at base qtz frequently with yellow or yellow brown staining.
35.000	45.000	Sand: brown to dark brown, slightly clayey; qtz; contains frags oxidised pyrite concretions at 38-40m.
45.000	47.500	Sand: yellow brown, slightly clayey, qtz sub ang to rounded.
47.500	50.000	Sand as 35-45m.
50.000	55.500	Sand yellow brown, slightly clayey, qtz sub ang to rounded.
55.500	58.000	Sand: light yellow brown, qtz most grains limonite stained.
58.000	60.000	Sand: yellow brown, faintly clayey, qtz most grains with limonitic staining.
60.000	73.000	Sand: light yellow brown, qtz all grains with light yellow limonitic staining; very rare heavy mineral grains and rare frags of oxidized pyrite.
73.000	80.000	Sand: light grey slightly silty, qtz about 10% of grains with limonitic staining; rare frags of coalified wood thin layers of pyrite cemented sand, rare heavy mineral grains, rare mica. Log condensed.

Site Details Report

Date: *23/08/2017*

Log Event - Summary *(Site reference: 61410060 WIN Site: 3022)*

Logged By	Authority Not Known	**Log Date**	1975 (Known year)	**Reference Point**	Ground level
Interpreted By	Non geologist - Unknown Org Type	**Interpreted Date**	03/01/1997 (Known day)		
Comments					

From (m)	To (m)	Stratigraphy	Lithology1	Lithology2	Lithology3
0.000	28.000	Tamala Limestone	sand	calcarenite	
28.000	80.000	Rockingham Sand	sand		

Advanced Data Summary (*Site reference: 61410060 WIN Site ID: 3022)*

Readings by Project

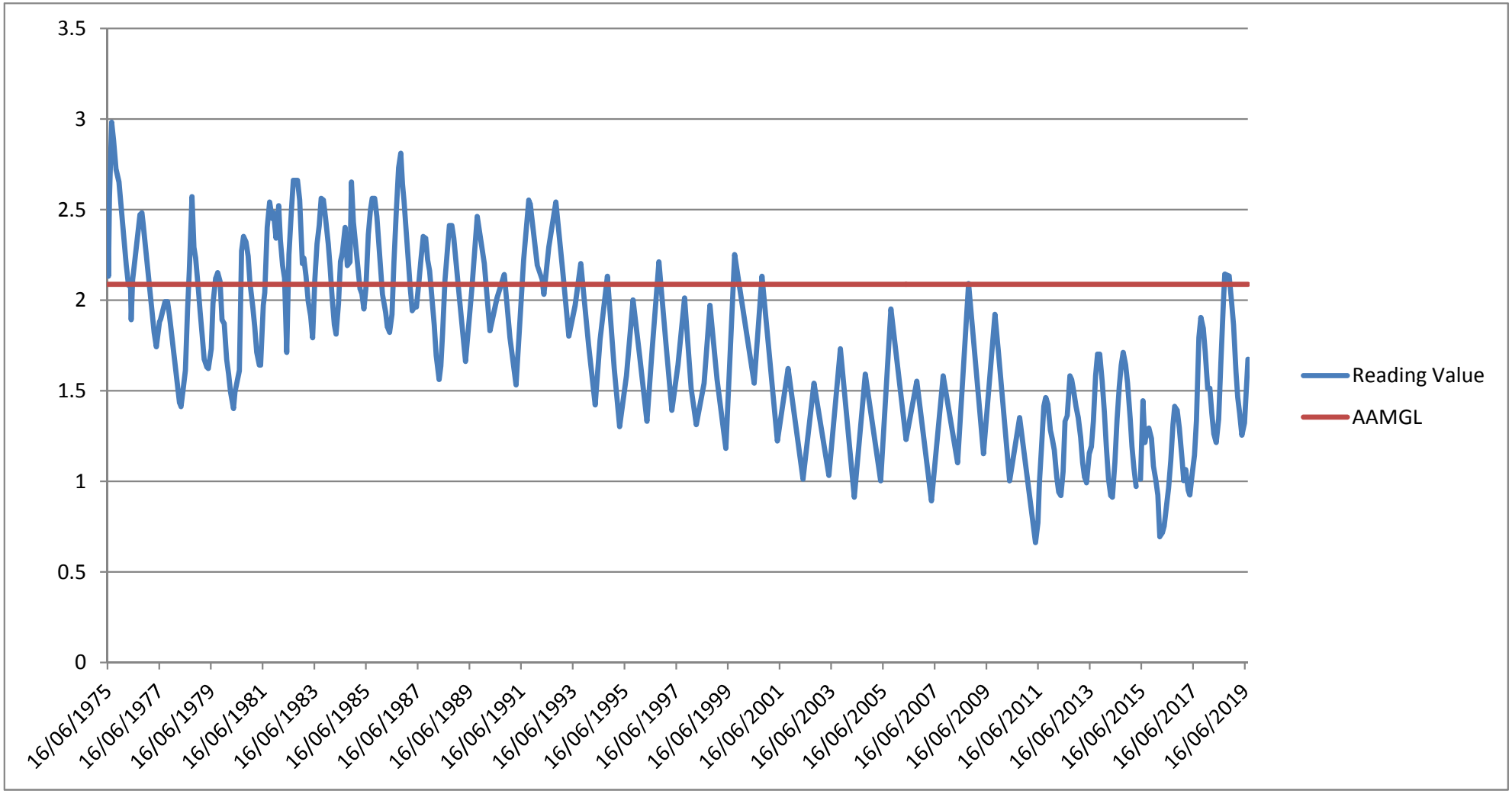
Default Site Reference	Project Code	Project Name	First Measurement	Last Measurement	No of Measurements
61410060	KP-G-GMKP	Groundwater Monitoring - Kwinana Peel Region	29/09/2010	2/06/2017	98
61410060	KP-G-SERPENTINE	Groundwater Resource Review - Serpentine	8/12/2009	8/12/2009	8
61410060	KP-R-DW3	Murray GW bores (Formerly KP-G-DW3)	15/06/2011	10/06/2013	50
61410060	SG-G-GMSG	Groundwater Monitoring Swan Goldfields Region	22/08/2001	12/05/2010	39
61410060	WA-G-<1996AQWADATA	Pre 1996 AQWABase Data Capture	30/06/1975	30/06/1975	2
61410060	WA-S-SWRISHIST	Historical Data from the SWRIS Database	10/06/1975	16/05/2001	484

Readings by Data Category

Default Site Reference	Data Category	First Measurement	Last Measurement	No of Measurements
61410060	Water levels - discrete	16/06/1975	2/06/2017	568
61410060	Water quality indicators - discrete	10/06/1975	19/01/2010	113

Readings By Variable Type

Default Site Reference	Variable Type	First Measurement	Last Measurement	No of Measurements
61410060	(none)	17/05/1976	17/05/1976	1
61410060	Inorganic metals	17/05/1976	28/04/1987	8
61410060	Inorganic non-metals	10/06/1975	28/04/1987	38
61410060	Nutrients	16/08/1978	28/04/1987	6
61410060	Physical	10/06/1975	19/01/2010	60
61410060	Water Level (discrete)	16/06/1975	2/06/2017	568


3.5
3
2.5
2
1.5
1
0.5
0
16/06/1975
16/06/1977
16/06/1979
16/06/1981
16/06/1983
16/06/1985
16/06/1987
16/06/1989
16/06/1991
16/06/1993
16/06/1995
16/06/1997
16/06/1999
16/06/2001
16/06/2003
16/06/2005
16/06/2007
16/06/2009
16/06/2011
16/06/2013
16/06/2015
16/06/2017
16/06/2019
Reading Value
AAMGL

Peak GWL - past 20 years - DWER WIN sites 3011 & 3022
Assume GWL for site is ~0.1m higher than Ave. of 3011 & 3022

	Year	3011	< DWER site >	3022	
1	1997	2.05		2.01	
2	1998	2.05		1.97	
3	1999	2.32	2.39	2.25	
4	2000	2.19	**2.26**	2.13	**< 95% of results at or below this figure (for past 20 years)**
5	2001	1.7		1.62	
6	2002	1.58		1.54	
7	2003	1.82		1.73	
8	2004	1.65		1.59	
9	2005	2.07		1.95	
10	2006	1.77		1.55	
11	2007	1.64		1.58	
12	2008	2.07	2.18	2.09	
13	2009	1.91	**2.02**	1.92	**< 90% of results at or below this figure (for past 10 years)**
14	2010	1.41		1.35	
15	2011	1.55		1.46	
16	2012	1.62		1.58	
17	2013	1.83		1.70	
18	2014	1.79		1.71	
19	2015	1.48		1.44	
20	2016	1.58		1.41	
21	2017	1.98		1.90	
22	2018	2.21		2.14	
23	2019	2.12		1.86	
		2.32	**2.39**	**2.25**	**< Max Values**

File No: SN10782

Water and Rivers Commission
Government of Western Australia

Instrument No. GWL63216(3)

LICENCE TO TAKE WATER

Granted by the Commission under section 5C of the Rights in Water and Irrigation Act 1914

Licensee(s)	Garbin, Josko Garbin, Ivan Garbin, Jerina		
Description of Water Resource	Rockingham Perth - Superficial	**Annual Water Entitlement**	540000 kL
Location of Water Source	Lot 877 On Plan 202761 - Volume/Folio 1293/787 - Lot 877 Stakehill Rd Karnup Lot 878 On Plan 202761 - Volume/Folio 1293/786 - Lot 878 Stakehill Rd Karnup		

Authorised Activities	**Taking of water for**	**Location of Activity**
	Irrigation of up to 25 ha of vegetables	Lot 878 On Plan 202761 - Volume/Folio 1293/786 - Lot 878 Stakehill Rd Karnup
	Irrigation of up to 11 ha of vegetables	Lot 877 On Plan 202761 - Volume/Folio 1293/787 - Lot 877 Stakehill Rd Karnup

Duration of Licence	From 9 October 2007 to 9 October 2017

This Licence is subject to the following terms, conditions and restrictions:

1 That the licensee shall record the volume of groundwater drawn monthly and forward the information to the Water and Rivers Commission by 30th June each year.

2 That should the licensee's draw adversely affect the aquifer or other users in the area, the Water and Rivers Commission may reduce the amount that may be drawn.

3 Approval by the Water and Rivers Commission is to be obtained prior to the construction of additional and replacement wells and the modification or refurbishment of existing wells.

4 That the licensee's draw from the approved groundwater source shall not exceed 540,000 kilolitres per annum.

5 The licensee shall install and maintain a cumulative water meter of a type authorised under the Rights in Water and Irrigation (Approved Meters) Order 2003 and the meter must be installed in accordance with the meter manufacturer's specifications.

6 The annual water year for water taken under this licence is defined as 1 July to 30 June.

7 The water year is defined as a specified 12 month period for the purposes of groundwater management planning, annual water accounting and annual reporting.

End of terms, conditions and restrictions

This Licence is granted subject to the Rights in Water and Irrigation Regulations 2000

AQUASURE

IRRIGATION WATER ANALYSIS REPORT

AGVITA ANALYTICAL

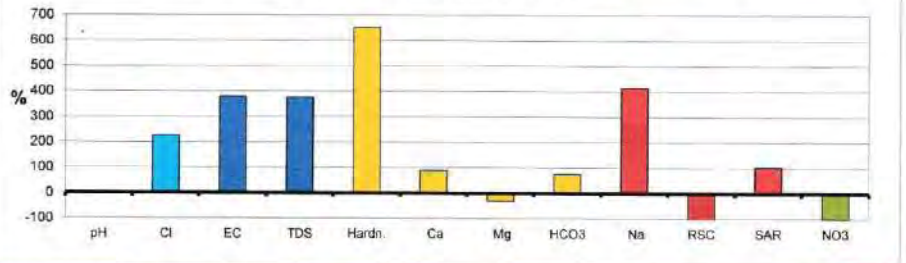
ABN 58 129 916 310
PO Box 188
Devonport, TAS, 7310
Ph: 03 6420 9600
Fax: 03 6427 0230
mailto:info@agvita.com.au

Client Name:	ACE OHLSSON P/L
Grower Name:	GARBIN
Sample ID:	DAM
Consultant:	TALLY MATTHEWS
Report date:	21/11/2012
Order Number:	

Water Quality:	YOUR RESULT	Optimal level	Unit	STATUS
Acidity or Alkalinity pH	7.7	6 - 7.4	N/A	
Electrical Conductivity - EC	3.12	0.65	dS/m	
Sodium Absorption Ratio - SAR	6.1	3	meq/L	
Chloride - Cl	652	200	ppm	
Hardness -calcite	751.8	100	ppm	
Carbonate - CO3	0.00	0.5	meq/L	
	1.5	30	ppm	
Bicarbonate - HCO3	3.50	2	meq/L	
	280.8	140	ppm	
Total Dissolved Salts - TDS	1997.00	420	ppm	
Residual Sodium Carbonate - RSC	-11.53	1.25	meq/L	
Cations:	**YOUR RESULT**	**Recommended upper limit**	**Unit**	**STATUS**
Sodium - Na	381.2	74	ppm	
	16.58	3.20	meq/L	
Calcium - Ca	188	100	ppm	
	9.38	5.00	meq/L	
Magnesium - Mg	68.6	100	ppm	
	5.64	8.30	meq/L	
Potassium - K	34.8	15	ppm	
	0.89	0.38	meq/L	
Other nutrients:	**YOUR RESULT**	**Recommended upper limit**	**Unit**	**STATUS**
Phosphorus - P	0	0.2	ppm	
Nitrate - NO3	0	40	ppm	
Zinc - Zn	0.02	2.0	ppm	
Boron - B	0.18	0.2	ppm	
Sulphur - S	114.77	25	ppm	
Copper - Cu	0	0.2	ppm	
Iron - Fe	0.95	1.0	ppm	
Manganese - Mn	0.06	0.2	ppm	
Molybdenum - Mo	0.005	0.02	ppm	
Total Dissolved Ions - TDI	1723	420	ppm	

Your water quality result as percent (%) of the recommended concentration limit

negative % values = % below limit, positive % values = % above limit



Analysis by AgVita Analytical

The information within this report should be used as part of a crop-monitoring program and under consideration of particular production conditions. Desirable levels are derived from ongoing research carried out by AgVita Analytical Pty. Ltd. The interpretation of analytical results presumes specific sampling, sample handling, extraction and analytical procedures. Results may be incompatible with interpretation dates developed via different procedures. AgVita Analytical Pty. Ltd and its employees or agents will not be liable for any loss or damage arising from application or interpretation of the data supplied. Please seek guidance on local interpretations and recommendations from your agronomist.

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Licence Details	
Instrument Number	83216
Type	Groundwater Licence
Applicants	Garbin, Ivan, Garbin, Josko, Garbin, Jerina
Issue Date	09/10/2007
Expiry Date	09/10/2017
Area	Stakehill
Sub Area	Churcher East
Resource	GWR - Stakehill, Churcher East, Perth - Superficial Swan and Rockingham Sand
Current Water Year	10/09/2014 - 09/09/2015
Abstraction Volume Entitlement	540 000 kilolitres
Total Usage	0 kilolitres

Page 3 of 4

Property: Lot 877 on Plan 202761, Volume 1293, Folio 786 877 Stakehill Rd, Karnup, 6176



Legal Access
This section is empty.

Page 4 of 4

Property: 878, STAKEHILL RD, KARNUP



Legal Access
This section is empty.

Water Usages

Category and Type	Properties	Estimated Irrigated Area	Estimated Annual Quantity
Agriculture > Vegetables > Vegetables	878, STAKEHILL RD, KARNUP	25 hectares	375 000 kilolitres
Agriculture > Vegetables > Vegetables	Lot 877 on Plan 202761, Volume 1293, Folio 786 877 Stakehill Rd, Karnup, 6176	11 hectares	165 000 kilolitres

Total Estimated Irrigated Area	Total Estimated Annual Quantity
36 hectares	540 000 kilolitres

Note: The estimated values may change based on the assessment.

Supporting Documents
There are no supporting documents for this application.

Page 1 of 4

Government of Western Australia
Department of Water

Renewal 016176

Application Information	
Reference Number	016176
Date Received	15/09/2017

Applicant Details	
First Name	Josko
Last Name	Garbin
Phone	0895241405
Mobile	0407999830
Email	joskogarbin@hotmail.com
Address	199 Stakehill Rd Karnup WA 6176 Australia
Postal Address	199 Stakehill Rd Karnup WA 6176 Australia

Note
Please note that if any of the details have changed an amendment to an in-force licence will need to be submitted to the Department of Water.

DEVELOPMENT
ENGINEERING
CONSULTANTS

APPENDIX E – DEC SERVICING REPORT

Refer to copy provided in Lots 877 & 878 Stakehill Road Structure Plan Report

Appendix 4

Local Water Management Strategy

J. GARBIN
C/- TERRANOVIS PTY LTD

PROPOSED RESIDENTIAL DEVELOPMENT
LOTS 877 & 878 STAKEHILL ROAD - KARNUP

LOCAL WATER MANAGEMENT STRATEGY

AUGUST 2024

DEVELOPMENT
ENGINEERING
CONSULTANTS

Revision History:

Revision	Description	Checked	Approved	Date
0	Original Issue	RDG		21st December 2017
1	Revised to suit new proposed layout	DMN	SRA	12th August 2019
2	Revised to Suit new Layout Plans	DMN	SRA	9th March 2020
3	Updated to Suit New Plan and To Include Shallow Water Table Modelling	SRA	SRA	8th September 2020
4	Base Plans Updated to Suit new Base Plans and Design earthworks Added	SRA	SRA	26th February 2021
5	Plans Updated to Suit New base Plan and Document Updated to reflect Comments from DLPH in May 2024	SRA	SRA	6th August 2024

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APPENDIX A – Site Details & Structure Plans
Development Concept Plan
L01 Locality Plan
L02 Aerial Photo with Superimposed Development Layout
City of Rockingham TPS No.2 Map sheet 18 - October 2016
APPENDIX B – Drainage Catchment Plans and Calculations
L03 Pre-development catchment plan
L04 Post-development catchment plan with indicative basin locations
L05 North Catchment Basin Details
L06 South Catchment Basin Details
APPENDIX C – Drainage Catchment Plans and Calculations
PC Sump Outputs – 63.2%, 20%, 10% & 1% AEP Storm Events
PC Sump Inputs – At Lot calculations to establish Initial and Continuing Loss
APPENDIX D – Groundwater Information
Summary Monitoring Bore Data from lots 877 & 878 (Jun-Dec 2017)
DWER Groundwater levels for Bore Sites 61410049 & 61410060
Summary of Peak GWLs 1997-2016 for Bore Sites 61410049 & 61410060
Irrigation Water Analysis Report - Nov 2012
GW License over lots 877 & 878 - Oct 2020 to Oct 2030

DEVELOPMENT ENGINEERING CONSULTANTS

Lots 877 & 878 Stakehill Road, Karnup - Local Water Management Strategy

LWMS Report Checklist (As based on the Appendix 2 Local Water Management Strategy checklist – DoW Dec 2008 Interim guide[8])

Applicant:	**TERRANOVIS Pty. Ltd.**	Locality:	**Karnup**	Version & Date:	**Rev 5** – 7-Aug -2024
Prepared by:	**Development Engineering Consultants - Robert Graieg**			Email:	rgraieg@deveng.biz
Address:	**Suite 3 / 123A Colin Street WEST PERTH WA 6005**			Phone:	**(08) 9481 1900**

No.	Item Description:	Status	Notes / Comments:
	Executive Summary	✓	Description of proposed water management objectives and how the objectives will be met.
1.0	**Introduction**		
1.1	Total water-cycle management – principles and objectives	✓	
1.2	Planning Background	✓	Site location, details of documents that strategy is supporting.
1.3	Previous studies	✓	Include references to key state &/or local policies, guidelines, strategies and relevance etc.
2.0	**Proposed Development**		
2.1	Structure Plan, Zoning and Land Use	✓	Key elements of LSP
2.1	Key Landscape Features	✓	Landscape plan – proposed public open space areas, public open space credits, water source, bore(s), lake details, irrigation areas (if applicable)
2.1	Previous Land Use	✓	
3.0	**Design Criteria**	✓	Agreed design objectives and source of objectives
4.0	**Pre-development Environment**		
4.1	Existing Information	✓	Existing information and more detailed assessments (monitoring). How do the site characteristics affect the design
4.2	Site Conditions	✓	Existing topography/contours, aerial photo underlay, major physical features
4.3	Geotechnical	✓	Topography, soils including acid sulfate soils and infiltration capacity, test pit locations (if available)
4.4	Environmental	✓	Areas of significant flora and fauna, wetlands and buffers, waterways and buffers, contaminated sites
4.5	Surface Water	✓	Topography, 100- year floodways and flood fringe areas, water quality of flows entering and leaving (if applicable)
4.6	Groundwater	✓	Topography, pre- development groundwater levels and water quality, test bore locations
5.0	**Water Sustainability Initiatives**		
5.1	Water Efficiency Measures	✓	Private and public open spaces including method of enforcement
5.2	Water Supply	✓	(Fit-for-purpose) strategy, agreed actions and implementation
5.3	Wastewater Management	✓	
6.0	**Stormwater Management Strategy**		
6.1	Flood Protection	✓	Peak flow rates, volumes and top water levels at control points, 100-year flow paths and 100-year detention storage areas
6.2	Serviceability Management	✓	Storage and retention required for the critical 5- year ARI storm events Minor roads should be passable in the 5-year ARI event
6.3	Ecology Protection	✓	Detention areas for the 1-year 1-hour ARI event, areas for water quality treatment and types of agreed structural and non-structural best management practices and treatment trains (including indicative locations). Protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages
7.0	**Groundwater Management Strategy**		
7.1	Post-development Aspects	✓	Groundwater levels, existing and likely final surface levels, outlet controls, and subsoil drain areas/exclusion zones
7.2	ASS and Contamination	✓	Actions to address any acid sulfate soils or contamination
8.0	**Future Subdivision and Urban Water Management Plan**	✓	Content and coverage of future urban water management plans to be completed at subdivision. Include areas where further investigations are required before detailed design
9.0	**Monitoring**	✓	Recommended future monitoring plan including timing, frequency, locations and parameters, together with arrangements for ongoing actions
10.0	**Implementation**		
10.1	Developer Commitments	✓	
10.2	Maintenance Schedules	✓	Roles, responsibilities
10.3	Funding	✓	Funding for implementation
10.4	Review	✓	

Executive Summary

This report has been prepared to support the proposed structure plan over lots 877 & 878 Stakehill Road, Karnup and to help guide the detailed design and construction of the drainage solution for the future subdivision of the land.

The site is currently zoned "Urban" under the Metropolitan Region Scheme (MRS) and "Urban" under the City of Rockingham Town Planning Scheme No. 2.

The site is underlain predominantly by pale yellowish brown, medium to course-grained sand primarily derived from Tamala limestone (Spearwood Sands), which possesses good infiltration characteristics suitable for disposal of storm water by soakage.

The majority of land area to be developed has been cleared and currently operates as a market garden. A portion of the Bush Forever site covering the south-eastern portion of site is proposed to be developed into residential lots, with a reduced area of Bush Forever remaining.

All rainfall will be infiltrated "on-site" for storms up to the 1% AEP (1 in 100yr ARI) event.

Peak groundwater levels are expected to be between RL 2 - 2.25m AHD and will therefore provide a minimum depth to groundwater of ~3.8 m for all proposed post-development finished lot levels.

The proposed development will include:

- public open space designed to have low water use with groundwater used for irrigation
- medium to small lot sizes to help minimise water usage outside of the home
- shallow unfenced basins / swales to treat and infiltrate stormwater close to source
- bulk earthworks managed via on-site cut to fill without the need for groundwater control

Design objectives for water conservation / efficiency and stormwater management will include:

- Targeting water usage to less than 100kl per person per year - with ideally no more than 60kl per person per year of scheme water usage both within and outside of the home
- Ensure that post-development discharge closely matches pre-development conditions
- Protection of all dwellings from flooding during extreme / infrequent storm events
- Improve the overall surface and groundwater quality of the water leaving the site

The proposed approach to achieve each of the above water conservation / efficiency and stormwater management objectives for this development will include:

- Lot purchasers being encouraged to install rain water tanks plumbed into their home; to plant water and nutrient-wise gardens, and to use water efficient devices and appliances
- Lot purchasers will be encouraged to use groundwater for irrigation outside of the home
- All "end-of-line" drainage facilities to be designed to accommodate the 1% AEP storm event via on-site infiltration
- All allotments to be finished a minimum of 0.5m above the 1% AEP flood level
- All surface water will be routed through planted swales or shallow sided unfenced basins
- All swales / basins within the development will be sized to collectively achieve a total minimum surface area equivalent to at least 2% of the total constructed impervious area and to contain a minimum of 15mm of rainfall within the bio retention areas. (CIA)

1 Introduction

This report has been prepared to support a local structure plan required to enable the future residential subdivision of lots 877 and 878 Stakehill Road in Karnup. Both lots are located on the south side of Stakehill Road within the City of Rockingham (CoR). This report has also been prepared to help guide the detailed design and construction of a water sensitive drainage solution that is intended to be used throughout the proposed subdivision of these properties.

A preliminary subdivision layout plan proposed over lots 877 and 878 is included on the locality plan in Appendix A together with a copy of sheet 18 of the CoR's Town Planning Scheme No.2 (District Zoning Scheme) that includes the Karnup area.

1.1 Total Water Cycle Management - Principles and Objectives

Total water cycle management can be achieved by completing a water balance study. "A Water Balance is an accounting of all water volumes that enter and leave a 3-dimensional space over a specified period of time."[7] Due to the permeable nature of the soil, and limited surrounding infrastructure, there is likely to be no noticeable water balance change occurring over the site as a result of current land use activities. Once the estate is fully developed, it is possible that this situation can remain in a similar status provided:-

- All scheme water entering the site leaves via a sewer system and all extracted ground water or captured rainwater is allowed to infiltrate back into the site and;

  Ideally minimal scheme water should be used outside of the home so that all wastewater can then leave the site via the house plumbing system. Also, the majority of all collected rainwater or bore water should also be used outside of the home for irrigation / cleaning purposes etc. so that all such water can then infiltrate back into the ground. Obviously it is unlikely that all residents will totally refrain from using scheme water outside the home meaning some "external water" will enter the site over time. Conversely, if rainwater tanks are used and plumbed into the home to flush toilets or for other internal purposes, then this will mean some internal water will "exit the site" over time.
- All storm water run-off is fully contained and infiltrated "on-site" close to source.

1.2 Planning Background

The site is currently zoned "Urban Deferred" under the Metropolitan Region Scheme (MRS) and "Development" under the City of Rockingham Town Planning Scheme No. 2. An application for the lifting of the urban deferred zoning is to be lodged concurrently with the WAPC.

1.3 Previous Studies

Known studies that have been conducted over the subject properties include the Department of Water's (DoW), Rockingham-Stakehill Groundwater Management Plan[1]; The City of Rockingham's (CoR) Karnup District Water Management Strategy[10]and Development Engineering Consultant's (DEC) Lots 877 & 878 Stakehill Road District Water Management Strategy (DWMS) report.

As outlined in DEC's DWMS report, all stormwater run-off from the site is to be managed in accordance with current Department of Water and Environmental Regulation's (DWER's) Water Sensitive Urban Design (WSUD) guidelines – which prompts the disposal / discharging of stormwater into appropriately designed disposal facilities by "soakage close to source" – i.e. via the use of swales or (unfenced) basins to help capture, infiltrate and treat as much nutrients as possible.

2 Proposed Development

2.1 Structure Plan, Zoning and Land Use

The land is to be developed into approximately 420 residential lots together with some commercial lots abutting Stakehill Road. The development will include 4 public open space areas of varying sizes plus a large "Bush Forever" site as outlined in the development concept plan in Appendix A.

2.2 Key Landscape Features

Landscape concept plans are included in Appendix B and shows indicative concept layouts for POS areas affected by drainage. Detailed landscape drawings will be prepared as part of subdivision approval process.

POS credit calculations are based upon current Liveable Neighbourhoods[9] policy guidelines – where 100% of the area impacted by the 1 EY (1 in 1 year ARI) event is not included as POS. Any POS area impacted by the 20% AEP (1 in 5 year ARI) storm event being defined as restricted POS and cannot exceed 20% of the total POS allocation for the estate.

2.3 Previous Land Use

The current and historic land use over the site has been horticulture practices with rural/residential lifestyle uses surrounding the site.

3 Design Criteria

The water sensitive principles and design objectives to be used throughout this proposed development are summarised in Table A below:-

Table B – Water Sensitive Principles and Design Objectives

#	**Principle**	**Objective(s)** - to satisfy principle	**Proposed Approach** - to achieve objective(s)
1	***Potable Water Conservation & Efficiency***	• Target water usage to less than 100kl per person per year • Minimise the use of scheme water outside of the home and to use water as efficiently as possible - both within and outside of the home	• Lot purchasers will be encouraged to install rain water tanks plumbed into their home; to use water efficient devices and appliances, and to plant "Water and Nutrient-wise" gardens • When applicable / appropriate lot purchasers will be encouraged to use groundwater for irrigation
2	***Stormwater Quantity Management***	• Ensure that post-development discharge matches pre-development conditions • Adequately protect dwelling from flooding during extreme events	• All drainage facilities designed so that the 1% AEP storm is satisfactorily disposed on site via infiltration • All allotments to be finished a minimum of 0.5m above the 1% AEP flood level
3	***Stormwater Quality Management***	• To improve the overall surface and groundwater quality of the water leaving the site	• All surface water will be routed through planted swales or shallow sided unfenced basins • All swales / basins installed throughout the development will be sized to collectively achieve a total surface area equivalent to at least 2% of the total constructed impervious area (CIA) and to contain at least 15mm of rainfall in the bio retention area.

Storm water drainage designs for developments within the City of Rockingham are also governed by specific requirements several of which are outlined in Table B below:-

Table C – Typical Storm Water Drainage Design Requirements

#	**Description**	**Requirement**	**Comment**
1	Lot storm water quantity	At least the 63.2% AEP (1EY) storm to be retained on site.	Typical DWER recommendation

#	Description	Requirement	Comment
2	Storm water quality	Total volume of installed swales to contain a minimum volume equivalent to 15mm of rainfall across the connected impervious area.	Min. DWER requirement
3	Pipe design	20% AEP (1 in 5 year ARI)	Typical Council standard
4	"End-of-line" Basin / Swale design	1% AEP (1 in 100 year ARI) without outflow from site.	DWER / Council standard
5	Flow rates	Pre & Post development flows from site to remain unchanged.	DWER / Council standard
6	Min. lot freeboard	0.5m above basin 1% AEP (trapped) flood level. 0.3m above 1% AEP HGL in road / by-pass system.	DWER / Council standard With overland flow along road network during extreme events
7	Side slopes for swales / shallow unfenced basins	Max. 1 in 6 for grassed slopes. Max. 1 in 3 for planted slopes.	Typical Council standard
8	Run-off coefficients	0.70 – residential road reserves. 0.05 – district road reserves (Nairn Drive). 0.11 – Residential Lots 1% AEP 0.25 – Comm. Lots 1% AEP	Typical Council standard Nairn Drive assumes Swales will be installed in medians to allow for infiltration prior to overflow Lot Calculations allow for On site Storage and infiltration prior to overflow
9	Standing Water	All collected storm water to be infiltrated in 96 hours (4 days)	Typical Council standard
10	Storm water discharge to receiving environments	No direct discharge permitted All discharges must be treated	DWER / Council standard

4 Pre-development Environment

4.1 Existing Information

There is no known drainage infrastructure on the site other than a basin / dam in the north–west corner of lot 878 which is being used to extract groundwater for market garden irrigation purposes.

Two poultry facilities are located around 500m east and west of the common boundary of lots 877 & 878 - both on the north side of Stakehill Road.

Although power and telecommunication services exist in the area, water and wastewater infrastructure extensions will require significant extension to fully facilitate the development over the entire site.

Appendix D also provides information on peak groundwater levels (GWLs) both from DWER monitoring bores (that have also been used to estimate the expected peak GWLs for the site) and from 5 bores installed around the perimeter of the site where GWLs measurements commenced in June 2017.

4.2 Site Conditions

The 48ha site is around 80% cleared and currently used for market gardening, with around 11ha of residual bush located in the southern portion of vacant lot 877. Lot 878 contains a residence and sheds along the northern boundary immediately abutting Stakehill Road. Land to the east is semi cleared with a small market garden adjacent to the south east corner.

The site is accessible via Stakehill Road which abuts its northern boundary. Stakehill Road is an 8m wide sealed rural standard road, which acts as a district distributor. Two rural subdivision roads (Cassia Drive west and south) also abut the land midway along the west and southern boundaries respectively, but are not used to access the site.

A north-south ridge runs along the eastern boundary of lot 877, which basically divides the land into 3 to 4 natural catchments being; the northern portion of lots 877 and 878 which drains west, a small section in the north-eastern corner of lot 877 which drains north and the southern portion which covers the south of the two lots which drains west and a remaining small portion in the SE corner of Lot 888 which drains south. The highest elevation of the site (ridge on mid-eastern part of lot 877), is ~RL 19m AHD and the land generally falls from this high point in a westerly direction at an overall average grade of ~3% towards two low areas at ~ RL 5m AHD near the western boundary of lot 878.

An aerial photo underlay and plans showing site contours, and other physical features over the site are shown on various plans contained in Drawing L-02 in Appendix A.

4.3 Geotechnical

The Perth Environmental Geology Mapping (Gozzard JR 1983 Rockingham part Sheets 2033 II and 2033 III)[2] indicates that the entire site consists of sand – pale yellowish brown, medium to course-grained, sub-angular to well-rounded quartz, trace of feldspar, shell debris, variably lithified, surface kankar, of "eolian" origin i.e.(from processes pertaining to erosion, transportation & deposition of material by wind). The sand is primarily derived from Tamala limestone which has good infiltration characteristics suitable for disposal of storm water by soakage.

ASS mapping indicates that there is a low to no risk of ASS soils being present over the site. Furthermore, there should not be any requirement for dewatering as all excavations are likely to be well within 3.0m of the finished surface levels. This means there is virtually no risk of the development creating any ASS issues even if ASS were actually present at depth.

4.4 Environmental

Flora and Fauna assets - Two major "Bush Forever" areas border the proposed development – one covers the southern portion of lot 877 and the other immediately abuts the mid-western boundary of lot 878 (as indicated on the Government of WA Department of Planning and Infrastructure Southern Metropolitan Sub-Regional Structure Plan A – dated 15th June 2009).

Water dependent eco-systems - The main two wetlands within the vicinity of the site is Stakehill Swamp (ID13083) is a conservation category sumpland which is located some 450m north of the site. Anstey swamp (ID6414) is a conservation category located some 1.1km south west of the site.

Water resource aspects – Lots 877 and 878 are within the Churcher East groundwater subarea[1] where groundwater availability has been fully allocated although Lots 877 and 878 have an allocation of some 540,000kl/annum. Appendix D contains a copy of the groundwater licence for the site (Ref: 2020-2030 GW Licence 63216) and irrigation water analysis report for the site, which indicates that the groundwater is suitable for irrigation of POS.

Contamination – There is no indication of any historical high nutrient and/or non-nutrient contamination on the site - but (in accordance with current practices / guidelines) further investigations will still need to be completed as a condition of subdivision approval.

4.5 Surface Water

Due to the sandy nature and high recharge characteristics of the land there is no evidence of any surface water flowing across; or emanating from; the site.

4.6 Groundwater

The superficial unconfined aquifer beneath the site is ~25m thick, consisting mainly of clayey limestone and sand. Recharge is mainly through infiltration of rainfall. Groundwater flow beneath the site possibly occurs west / south-westerly to the coast as well as east towards the Serpentine River.

Lots 877 and 878 are located just outside of the Groundwater Atlas (1997)[4] coverage area. Peak groundwater levels for the site have therefore been estimated by examining the water level records from three surrounding DWER bores (Sites: 61410049, 6140050 and 61410060) and comparing these levels with readings obtained from "on-site" monitoring bores – refer Appendix D. The readings for the site were taken to show peaks in 2017 and 2018. The long term bore records indicated that on average, the MGL was sone 0.43m higher than the maximum levels measured across the site in September 2018. As a result, the MGL has been assessed by adding the average difference to the measured levels which indicate that the MGL ranges from RL2.6m AHD to 2.70mAHD across the site, rising from north to south. The measured groundwater levels across the site are shown in Table 4.1.

Table 4.1 – Groundwater Depth Results

Bore	**MB01**	**MB02**	**MB03**	**MB04**	**MB05**
RL Top of Casing (mAHD)	**10.12**	**18.70**	**5.78**	**6.87**	**6.28**
Ground level (mAHD)	**9.45**	**18.03**	**5.18**	**6.09**	**5.69**
29/06/2017	1.23	1.11	1.17	1.14	1.14
30/08/2017	1.85	1.83	1.87	1.84	1.85
03/10/2017	1.92	1.88	1.95	1.9	1.9
03/11/2017	1.85	1.82	1.88	1.84	1.84
05/12/2017	1.69	1.66	1.71	1.69	1.67
08/03/2018	1.36	1.34	1.39	1.37	1.47
20/06/2018	2.13	2.09	2.15	2.12	2.12
27/09/2018	2.21	2.18	2.23	2.19	2.2
25/10/2018	2.19	2.16	2.21	2.18	2.18
23/11/2018	2.06	2.03	2.08	2.05	2.04

Chemical analysis has been undertaken within bores MB1 to MB 5 and the information for that and adjoining bores is outlined in table 4.2 below.

Table 4.2 – Groundwater Quality test results

Sample ID	Date	Trigger	Nutrients		
			Total P	Total N	NH_4-N
		LOR	0.01	0.1	0.01
		Refer Below	0.8-12[1]	5 [1]	0.04 [2]
		LIWG	NG	NG	NG
MB1	29/06/2017		0.17	8.0	7.0
MB2	29/06/2017		0.82	22.2	18.4

Sample ID	Date	Trigger	Nutrients		
			Total P	Total N	NH_4-N
		LOR	0.01	0.1	0.01
		Refer Below	0.8-12[1]	5 [1]	0.04 [2]
		LIWG	NG	NG	NG
MB3	29/06/2017		0.07	0.1	0.01
MB4	29/06/2017		0.42	0.5	0.01
MB5	29/06/2017		0.14	36.7	30.4
MB1	20/06/2018		0.08	3.8	3.22
MB2	20/06/2018		0.29	18.4	15.7
MB3	20/06/2018		0.03	0.1	0.04
MB4	20/06/2018		0.03	0.5	0.30
MB5	20/06/2018		0.23	21.9	18.0

1. Irrigation Guidelines ANZECC/ARMCANZ 2000, Chapter 9
2. Values for Wetland environments - Table 3.3.6 ANZECC/ARMCANZ 2000 Freshwater and Marine WQ Guidelines Chapter 3

In looking at the measured nutrient levels it is evident that the majority of nitrogen and phosphorous levels are currently outside allowable ANZECC limits and it is expected that this is due to the land being used for market gardening for many years. On the scale of exceedances, particularly in land areas where market gardening activities have and are still being undertaken and these high levels are not unusual. The change in land use and reduced fertilizer use across this site will result in lower nitrogen loadings. Given the duration between the cessation of market garden activity and the release of residential land is likely to be at least 2 years, it is likely that levels will reduce prior to any irrigation being required.

In addition to this, it is noted that although the measured levels of nitrogen exceed the threshold for Australian drinking Water Guidelines (>50mg/l) for which they can be harmful to pregnant women and young infants for drinking, this water will be used for irrigation only, which will not propose a significant risk to future purchasers or residents. Prior to implementation of any irrigation system, further testing will be undertaken to check levels at that time. If necessary, care will be taken with the use of groundwater for irrigation purposes, which may include erecting warning signs, irrigation at night or sub-surface irrigation methods.

5 Water Sustainability Initiatives

5.1 Water Efficiency Measures

In terms of water conservation, it is well acknowledged that water is rapidly becoming a valuable natural resource. Much of the water conservation effort is now focusing on encouraging the community to use water saving devices and appliances; promoting the use of appropriate planting to suit their local environment, and by providing on-going information &/or community education on water conservation initiatives.

5.1.1 Individual Lot Owner Initiatives

The current state government's requirement to increase the efficiency of water use in new developments to a target of around 100kL per person per year is proposed to be implemented within the development.

An estimate of the allocation of water for all types of uses is illustrated below:-

Household scheme / potable water: Target a maximum of 60kl per person per year.

Non-potable water: Assume an average of 40kl per person per year throughout the development. (Which could be achieved by installing rainwater tanks &/or bores and would significantly assist with achieving a target of no more than 60kl/person/year of scheme water usage).

The target of around 100kL per person per year for all water types can be achieved by:

- Increased water efficiency in the household by encouraging the use of water wise appliances through current state government regulation and financial incentives.
- Use of rainwater tanks and bores etc. for general irrigation, washing and for the flushing of toilets etc. and to help minimise / avoid scheme water usage outside of the home.
- Using low water requirement plants and minimising turf areas in gardens and POS areas.

Note: The above initiatives can be readily communicated to each lot purchaser as part of the purchase contract or in pre-purchase marketing/information handout sheets. The handouts can also outline how each lot owner can install rainwater tanks plumbed into their homes to assist with the capture and re-use of at least a portion of the 63% AEP (1 in 1 year ARI) rainfall event.

5.1.2 Estate POS Initiatives

The proposed landscaping of the POS areas will be completed in accordance with Council requirements (&/or specific conditions of subdivision). Wherever possible, all landscaped POS areas will be created in a manner that:

- Minimises irrigation and fertiliser demands by appropriate species selection;
- Use properly managed fertiliser application methods that minimise water quality issues, and
- Incorporates appropriate Weed Management and Fauna Protection etc.

Most POS areas will be designed to avoid the need to be fully irrigated meaning only certain zones in specific POS areas will actually require permanent irrigation. Significant POS areas will be developed using native plantings and/or incorporate the use of low or no water requirement grasses etc. Some POS area(s) may initially need to be irrigated on a temporary basis using – but this will depend upon several factors (like development time tables, planting times etc.) and will obviously be avoided if at all possible.

Even if temporary irrigation is used, the overall water use will be limited to specific permitted usage rates (in kL/hectare/annum) in accordance with state and local government requirements.

Based on the standard DWER requirement of 7,200 kl/ha/annum for POS irrigation, the required allocation for the POS areas would be around 56,000 kl/annum. It is noted that this is well below the allocated 540,000kl/annum currently available to the site. The current bore licence is included in Appendix D. This licence (Number 63216) is current until 2030.

The exact requirements for POS ground water usage within this proposed development cannot be established until the final / detailed subdivision plan has been prepared and the extent of treed area and grass particularly at the interface with the Bush Forever site. Consequently an accurate portion of the existing ground water allocation for this site that can be transferred, traded or cancelled will ultimately be established at a future date.

In reality even if the whole of the bush forever site was irrigated, together with the balance of the POS which is a total of some 3.25ha, the maximum required water allocation required would be

24,325Kl/annum which is well below the current allocation of 540,000Kl/annum which means that more than sufficient ground water will be available to support irrigation over all POS areas within the proposed development if required.

Any installed irrigation bores and associated assets will be handed-over to the City of Rockingham after the completion of a standard maintenance period – unless otherwise agreed with &/or approved by Council.

5.2 Water Supply

A standard Water Corporation reticulated water supply service is to be installed within this development. All potable water required by the proposed development will be obtained by extending the Water Corporation water supply network to the site. The design and management of these services will be completed in accordance with Water Corporation design standards and management objectives.

All lot purchasers will be encouraged to minimise the use of scheme water and to use water as efficiently as possible - both within and outside of the home (Refer to initiatives in section 5.1).

5.3 Wastewater Management

A standard Water Corporation reticulated sewer system is to be used within the development.

6 Stormwater Management Strategy

6.1 Flood Protection

As there is no physical or anecdotal evidence of any pre-development run-off from the site, the drainage strategy is to dispose of stormwater by soakage and fully contain all post development flow on site. Drawing L03 in Appendix B shows the predevelopment sub-catchment boundaries within this site, which are also described in Section 4.2 of this document

All storm water is to be infiltrated as reasonably close to the source as possible, so as to help ensure that pre- and post-development flows essentially remain unchanged with all post-development surface flows, up to and including the 1% AEP storm event, being fully retained “on-site”.

Due to the natural topography of the land and constraints associated with interfacing with existing properties along the western boundary of lot 878, the developed site is expected to be divided into 2 main sub-catchments – being the north and south of the site. Drawing L04 in Appendix B shows the proposed post-development catchment boundaries and the likely locations of the two major “end-of-line” infiltration basins. These two basins will contain the 1% AEP storm and will be used in conjunction with a swale system along the North South roads within the proposed development.

A swale is proposed to be located along the road on the western boundary in addition to a series of swales within the central north south roadway. The central roadway is proposed to be constructed as a boulevard style road with a central median swale which will collect all water from the roads to the east and the road itself. The median will surcharge under higher AEP storm events and will overflow to the drainage system which will in turn be directed to the western swale, then the end of line basins. This will minimize the size of the end of line basins and maximise opportunities for soakage at source. The western swale will be split to provide bushfire access to Cassia Drive and will be culverted across that access point using a bubble up/soakwell system.

The swales are proposed to be constructed with a 1.0m wide base with slopes at 1 in 4 and a maximum depth of 0.5m thereby confining the width to 5.0m. Flow from upper catchments as shown in Drawing L-04 will be directed to the swales. The swales will be graded quite flat (At around 1 in 300) but will generally flow towards the basins. All the water not infiltrated will be directed to the end of line basins.

The two "end-of-line" infiltration basins / swales will be constructed within or immediately adjoining POS areas. Modelling has been undertaken on the basis of the basins working in conjunction with the swales and the proposed sizing details are outlined below in Table D. The basins are larger than generally required due to the high proximity of maximum groundwater levels beneath the basins meaning that infiltration outflows are lower.

The drainage calculations have been undertaken using the shallow water table model PC Sump which has recently been updated by JDA Consultants. Catchment plans and output files for PC Sump are included in Appendix B and Appendix C of this document.

Table D – Preliminary Drainage Storage and Area Requirements

Basin parameter	North Catchment (Catchment N)	South Catchment (Catchment S1S2)
Impervious catchment (Ha) ($C_{1\%}$)	4.53	6.12
Storage provided (1%) (m^3)	3,465	4,555
Storage provided (20%) (m^3)	847	1,344
Storage provided (1EY) (m^3)	353	637
Site area required (1%) (m^2)	4,126	5,061
Site area required (20%) (m^2)	1,346	1,932
Site area required (1EY (m^2)	1,008	1,523
$TWL_{1\%}$ (mAHD)	4.50	4.99
Base of Basin (mAHD)	3.3	3.80
Critical T_C (1%) (hrs)	2	2
Critical T_C (20%) (hrs)	2	2
Critical TC (63.2%) (1EY) (hrs)	2	2
Emptying Time (1% AEP)(hrs)	13	71
Emptying Time (20% AEP)(hrs)	4	22
Emptying Time (63.2% AEP)(hrs)	4	20

All roads within the estate will also be designed to direct all extreme event by-pass flows towards specific POS areas and basins where sufficient infiltration areas are available to contain and dissipate the stormwater.

All lots adjoining / surrounding a proposed drainage basin / infiltration area located at a (trapped) low-point will be filled to a minimum of 500mm above the estimated 1% AEP basin top water level or at least 300mm above the estimated 1% AEP top water level overflow by-pass path. This will ensure flooding of homes is minimised and that the conveyance of stormwater safely occurs along the abutting roadway(s) during infrequent storm events.

Indicative extreme event overland flow paths are also shown on the post development catchment plan (L-04) in Appendix B.

6.2 63.2% AEP (1 EY) Event

6.2.1 General

The 63.2% AEP event is typically seen as the storm that generates most nutrients and particulate matter.

It is proposed that the 63.2% AEP 1 hour storm will be retained on site within the bio retention area of swales without outflow in accordance with DoW requirements. This is proposed to be undertaken at the various levels as outlined in the following sections.

6.2.1.1 Lots:

Lots are proposed to either retain water on site in rainwater tanks in conjunction with soakwells or install soakwells to infiltrate water to ensure no outflow into the street drainage system. All soakwells will be located at the front of lots to ensure that subsoil drainage will effectively empty the soakwells within a reasonable period after cessation of rainfall.

All Lots are proposed to be will be fitted with the equivalent of 2 by 1500 diameter by 1.2m deep soakwells which will achieve full retention of the 63.2% AEP 1 hour storm. The volume provided within the soakwells has been assumed to be an initial loss for the rain event which equates to 13.6mm of rainfall for a residential lot and 24.4mm for commercial lots on the assumption that the commercial lots provide 1 cubic metre of storage per 37 square metres of paved area. The soakage rate for the soakwells represents the continuing loss which is 9.7mm/hr for residential lots and 4.6mm/hr for commercial lots respectively.

6.2.1.2 Streets:

Drainage pits will be laid with open bases to permit soakage for small rainfall events thereby encouraging further soakage "at source". The baseless pits will cater for around 1.5-2.0mm of rainfall. Swales will be installed within the Nairn Drive reserve and the road located on the western side of the development to accommodate the whole of the 63.2% AEP storm and the majority of higher AEP storms. Further investigation into the used of further swales and/or bio-retention basins will be undertaken as part of the UWMP once the detailed lot layout has been finalized.

The remainder of the 15mm event has been allowed to be contained within the soakage basin and will be retained until prior to infiltration. The 63.2% AEP (1EY) for roadways will be contained within basins in POS and in the end of line biological treatment basins without outflow other than infiltration through biological treatment and high PRI media. The media will have a minimum PRI of 12 and will be installed for a 400mm depth in the base of basins.

The 63.2% AEP area storage area will be defined using retaining walls, thereby ensuring that stormwater will be constricted to cause minimal inundation for minor rainfall events, thereby maximizing the usability of the POS area and associated swales.

A GPT will be installed prior to any inflow from the piped drainage system into the drainage basin to limit the siltation of the basin.

6.2.2 Non-structural measures

Non-structural measures will also be employed to reduce the sources of nutrients. These measures involve providing advice to lot purchasers and stakeholders to reduce nutrient sources from the application of garden fertilisers and eroded particulate matter particularly from the new urban areas during the housing construction phase and in establishment of gardens.

Minimisation of nutrient loading will be achieved through:

- Education of local residents and Council maintenance personnel through fliers to be provided as part of the sales documentation; and
- By implementing frequent street and storm water maintenance programs – particularly during housing construction.
- By planting and using appropriate native species within POS and in encouraging their use in residential gardens.

6.3 20% AEP Event

All piped drainage systems will be designed to accommodate the 20% AEP event.

6.4 1% AEP Event

For the major event, lot drainage flows in excess of the 5% AEP storm will surcharge and run overland. All roads within the estate will be designed to accommodate and direct extreme event flows towards each POS and basin. The land will be divided into the catchment areas as detailed in the post development plan as Appendix B.

6.5 Finished Lot Levels

The finished levels for the proposed development have been set based on three major criteria as follows:

- 1% AEP levels from the proposed detention basins, the land is proposed to be filled a minimum of 0.5m above the top water level of drainage basins.
- Minimum separation requirements from maximum groundwater level of 1.2m.

In all cases, lots will be set to ensure conveyance for major storms will be along the roadways without flooding homes.

6.6 Ecology Protection

A prime concern for the nutrients emanating from the development is the long term health of the below ground water. Hence all stormwater runoff from roads will be detained in appropriately sized "first-flush" / nutrient retention swales and further detained in surrounding overflow / POS infiltration areas. As such, the opportunity for nutrients from within this proposed development to impact on the ground water should be minimal.

Obviously, the lower the concentrations of nutrients in run-off, then the lower the net nutrient export will be from the site and as a result it is important that all stakeholders are educated in ways to minimise nutrients mobilizing in stormwater. Given that the major source of nutrients in the storm water system is likely to be from the application of garden fertilisers and eroded particulate matter from new urban areas during the house construction / garden establishment phase, minimisation of nutrient loading can be achieved through:

a) Education of local residents and Council maintenance personnel; and
b) By implementing frequent street sweeping and stormwater maintenance programs.

The DWER's Storm Water Manual also provides guidelines and information on best management practices that may be applied at land development and construction sites to improve storm water management and environmental performance.

Poorly managed land development sites can often be a major source of storm water pollution. Certain construction activities can allow pollutants to be transported (via existing storm water systems or over-land flow) to adjoining receiving water bodies.

The major source of pollutants from subdivision construction activities will potentially be from:

- Eroded materials in the interim period between opening up the surface of the site and implementing the drainage management measures.
- Litter and waste storage areas- that allow materials to be blown by wind or washed away by rainfall into existing storm water systems.
- Wash-down areas– poor practices can allow materials to enter storm water systems.
- Placement and storage of delivered products- particularly sand and soil stockpiles where such materials may be tracked by vehicles, or blown, or washed onto roads which then get into existing storm water systems.
- Dewatering activities– which can cause sedimentation of downstream water bodies.

Consequently no construction activities will commence on the site until an appropriate approved Environmental Management Plan (EMP) is prepared by the contractor that fully addresses:

- Litter and waste management practices (non-hazardous and hazardous materials);
- Vehicle and equipment washing-down practices;
- Water conservation practices;
- Product placement and, storage practices;
- Dewatering activities (if applicable); and
- Any other practices that may adversely impact upon receiving water bodies.

The Best Management measures proposed for this site are likely to include:

- Implementation of non-structural measures to reduce applied nutrient loading.
- On site retention of at least the 1 in 1 year 1 hour ARI storm event.
- Use of infiltration basins / bio-retention swales.
- Construction activities only implemented using a pre-approved EMP.

7 Groundwater Management Strategy

7.1 Post-development Aspects

Maximum groundwater levels over the site are expected to be approximately 3.0m below proposed finished lot levels and a minimum of 1.1m below and 0.6m below the base of south and north basins respectively. This means that that no groundwater level control will be needed for this development.

The estimated maximum water depth in each end-of-line basin / swale will not exceed 1.2m for the 1% AEP event. The invert levels for all drainage pipes are expected to be around 1.0m below the finished road pavement levels with at least 600mm cover.

All swales / basins installed throughout the development will be landscaped / planted and sized to collectively achieve a total surface area equivalent to at least 2% of the CIA and will contain a minimum of 15mm (1EY 1 hour) of rainfall in the bio retention area.

All lot owners will be encouraged to install rainwater tanks plumbed into their homes for household use and to retain at least the 1EY I hour event "on-site". Rainwater tanks (plumbed into the home) can also be used in conjunction with soak wells to infiltrate the stormwater and thereby further help to minimise any outflow to the street drainage system during infrequent / major storm events. All lots should be required to provide on-site storage of around 4.0 cubic metres to at least achieve full retention of the 1 EY storm event. This can be achieved via the:

- Installation of (say) 2 – 1200mm diameter x 1,500mm deep soak wells or
- An equivalent volume using rainwater tanks with an overflow to garden areas.

Roof run-off from homes captured in rainwater tanks can be re-used on for gardening, laundry or toilets.

7.2 Acid Sulfate and Contamination

As indicated in section 4, there is little to no risk of ASS soils being present over the site and no indication of any site contamination.

8 Future Subdivision and Urban Water Management Plan

It is anticipated that the development of lots 877 and 878 will be completed in a number stages (probably between 12 and 16) and an Urban Water Management Plan will be required as a condition of subdivision in order to support the final / detailed drainage design for the estate.

As part of the UWMP, the final design of the shape and arrangement of the basins will be finalized and further monitoring will be recommenced.

In addition to this detailed geotechnical investigations including hydraulic conductivity testing to confirm drainage modelling assumptions will be undertaken.

9 Monitoring

Pre-development site monitoring of groundwater levels commenced in late June 2017 and has continued to November 2018, but has been deferred pending subdivision works at which time it will be restarted. The results recorded to date are included in Appendix D. Due to the size of this development and the position of existing bores, it is expected that several of these bores will be retained for long-term post-development monitoring and any damaged as a result of works will be replaced in a suitable area.

If in the event that any measured water quality parameter happens to exceed acceptable levels, then corrective action could be readily initiated – including:

1. Reduction in POS irrigation or fertiliser application rates including the review of required use, timing or manner in which the fertilisers were being applied.
2. Additional soil amendment / augmentation in high nutrient inundation areas.
3. Increased planting of water and "nutrient thirsty" plants in/around created infiltration areas.

10 Implementation

The proposed drainage approach (as outlined above) will incorporate several WSUD objectives and principals for managing stormwater disposal as close to source as possible – including the installation of vegetated swales / basins and the provision of water conservation advice to all purchases via information brochures distributed at the time of land sale etc.

All water management strategies (as outlined in this report) can be implemented as part of this proposed development.

10.1 Developer Commitments

The developer is committed to:

- Implementing a pre and post development monitoring program. (As per section 9 above).
- Installing suitably sized swales / basins throughout the estate to maximise stormwater disposal as close to source as possible, and to pre-treat all "first-flush" storm events prior to any stormwater flowing to other overflow / POS infiltration areas.
- Installing infiltration swales / basins that are designed and constructed to manage flows up to and including the 1% AEP storm event; and
- Providing Information Packages to all lot purchasers to encourage:
  (a) The use of rainwater tanks (plumbed into the home);
  (b) The use of water efficient devices and appliances; and to encourage
  (c) All purchasers to plant Water-wise and Nutrient-wise gardens.

10.2 Maintenance Schedules (Incl. Roles & Responsibilities)

Each property owner will be encouraged to regularly inspect and clean-out their rainwater tanks &/or soakage pits – on at least an annual basis. (This could, for example, very easily be achieved by providing some form of notification as part of Councils issuing of rate payment advice notices).

Bio-retention swales / basins will be designed / constructed with an appropriate inlet facility - to ensure that the swales are not unnecessarily inundated with excessive amounts of sediment and to minimise inlet scour. Initially it is anticipated that the "vegetated" swales will need to be maintained on a regular basis – ideally, as part-of, or in conjunction with, the standard POS maintenance program. Eventually (after most housing construction is complete) the only long-term maintenance requirements will be the removal of deposited wind-born materials and the very occasional removal of sediment build-up in the base of the swale (which will be minimised through Council's regular maintenance programs / cleaning of, and around, the inlet structures etc.).

Over the summer period, particulate matter may also build up in storm water drainage system. In the initial years of housing construction, this will be from soil washed into the storm water system, while leaves, litter and grass clippings etc. impacting the system in the longer term.

Furthermore, small volumes of litter and leaves left in the drainage system, in trapped pits or in the base of swales for long periods of time can break down and contribute to higher nutrient outflows from the site. Hence, the following maintenance programs are recommended:

a) Cleaning of drainage infrastructure. By regular removal of trapped debris from drainage pits and silt traps. In the long term particulate matter may build up in the drainage swales and may also require some cleaning. To account for this the swales can be installed with an additional / extra "sacrificial depth" or designed to function with a "clogged" layer to allow for the effects of some sediment build up to occur – which will help to minimise the regularity of cleaning these swales.
b) Regular street sweeping to remove particulate build-up on road surfaces and gutters (particularly during the home construction phase).
c) Appropriate disposal or composting of grass clippings etc. to ensure that they do not reach downstream storm water systems.

Drainage infrastructure maintenance should at least occur on a biannual basis - just prior to winter and again in the middle of winter, and obviously more regularly, during periods of major housing construction. Maintenance of any silt traps (& street sweeping) will probably need to occur at ~2 - 6 month intervals depending on the loading.

In the long-term - it is anticipated that only standard Council checks and cleaning maintenance requirements will need to be applied to the drainage system proposed for this estate – with suggested inspection / maintenance frequencies as outlined in the table below:

#	Drainage Element:	Possible Maintenance and Inspection Frequency:	Responsibility:
1	Rainwater tank(s) / "on-lot" soakage pit(s) etc.	Annually inspection and clean-out (as necessary) – just prior to winter rains.	Lot Owner
2	Infiltration basin, vegetated bio-retention swales, landscaped table drains and unfenced basins.	During developer maintenance period: Inspect, clean-out & maintain plants ~3 - 4 month intervals (depending on loading) – ideally as part of standard POS maintenance works.	Developer
		After developer maintenance period: Inspect, clean-out & maintain plants (as required) as part of Council's standard POS maintenance program.	Council
3	Drainage culverts, standard table drains, pipes, pits & fenced basins.	During developer maintenance period: Inspect, clean-out & maintain structures annually – just prior to winter (& then again in Aug / Sept if necessary).	Developer
		After developer maintenance period: Inspect, clean-out & maintain structures at least annually – just prior to winter – but inspection frequency will need to be higher during the home construction phase.	Council

10.3 Funding

The developer will be funding the installation of all subdivision drainage infrastructures (swales, stormwater drainage pits and pipes, POS / verge infiltration facilities etc.) as well as the initial maintenance and monitoring costs associated with each of these facilities for the periods as outlined in the maintenance schedule table in section 10.2 above.

10.4 Review

Once approved / accepted by Council - there should not be a need to review this LWMS report as any minor adjustments can readily be addressed in the UWMP (which is expected to be a

requirement of the WAPC conditions of subdivision) and/or as part of the detailed civil design submission to Council.

11 References

1. Rockingham-Stakehill Groundwater Management Plan – Dept. of Water Report No.23 Nov 2008
2. Environmental Geology Mapping- Gozzard JR 1983 Rockingham part Sheets 2033 II & 2033 III
3. Australian Rainfall and Run-off - A Guide to Flood Estimation Vol. 1, Institute of Engineers, 1987
4. Perth Groundwater Atlas, Waters and Rivers Commission, October 1997
5. Perth Groundwater Atlas (2nd Edition), Department of Environment, 2004
6. Better Urban Water Management, WAPC 2008
7. Irrigation Water Balance Fundamentals ITRC Paper 99-001, 1999
   http://www.itrc.org/papers/irrwaterbalance/irrwaterbal.pdf
8. Interim guide for Developing a Local Water Management Strategy – Dept. of Water Dec 2008
9. Liveable Neighbourhoods, WAPC Jan 2009 Update 2
10. Karnup District Water Management Strategy, GHD March 2014

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APPENDIX A – SUBDIVISION PLANS

- **Development Concept plan**
- **L01 - Locality plan**
- **L02 - Aerial Photo with Superimposed Development Layout**
- **City of Rockingham TPS No.2 Map sheet 18 - October 2016**

826

849

169

(3372m²)

3490m²

23m Road

1

Subject to
Further Planning
2.7367ha

24.5m Road

6996m²

(9693m²)

18m Road

15m Road

13.5m Road

6307m²

15m Road

15m Road

15m Road

6m Lane

NAIRN DRIVE EXTENSION

15m Road

6m Lane

15m Road

ASSIA DR

878

877

15m Road

24.5m Road

24.5m Road

23m Road

26188m²

15m Road

15m Road

67380m²

15m Road

13.5m

15m Road

6085m²

13.5m

18m Road

24.5m Road

7127m²

146

624

Potential future public
open space by others.

CASSIA DR

145

625

LEGEND

Metropolitan Region Scheme

Region Scheme Reserves

- Other Regional Road
- Parks & Recreation

Other

- Bush Forever

Local Scheme

Local Scheme Reserves

- Public Open Space

Local Scheme Zones

- Residential R12.5-R25
- Residential R30-R40
- Commercial

Other

- 50 Significant Tree Survey
- Vegetation Condition
- VG Very Good
- G Good
- D Degraded
- CD Completely Degraded
- Intersection - Left In/Out
- Intersection - Interim full movement with ultimate roundabout treatment
- Acoustic Wall
- Emergency Access 10m wide Right-of-Carriageway Easement (Gated)
- Emergency Access (Gated)
- Bush Forever Original Boundary
- Planning Control Area
- Subject to Future Planning
- Potential future road connection
- Landscape Swale
- Poultry Odour Extent

NOTES

1. Area identified as subject to future planning for possible additional commercial and service commercial uses for expansion to a neighbourhood centre based on outcomes of the Karnup District Structure Plan. Alternative land uses such as residential may be considered where commercial/service commercial uses are not supported. Refer to Structure Plan Part One Clause 4.5 regarding control of land uses within the poultry farm odour buffer.

Development Concept Plan

Lots 877 and 878 Stakehill Road, Karnup

0 80m

Date: 2 July 2024 Scale: 1:4000 @ A3 File: **19-338 ST04C** Staff: JP GW Checked: JP

element.

Level 18, 191 St Georges Terrace, Perth Western Australia 6000.
PO Box 7375 Cloisters Square, Perth Western Australia 6850.
T. +61 8 9289 8300 | **E.** hello@elementwa.com.au **elementwa.com.au**

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F	18/8/20	JEG	UPDATED LAYOUT	SRA
E	9/3/20	BVS	LAYOUT UPDATED	SRA
D	7/8/19	JEG	LAYOUT AMENDED	SRA
C	13/12/17	JEG	PLAN NAME AMENDED	RDG
I	31/7/24	JEG	UPDATED LAYOUT TO PLANNER'S REV C	SRA
H	21/11/23	JEG	UPDATED LAYOUT	SRA
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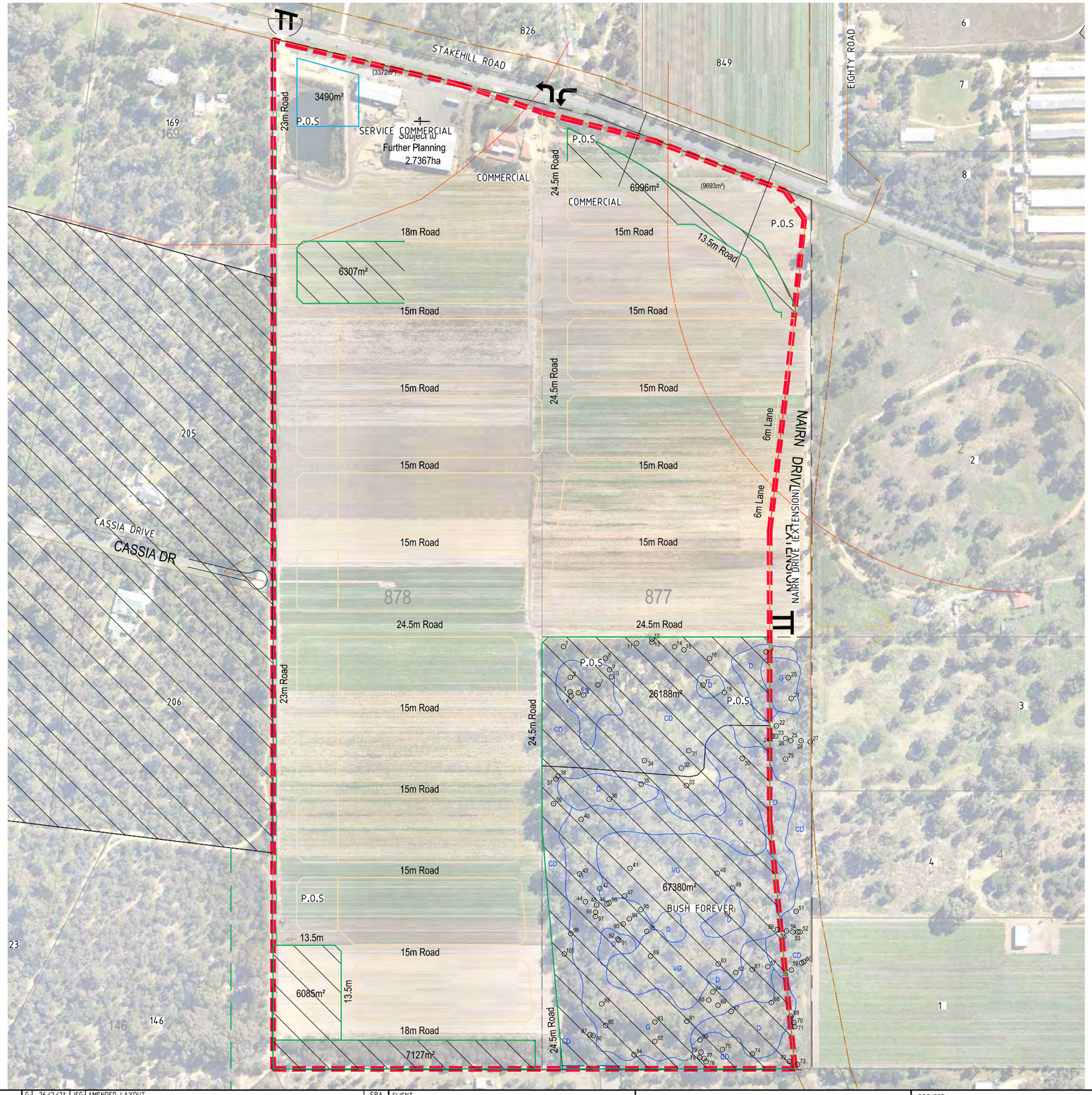
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PROJECT:
LOTS 877 & 878 STAKEHILL RD BALDIVIS
W.A.P.C. No. -

DRAWING:
WATER MANAGEMENT STRATEGY
LOCALITY PLAN
CAD DRAWING DO NOT MANUALLY ALTER
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DRAWING NUMBER: L01



LEGEND

SITE BOUNDARY

BUSH FOREVER

1:2000 (A1)

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W.A.P.C. No. -

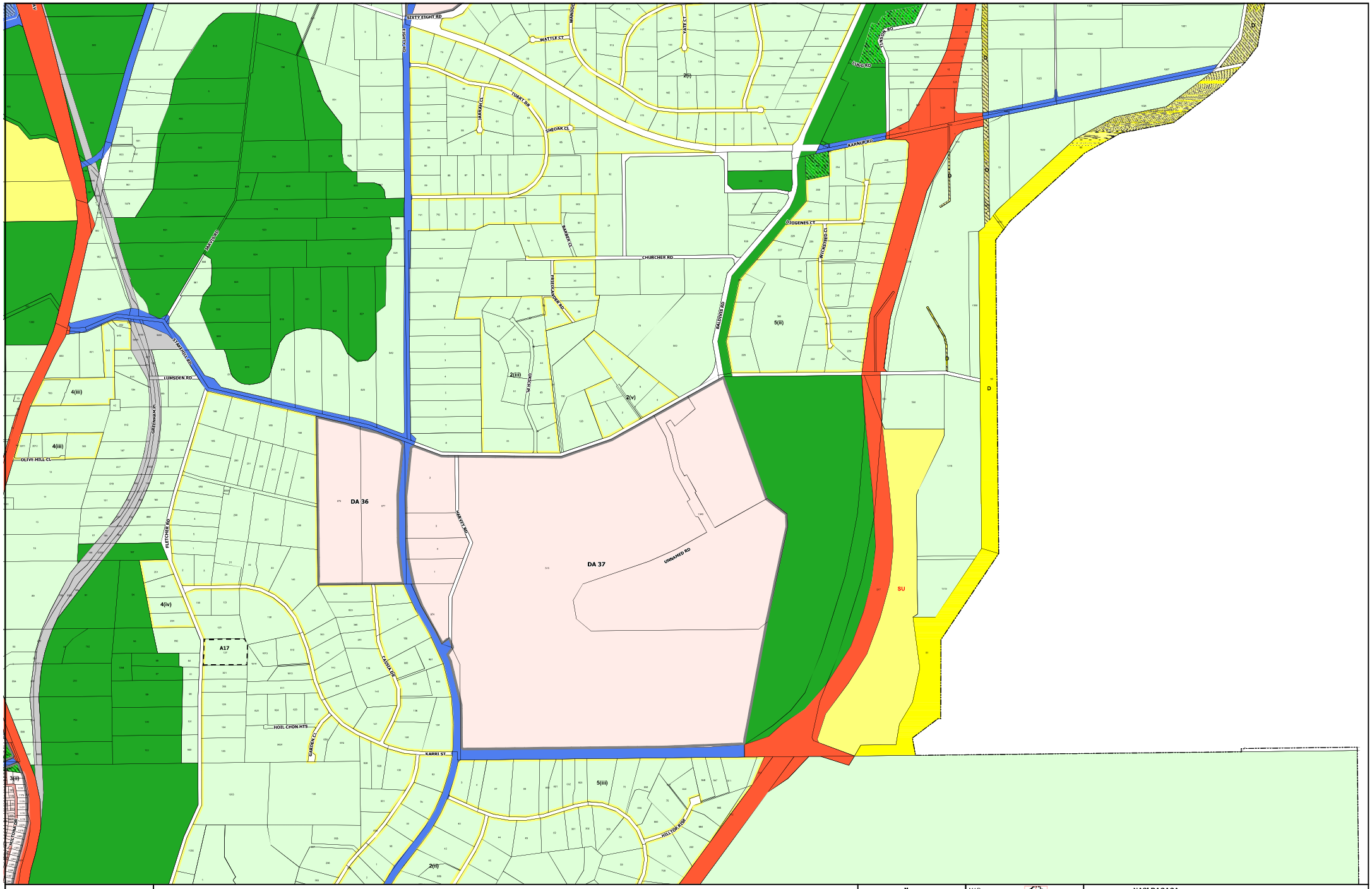
DRAWING: WATER MANAGEMENT STRATEGY AERIAL PHOTO

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Whilst all care has been taken to accurately portray the current Scheme provisions, no responsibility will be taken for any omissions or errors in this documentation.

CITY OF ROCKINGHAM

TOWN PLANNING SCHEME No. 2
(DISTRICT ZONING SCHEME)

SCALE 1 : 10000

MAP LEGEND

Authorised NASI RACACA

Plot Information : G:\GIS Data\Workspace\GIS_Planning\TPS\Maps\TPS Sheets\Sheet 18 .WOR

Date : OCTOBER 2016

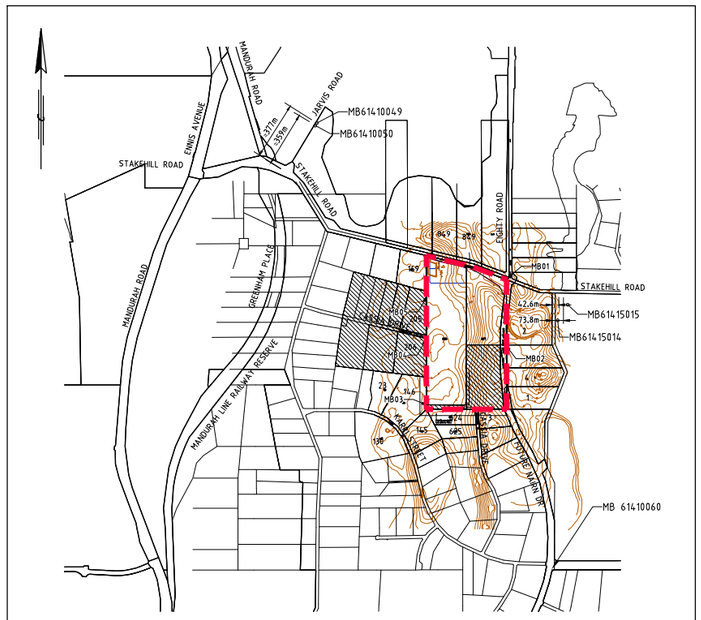
Govt. Gazette : 19th NOVEMBER 2004

TOWN PLANNING SCHEME MAP

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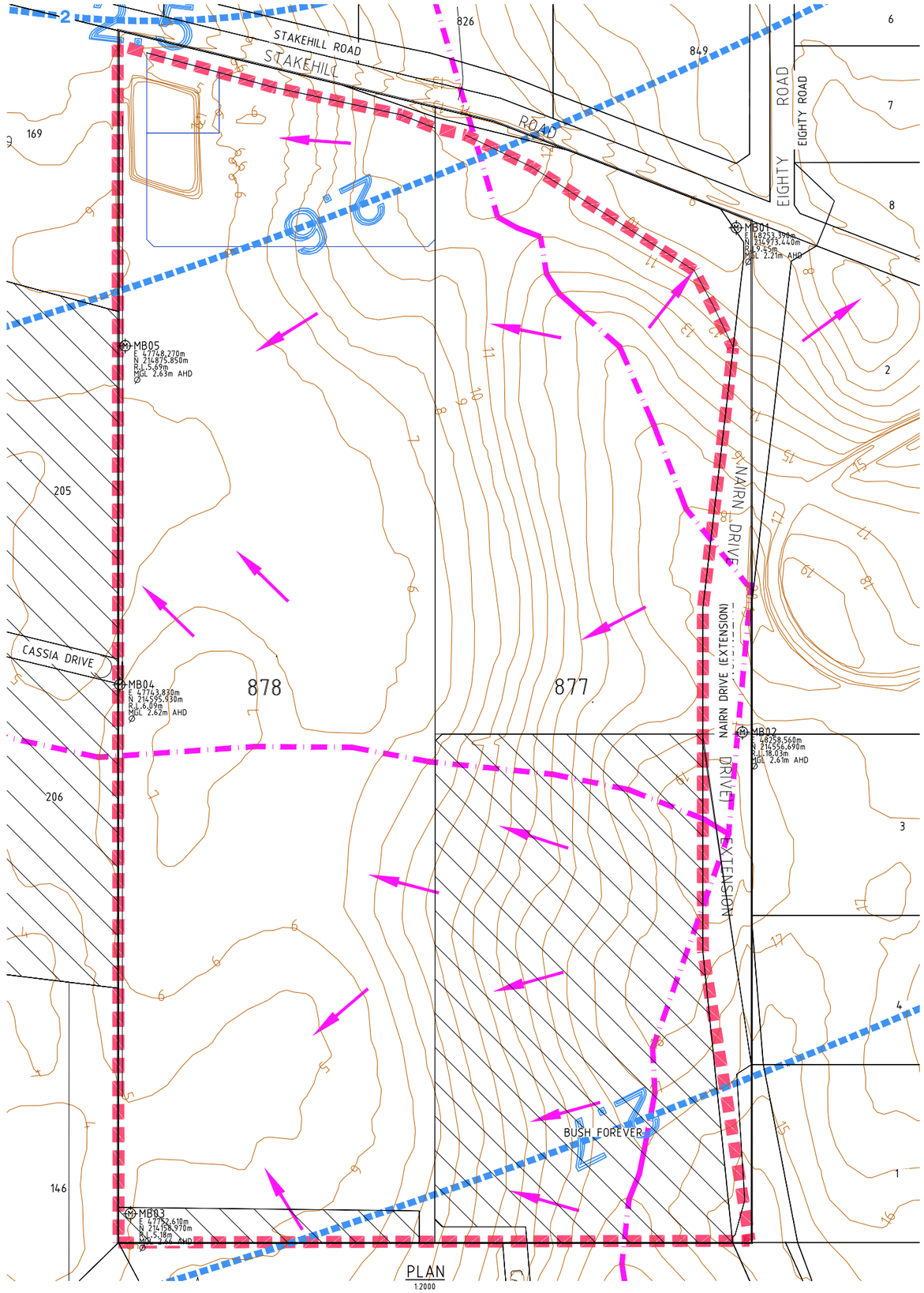
APPENDIX B – DRAINAGE CATCHMENT PLANS

- **L03 Pre-development catchment plan**
- **L04 Post-development catchment plan with indicative basin locations**
- **L05 North Catchment Basin Details**
- **L06 South Catchment Basin Details**



MONITORING BORE LOCALITY PLAN

N.T.S.



PLAN

1:2000

LEGEND

- SUBJECT SITE
- EXISTING SURFACE CONTOURS
- GROUND WATER CONTOURS (MGL)
- IMPLIED NATURAL RIDGE
- SURFACE FLOW ARROW
- MONITORING BORE (MB01 — NAME; E 478,888m; N 496,896m; RL 0.00m — SURFACE LEVEL; 2.5m — DEPTH; Ø150 — BORE DIAMETER)
- BUSH FOREVER/SPECIAL AREAS

MONITORING BORE LOCATION INFORMATION			
BORE NUMBER	EASTING	NORTHING	ROAD NAME
61410049	47028.46	216001.06	JARVIS ROAD
6140050	47018.88	215984.28	JARVIS ROAD
61415015	48606.03	214885.50	STAKEHILL ROAD
61415014	48637.20	214882.13	STAKEHILL ROAD
MB01	48253.39	214973.44	STAKEHILL ROAD
MB02	48258.56	214556.69	NAIN DRIVE (EXTENSION)
MB03	47752.61	214158.97	
MB04	4774383	214595.93	
MB05	47748.270	214875.85	

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C	13/12/17	JEG	DRAWING NAME CHANGE	RDG
B	6/12/17	JEG	AMENDED PLAN	RDG
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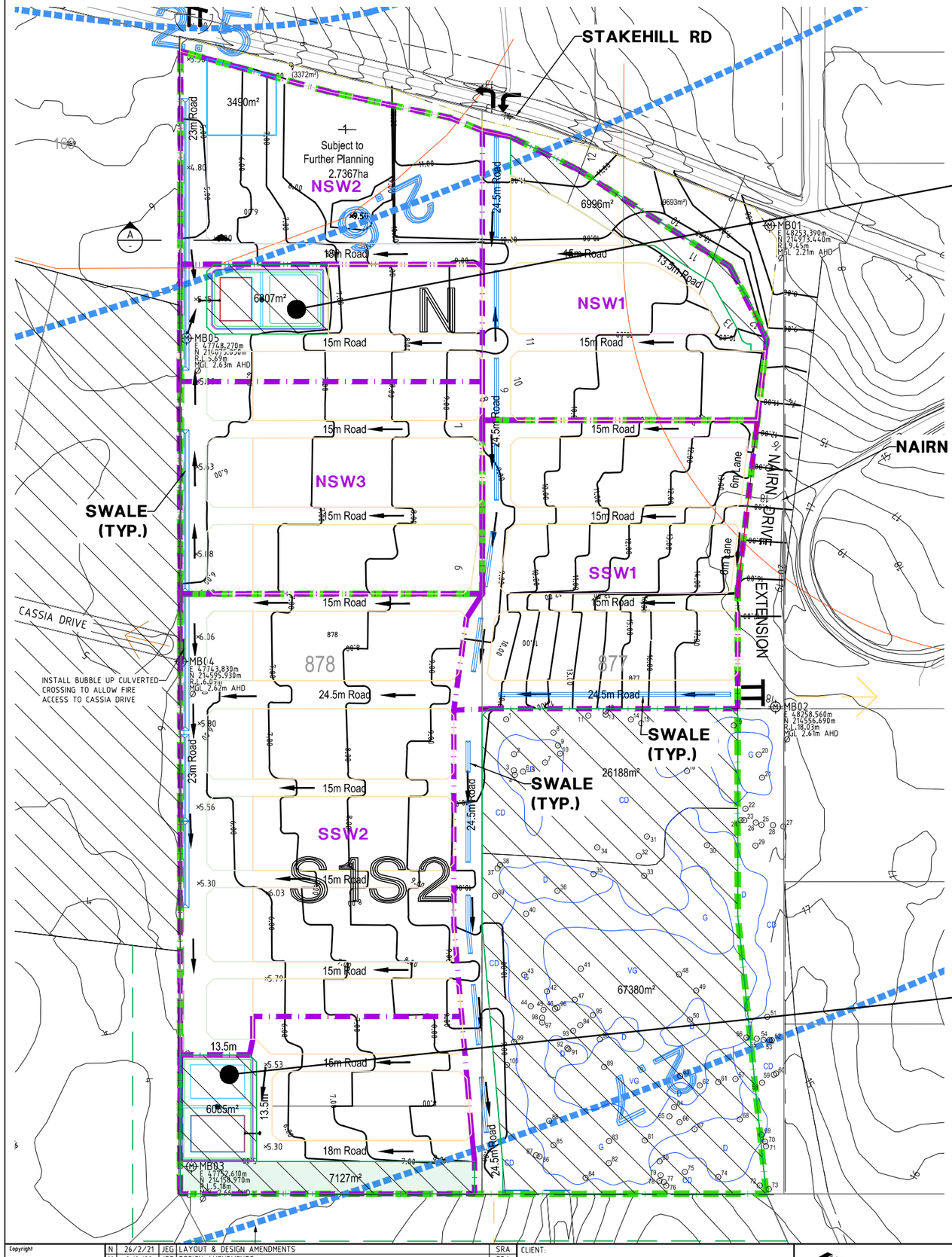
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PROJECT NUMBER **PRO1043** DRAWING NUMBER **L03**

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BASIN DETAILS - CATCHMENT N

TOTAL IMPERVIOUS AREA (1%)	4.53ha
1% AEP STORAGE REQUIRED	3465m³
AREA AT TWL (1% AEP)	4126m²
RL (TWL) (1% AEP)	4.50m AHD
10% AEP STORAGE REQUIRED	1279m³
AREA AT TWL (10% AEP)	1626m²
RL (TWL) (10% AEP)	4.36m AHD
20% AEP STORAGE REQUIRED	847m³
AREA AT TWL (20% AEP)	1356m²
RL (TWL) (20% AEP)	4.07m AHD
1EY STORAGE REQUIRED	353m³
AREA AT TWL (1EY)	1008m²
RL (TWL) (1EY)	3.65m AHD
PEAK OUTFLOW (1% AEP)	0 l/s
BASE RL (LWL)	3.30m AHD

BASIN DETAILS - CATCHMENT S1S2

TOTAL IMPERVIOUS AREA (1%)	6.12ha
1% AEP STORAGE REQUIRED	4555m³
AREA AT TWL (1% AEP)	5061m²
RL (TWL) (1% AEP)	5.00m AHD
10% AEP STORAGE REQUIRED	1773m³
AREA AT TWL (10% AEP)	2160m²
RL (TWL) (10% AEP)	4.86m AHD
20% AEP STORAGE REQUIRED	1344m³
AREA AT TWL (20% AEP)	1932m²
RL (TWL) (20% AEP)	4.65m AHD
1EY STORAGE REQUIRED	637m³
AREA AT TWL (1EY)	1523m²
RL (TWL) (1EY)	4.24m AHD
PEAK OUTFLOW (1% AEP)	0 l/s
BASE RL (LWL)	3.80m AHD

LEGEND

- SITE BOUNDARY
- CATCHMENT AREA
- NATURAL SURFACE CONTOURS (23)
- GROUND WATER CONTOURS (2.00)
- DRAINAGE BASIN
- OVERLAND FLOW ARROW
- 1 EY STORAGE
- 20% AEP STORAGE
- 10% AEP STORAGE
- 1% AEP STORAGE
- MONITORING BORE (MB01 — NAME; SURFACE LEVEL; DEPTH; BORE DIAMETER)
- COMMERCIAL AREA (TYP.)
- BUSH FOREVER SITE / SPECIAL AREAS

CATCHMENT DATA

CATCHMENT	TOTAL AREA m²	LOT AREA m²	COMMERCIAL LOT AREA m²	ROAD RESERVE AREA m²	POS AREA m²	BUSH FOREVER AREA m²
N	159532	79520	24397	38861	16754	-
S1S2	288246	114169	-	67332	13220	93525

SUB-CATCHMENT DATA

CATCHMENT	TOTAL AREA m²	LOT AREA m²	COMMERCIAL LOT AREA m²	ROAD RESERVE AREA m²	POS AREA m²
NSW1	45634	26222	-	12466	-
NSW2	39378	-	30873	8505	-
NSW3	48170	36150	-	12020	-
SSW1	58170	36826	-	21344	-
SSW2	89900	61368	-	28532	-

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L	4/9/20	JEG	UPDATED WITH LANDSCAPERS DESIGN — SRA
R	31/7/24	JEG	UPDATED LAYOUT, AMENDED CATCHMENT SSW2 — SRA
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P	22/11/23	JEG	UPDATED LAYOUT, UPDATED DESIGN — SRA
O	5/10/23	JEG	UPDATED LAYOUT — SRA

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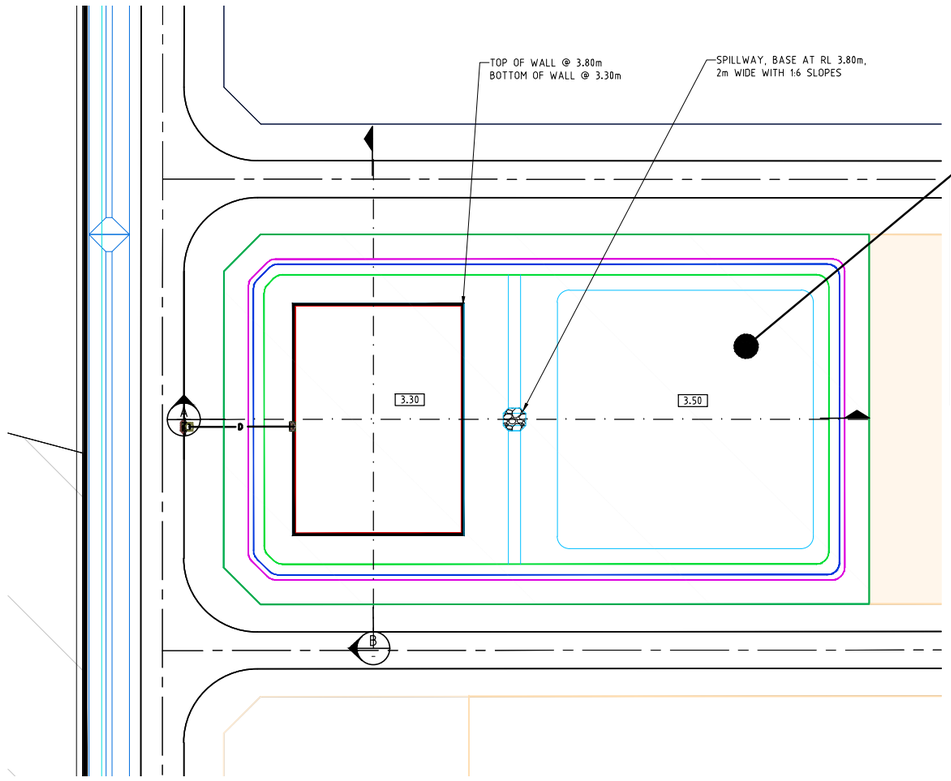
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PROJECT: **LOTS 877 & 878 STAKEHILL RD BALDIVIS**
W.A.P.C. No. -

DRAWING: **WATER MANAGEMENT STRATEGY POST-DEVELOPMENT CATCHMENT PLAN**
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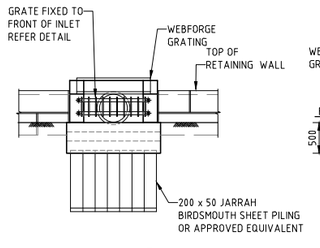
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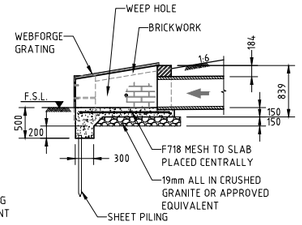


BASIN DETAILS - CATCHMENT N

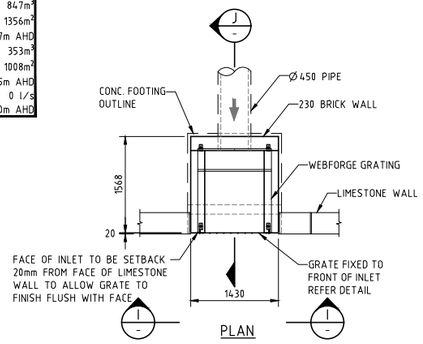
TOTAL IMPERVIOUS AREA (1%)	4.53ha
1% AEP STORAGE REQUIRED	3465m³
AREA AT TWL (1% AEP)	4126m²
RL (TWL) (1% AEP)	4.50m AHD
10% AEP STORAGE REQUIRED	1279m³
AREA AT TWL (10% AEP)	1626m²
RL (TWL) (10% AEP)	4.36m AHD
20% AEP STORAGE REQUIRED	847m³
AREA AT TWL (20% AEP)	1356m²
RL (TWL) (20% AEP)	4.07m AHD
1EY STORAGE REQUIRED	353m³
AREA AT TWL (1EY)	1008m²
RL (TWL) (1EY)	3.65m AHD
PEAK OUTFLOW (1% AEP)	0 l/s
BASE RL (LWL)	3.30m AHD



ELEVATION
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SECTION
1:50

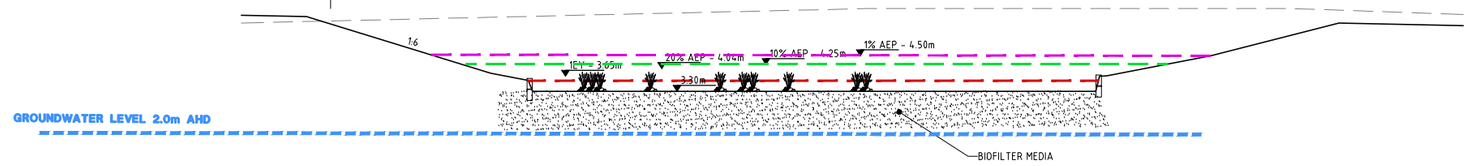


PLAN

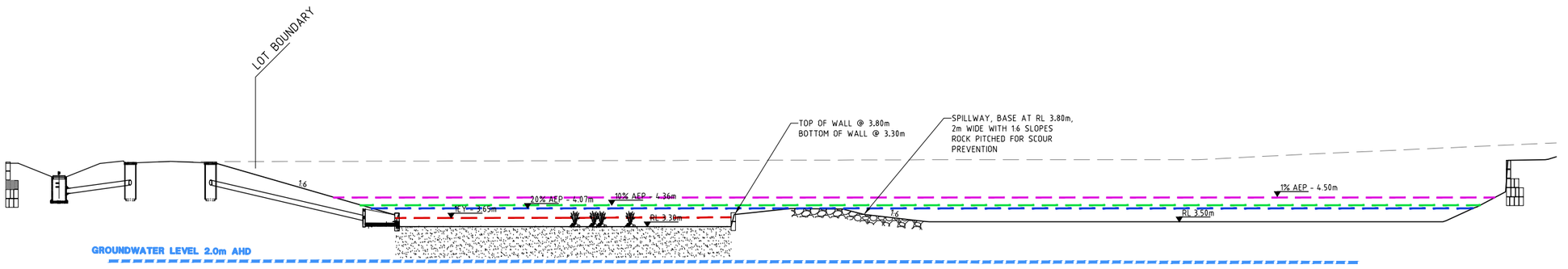
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1:50

LEGEND

- SITE BOUNDARY
- CATCHMENT AREA
- 23 — NATURAL SURFACE CONTOURS
- 2.00 — GROUND WATER CONTOURS
- DRAINAGE BASIN
- OVERLAND FLOW ARROW
- 1 EY STORAGE
- 20% AEP STORAGE
- 10% AEP STORAGE
- 1% AEP STORAGE
- MB01 (NAME)
  E 672.299m
  N 434.168m
  RL 0.00m (SURFACE LEVEL)
  2.5m (DEPTH)
  Ø150 (BORE DIAMETER)
  — MONITORING BORE



TYPICAL DETAIL
SECTION B



TYPICAL DETAIL
SECTION A
NOT TO SCALE

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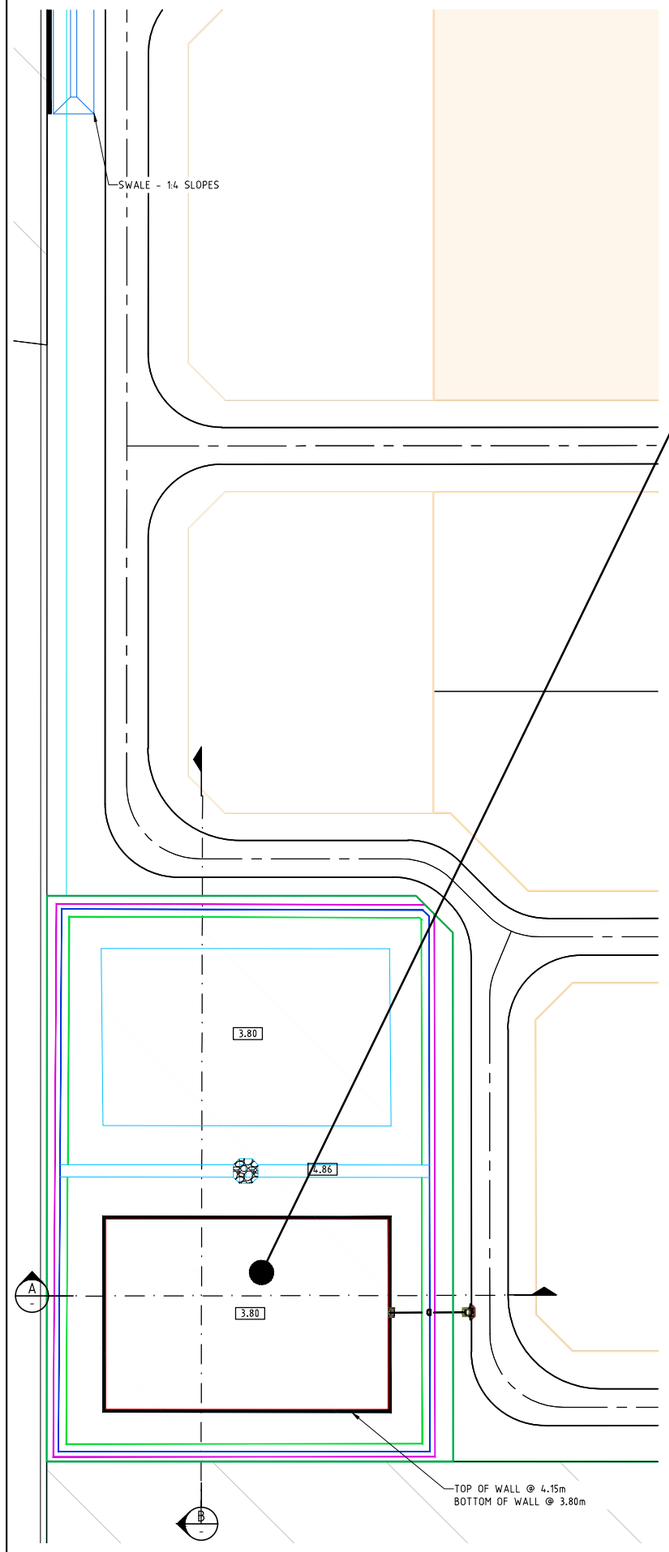
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Fax: (08) 9481 1700

PROJECT: **LOTS 877 & 878 STAKEHILL RD BALDIVIS**
W.A.P.C. No. -

DRAWING: **WATER MANAGEMENT STRATEGY NORTH CATCHMENT BASIN DETAILS**
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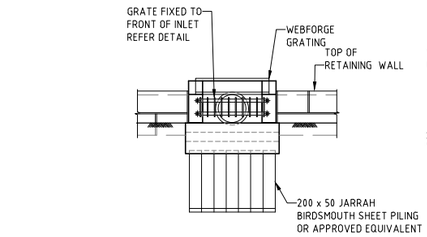
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DATE 4/8/20	DESIGNED JEG	APPROVED SRA	

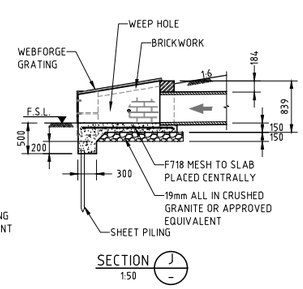
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BASIN DETAILS - CATCHMENT S1S2

TOTAL IMPERVIOUS AREA (1%)	6.12ha
1% AEP STORAGE REQUIRED	4555m³
AREA AT TWL (1% AEP)	5061m²
RL (TWL) (1% AEP)	5.00m AHD
10% AEP STORAGE REQUIRED	1773m³
AREA AT TWL (10% AEP)	2160m²
RL (TWL) (10% AEP)	4.86m AHD
20% AEP STORAGE REQUIRED	1344m³
AREA AT TWL (20% AEP)	1932m²
RL (TWL) (20% AEP)	4.65m AHD
1EY STORAGE REQUIRED	637m³
AREA AT TWL (1EY)	1523m²
RL (TWL) (1EY)	4.24m AHD
PEAK OUTFLOW (1% AEP)	0 l/s
BASE RL (LWL)	3.80m AHD

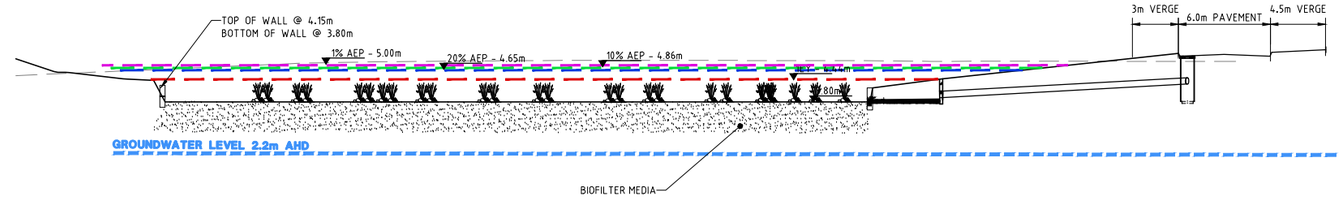




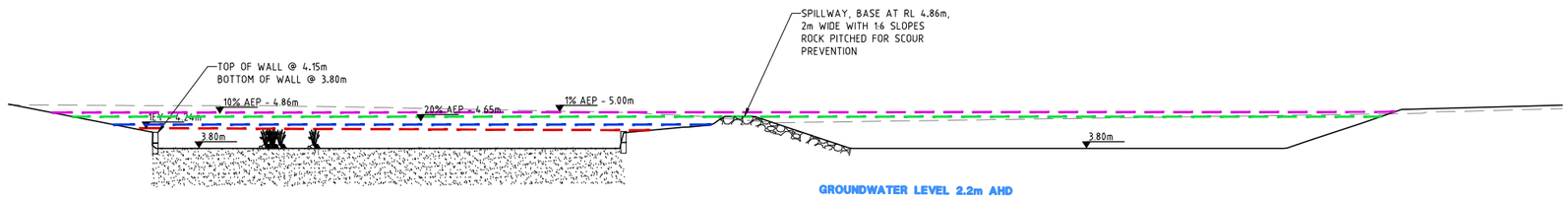
Ø450 OUTLET STRUCTURE
1:50

LEGEND

- SITE BOUNDARY
- CATCHMENT AREA
- 23 — NATURAL SURFACE CONTOURS
- 2.00 — GROUND WATER CONTOURS
- DRAINAGE BASIN
- OVERLAND FLOW ARROW
- 1 EY STORAGE
- 20% AEP STORAGE
- 10% AEP STORAGE
- 1% AEP STORAGE
- MB01 — NAME; E 674.967m, N 429.067m, R.L.8.00m — SURFACE LEVEL; 2.5m — DEPTH; Ø150 — BORE DIAMETER — MONITORING BORE
- BUSH FOREVER SITE



TYPICAL DETAIL SECTION A



TYPICAL DETAIL SECTION B
NOT TO SCALE

1:500 (A1)

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No.	DATE	BY	REVISION	
E	22/11/23	JEG	UPDATED LAYOUT AND DESIGN	SRA
D	9/9/20	JEG	UPDATED DESIGN	SRA
C	4/9/20	JEG	UPDATED WITH LANDSCAPERS DESIGN	SRA
B	18/8/20	JEG	UPDATED LAYOUT	SRA
A	4/8/20	JEG	INITIAL ISSUE	SRA

CLIENT: **TERRANOVIS**

DEVELOPMENT ENGINEERING CONSULTANTS
SUITE 3, 123A COLIN ST, WEST PERTH, 6005 WESTERN AUSTRALIA
Ph: (08) 9481 1900
Fax: (08) 9481 1700

PROJECT: **LOTS 877 & 878 STAKEHILL RD BALDIVIS**
W.A.P.C. No. -

DRAWING: **WATER MANAGEMENT STRATEGY S1S2 CATCHMENT BASIN DETAILS**
CAD DRAWING DO NOT MANUALLY ALTER
Z:\Proposals\PRO1043 - Terranovis - Lots 877 & 878 Stakehill Road, Baldivis\Design\Drawings\PRO1043 L06.dwg 22/11/2023

SCALE	DRAWN	CHECK	REV No.
1:500	JEG	SRA	E
DATE	DESIGNED	APPROVED	
4/8/20	JEG	SRA	

PROJECT NUMBER: **PRO1043**
DRAWING NUMBER: **L06**

DEVELOPMENT
ENGINEERING
CONSULTANTS

APPENDIX C – DRAINAGE CALCULATIONS

- **PC Sump Outputs – 63.2%, 20%, 10% & 1% AEP Storm Events**
- **PC Sump Inputs – At Lot calculations to establish Initial and Continuing Loss**
- **Typical Lot Drainage Calculations**

PCSump Version 6.1

Environmental and Water Resource Software

Project Number/Name: Lots 877 and 878 Stakehill Road, Baldivis

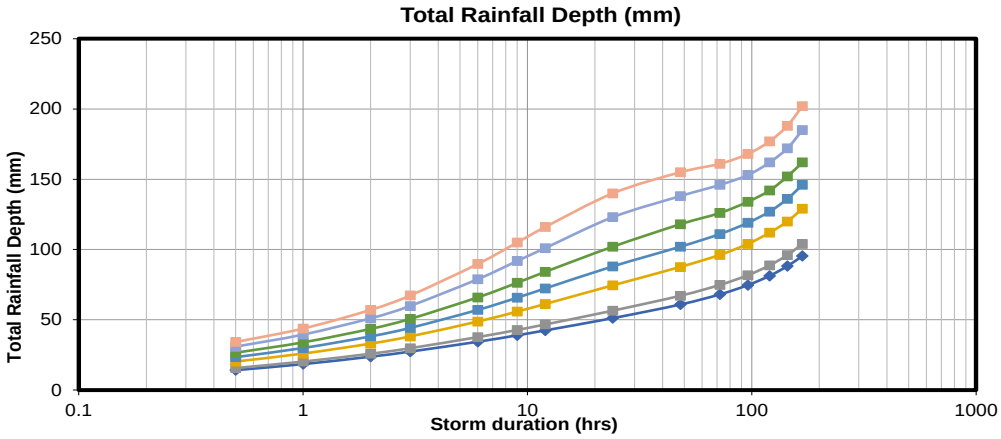
Project Description: Basin North(N)

Model Selection:	Shallow Water Table Model
Design AEP(EY)/ARI	1% AEP (100 year ARI)
Design Rainfall Region:	Perth Metro
Design Rainfall Location:	Rockingham
Latitude:	-32.28342204
Longitude:	115.7114576
Temporal Pattern:	West Flatlands
Climate Change Selection (Y/N)	N
Effective Service Life	
Consequence of Failure	
Adjustment Applied	

Swale Selection (Y/N)	Y

Total Rainfall Depth (mm)

Duration	EY	Annual Exceedance Probability (AEP)					
	1 EY	50%	20%	10%	5%	2%	1%
30 min	14.2	15.7	20.2	23.4	26.5	30.8	34.2
1 hour	18.5	20.3	25.9	29.9	33.9	39.4	43.8
2 hour	23.8	25.9	33	38.2	43.5	51	57.1
3 hour	27.4	29.8	38.1	44.2	50.6	59.8	67.3
6 hour	34.4	37.7	48.7	57	65.9	78.8	89.7
9 hour	39	42.8	55.8	65.7	76.3	91.8	105
12 hour	42.5	46.7	61.2	72.3	84.1	101	116
24 hour	51.2	56.5	74.5	88	102	123	140
48 hour	60.9	67.1	87.6	102	118	138	155
72 hour	68.1	74.8	96.2	111	126	146	161
96 hour	74.7	81.7	104	119	134	153	168
120 hour	81.3	88.7	112	127	142	162	177
144 hour	88.2	96	120	136	152	172	188
168 hour	95.4	104	129	146	162	185	202



Swale 1:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Resi Lots	2.446	12	19.15	
Roads	1.4093			30.0%

Swale 2:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Comm Lots	3.026	25	5.6	
Roads	0.927			30.0%

Swale 3:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Resi Lots	3.48	12	19.15	
Roads	1.114			30.0%

Swale Geometry:

Swale Length (m)	180.0
Swale Base Width (m)	0.0
Left Batter (1 in X)	6.0
Right Batter (1 in X)	6.0
Ave. Swale Base Elevation (mAHD)	9.50
Maximum Swale Depth (m)	0.30
Swale Slope (m/m)	0.003
Manning's Roughness	0.03

Soil Characteristics:

Saturated Hydraulic Cond. (m/day)	5
Design Groundwater Level	2.6
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	

Swale Geometry:

Swale Length (m)	150
Swale Base Width (m)	1
Left Batter (1 in X)	4
Right Batter (1 in X)	4
Ave. Swale Base Elevation (mAHD)	4.8
Maximum Swale Depth (m)	0.5
Swale Slope (m/m)	0.003
Manning's Roughness	0.03

Soil Characteristics:

Saturated Hydraulic Cond. (m/day)	5
Design Groundwater Level	2.6
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	

Swale Geometry:

Swale Length (m)	240
Swale Base Width (m)	1
Left Batter (1 in X)	4
Right Batter (1 in X)	4
Ave. Swale Base Elevation (mAHD)	5
Maximum Swale Depth (m)	0.5
Swale Slope (m/m)	0.003
Manning's Roughness	0.03

Soil Characteristics:

Saturated Hydraulic Cond. (m/day)	5
Design Groundwater Level	2.6
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	

Basin:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Resi Lots	2.026	12	19.15	
Comm Lots		25	5.6	
Basin	0.45			0.0%
POS	1.2254			100.0%
Roads	0.4358	2		30.0%

Basin Parameters:

Soil Characteristics:	
Saturated Hydraulic Cond. (m/day)	5
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	
Soil Suction (cm)	
Porosity	
Aquifer Storage Coefficient	0.2
Base of Aquifer (mAHD)	-14
Design Groundwater Level (mAHD)	2.7
Initial Conditions:	
Water Depth in Basin (m)	0
Wetting Front Depth (m)	0
Initial Degree of Soil Saturation (%)	0%
Basin Geometry:	
Stage-Area-Volume Relationship Entered (Y/N)	Y
Base Length (m)	60
Base Width (m)	36
Average Slope (1 in X)	6

Stage-Area-Volume Relationship:

Stage (mAHD)	Area (m^2)	Volume (m^3)
3.3	1000	0
3.65	1000	353
4.36	1626	1279

Basin Base Elevation (mAHD)	3.3
Maximum Allowable TWL (mAHD)	5

4.5	4126	3465

Pipe Outflow:

Entrance Type	
Pipe Diameter (mm)	
Pipe Length (m)	
Upstream Invert Level (mAHD)	
Downstream Invert Level (mAHD)	

Weir Outflow:

Weir Type:	
Weir Coefficient	
Weir Width (m)	
Weir Level (mAHD)	

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Environmental and Water Resource Software

Project Number / Name:

Lots 877 and 878 Stakehill Road, Baldivis

Project Description:

Basin South(N)

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	14.2	1 EY	0.18	3.48	1.02	177	1,000	2
	2	1 hour	18.5	1 EY	0.25	3.55	0.95	251	1,000	9
	3	2 hour	23.8	1 EY	0.32	3.62	0.88	322	1,000	3
	4	3 hour	27.4	1 EY	0.19	3.49	1.01	190	1,000	2
	5	6 hour	34.4	1 EY	0.22	3.52	0.98	224	1,000	9
	6	9 hour	39.0	1 EY	0.09	3.39	1.11	92	1,000	5
	7	12 hour	42.5	1 EY	0.07	3.37	1.13	71	1,000	5
	8	24 hour	51.2	1 EY	0.08	3.38	1.12	78	1,000	5
	9	48 hour	60.9	1 EY	0.03	3.33	1.17	25	1,000	2
	10	72 hour	68.1	1 EY	0.08	3.38	1.12	81	1,000	4
Critical	***3***	***2 hour***	***23.8***	***1 EY***	***0.32***	***3.62***	***0.88***	***322***	***1,000***	***3***

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

Lots 877 and 878 Stakehill Road, Baldivis

Project Description:

Basin South (N)

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	20.2	20%	0.55	3.85	0.65	613	1,175	8
	2	1 hour	25.9	20%	0.61	3.91	0.59	694	1,231	1
	3	2 hour	33.0	20%	0.8	4.10	0.40	943	1,399	3
	4	3 hour	38.1	20%	0.72	4.02	0.48	830	1,322	3
	5	6 hour	48.7	20%	0.69	3.99	0.51	790	1,296	3
	6	9 hour	55.8	20%	0.42	3.72	0.78	443	1,061	10
	7	12 hour	61.2	20%	0.32	3.62	0.88	319	1,000	1
	8	24 hour	74.5	20%	0.26	3.56	0.94	265	1,000	2
	9	48 hour	87.6	20%	0.09	3.39	1.11	93	1,000	2
	10	72 hour	96.2	20%	0.18	3.48	1.02	186	1,000	4
Critical	***3***	***2 hour***	***33.0***	***20%***	***0.8***	***4.10***	***0.40***	***943***	***1,399***	***3***

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

Lots 877 and 878 Stakehill Road, Baldivis

Project Description:

Basin South (N)

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	23.4	10%	0.77	4.07	0.43	899	1,369	5
	2	1 hour	29.9	10%	0.9	4.20	0.30	1,070	1,485	6
	3	2 hour	38.2	10%	1.05	4.35	0.15	1,265	1,617	4
	4	3 hour	44.2	10%	1.03	4.33	0.17	1,234	1,596	8
	5	6 hour	57.0	10%	0.81	4.11	0.39	958	1,409	2
	6	9 hour	65.7	10%	0.68	3.98	0.52	777	1,287	3
	7	12 hour	72.3	10%	0.49	3.79	0.71	539	1,126	4
	8	24 hour	88.0	10%	0.36	3.66	0.84	367	1,009	7
	9	48 hour	102.0	10%	0.18	3.48	1.02	179	1,000	4
	10	72 hour	111.0	10%	0.13	3.43	1.07	130	1,000	7
Critical	***3***	***2 hour***	***38.2***	***10%***	***1.05***	***4.35***	***0.15***	***1,265***	***1,617***	***4***

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

Lots 877 and 878 Stakehill Road, Baldivis

Project Description:

Basin South (N)

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	34.2	1%	1.12	4.42	0.08	2,239	2,724	5
	2	1 hour	43.8	1%	1.15	4.45	0.05	2,677	3,225	10
	3	2 hour	57.1	1%	1.2	4.50	0.00	3,387	4,037	4
	4	3 hour	67.3	1%	1.17	4.47	0.03	2,962	3,551	3
	5	6 hour	89.7	1%	1.17	4.47	0.03	2,971	3,561	6
	6	9 hour	105.0	1%	1.18	4.48	0.02	3,076	3,681	1
	7	12 hour	116.0	1%	1.1	4.40	0.10	1,895	2,330	7
	8	24 hour	140.0	1%	1.03	4.33	0.17	1,239	1,599	1
	9	48 hour	155.0	1%	0.57	3.87	0.63	643	1,196	10
	10	72 hour	161.0	1%	0.48	3.78	0.72	524	1,116	4
Critical	***3***	***2 hour***	***57.1***	***1%***	***1.2***	***4.50***	***0.00***	***3,387***	***4,037***	***4***

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

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Environmental and Water Resource Software

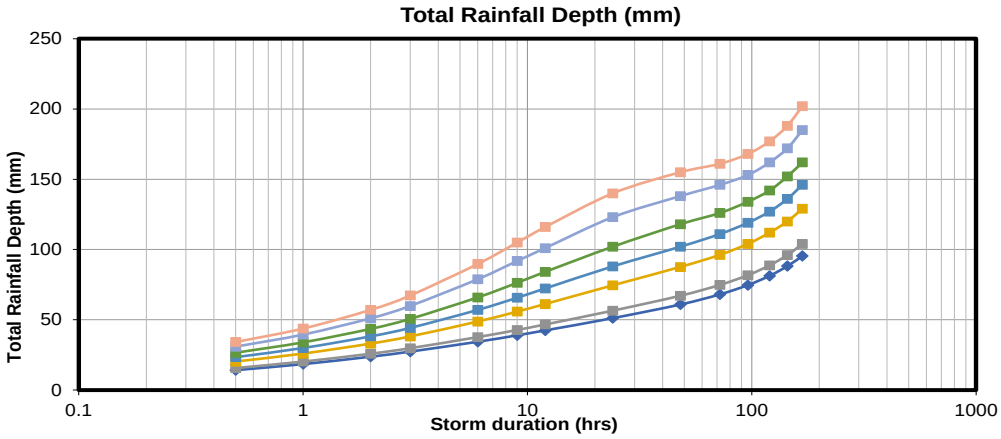
Project Number/Name:	Lots 877 and 878 Stakehill Road, Baldivis
Project Description:	Basin S

Model Selection:	Shallow Water Table Model
Design AEP(EY)/ARI	1% AEP (100 year ARI)
Design Rainfall Region:	Perth Metro
Design Rainfall Location:	Rockingham
Latitude:	-32.28342204
Longitude:	115.7114576
Temporal Pattern:	West Flatlands
Climate Change Selection (Y/N)	N
Effective Service Life	
Consequence of Failure	
Adjustment Applied	

Swale Selection (Y/N)	Y

Total Rainfall Depth (mm)

Duration	EY	Annual Exceedance Probability (AEP)					
	1 EY	50%	20%	10%	5%	2%	1%
30 min	14.2	15.7	20.2	23.4	26.5	30.8	34.2
1 hour	18.5	20.3	25.9	29.9	33.9	39.4	43.8
2 hour	23.8	25.9	33	38.2	43.5	51	57.1
3 hour	27.4	29.8	38.1	44.2	50.6	59.8	67.3
6 hour	34.4	37.7	48.7	57	65.9	78.8	89.7
9 hour	39	42.8	55.8	65.7	76.3	91.8	105
12 hour	42.5	46.7	61.2	72.3	84.1	101	116
24 hour	51.2	56.5	74.5	88	102	123	140
48 hour	60.9	67.1	87.6	102	118	138	155
72 hour	68.1	74.8	96.2	111	126	146	161
96 hour	74.7	81.7	104	119	134	153	168
120 hour	81.3	88.7	112	127	142	162	177
144 hour	88.2	96	120	136	152	172	188
168 hour	95.4	104	129	146	162	185	202



Swale 1:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Resi Lots	3.7421	12	19.15	
Roads	2.008			30.0%

Swale 2:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Resi Lots	6.586	12	19.15	
Roads	3.046			30.0%

Swale Geometry:

Swale Length (m)	150.0
Swale Base Width (m)	0.0
Left Batter (1 in X)	6.0
Right Batter (1 in X)	6.0
Ave. Swale Base Elevation (mAHD)	9.00
Maximum Swale Depth (m)	0.30
Swale Slope (m/m)	0.003
Manning's Roughness	0.03

Soil Characteristics:

Saturated Hydraulic Cond. (m/day)	5
Design Groundwater Level	2.7
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	

Swale Geometry:

Swale Length (m)	570
Swale Base Width (m)	1
Left Batter (1 in X)	4
Right Batter (1 in X)	4
Ave. Swale Base Elevation (mAHD)	5.3
Maximum Swale Depth (m)	0.5
Swale Slope (m/m)	0.003
Manning's Roughness	0.03

Soil Characteristics:

Saturated Hydraulic Cond. (m/day)	5
Design Groundwater Level	2.7
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	

Basin:

Type	Area (ha)	IL (mm)	CL (mm/hr)	PL(%)
Resi Lots	1.2937	12	19.15	
Comm Lots		25	5.6	
Basin	0.3			0.0%
POS	0.812			100.0%
Roads	1.4743	2		30.0%

Basin Parameters:

Soil Characteristics:	
Saturated Hydraulic Cond. (m/day)	5
Clogged Layer Permeability (m/day)	
Clogged Layer Thickness (mm)	
Soil Suction (cm)	
Porosity	
Aquifer Storage Coefficient	0.2
Base of Aquifer (mAHD)	-14
Design Groundwater Level (mAHD)	2.7
Initial Conditions:	
Water Depth in Basin (m)	0
Wetting Front Depth (m)	0
Initial Degree of Soil Saturation (%)	0%
Basin Geometry:	
Stage-Area-Volume Relationship Entered (Y/N)	Y
Base Length (m)	76
Base Width (m)	36
Average Slope (1 in X)	6

Stage-Area-Volume Relationship:

Stage (mAHD)	Area (m^2)	Volume (m^3)
3.8	1440	0
4.15	1440	504
4.86	2160	1773

Basin Base Elevation (mAHD)	3.8
Maximum Allowable TWL (mAHD)	5

Pipe Outflow:

Entrance Type	
Pipe Diameter (mm)	
Pipe Length (m)	
Upstream Invert Level (mAHD)	
Downstream Invert Level (mAHD)	

Weir Outflow:

Weir Type:	
Weir Coefficient	
Weir Width (m)	
Weir Level (mAHD)	

5	5061	4555

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Project Number / Name:

Lots 877 and 878 Stakehill Road, Baldivis

Project Description:

Basin S

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	14.2	1 EY	0.22	4.02	0.98	317	1,440	7
	2	1 hour	18.5	1 EY	0.31	4.11	0.89	444	1,440	9
	3	2 hour	23.8	1 EY	0.41	4.21	0.79	611	1,501	3
	4	3 hour	27.4	1 EY	0.26	4.06	0.94	369	1,440	6
	5	6 hour	34.4	1 EY	0.19	3.99	1.01	275	1,440	6
	6	9 hour	39.0	1 EY	0.12	3.92	1.08	176	1,440	6
	7	12 hour	42.5	1 EY	0.08	3.88	1.12	114	1,440	2
	8	24 hour	51.2	1 EY	0.11	3.91	1.09	159	1,440	5
	9	48 hour	60.9	1 EY	0.03	3.83	1.17	41	1,440	2
	10	72 hour	68.1	1 EY	0.08	3.88	1.12	110	1,440	4
Critical	***3***	***2 hour***	***23.8***	***1 EY***	***0.41***	***4.21***	***0.79***	***611***	***1,501***	***3***

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

Lots 877 and 878 Stakehill Road, Baldivis

Project Description:

Basin S

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	20.2	20%	0.63	4.43	0.57	1,012	1,729	1
	2	1 hour	25.9	20%	0.7	4.50	0.50	1,132	1,796	7
	3	2 hour	33.0	20%	0.81	4.61	0.39	1,331	1,909	5
	4	3 hour	38.1	20%	0.61	4.41	0.59	961	1,699	6
	5	6 hour	48.7	20%	0.63	4.43	0.57	1,005	1,724	9
	6	9 hour	55.8	20%	0.39	4.19	0.81	577	1,481	6
	7	12 hour	61.2	20%	0.32	4.12	0.88	453	1,440	2
	8	24 hour	74.5	20%	0.26	4.06	0.94	380	1,440	5
	9	48 hour	87.6	20%	0.12	3.92	1.08	172	1,440	2
	10	72 hour	96.2	20%	0.2	4.00	1.00	294	1,440	4
Critical	***3***	***2 hour***	***33.0***	***20%***	***0.81***	***4.61***	***0.39***	***1,331***	***1,909***	***5***

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

Lots 877 and 878 Stakehill Road, Baldivis

Project Description:

Basin S

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	23.4	10%	0.87	4.67	0.33	1,436	1,969	5
	2	1 hour	29.9	10%	0.96	4.76	0.24	1,601	2,062	6
	3	2 hour	38.2	10%	1.04	4.84	0.16	1,744	2,144	4
	4	3 hour	44.2	10%	1.01	4.81	0.19	1,687	2,111	4
	5	6 hour	57.0	10%	0.71	4.51	0.49	1,147	1,805	4
	6	9 hour	65.7	10%	0.57	4.37	0.63	905	1,667	6
	7	12 hour	72.3	10%	0.41	4.21	0.79	610	1,500	6
	8	24 hour	88.0	10%	0.21	4.01	0.99	306	1,440	1
	9	48 hour	102.0	10%	0.18	3.98	1.02	262	1,440	7
	10	72 hour	111.0	10%	0.21	4.01	0.99	298	1,440	1
Critical	***3***	***2 hour***	***38.2***	***10%***	***1.04***	***4.84***	***0.16***	***1,744***	***2,144***	***4***

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

PCSUMP
Environmental and Water Resource Software

Project Number / Name:

Lots 877 and 878 Stakehill Road, Baldivis

Project Description:

Basin S

Model Selection: **Shallow Water Table Model**

Results:

	Design Storms				Maximum (Mean of Temporal Patterns)					
	Storm	Duration [hrs]	Rainfall Depth [mm]	EY/AEP [%]	Depth [m]	Level [mAHD]	Clearance to Allowable TWL [m]	Volume [m^3]	Area [m^2]	Temporal Pattern No.
	1	30 min	34.2	1%	1.13	4.93	0.07	3,092	3,535	5
	2	1 hour	43.8	1%	1.14	4.94	0.06	3,451	3,910	10
	3	2 hour	57.1	1%	1.19	4.99	0.01	4,320	4,816	4
	4	3 hour	67.3	1%	1.16	4.96	0.04	3,654	4,121	3
	5	6 hour	89.7	1%	1.14	4.94	0.06	3,399	3,856	6
	6	9 hour	105.0	1%	1.16	4.96	0.04	3,703	4,173	1
	7	12 hour	116.0	1%	0.97	4.77	0.23	1,605	2,065	4
	8	24 hour	140.0	1%	0.92	4.72	0.28	1,514	2,013	7
	9	48 hour	155.0	1%	0.52	4.32	0.68	809	1,613	9
	10	72 hour	161.0	1%	0.4	4.20	0.80	599	1,494	10
Critical	***3***	***2 hour***	***57.1***	***1%***	***1.19***	***4.99***	***0.01***	***4,320***	***4,816***	***4***

Notes:

Temporal pattern matching closest to mean water level

If Water Level is coloured Red, Maximum Capacity of the Basin has been Exceeded

Development Engineering Consultants - Drainage Basin Spreadsheet

Project: Lots 877 and 878 Stakehill Road, Baldivis

Client: Garbin

Location: At-lot detention calculations to establish runoff coefficient

Designer: SRA

Location:	**Stakehill Road, Baldivis**			
Nearest grid cell:	**Latitude**	**32.3125(S)**	**Longitude**	**115.8125(E)**

Data to be input

Rainfall AEP (percentage)	1	ARI	**v** Descriptor **v**
1EY impervious catchment (Ha)	0.025	100	Infrequent
Required storage (1EY - 1hr) (m^3)	3.881		

Catchment details	Paved area	Unpaved area	Total
Lot area (m^2)			**400.00**
Proportion paved	**70%**	**30%**	**100%**
Area paved (Ha)	**0.028**	**0.012**	**0.040**
Runoff coefficient (C_{10})	0.90	0.00	
ARI multiplier	1.00	1.20	
Runoff coefficient (C_y)	0.90	0.00	
Impervious area (Ha)	**0.025**	**0.000**	**0.025**

Effective C

0.63

AEP	ARI	Effective C	Multiplier
63.2	1	0	-
50	1.44	0	-
20	4.48	0	-
10	9.49	0	-
5	20	0	-
2	50	0.05	-
1	100	0.11	-

Volume and dimensions of available storage

Area above ground inundated to 0.03m deep (backyard and front yard) (m^2)	40.00	0.03	1.20
Storage provided manholes/pipe (m^3)	-		
Number of soakwells	2.00		
Diameter of soakwells (m)	1.50		
Depth of each soakwell (m)	1.20		
Storage required soakwells (m^3)	**4.24**		
Storage provided (m^3)	5.44		
Effective Initial Loss (mm)	**13.60**		
Soakage rate ($L/s/m^2$)	0.020	*1.70*	*m/day*

NOTE: All water is retained in soakwells up to and including 5% AEP (1 in 20yr ARI) without surcharge. For greater AEP storms water will surcharge soakwells and soak over an area of 40m² to a maximum depth of 30mm within the lot, and then enter the road drainage system.

Volume of storage required is 1m^3 per	**59.42 m^2**	**of paved lot area**
Volume of storage required is 1m^3 per	**73.51 m^2**	**of total lot area**

Development Engineering Consultants - Drainage Basin Spreadsheet

Project: **Lots 877 and 878 Stakehill Road, Baldivis**

Client: **Garbin**

Location: **At-lot detention calculations to establish runoff coefficient**

Designer: **SRA**

Location:	**Stakehill Road, Baldivis**			
Nearest grid cell:	**Latitude**	**32.3125(S)**	**Longitude**	**115.8125(E)**

DEVELOPMENT ENGINEERING CONSULTANTS

T_C (min)	T_C (hr)	I (mm/hr)	Q_{IN} (L/s)	Total V_{IN} (m^3)	Q_{OUT} (soakage) (L/s)	Effective Continuing Loss (mm/hr)	V_{OUT} (soakage) (m^3)	Net storage (after soakage) (m^3)	V_{OUT} required (m^3)	Q_{OUT} (L/s)
10	0.17	131.00	9.2	5.50	1.08	**9.71**	0.65	4.85	0.00	0.00
15	0.25	106.00	7.4	6.68	1.08	**9.71**	0.97	5.71	0.27	0.30
20	0.33	89.10	6.2	7.48	1.08	**9.71**	1.29	6.19	0.75	0.62
30	0.50	69.10	4.8	8.71	1.08	**9.71**	1.94	6.76	1.32	0.74
45	0.75	53.10	3.7	10.04	1.08	**9.71**	2.91	7.12	1.68	0.62
60	1.00	44.10	3.1	11.11	1.08	**9.71**	3.88	7.23	1.79	0.50
90	1.50	34.20	2.4	12.93	1.08	**9.71**	5.83	7.10	1.66	0.31
120	2.00	28.60	2.0	14.41	1.08	**9.71**	7.77	6.64	1.20	0.17
150	2.50	25.00	1.8	15.75	1.08	**9.71**	9.71	6.04	0.60	0.07
180	3.00	22.50	1.6	17.01	1.08	**9.71**	11.65	5.36	0.00	0.00
240	4.00	19.00	1.3	19.15	1.08	**9.71**	15.54	3.61	0.00	0.00
300	5.00	16.70	1.2	21.04	1.08	**9.71**	19.42	1.62	0.00	0.00
360	6.00	15.00	1.1	22.68	1.08	**9.71**	23.31	-0.63	0.00	0.00
480	8.00	12.60	0.9	25.40	1.08	**9.71**	31.08	-5.68	0.00	0.00
720	12.00	9.76	0.7	29.51	1.08	**9.71**	46.62	-17.10	0.00	0.00
960	16.00	8.02	0.6	32.34	1.08	**9.71**	62.16	-29.82	0.00	0.00
1440	24.00	5.95	0.4	35.99	1.08	**9.71**	93.23	-57.25	0.00	0.00
2880	48.00	3.35	0.2	40.52	1.08	**9.71**	186.47	-145.95	0.00	0.00
4320	72.00	2.35	0.2	42.64	1.08	**9.71**	279.70	-237.07	0.00	0.00

APPENDIX D – GROUNDWATER INFORMATION

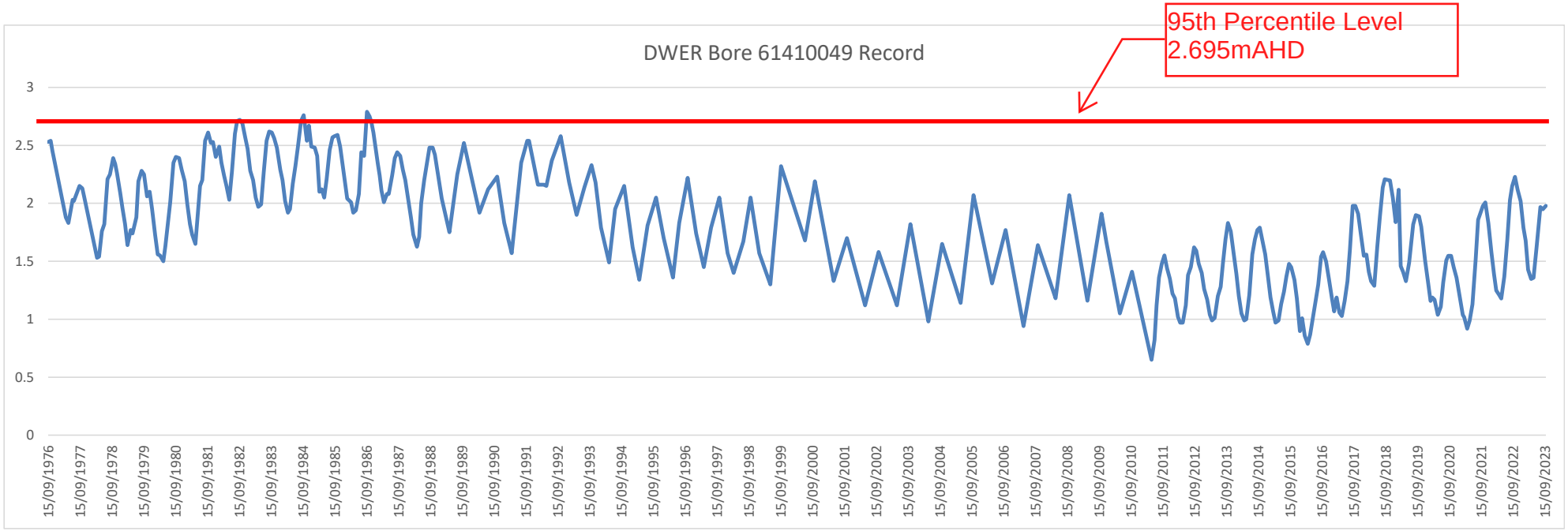
- Summary Monitoring Bore Data from lots 877 & 878
- DWER Groundwater levels for Bore Sites 61410049, 6140050 & 61410060
- Irrigation Water Analysis Report - Nov 2012
- GW License over lots 877 & 878 – September 2020 to September 2030

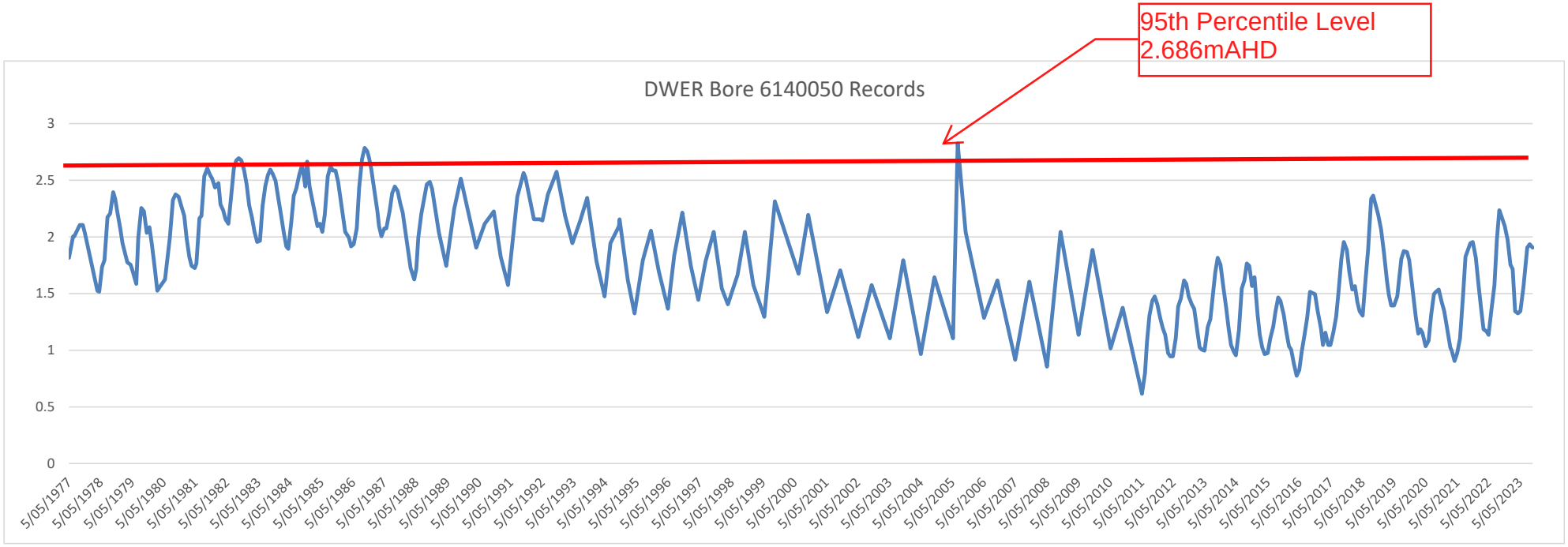
Bore Details

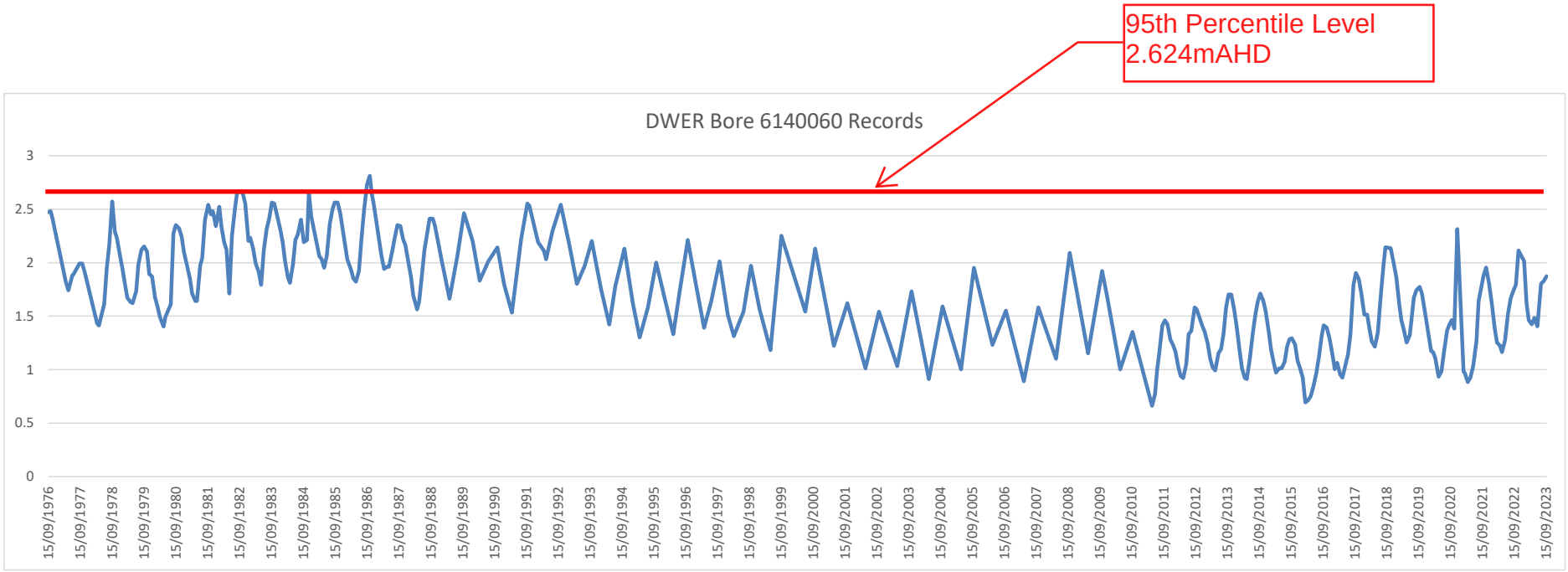
Bore#	PCG 94 - East	PCG 94 - North	MGA 50 - East	MGA 50 - North	RL of Top of casing	GL (m) base of casing	Height (m) of cap above GL
MB01	48253.39	214973.44	386953.30	6415769.03	10.12	9.45	0.67
MB02	48258.56	214556.69	386963.07	6415352.47	18.70	18.03	0.67
MB03	47752.61	214158.97	386461.67	6414949.27	5.78	5.18	0.60
MB04	47743.83	214595.93	386448.07	6415386.01	6.87	6.09	0.78
MB05	47748.27	214875.85	386449.41	6415665.89	6.28	5.69	0.59

9.00 **SUMMARY OF RESULTS**

	Groundwater Levels	Date of Max. >	27-Sep-18	Date of Max. >	27-Sep-18	Date of Max. >	27-Sep-18	Date of Max. >	27-Sep-18	Date of Max. >	27-Sep-18	
		Max. value >	2.21	Max. value >	2.18	Max. value >	2.23	Max. value >	2.19	Max. value >	2.20	
	Bore No. >>>	**MB01**		**MB02**		**MB03**		**MB04**		**MB05**		
	v Date of Reading v	Depth to GWL from Top of casing	RL GWL (m)	Depth to GWL from Top of casing	RL GWL (m)	Depth to GWL from Top of casing	RL GWL (m)	Depth to GWL from Top of casing	RL GWL (m)	Depth to GWL from Top of casing	RL GWL (m)	
1	29-Jun-17	8.891	1.23	17.595	1.11	4.611	1.17	5.726	1.14	5.145	1.14	
2	30-Aug-17	8.275	1.85	16.871	1.83	3.908	1.87	5.035	1.84	4.426	1.85	
3	03-Oct-17	8.203	1.92	16.821	1.88	3.835	1.95	4.967	1.90	4.384	1.90	< 2017 Max.
4	03-Nov-17	8.267	1.85	16.879	1.82	3.897	1.88	5.029	1.84	4.437	1.84	
5	05-Dec-17	8.426	1.69	17.043	1.66	4.066	1.71	5.185	1.69	4.608	1.67	
6	08-Mar-18	8.759	1.36	17.364	1.34	4.39	1.39	5.505	1.37	4.916	1.36	
7	20-Jun-18	8.644	1.48	17.263	1.44	4.273	1.51	5.407	1.46	4.807	1.47	
8	27-Aug-18	7.995	2.13	16.613	2.09	3.631	2.15	4.752	2.12	4.163	2.12	
9	27-Sep-18	7.915	2.21	16.522	2.18	3.547	2.23	4.677	2.19	4.081	2.20	< 2018 Max.
10	25-Oct-18	7.931	2.19	16.541	2.16	3.568	2.21	4.693	2.18	4.105	2.18	
11	23-Nov-18	8.06	2.06	16.673	2.03	3.699	2.08	4.816	2.05	4.245	2.04	


DWER Bore 61410049 Record
95th Percentile Level
2.695mAHD
3
2.5
2
1.5
1
0.5
0
15/09/1976
15/09/1977
15/09/1978
15/09/1979
15/09/1980
15/09/1981
15/09/1982
15/09/1983
15/09/1984
15/09/1985
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15/09/2014
15/09/2015
15/09/2016
15/09/2017
15/09/2018
15/09/2019
15/09/2020
15/09/2021
15/09/2022
15/09/2023


95th Percentile Level
2.686mAHD
DWER Bore 6140050 Records
3
2.5
2
1.5
1
0.5
0
5/05/1977
5/05/1978
5/05/1979
5/05/1980
5/05/1981
5/05/1982
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5/05/2019
5/05/2020
5/05/2021
5/05/2022
5/05/2023


95th Percentile Level
2.624mAHD
DWER Bore 6140060 Records
3
2.5
2
1.5
1
0.5
0
15/09/1976
15/09/1977
15/09/1978
15/09/1979
15/09/1980
15/09/1981
15/09/1982
15/09/1983
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15/09/2021
15/09/2022
15/09/2023

AQUASURE

IRRIGATION WATER ANALYSIS REPORT

AGVITA ANALYTICAL

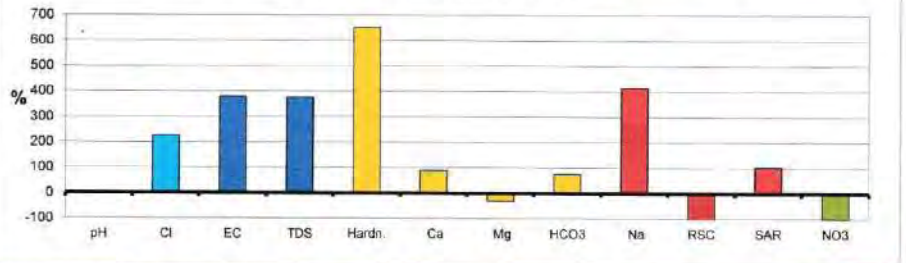
ABN 58 129 916 310
PO Box 188
Devonport, TAS, 7310
Ph: 03 6420 9600
Fax: 03 6427 0230
mailto:info@agvita.com.au

Client Name:	ACE OHLSSON P/L
Grower Name:	GARBIN
Sample ID:	DAM
Consultant:	TALLY MATTHEWS
Report date:	21/11/2012
Order Number:	

Water Quality:	YOUR RESULT	Optimal level	Unit	STATUS
Acidity or Alkalinity pH	7.7	6 - 7.4	N/A	
Electrical Conductivity - EC	3.12	0.65	dS/m	
Sodium Absorption Ratio - SAR	6.1	3	meq/L	
Chloride - Cl	652	200	ppm	
Hardness -calcite	751.8	100	ppm	
Carbonate - CO3	0.00	0.5	meq/L	
	1.5	30	ppm	
Bicarbonate - HCO3	3.50	2	meq/L	
	280.8	140	ppm	
Total Dissolved Salts - TDS	1997.00	420	ppm	
Residual Sodium Carbonate - RSC	-11.53	1.25	meq/L	
Cations:	**YOUR RESULT**	**Recommended upper limit**	**Unit**	**STATUS**
Sodium - Na	381.2	74	ppm	
	16.58	3.20	meq/L	
Calcium - Ca	188	100	ppm	
	9.38	5.00	meq/L	
Magnesium - Mg	68.6	100	ppm	
	5.64	8.30	meq/L	
Potassium - K	34.8	15	ppm	
	0.89	0.38	meq/L	
Other nutrients:	**YOUR RESULT**	**Recommended upper limit**	**Unit**	**STATUS**
Phosphorus - P	0	0.2	ppm	
Nitrate - NO3	0	40	ppm	
Zinc - Zn	0.02	2.0	ppm	
Boron - B	0.18	0.2	ppm	
Sulphur - S	114.77	25	ppm	
Copper - Cu	0	0.2	ppm	
Iron - Fe	0.95	1.0	ppm	
Manganese - Mn	0.06	0.2	ppm	
Molybdenum - Mo	0.005	0.02	ppm	
Total Dissolved Ions - TDI	1723	420	ppm	

Your water quality result as percent (%) of the recommended concentration limit

negative % values = % below limit, positive % values = % above limit

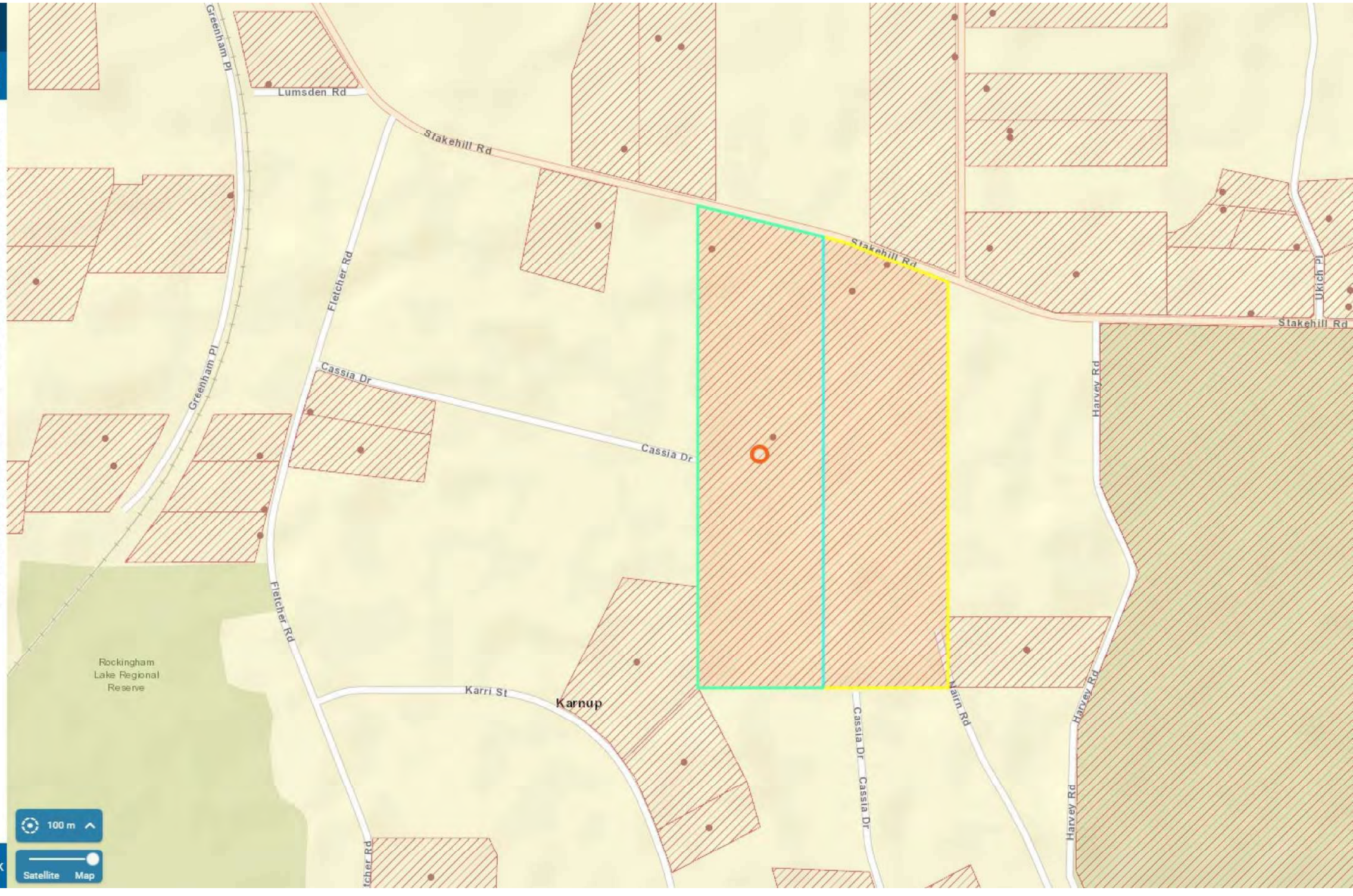


Analysis by AgVita Analytical

The information within this report should be used as part of a crop-monitoring program and under consideration of particular production conditions. Desirable levels are derived from ongoing research carried out by AgVita Analytical Pty. Ltd. The interpretation of analytical results presumes specific sampling, sample handling, extraction and analytical procedures. Results may be incompatible with interpretation dates developed via different procedures. AgVita Analytical Pty. Ltd and its employees or agents will not be liable for any loss or damage arising from application or interpretation of the data supplied. Please seek guidance on local interpretations and recommendations from your agronomist.

of 1

	63216
	Groundwater Licence
	30/9/2020
	30/9/2030
	540000 KL
	n, Garbin, Jerina; Garbin, Josko Michael
	9 Stakehill Rd Karnup WA 6176 Australia
	Stakehill
	Churcher East
	ial Swan and Rockingham Sand
	'AKEHILL RD, KARNUP; Lot 877 an 202761, Volume 1293, Folio 877 Stakehill Rd, Karnup, 6176
	No
	No
	No
	No
	No



mber: 63216 Track

Appendix 5

Acoustic Assessment (2025)

SUBDIVISION

LOT 877 & 878 STAKEHILL RD, KARNUP

ROAD TRAFFIC (SPP 5.4) NOISE MANAGEMENT PLAN

MAY 2025

OUR REFERENCE: 34634-1-25161

Rochdale Holdings Pty Ltd A.B.N. 85 009 049 067 trading as:
HERRING STORER ACOUSTICS
P.O. Box 219, Como, W.A. 6952
(08) 9367 6200
hsa@hsacoustics.com.au

DOCUMENT CONTROL PAGE

SPP 5.4 NOISE MANAGEMENT PLAN
STAKEHILL ROAD, KARNUP

Job No: 34161

Document Reference: 34634-1-25161

FOR

TERRANOVIS

DOCUMENT INFORMATION			
Author:	Tim Reynolds	**Checked By:**	Paul Daly
Date of Issue:	26 May 2025		

REVISION HISTORY

Revision	Description	Date	Author	Checked

DOCUMENT DISTRIBUTION

Copy No.	Version No.	Destination	Hard Copy	Electronic Copy
1	1	Terranovis Attn : Warren Spencer Email : warren@terranovis.com.au		✓

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1.	INTRODUCTION		1
2.	CRITERIA		1
	2.1	ROAD TRAFFIC NOISE	1
	2.2	Appropriate Criteria	4
3.	MODELLING		4
4.	TRAFFIC NOISE ASSESSMENT		6

APPENDICIES

A Subdivision Plan

B Noise Contour Plots

C Lot Requiring Quiet House Design and Notification on Titles

D "Quiet House" Design – General Information

EXECUTIVE SUMMARY

Herring Storer Acoustics were commissioned by Terranovis to carry out an acoustical assessment of noise received at the Subdivision stage of the residential development located at Lots 877 and 878 Stakehill Road, Baldivis.

Under the Western Australian Planning Commission (WAPC) Planning Policy 5.4 "Road and Rail Noise" (SPP 5.4), the appropriate criteria for assessment for this development are:

EXTERNAL

$L_{Aeq(Day)}$ of 55 dB(A);
$L_{Aeq(Night)}$ of 50 dB(A).

INTERNAL

$L_{Aeq(Day)}$ of 40 dB(A) in living and work areas; and
$L_{Aeq(Night)}$ of 35 dB(A) in bedrooms.

Additional to the above, noise received at an outdoor living area should also be reduced as far as practicable, with an aim of achieving an L_{Aeq} of 50 dB(A) during the night period.

With regards to the difference between the $L_{Aeq(Day)}$ and $L_{Aeq(Night)}$ for Nairn Road, guidance is taken from the DEFRA publication and using this publication, the difference would be greater than 5 dB(A). Thus, for Nairn Road, the critical period for compliance is the day period, for if compliance with the day period is achieved, then compliance with the night period would also be achieved.

The noise modelling indicates that without any noise amelioration, noise received at the development for the future Nairn Road traffic volumes would exceed the acoustic criteria. Thus, to comply, the following noise mitigation methods are recommended:

- A 2.2-metre-high barrier at the boundary to the roadway, as shown on the plan attached in Appendix A to be constructed.

- "Quiet House" design to be incorporated into the design of each residence, as shown on the Figure C1 attached in Appendix C. Additionally, these residences also require Notifications on Titles.

Notes:

1 Given the location of the development and the projected market, we understand that 2 storey residences are unlikely, hence the "Quiet House" design requirements outlined above are for single storey residence only. If double storey residences are proposed, then it is recommended that specialist acoustic advice be sought by the proponent.

2 We understand that the development is a structure plan stage, hence the information contained in Appendix D regarding areas requiring "Quiet House" design will need to be refined once the lots have been defined. Additionally, any modifications to the Structure Plan, would vary the noise mitigation requirements, as outlined in Appendix C.

3 The summary of the Quiet House Design Packages are attached in Appendix D, are "Deemed to Satisfy" constructions. Alternative constructions would be acceptable, provided they are supported by an acoustic report prepared by a suitably qualified acoustic consultant.

1. INTRODUCTION

Herring Storer Acoustics was commissioned by Terranovis to undertake an acoustical assessment of noise received within the proposed Local Structure Plan (LSP) which encompasses Lots 877 and 878 Stakehill Road, Baldivis. As part of the study, the following was carried out:

- Determine by noise modelling, the noise levels that would be received at residences within the development from vehicles travelling on the future Nairn Road.
- Assess the predicted noise levels received at residence for compliance with the requirements of the WAPC State Planning Policy 5.4 *"Road and Rail Transportation Noise and Freight Consideration in Land Use Planning"* (SPP 5.4).
- If exceedances are predicted, comment on possible noise amelioration options for compliance with the appropriate criteria.

For information, the local structure plan is attached in Appendix A.

2. CRITERIA

2.1 ROAD TRAFFIC NOISE

The Western Australian Planning Commission (WAPC) released on 6th September 2019 State Planning Policy 5.4 *"Road and Rail Noise".* The requirements of State Planning Policy 5.4 are outlined below.

POLICY APPLICATION (Section 4)

When and where it applies (Section 4.1)

SPP 5.4 applies to the preparation and assessment of planning instruments, including region and local planning schemes; planning strategies, structure plans; subdivision and development proposals in Western Australia, where there is proposed:

*a) noise-sensitive land-use within the policy's trigger distance of a transport corridor as specified in **Table 1**;*

*b) New or major upgrades of roads as specified in **Table 1** and maps **(Schedule 1,2 and 3);** or*

*c) New railways or major upgrades of railways as specified in maps (**Schedule 1, 2 and 3);** or any other works that increase capacity for rail vehicle storage or movement and will result in an increased level of noise.*

Policy trigger distances (Section 4.1.2)

***Table 1** identifies the State's transport corridors and the trigger distances to which the policy applies.*

*The designation of land within the trigger distances outlined in **Table 1** should not be interpreted to imply that land is affected by noise and/or that areas outside the trigger distances are un-affected by noise.*

*Where any part of the lot is within the specified trigger distance, an assessment against the policy is required to determine the likely level of transport noise and management/ mitigation required. An initial screening assessment (**guidelines: Table 2: noise exposure forecast**) will determine if the lot is affected and to what extent."*

TABLE 1: TRANSPORT CORRIDOR CLASSIFICATION AND TRIGGER DISTANCES

Transport corridor classification	***Trigger distance***	***Distance measured from***
Roads		
Strategic freight and major traffic routes *Roads as defined by Perth and Peel Planning Frameworks and/or roads with either 500 or more Class 7 to 12 Austroads vehicles per day, and/or 50,000 per day traffic volume*	*300 metres*	*Road carriageway edge*
Other significant freight/traffic routes *These are generally any State administered road and/or local government road identified as being a future State administered road (red road) and other roads that meet the criteria of either >=23,000 daily traffic count (averaged equivalent to 25,000 vehicles passenger car units under region schemes)*	*200 metres*	*Road carriageway edge*
Passenger railways		
	100 metres	*Centreline of the closest track*
Freight railways		
	200 metres	*Centreline of the closest track*

Proponents are advised to consult with the decision making authority as site specific conditions (significant differences in ground levels, extreme noise levels) may influence the noise mitigation measures required, that may extend beyond the trigger distance.

POLICY MEASURES (Section 6)

The policy applies a performance-based approach to the management and mitigation of transport noise. The policy measures and resultant noise mitigation will be influenced by the function of the transport corridor and the type and intensity of the land-use proposed. Where there is risk of future land-use conflict in close proximity to strategic freight routes, a precautionary approach should be applied. Planning should also consider other broader planning policies. This is to ensure a balanced approach takes into consideration reasonable and practical considerations.

Noise Targets (Section 6.1)

***Table 2** sets out noise targets that are to be achieved by proposals under which the policy applies. Where exceeded, an assessment is required to determine the likely level of transport noise and management/mitigation required.*

In the application of the noise targets the objective is to achieve:

- *indoor noise levels as specified in **Table 2** in noise sensitive areas (for example, bedrooms and living rooms of houses, and school classrooms); and*

- *a reasonable degree of acoustic amenity for outdoor living areas on each residential lot. For non-residential noise-sensitive developments, for example schools and child care centres the design of outdoor areas should take into consideration the noise target.*

It is recognised that in some instances, it may not be reasonable and/or practicable to meet the outdoor noise targets. Where transport noise is above the noise targets, measures are expected to be implemented that balance reasonable and practicable considerations with the need to achieve acceptable noise protection outcomes.

TABLE 2: NOISE TARGETS

Proposals	***New/Upgrade***	***Noise Targets***		
		Outdoor		***Indoor***
		Day (L_{Aeq}(Day) dB) (6 am-10 pm)	***Night (L_{Aeq}(Night) dB) (10 pm-6 am)***	***(L_{Aeq} dB)***
Noise-sensitive land-use and/or development	*New noise sensitive land use and/or development within the trigger distance of an existing/proposed transport corridor*	*55*	*50*	*L_{Aeq} (Day) 40(Living and work areas)* *L_{Aeq} (Night) 35 (bedrooms)*
Roads	*New*	*55*	*50*	*N/A*
	Upgrade	*60*	*55*	*N/A*
Railways	*New*	*55*	*50*	*N/A*
	Upgrade	*60*	*55*	*N/A*

Notes:

- *The noise target is to be measured at one metre from the most exposed, habitable façade of the proposed building, which has the greatest exposure to the noise-source. A habitable room has the same meaning as defined in State Planning Policy 3.1 Residential Design Codes.*

- *For all noise-sensitive land-use and/or development, indoor noise targets for other room usages may be reasonably drawn from Table 1 of Australian Standard/New Zealand Standard AS/NZS 2107:2016 Acoustics – Recommended design sound levels and reverberation times for building interiors (as amended) for each relevant time period.*

- *The 5dB difference in the criteria between new and upgrade infrastructure proposals acknowledges the challenges in achieving noise level reduction where existing infrastructure is surrounded by existing noise-sensitive development.*

- *Outdoor targets are to be met at all outdoor areas as far as is reasonable and practical to do so using the various noise mitigation measures outlined in the guidelines. For example, it is likely unreasonable for a transport infrastructure provider to achieve the outdoor targets at more than 1 or 2 floors of an adjacent development with direct line of sight to the traffic.*

Noise Exposure Forecast (Section 6.2)

*When it is determined that SPP 5.4 applies to a planning proposal as outlined in Section 4, proponents and/or decision makers are required to undertake a preliminary assessment using **Table 2**: noise exposure forecast in the guidelines. This will provide an estimate of the potential noise impacts on noise-sensitive land-use and/ or development within the trigger distance of a specified transport corridor. The outcomes of the initial assessment will determine whether:*

- *no further measures is required;*
- *noise-sensitive land-use and/or development is acceptable subject to deemed-to- comply mitigation measures; or*
- *noise-sensitive land-use and/or development is not recommended. Any noise-sensitive land-use and/ or development is subject to mitigation measures outlined in a noise management plan."*

2.2 APPROPRIATE CRITERIA

Based on the above, the following criteria are proposed for this development:

External

Day	Maximum of 60 dB(A) L_{Aeq}
Night	Maximum of 55 dB(A) L_{Aeq}

Internal

Sleeping Areas	35 dB(A) $L_{Aeq(night)}$
Living Areas	40 dB(A) $L_{Aeq(day)}$

Additional to these criteria, noise received at an outdoor area, where practicable, should also achieve an L_{Aeq} of 50 dB(A) during the night period.

3. MODELLING

To determine the requirements of any noise amelioration, acoustic modelling was carried out using the computer program 'SoundPlan'. Acoustic modelling was carried out for road traffic flows 20 years in the future.

TABLE 5.1 - NOISE MODELLING INPUT DATA

Parameter	Value	
	Current	Future
Traffic flows		
Nairn Road	-	20,400
Heavy Vehicles (%)	8.0	

The future road traffic volumes were based on information provided by the MRWA ROM department (shown in Appendix E) and the traffic maps.

Other input data for the model included:

- Topographical data, with the ground level within the subdivision from information supplied by client.
- For future traffic, as listed in Table 5.1.
- Noise source heights for the three road source strings (Passenger Vehicles, Heavy Vehicles Engine and Heavy Vehicle Exhausts) are +0.5, +1.5 and +3.6m, with a noise correction of -0.8 and -8.0 applied to the heavy vehicles engine and exhaust noise sources.
- A +2.5 dB adjustment to allow for façade reflection.
- Development receiver heights at 1.4m above ground level.
- Future buildings located on the boundary Lots of the development (assumed to be present for future road traffic volumes).
- Calculations based on CoRTN algorithms.
- Other parameter listed in SPP 5.4 as to guidance for modelling road traffic noise / assessment.

To determine the noise that would be received within the development from the surrounding road network, acoustic modelling was carried out using the computer program 'SoundPlan'.

The following future traffic flow scenarios were modelled:

1. Without any noise amelioration.
2. With a 2.2m high barrier at boundary of the road reserve to Nairn Road.

As Nairn Road would be constructed sometime in the future as per the Implementation Guidelines for SPP 5.4, reference is made to the DEFRA publication. Thus based on the DEFRA publication, for Nairn Road the difference between the $L_{A10(18hr(}$ and the $L_{Aeq(8hr)}$ and the $L_{Aeq(16hr)}$ has been determined to be around 10 and 2 dB(A) respectively. Thus, for residence located adjacent to Nairn Road, the difference between the $L_{Aeq(16hr)}$ and the $L_{Aeq(8hr)}$ would be greater than 5 dB(A) and the day period is the critical period for compliance.

Based on the above, the noise contours for noise the above modelling scenarios are attached in Appendix B.

4. TRAFFIC NOISE ASSESSMENT

Under the Western Australian Planning Commission (WAPC) Planning Policy 5.4 "Road and Rail Noise" (SPP 5.4), the appropriate criteria for assessment for this development are:

EXTERNAL

$L_{Aeq(Day)}$ of 55 dB(A);
$L_{Aeq(Night)}$ of 50 dB(A).

INTERNAL

$L_{Aeq(Day)}$ of 40 dB(A) in living and work areas; and
$L_{Aeq(Night)}$ of 35 dB(A) in bedrooms.

Additional to the above, noise received at an outdoor living area should also be reduced as far as practicable, with an aim of achieving an L_{Aeq} of 50 dB(A) during the night period.

For this development, compliance with the requirements of SP 5.4, noise modelling and assessment are based on the day period for residence located adjacent to Nairn Road.

The noise modelling indicates that without any noise amelioration, noise received at the development for the future Nairn Road traffic volumes would exceed the acoustic criteria. Thus, to comply, the following noise mitigation methods are recommended:

- A 2.2-metre-high barrier at the boundary to the roadway, as shown on the plan attached in Appendix A to be constructed.

- "Quiet House" design to be incorporated into the design of each residence, as shown on the Figure C1 attached in Appendix C. Additionally, these residences also require Notifications on Titles.

Information on Packages A and B "Quiet House" design measures are also attached in Appendix D.

Notes:

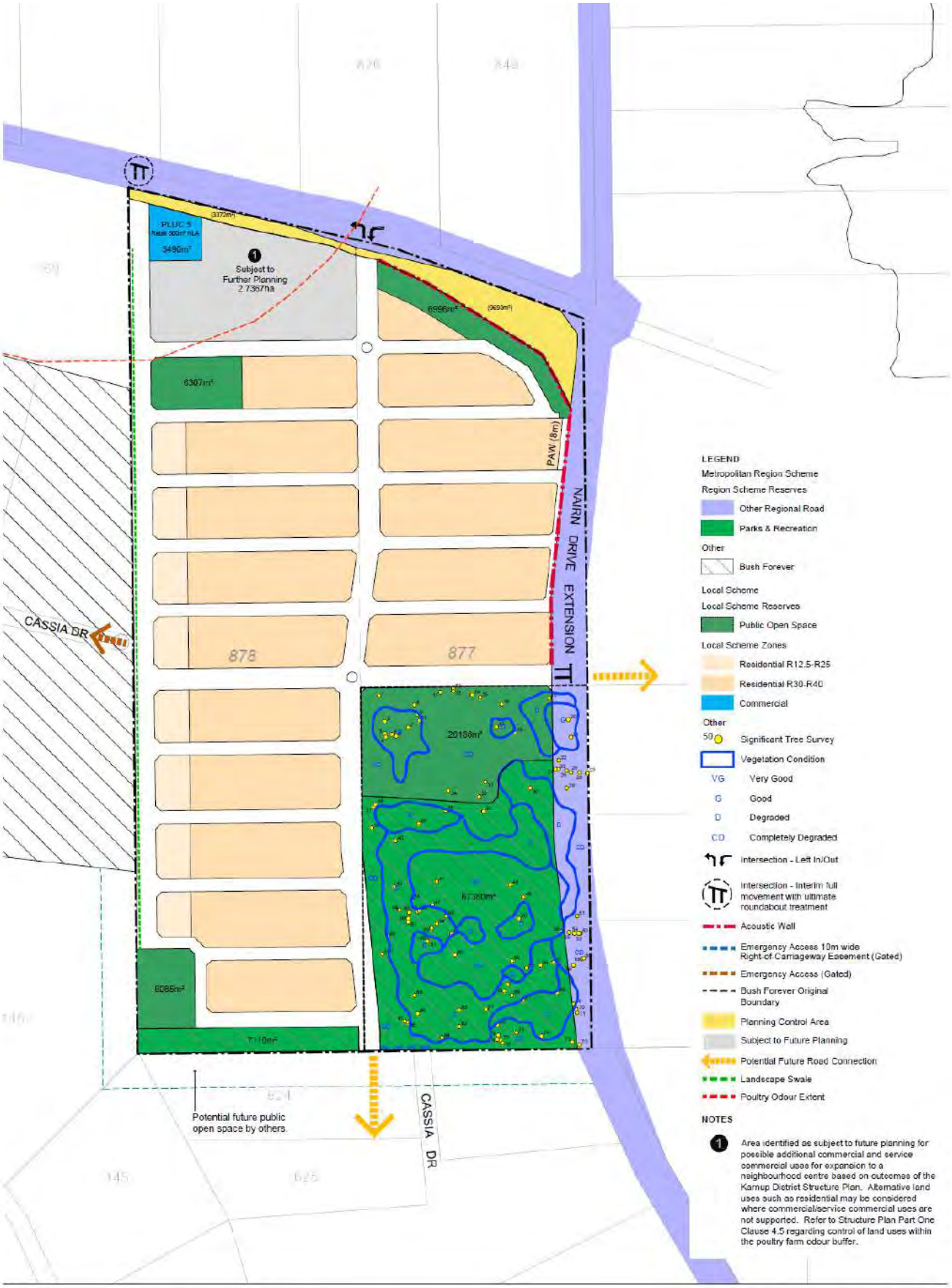
1 Given the location of the development and the projected market, we understand that 2 storey residences are unlikely, hence the "Quiet House" design requirements outlined above are for single storey residence only. If double storey residences are proposed, then it is recommended that specialist acoustic advice be sought by the proponent.

2 We understand that the development is a structure plan stage, hence the information contained in Appendix D regarding areas requiring "Quiet House" design will need to be refined once the lots have been defined. Additionally, any modifications to the Structure Plan, would vary the noise mitigation requirements, as outlined in Appendix C.

3 The summary of the Quiet House Design Packages are attached in Appendix D, are "Deemed to Satisfy" constructions. Alternative constructions would be acceptable, provided they are supported by an acoustic report prepared by a suitably qualified acoustic consultant.

APPENDIX A

PROPOSED LOCAL STRUCTURE PLAN



Development Concept Plan

Lots 877 and 878 Stakehill Road, Karnup

Date: 9 Apr 2025 Scale: 1:4000 @ A3 File: 19-338 STHC Staff: JP GW Checked: JP

element.

APPENDIX B

FIGURE B1
$L_{Aeq(16hr)}$ NOISE CONTOURS FOR NAIRN ROAD


Signs and symbols
Line
Road axis
Emission line
Surface
Noise level
LAeqDay
in dB(A)
<= 50
50 < <= 55
55 < <= 60
60 < <= 65
65 <
Subject to
Further Planning
2.7367ha
6307m²
876
877
26188m²
67380m²
6085m²
7110m²
HERRING
STORER
ACOUSTICS
LAeq(16hr) DAY NOISE CONTOUR PLOT - NO NOISE CONTROL
FUTURE STAKEHILL ROAD AND NAIRN DRIVE

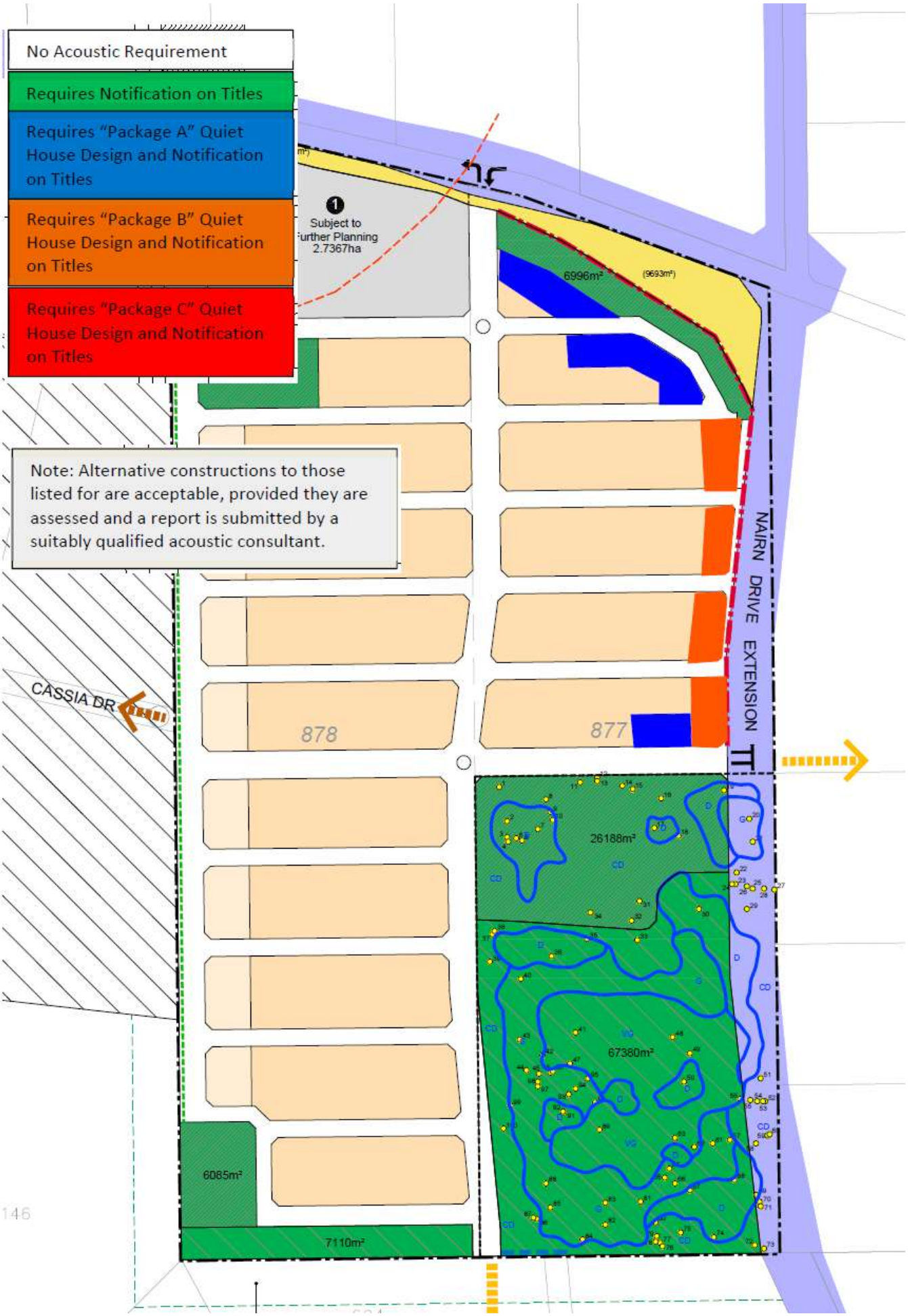


HERRING STORER ACOUSTICS

LAeq(16hr) DAY NOISE CONTOUR PLOT WITH 2.2m HIGH WALL
FUTURE STAKEHILL ROAD AND NAIRN DRIVE

APPENDIX C

LOTS REQUIRING “QUIET HOUSE” DESIGN AND NOTIFICATIONS


No Acoustic Requirement
Requires Notification on Titles
Requires "Package A" Quiet House Design and Notification on Titles
Requires "Package B" Quiet House Design and Notification on Titles
Requires "Package C" Quiet House Design and Notification on Titles
Note: Alternative constructions to those listed for are acceptable, provided they are assessed and a report is submitted by a suitably qualified acoustic consultant.
1
Subject to further Planning
2.7367ha
6996m²
(9693m²)
NAIRN DRIVE EXTENSION
CASSIA DR
878
877
26188m²
67380m²
6085m²
7110m²

APPENDIX D

"QUIET HOUSE" DESIGN PACKAGES
GENERAL INFORMATION

Exposure Category	Orientation to corridor	Acoustic rating and example constructions				
		Walls	**External doors**	**Windows**	**Roofs and ceilings of highest floors**	**Outdoor living areas**
A **Quiet House A**	Facing	**Bedroom and indoor living and work areas to Rw+Ctr 45dB** • One row of 92mm studs at 600mm centres with: – Resilient steel channels fixed to the outside of the studs; and – 9.5mm hardboard or 9mm fibre cement sheeting or 11mm fibre cement weatherboards or one layer of 19mm board cladding fixed to the outside of the channels; and – 75mm glass wool (11kg/m3) or 75mm polyester (14kg/m3) insulation, positioned between the studs; and – Two layers of 16mm fire-protective grade plasterboard fixed to the inside face of the studs. – Single leaf of 150mm brick masonry with 13mm cement render on each face. – Double brick: two leaves of 90mm clay brick masonry with a 20mm cavity between leaves.	**Bedrooms:** • Fully glazed hinged door with certified Rw+Ctr 28dB rated door and frame including seals and 6mm glass Other external doors to Rw+Ctr 25dB, e.g. • 35mm solid core timber hinged door and frame system certified to Rw 28dB including seals • Glazed sliding door with 10mm glass and weather seals	**Bedrooms:** • Total external door and window system area up to 40% of room floor area: Sliding or double hung with minimum 10mm single or 6mm-12mm-10mm double insulated glazing (Rw+Ctr 28 dB). Sealed awning or casement windows may use 6 mm glazing instead. • Up to 60% floor area: as per above but must be sealed awning or casement type windows (Rw+Ctr 31dB). **Indoor living and work areas** • Up to 40% floor area: Sliding, awning, casement or double hung with minimum 6mm single pane or 6mm-12mm-6mm double insulated glazing (Rw+Ctr 25dB). • Up to 60% floor area: As per Bedrooms at up to 40% area (Rw+Ctr 28 dB). • Up to 80% floor area: As per Bedrooms at up to 60% area (Rw+Ctr 31dB).	**To Rw+Ctr 35dB** • Concrete or terracotta tile or metal sheet roof with sarking and at least 10mm plasterboard ceiling	At least one outdoor living area located on the opposite side of the building from the transport corridor and/or at least one ground level outdoor living area screened using a solid continuous fence or other structure of minimum 2 metres height above ground level.
	Side on					
	Opposite		As per 'Facing' above, except Rw+Ctr values may be 3dB less, e.g. glazed sliding door with 10mm glass and weather seals for bedrooms.	As above, except Rw+Ctr values may be 3dB less, or max % area increased by 20%		
			No specific requirements			
B **Quiet House B**	Facing	**Bedroom and indoor living and work areas to Rw+Ctr 50dB** • Single leaf of 90mm clay brick masonry with: – A row of 70mm x 35mm timber studs or 64mm steel studs at 600mm centres; – A cavity of 25mm between leaves; – 50mm glass wool or polyester cavity insulation (R2.0+) insulation between studs; and – One layer of 10mm plasterboard fixed to the inside face • Single leaf of 220mm brick masonry with 13mm cement render on each face	**Bedrooms** • Fully glazed hinged door with certified Rw+Ctr 31dB rated door and frame including seals and 10mm glass • Other external doors to Rw+Ctr 28dB, e.g. • As per Quiet House A Bedrooms.	**Bedrooms:** • Total external door and window system area up to 40% of room floor area: Fixed sash, awning or casement with minimum 6mm single or 6mm-12mm-6mm double insulated glazing (Rw+Ctr 31 dB). • Up to 60% floor area: as per above but must be minimum 10 mm single or 6mm-12mm-10mm double insulated glazing (Rw+Ctr 34dB). **Indoor living and work areas** • Up to 40% floor area: Sliding or double hung with minimum 6mm single pane or 6mm-12mm-6mm double insulated glazing (Rw+Ctr 28dB). Sealed awning or casement windows may use 6 mm glazing instead. • Up to 60% floor area: As per Bedrooms at up to 40% area (Rw+Ctr 31 dB). • Up to 80% floor area: As per Bedrooms at up to 60% area (Rw+Ctr 34dB).	**To Rw+Ctr 35dB** • Concrete or terracotta tile or metal sheet roof, sarking and at least 10mm plasterboard ceiling, R3.0+ insulation	At least one outdoor living area located on the opposite side of the building from the corridor and/or at least one ground level outdoor living area screened using a solid continuous fence or other structure of minimum 2.4 metres height above ground level
	Side-on	• 150mm thick unlined concrete panel or 200mm thick concrete panel with one layer of 13mm plasterboard or 13mm cement render on each face				
	Opposite	• Double brick: two leaves of 90mm clay brick masonry with: – A 50mm cavity between leaves – 50mm glass wool or polyester cavity insulation (R2.0+) – resilient ties where required to connect leaves • Double brick: two leaves of 110mm clay brick masonry with a 50mm cavity between leaves and R2.0+ cavity insulation	As per Quiet House A 'Facing' above (Rw+Ctr values may be 3dB less, or max % area increased by 20%).			
			As per Quiet House A 'Side-on' above.			

Appendix 6

Bushfire Management Plan



BUSHFIRE MANAGEMENT PLAN

Lots 877 and 878 (No 199) Stakehill Road, Karnup

City of Rockingham

BPAD Bushfire Planning & Design Accredited Practitioner Level 2

Prepared by Ralph Smith
SMITH BUSHFIRE CONSULTANTS PTY LTD
BPAD 27541
smith.consulting@bigpond.com
0458 292 280

Site visited 30 July 2024; Report completed 29 August 2024

NOTE

This Bushfire Management Plan has been developed by Smith Bushfire Consultants Pty Ltd for the exclusive use of the client, Terranovis Pty Ltd and their agents.

The plan has been compiled using the standard methodologies required by Western Australian government departments and agencies. It is based on the following:

- *State Planning Policy 3.7 Planning in Bushfire Prone Areas (SPP 3.7)*, December 2015
- *Guidelines for Planning in Bushfire Prone Areas*, December 2021
- Australian Standard 3959 – Construction of buildings in bushfire-prone areas, November 2018

The techniques described in the above publications have been applied in the appropriate areas and circumstances for the subdivision of this document.

Where there was no public access, the interpretation is based on photographic and satellite imagery, and a laser distance meter was used to measure distances and the effective slope has been determined through Near Maps.

It is recommended that this Bushfire Management Plan be revised every five years to ensure that it remains relevant and in-line with current requirements. This will optimise protection. It is proposed that the property owners undertake the review.

DISCLAIMER

This Bushfire Management Plan has been prepared in good faith. It is derived from sources believed to be reliable and accurate at the time of publication. Nevertheless, this plan is distributed on the terms and understanding that the author is not responsible for results of any actions taken based on information in this publication or for any error or omission from this publication.

Smith Bushfire Consultants Pty Ltd has exercised due and customary care in the preparation of this Bushfire Management Plan and has not, unless specifically stated, independently verified information provided by others.

Any recommendations, opinions or findings stated in this report are based on circumstances and facts as they existed at the time Smith Bushfire Consultants Pty Ltd performed the work. Any changes in such circumstances and facts upon which this document is based may adversely affect any recommendations, opinions or findings contained in this plan.

Document control

Report Version	Purpose	Author/reviewer and accreditation details	Date Submitted
4	Support BMP for the lifting of urban deferment	R Smith	21 February 2020
4.1	Maps and minor text changes	R Smith	16 March 2020
5	Support the application for the subdivision. Maps and text changes.	R Smith	29 August 2024

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Bushfire management plan/Statement addressing the Bushfire Protection Criteria coversheet

Site address: Lot 877 & 878 Stakehill Road, Karnup

Site visit: Yes ☑ No ☐

Date of site visit (if applicable): Day 30 Month July Year 2024

Report author: Ralph Smith

WA BPAD accreditation level (please circle):

Not accredited ☐ Level 1 BAL assessor ☐ Level 2 practitioner ☑ Level 3 practitioner ☐

If accredited please provide the following.

BPAD accreditation number: 27541 Accreditation expiry: Month August Year 2024

Bushfire management plan version number: 5

Bushfire management plan date: Day 28 Month August Year 2024

Client/business name: Terranovis Pty Ltd

	Yes	No
Has the BAL been calculated by a method other than method 1 as outlined in AS3959 (tick no if AS3959 method 1 has been used to calculate the BAL)?		✓
Have any of the bushfire protection criteria elements been addressed through the use of a performance principle (tick no if only acceptable solutions have been used to address all of the bushfire protection criteria elements)?		✓

Is the proposal any of the following (see SPP 3.7 for definitions)?	Yes	No
Unavoidable development (in BAL-40 or BAL-FZ)		✓
Strategic planning proposal (including rezoning applications)		✓
Minor development (in BAL-40 or BAL-FZ)		✓
High risk land-use		✓
Vulnerable land-use		✓

None of the above ☐

Note: Only if one (or more) of the above answers in the tables is yes should the decision maker (e.g. local government or the WAPC) refer the proposal to DFES for comment.

Why has it been given one of the above listed classifications (E.g. Considered vulnerable land-use as the development is for accommodation of the elderly, etc.)?

The information provided within this bushfire management plan to the best of my knowledge is true and correct:

Signature of report author  Date 28/8/2024

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Section 1: Proposal Details

This BMP supports the proposed changes to the Local Structure Plan.

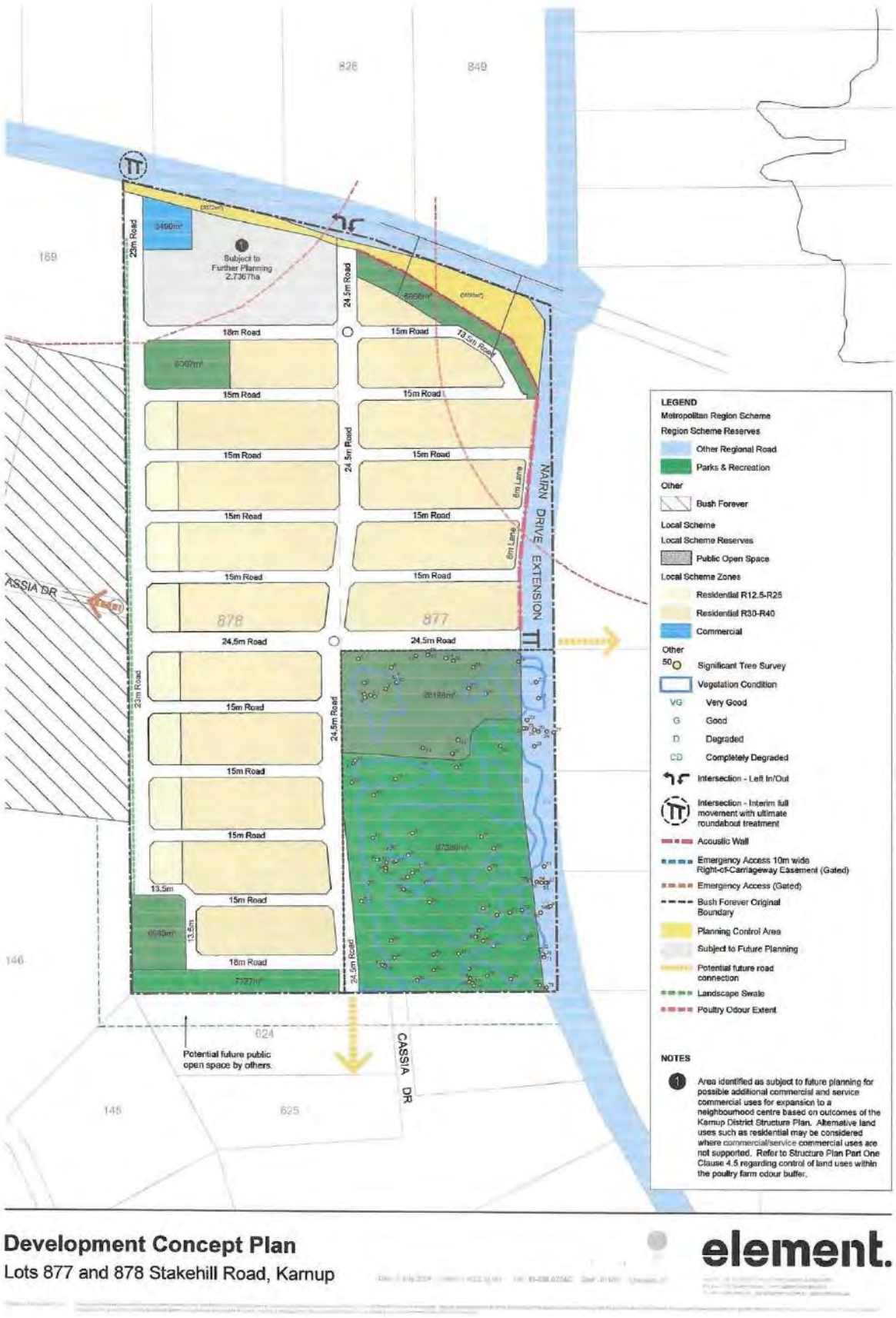


Figure 1: Copy of Development Concept Plan.

The site is declared only in part as bushfire prone. The Building Code of Australia only references AS 3959 for Class 1, 2, 3 and appropriate 10a buildings and thus influences the construction standards. The State Government requirements are that the BAL rating must be BAL–29 or less for all other classes of buildings to facilitate development through the planning process. The site is currently an active commercial market garden.



Figure 2. Aerial photo of the bushfire prone area for the subject site.

Section 2: Environmental Considerations

The site is designated for development and some of the mixed tuart and banksia forest will need to be cleared. The area has been prepared for development and has already been subject to numerous reviews and approvals. The area to the south, which will remain as public open space, is not affected by this development.

Subsection 2.1: Native Vegetation – modification and clearing

A portion of the development site, to the north of the Bush Forever Site (site number 278), will be 'managed open space'. These areas will be developed as irrigated grass under a tree overstorey. The native vegetation in the Bush Forever site southern portion will not be cleared.

Subsection 2.2: Re-vegetation/Landscape Plans

All revegetation within the residential development site will be managed so that it is 'low threat vegetation' and will not increase the bushfire threat. There is also a plan for the vegetation buffer which will include three rows of trees behind an acoustic wall in the north-east edge of the development. There will also be an area of low threat vegetation landscaping, shared path, residential area and sections of retained native vegetation in the south-east POS.

Section 3: Bushfire Assessment Results

Subsection 3.1: Assessment inputs



Figure 3: Vegetation Classification Map.

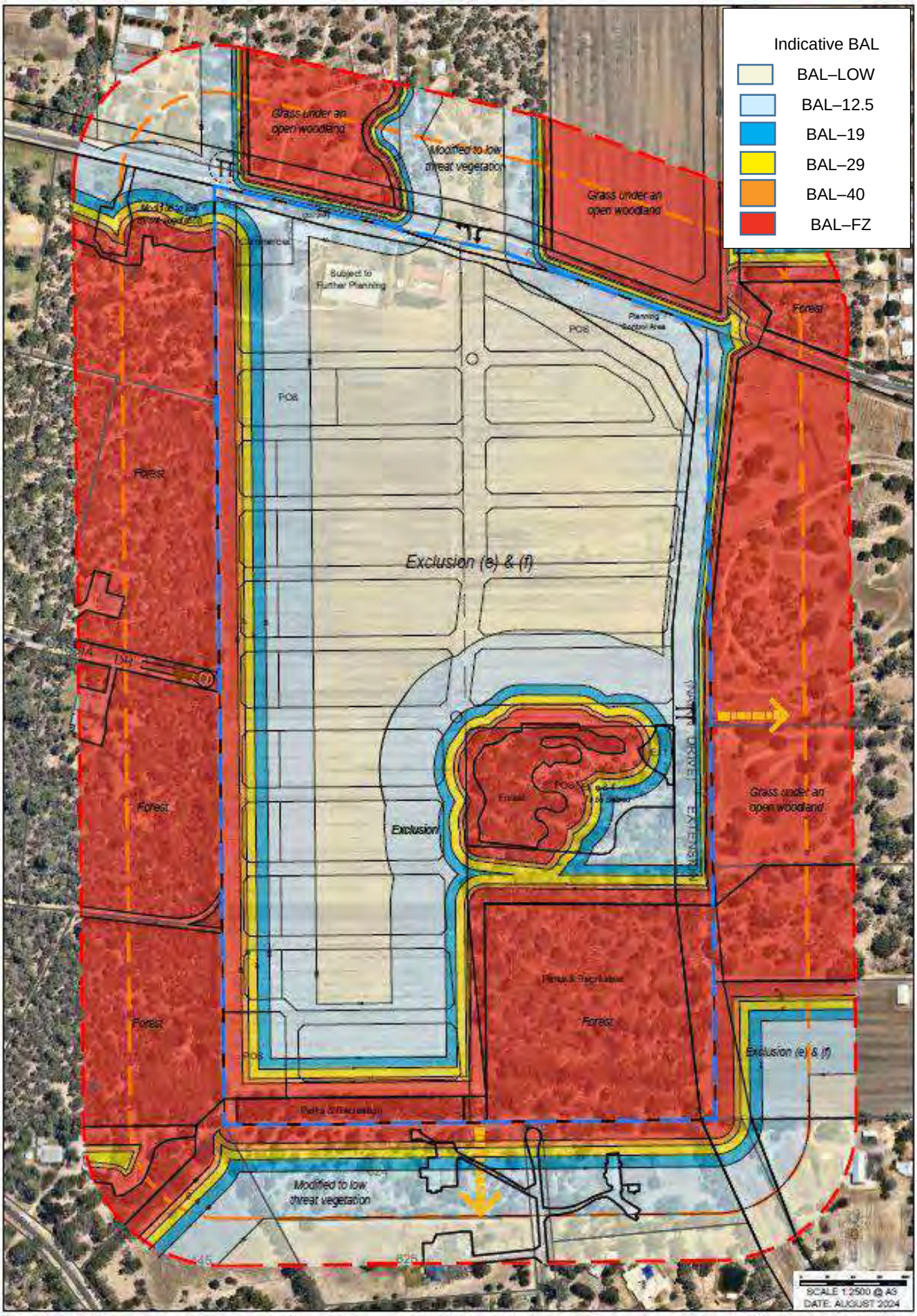


Figure 4: BAL Contour Map.

Vegetation Classification

All vegetation within 150 metres of the proposed subdivision as indicated on the site assessment plan was classified in accordance with the Western Australian Government criteria and Clause 2.2.3 of AS 3959 was applied. Each distinguishable vegetation plot with the potential to determine the Bushfire Attack Level is identified below. AS 3959 only requires consideration of 100 metres between vegetation and the building and 50 metres for grassland. As there are areas east of Lyon Road that are private property with very restricted access, photographs from an earlier vegetation assessment have been included in this BMP to provide additional information.

Plot 1

Exclusion – Low threat vegetation and non-vegetated areas and includes modified to 'low threat state' vegetation required by the City's firebreak and fuel load order.
Clause 2.2.3.2 (e) and (f)



Photo ID: Photo 1 Looking at the established buildings and access to the processing sheds.



Photo ID: Photo 2 Looking at the established market garden on a development property.



Photo ID: Photo 3 Looking at the established market garden on a development property.



Photo ID: Photo 4 Looking at the established market garden and forest in the background.



Photo ID: Photo 5 Looking at Cassia Drive.



Photo ID: Photo 6 Looking at the established market garden and forest in the background.



Photo ID: Photo 7 Looking at the market garden east of the Bush Forever Site.



Photo ID: Photo 8 Looking north at the established market garden and processing sheds in the background.



Photo ID: Photo 9 Looking at the managed to Exclusion - low threat vegetation on the lot to the north.

Plot 2
Exclusion – Low threat vegetation.
Clause 2.2.3.2 (f)



Photo ID: Photo 10 Looking at the horse facilities to the north of Stakehill Road.



Photo ID: Photo 11 Looking at the managed grassland and dwelling south of the development lot.



Photo ID: Photo 12 Looking at the managed vegetation to the south-west of the development site.



Photo ID: Photo 13 Looking at the managed vegetation to the south of the development site.



Photo ID: Photo 14 Looking at the managed vegetation to the south of the development site.



Photo ID: Photo 15 Looking at the managed vegetation to the south-east of the development site.

Plot 3
Class G – Grassland under an open forest (AS 3959 vegetation classification G–06).



Photo ID: Photo 16 Looking at the grass vegetation north of Stakehill Road.



Photo ID: Photo 17 Looking at the grass vegetation east of the development site. Note the crown density increases out past the 150 metre assessment line.



Photo ID: Photo 18 Looking at the grass vegetation under a crown cover that is less than 10%.



Photo ID: Photo 19 Looking at the grass vegetation.



Photo ID: Photo 20 Looking at the grass vegetation which is reticulated and may still be an active market garden. The precautionary principle has been applied.

Plot 4
Class A – Forest (AS 3959 vegetation classification A–03).



Photo ID: Photo 21 Looking at the forest vegetation east of the development site.



Photo ID: Photo 22 Looking at the forest vegetation.



Photo ID: Photo 23 Looking at the forest vegetation which is influenced by the edge effect



Photo ID: Photo 24 Looking at the forest vegetation.



Photo ID: Photo 25 Looking at the forest vegetation. Note the level of shade on the ground.



Photo ID: Photo 26 Looking at the forest vegetation.



Photo ID: Photo 27 Looking at the forest vegetation east of the Bush Forever Site.



Photo ID: Photo 28 Looking at the forest vegetation north of Stakehill Road.

Notes to Accompany Vegetation Classification

1. Plot 1
Exclusion
Section 2.2.3.3 (e) and (f)

This plot comprises the houses, cultivated and reticulated gardens and infrastructure adjacent to the development site. The plot includes the road infrastructure and developed land surrounding the lot. Also included in this classification is the market gardens around the development site where a number of reticulated areas are left fallow so that the soil can regenerate. These fallow areas vary across the neighbouring properties and will be subject to seasonal change.

There are currently forest areas on the development site that will be 'managed open space'. These areas will be developed as irrigated grass under a tree overstorey as a component of this development, and will therefore become 'low threat vegetation' or 'exclusion areas' as described in AS 3959.

2. Plot 2
Exclusion
Section 2.2.3.3 (f)

This plot comprises the cultivated and reticulated lawns, gardens and paddocks adjacent to the subdivision site on private property to the south. This plot is in two types, being the vegetation as an extensive, managed lawn or paddock under a sparse overstorey and designed to reduce the potential impact of a bushfire on the dwelling and other assets on the lot. AS 3959 Exclusions do not consider crown cover when assessing s 2.2.3.2 (f) it considers the surface vegetation and nominates a height where managed grassland is considered to be 'low threat vegetation'.

The second type of the plot includes the horse training infrastructure that is adjacent to the subdivsion lot to the north and west.

3. Plot 3
Class G – Grassland under an open forest (AS 3959 vegetation classification G–06).

This plot comprises the grassland located on the east and adjacent to the subdivision site. The grassland is under a sparse overstorey.

There are another two sections of grassland areas to the north of Stakehill Road. The western section is grassland under an open forest. The eastern section north of Stakehill Road is fallow market garden, which appears to be no longer an active market garden. The precautionary principle has been applied to the section.

4. Plot 4

Class A – Forest (AS 3959 vegetation classification A–03).

This plot covers two areas within the 150 metre vegetation assessment area. The area to the west of the development site is a large area of forest (as classified by DFES), which has a tuart overstorey (*Eucalyptus gomphocephala*) (with a crown cover of 10% as described in PlanWA) and a number of dwellings and APZs. The State has mapped these areas for crown cover and this confirms that they meet the woodland crown cover classification, although DFES require this to be classified as forest. The vegetation within the photographs in the BMP of this plot are influenced by the narrow edge effect where the extra water from the market garden and light provide an impression of a significantly denser crown cover within the perimeter of the vegetation. The area is fenced and access is not available, but the less dense crown cover away from the edge effect is visible to the naked eye. The photographs distort the appraent vegetation density in the plot.

The eastern section of the plot has been considered by DFES and they require it to be classified as a forest. This plot has also been assessed by the Bush Forever Site (site number 278) site classification process which classified the site as a mixed overstorey forest. The vast majority of this plot is "classified as open forest, either as a low open forest or open forest" by the Bush Forever Site (site number 278) site classification process.

Slope

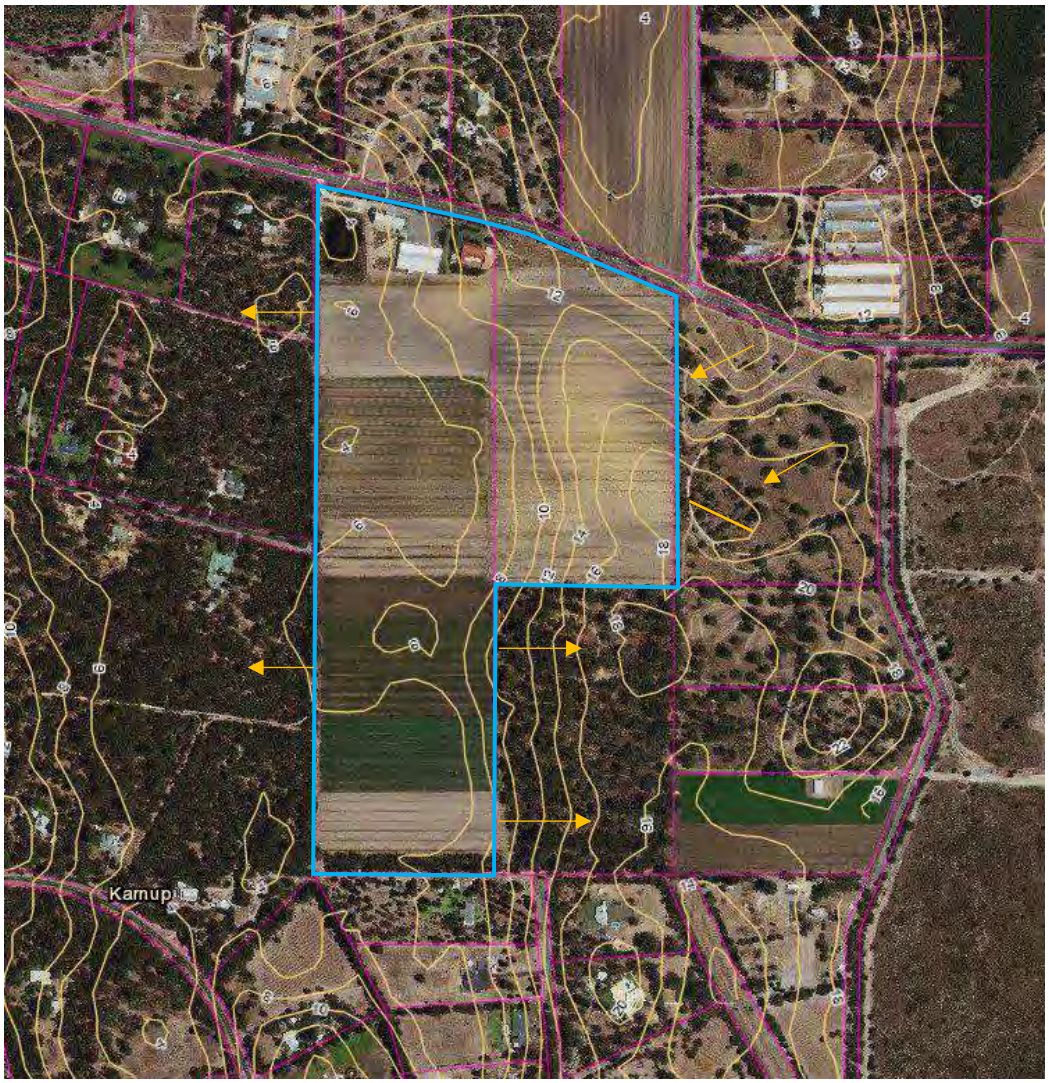


Figure 5: Two-metre contours for the site and surrounding areas.

The yellow lines are the slope contour lines. The blue lines show the lots covered by this BMP. The orange arrows show the slope under threat vegetation. The orange line shows the level top of the hill.

Other environmental values

A desktop search of the State Government websites was conducted and found to contain no significant environmental assets within or adjacent to the development site, including:

- Threatened and priority rare flora;
- Threatened and priority rare fauna;
- Threatened ecological community;
- Contaminated site register;
- Environmentally sensitive areas – neighbouring but not on this land;
- Carnaby Cockatoo confirmed roost sites;
- Carnaby Cockatoo confirmed breeding area within the Swan Coastal Plain and Jarrah IBRA regions;
- Black Cockatoo Roosting Sites buffered – neighbouring but not on this land; and
- Black Cockatoo Breeding Sites buffered.

The site is covered by the:

- Carnaby Cockatoo confirmed roost sites buffered by six kilometres.

Subsection 3.2: Assessment outputs

Method 1 BAL Determination				
Vegetation Area/Plot	Applied Vegetation Classification	Effective Slope Under the Classified Vegetation (degrees)	Separation Distance to the Classified Vegetation (metres)	Bushfire Attack Level
1	Exclusion Section 2.2.3.3 (e) and (f)	Not applicable	Not applicable	Low
2	Exclusion Section 2.2.3.3 (f)	Not applicable	Not applicable	Low
3	Grassland under an open forest	>0-5°	20	12.5
4	Forest	Level or upslope	18	29

Section 4: Identification of bushfire hazard issues

The subject site has been designated in part by the Fire and Emergency Services as bushfire prone.

The land in the northern portion of the current bushland area within the development site will be 'managed open space'. These areas will be developed as irrigated grass under a tree overstorey during the development process. The immediate neighbouring properties to the south provide a reduced potential bushfire threat through the managed to 'low threat vegetation' and houses. To the west is the forest vegetation with a number of dwellings and APZ. To the north and southern portion of the eastern side are market garden vegetation areas. To the east (north of the market garden) is open forest with a grass surface vegetation. The development site will ultimately be separated from the vegetation by roads and other clearing. The most significant bushfire threat will be from the forest with a grass surface vegetation to the east, within the Bush Forever Site to the south of the future residential site and the forest to the west of the development site.

In the south there is a Bush Forever Site (No 278) immediately adjacent to the residential component of the development of the site. This area is the forest to the south of the residential component of the development to the site. It is separated by a proposed 18-metre-wide road.

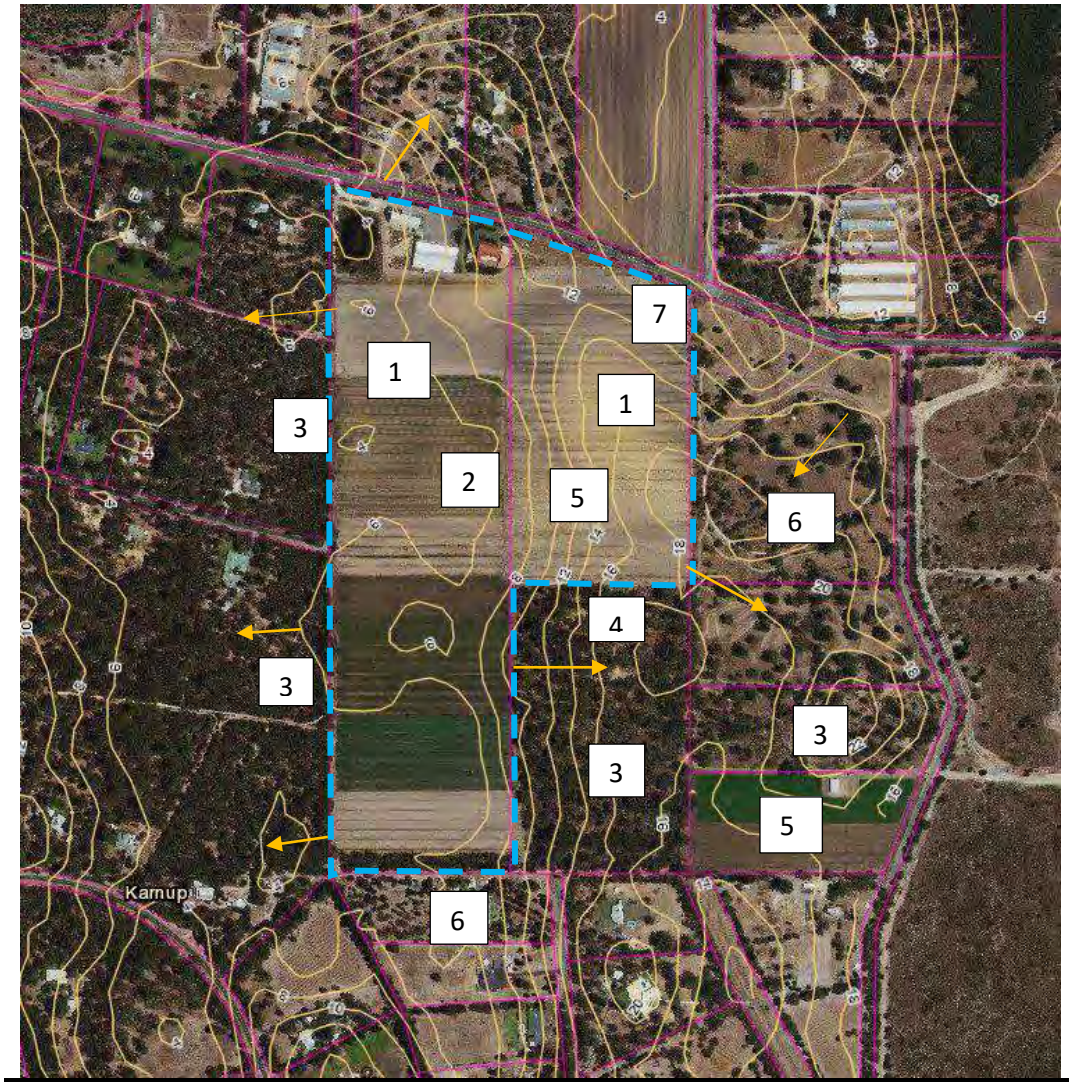
The proposed road extension to Narin Drive will provide the required separation to reduce the BAL rating between the vegetation to the east.

Section 5: Assessment against the bushfire protection criteria

Section 5.1 Compliance Tables

Bushfire protection criteria	Method of Compliance Acceptable solutions	Proposed bushfire management strategies
Element 1: Location	A1.1 Development location	This development will be developed in such a manner that on completion the BAL rating is BAL–29 or lower for the future dwellings.
Element 2: Siting and design	A2.1 Asset Protection Zone (APZ)	There is no requirement that an APZ for the lots. Lots must have the vegetation managed to low threat vegetation standard.
Element 3: Vehicular access	A3.1 Public road	Stakehill Road provides multiple access options that facilitate movement to a range of alternative locations and directions of travel. Cassia Drive west and south provide additional access to the established road network.
	A3.2a Multiple access routes	Access will be along Stakehill Road and then through the established bitumen roads to the east or west.
	A3.2b Emergency access way	Not applicable.
	A3.3 Through roads	Stakehill Road is a through-road which is completed and fully functioning.
	A3.4a Perimeter roads	There are bitumen roads planned on the perimeter of the subdivision site.
	A3.4b Fire service access routes	There are no FASR on the perimeter of the subdivision site.
	A3.5 Battle-axe access legs	There is no battle-axe access planned for the subdivision site.
	A3.6 Private driveways	No new driveway will be over 50 metres in length associated with this subdivision.
Element 4: Water	A4.1 Identification of future water supply	The subdivision will be serviced with the reticulated water scheme.
	A4.2 Provision of water for firefighting purposes	Hydrants will be located as required with the State's criteria.

Section 5.2: Additional management strategies



Legend

Subject land

Slope direction (under threat vegetation)

Notes

1. AS 3959 construction standards apply to Class 1, 2, 3 buildings in the portions of the development site that are declared as bushfire prone
2. The site will have reticulated mains water supply.
3. Forest to the west, east and south, is a significant vegetation plot that provide an ongoing bushfire threat.
4. This portion of the site will be 'managed open space' and developed as a mixed POS and retained native vegetation. The open space areas will be developed as irrigated grass under a tree overstorey during the development. This is covered by the separate Landscape Plan.
5. This vegetation is an exclusion as it a market garden.
6. This area is grassland vegetation.
7. Vegetation buffer plan for the north-east POS area.

Figure 6: Spatial representation of the bushfire management strategies.

Section 6: Responsibilities for Implementation & Management of the Bushfire Measures

DEVELOPER/LANDOWNER – PRIOR TO SALE OR OCCUPANCY	
No.	**Implementation Action**
1	Install the access ways and associated signs to the standards stated in the Guidelines.
2	Establish the water reticulation system and associated infrastructure, including hydrants at the prescribed standard where appropriate.
3	A notification, pursuant to Section 165 of the *Planning and Development Act 2005* is to be placed on the certificate(s) of title of the proposed lot(s) with a Bushfire Attack Level (BAL) rating of 12.5 or above, advising of the existence of a hazard or other factor. Notice of this notification is to be included on the diagram or plan of survey (deposited plan). The notification is to state as follows: *"This land is within a bushfire prone area as designated by an Order made by the Fire and Emergency Services Commissioner and may be subject to a Bushfire Management Plan. Additional planning and building requirements may apply to development on this land".* (Western Australian Planning Commission)

LANDOWNER/OCCUPIER – ONGOING MANAGEMENT	
No.	**Management Action**
1	Comply with the relevant local government annual firebreak notice issued under s33 of the Bush Fires Act 1954.
2	Ensure that any new Class 1, 2, 3 and associated Class 10a buildings that are built on the properties are designed and constructed in full compliance with the requirements of the City of Rockingham and as detailed in *Australian Standard 3959 – Construction of buildings in bushfire-prone areas.*
3	Maintain the buildings in good order and condition so that they comply with the appropriate construction standards.

Appendix 1

External access options post development.



Appendix 2
Copy of the City of Rockingham Fire Control Notice.

All land with an area of 4047 m² or more (more than one acre)

Owners/Occupiers of developed and vacant land are required to:

- install and maintain mineral earth firebreaks as per firebreak specifications
- ensure driveways and access ways to all buildings are maintained at a minimum of three (3) metres in width and a vertical clearance height of four (4) metres, with all overhanging vegetation trimmed back to clear access.

All land with an area of less than 4047 m² (less than one acre)

Owners/Occupiers of vacant land are required to:

- remove accumulated fuel such as leaf litter, twigs, dead bush and dead trees capable of carrying a running fire
- have the entire vacant land clear of weed or long grasses by slashing, mowing or other means to a height no greater than 50 mm and maintained in this state.

Owners/Occupiers of developed land are required to:

- ensure driveways and access ways to all buildings are maintained at a minimum of three (3) metres in width and a vertical clearance height of four (4) metres, with all overhanging vegetation trimmed back to clear access.

Bushfire Management Plan

Previously known as a Fire Management Plan. All properties that are subject to a Bushfire Management Plan as a result of a subdivision or development application or an approved treatment plan, must comply with the requirements of such plans in their entirety.

Firebreak Specifications

- must be not less than three (3) metres wide immediately inside and along all boundaries (including on boundaries adjacent to roads, rail and drain reserves and all public open space reserves)
- must be not more than four (4) metres wide (further width extensions may be considered upon written application for approval by the City)
- may have a corner turning radius of up to ten (10) metres
- must have a vertical clearance height of four (4) metres, with all overhanging vegetation trimmed back clear of the firebreak
- must be a mineral earth firebreak with a continuous trafficable surface for a 4WD vehicle, clear of any obstructions and must not terminate in a cul-de-sac (dead end)
- maintained and living lawns are acceptable in conjunction with, or in lieu of mineral earth firebreaks, provided that the same width and height requirements for a firebreak are maintained.

Firebreaks are intended to minimise the spread or extension of a bushfire and provide safe access on your property for emergency vehicles (ensuring fire does not travel under the vehicles or underfoot).



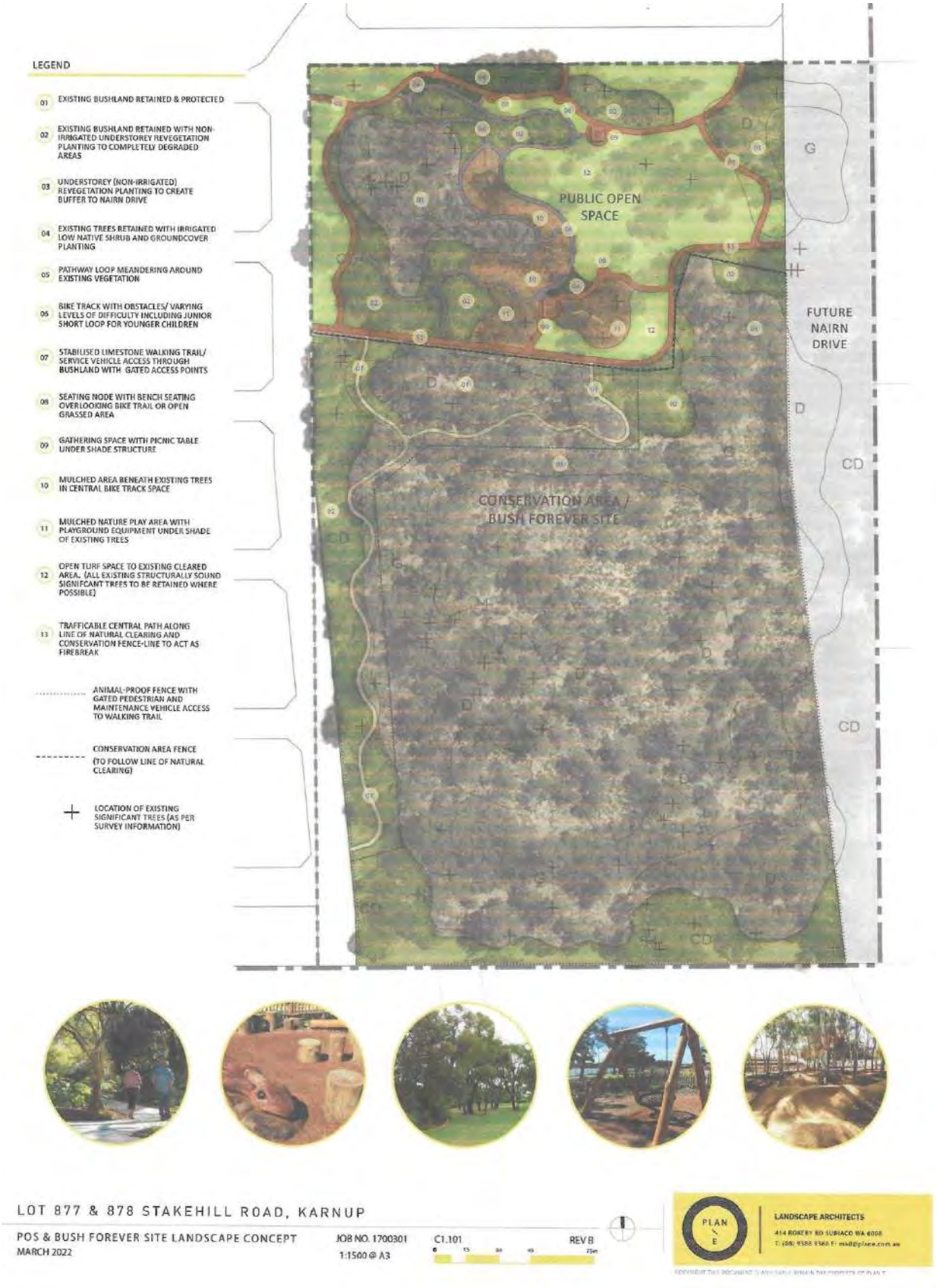
Appendix 3

Copy of the State Government crown cover percentage map for the native vegetation surrounding the development lot.



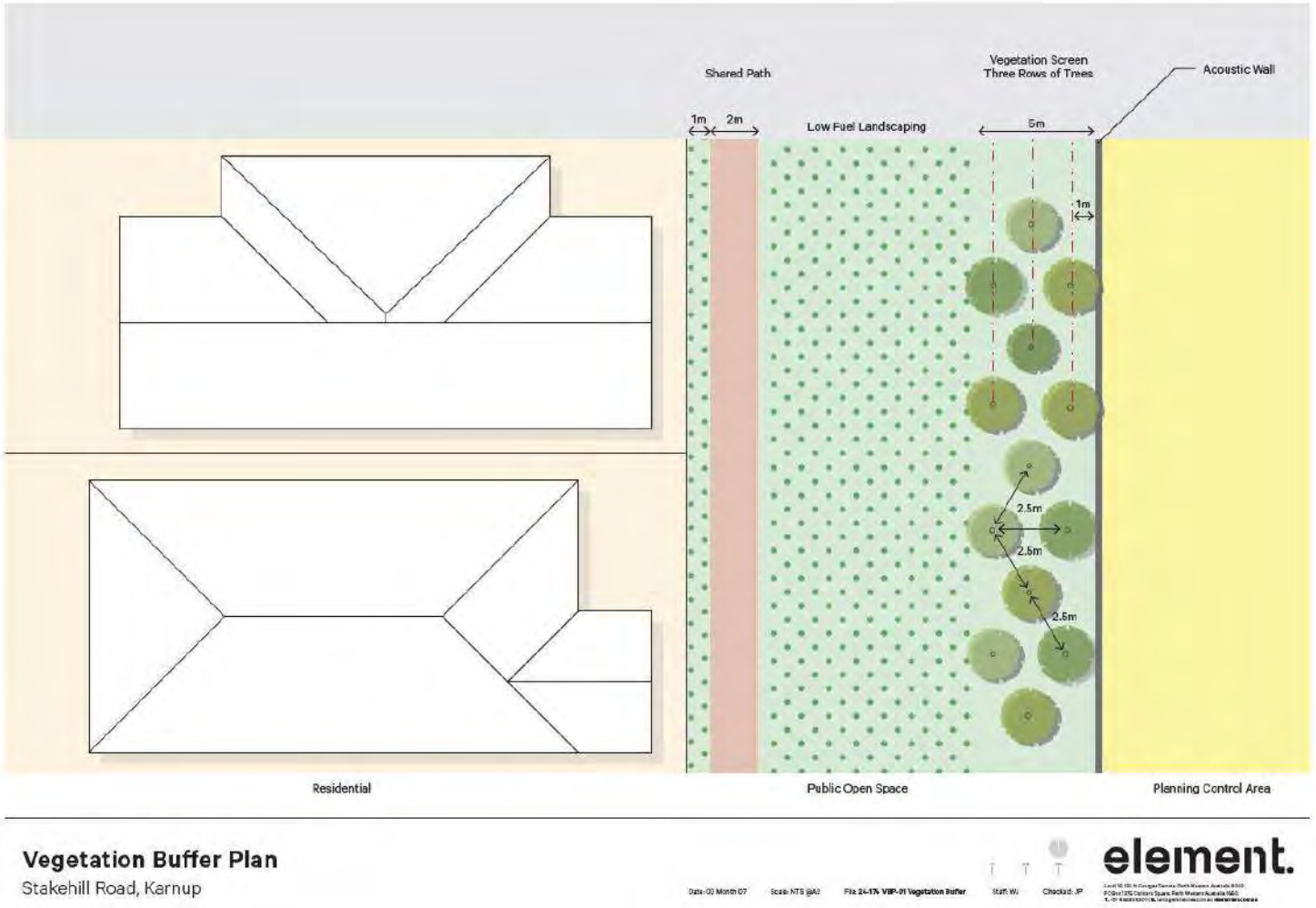
Appendix 4

Copy of the Landscape Plan for the south-east POS.



Appendix 5

Copy of the vegetation buffer plan for the north-east POS area.



References

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Appendix 7

Transport Assessment

Engineering a better future for over 20 years!

Proposed Revised Local Structure Plan

Lots 877 & 878 Stakehill Road, Karnup

PREPARED FOR:
Terranovis Pty Ltd

July 2024

Document history and status

Author	Revision	Approved by	Date approved	Revision type
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Vladimir Baltic	r01b	B Bordbar	29/09/2020	2nd Revision
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Project: Lots 877 & 878 Stakehill Road, Karnup

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1 Summary

Transcore prepared a Transport Impact Assessment report in late 2017 (hereafter TIA 2017) with respect to the proposed Development Concept Plan over Lots 877 & 878 Stakehill Road in Karnup, City of Rockingham. Following the preliminary review by the City of Rockingham, the proposal has undergone several modifications to better align with the future road network and land use planning for the locality. The revised submission and appropriate update to the TIA 2017 was therefore necessitated in order to address the proposed changes made to the original Development Concept Plan and to provide additional information and analysis as requested by the City.

A Revised Transport Impact Assessment was subsequently prepared in early 2021 with respect to the proposed Scheme Amendment and the then revised Development Concept Plan for the subject site in Karnup. Following initial review, WAPC provided a comprehensive schedule of modifications in the early part of 2024 which has subsequently been reflected in the latest Structure Plan proposal. Accordingly, a revised Transport Impact Assessment report is necessitated to address the structure plan modifications in line with WAPC advice.

Hence, this Revised Transport Impact Assessment (hereafter RTIA) addresses the transport implications of the proposed revised structure plan over Lots 877 & 878 Stakehill Road which contemplates a development of approximately 420 residential lots with a commercial element fronting Stakehill Road representing a significant reduction in development scope and intensity compared to the previous scheme. Similarly, the new structure plan contemplates reversed format of the two access intersections on Stakehill Road with the western one now featuring a full-movement access and the eastern one a restricted, left-in/left-out only access.

This RTIA includes estimation of traffic that would be generated by the proposed revised structure plan area and the resultant traffic patterns on the surrounding road network. A capacity assessment of the proposed structure plan access system including key local intersections is undertaken to establish the capacity of the road network to accommodate the anticipated traffic flows. RTIA also provides recommendations for any traffic management measures that may be required to ensure satisfactory traffic operations.

The development proposal allows for the planned extension of Eighty Road south of Stakehill Road intersection (future Nairn Drive) and the subsequent creation of a new dual-lane, four-way roundabout, with Stakehill Road, as well as the future duplication of Stakehill Road.

Transcore has worked closely over a number of years with the City of Rockingham on the (former) LandCorp's Karnup Master Plan, which is located to the immediate east of subject site, and has reviewed the relevant strategic planning documents published by WAPC and DPLH during this process.

Accordingly, Transcore has made use of the relevant and available strategic planning information to assist in preparation of this RTIA for the proposed Lot 877 & 878 Stakehill Road structure plan.

2 Introduction

This Revised Transport Impact Assessment has been prepared by Transcore on behalf of Terranovis Pty Ltd with regard to the proposed Local Structue Plan over Lots 877 & 878 Stakehill Road in Karnup, City of Rockingham. Refer **Figure 1** for locality map.



Figure 1: Location of the subject site (Lots 877 & 878 Stakehill Road)

The subject site occupies an area of approximately 49ha at the south side of Stakehill Road immediately west of the Eighty Road intersection. The subject locality is rural in nature with a number of farms, plantations and various other small-scale agricultural operations such as market gardens, poultry farms, wineries, etc. A large-scale sand mining operation is presently located some 1.5km east of the subject site and to the south of Stakehill Road. This particular operation is planned to ultimately be terminated with the subject land earmarked for large-scale residential and commercial/retail development (former Landcorp's Karnup Master Plan).

The existing local road network generally consists of rural-style single carriageway roads with limited, if any, pedestrian/cyclist paths and facilities.

3 Proposed Local Structure Plan

The location of the proposed Stakehill Road LSP in its regional context and within the *Metropolitan Region Scheme (MRS)* is illustrated in **Figure 2**.

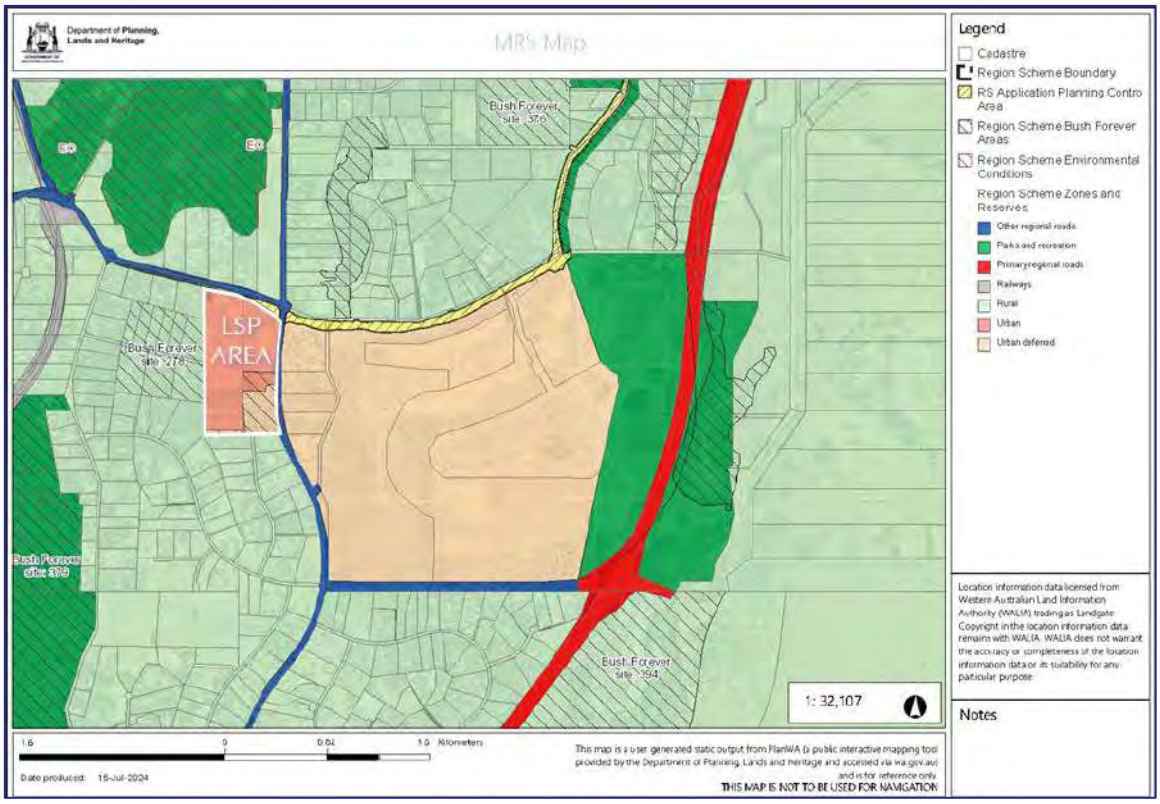


Figure 2: Site location within Metropolitan Region Scheme context

The LSP area extends approximately 850m to the south of Stakehill Road and about 570m to the west of Eighty Road. The subject site is zoned as "Urban" and "Urban Deferred" in *MRS*.

Stakehill Road (west of Eighty Road), Eighty Road and the future Nairn Drive (southbound extension of Eighty Road south of Stakehill Road) are all classified as *Other Regional Roads (Blue Roads)* and as such are managed by local authority but with ultimate control resting with WAPC/DoPLH.

The proposed LSP contemplates approximately 420 residential lots including a commercial zone at the northwestern corner of the site, with the estimated combined NLA of about 3,340m^2, proposed to front Stakehill Road.

Additional 2.7367ha of land at the northwest corner of the site are set aside for the future development; however, this area does not form part of the subject structure plan application. According to the current planning, the subject commercial zone is earmarked for a service station.

The proposed LSP road system facilitates internal distribution of vehicular, pedestrian and cyclist traffic. The internal structure plan road system is intended to ultimately connect to Stakehill Road and the future Nairn Drive (extension) via three access intersections as follows:

- Centrally-located, left-in/left-out only access intersection on Stakehill Road, approximately 260m west of the existing Eighty Road intersection;
- A full-movement access intersection on Stakehill Road at the westernmost end of the site, some 560m west of Eighty Road intersection; and,
- A full-movement access intersection on Nairn Drive (extension) at the eastern end of the site, some 400m south of Eighty Road intersection.

In addition to the three-point vehicular access/egress system, an emergency access to Cassia Drive at the southern end of the site is proposed to secure additional escape route in case of bushfire emergency. This access will be chained off only to be opened by DFES in case of emergency to secure additional evacuation route for local residents.

The proposed LSP allows for the planned future Nairn Drive southbound extension past Stakehill Road which would abut the subject site along the east side.

Similarly, Stakehill Road is planned to ultimately be upgraded to a dual-carriageway four-lane standard in accordance with its intended future *Integrator Arterial* role and the anticipated future traffic volumes as a result of the long-term planning to urbanise the locality.

The proposed LSP is intended to be developed in stages commencing with the residential component and then progressing with the commercial/retail element.

Refer to **Appendix A** for the proposed LSP plan.

4 Existing Situation

4.1 Existing Land Use

The LSP area is located approximately 48km south of the Perth CBD and approximately 14km southeast of Rockingham town centre.

The subject site is situated at the south side of Stakehill Road and immediately west of Eighty Road (refer **Figure 1** for more details). The subject site is located within predominantly rural setting.

4.2 Existing Road Network

Stakehill Road (including relevant sections of Baldivis Road and Karnup Road), provide east-west connection between Kwinana Freeway and Mandurah Road.

In the immediate vicinity of the subject site, Stakehill Road is constructed as approximately 8m wide single carriageway, two-lane road with an 70km/h posted speed-limit.

A number of local roads and informal private property accesses connect to Stakehill Road along the northern side serving local rural estates or farms/businesses. This road also provides access to the sand mining operation located at the southern side of Stakehill Road and about 1.5km to the east of the subject site.

According to the *Metropolitan Region Scheme (MRS)* Stakehill Road, section between Mandurah Road and Eighty Road, is classified as *Other Regional Road* (i.e. *"Blue Road")* with section east of Eighty Road being a local road under care and control of City of Rockingham. In the *South Metropolitan Peel Sub-Regional Planning Framework (March 2018)* document section of Stakehill Road between Eighty Road and Baldivis Road is identified as future Integrator Arterial road with proposed *"Blue Road"* status.

The Main Roads WA *Perth Metropolitan Area – Functional Road Hierarchy* document, classifies Stakehill Road as a *Regional Distributor* road.

Eighty Road is an important regional road connecting Safety Bay Road at the north to Stakehill Road at the south thus providing access to the large residential area in Baldivis, as well as various important educational and (future) recreational/leisure nodes to the north of the subject site.

It is constructed as an 8.0m wide single carriageway, two-lane road with a posted speed limit of 80km/h on the approach to Stakehill Road. It is a typical rural road between Sixty-Eight Road and Stakehill Road, terminating with a T-junction at Stakehill Road.

In the Main Roads WA *Perth Metropolitan Area – Functional Road Hierarchy* document, Eighty Road is classified as a *Local Distributor* road. Eighty Road forms a simple, priority-controlled T-intersection with Stakehill Road immediately adjacent to the subject site, terminating on its northern approach to the intersection.

There are a number of driveway accesses to rural properties and a limited number of side road intersections on both sides of Eighty Road south of Sixty-Eight Road.

The Stakehill Road/Eighty Road intersection is constructed as a simple priority-controlled T-junction with no turn lanes or splitter islands.

4.3 Existing Traffic Volumes

According to the most up-to-date traffic survey data sourced from Main Roads WA (March 2022), Stakehill Road east of Eighty Road averages weekday traffic volumes of about 5,400vpd. A copy of the relevant traffic volume survey data is appended in **Appendix C** of this report.

According to the most up-to-date traffic survey data sourced from Main Roads WA (March 2022), Eighty Road north of Stakehill Road shows average weekday traffic volumes of about 1,160vpd. A copy of the relevant traffic volume survey data is appended in **Appendix C** of this report.

4.4 Crash Data

The Main Roads WA *Intersection Crash Ranking Report* provides detailed crash data for the Stakehill Road/Eighty Road intersection over the 5-year period ending 31 December 2023.

Information available on the Main Roads WA website indicates that the intersection of Stakehill Road/Eighty Road recorded three crashes with one casualty (medical) over the five-year period ending in December 2023. More details on the crash records are provided in **Table 1**.

Table 1: Crash history for the Stakehill Road/Eighty Road intersection

Intersection				Total Crashes	Casualty
Stakehill Road/Eighty Road				3	1
Right Angle	**Rear End**	**Pedestrian**	**Cycle**	**Wet**	**Night**
1	2	0	N/A	0	0

4.5 Heavy Vehicle Routes

Restricted Access Vehicle (RAV) Network routes are designated for access by large heavy vehicle combinations that require special permits for each trip. Main Roads WA manages the RAV Networks and the permits for trucks to use them.

Figure 3 shows that Eighty Road is classified as RAV Network 3 road while Stakehill Road is classified as RAV Network 4 road. RAV Networks 3 and 4 permit access by a number of vehicle combinations of up to 27.5m long.

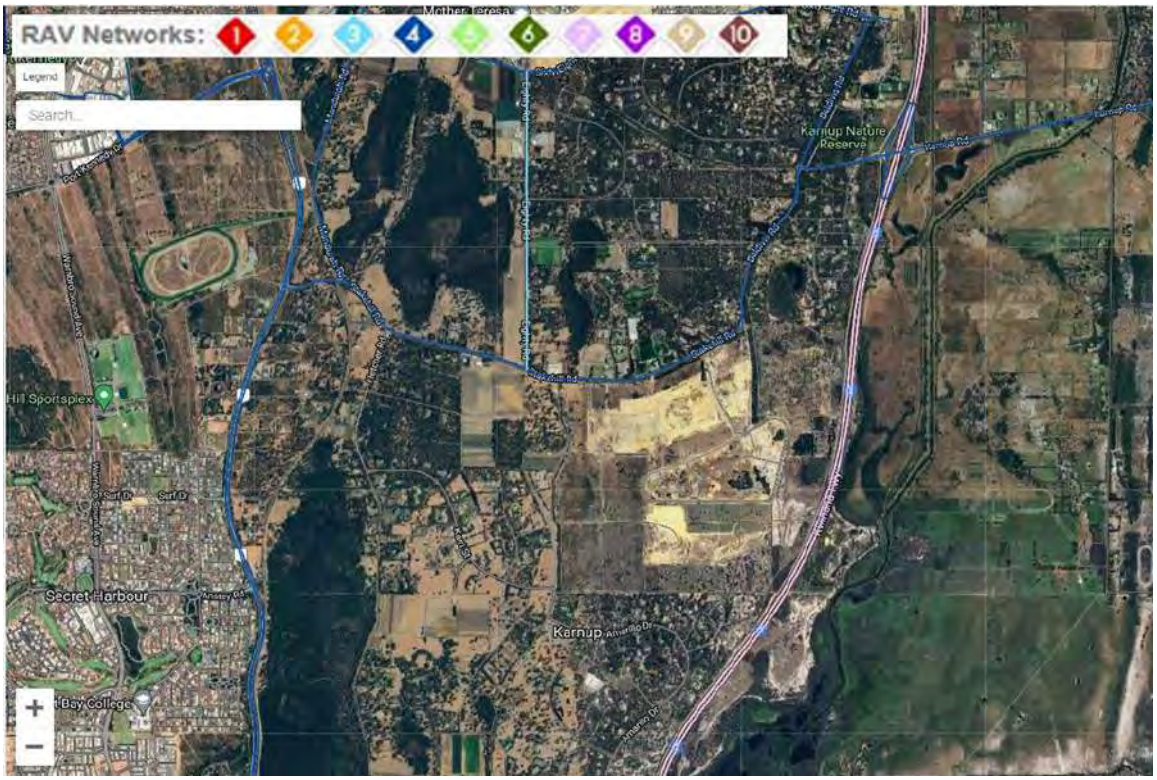


Figure 3: Existing heavy vehicle road network classification (RAV)

4.6 Public Transport

The Baldivis locality is presently served by a total of five bus services which all provide connection to the bus/rail transfer facility at Warnbro Train Station. The bus route No. 565 has its terminal at the southernmost end of the higher density urban zone; however, does not extend further south than Sixty-Eight Road. Accordingly, no convenient public transport opportunities are currently available for the subject site's immediate locality.

The map of existing public transport services available in the vicinity of the subject site is provided in **Figure 4**.



Figure 4: Existing bus routes (source: Transperth)

4.7 Pedestrian and Cyclist Facilities

The road network adjacent to the LSP area, Eighty Road (southern section adjacent to the site) and Stakehill Road has no formal footpaths or cycling facilities at present.

5 Changes to Surrounding Road Network

The DPLH is currently working on a road network planning study for Stakehill Road with the aim of establishing alignment, carriageway pattern and profile including access strategy along the entire section of the road. Transcore has attempted to source the relevant data, including ultimate traffic projections for Stakehill Road and (future) Nairn Drive from DPLH for the purpose of this assessment; however, as advised, such information will not be available to public at this time.

It is understood that the new dual-carriageway, four-lane Stakehill Road carriageway, parallel to the current alignment of the road (between Eightly Road and Baldivis Road) will be offset to the south while the existing carriageway will be downgraded to function as a local service road and be cul-de-saced at both ends. A dual-lane roundabout intersection is planned for the future four-way Stakehill Road/Eighty Road intersection with provision for the future connection at the southern side (i.e., future Nairn Drive extension).

A Planning Control Area (PCA) No. 155 was established for Stakehill Road in July 2020 affecting the land along southern side of Stakehill Road and adjacent to the subject site. It should be noted that the latest version of the LSP allows for the land affected by the PCA No. 155.

The LSP also interfaces with the future road network at this locality, namely Nairn Drive, which is planned as the southbound extension of Eighty Road from Stakehill Road to Paganoni Road. This road features in the WAPC *Metropolitan Region Scheme* as *"Other Regional Road" (i.e., "Blue Road")*. As such, planning, design and construction of this road is subject to local government and WAPC planning outcomes.

City of Rockingham has advised that planning, design and construction of future roads within the locality, including Nairn Drive and Anstey Road (east-west road forming an interchange with Kwinana Freeway at its eastern end), is subject to urban growth within the locality.

The alignment of the two planned *"Other Regional Roads"* in the *Metropolitan Region Scheme (MRS)* is shown in **Figure 2**.

6 Proposed Internal Transport Network

6.1 Road Hierarchy

The review of traffic projections shows that, in accordance with the WAPC *"Liveable Neighbourhoods"* document, all internal LSP roads can be classified as *Neighbourhood Connector B*, *Access Street D (narrow yield)* and *Laneways*. Refer **Figure 6** for more details. Some key characteristics of typical cross-sections, defined in WAPC *Liveable Neighbourhoods* publication are discussed further in this section.

It should be noted that section of the internal LSP road abuting the future retail/commercial area designated as "Subject to further planning" is initially proposed to be classified as lower ranking connector (i.e., *Neighbourhood Connector B*) but suggested to maintain sufficient road reservation (min 24.4m) for future upgrade to higher rank connector - *Neighbourhood Connector A*.

This is proposed so to secure sufficient road capacity for the future scenario where the "Subject to further planning" zone is ultimately developed in line with its intention.

Neighbourhood Connector roads are intended to link neighbourhoods and centres and facilitate pedestrian use, calm traffic and have frequent local street connections. These roads should not attract long distance through traffic but rather provide for safe and convenient local travel.

Neighbourhood Connector A is intended to carry up to 7,000vpd with speeds of up to 50km/h and is typically designed to entail central median, cycle lanes and indented on-street parking. For larger trees or in order to accommodate a turning lane the central median can be widened to 4.0m. In this particular case, on-street parking may not be practical due to proximity to Stakehill Road intersection. Refer to **Figure 5** for typical *Neighbourhood Connector A* cross section.

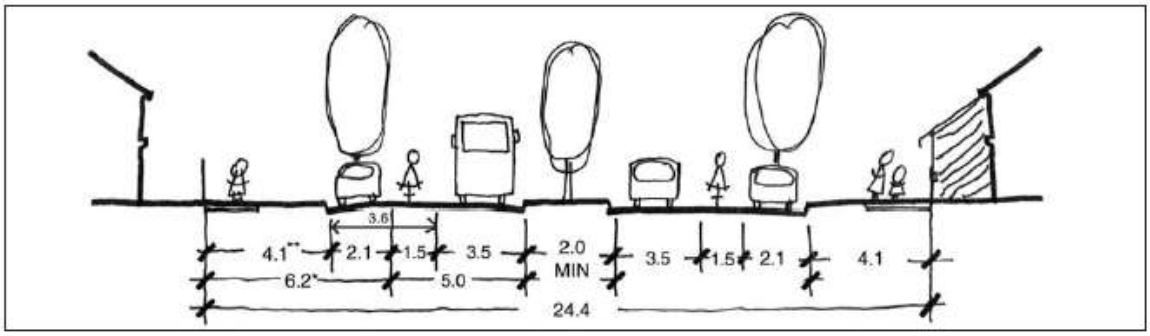


Figure 5. Neighbourhood Connector A - up to 7,000vpd and with target speed of 50 km/h (>3,000vpd preferred)



Figure 6. Proposed LSP road hierarchy

Neighbourhood Connector B is intended to carry up to 3,000vpd with speeds of up to 50km/h and is typically designed to entail indented on-street parking which facilitates visitor parking in residential areas. Potentially a bus route with stops in travel lane. Refer to **Figure 7** for typical *Neighbourhood Connector B* cross section.

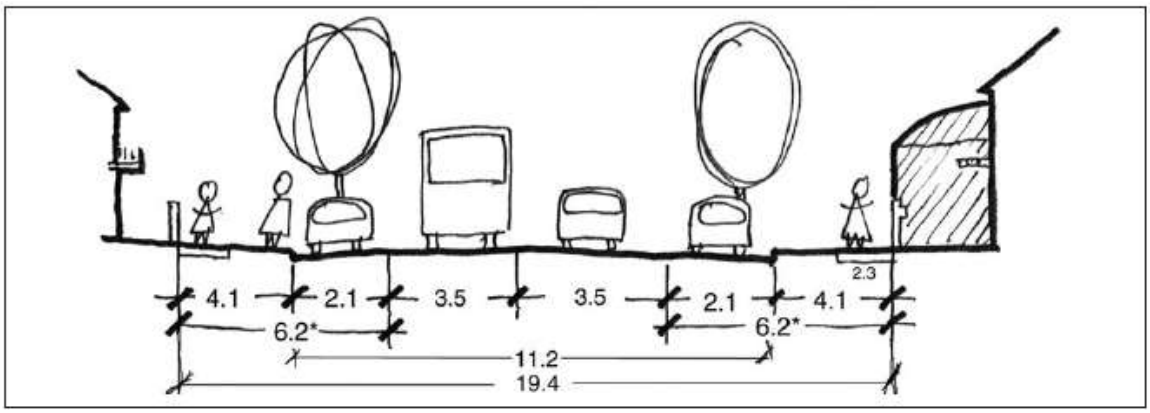


Figure 7. Neighbourhood Connector B - up to 3,000vpd and with target speed of 50 km/h (>3,000vpd preferred)

Accordingly, roads abuting the future retail/commercial zone at the northwest corner of the LSP area are classified as *Neighbourhood Connector B* roads with the road bounding the zone along the western side, and connecting to Stakehill Road forming a full-movement intersection, intended to ultimately assume *Neighbourhood Connector A* status. In addition, the two main internal central north-south and east-west spine roads connecting to each of the three LSP access intersections are also proposed to be classified as *Neighbourhood Connector B*.

If fronting P.O.S., road verge adjacent to P.O.S. may be reduced to 1.0m. This is the case with the central north-south *Neighbourhood Connector B* road skirting "Bush Forever" reserve.

The typical road reserve for *Access Street D (narrow yield)* entails a road reserve width of 14.2m with 6.0m wide trafficable carriageway pavement and up to 4.1m wide verges on both sides. This type of street is recommended for the balance of LSP road network.

If fronting P.O.S., access street verge adjacent to P.O.S. may be reduced. This is the case with the internal LSP roads fronting "Bush Forever" reserve and internal structure plan P.O.S.

Maximum desirable daily traffic volume for this type of road is 1,000vpd. The typical cross-section of the *Access Street D* sourced from *"Liveable Neighbourhoods"* is illustrated in **Figure 8**.

In order to facilitate visitor parking demand public parking in form of embayed parking bays are also recommended to be implemented on one side of Access Streets next to parks and in front of rear-access residential lots, where practical.

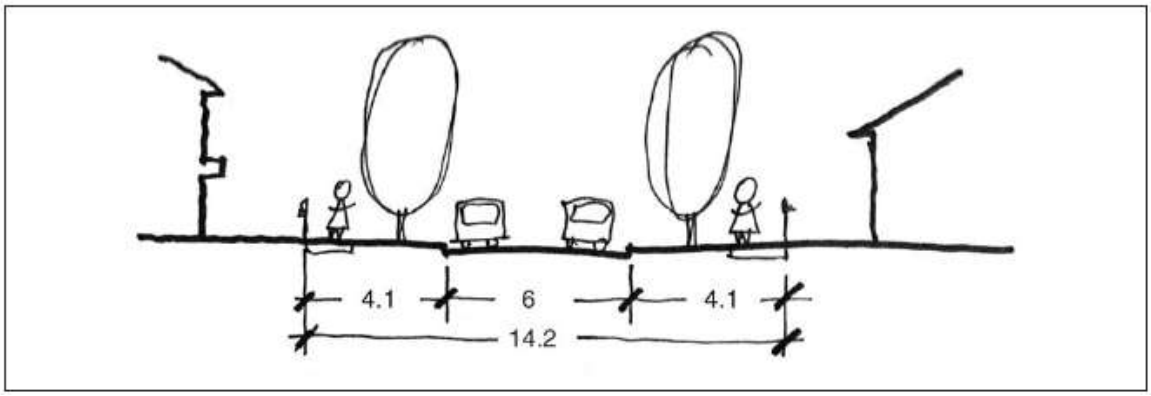


Figure 8. Access Street D (narrow yield) with target speed of 30 km/h (<1,000vpd)

The typical road reserve for *Laneways* entails a 6m wide trafficable pavement sufficient to allow two-way movements, rubbish collection and vehicle access into garages located on the rear of properties. Maximum desirable traffic volume for a laneway is 300vpd. The typical cross-section of the *Laneways* is illustrated in **Figure 9**.

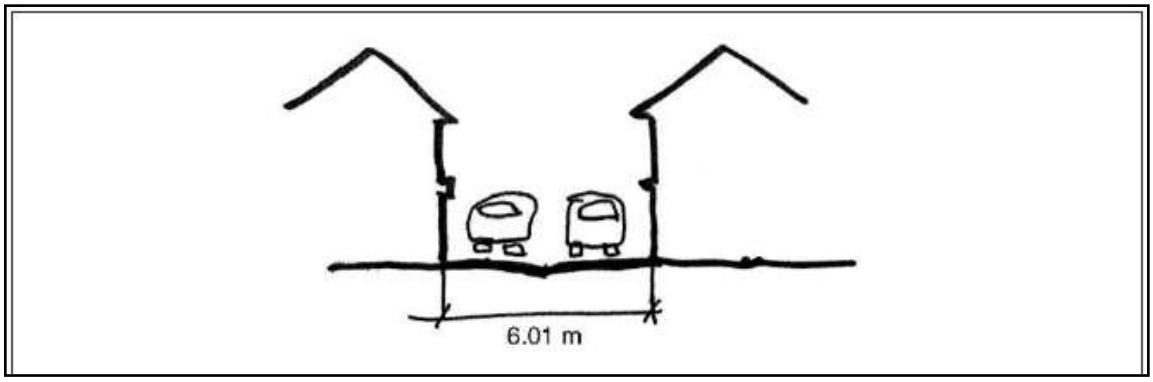


Figure 9. Laneways – for rear vehicle access with target speed of 15km/h (<300vpd)

A number of intersection treatments have also been recommended for the internal LSP road network to improve the efficiency and safety of traffic operations. These intersection treatments and corresponding locations have also been noted in **Figure 5**.

As can be seen, the majority of internal subdivision intersections are designed as T-intersections and will therefore not require any specific traffic management measures due to relatively low traffic volumes and low speeds involved. It is recommended that all these intersections be designed as priority-controlled intersections.

A total of six internal structure plan intersections along the north-south spine road are proposed as four-way intersections. The northernmost and southernmost ones, carrying the highest forecast traffic volumes, are proposed in the form of four-way roundabout intersections with the balance recommended to be designed in the form of priority-controlled intersections with the priority on major direction of traffic (i.e. north-south) and threshold treatments on side road approaches (refer **Figure 5**).

6.2 Public Transport

The existing bus services at this locality are described in great detail in section **4.6** of this report.

With further urbanisation and development of the subject locality there is a realistic opportunity that Karnup Train Station at Paganoni Road will be constructed in the medium-term as part of the Metronet project. According to PTA, a full business case for the station is being progressed.

Due to the size and the potential public transport patronage of the proposed (former) Landcorp Karnup Master Plan and the LSP, including relative proximity to the future Karnup Train Station, it is likely that a feeder bus service along Stakehill Road from the future train station is introduced once the anticipated patronage within the locality justifies such a service.

With a bus stop on Stakehill Road located centrally to the LSP area it is estimated that about 30% of the LSP could be serviced being located within the 400m comfortable walking distance radius from the bus stop.

6.3 Pedestrian and Cyclist Facilities

The existing pedestrian and cyclist facilities available at this locality are discussed in previous sections (refer section **4.6** for more details). The subject site is at this point relatively isolated and removed from the nearest developed areas. As such, the proposed network of LSP cycle and pedestrian paths is generally a self-one serving with limited potential for external connectivity in the short term.

In accordance with current City of Rockingham practice it is proposed to construct all paths to a minimum width of 2.0 metres so that they can all be designated as shared paths for pedestrians and cyclists.

As a general principle, the 2.0m wide pedestrian paths are proposed on one side of all *Neighbourhood Connector* roads with a 2.5m path on the other side. Access Streets will generally have a 2.0m path on one side only.

Similarly, 2.5m shared paths are proposed along the perimeter of the commercial precinct due to anticipated higher pedestrian/cyclist activity at these locations. The 2.5m shared paths are intended to ultimately connect to future regional 3.0m wide shared paths along Stakehill Road and Nairn Drive at the three external LSP intersections. Refer **Figure 10** for more details.



Figure 10: Pedestrian / Cycle Network

7 Integration with Surrounding Area

The proposed LSP is consistent with long-term planning for the subject locality.

The road network of the LSP area will connect to Stakehill Road at two locations ensuring connectivity and integration with the existing and the future road network system in the locality.

The proposed internal LSP pedestrian and cyclist path network makes provisions for future connections with planned regional shared path routes along (upgraded) Stakehill Road and new Nairn Drive extension.

8 Analysis of the Transport Network

8.1 Assessment Period

The assessment year adopted for this analysis is 2041, as it is assumed that the LSP could be fully developed by this timeframe. Further, the 2041 scenario modelled is likely to reflect the land use and road network aspirations for the locality. Accordingly, it is anticipated that Nairn Drive is constructed to its ultimate standard and connecting to Anstey Road at the south end by this time horizon.

Weekday morning and afternoon peak hours are typical peak hours for the residential developments. Hence, typical weekday morning and afternoon peak periods are deemed appropriate for analysis of key LSP intersections in this transport assessment.

8.2 Traffic Generation

The proposed LSP is intended to yield about 420 residential lots with a service station at the northwest corner of the future commercial/retail precinct.

The traffic generation rates for the proposed LSP land uses were sourced from the Roads and Traffic Authority NSW, *"Guide to Traffic Generating Developments"* and Institute of Transportation Engineers *Trip Generation Manual (11th Edition)* publications.

The residential traffic generation rates of 9.0 trips per dwelling per day and 0.85 trips per dwelling per hour were applied in this TIA in order to establish the total traffic generation from the proposed residential component of the LSP and to reflect reflect lack of public transport opportunities. Therefore, the anticipated (approximately) 420 dwellings are estimated to generate approximately 3,790vpd and 358vph total daily and morning/afternoon peak hour trips on typical weekday, respectively.

The *ITE 11th Edition* publication stipulates daily, morning and afternoon peak hour trip rates for Service Station with Convenience Store (945) type of 265.12vpd, 16.06vph and 18.42vph per bowser. Assuming a typical 8-bowser service station, the estimated traffic generation of the service station is anticipated to be in order of approximately 2,120vpd, 129vph and 148vph of total daily, morning and afternoon peak hour trips, respectively. It is anticipated that due to the location of the service station a proportion of trips to the station will be generated from within the LSP.

Accordingly, the LSP area is estimated to generate a total of approximately **5,910** total daily vehicular trips for a typical weekday. The total daily vehicular traffic includes both inbound and outbound trips. Similarly, trip generation during the AM and PM peak periods for the LSP is estimated to be in order of **487** and **506** trips per hour.

It is also estimated that the residential element of the LSP would generate between 13% - 15% of service station trade (internal LSP trips between residents and the service station) with the balance of trips being attracted via external road network.

Trips associated with the service station also comprise a significant proportion of passing-trade trips (and diverted trips) which are trips already present on the road network. In this case a passing trade discount of around 59% of total service station trips generated was assumed, based on the passing trip discount recommendations stipulated in the *ITE Trip Generation Handbook* publication.

It is therefore estimated that the proposed LSP development would generate approximately **4,660** additional daily trips with additional **410**/**418** AM/PM peak hour trips on the external road network, respectively (less the internal LSP to service station trips element).

The distribution and assignment of the LSP-generated traffic was based on the actual location of the subject development, the existing and planned local and regional road network and the location of various existing and future district attraction nodes. Accordingly, the following assumptions were made for the distribution and assignment of the generated traffic:

- Approximately 10% of the traffic generated from the LSP would travel to/from the Eighty Road north direction;
- Approximately 15% of the traffic generated from the LSP would travel to/from the future Nairn Drive direction;
- Approximately 45% of the traffic generated from the LSP would travel to/from the future Stakehill Road east direction (towards Kwinana Freeway); and,
- Approximately 30% of the traffic generated from the LSP would travel to/from the Stakehill Road west direction (Rockingham area.

8.3 Traffic Flow Forecasts

The forecast daily traffic volumes on internal LSP roads and local road network around the project area is shown in **Figure 11**.

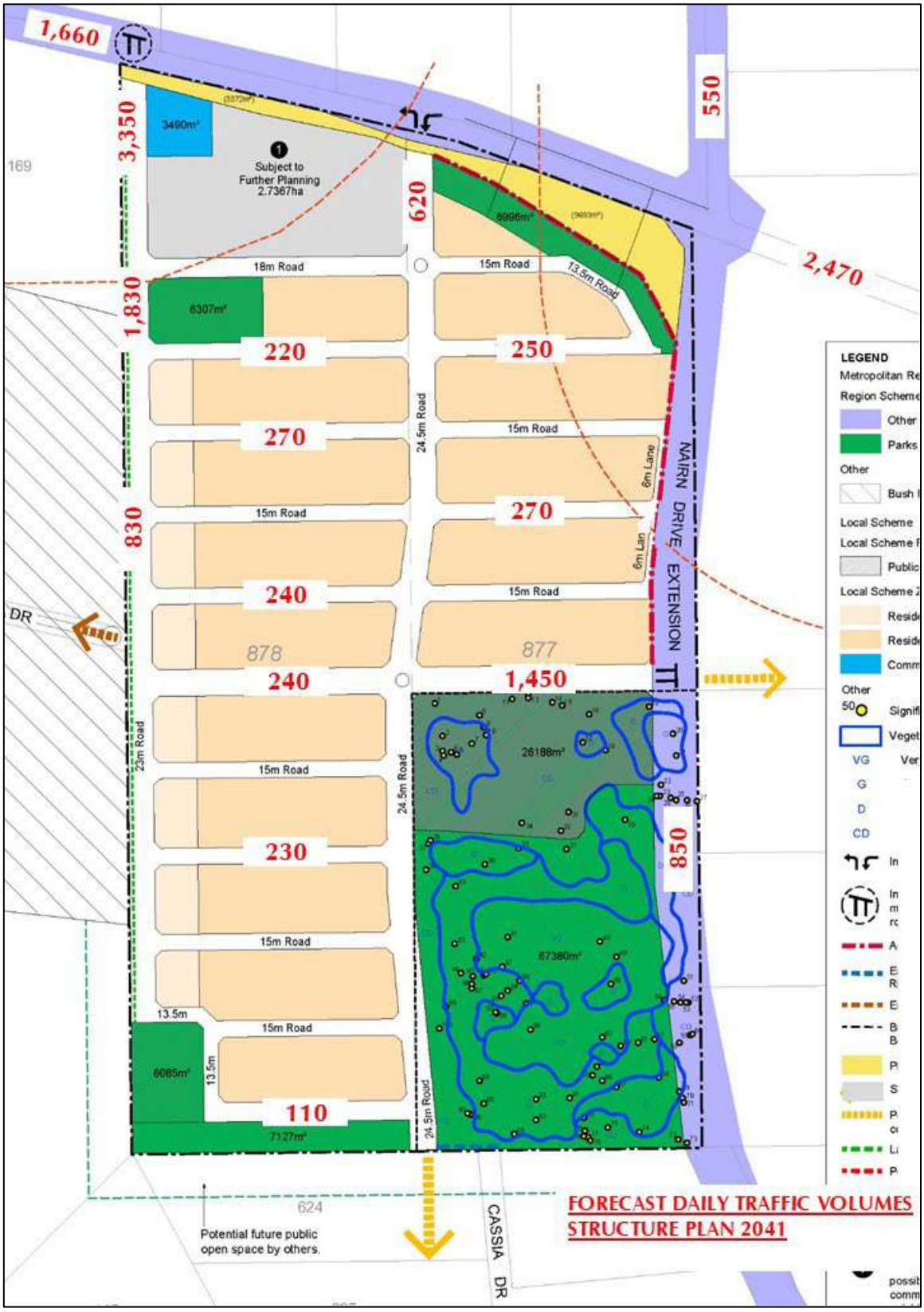


Figure 11: Daily traffic flows

8.4 Internal Roads and Intersections

The internal LSP road network proposed to accommodate the projected traffic volumes, including the details of the proposed road hierarchy and indicative cross sections have been detailed in section **6.1** of this report and illustrated in **Figure 6**.

The LSP plan presented in **Figure 6** also details the proposed intersection controls and treatments for key intersections.

The type of the internal LSP intersection traffic control has been determined using recommendations presented in AUSTROADS *"Guide to Traffic Management Part 6: Intersections, Interchanges and Crossings (2020)"*. As stipulated in Table 3.6 roundabouts are appropriate treatment for intersections formed by collector roads and local crossing roads based on operational and Safe System objectives.

Figure 7.7 from AUSTROADS *"Guide to Traffic Management Part 3: Traffic Studies and Analysis (2012)"* provides reasonably good indication of traffic volume conducive to the lower, typical and upper-bound capacity estimates for the operation of a single-lane roundabout. Based on the projected traffic flows at the internal LSP four-way roundabout intersection good operational conditions are anticipated at this intersection.

Similarly, the priority-controlled intersections are a suitable form of intersection control for local streets. Accordingly, this type of intersection control (with threshold treatments on side roads) are proposed for the remainder of internal LSP four-way intersections.

Accordingly, it is confirmed that the proposed internal LSP road network provides for satisfactory permeability and efficient traffic distribution throughout the area with no bottlenecks or traffic congestion anticipated during typical operating conditions.

However, in order to ensure efficient and safe traffic movements within the LSP area a number of intersection treatments are proposed as shown in **Figure 6.** The details of the proposed intersection treatments will be finalised at the subdivision design stage.

8.5 External Intersection Analysis

The external LSP access intersections are proposed on both Stakehill Road and Nairn Drive. The capacity analysis of these intersections during typical weekday morning and afternoon peak hours was undertaken using the SIDRA Network intersection-modelling software for 2041 assessment year. For the purpose of this assessment and in absence of more firm road network planning information, it is anticipated that

Stakehill Road will be upgraded to its ultimate four-lane dual-carriageway standard while Nairn Drive is also anticipated to be constructed to the similar standard[1].

In order to provide for a robust assessment, it is assumed that by 2041 the LSP is fully developed. In the absence of government supplied traffic projections, the relevant future traffic projections on key district roads have been based on the transport model previously developed by Transcore for the (former) Landcorp Karnup Master Plan but significantly scaled back to reflect the most recent and likely land development aspirations. The population estimates are in line with the demographic study/spatial analysis prepared by ID (urban economy consultants), for Karnup-Keralup area and have been confirmed through extensive discussions with the City of Rockingham planning department.

Based on the population and dwellings forecasts, it is estimated that Stakehill Road could carry between 10,000 – 11,000vpd by 2041.

In order to establish 2041 traffic volumes on Stakehill Road, a higher-than-average annual growth of 4.5%p.a. has been applied to 2022[2] baseline Stakehill Road traffic volumes, resulting in cumulative growth of about 85% between 2022-2041 for this road. This traffic forecast strategy was established through extensive discussions with the City of Rockingham.

The proposewd access system designed to serve the proposed LSP comprises the following three access intersections:

- Centrally-located, left-in/left-out only access intersection on Stakehill Road, approximately 260m west of the existing Eighty Road intersection;
- A full-movement access intersection on Stakehill Road at the westernmost end of the site, some 560m west of Eighty Road intersection; and,
- A full-movement access intersection on Nairn Drive (extension) at the eastern end of the site, some 400m south of Eighty Road intersection.

The future western LSP T-intersection on Stakehill Road is planned as a priority-controlled format with appropriate turning facilities on approaches using the future wide central median on Stakehill Road to facilitate two stage right-turn movements.

The eastern LSP access intersection on Stakehill Road is proposed to be designed in form of a left-in/left-out only intersection.

Similarly, to western LSP access intersection on Stakehill Road, the LSP access intersection on Nairn Drive is also proposed in form of a priority-controlled intersection with appropriate turning facilities on approaches using the future wide central median on Nairn Drive to facilitate two stage right-turn movements. However this intersection maybe upgraded to a roundabout to facilitate access to the future

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[1] DPLH is presently working on Stakehill Road study however traffic projections or road/intersection design details have not been made available to date
[2] Source: Main Roads WA March 2022 traffic survey of Stakehill Road/Eighty Road

developments to the east of Nairn Drive. Hence, in order to future-proof creation of a four-way, dual-lane roundabout appropriate allowances will need to be made with respect to land requirements for such facility.

Apart from the three LSP access intersections, a detailed capacity assessment of Stakehill Road/Nairn Drive roundabout intersection is also deemed necessary to ascertain the capacity of this intersection to accommodate the future traffic volumes for the full LSP and local area build-out scenario in 2041.

Accordingly, for the purpose of this assessment the three LSP access intersections and the future Stakehill Road/Nairn Drive roundabout intersection were integrated into a single network so to ascertain the mutual impacts and flow on effects. The capacity assessments have been undertaken for the typical weekday morning and afternoon peak network traffic activity period in 2041.

The capacity analysis of the LSP intersections on Stakehill Road and Nairn Drive and the Stakehill Road/Nairn Drive intersection has been undertaken using the SIDRA Network computer software package. SIDRA is an intersection modelling tool commonly used by traffic engineers for all types of intersections. SIDRA outputs are presented in the form of Degree of Saturation, Level of Service, Average Delay and 95% Queue. These characteristics are defined as follows:

- Degree of Saturation is the ratio of the arrival traffic flow to the capacity of the approach during the same period. The Degree of Saturation ranges from close to zero for infrequent traffic flow up to one for saturated flow or capacity.
- Level of Service is the qualitative measure describing operational conditions within a traffic stream and the perception by motorists and/or passengers. In general, there are 6 levels of service, designated from A to F, with Level of Service A representing the best operating condition (i.e., free flow) and Level of Service F the worst (i.e. forced or breakdown flow).
- Average Delay is the average of all travel time delays for vehicles through the intersection.
- 95% Queue is the queue length below which 95% of all observed queue lengths fall.

The relevant intersection and network layout plans including the associated capacity assessment results of the SIDRA analysis are summarised in **Appendix B**.

Western LSP Access Intersection on Stakehill Road (full-movement)

This access intersection is modelled as a priority-controlled T-intersection with turn lanes with the assumption that Stakehill Road is upgraded to dual-divided carriageway standard.

The 2041 SIDRA analysis indicates that this intersection will operate satisfactorily during noth AM and PM peak hour periods with an overall LoS A, ample spare capacity and no excessive queuing or delays. Accordingly, the capacity analysis undertaken confirms that the western LSP access intersection has the capacity to

accommodate the anticipated LSP-generated traffic. Refer **Table 2** and **Table 3** for more details.

Eastern LSP Access intersection on Stakehill Road (Left-in/Left-out)

This LSP access intersection is proposed in a restricted left-in/left-out only format. The 2041 SIDRA analysis indicates that this intersection will operate satisfactorily during both AM and PM peak periods with an overall LoS A and ample spare capacity, as is typically the case with these types of intersections. Refer **Table 4** and **Table 5** for more details.

LSP Access Intersection on Nairn Drive (full-movement)

This access intersection is modelled as a priority-controlled T-intersection with turn lanes with the assumption that Nairn Drive is upgraded to dual-divided carriageway standard.

The 2041 SIDRA analysis indicates that this intersection will operate satisfactorily during noth AM and PM peak hour periods with an overall LoS A, ample spare capacity and no excessive queuing or delays. Accordingly, the capacity analysis undertaken confirms that the LSP access intersection on Nairn Drive is not anticipated to experience any capacity issues and will comfortably accommodate the anticipated LSP-generated traffic. Refer **Table 6** and **Table 7** for more details.

Stakehill Road/Eighty Road/Nairn Drive roundabout intersection

This intersection is modelled as a dual-lane, four-way roundabout with the southern leg being the future Nairn Drive.

The two regional distributor roads will ultimately intersect at the northeast corner of the LSP area. This intersection is expected to carry substantial volumes of traffic by 2041 and as such is planned to assume a dual-lane, four-way roundabout standard.

The SIDRA analysis results show overall LoS A for this intersection and capacity levels of under 30% during both peak periods. Maximum queues of about two vehicles are anticipated only on Stakehill Road east approach. Refer **Table 8** and **Table 9** for SIDRA 2041 results for AM and PM weekday periods.

8.6 Access to Frontage Properties

The WAPC *Liveable Neighbourhoods* policy requires that *"Development along Integrator B and Neighbourhood Connector streets with ultimate vehicle volumes over 5,000 vehicles per day should be designed either so vehicles entering the street can do so travelling forward, or are provided with alternative forms of vehicle access. Wider lots with paired driveways and protected reversing areas in the parking lane may be used on streets with up to 7,000 vehicles per day."*

No LSP roads are experiencing these levels of daily traffic except hence access to properties fronting all internal LSP roads should not be an issue.

8.7 Pedestrian and Cycle Networks

The proposed network of shared paths for pedestrians and cyclists is described in section 4.6 of this transport assessment. This network of paths will provide a satisfactorily level of accessibility and permeability for pedestrians and cyclists within the structure plan area and connections to the future internal retail/commercial node.

The WAPC *Transport Impact Assessment Guidelines for Developments* provides guidance on the levels of traffic volumes that are likely to affect the ability for pedestrians to cross various types of road. Based on that guidance an undivided two-lane road should be acceptable for pedestrians crossing traffic volumes of up to approximately 11,000vpd and this threshold can be increased to around 28,000vpd by adding a central median or pedestrian refuge islands.

None of the roads within the structure plan area will reach these levels of traffic to warrant any detailed investigation of crossing facilities at this stage.

At present, and for the foreseeable future, no significant pedestrian attractors are anticipated on the northern side of Stakehill Road; however, with the development of commercial nodes within the LSP area (fronting Stakehill Road) some pedestrian traffic demand from those areas may be experienced. As such, pedestrian crossing facilities should be contemplated in the design of the future roundabout at the western LSP access intersection.

8.8 Access to Public Transport

At this stage of planning process neither bus stop locations nor subdivision lot layouts are known. However, in these circumstances the WAPC *Transport Impact Assessment Guidelines* suggest that it is desirable for at least 90 per cent of dwellings to be within 400m straight line distance of a bus route.

Current planning by the Public Transport Authority (PTA) does not propose any future bus routes within the LSP area or the Karnup locality. However, should Stakehill Road and Nairn Drive become bus transit routes with stops in immediate vicinity of the structure plan, it is estimated that up to about 80% of the structure plan area could potentially be covered by the prescribed 400m walking catchment.

8.9 Access to Schools

The proposed LSP plan does not propose any primary or secondary schools. Accordingly, all future students from the LSP would need to be transported to local schools.

9 Conclusions

This Revised Transport Impact Assessment has been prepared with regard to the proposed Local Structue Plan over Lots 877 & 878 Stakehill Road in Karnup, City of Rockingham. The subject site is situated at the south side of Stakehill Road and to the west of Eighty Road.

The proposed LSP contemplates a total of approximately 420 residential lots including a commercial zone at the northwestern corner of the site and fronting Stakehill Road, with the estimated NLA of about 3,340m^2.

The LSP is proposed to be served by three access intersections on Stakehill Road and the future Nairn Drive (extension):

- Centrally-located, left-in/left-out only access intersection on Stakehill Road, approximately 260m west of the existing Eighty Road intersection;
- A full-movement access intersection on Stakehill Road at the westernmost end of the site, some 560m west of Eighty Road intersection; and,
- A full-movement access intersection on Nairn Drive (extension) at the eastern end of the site, some 400m south of Eighty Road intersection.

In addition to the three-point vehicular access/egress system, an emergency access to Cassia Drive at the southern end of the site is proposed to secure additional escape route in case of bushfire emergency. This access will be chained off only to be opened by DFES in case of emergency to secure additional evacuation route for local residents.

The internal LSP road system consists of *Neighbourhood Connector A, Access Streets B* and *D* and *Laneways* designed to facilitate inter-LSP vehicular, cyclist and pedestrian movements with provisions for future connections to Stakehill Road to the north.

The LSP is estimated to generate approximately 5,910 total daily, 487 AM peak and 506 PM peak hour vehicular trips. However, allowing for the passing trade discount of the commercial element, the estimated total additional daily vehicular traffic on local road network is estimated to be in order of 4,660 additional daily trips with additional 410 AM peak and 418 PM peak hour trips, respectively.

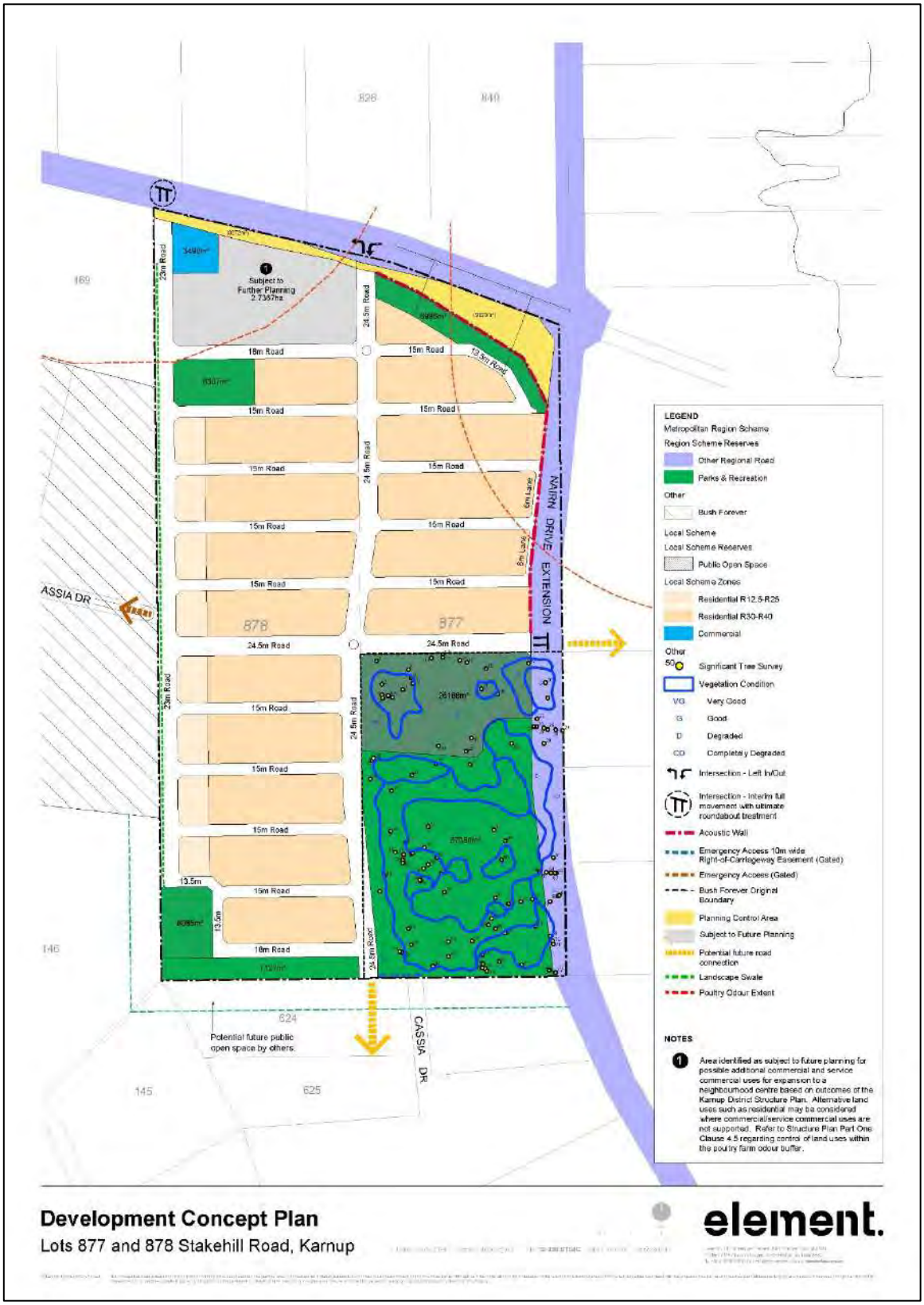
The capacity assessments undertaken for the surrounding roads and key LSP intersections indicate that the future road network and the proposed LSP intersections will have sufficient capacity to accommodate the anticipated traffic from the proposed LSP. The planned upgrade of existing Stakehill Road to dual-carriageway and similar road standard of the yet to be constructed Nairn Drive extension will deliver the required capacity to accommodate the anticipated future traffic volumes at this location as a result of full build out locality including the proposed LSP.

Appendix A

STRUCTURE PLAN - CONCEPT

transcore

Engineering a better future for over 20 years!


Development Concept Plan
Lots 877 and 878 Stakehill Road, Karnup
element.
LEGEND
Metropolitan Region Scheme
Region Scheme Reserves
Other Regional Road
Parks & Recreation
Other
Bush Forever
Local Scheme
Local Scheme Reserves
Public Open Space
Local Scheme Zones
Residential R12.5-R25
Residential R30-R40
Commercial
Other
Significant Tree Survey
Vegetation Condition
Very Good
Good
Degraded
Completely Degraded
Intersection - Left In/Out
Intersection - Interim full movement with ultimate roundabout treatment
Acoustic Wall
Emergency Access 10m wide Right-of-Carriageway Easement (Gated)
Emergency Access (Gated)
Bush Forever Original Boundary
Planning Control Area
Subject to Future Planning
Potential future road connection
Landscape Swale
Poultry Odour Extent
NOTES
1 Area identified as subject to future planning for possible additional commercial and service commercial uses for expansion to a neighbourhood centre based on outcomes of the Karnup District Structure Plan. Alternative land uses such as residential may be considered where commercial/service commercial uses are not supported. Refer to Structure Plan Part One Clause 4.5 regarding control of land uses within the poultry farm odour buffer.
MAIRN DRIVE EXTENSION
ASSIA DR
CASSIA DR
Subject to Further Planning 2.7357ha
878
877
Potential future public open space by others
828
840
169
146
145
624
625

Appendix B

SIDRA MODELLING OUTPUTS

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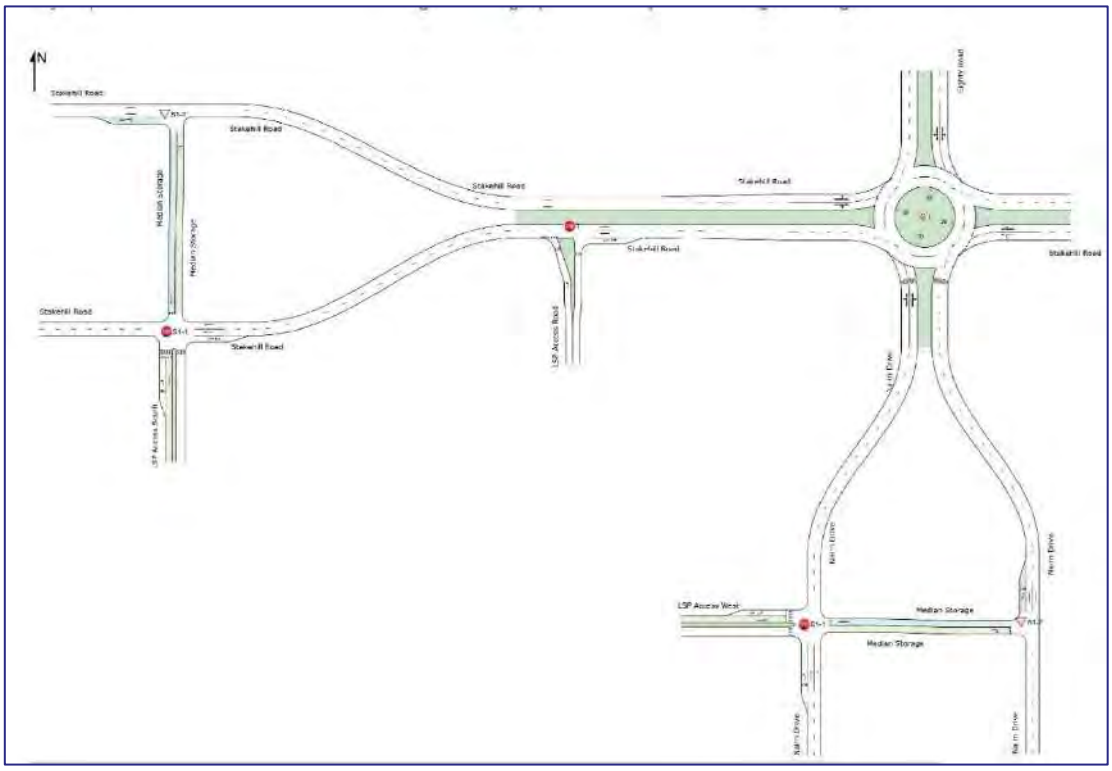


Figure 12: Road network layout modelled in SIDRA (year 2041)

Table 2: SIDRA results for the West LSP Stakehill Road Access Intersection - AM peak (year 2041)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: LSP Access South															
1	L2	All MCs	52	0.0	52	0.0	0.044	5.8	LOS A	0.2	1.3	0.39	0.58	0.39	54.1
2	T1	All MCs	102	0.0	102	0.0	0.297	17.1	LOS C	1.4	10.5	0.77	0.94	0.90	16.1
Approach			154	0.0	154	0.0	0.297	13.3	LOS B	1.4	10.5	0.64	0.82	0.73	33.3
East: Stakehill Road															
3	L2	All MCs	49	0.0	49	0.0	0.027	6.9	LOS A	0.0	0.0	0.00	0.63	0.00	50.6
4	T1	All MCs	674	0.1	674	0.1	0.188	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	79.9
Approach			723	0.1	723	0.1	0.188	0.5	NA	0.0	0.0	0.00	0.04	0.00	78.2
North: Median Storage															
5	T1	All MCs	42	0.0	42	0.0	0.078	5.6	LOS A	0.3	2.3	0.62	0.59	0.62	23.7
Approach			42	0.0	42	0.0	0.078	5.6	LOS A	0.3	2.3	0.62	0.59	0.62	23.7
All Vehicles			919	0.1	919	0.1	0.297	2.9	NA	1.4	10.5	0.14	0.20	0.15	70.3
South: Median Storage															
1	R2	All MCs	102	0.0	102	0.0	0.104	2.3	LOS A	0.3	2.6	0.40	0.46	0.40	11.4
Approach			102	0.0	102	0.0	0.104	2.3	LOS A	0.3	2.6	0.40	0.46	0.40	11.4
West: Stakehill Road															
2	T1	All MCs	409	0.1	409	0.1	0.114	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	79.9
3	R2	All MCs	42	0.0	42	0.0	0.023	6.8	LOS A	0.0	0.0	0.00	0.67	0.00	61.7
Approach			452	0.1	452	0.1	0.114	0.7	NA	0.0	0.0	0.00	0.06	0.00	77.8
All Vehicles			554	0.1	554	0.1	0.114	1.0	NA	0.3	2.6	0.07	0.14	0.07	74.5

Table 3: SIDRA results for the West LSP Stakehill Road Access Intersection - PM peak (year 2041)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: LSP Access South															
1	L2	All MCs	36	0.0	36	0.0	0.029	5.5	LOS A	0.1	0.8	0.35	0.55	0.35	54.3
2	T1	All MCs	77	0.0	77	0.0	0.185	12.8	LOS B	0.8	5.9	0.69	0.84	0.69	19.4
Approach			113	0.0	113	0.0	0.185	10.5	LOS B	0.8	5.9	0.58	0.75	0.58	36.0
East: Stakehill Road															
3	L2	All MCs	81	0.0	81	0.0	0.045	6.9	LOS A	0.0	0.0	0.00	0.63	0.00	50.6
4	T1	All MCs	564	0.1	564	0.1	0.157	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	79.9
Approach			645	0.1	645	0.1	0.157	0.9	NA	0.0	0.0	0.00	0.08	0.00	76.9
North: Median Storage															
5	T1	All MCs	92	0.0	92	0.0	0.150	4.9	LOS A	0.6	4.6	0.62	0.59	0.62	24.6
Approach			92	0.0	92	0.0	0.150	4.9	LOS A	0.6	4.6	0.62	0.59	0.62	24.6
All Vehicles			849	0.1	849	0.1	0.185	2.6	NA	0.8	5.9	0.14	0.22	0.14	69.3
South: Median Storage															
1	R2	All MCs	77	0.0	77	0.0	0.093	3.1	LOS A	0.3	2.2	0.47	0.54	0.47	9.9
Approach			77	0.0	77	0.0	0.093	3.1	LOS A	0.3	2.2	0.47	0.54	0.47	9.9
West: Stakehill Road															
2	T1	All MCs	536	0.1	536	0.1	0.149	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	79.9
3	R2	All MCs	92	0.0	92	0.0	0.050	6.8	LOS A	0.0	0.0	0.00	0.67	0.00	61.7
Approach			627	0.1	627	0.1	0.149	1.0	NA	0.0	0.0	0.00	0.10	0.00	76.6
All Vehicles			704	0.1	704	0.1	0.149	1.2	NA	0.3	2.2	0.05	0.15	0.05	74.6

Table 4: SIDRA results for the East LSP Stakehill Road Access Intersection - AM peak (year 2041)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: LSP Access Road															
1	L2	All MCs	47	0.1	47	0.1	0.058	6.1	LOS A	0.2	1.6	0.44	0.62	0.44	23.5
Approach			47	0.1	47	0.1	0.058	6.1	LOS A	0.2	1.6	0.44	0.62	0.44	23.5
East: Stakehill Road															
4	L2	All MCs	16	0.0	16	0.0	0.009	6.9	LOS A	0.0	0.0	0.00	0.63	0.00	47.6
5	T1	All MCs	676	0.1	676	0.1	0.188	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	79.9
Approach			692	0.1	692	0.1	0.188	0.2	NA	0.0	0.0	0.00	0.01	0.00	78.4
West: Stakehill Road															
11	T1	All MCs	512	0.1	512	0.1	0.143	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	79.9
Approach			512	0.1	512	0.1	0.143	0.0	NA	0.0	0.0	0.00	0.00	0.00	79.9
All Vehicles			1251	0.1	1251	0.1	0.188	0.3	NA	0.2	1.6	0.02	0.03	0.02	77.3

Table 5: SIDRA results for the East LSP Stakehill Road Access Intersection - PM peak (year 2041)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: LSP Access Road															
1	L2	All MCs	19	0.1	19	0.1	0.022	5.8	LOS A	0.1	0.6	0.41	0.57	0.41	24.1
Approach			19	0.1	19	0.1	0.022	5.8	LOS A	0.1	0.6	0.41	0.57	0.41	24.1
East: Stakehill Road															
4	L2	All MCs	42	0.0	42	0.0	0.023	6.9	LOS A	0.0	0.0	0.00	0.63	0.00	47.6
5	T1	All MCs	626	0.1	626	0.1	0.175	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	79.9
Approach			668	0.1	668	0.1	0.175	0.5	NA	0.0	0.0	0.00	0.04	0.00	76.1
West: Stakehill Road															
11	T1	All MCs	613	0.1	613	0.1	0.171	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	79.9
Approach			613	0.1	613	0.1	0.171	0.0	NA	0.0	0.0	0.00	0.00	0.00	79.9
All Vehicles			1300	0.1	1300	0.1	0.175	0.3	NA	0.1	0.6	0.01	0.03	0.01	77.3

Table 6: SIDRA results for the LSP Nairn Drive Access Intersection - AM peak (year 2041)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	[Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: LSP Access South															
1	L2	All MCs	52	0.0	52	0.0	0.044	5.8	LOS A	0.2	1.3	0.39	0.58	0.39	54.1
2	T1	All MCs	102	0.0	102	0.0	0.297	17.1	LOS C	1.4	10.5	0.77	0.94	0.90	16.1
Approach			154	0.0	154	0.0	0.297	13.3	LOS B	1.4	10.5	0.64	0.82	0.73	33.3
East: Stakehill Road															
3	L2	All MCs	49	0.0	49	0.0	0.027	6.9	LOS A	0.0	0.0	0.00	0.63	0.00	50.6
4	T1	All MCs	674	0.1	674	0.1	0.188	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	79.9
Approach			723	0.1	723	0.1	0.188	0.5	NA	0.0	0.0	0.00	0.04	0.00	78.2
North: Median Storage															
5	T1	All MCs	42	0.0	42	0.0	0.078	5.6	LOS A	0.3	2.3	0.62	0.59	0.62	23.7
Approach			42	0.0	42	0.0	0.078	5.6	LOS A	0.3	2.3	0.62	0.59	0.62	23.7
All Vehicles			919	0.1	919	0.1	0.297	2.9	NA	1.4	10.5	0.14	0.20	0.15	70.3
South: Median Storage															
1	R2	All MCs	102	0.0	102	0.0	0.104	2.3	LOS A	0.3	2.6	0.40	0.46	0.40	11.4
Approach			102	0.0	102	0.0	0.104	2.3	LOS A	0.3	2.6	0.40	0.46	0.40	11.4
West: Stakehill Road															
2	T1	All MCs	409	0.1	409	0.1	0.114	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	79.9
3	R2	All MCs	42	0.0	42	0.0	0.023	6.8	LOS A	0.0	0.0	0.00	0.67	0.00	61.7
Approach			452	0.1	452	0.1	0.114	0.7	NA	0.0	0.0	0.00	0.06	0.00	77.8
All Vehicles			554	0.1	554	0.1	0.114	1.0	NA	0.3	2.6	0.07	0.14	0.07	74.5

Table 7: SIDRA results for the LSP Nairn Drive Access Intersection - PM peak (year 2041)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	[Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: LSP Access South															
1	L2	All MCs	36	0.0	36	0.0	0.029	5.5	LOS A	0.1	0.8	0.35	0.55	0.35	54.3
2	T1	All MCs	77	0.0	77	0.0	0.185	12.8	LOS B	0.8	5.9	0.69	0.84	0.69	19.4
Approach			113	0.0	113	0.0	0.185	10.5	LOS B	0.8	5.9	0.58	0.75	0.58	36.0
East: Stakehill Road															
3	L2	All MCs	81	0.0	81	0.0	0.045	6.9	LOS A	0.0	0.0	0.00	0.63	0.00	50.6
4	T1	All MCs	564	0.1	564	0.1	0.157	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	79.9
Approach			645	0.1	645	0.1	0.157	0.9	NA	0.0	0.0	0.00	0.08	0.00	76.9
North: Median Storage															
5	T1	All MCs	92	0.0	92	0.0	0.150	4.9	LOS A	0.6	4.6	0.62	0.59	0.62	24.6
Approach			92	0.0	92	0.0	0.150	4.9	LOS A	0.6	4.6	0.62	0.59	0.62	24.6
All Vehicles			849	0.1	849	0.1	0.185	2.6	NA	0.8	5.9	0.14	0.22	0.14	69.3
South: Median Storage															
1	R2	All MCs	77	0.0	77	0.0	0.093	3.1	LOS A	0.3	2.2	0.47	0.54	0.47	9.9
Approach			77	0.0	77	0.0	0.093	3.1	LOS A	0.3	2.2	0.47	0.54	0.47	9.9
West: Stakehill Road															
2	T1	All MCs	536	0.1	536	0.1	0.149	0.0	LOS A	0.0	0.0	0.00	0.00	0.00	79.9
3	R2	All MCs	92	0.0	92	0.0	0.050	6.8	LOS A	0.0	0.0	0.00	0.67	0.00	61.7
Approach			627	0.1	627	0.1	0.149	1.0	NA	0.0	0.0	0.00	0.10	0.00	76.6
All Vehicles			704	0.1	704	0.1	0.149	1.2	NA	0.3	2.2	0.05	0.15	0.05	74.6

Table 8: SIDRA results for the Stakehill Road/Nairn Drive Roundabout - AM peak (year 2041)

Vehicle Movement Performance

Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Nairn Drive															
1	L2	All MCs	20	0.5	20	0.5	0.105	7.8	LOS A	0.4	3.1	0.52	0.67	0.52	54.9
2	T1	All MCs	66	0.5	66	0.5	0.105	8.2	LOS A	0.4	3.1	0.52	0.67	0.52	61.7
3	R2	All MCs	127	0.5	127	0.5	0.125	13.5	LOS B	0.5	3.8	0.50	0.76	0.50	55.2
Approach			214	0.5	214	0.5	0.125	11.4	LOS B	0.5	3.8	0.51	0.72	0.51	57.1
East: Stakehill Road															
4	L2	All MCs	36	0.1	36	0.1	0.268	5.9	LOS A	1.4	11.3	0.26	0.47	0.26	61.2
5	T1	All MCs	645	0.1	645	0.1	0.268	6.4	LOS A	1.4	11.3	0.26	0.48	0.26	60.6
6	R2	All MCs	40	0.1	40	0.1	0.268	12.2	LOS B	1.4	11.1	0.27	0.50	0.27	61.1
Approach			721	0.1	721	0.1	0.268	6.7	LOS A	1.4	11.3	0.26	0.48	0.26	60.7
North: Eighty Road															
7	L2	All MCs	81	0.5	81	0.5	0.081	7.1	LOS A	0.3	2.6	0.48	0.65	0.48	63.1
8	T1	All MCs	51	0.5	51	0.5	0.081	7.9	LOS A	0.3	2.6	0.50	0.69	0.50	56.1
9	R2	All MCs	26	0.5	26	0.5	0.081	13.7	LOS B	0.3	2.5	0.50	0.69	0.50	55.8
Approach			158	0.5	158	0.5	0.081	8.4	LOS A	0.3	2.6	0.49	0.67	0.49	60.5
West: Stakehill Road															
10	L2	All MCs	23	0.1	23	0.1	0.216	6.3	LOS A	1.0	8.2	0.37	0.52	0.37	58.4
11	T1	All MCs	464	0.1	464	0.1	0.216	6.8	LOS A	1.0	8.2	0.37	0.53	0.37	59.6
12	R2	All MCs	24	0.1	24	0.1	0.216	12.7	LOS B	1.0	8.1	0.38	0.55	0.38	48.9
Approach			512	0.1	512	0.1	0.216	7.1	LOS A	1.0	8.2	0.38	0.53	0.38	59.3
All Vehicles			1604	0.2	1604	0.2	0.268	7.6	LOS A	1.4	11.3	0.35	0.55	0.35	59.5

Table 9: SIDRA results for the LSP Nairn Drive Access Intersection - PM peak (year 2041)

Vehicle Movement Performance

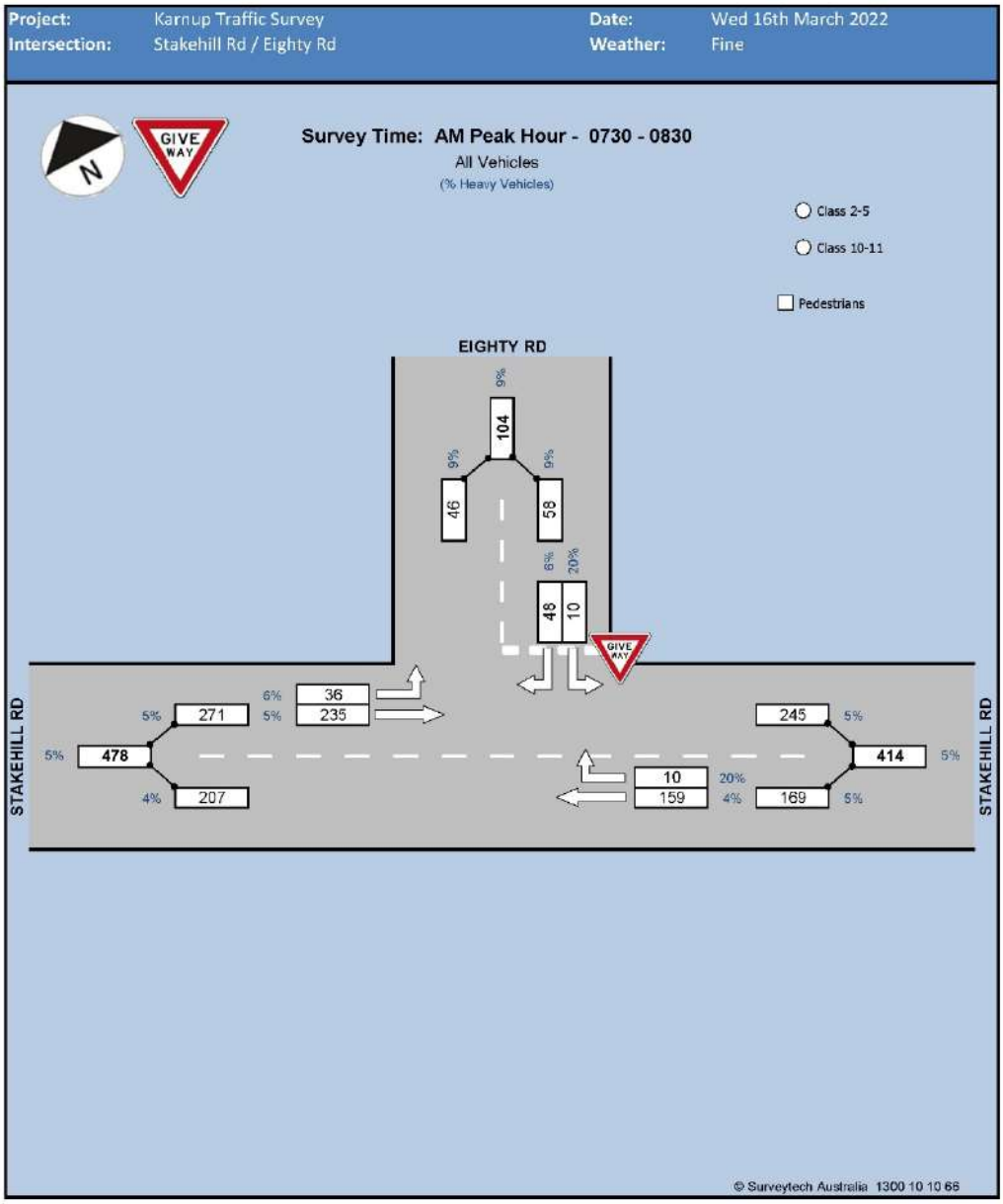
Mov ID	Turn	Mov Class	Demand Flows [Total veh/h	HV] %	Arrival Flows [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% Back Of Queue [Veh. veh	Dist] m	Prop. Que	Eff. Stop Rate	Aver. No. of Cycles	Aver. Speed km/h
South: Nairn Drive															
1	L2	All MCs	16	0.5	16	0.5	0.060	7.7	LOS A	0.2	1.7	0.51	0.66	0.51	55.2
2	T1	All MCs	35	0.5	35	0.5	0.060	8.1	LOS A	0.2	1.8	0.51	0.66	0.51	61.8
3	R2	All MCs	60	0.5	60	0.5	0.060	13.5	LOS B	0.2	1.8	0.49	0.75	0.49	55.3
Approach			111	0.5	111	0.5	0.060	11.0	LOS B	0.2	1.8	0.50	0.71	0.50	57.3
East: Stakehill Road															
4	L2	All MCs	83	0.1	83	0.1	0.288	5.9	LOS A	1.5	12.2	0.24	0.47	0.24	61.4
5	T1	All MCs	623	0.1	623	0.1	0.288	6.3	LOS A	1.5	12.2	0.25	0.49	0.25	60.4
6	R2	All MCs	79	0.1	79	0.1	0.288	12.2	LOS B	1.5	12.1	0.26	0.52	0.26	60.7
Approach			785	0.1	785	0.1	0.288	6.9	LOS A	1.5	12.2	0.25	0.49	0.25	60.6
North: Eighty Road															
7	L2	All MCs	46	0.5	46	0.5	0.058	7.1	LOS A	0.2	1.8	0.48	0.64	0.48	62.9
8	T1	All MCs	37	0.5	37	0.5	0.058	7.7	LOS A	0.2	1.8	0.49	0.69	0.49	56.4
9	R2	All MCs	29	0.5	29	0.5	0.058	13.7	LOS B	0.2	1.7	0.49	0.72	0.49	54.6
Approach			113	0.5	113	0.5	0.058	9.0	LOS A	0.2	1.8	0.49	0.68	0.49	59.5
West: Stakehill Road															
10	L2	All MCs	25	0.1	25	0.1	0.244	6.2	LOS A	1.2	9.3	0.32	0.50	0.32	58.8
11	T1	All MCs	562	0.1	562	0.1	0.244	6.6	LOS A	1.2	9.3	0.32	0.51	0.32	60.0
12	R2	All MCs	25	0.1	25	0.1	0.244	12.5	LOS B	1.2	9.2	0.33	0.52	0.33	49.7
Approach			613	0.1	613	0.1	0.244	6.8	LOS A	1.2	9.3	0.32	0.51	0.32	59.7
All Vehicles			1621	0.2	1621	0.2	0.288	7.3	LOS A	1.5	12.2	0.31	0.53	0.31	59.8

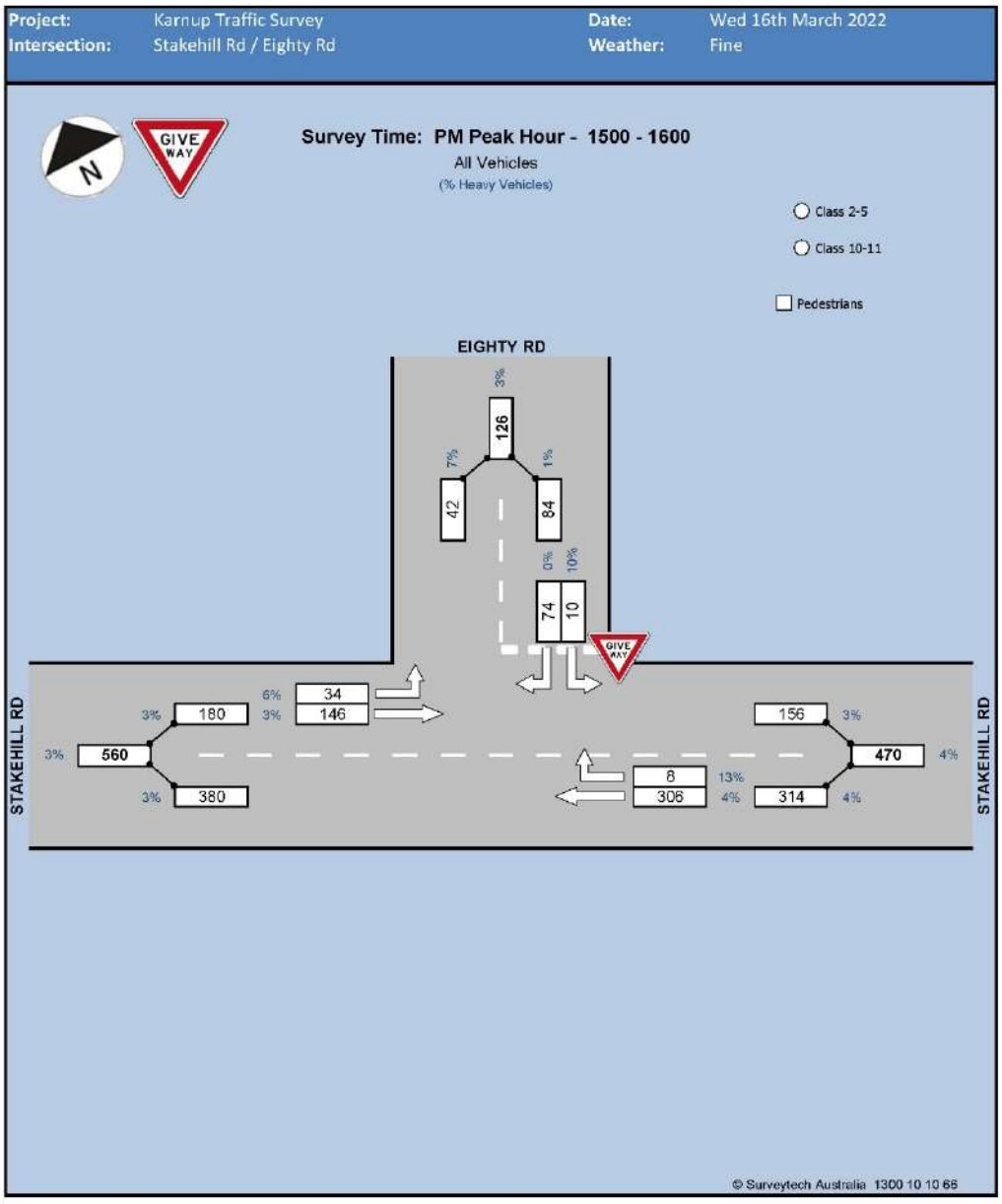
Appendix C

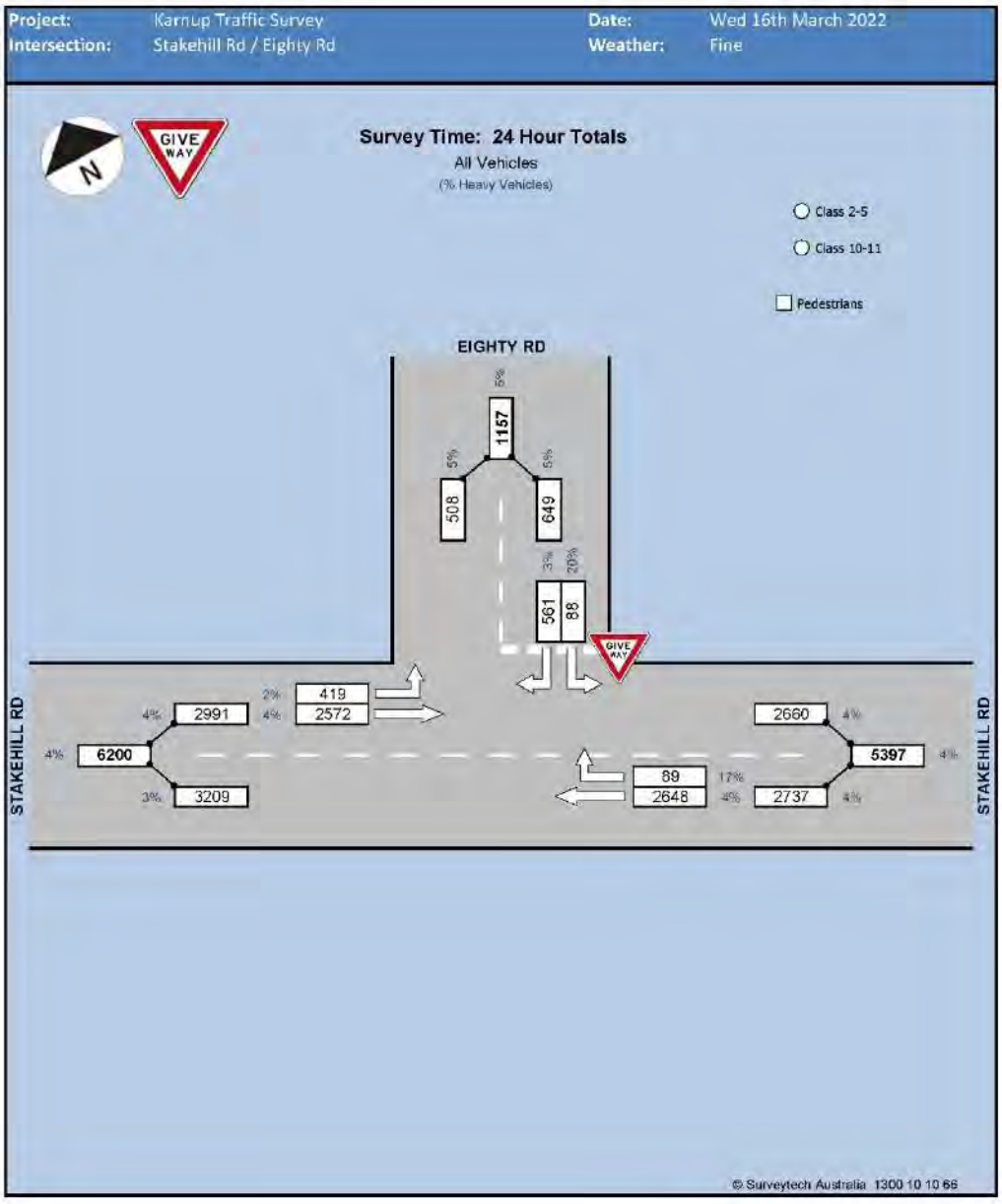
TRAFFIC SURVEY DATA

transcore

Engineering a better future for over 20 years!


Project: Karnup Traffic Survey
Intersection: Stakehill Rd / Eighty Rd
Date: Wed 16th March 2022
Weather: Fine
GIVE WAY
Survey Time: AM Peak Hour - 0730 - 0830
All Vehicles
(% Heavy Vehicles)
Class 2-5
Class 10-11
Pedestrians
EIGHTY RD
STAKEHILL RD
STAKEHILL RD
9%
104
9%
9%
46
58
6%
20%
48
10
GIVE WAY
6%
36
5%
271
5%
478
4%
207
5%
235
245
5%
414
5%
10
20%
159
4%
169
5%
© Surveytech Australia 1300 10 10 66


Project: Karnup Traffic Survey
Intersection: Stakehill Rd / Eighty Rd
Date: Wed 16th March 2022
Weather: Fine
GIVE WAY
Survey Time: PM Peak Hour - 1500 - 1600
All Vehicles
(% Heavy Vehicles)
Class 2-5
Class 10-11
Pedestrians
EIGHTY RD
STAKEHILL RD
STAKEHILL RD
3%
126
7%
42
1%
84
0%
74
10%
10
6%
34
3%
146
3%
180
3%
560
3%
380
8
13%
306
4%
156
3%
470
4%
314
4%
© Surveytech Australia 1300 10 10 65


Project: Karnup Traffic Survey
Intersection: Stakehill Rd / Eighty Rd
Date: Wed 16th March 2022
Weather: Fine
GIVE WAY
Survey Time: 24 Hour Totals
All Vehicles
(% Heavy Vehicles)
Class 2-5
Class 10-11
Pedestrians
EIGHTY RD
1157
508
649
561
88
GIVE WAY
419
2572
2991
6200
3209
89
2648
2660
5397
2737
STAKEHILL RD
STAKEHILL RD
© Surveytech Australia 1300 10 10 66

Appendix 8

Landscaping Concept Plans



MELALEUCA VIRIDIFLORA
'BROADLEAF'



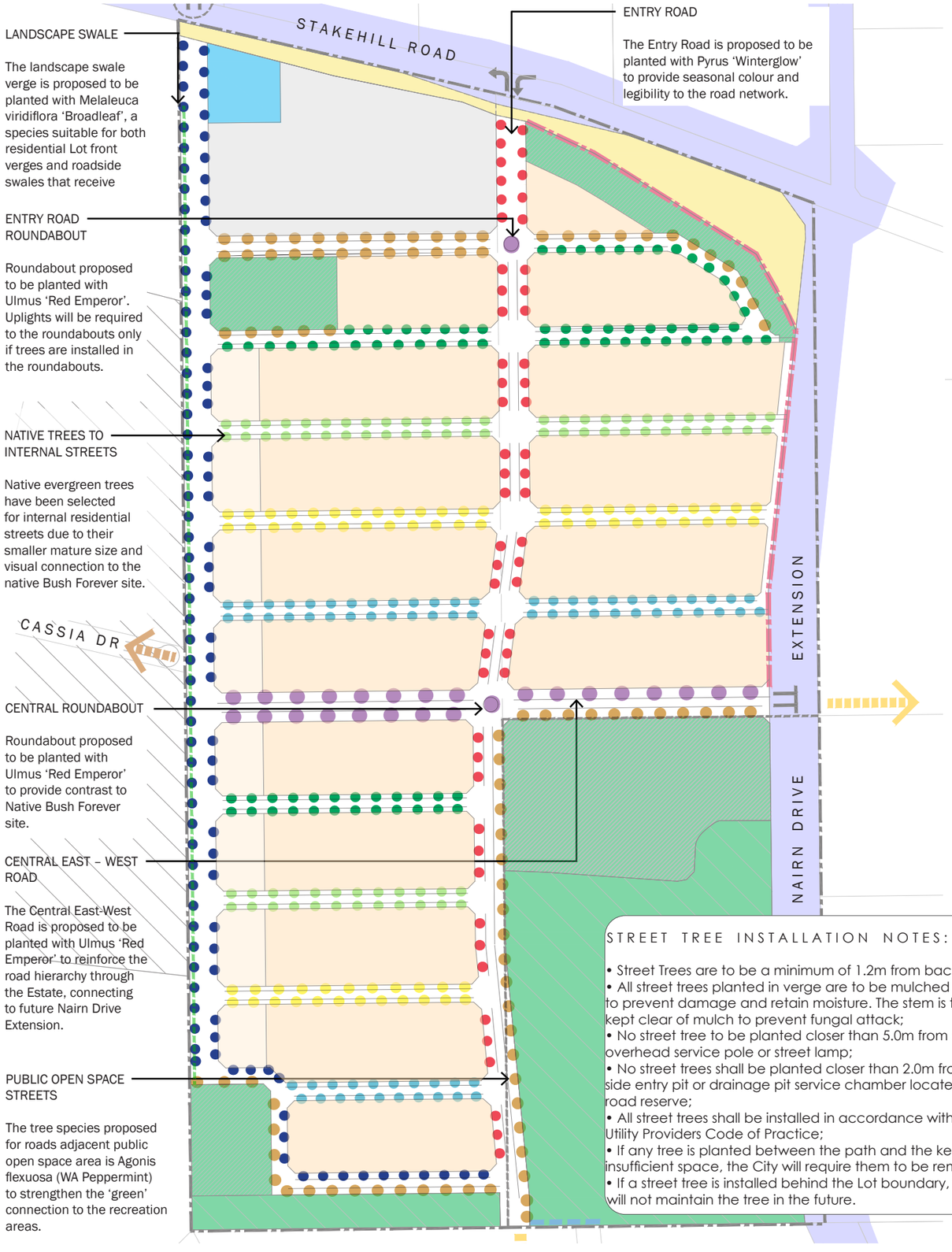
ULMUS 'RED EMPEROR'



PYRUS 'WINTER GLOW'



AGONIS FLEXUOSA



LANDSCAPE SWALE

The landscape swale verge is proposed to be planted with Melaleuca viridiflora 'Broadleaf', a species suitable for both residential Lot front verges and roadside swales that receive

ENTRY ROAD

The Entry Road is proposed to be planted with Pyrus 'Winterglow' to provide seasonal colour and legibility to the road network.

ENTRY ROAD ROUNDABOUT

Roundabout proposed to be planted with Ulmus 'Red Emperor'. Uplights will be required to the roundabouts only if trees are installed in the roundabouts.

NATIVE TREES TO INTERNAL STREETS

Native evergreen trees have been selected for internal residential streets due to their smaller mature size and visual connection to the native Bush Forever site.

CENTRAL ROUNDABOUT

Roundabout proposed to be planted with Ulmus 'Red Emperor' to provide contrast to Native Bush Forever site.

CENTRAL EAST – WEST ROAD

The Central East-West Road is proposed to be planted with Ulmus 'Red Emperor' to reinforce the road hierarchy through the Estate, connecting to future Nairn Drive Extension.

PUBLIC OPEN SPACE STREETS

The tree species proposed for roads adjacent public open space area is Agonis flexuosa (WA Peppermint) to strengthen the 'green' connection to the recreation areas.

LEGEND

- Other Regional Road
- Parks & Recreation
- Bush Forever
- Public Open Space
- Residential R12.5-R25
- Residential R30-R40
- Commercial
- Intersection - Left In/Out
- Intersection - Interim full movement with ultimate roundabout treatment
- Acoustic Wall
- Planning Control Area
- Subject to Future Planning
- Landscape Swale

LEGEND - STREET TREES

- MELALEUCA VIRIDIFLORA 'BROADLEAF' (8m tall x 4m wide)
- ULMUS 'RED EMPEROR' (12m tall x 12m wide)
- PYRUS 'WINTER GLOW' (7m tall x 4m wide)
- AGONIS FLEXUOSA (4-10m tall and wide)
- CORYMBIA EXIMIA 'NANA' (9m tall x 7m wide)
- CORYMBIA CITRIODORA 'GRAFTED DWARF' (7m tall x 4m wide)
- EUCALYPTUS LEUCOXYLON MEGALOCARPA (8m tall x 5m wide)
- CUPANIOPSIS ANACARDIOIDES (8m tall x 4m wide)

STREET TREE INSTALLATION NOTES:

- Street Trees are to be a minimum of 1.2m from back of kerb;
- All street trees planted in verge are to be mulched at base, to prevent damage and retain moisture. The stem is to be kept clear of mulch to prevent fungal attack;
- No street tree to be planted closer than 5.0m from any overhead service pole or street lamp;
- No street trees shall be planted closer than 2.0m from any side entry pit or drainage pit service chamber located within road reserve;
- All street trees shall be installed in accordance with the Utility Providers Code of Practice;
- If any tree is planted between the path and the kerb with insufficient space, the City will require them to be removed;
- If a street tree is installed behind the Lot boundary, the City will not maintain the tree in the future.



CORYMBIA EXIMIA 'NANA'



CORYMBIA CITRIODORA 'GRAFTED DWARF'



EUCALYPTUS LEUCOXYLON MEGALOCARPA



CUPANIOPSIS ANACARDIOIDES

LOT 877 & 878 STAKEHILL ROAD, KARNUP

PREPARED FOR TERRANOVIS PTY LTD

STREET TREE MASTER PLAN
APRIL 2025

JOB NO. 1700301
1:2000 @ A3

C1.101

REV A

0 1 2 4 6 10m

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PLAN E
LANDSCAPE ARCHITECTS
LEVEL 1 278 RAILWAY PARADE WEST LEEDERVILLE 6007
T: (08) 9388 9566 E: mail@plane.com.au

LEGEND

01 EXISTING BUSHLAND RETAINED & PROTECTED

02 EXISTING BUSHLAND RETAINED WITH NON-IRRIGATED UNDERSTOREY REVEGETATION PLANTING TO COMPLETELY DEGRADED AREAS

03 UNDERSTOREY (NON-IRRIGATED) REVEGETATION PLANTING TO CREATE BUFFER TO NAIRN DRIVE

04 EXISTING TREES RETAINED WITH IRRIGATED LOW NATIVE SHRUB AND GROUNDCOVER PLANTING

05 PATHWAY LOOP MEANDERING AROUND EXISTING VEGETATION

06 BIKE TRACK WITH OBSTACLES/ VARYING LEVELS OF DIFFICULTY INCLUDING JUNIOR SHORT LOOP FOR YOUNGER CHILDREN

07 STABILISED LIMESTONE WALKING TRAIL/ SERVICE VEHICLE ACCESS THROUGH BUSHLAND WITH GATED ACCESS POINTS

08 SEATING NODE WITH BENCH SEATING OVERLOOKING BIKE TRAIL OR OPEN GRASSED AREA

09 GATHERING SPACE WITH PICNIC TABLE UNDER SHADE STRUCTURE

10 MULCHED AREA BENEATH EXISTING TREES IN CENTRAL BIKE TRACK SPACE

11 MULCHED NATURE PLAY AREA WITH PLAYGROUND EQUIPMENT UNDER SHADE OF EXISTING TREES

12 OPEN TURF SPACE TO EXISTING CLEARED AREA. (ALL EXISTING STRUCTURALLY SOUND SIGNIFCANT TREES TO BE RETAINED WHERE POSSIBLE)

13 TRAFFICABLE CENTRAL PATH ALONG LINE OF NATURAL CLEARING AND CONSERVATION FENCE-LINE TO ACT AS FIREBREAK

ANIMAL-PROOF FENCE WITH GATED PEDESTRIAN AND MAINTENANCE VEHICLE ACCESS TO WALKING TRAIL

CONSERVATION AREA FENCE (TO FOLLOW LINE OF NATURAL CLEARING)

LOCATION OF EXISTING SIGNIFICANT TREES (AS PER SURVEY INFORMATION)

PUBLIC OPEN SPACE

CONSERVATION AREA / BUSH FOREVER SITE

FUTURE NAIRN DRIVE











LOT 877 & 878 STAKEHILL ROAD, KARNUP

POS & BUSH FOREVER SITE LANDSCAPE CONCEPT
MARCH 2022

JOB NO. 1700301
1:1500 @ A3

C1.101 REV B

0 15 30 45 75m

PLAN E
LANDSCAPE ARCHITECTS
414 ROKEBY RD SUBIACO WA 6008
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Appendix 9

Engineering Servicing Report with Earthworks Plans

LOT 877 AND LOT 878 STAKEHILL ROAD, KARNUP

ENGINEERING SERVICES REPORT

1. General:

The subject site is generally located immediately south of Stakehill Road opposite Eighty Road, some 2km east of Mandurah Road, in the district of Karnup within the City of Rockingham. This area is ultimately planned to be developed into urban residential lots. The area is currently zoned rural, and covers some 48 hectares, of which some 10 hectare is bush, and the remainder currently used as market garden.

The land is to be subdivided for residential development comprising some 420 residential lots, plus commercial and service commercial fronting Stakehill Road.

This report covers existing and proposed services plus proposals for earthworks, retaining walls, roads, drainage, groundwater, water supply, power supply, gas, telecommunications and sewerage as required for current urban development standards.

2. Executive Summary

The subject land of this report is located on the south side of Stakehill Road, some 2km east of Mandurah Road, and some 500 metres west of Harvey Road, in the district of Karnup of the City of Rockingham. The land is 50% cleared and currently used for market gardening, with approximately 9.3 hectares of residual bush located in the south east corner of the site. Lot 878 abutting on the west contains a residence and sheds along the northern boundary fronting on to Stakehill Road.

The site is accessed from Stakehill Road along its northern boundary. Stakehill Road is an 8 metre wide sealed rural standard road, which acts as a district distributor. A rural subdivision road (Cassia Drive south) abuts the land midway along the southern boundary. Cassia Drive west connects to the western boundary of Lot 878, but does not connect through Lot 877 to join the southern portion. These roads are sealed to rural standard.

The basic land form in the most part is free draining undulating sand hills, varying in elevation from a high point of approximately RL 19m AHD, forming a ridge along the southern half of the eastern boundary, falling generally west to RL 6m AHD along the western boundary. The site maximum groundwater level is generally at RL2.20m AHD.

The Environmental Geology map of the Geological Survey of Western Australia classifies this site as generally “S7” Sand derived from Tamala Limestone, which soil type is considered “suitable for urbanization”. Its current process is listed as “ground water recharge”. It has excellent water infiltration capability.

The land is distant from Water Corporation services, but planning does exist for the extension of such to the site.

Power and telephone services do exist in the area. Overhead low and high voltage power lines exist along constructed roads.

3. The Site

The site is located on the southern side of Stakehill Road, opposite and west of Eighty Road, which currently terminates at Stakehill Road.

The site is composed of free draining sands, which will allow stormwater from the proposed development to infiltrate with ease. The land generally consists of undulating old sand dunes, with an eastern north – south ridge approximately located along the eastern boundary, with slopes up to 10%. Site levels vary from RL 19m AHD at the ridge, down to RL 6m AHD along the western boundary.

The geology of the land is described by the Environmental Geology Map of the Geological Survey of WA, as being "S7 being sand derived from Tamala Limestone". This soil type is described as being "suitable for urbanization". Its current process is groundwater recharge.

Stakehill Road, which forms the main access to the site along the northern boundary, is a well- constructed rural road with an 8m wide bitumen seal in fair condition, with stabilized shoulders. It does not have formal stormwater drainage to the roads, with stormwater currently being dispersed off the road to the verge. Cassia Drive, which abuts the land on the southern boundary are also sealed rural standard roads. No formal drainage exists on these roads.

The site is adjacent to telephone and power, but distant from Sewer and Water Supply services.

The power and Telstra services are currently located in Stakehill Road. The servicing 22kVA aerial power line is located along the northern verge, whilst there is a 132kVA power line located along the southern verge adjacent to the site.

The peak water table appears to be at approximately RL 2.20m AHD extrapolating from bore investigations over the site and DoW bore records.

4. Development Proposal

It is proposed to develop the land into some 420 lots, with all normal services extended to the urban lots, including links to abutting developments for sewer, water, power, roads, and telephone services with all drainage to be retained on site, using best management practices.

The Water Corporation has advised that their water supply planning shows water can be supplied by extending existing mains from north of the site along Eighty Road, but there are no plans to do such in the near future, or until demand requires it. It is likely a temporary 200mm diameter reticulation main will be extended from the intersection of Cheshire Drive and Eighty Road, some 3,200m north of the subject land.

Water Corporation sewer planning shows the land being served by a future Waste Water Pump Station (WWPS) to be located some distance to the south. They have advised that a "temporary" or "interim" WWPS may be authorized, with funding by the developer. The likley discharge point is proposed to be at the intersection of Sixty Eight Road and Percival Place in Baldivis some 6.5km from the site.

The development will entail earthworks to provide level, free draining building blocks with extensive low height retaining walls, given the sloping site. Fill is unlikely to be

required as the MGL is well below (some 4.0m) the low point of the land which is around RL6.0m AHD.

Drainage will be affected by site soakage in a series of landscaped drainage swale basins located within POS and a long swale on the western boundary in line with current water sensitive design practice. The proposed basins will contain the 1% AEP storm runoff. There will not be any runoff exiting the site.

The existing abutting roads will be upgraded to City of Rockingham requirements, and all internal subdivisional roads will be designed and constructed to current Council standards.

The future extension of Eighty Road (as Nairn Drive) will be extended south of Stakehill Road along the eastern boundary as a dual carriageway, and Stakehill Road will be upgraded to a dual carriageway; both roads to act as district distributors for the future. Both roads will have restricted road access, and no lot access.

Geotechnical site investigations will be carried out as required when the development proceeds past the rezoning to "urban".

5. Earthworks, Fill & Retaining Walls

Because of the sloping nature of the site, substantial overall earthworks will be required across the site to provide level building blocks, thus necessitating extensive medium height retaining walls. Preliminary earthworks plans are included in Attachment C.

This indicates generally flattened terrain over the total site area, with steepened areas abutting the bush forever areas to the south east to ensure that the maximum area of bushland is preserved.

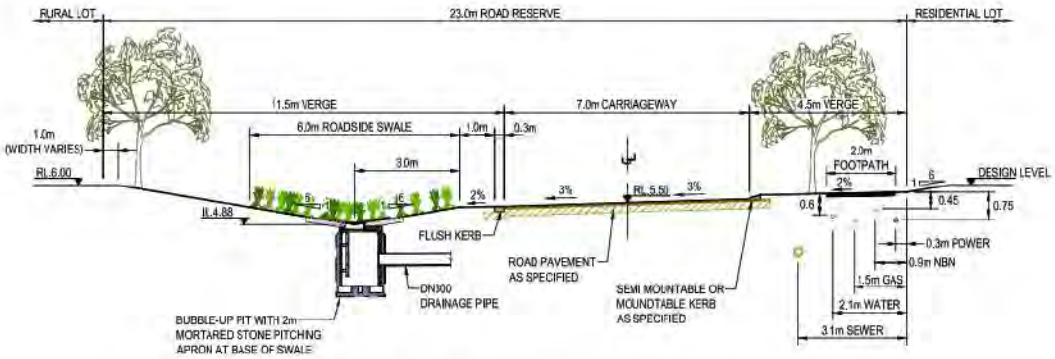
All retaining walls will be subject to Council building approval.

Earthworks on site will entail removal of topsoil, cut and fill. No importation of sand fill is envisaged, although it is likely that the high ridge areas will lowered to facilitate a reasonable profile for Nairn Drive and better grades for roadways and to provide level lots.

6. Roads

All roads will be constructed to City of Rockingham standards and approval, including kerbing and piped drainage plus provision of footpaths as required.

The interface with the rural area to the west will be constructed as a single road carriageway offset within a 23m road reserve with a long swale and landscaping buffer to separate the area as per the cross section below.



TYPICAL ROAD RESERVE SECTION
(7.0m PAVEMENT - 23.0m ROAD RESERVE)
1:100

Upgrading of the existing Stakehill Road and also the abutting portion of the future Nairn Drive will be upgraded or constructed to City of Rockingham requirements at the appropriate stages of development. Such works normally involve full earthworks, plus one carriageway with accompanying drainage and intersection lighting.

7. Drainage

The site will be self-contained as far as storm water drainage is concerned.

The site generally falls to the west in one large catchment, but two smaller catchments are located in the north east and the south east corner. The main catchment will be split into two separate catchments with basins in the north west and south west corners of the site. Flows from the upper areas of the catchments will be directed to a long swale along the western boundary which will assist infiltration of stormwater prior to reaching the basins.

The soil characteristics of the site will allow site soakage, based on the geology and the depth to groundwater over the land. The minimum depth to the MGL is estimated at 3.8 metres, with the MGL being approximately at RL 2.2m AHD, and the lowest land level is at RL 6m AHD.

8. Groundwater

The maximum groundwater level at the site has been calculated from site bore records and comparing them to the adjacent DoW bore information and is around RL2.20mAHD across the site.

The WAPC approval for urban lots generally requires a minimum 1.2m clearance to the water table and as a result, site filling will therefore not be required to meet this requirement.

9. Underground Power

A detailed report from 3E Consulting Engineers has been sought for the areas and this report is included in Attachment B.

In summary of the report findings, it appears that sufficient power supply exists in the area to supply the development. High and low voltage aerial power lines are located along the northern verge of Stakehill Road, and a transmission line is located along the southern verge adjacent to the site.

The existing aerial power lines located on Stakehill Road will remain in place, but any private power lines within the site will be removed as part of the development. Maintenance of power to occupied homes will be ensured during subdivision construction.

New internal infrastructure to the development will be relocated underground in line with current development guidelines. All internal power reticulation lines and transformer installations will be constructed at the cost of the developer. Transformer sites will be determined at the detailed subdivision design stage.

Western Power will require several sub-station and switchgear sites to be provided for the site. These are mostly provided contiguous to large power users and in POS areas.

10. Water Supply

The current water planning indicates that this area will be serviced by gravity from the Tamworth Reservoir. The existing trunk main from that reservoir is currently available just north of the intersection between Cheshire Drive and Eighty Road, some 3,200m north of the subject land.

While ultimately it is proposed to extend a large trunk main down Baldivis road and along Stakehill Road to service the area, there is also a 200mm main proposed along Baldivis Road to link the system. It is proposed to install the 200mm main along Eighty Road at the cost of the developer.

All internal mains will be designed and constructed to Water Corporation guidelines and requirements, inclusive of valves and hydrants.

There are no height restrictions for servicing as the highest point of the land is at RL 19m AHD.

The Corporation has advised that funding of trunk services to the area is not on their current program, and that some funding arrangement with the developer may be required.

11. Sewer

The site is not currently connected to sewer and a new Wastewater Pumping Station (WWPS) together with a pressure main of some 6.5km will need to be installed to service the development.

The conceptual planning for Karnup SD shows that this area will be serviced by the planned Karnup Wastewater Pumping Station (WWPS) PS F, located approximately 950m south of lots 877 & 878 Stakehill Road on existing Hol Chon Heights. This is a large station and given the fledgling nature of the development in this area and the lack of available downstream medium-term capacity, it is unlikely that it will be implemented for some time.

It is proposed to seek approval to install an interim WWPS to service lots 877 & 878 Stakehill Road. As part of this design, careful attention will be made to construct the gravity sewers as shallow as possible to minimise the depth of ultimate Karnup PS F, when the temporary PS is eventually graded out.

Based on the maximum development of the total area of these lots (48.7 Ha), this equates to 730 new lots (assuming a net area 75% and R20 density), which is calculated to produce a maximum potential flow of 8.9L/s. The pressure main discharge point is

proposed to be ACS1573, located at the intersection of Sixty Eight Road and Percival Place in Baldivis. The DN375 gravity sewer stub off AC S1573 has an invert level of RL15.73mAHD. To ensure this discharge level is the high point of the pressure main, this will likely mean the alignment has to follow Stakehill Road east, then Baldivis Road north, then Sixty Eight Road west; a total length of approximately 6.5km. This pressure main would have a very long retention time, particularly with low initial flows, meaning odours and gases will need to be considered, which may require mixing potable water with effluent discharge or other measures to deal with these short term issues.

Wastewater servicing of this development would also need to be considered to ensure tie-in with other areas in Karnup SD developing around the same time. It would be preferable to avoid a fragmented servicing strategy with multiple small pressure mains discharging to Baldivis South SD.

As outlined above, the flows will require either a "Type 90" or "Type 40" WWPS depending on the medium term agreed flow rate and at this stage it has been proposed to install a 150mm pressure main.

The lead time for the WWPS approval and construction, including preliminaries to design, design, design approvals and tender process, is likely to be some 24 months, plus a 6 to 9 month construction and commissioning period. If subdivisional approval and site development occurs prior to the WWPS being constructed, the Water Corporation will allow a 12 month period of "tankering" whilst the WWPS is being built, subject to approvals for the site and its servicing.

The Water Corporation has provided a copy of their overall sewer planning of 2010, which we have marked up for this report in Attachment 1.

12. Telephone & NBN

See the detailed 3ECE report in Attachment B.

Telstra services exist in the area along existing streets and in the abutting developments. These services will be extended to service this proposed development.

In accordance with recent requirements, the developer is required to install NBN "pipe and pit" to allow for future installation of cables for the NBN. The design of the "pipe & pit" is the responsibility of the developer, and will be designed in conjunction with the underground power network, and installed during the construction phase of the development.

13. Gas

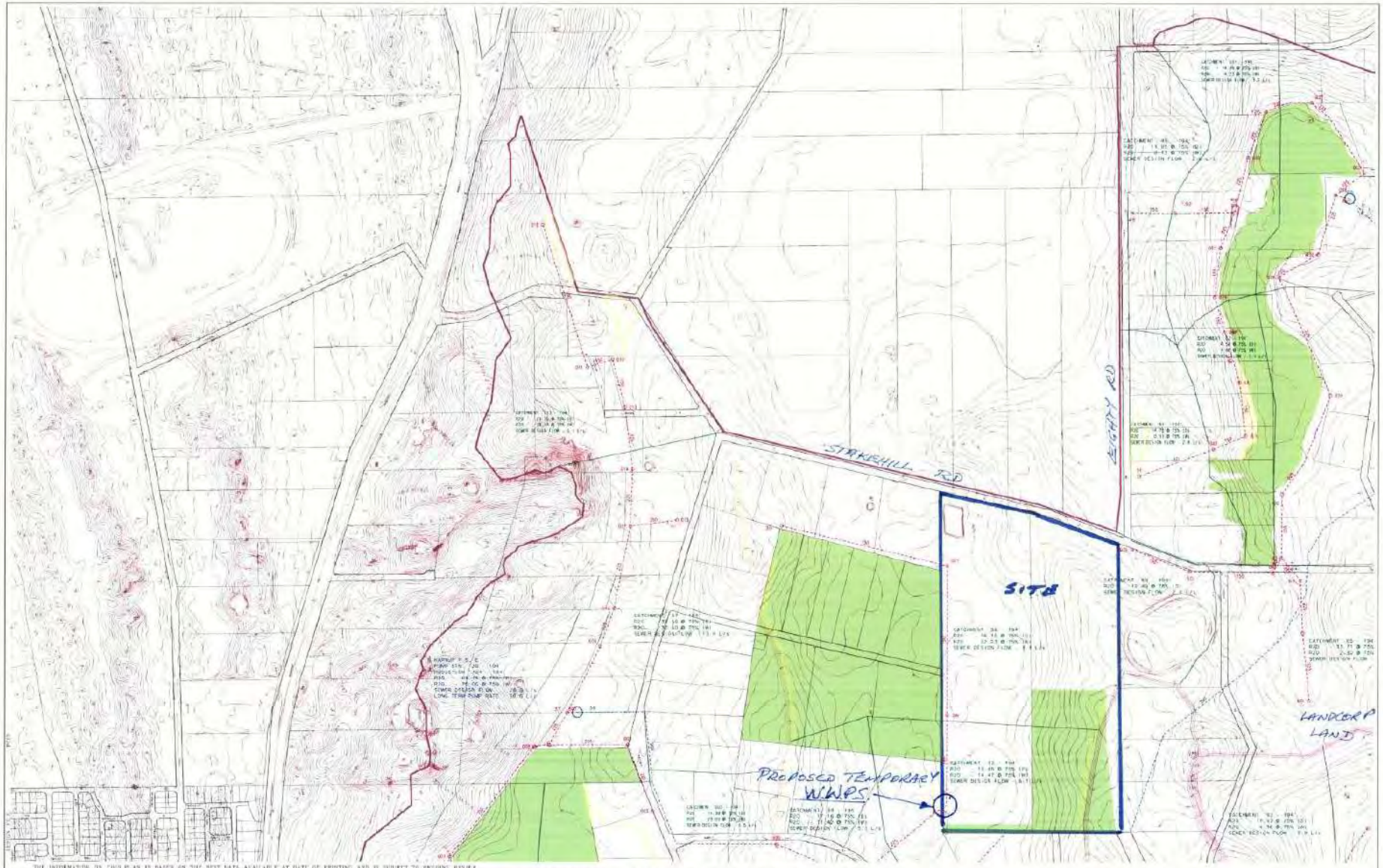
Gas is not available at present to the site, but may be extended to the site in consultation with the service company ATCO. Internal mains are currently supplied by ATCO in trenches provided by the developer. This situation is expected to continue for this development if gas is available.

DEVELOPMENT ENGINEERING CONSULTANTS PTY LTD

THIS REPORT IS DATED 24TH APRIL 2025

DEVELOPMENT
ENGINEERING
CONSULTANTS

ATTACHMENT A – WATER CORPORATION PLANNING



THE INFORMATION ON THIS PLAN IS BASED ON THE BEST DATA AVAILABLE AT DATE OF PRINTING AND IS SUBJECT TO ONGOING REVIEW. THE WATER CORPORATION ACCEPTS NO RESPONSIBILITY FOR ACCURACY OF DATA SUPPLIED BY EXTERNAL AGENCIES

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LEGEND

- EXISTING PUMPING STATION
- EXISTING PRESSURE MAIN
- EXISTING GRAVITY SEWER
- PROPOSED PUMPING STATION
- PROPOSED PRESSURE MAIN
- PROPOSED GRAVITY SEWER
- POWER AND FOR SEWER SPINE
- EXISTING SEWERAGE ZONE
- REMOVED BY PRESENT PS
- WWPS CATCHMENT
- PUMP SEWER CATCHMENTS
- SEWER CLOSER CATCHMENT
- MAIN CATCHMENT

NOTATION

SHEET INDEX

WATER CORPORATION

WASTEWATER SCHEME PLANNING SERIES

KARNUP - SD194

CONCEPTUAL PLANNING

LONG TERM SCHEME: SHEET 1 OF 4

PLANNING BY	DRAWN BY	ACCEPTED BY
C PEDERSEN	G PEDERSEN	T ZIERSE
SCALE 1:5000	VERSION 22 OCTOBER 2008	A1

DEVELOPMENT
ENGINEERING
CONSULTANTS

ATTACHMENT B – 3ECE ELECTRICAL AND COMMUNICATIONS SERVICING REPORT

SECTION 1 INTRODUCTION

1.1 SCOPE, BASIS OF SERVICING ESTIMATES AND ASSUMPTIONS

We understand that the development site is planned to comprise approximately 600 residential lots on land bounded by Stakehill Rd, Harvey Rd and opposite Eighty Road.

This report shall provide information on the existing electrical and communications networks adjacent to the site, including estimations of their capacity. It shall provide estimates of the power load and communication service demand required for the proposed development. It shall then provide analysis of the effects of the proposed development on the networks, in terms of capacity and any new infrastructure that may be required, as well as any asset relocations that may be applicable. Lastly, it will provide order of cost estimates for the required works.

SECTION 2 ELECTRICAL SERVICES

2.1 EXISTING POWER DISTRIBUTION NETWORK

The existing Western Power (WP) distribution infrastructure in the vicinity of the site comprises of a

22kV three phase aerial High Voltage (HV) and aerial three phase Low Voltage (LV) network. With 22kV HV aerials running along the northern side of Stakehill Road, with small sections of underground cable branching off this line at multiple roads off Stakehill Road.

Information on the capacity of the local zone substation can be determined from Western Power's public Network Capacity Mapping Tool (NCMT). The substation that appears to supply the HV network adjacent to the subject site is the Meadow Springs zone substation, which is located between Mandjoogoordap Drive and Mandurah Drive, just south of Lakelands approximately 11km from this site. Currently there is less than 5MVA capacity in the zone substation, with no expected upgrades planned for this site within the next 5 years. Thus any significant development works in the area would need to commence before any network planning action would be taken to increase the capacity of the zone substation. Appendix 1 – Existing HV and Transmission Network.

2.2 LIKELY LOAD

For the 600 residential free hold lots, at Western Power's standard 4.7kVA per lot allocation, the total load will be in the order of 2.8MVA.

2.3 LIKELY POWER SUPPLY SCENARIO

2.3.1 SITE SUPPLY INFRASTRUCTURE

WP requires that all new developments are to be serviced by underground three phase power. WP also require any existing HV and LV aerials adjacent to the land being subdivided to be undergrounded and any existing consumers affected will have to have their consumer mains reconnected to the network.

In the freehold residential development scenario this would be by traditional WP owned and maintained Underground Residential Distribution (URD) 3-phase direct buried underground cabling from new transformer(s) to pillars servicing each freehold lot on the general basis of one pillar serving two adjacent lots.

Based on the estimated load for the site, the proposed development will require new WP infrastructure to be installed. The existing adjacent network will not have the capacity to service the estimated load.

To service the proposed development, new Western Power owned substations will need to be installed on the site. The substations shall consist of a HV switchgear unit and new 630kVA transformers. The substations will be fed from the existing 22KV HV aerials along Stakehill Road. Two HV cables will emanate from the substation to appropriate poles on the existing line. The HV aerials in between these poles shall then be removed. Some other modifications to the HV line will be needed to maintain both fused circuits to existing transformers.

As the existing HV aerials are on the northern side of Stakehill Road on the opposite side of the road to the development, WP will not mandate their removal. Only major level changes to the road verge adjacent to the aerial line may result in undergrounding being proposed.

Typically, HV substations are placed on Public Open Space (POS) lots to avoid affecting one of the newly created residential lots. This cannot always be achieved as POS lots may not be available or due to the need to meet technical requirements. Typical land requirements for HV substations are as follows:

- HV Switchgear and transformer 6.2m (W) x 4m (D)
- Transformer only 3.7m (W) x 4m (D)
- Switchgear only 4.5m (W) x 3m (D)

For this project 5 sets of substations will be required with transformers, and 3 sets of HV switchgear.

2.3.2 TRANSMISSION LINES

There are existing transmission lines that run along a portion of the northern part of the development. The current requirement is that the new development will need to incorporate an easement within the development plan to protect the transmission line. For this current transmission line pole structure the easement width is approximately 9m either side of the centre line. Assuming that the poles are on the standard alignment of 2.7m from boundary, this will require an easement extending about 6m into the edge of the property. The stay wires will also need to be protected by easements, which will need to extend 1m out from the stay wire in all directions. See Appendix 2 – Transmission Pole Type.

We can seek a variation to the easement width from Western Power Transmission by asking them to assess the sag and swing of each bay of the transmission line and calculate a more accurate and specific easement for a given bay length. We would need to submit a feasibility request to WP Transmission, and it will take about 8 weeks for a response. See Appendix 3 – Transmission Poles and Stays.

2.3.3 RELOCATION OF EXISTING ASSETS

On the assumption that neither of the HV aerial lines traverse through the subject site, no relocations are likely, and so no allowance for costs for relocations has been included (other than the interface works to provide new infrastructure).

2.3.4 HEADWORKS

The NCMT indicated that available capacity is currently less than 5MVA, with an expectation that it will diminish below that in the near future. The estimated demand of this site is just

under 3MVA, and thus will have a significant impact on the remaining capacity in the network. However, if the project release is below approximately 1.5MVA of additional load per year, the development is considered natural load growth. And therefore it will not likely warrant the project being responsible for contributing towards the costs of any upgrade at the zone substation, to create additional capacity.

The existing capacity of the HV aerial line adjacent to the site is unknown. This information must be sort from Western Power via a formal application. From the information available to us, we would anticipate significant load on the HV feeder, possibly in the order of the feeder's capacity. Therefore, it's plausible that some augmentation of the existing network will be required. This would most likely consist of the shifting of load between adjacent existing HV circuits. This could include a section of new underground HV cable being installed at a location well away from the site, and also one or more pole top HV switches or padmount HV switchgear units being installed.

So while the costs for these works are unlikely to be passed on to the customer, a significant allowance for these works has been included in the cost estimates section of this report.

2.3.5 LIGHTING FOR NEW ROADWAYS

All newly created roadways will require new lighting to satisfy the requirements of AS1158 and the Local Government Authority. The lighting could consist of standard or decorative Western Power lighting poles, or if the Local Government preferred, "privately" (Local Government) owned lighting, where any range of suitable lighting products could be utilised, opening up the opportunity to use broader technologies and strategies, including:

- Architectural lighting poles and luminaires.
- High efficiency and low glare LED luminaires.
- Multi-technology poles, including banner mounts, CCTV cameras and power outlets.
- Time based, light level and motion detection controlled lighting operation and output levels.

2.4 POWER SUPPLY TIMELINES

Western Power will neither reserve capacity nor guarantee supply to this development without a formal request being lodged. A Subdivision Design Information Package (DIP) request must be prepared and submitted to Western Power for the design and construction of the proposed development to commence.

From the date of DIP request submission DIP is typically provided between eight to twelve weeks. Soon after, a design can be lodged with WP for conformance and quoting. From the date of the design being lodged with WP, the design acceptance and works quote is typically provided within eight to twelve weeks. Once the quote is paid, typically within two to four weeks a Construction QA Manager is appointed and the pre-start meeting can occur. One the pre-start is complete, construction can commence.

To avoid any project delays, it is highly advised that a DIP request is prepared and submitted to Western Power as soon as possible.

SECTION 3 COMMUNICATION SERVICES

3.1 EXISTING TELSTRA NETWORK

The existing area is serviced from Baldivis Exchange to the north and via a multiplexer on Baldivis Rd, near the corner of Sixty Eight Rd – see Telstra DBYD attached. Telstra P100 on

the southern side of Stakehill Rd extends from Baldivis Rd to Ukich Pl. To the west of Ukich Pl, on Stakehill Rd, direct buried cable only is available. Baldivis Rd, south of Karnup Rd is only serviced with P50 pipe, limiting capacity for future fibre hauling. Given the distance of 2.9Km from the Multiplexer on Baldivis Rd, existing broadband service is likely to be poor, with voice being the only reliable service.

Telstra's 4GX mobile service provides coverage to the development, so reasonable download speeds would be available to prospective home owners, at a cost.

3.2 PROPOSED TELSTRA NETWORK

Telstra are still Infrastructure Provider of Last Resort (IPOLR) for voice infrastructure, in the NBN Fixed Wireless Footprint, which this area falls within. Telstra would only have capacity for an additional 50 voice services, without augmenting existing infrastructure. Telstra would most likely not accept this development for voice infrastructure, given the size of the development. However, if it did, Telstra would require a substantial capital contribution to voice infrastructure – of the order of $1M. Appendix 4 – Telstra Map

3.3 EXISTING NBN CO NETWORK

NBN Co have established two Radio Base Stations adjacent to the area but currently have no fixed line network in the vicinity of the proposed development. Please see Appendix 5 – NBN Rollout Map.

3.4 PROPOSED NBN CO NETWORK

Although NBN Co's website indicates that they are currently building their Fixed Wireless network, to provide broadband to home owners in the area – see Rollout Map attached, we understand that the Fixed Wireless network is already in service. Strictly speaking this developments falls within the Fixed Wireless Footprint. Note that only broadband is offered by NBN Co on their wholesale Fixed Wireless network, although a number of Retail Service Providers offer Voice over IP (VoIP), on the NBN broadband network. However, if an infrastructure application were lodged with NBN Co, it is highly likely that NBN Co would accept this development for Fixed Line infrastructure, supporting both voice and broadband services, by reclassifying this development to fall within the Fixed Line Footprint. NBN Co's standard technology solution in the Fixed Line Footprint is Fibre to the Premises (FTTP) and we see no reason as to why this technology would not be rolled out for this new development. NBN Co may choose to classify this development as a Fixed Line Footprint island, with the surrounding low density area remaining within the Fixed Wireless Footprint. If the development were to remain in the Fixed Wireless Footprint, the Developer would not be required to make a capital contribution to NBN infrastructure, since NBN Co have yet to implement that portion of the policy requiring Developers to contribute. Note that this lack of policy application and charging could change at any time.

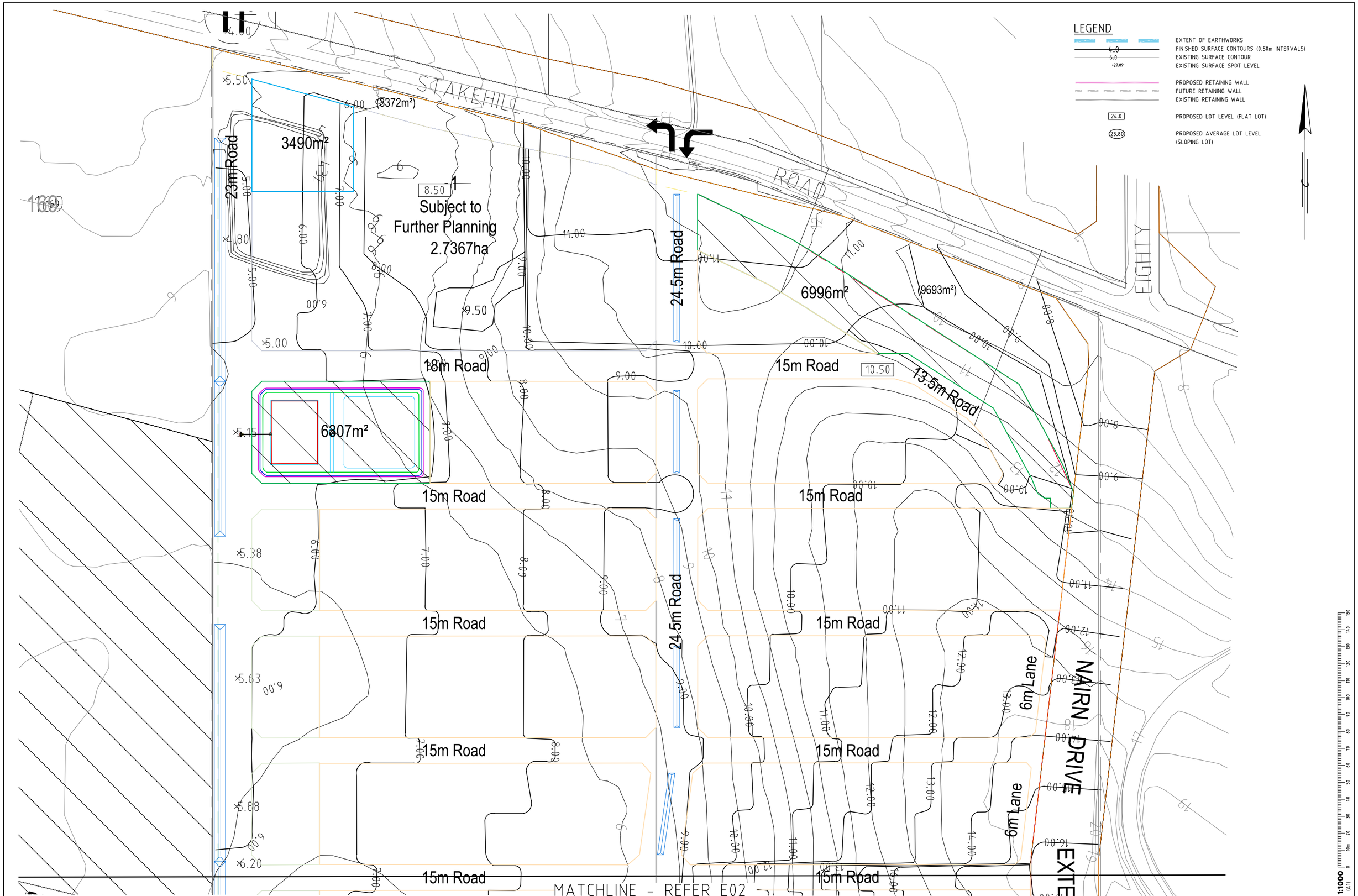
Under the Telecommunications Act 1997, Developers are required to provide fibre ready pit and pipe to new developments, where those developments fall within the Fixed Line Footprint. We recommend an allowance of $800/lot be made for pit and pipe construction. Under Federal Ministerial policy released in March 2015, Developers are also responsible for the provision of telecommunications infrastructure to new developments. NBN Co charge for infrastructure on a partial cost recovery basis. NBN Co's charges are made up of two components, a Deployment Charge of $600/lot and a Backhaul Charge, should head works be required. In the absence of an NBN Co Feasibility Assessment, we

recommend making a provision for Backhaul, of $30K. To de risk this development, we recommend seeking an NBN Co Feasibility Assessment.

3.5 RELOCATIONS

Any proposed level or alignment changes on Stakehill Rd, could affect the Telstra network. We would recommend that existing levels on the communications alignment be maintained wherever possible, but if not, an allowance for relocation of those assets may be necessary. Relocation could cost of the order of $100K.

ATTACHMENT C – PRELIMINARY EARTHWORKS PLANS



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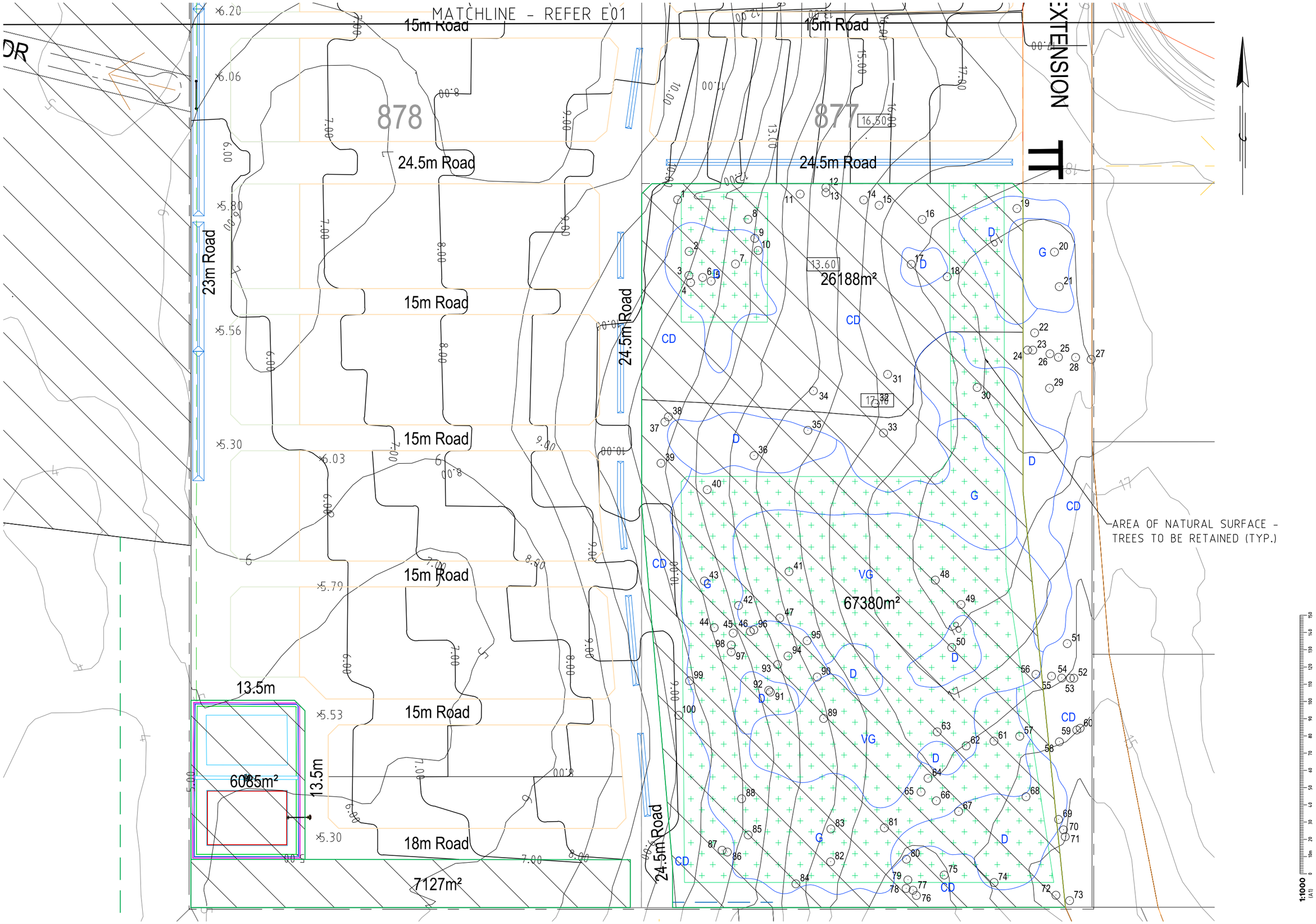
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Ph: (08) 9481 1900
Fax: (08) 9481 1700

PROJECT: **LOTS 877 & 878 STAKEHILL RD BALDIVIS**
W.A.P.C. No. -

DRAWING: **EARTHWORKS LAYOUT PLAN SHEET 1 OF 2**
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W.A.P.C. No. -

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Appendix 10

Retail Sustainability Assessment September 2020 V2

PROPOSED NEIGHBOURHOOD ACTIVITY CENTRE

Lots 877 and 888 Stakehill Road, Karnup

Retail Sustainability Assessment

Prepared for

Terranovis Pty. Ltd.

September 2020

MGA
TOWN PLANNERS

Executive Summary

This retail sustainability assessment (RSA) has been prepared by MGA Town Planners on behalf of TerraNovis Pty. Ltd. to investigate the impact of a proposed neighbourhood activity centre identified on a local structure plan (LSP) prepared by Element in respect of Lots 877 and 888 Stakehill Road, Karnup (subject land).

The proposed activity centre will be limited to a total of 2,500m² net lettable area (nla) of PLUC 5 shop/retail floor space. Currently, there are no basic shopping facilities in Karnup, with local residents resorting to activity centres in surrounding suburbs. The proposed activity centre is intended to provide for the day to day needs of future residents that establish to the south of Stakehill Road in the LSP area, and existing residents in Karnup.

The analysis undertaken identifies the trade impacts of the proposal on competing shopping facilities at future time-frames, closer to the time of development. It has been determined that there is sufficient capacity for the proposal to occur, having limited impact on the performance of competing activity centres, while taking into consideration approved future expansions among the network of centres.

In summary:

- The immediate locality contains no competing activity centres, with the nearest located 6.2km to the south west by road, and 7.0km to the north. In the future, an activity centre will be located 3.5km to the north of the subject land by road.

- Trade impacts on surrounding competing centres in Singleton, Secret Harbour, Golden Bay and Baldivis following establishment of the proposed neighbourhood activity centre range between 1.6% - 2.9% as at 2026. The assessment identifies the proposal will result in no significant adverse impact on competing retail facilities, which will continue to operate viably.

- Approvals have been granted (structure plan amendments) facilitating future expansions to various activity centres in Baldivis, and planned future growth is also identified for a range of activity centres within the City of Rockingham's *Local Planning Policy 3.2.1 (Local Commercial Strategy).* These planned / approved future expansions have been accommodated in the analysis undertaken, and were found to be orderly. The analysis reveals capacity for the proposed neighbourhood activity centre to be established in conjunction with planned future expansions.

- The neighbourhood activity centre will front Stakehill Road, being a major east – west route identified as an 'Other Regional Road' under the Metropolitan Region Scheme (MRS), which distributes local residents and passers-by centrally through the locality of Karnup. Stakehill Road is accessible from both Ennis Avenue and Mandurah Road to the west. To the east, Stakehill Road links to Baldivis Road, being the only road providing access to Karnup from the Kwinana Freeway south of Safety Bay Road.

- Being positioned centrally in Karnup, the activity centre will be well placed to facilitate equitable access for existing residents and new residents in emerging estates surrounding the subject land.

- The proposed LSP will facilitate residential development immediately south of the activity centre, which will meet various daily household needs for the growing resident population, and the convenience needs of those passing through Karnup via Stakehill Road.

- It is expected that the ongoing establishment of residential development in Karnup will result in a community profile featuring a high proportion of young families and children (similar to that observed in the suburb of Baldivis), who will require convenient access to shopping facilities, particularly within a walkable distance.

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2 Subject Land and Locality 3
3 Population and Socio – Economic Characteristics 6
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Report Details

File Name:	RSA - Lots 877 - 888 Stakehill Road, Karnup
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Client:	TerraNovis Pty Ltd
Document Version:	V2 September 2020
Project Number:	3010

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1 Introduction

1.1 This retail sustainability assessment (RSA) has been prepared by MGA Town Planners on behalf of TerraNovis Pty. Ltd. to investigate the impact of a proposed neighbourhood activity centre identified on a local structure plan (LSP) prepared by Element in respect of Lots 877 and 888 Stakehill Road, Karnup (subject land).

1.2 The proposed activity centre will be limited to containing a total of 2,500m² net lettable area (nla) of PLUC 5 shop/retail floor space, making it relatively small in comparison to other competing neighbourhood activity centres in surrounding suburbs.

1.3 The analysis undertaken identifies the trade impacts of the proposed activity centre on the network of competing activity centres at future time-frames. The projected level of population growth within individual suburbs (or part thereof) has been prepared by Forecast ID on behalf of the City. These population projections have been utilised in the analysis undertaken for future time-frames through to 2031. The investigation reveals there is sufficient capacity for the proposed 2,500m² nla of PLUC 5 shop/retail floorspace to be accommodated, having limited impact on the existing and planned hierarchy of centres.

1.4 The subject land is currently surrounded by sparse rural residential development, undeveloped rural land and Parks and Recreation Reserves, extending 2.5km north from the subject land to Sixty Eight Road, and 5.0km south to Paganoni Road. Currently, existing residents in Karnup must resort to shopping facilities located 6.2km to the south west by road (Secret Harbour DC) or 7.0km north of the subject land (Warnbro DC and Tuart Ridge NC).

1.5 The proposed neighbourhood activity centre will contain convenience shops and vehicle – oriented premises such as fast food outlets that will benefit from the prominent location of the subject land fronting Stakehill Road.

1.6 The proposal is considered with reference to various planning instruments, the most relevant of which include:

- *City of Rockingham Local Planning Policy 3.2.1 (Local Commercial Strategy) (LCS).*
- *Approved structure plans and structure plan amendments.*
- *State Planning Policy 4.2 – Activity Centres for Perth and Peel (SPP4.2).*

1.7 Approvals have been granted (structure plan amendments) facilitating future expansions to various activity centres in Baldivis, and planned future growth is also identified for a range of activity centres in the City's LCS. These planned / approved future expansions have been accommodated in the analysis undertaken.

1.8 The City's LCS also identifies the hypothetical location of four neighbourhood activity centres in Karnup, with one being in close proximity to the subject land. However, the LCS states explicitly that no specific recommendations are made in connection with the scale and distribution of activity centres in Karnup. This will be resolved more definitively through the preparation of a District Structure Plan (DSP) for the Karnup / Keralup area at some point in the future.

1.9 The LCS states that approximately 28,600m² of neighbourhood shopping floor area and some 13,000m² of district level floorspace may be accommodated in Karnup. It is likely that this is understated, given that contemporary planning provides for higher residential densities in new urban areas. However, the proposed neighbourhood activity centre represents a small portion of total potential floorspace in Karnup, and given its small size it is not likely to prejudice orderly future planning.

1.10 The following report describes the analysis undertaken and provides a summary of results and observations.

2 Subject Land and Locality

2.1 **Figure 1** shows the subject land positioned at the southern side of Stakehill Road, approximately 300m west from the corner of Eighty Road. The zoning of the land and surrounding locality under the Metropolitan Region Scheme (MRS) is also depicted.

2.2 The subject land is located within 14.5km south - east from the Rockingham Strategic Metropolitan Centre (SMC) by road, and the Mandurah CBD is 21.0km to the south.

2.3 Areas to the north and north – east of the subject land are zoned Rural, containing low density rural – residential development extending for approximately 2.5km north to Sixty Eight Road. Land to the south also contains low density rural – residential development, which extends approximately 5.0km south to Paganoni Road. The suburb of Karnup extends an additional 2.0km south from Paganoni Road, although the land in this area (not depicted) is zoned 'Parks and Recreation' and 'Bush Forever'.

2.4 The subject land and adjoining land to the east is zoned 'Urban Deferred', being land identified for urban purposes such as residential and commercial development, subject to structure planning first being undertaken. The proposed LSP prepared by Element will facilitate the lifting of Urban Deferment and enable urban development to occur.

2.5 To the north - west and south - west of the subject land, there are large pockets of land zoned 'Parks and Recreation', with the land to the south – west also being identified as a 'Bush Forever' site. Additional 'Parks and Recreation' reserve areas adjoin the eastern side of the Urban Deferred land.

2.6 Regional Roads facilitating access to and from the suburb of Karnup include the Kwinana Freeway, which is a 'Primary Regional Road' passing north – south at the eastern edge of the suburb, linking residents through to the Perth CBD.

2.7 Ennis Avenue is identified as a 'Primary Regional Road' and passes in a north – south alignment at the western periphery of the suburb of Karnup, connecting residents in Karnup north to the Rockingham CBD and south to Mandurah. Mandurah Road is another 'Other Regional Road' and also passes in a north – south alignment at the western edge of the suburb of Karnup. Ennis Avenue becomes Mandurah Road at the intersection with Stakehill Road.

2.8 Eighty Road is identified as an 'Other Regional Road', and is a major north – south connection positioned centrally within the suburb of Karnup 300m east of the subject land. This road facilitates movement between the suburbs of Karnup and Baldivis.

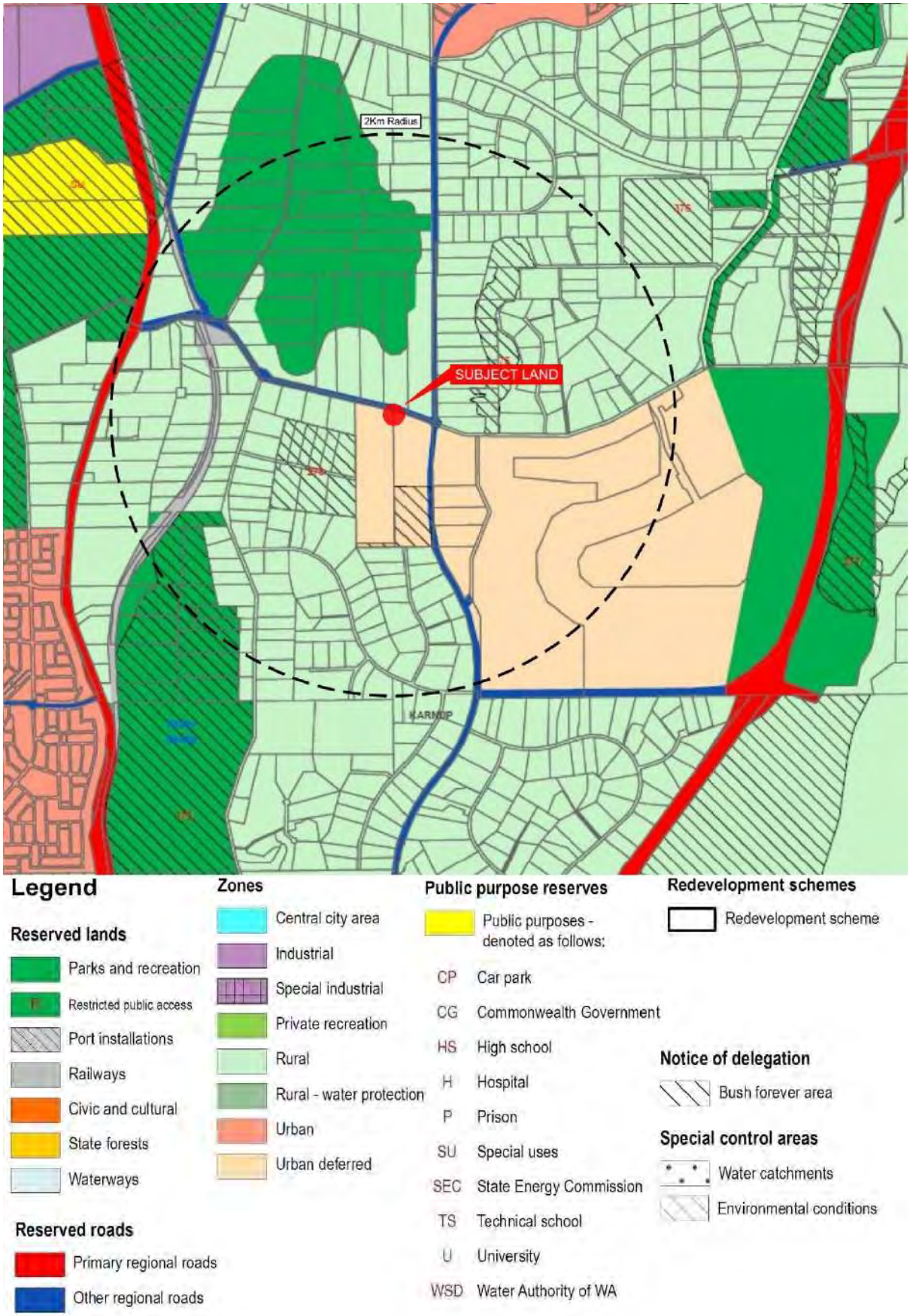
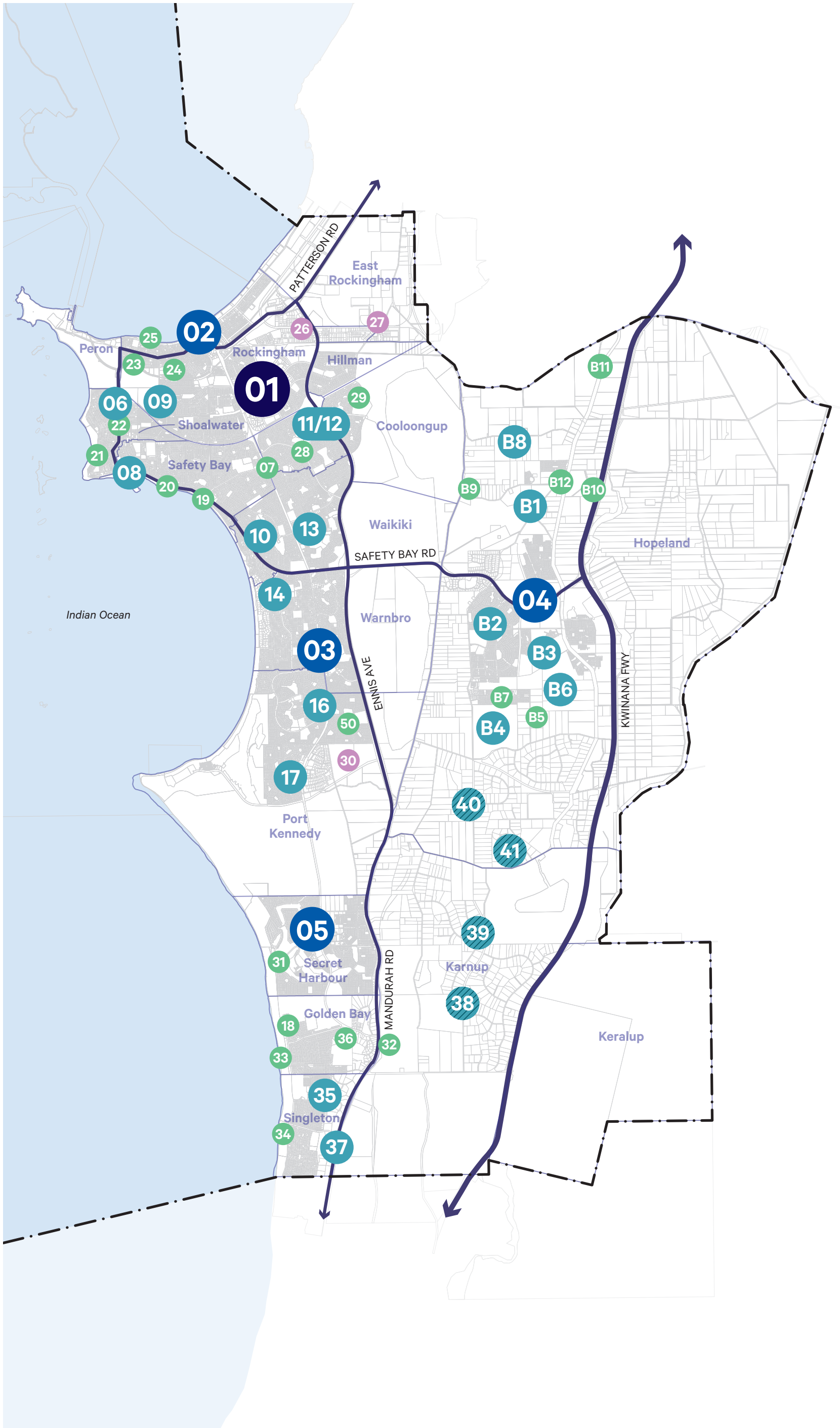


Figure 1 – Subject Land and MRS map.



Legend

City of Rockingham Local Government Boundary

Stategic Centres

01. Rockingham City Centre

District Centres

02. Rockingham Beach
03. Warnbro
04. Baldivis
05. Secret Harbour

Neighbourhood Centres

Neighbourhood Centres (Hypothetical)

06. Shoalwater
08. Safety Bay
09. Cape Peron (Anchorage)
10. Charthouse
11. Grange / Eleanora
12. Elanora Drive
13. Waikiki Village
14. Hokin
16. St Clare
35. Bayshore
37. Singleton East
40. Karnup 1. (Hypothetical)
41. Karnup 2. (Hypothetical)
39. Karnup 3. (Hypothetical)
38. Karnup 4. (Hypothetical)
B1. Baldivis North
B2. Settlers Hill
B3. Tuart Ridge
B4. Parkland Heights
B6. Stargate
B8. Spud Shed

Local Centres

07. Malibu
17. Palm Meadows
18. Golden Bay
19. Waikiki Hotel
20. Bent Street
21. McLarty
22. Saftey Bay Road
23. Bell
24. Parkin Street
25. Fisher
28. Soraya Place
29. Hospital
31. Foreshore Village
32. Mandurah Road
33. Golden Bay South
34. Singleton
36. Golden Bay East
B5. Avalon
B7. The Ridge
B9. Lakeside Caravan
B10. Freeway
B11. Baldivis East
B12. Baldivis / Fifty Rd
50. St Michel

Industrial / Mixed Business Centres

26. Dixon Road
27. Enterprise
30. Port Kennedy

city of Rockingham

Existing and Planned Activity Centres

City of Rockingham

Date: 15 Sep 2020 Scale: 1:90k@ A3 File: **19-338 CP-1 A** Staff: JP GW Checked: JP

0 900 1.8km

element.

Level 18, 191 St Georges Terrace, Perth Western Australia 6000.
PO Box 7375 Cloisters Square, Perth Western Australia 6850.
T. +61 8 9289 8300 | **E.** hello@elementwa.com.au **elementwa.com.au**

2.9 Stakehill Road is an 'Other Regional Road' passing east – west immediately north of the subject land. Stakehill Road becomes Baldivis Road to the east of the 'Urban Deferred' areas and subsequently links to the Kwinana Freeway via Karnup Road. Stakehill Road provides the most convenient means of access to Ennis Avenue/Mandurah Road for the majority of residents in Karnup.

2.10 Finally, the railway line linking the Perth, Mandurah and Rockingham CBD's passes through the suburb of Karnup 1.25km west of the subject land.

2.11 The above observations reveal the natural and man – made barriers affecting the travel patterns of residents seeking to access shopping facilities. These include the abovementioned 'Parks and Recreation' reserves and railway line that form a barrier to movement west through to Ennis Avenue / Mandurah Road. Stakehill Road has a crossing, facilitating movement across the railway line to Mandurah Road.

2.12 **Figure 2** above shows the hierarchy of centres in Rockingham, and that the closest higher order shopping centre for the majority of residents in Karnup is the Secret Harbour District Activity Centre (DC), located 6.2km to the west by road in the suburb of Secret Harbour. The majority of residents in Karnup and South Baldivis seeking to access this higher order shopping facility, the Mandurah CBD or the Rockingham CBD, must first travel to Ennis Avenue or Mandurah Road via Stakehill Road, where the railway crossing is located. The subject land fronts Stakehill Road, and therefore residents seeking to access higher order centres to the west / north are often likely to travel in close proximity to the subject land.

2.13 Aside from the Secret Harbour DC 6.2km to the west, the nearest alternative higher order district activity centres include the Warnbro DC (7.0km to the north – west of the subject land by road) and the Baldivis DC (8.0km north).

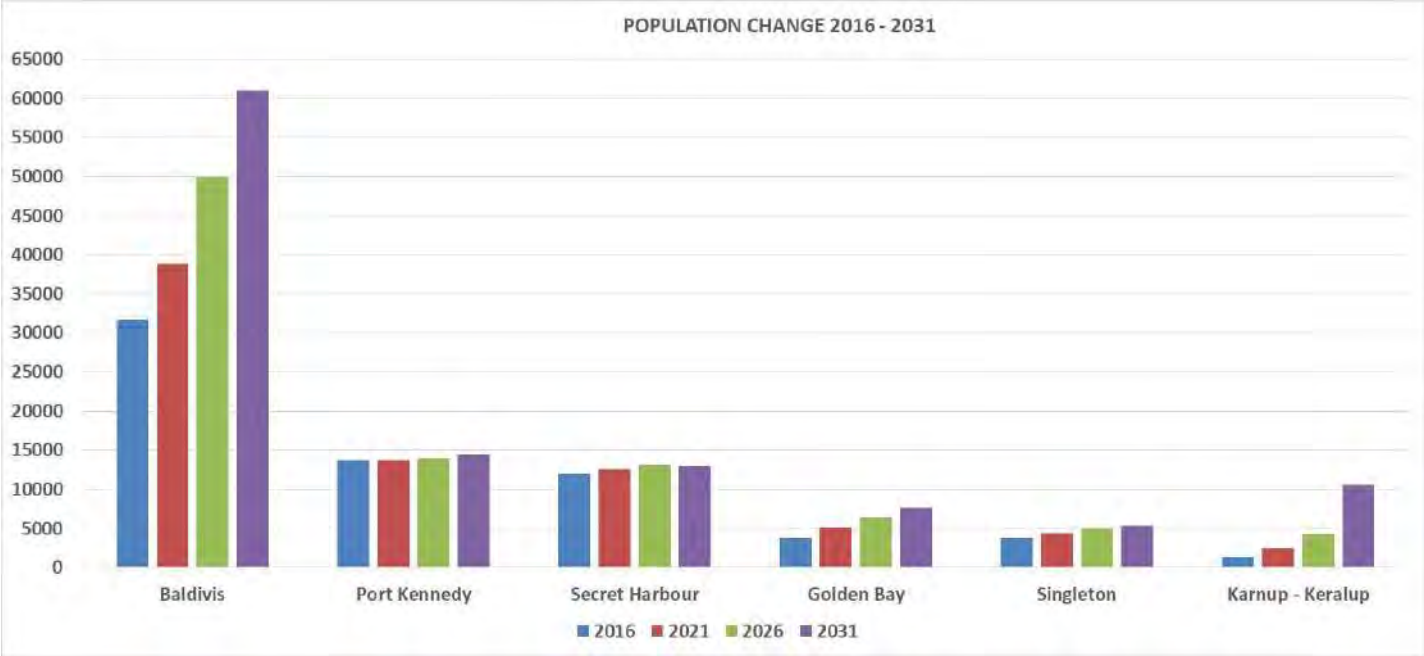
2.14 The subject land is well placed to accommodate a small neighbourhood activity centre given its location fronting Stakehill Road, and the distribution of roads and man – made / natural barriers influencing travel patterns.

3 Population and Socio – Economic Characteristics

3.1 Population data utilised to inform the analysis included the following:

- ABS 2016 Census data for the base calibration year.
- Population projections produced by Forecast ID on behalf of the City of Rockingham dated July 2020.

3.2 The projected population growth within the suburb of Karnup and surrounding suburbs within the area of analysis are shown in **Graph 1** and **Table 1.**



Graph 1: Suburb Population Growth 2016 – 2031 (Data Source: ABS, 2016, ID Forecast 2020)

Location	Baldivis	Port Kennedy	Secret Harbour	Golden Bay	Singleton	Karnup - Keralup
Year						
2016	31,643	13,777	12,071	3,783	3,756	1,373
2021	38,799	13,770	12,603	5,177	4,350	2,468
2026	49,899	13,919	13,156	6,345	5,014	4,324
2031	60,932	14,518	12,973	7,654	5,320	10,582

Table 1: Suburb Population Growth 2016 – 2031 (Data Source: ABS, 2016, ID Forecast 2020)

3.3 With reference to Graph 1, it is evident that population growth in the suburb of Karnup / Keralup will occur at a higher rate from 2021, reflecting the rate observed in Baldivis, and will exceed the population in each of the suburbs of Golden Bay and Singleton by 2031.

3.4 Advice provided by Forecast ID indicates that much of the population growth projected for the Karnup / Keralup area through to 2021 will occur around Vista Estate, located at the south western edge of Karnup in proximity to Mandurah Road. By 2026, the Urban Deferred lands (including the subject land and adjoining properties immediately to the east) are anticipated to have commenced development. The LSP area will accommodate up to 1,300 persons @ 2.4 persons per dwelling.

3.5 For the purpose of this analysis it has been assumed that any development on the subject land will form portion of the overall totals projected by Forecast ID. In addition, no development is forecast to commence in Keralup by 2031.

Location	Baldivis	Port Kennedy	Secret Harbour	Golden Bay	Singleton	Karnup	Greater Perth
Weekly Income							
Median Individual ($)	842	680	825	743	757	777	728
% variation from state median	16	-7	13	2	4	7	NA
Median Household ($)	1,928	1,718	2,238	1,697	1,853	1,802	1,643
% variation from state median	17	5	36	3	13	10	NA

Table 2: Income (Source: ABS, 2016)

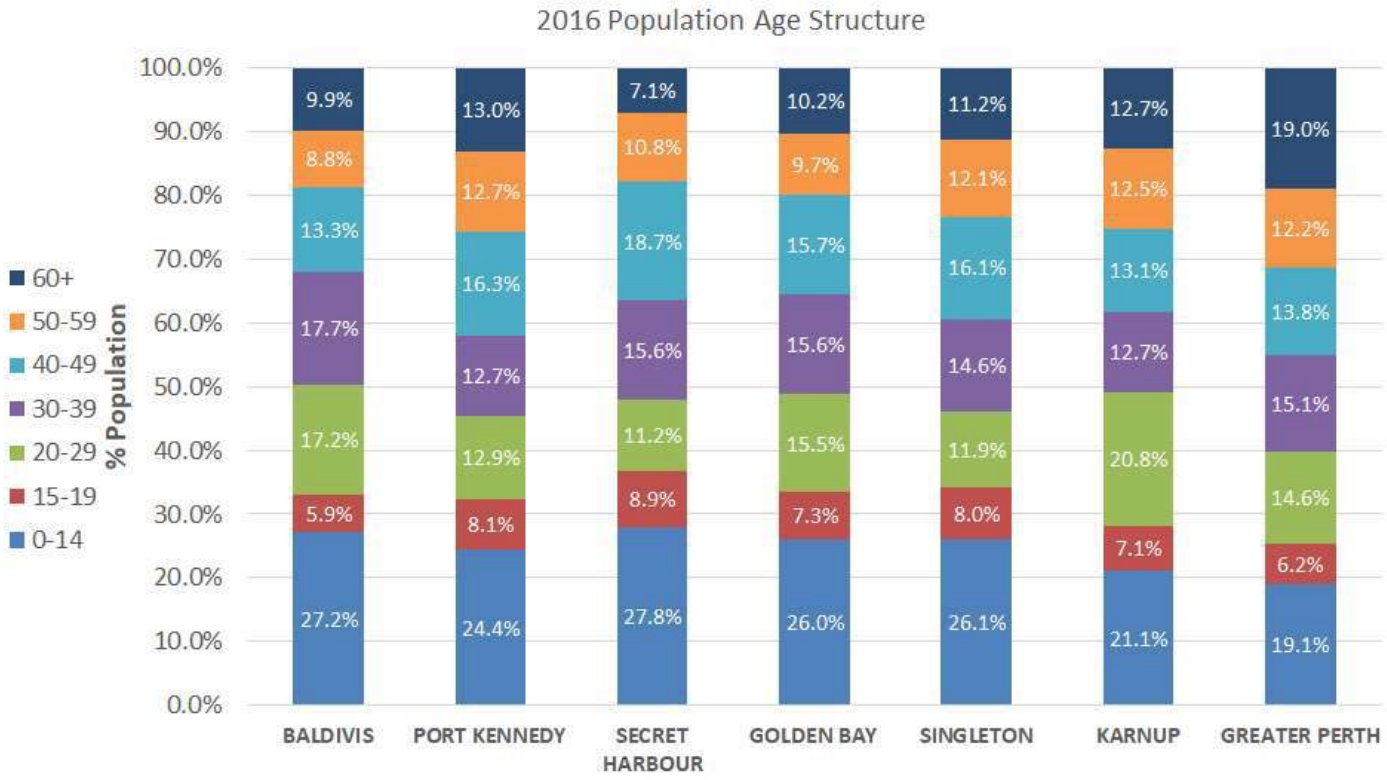
PLUC 5 Expenditure	Model Study Area	Rockingham – Mandurah – Murray
Per Capita Expenditure (2016$)	$12,417	$11,993

Table 3: Expenditure on PLUC 5 goods (Marketinfo 2016)

3.6 **Table 2** shows that median individual and household incomes in Karnup exceeded the Greater Perth average, resembling income levels in Golden Bay and Singleton. The suburb of Baldivis featured the highest income levels. It is expected that ongoing urban expansion in Karnup will see income levels trend higher as new families / first home – builders move in and begin servicing mortgages and raising families.

3.7 **Table 3** shows that expenditure on all PLUC 5 shop/retail goods exceeded the average throughout the Rockingham, Mandurah and Murray LGA areas as at 2016.

3.8 Overall, Karnup and surrounding suburbs were relatively youthful in comparison to Greater Perth. **Graph 2** shows that the proportion of those in Karnup aged 60+ (12.7%) was lower than throughout Greater Perth (19.0%).



Graph 2: Age Structure (Source ABS, 2016)

3.9 **Table 4** below shows family composition, with the proportion of couple families having children in Karnup exceeding that of Greater Perth in 2016. The proportion will likely grow, reinforcing the need for shopping facilities in Karnup.

3.10 **Table 5** reveals that households in Karnup and surrounding suburbs were predominantly family households, exceeding the proportion throughout Greater Perth, and with a lower proportion of group and lone - person households.

	Total Families		Couple + children		Couple No Children		Single Parent Families		Other Families	
	No.	%	No.	%	No.	%	No.	%	No.	%
Baldivis	8,394	100	4558	54.3	2733	32.6	1026	12.2	77	0.9
Port Kennedy	3,665	100	1886	51.5	1063	29.0	670	18.3	46	1.3
Secret Harbour	3,242	100	2047	63.1	773	23.8	397	12.2	25	0.8
Golden Bay	994	100	508	51.1	278	28.0	197	19.8	11	1.1
Singleton	1,026	100	565	55.1	308	30.0	145	14.1	8	0.8
Karnup	375	100	193	51.5	145	38.7	37	9.9%	0	0
Greater Perth	-	100	-	46.3	-	37.5	-	14.5	-	1.8

Table 4 – Family Composition (Source ABS, 2016)

Household Type	Family	Group	Lone Person
Baldivis	82.7%	14.6%	2.7%
Port Kennedy	84.1%	13.8%	2.1%
Secret Harbour	90.0%	8.6%	1.4%
Golden Bay	78.7%	18.2%	3.2%
Singleton	85.8%	13.3%	0.9%
Karnup	83.8%	15.0%	1.1%
Greater Perth	73.0%	23.0%	4.0%

Table 5: Household Type (Source ABS, 2016)

4 Policy Context

4.1 The Western Australian Planning Commission administers State Planning Policy 4.2 – *Activity Centres for Perth and Peel* (SPP4.2). The policy sets out the strategic distribution of activity centres and a hierarchy meeting different levels of community need. It also promotes a competitive retail and commercial market.

4.2 Clause 5.1.2 of SPP4.2 specifies the functional role of neighbourhood centres as follows:

> *5.1.2 Neighbourhood and local centres*
> *(1) Neighbourhood centres are important local community focal points that help to provide for the main daily to weekly household shopping and community needs. They are also a focus for medium - density housing.*

4.3 Clause 5.3.1 (2) of SPP4.2 states that activity centres should be accessible by cars and freight vehicles, in addition to public transport, walking and cycling. In the absence of the proposed neighbourhood activity centre, residents in the LSP area and emerging estates east of the subject land will have no activity centre providing local goods and services within a reasonable drive - time or walking distance, which is ideally 1km.

4.4 Some uses and development are intended to be vehicle – oriented given the location of the centre fronting Stakehill Road, but will also be within a walkable catchment (800m – 1km) of all residents within the LSP area. Development would therefore be designed appropriately to accommodate safe and attractive pedestrian access.

4.5 The City's LCS states that approximately 28,600m² of neighbourhood shopping floor area and some 13,000m² of district level floorspace may be accommodated in Karnup in the future. It is likely that this is understated, given that contemporary structure planning generally provides for higher average residential densities in new urban areas. Therefore, the proposed neighbourhood activity centre represents a small portion of potential neighbourhood shopping floorspace, and total potential floorspace in Karnup. Given the small scale of the centre and its location, it is considered the centre will not prejudice the future distribution of retail centres when district structure planning is undertaken.

4.6 The City's LCS identifies four hypothetical centres in Karnup, but provides no definitive level of floorspace for these centres and their locations are also not fixed. The proposed centre is within 900m from the approximate location of the central hypothetical centre (#41 on Figure 2).

5 Retail Potential Model

5.1 Study Area

The network of centres and study area are depicted in Figure 3. The study area takes in the suburbs of Karnup/Keralup, portion of Port Kennedy, Singleton, Secret Harbour, Golden Bay and South Baldivis. The northern edge of Madora Bay / Lakelands in City of Mandurah was also included. The area defined was utilised in order to assist estimating the performance of centres closest to residents in Karnup, and the impacts of the development.

Activity centres modelled external to the study area included the Rockingham CBD, Enterprise, Dixon Road, Warnbro DC, Kwinana SC, in addition to the Mandurah CDB / Centro and Lakelands DC to the south. These peripheral/external centres are attractions for those in the study area. **Appendix 1** contains a description of the model, and the inputs are also described below.

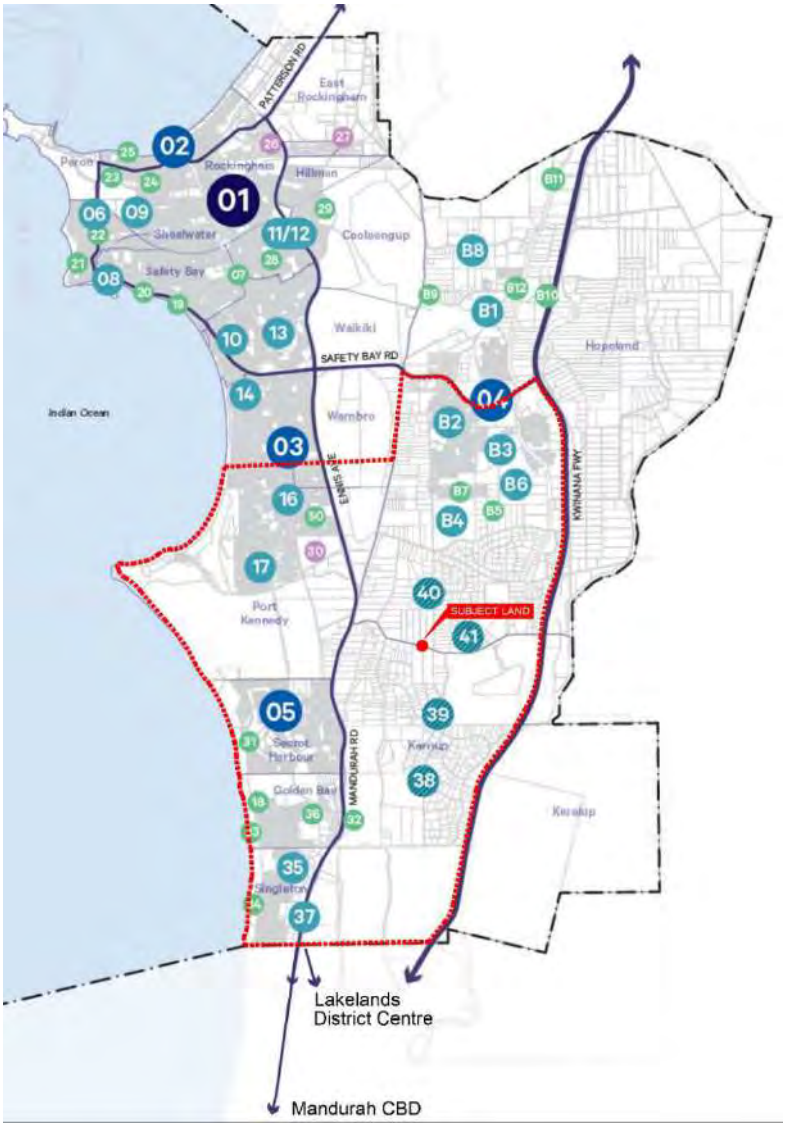


Figure 3 – Study Area

5.2 Data Inputs

5.2.1 Floorspace Modelled

All activity centres having PLUC 5 shop/retail floor space in the study area and selected external centres were modelled, including the future activity centres identified in the City of Rockingham LCS (Figure 3). The WAPC Land Use and Employment Survey (LUES) was reviewed to determine existing PLUC 5 shop/retail floor space for the base modelling year (2016), with updates provided by the City of Rockingham.

5.2.2 Travel Time

Travel time is a measurement taken into account in the retail gravity model. The shortest travel time through the road network from each population zone to the location of each activity centre is used.

5.2.3 Household and Per Capita Expenditure

Per capita expenditure data was prepared by MDS Market Data Systems based on the Western Australian PLUC 5 shop/retail goods and services category. The micro-simulation model run by MDS Market Data Systems is provided at SA1 level, based on the ABS Household Expenditure Survey (HES) and census population data, which is updated using data sources informing spending behaviour such as Australian National Accounts and Taxation Statistics. The data provides an accurate representation of actual variations in expenditure by residents across the study area. To account for the loss of expenditure due to online retailing, or spending outside of the Perth – Peel region, expenditure on non – food goods was reduced by 20%.

5.2.4 Calibration

Calibration of the model involves refinement utilising performance values reported by shopping centre owners or metropolitan benchmarks. Turnover levels used included the following sourced from the Property Council's Shopping Centre Directory (2016) and Shopping Centre News publications (2016).

- Rockingham SMC: $442 million p.a. ($7,865/m²).
- Warnbro DC: $168.5 million p.a. ($8,287/m²).
- Baldivis DC: $224.1 million p.a. ($7,210/m²).

6 Model Outputs

6.1 Model Scenarios

The following scenarios were generated:

1 – The base year, 2016.
2 – 2026 scenario assuming 2,500m² nla is established at the centre.
3 – 2031 scenario, assuming 2,500m² nla is established at the centre.

6.2 Floorspace Modelled

Table 6 below lists floorspace modelled for the years 2016, 2026 and 2031. **Table 7** shows the floorspace and turnover for centres as at 2016, separated into those centres being within or peripheral/external to the study area.

Ref	Centre Name	2016	2026	2031
B2	Settlers Hill NC	600	3240	3240
B3	Tuart Ridge NC	3005	3005	3005
B4	Parkland Heights NC	0	10000	10000
B5	Avalon LC	0	1500	1500
B6	Stargate NC	0	4500	4500
B7	The Ridge LC	300	2240	2240
16	St Claire NC	4625	5000	5000
50	St Michel	0	0	1200
17	Palm Meadows NC	3555	3555	5966
5	Secret Harbour DC	7270	15000	15000
18	Golden Bay LC	737	737	1220
31	Foreshore Village LC	330	330	1220
32	Mandurah Road LC	0	0	150
33	Golden Bay South LC	307	307	307
36	Golden Bay East LC	0	0	3540
35	Bayshore NC	527	527	3000
34	Singleton LC	0	0	1000
37	Singleton East NC	165	3500	3500
41	Karnup 2 NC (Subject Land)	0	2500	2500
External / Peripheral Rockingham Centres				
1	Rockingham SMC	63978	80000	80000
2	Rockingham Beach DC	13848	13848	18250
3	Warnbro DC	21029	21029	21029
4	Baldivis DC	29435	36000	36000
27	Enterprise	7298	7298	7298
30	Port Kennedy MBA	6152	6152	6152
26	Dixon Road MBA	8971	8971	8971
B8	Spudshed	5165	5165	5165
B1	Baldivis North	0	6000	11,000

Map Ref	Centre Name	Floorspace 2016 (m²)	Turnover 2016 ($M)	Turnover 2016 ($/m²)
B2	Settlers Hill NC	600	$9.3	$14,592
B3	Tuart Ridge NC	3005	$48.7	$14,929
B4	Parkland Heights NC	0	_	_
B5	Avalon LC	0	_	_
B6	Stargate NC	0	_	_
B7	The Ridge LC	300	$3.8	$11,996
16	St Claire NC	4625	$50.1	$10,475
50	St Michel	0	_	_
17	Palm Meadows NC	3555	$36.5	$9,932
5	Secret Harbour DC	7270	$91.1	$12,114
18	Golden Bay LC	737	$7.1	$9,306
31	Foreshore Village LC	330	$3.3	$9,773
32	Mandurah Road LC	0	_	_
33	Golden Bay South LC	307	$2.5	$7,925
36	Golden Bay East LC	0	_	_
35	Bayshore NC	527	$4.6	$8,369
34	Singleton LC	0	_	_
37	Singleton East NC	165	$1.4	$8,368
41	Karnup 2 NC (Subject Land)	0	_	_
External/Peripheral Rockingham Centres				
1	Rockingham SMC	63978	$99.6	$1,557
2	Rockingham Beach DC	13848	$12.6	$912
3	Warnbro DC	21029	$79.5	$3,773
4	Baldivis DC	29435	$120.2	$4,086
27	Enterprise	7298	$8.8	$1,200
30	Port Kennedy MBA	6152	$29.2	$4,746
26	Dixon Road MBA	8971	$12.7	$1,125

Table 7: Study Area Modelled Turnover 2016

6.3 Model Outputs

Table 8 below lists the turnover outputs where testing the establishment of 2,500m² nla of PLUC 5 shopping floorspace in the activity centre at approximately 2026.

The column to the far right of the table shows the modelled turnovers as at 2031.

These scenarios assume all approved / planned expansions are actually established, which may or may not be the case.

Map Ref	Centre Name	Turnover 2026 ($2016)		Turnover 2031 ($2016)
B2	Settlers Hill NC	$9,290		$9,926
B3	Tuart Ridge NC	$10,613		$11,476
B4	Parkland Heights NC	$8,517		$9,786
B5	Avalon LC	$9,132		$10,307
B6	Stargate NC	$9,455		$10,364
B7	The Ridge LC	$8,053		$8,964
16	St Claire NC	$8,010		$8,176
50	St Michel	$8,042		$8,238
17	Palm Meadows NC	$7,549		$7,726
5	Secret Harbour DC	$8,364		$8,738
18	Golden Bay LC	$6,982		$7,408
31	Foreshore Village LC	$6,785		$7,177
32	Mandurah Road LC	$8,409		$9,541
33	Golden Bay South LC	$6,293		$6,879
36	Golden Bay East LC	$8,930		$9,717
35	Bayshore NC	$6,834		$7,063
34	Singleton LC	$6,959		$7,529
37	Singleton East NC	$7,430		$8,270
41	Karnup 2 NC (Subject Land)	$8,002		$10,001

Table 8 – Study area modelled turnover 2016, 2026 and 2031

6.4 Impacts

The impacts assuming the establishment of 2,500m² nla of PLUC 5 shopping floorspace at the proposed activity centre are shown in Table 9.

Map Ref	Centre Name	Impact 2026
B2	Settlers Hill NC	-2.0%
B3	Tuart Ridge NC	-1.9%
B4	Parkland Heights NC	-2.9%
B5	Avalon LC	-2.7%
B6	Stargate NC	-2.2%
B7	The Ridge LC	-2.5%
16	St Claire NC	-1.9%
50	St Michel	-2.0%
17	Palm Meadows NC	-2.1%
5	Secret Harbour DC	-2.3%
18	Golden Bay LC	-1.8%
31	Foreshore Village LC	-2.0%
32	Mandurah Road LC	-2.0%
33	Golden Bay South LC	-1.5%
36	Golden Bay East LC	-1.9%
35	Bayshore NC	-1.4%
34	Singleton LC	-1.4%
37	Singleton East NC	-1.6%

Table 9: Impacts 2026

7 Observations

7.1 If development of the proposed local activity centre occurs at approximately 2026, Table 8 (column 3) shows that due to the small size of the centre, prominent location on the regional road network and lack of competing facilities in immediate proximity, any impacts arising from the proposal would be minor, ranging between 1.4% - 2.9%.

7.2 Currently, it is intended that the development would commence after 2023, or later, once residential development within the balance of the LSP area has substantially commenced. If this occurs, the centre may be operational between 2024 and 2026, which would be tolerable relative to the performance of competing centres. The intended development timeframe may coincide with establishment of the Parkland Heights NC 3.5km to the north and other planned activity centre developments in Baldivis.

7.3 The extent of population growth projected by Forecast ID through to 2031 is sufficient to mitigate any significant impacts on the performance of planned activity centres or approved expansions to existing centres that are yet to occur. Based on the observed turnover among centres in Baldivis as at 2031 (Column 5, Table 8), an additional centre in Karnup might be appropriate by this time.

Appendix 1 – Model Description

The gravity model forecasts customer choice for different retail centres, resulting from the distribution of shopping floor space and the nature of the transport network.

The gravity model assumes that shoppers are more likely to use shopping centres which are located closer to their homes, rather than centres that are further away. However, the model also accommodates the potential for shoppers to travel to other competing centres further away through bypassing smaller shopping centres to visit larger centres. The model determines a trade area for each activity centre simultaneously, based on the probability of visitation to each centre. That is, the model accommodates the overlapping of catchments among centres.

$$S_{ij} = Oi \frac{A_j^a \ (exp^{-bTij})}{\sum_j A_j^a \ (exp^{-bTij})}$$

The modelling involves use of the above formula, where:

- *Sij* = the proportion of population or $ household expenditure attracted from origin zone *i* to centre *j*;
- *'Oi'* = population or household expenditure in zone *i*;
- *'A'* = is a measure of centre *j* size;
- *'T'* = travel time from each origin zone to each activity centre; and
- *'b'* = the gravity parameter;
- A separate attraction factor 'a' is applied to an activity centres' floor space 'A', to calibrate against reported turnover / benchmarks.

In summary, the model estimates the probability of visitation and level of expenditure at each activity centre, based on:

- the size of each activity centre.
- the travel time to all competing activity centres from origin zones modelled; and
- population and aggregate household expenditure from origin zones modelled to each centre.

The gravity model assumes that the probability of visitation from any given *origin zone* to each activity centre is proportional to a product of the size of centres, and inversely proportional to travel time to each competing activity centre. Calibration against reported turnover or metropolitan benchmarks is also applied.

Appendix 11

Odour Impact Assessment Addendum - EAQ January 2022

EAQ Consulting

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25 January 2022

Mr Warren Spencer
Director
Terranovis Pty Ltd
Western Australia

By email: warren@terranovis.com.au

[EAQ Project: 20024]

Report Clarifications: Stakehill Road Poultry Odour Impact Assessment (2020)

Dear Warren,

Environmental and Air Quality Consulting Pty Ltd (EAQ) provides the following information and clarifications in response to queries by the Western Australian (WA) Department of Planning, Lands and Heritage (DPLH) in relation to an EAQ Odour Impact Assessment (OIA) of two (2) Poultry Farms (the Farms) located along Stakehill Road, Karnup WA and adjacent to landholdings (the Site) proposed for redevelopment by Mr. Joe Garbin. The Site is immediately south of both Farms.

DPLH also raised queries of another OIA undertaken in 2017 by Envall. EAQ had no involvement in the Envall OIA but takes review of the OIA for the purposes of this letter of clarification.

Of the two Farms, the Farm to the north-east of the Site is known to conduct poultry rearing activities. This Farm was denoted in the OIA as Farm 'A'. the Farm to the north-west of the Site was denoted as Farm 'B'.

DPLH has raised queries in relation to the methods and outcomes of two OIA reports undertaken for the Site.

EAQ's advise and clarifications for the DPLH are discussed below.

1. Envall OIA (2017)

An OIA was undertaken in 2017 by Envall which assessed Farm B using desktop dispersion modelling techniques. At that time this form of OIA was an accepted methodology.

In 2019 the WA Department of Water and Environmental Regulation (DWER) released a formal odour guideline (the Guideline) that details the methods and tools that are to be used to make a formal OIA. The Guideline states that the use of criterion dispersion modelling for odour impacts is no longer an acceptable method of assessment for the purposes of determining the risk and likelihood of odour impacts from an odour source. Prior to the Guideline, dispersion modelling was widely utilised for odour impact assessments.

The operational detail for Farm B is not known. The Envall OIA assumed it to be an operational egg layer with 25,000 hens.

The Envall OIA utilised a Caversham meteorological (met) dataset to model odour emissions and subsequently predict an odour footprint surrounding Farm B. The Caversham met dataset would overestimate odour impacts given the larger frequency of low wind speeds in the Caversham met dataset. Moreover, the Caversham met dataset is relatively 'uniform' in wind direction distribution, which can be seen from the model output odour contours in Figure 1 (pg. 6) of the Envall OIA report.

The Envall OIA outcome for 25,000 egg layer hens, modelled as broilers, showed that observable odours (from modelling) intersected into the Site in the north-west corner of the Site. Envall noted this 'impact' to be 120 metres (m) into the north-west corner of the Site.

The Envall OIA utilised 'broiler' odour emission rates, which refer to growing of meat birds. Broilers produce much larger odour emissions than egg layer farms. The Envall OIA is therefore conservative based on these heightened odour emissions used to characterise odours from Farm B, as well as the use of the Caversham met dataset which conservatises odour modelling outcomes.

The local met surrounding the Farms would not reflect the Caversham met dataset.

The Mandurah Bureau of Meteorology (BoM) Automatic Weather Station (AWS) was reviewed and interrogated in the EAQ OIA 2020 report. This AWS is the closest AWS to the Farms and is representative of local wind characteristics across the Farms.

2. EAQ OIA (2020)

The EAQ 2020 OIA addressed the risk and likelihood of odour impacts from the Farms by adopting those methods and tools prescribed in the Guideline.

Notwithstanding, the Envall OIA is still useful to 'gauge' the likely odour footprint from Farm B. Practitioners often utilise dispersion modelling to predict an odour contour and then use the 'shape' of the odour contour to plan a series of odour field assessments (OFAs) that empirically determine odour impacts from an odour source.

The EAQ OIA utilised OFAs to empirically measure odour impacts (intensity and frequency) from the Farms. Both Farms were included in the OIA under the assumption that both Farms were operational.

- During the OFAs it was evident that Farm A was operational given the activity at the Farm, the noise and subsequent odour emissions; and
- Fam B was investigated as much as practicable without formal access granted to it. However, it cannot be said with confidence that Farm B was entirely operational during the EAQ 2020 OIA.

Under the assumption that Farm B was operational, the odours observed from Farm B under succinct wind conditions were negligible/nil.

Assuming that Farm B was not operational, DPLH has noted that Farm B's owner has an application in place to increase production to 50,000 birds (egg layers assumedly).

EAQ understands that in accordance with WA EPA licencing, premises that aren't operational for a given period forego their current licence and must reapply for a licence to recommence operations. Farm B is not a WA EPA licensed premise, and therefore these stipulations in reference to operations may not be relevant to increasing production at poultry farms.

One would expect however that an approval to increase production to 50,0000 hens would require further investigation as to the locality and existing and future land uses, existing and future receptors and overall future planning before an approval was granted.

Figure 5-8 of the EAQ OIA report shows that under a northerly wind both Farms can be accurately separated in terms of odours observable downwind. During this OFA (16th Nov. 2020) there were no odours observed from Farm B. OFA technicians noted that Farm B was quiet during the OIA.

The EAQ OIA showed that odours were observable from Farm A and that those odours encroached into the Site to a distance of approximately 350 m from the nearest odour source at Farm A.

Farm B is notably smaller in size compared to Farm A and one can reasonably assume that odour impacts would also be lower than that of Farm A.

Importantly, the local meteorological trends govern odour impacts, in particular wind direction.

The meteorological trends presented in the EAQ OIA show a strong proliferation of winds from the south-west with a resultant vector (average) direction from the south (170^0). These wind characteristics show that problematic winds are blowing away from the Site with respect to both Farms, in particular with reference to Farm B.

Those winds most problematic for the Site when considering odours from Farm B are those blowing from the north-west. North-west winds usually typify stormy conditions with high winds, high atmospheric instability and at times rainfall. These conditions promote odour dispersion and rarely cause odour nuisance from an odour source.

Winds blowing from the vector of 315^0 – 5^0 would blow odours from Farm B toward the Site. These winds occur for 6.22%, or 23 days, annually based on the met analysis in EAQ's OIA (Section 4).

Within these 23 days, winds ≤ 8 metres/second (m/s) would pose the largest risk given that higher wind speeds promote mechanical dispersion for odours. During higher wind speeds the atmospheric instability also increases.

Winds ≤ 8 m/s, within the wind direction vector of 315^0 – 5^0, occur for 4.45%, or 17 days, annually. During these 17 days it must be assumed that odours are not observable across every hour daily due to human movements, work commitments etc.

Early morning/evening/night-time observations would be the most problematic since atmospheric instability is typically at its 'worst' during daytime hours under these wind conditions. Importantly, these wind conditions blowing from the vector of 315^0 – 5^0 are seasonally stormy conditions which are least problematic for ground level odour observations.

3. Summary

The Envall OIA utilised dispersion modelling techniques to predict a ground level odour impact from Farm B and based its assessment on a total stock of 25,000 hens which were modelled as broilers. Broiler odours are notably higher than egg layer odour emissions of which Farm B is known to be an egg layer farm. The Envall OIA also used the Caversham met dataset which will have added conservatism to the OIA given the differences in wind conditions for Caversham compared to the locality met characteristics of Farm B.

Caversham met shows dominance of easterly and south-westerly winds with the overall outcome producing a relatively uniform wind profile in all compass directions i.e., approx., circular wind profile.

The locality winds across the Farms shows proliferation of south-easterly winds where the dominant wind patterns blow away from the Site, rather than blowing odours toward the Site.

The EAQ OIA showed the depth and breadth of observable odours from Farm A travelled approximately 350 m from the nearest odour source at Farm A.

Odours from Farm B were negligible/nil. EAQ assumed that Farm B was operational, although it cannot be concluded with confidence that Farm B was operational given the low activity observed and lack of noise coming from Farm B.

Where the owner of Farm B intends to increase production to 50,000 hens, EAQ would expect that any approval to increase production would be met with some degree of assessment given the locality's exiting and future planning considerations.

In lieu of any additional assessment for Farm B, the local met trends show that the incidence of winds blowing odours from Farm B across the Site occur for 4.45% annually and that during these periods the seasonal characteristics reflect stormy conditions for the majority of all met conditions.

In EAQ's view, the consequence of any odour impact from Farm B would be *Slight* (minimal impacts to amenity), and the likelihood of an odour impact from Farm B is U*nlikely* (the risk event will probably not occur in most circumstances). On this basis the risk rating would be *Low*.

4. Close

Should you have any queries, clarifications or discussion points on the detail above please don't hesitate to get in touch as required.

Yours sincerely,



John Hurley (B.Sc, CAQP)
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Appendix 12

Vegetation Buffer Technical Note (PGV)

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Osborne Park WA 6017

ABN 44 881 725 498
Knightside Nominees Pty Ltd

9 February 2022

Anthony Muscara

Principal Planning Officer- Land Use Planning
Department of Planning, Lands and Heritage
140 William Street
Perth WA 6000

Dear Anthony,

RE: Lots 877 and 878 Stakehill Road, Karnup

PGV Environmental provides the following update to address the suitability of the proposed spray drift buffer to the Market Garden on Lot 849 at the corner of Stakehill Road and Eighty Road in relation to the proposed development of Lots 877 and 878 Stakehill Road, Karnup.

Landscaping and vegetation management, in accordance with the Department of Health (DoH) *Guidelines for Separation of Agricultural and Residential Land Uses,* should include an effective vegetated barrier to minimise spray drift (DoH, 2012). The vegetated barrier needs to meet the following criteria set out in the DoH Guidelines:

1. Be located as close as practicable to the point of release of the spray.
2. A minimum total width of 40m made up of 10m cleared fire break area either side of a 20m wide planted area.
3. Contain random plantings of a variety of tree and shrub species of differing growth habitats, at spacings of 4-5m.
4. Include species with long, thin (needle-like) and rough (furry/hairy) foliage which facilitates the more efficient capture of spray droplets and which are fast growing and hardy;
5. Foliage should be from the base to the crown; mixed plantings of trees may be required to ensure there are no gaps in the lower canopy.
6. Provide a permeable barrier which allows air to pass through the buffer. A porosity of 0.5 is acceptable (that is, approximately 50% of the screen should be air space).
7. Have a mature tree height twice the height of the spray release height.

8. Have mature height and width dimensions which do not detrimentally impact upon adjacent crop land.

The Market Garden beds extend to 7m north of the southern boundary of lot 849. The beds stop at this location to provide for a firebreak and turn-around space for tractors. The distance to Stakehill Road itself is currently 20m wide. A single line of trees with a canopy width of approximately 4 metres is planted on the boundary of Lot 849 and the Stakehill Road reserve. The trees provide a buffer protection along 117m of the 192m boundary to Stakehill Road.

On the following page we provide a diagram with distances of the Planning Control Area (PCA) to the southern boundary of Lot 849 (Plate 1). The total distance to proposed housing is set out in Table 1 below. The distances are measured in a north-south orientation.

Table 1: Distances between the Market Garden on Lot 849 and the proposed development on Lots 877 and 878 Stakehill Road

.	**Stakehill Road and PCA width**	**Tree Buffer Lot 877**	**Market Garden setback – Lot 877**	**Future Widening Stakehill Rd N**	**Total Buffer**
In line with western boundary of lot 849 (red line)	50m	5m	7m	20m	62m- 82m
Central truncation point (blue line)	75m	5m	7m	20m	87m-107m
East boundary. (green line	130m	5m	7m	20m	142m-162m

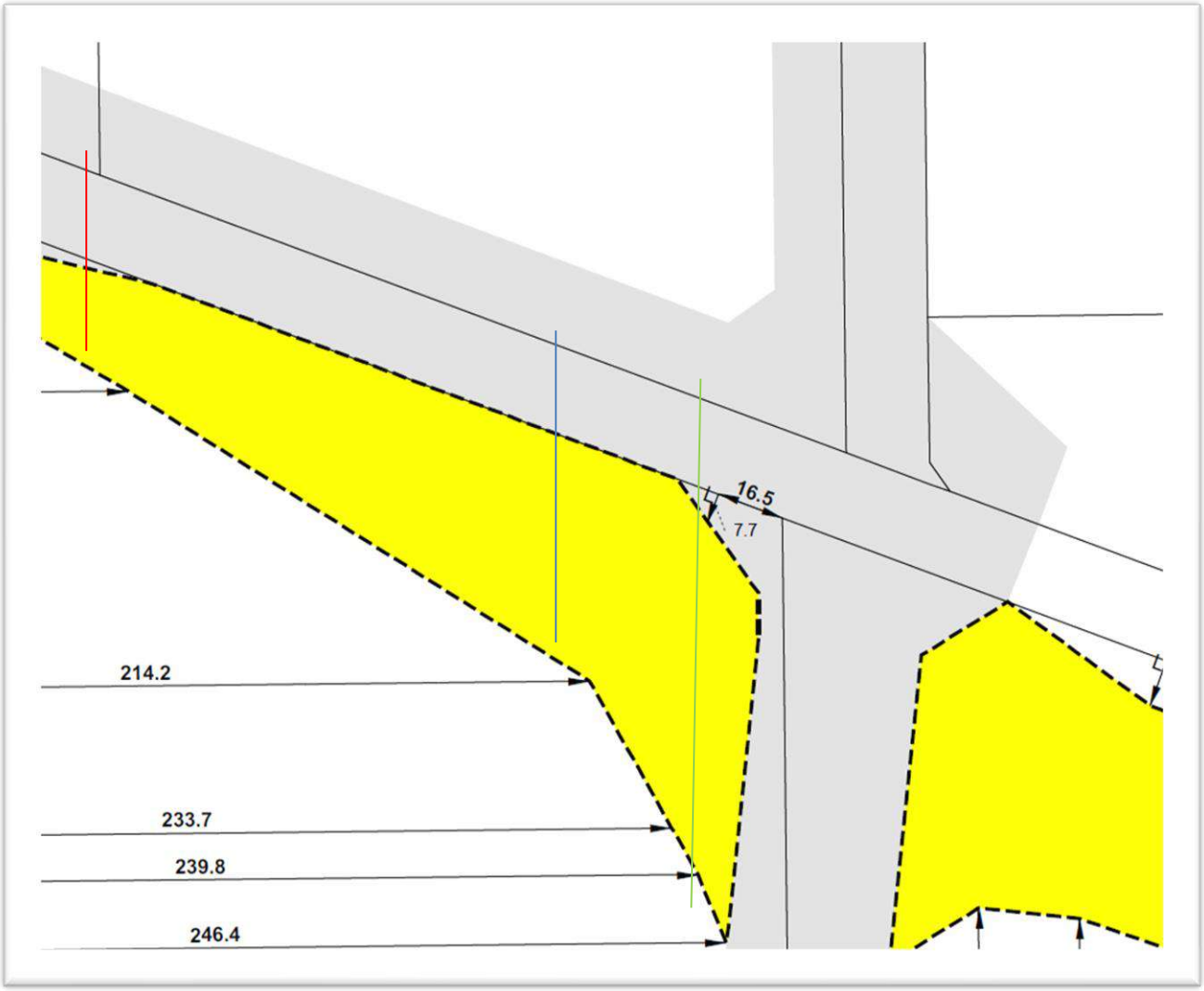


Plate 1: Distances from PCA (Yellow Area) to Lot 849

It is recommended that a vegetated buffer (5m wide) is planted along the southern PCA boundary to provide a barrier to any potential air quality issues from adjacent land uses. The vegetated buffer will also provide a noise attenuation barrier to Stakehill Road.

A noise wall will also be built along the northern boundary of Lot 877.

The proposed cross section is per the following illustration (Plate 2).

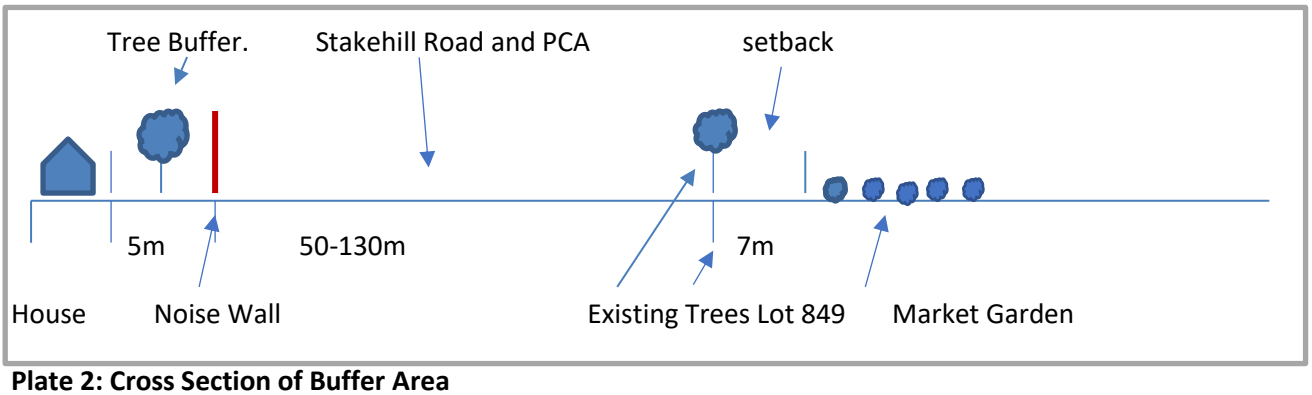
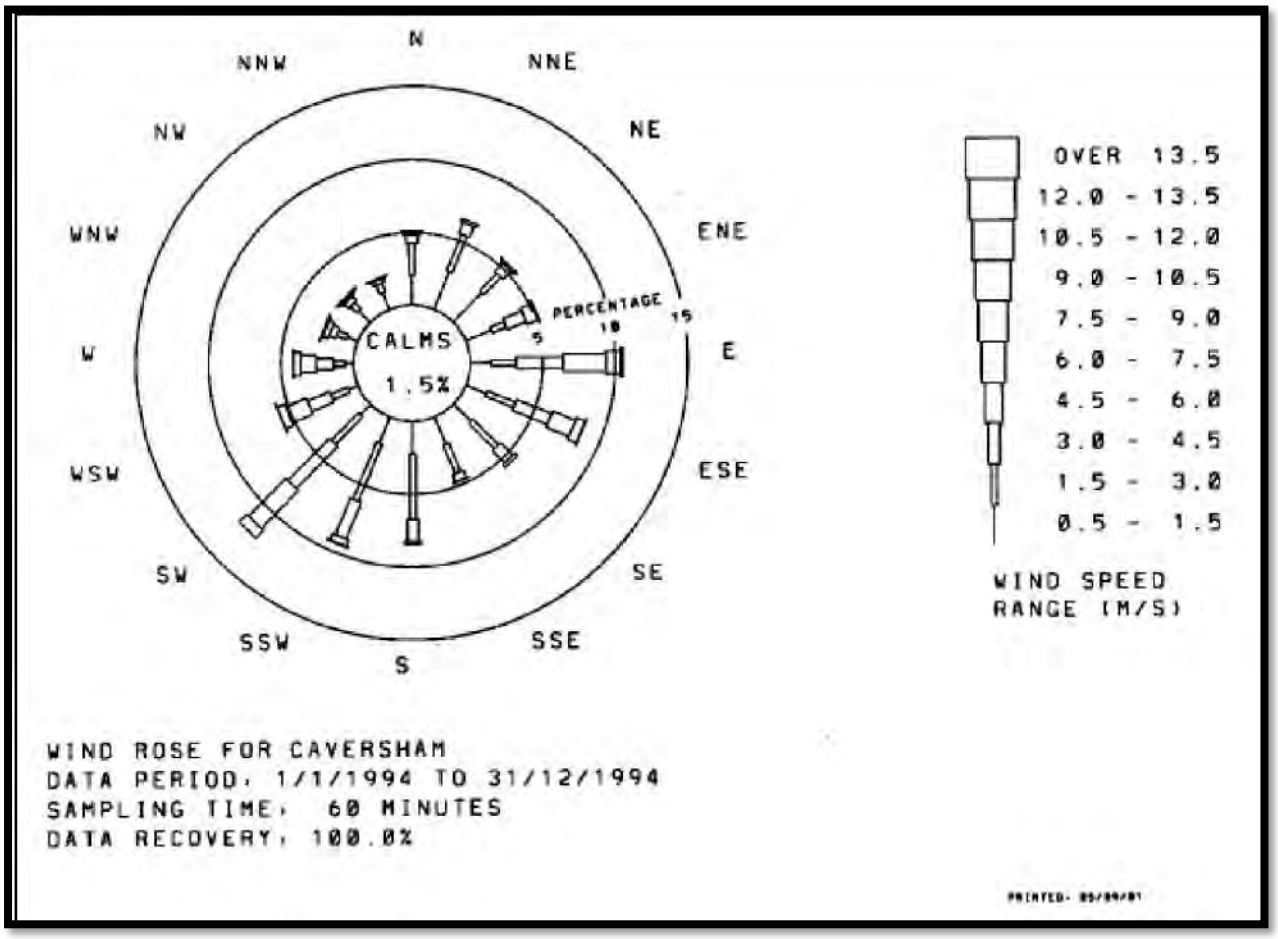


Plate 2: Cross Section of Buffer Area

The market garden on Lot 849 is due north of the proposed development on Lots 877 and 878. Prevailing winds are provided in the odour modelling report by ENVALL (2017) and are shown below. This shows that northerly winds only make up 5% of the prevailing winds with a wind speed between 1.5-3.0m/s.



The WAPC previously endorsed Policy DC 79 which provides for reduced buffers down to the boundary of the adjoining market garden when accompanied by tree planting and a solid fence and memorials on titles to 300m. Attached is a copy of that planning bulletin.

In summary, the DoH guidelines provide for a buffer of 40m including a 20m planted area.

We are proposing a buffer that includes the following criteria:

- A total buffer width of a minimum 62m at the western boundary of lot 849;
- At the eastern boundary where there is no planting north of Stakehill Road we provide a 130m buffer;
- Plant a 5m wide vegetated buffer including trees, shrubs and groundcover;
- To construct a noise wall;
- Existing 7m wide tree buffer, north of Stakehill Road.
- In the future - a further widening of 20m of Stakehill road.
- All lots within 300m of lot 849 to have spray drift memorials on title.

The above buffer distances are 50% to 325% bigger than the DoH guidelines, however the tree planting area is less. This is offset by the noise wall and the fact that the land is located south of the market garden buffer and out of the prevailing wind direction.

If you have any queries please contact the undersigned.

Yours sincerely



Paul van der Moezel
Managing Director

CC Warren Spencer (Terranovis)

Appendix 13

Planning Technical Note No.2 ‘Market Garden Spray Drift Buffer’

12 July 2022

Planning Technical Note No. 2

MARKET GARDEN SPRAY DRIFT BUFFER

Purpose and Introduction

This technical note provides information to justify the market garden spray drift mitigation measures that are proposed in the Lots 877 & 878 Stakehill Road Structure plan ("LSP"). These will address the issue of potential spray drift (if any) arising from a market garden use (if any proposed in future) at Lot 849 Stakehill Road, Karnup.

1. Current Planning Practice

1.1. In the Perth Metropolitan area there are numerous examples of where commercial broadscale market garden operations peacefully co-exist alongside sensitive urban (residential) development. **Table 1** lists just a few of those examples.

1.2. The market garden examples provided in Table 1 all grow produce that is low to the ground and therefore only require low level ground spraying. Compliance with the relevant regulations for use of pesticides ensures that such market gardens will not have an adverse impact on nearby residential use.

1.3. The LSP incorporates a combination of (i) land separation distance and (ii) vegetation buffer. This is outlined in detail in the *Lots 877 & 878 Stakehill Road Environmental Assessment* (PGV December 2020 version 5) under Section 4.2.2 'Market Garden', which specifies:

- DoH guidelines generally support a 40m buffer comprising 10m firebreak or road on either side of a 20m vegetation buffer
- A vegetation buffer is to consist of vegetation with an established height being twice the height of the spray release height
- Given the context of Lot 849 in relation to the subject site (i.e. Lot 849 is upwind, low ground produce, the LSP provides for a 2.1m high acoustic noise wall along Stakehill Rd and the separation provided by the Planning Control Area), a 50m separation distance plus 5m vegetation buffer will suffice. This is a balanced outcome to address any potential impacts from spray drift, if a market garden use were to re-commence on Lot 849.

Use of Best Practice

1.4. A key consideration in any market garden operation regarding spray activities is to manage spray drift so it does not go off-site, as this will result in:

- Waste of costly spray material
- Wasted time for re-spraying
- Ensuring spray reaches its intended target for maximum protection of crops
- Potential damage to crops and/or native vegetation on neighbouring and surrounding land.
- Undesirable increased exposure of chemicals to workers (and other persons).

1.5. It is important that market garden operators apply chemical sprays properly. For instance, DPIRD advises that the knockdown herbicides Spray.Seed® and glyphosate sometimes damage crops and native vegetation by spray drift. Thus there is a civil duty of care to protect neighbouring land from spray drift.

1.6. Wind causes spray drift. Wind can thus derail plans to spray as farmers will not waste money on sprays that will not stay low and target produce. Best practice ensures minimal spray drift by applying the following (which commonly appears on product labels and application guides[2] for operators – *as outlined in 2.1 and 2.3 below*):

- Spray at low wind velocities to reduce potential for drift off-target
- Reduce spray pressure so droplets are heavier and fall more directly onto the target. (Note: There has been advancement over time in spray nozzle technology which improves spray efficiency).
- Use low spray boom heights.
- Reduce spray ground speed.
- Spray when winds are not in the direction of sensitive land uses.

2. Market garden operators to comply with existing legislation

2.1. The Department of Health legislation *Health (Pesticides) Regulations 2011* provides the statutory provisions for the safe use of pesticides. The regulations require market garden operators to use pesticides safely and enforces label directions.

For instance, Regulation 84 'Pesticides to be kept and used safely':

> *"A person must not keep, handle, transport or use a registered pesticide in a manner that might reasonably be expected to be dangerous or to pose a threat to the health or safety of any individual or of the public".*

2.2. The use of pesticides/herbicides (including fumigants) for market gardens in WA is highly regulated. Regulated standards have recently become more strict on minimising spray drift[1]. For example, labels prescribe 'DO NOT use in high winds'.

2.3. Market garden operators must adhere to the protocols on pesticide labels, which includes the safe application such as spray height and not spraying during high winds.

2.4. The potential for market garden spray drift, particularly for low ground produce where the spray release height is low to the ground, is therefore significantly reduced given the current strict statutory regulations.

3. Future market gardening use of Lot 849 Stakehill Road

3.1. If a market garden were to commence on Lot 849, the operator would need to comply with the relevant statutory requirements for pesticide (and other chemical spray) use, and this ensures best practice. The **enclosed letter from Milana Farms,** being the previous market garden operator, who owned and operated a market garden at Lot 849, provides practical information to demonstrate that any market gardening activity on Lot 849 can be undertaken without causing adverse spray drift.

3.2. The operator of Lot 849 would need to consider the implications of any spray drift in regard to proximity of existing sensitive uses as shown in **Image 7**. The operator would need to apply the use of chemical spray in accordance with label directions, which uses best practice methods to overcome the risk of spray drift.

[1] Website source links:
https://www.agric.wa.gov.au/residues-crops/herbicide-application-legal-aspects?nopaging=1
https://apvma.gov.au/node/958
Division 3 of the *Health (Pesticide) Regulations 2011* outline fumigation requirements to minimise public health risks from accidental exposure to fumigants. https://ww2.health.wa.gov.au/Articles/F_I/Fumigation-site-advice-for-local-government). (WA Department of Health)
[2] Telone Application Guide https://teleosag.com/download/telone-application-guide/

3.3. Currently the LSP is exposed to the short frontage of Lot 849, hence the reduced likelihood of the impact of spray drift on the LSP area. Any risk is also likely to be further reduced if Nairn Drive regional road reservation is moved further west onto Lot 849 as a result of extending the road south of Stakehill Road in a manner than avoids the Bush Forever No. 278. Furthermore, the separation distance between a market garden use on Lot 849 and the LSP will also increase when Stakehill Road is upgraded, requiring the regional road reservation taken from Lot 849 - refer to **Image 8**.

3.4. Lot 849 landowner would also be required to give consideration to the potential impact of market garden operations (including use of chemical sprays) on the existing Conservation Category Wetland neighbouring Lot 849 to the west and north.



Image 7. Existing sensitive uses (rural residential dwellings) within 300m to Lot 849

4. Meteorological Analysis

4.1. As wind is the cause of spray drift, consideration needs to be given to the likelihood of spray drift occurring, which in this case would be driven by north to north-easterly winds.

4.2. Both the *Environmental Assessment Report* (PGV, December 2020) and *Odour Impact Assessment of Poultry Farms – Stakehill Road Karnup* (EAQ, December 2020) identify from WA Bureau of Meteorology data that the prevailing winds in this area are predominantly southerly (refer to **Image 9**).

4.3. Thus the north and north-easterly winds which has the potential to allow spray drift to occur from Lot 849 only occurs for a marginal period of the year and generally during the cooler winter months. If fumigants were to be applied at Lot 849, the cooler winter months would be beneficial in that soil temperatures would be cooler thus reducing vapour cloud drift identified under pesticide labels. Given the prevailing wind directions in this area, the overall impact of spray drift from Lot 849 is therefore low.

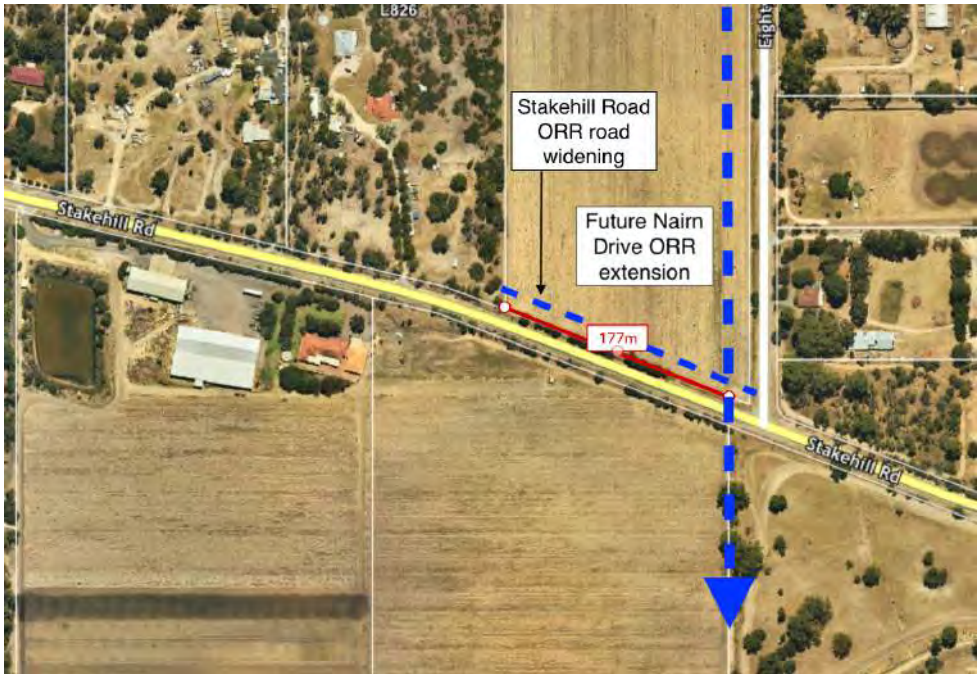


Image 8. Limited interface between Lot 849 and the structure plan area when considering the upgrading of Stakebhill Road and extension of Nairn Drive in the regional road planning requirements.

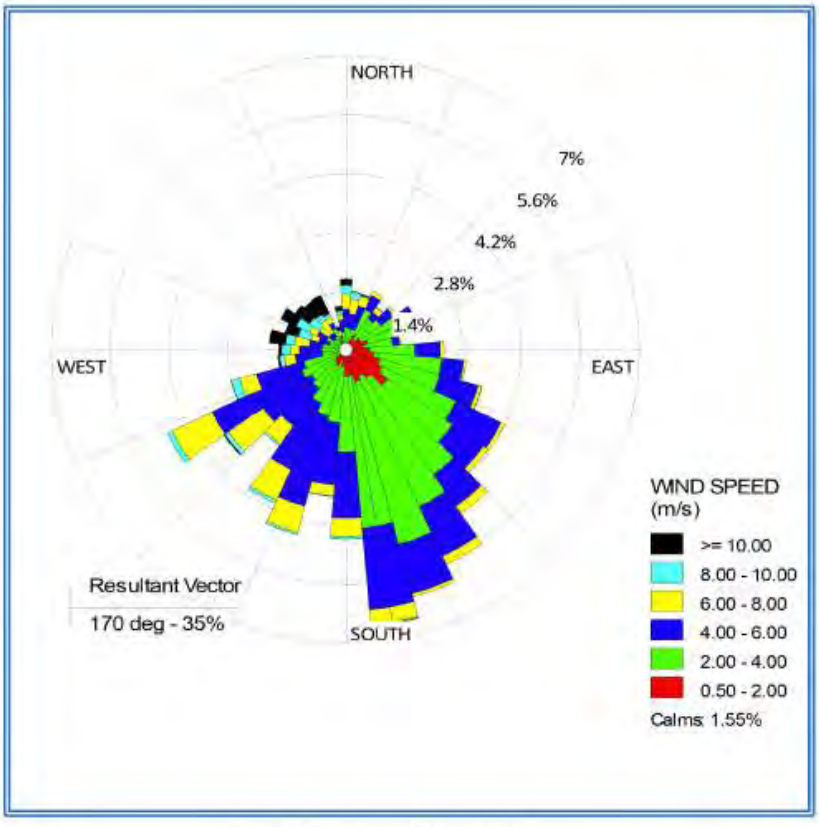


Figure 4-1: Windrose of Meteorological Dataset

Image 9. Windrose of meteorlogical dataset from EAQ report showing winds are predominantly from a southerly direction and at greater strength.

5. Existing Stakehill Road vegetation buffer

5.1. There is already an established vegetation buffer of trees and shrubs within the Stakehill Road road reserve adjacent Lot 849 and on the southern side within the road reserve and Lots 877 & 878 – refer to **Image 10** & **Image 11**.

5.2. In addition to the structure plan mitigation measures, market garden operator's statutory regulated use of pesticides and low likelihood of spray drift occurring from Lot 849, based on the prevailing southerly winds/meteorlogical conditions in the area, the existing vegetation buffer would also act to mitigate any potential spray drift impacting the structure plan residential areas.

5.3. Until the upgrading of Stakehill Road occurs, the existing vegetation would serve as a buffer to spray drift. When the upgrading of Stakehill Road occurs, a new line of vegetative landscaping/screening could be provided as a replacement to the existing vegetation screen/buffer.

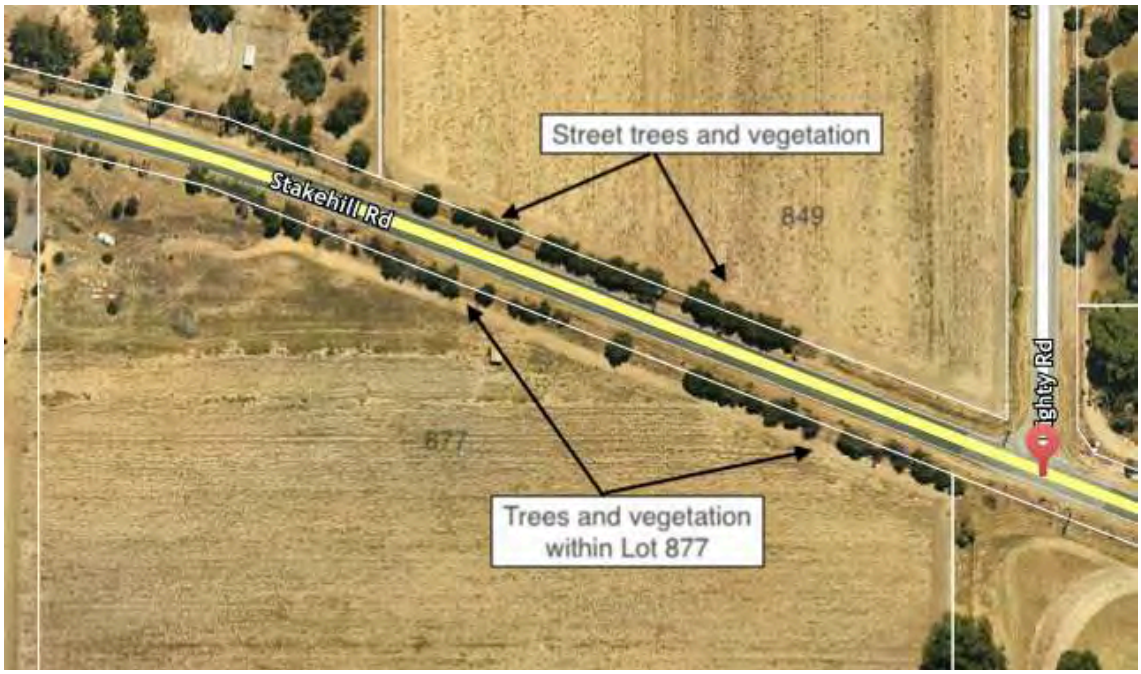


Image 10. Aerial view showing existing trees and vegetation within Stakehill Road road reserve separating Lot 849 potential market garden areas from the structure plan.

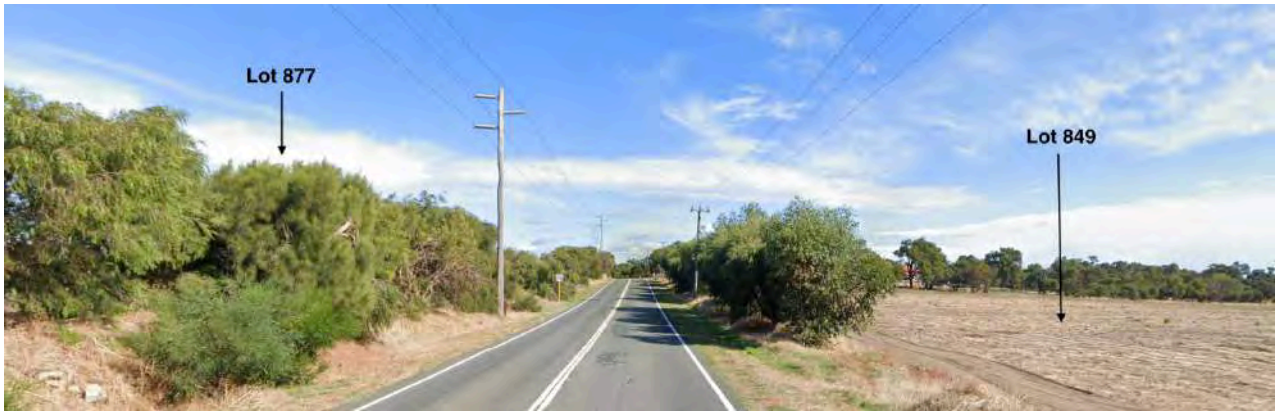


Image 11. Street view showing existing trees and vegetation within Stakehill Road road reserve separating Lot 849 potential market garden areas from the structure plan. (Source: Google, 2022)

Summary

In consideration of the above, if the landowner of Lot 849 were inclined to re-commence the historical market garden use on Lot 849, the chances of any market garden spray drift affecting the structure plan residential areas (at levels deemed unsafe to the public) is considered to be highly remote.

The combined factors outlined below represent a sufficient and reasonable planning response for addressing the market garden spray drift concern:

- Future Stakehill Road regional road separation distance (including the planning control area) of 60m – 90m
- Proposed structure plan on-site 30m buffer (including 5m vegetation strip), in addition to the existing Stakehill Road vegetation screen and/or future landscape planting within the verge
- Proposed 2.1m high transport acoustic wall along Stakehill Road to protect residential properties from transport noise, and
- Meteorlogical conditions in the area whereby winds are predominantly from the south and north/ north-easterly winds are infrequent and generally during cooler winter months.

There are numerous examples of Perth metropolitan commercial market gardens co-existing alongside or in close proximity to residential areas, as shown in Table 1. These examples demonstrate that it is possible for market garden operators to conduct their market garden spraying activities in a manner which does not adversely impact residential land use – even those within 30m – 50m of the market garden.

If in the event there is some form of a sustained level of chemical spary drift pollution breach by the operations of a market garden at Lot 849, in a manner that exceeds public nuisance and health limits, and of which overcome the above combined spray drift mitigation measures put in place, then clearly this would most likely be an act of negligence by the market garden operator. Such level of spray drift would most likely be the result of the operator having disregard to the proper (and label direction) use of spray chemicals, by which such spray chemicals must be applied under legislation. The health regulations cited in 2.1 above can be enforced by the City of Rockingham environmental health officers.

Thus the Proponent's proposed off-site market garden spray drift buffer is a sensible and reasonable planning response to address (on balance) the planning consideration of market garden spray drift.

Table 1: Examples of Perth market gardens co-existing alongside residential development

Market Garden Address	Comments
Lots 3 – 5, 157 & 158 corner Sixty Eight Road/Eighty Road, Baldivis (**Image 1**)	Large commercial market garden located opposite a recently constructed private high school and residential (medium density) lifestyle village. The sensitive residential and school land uses are downwind (i.e. prevailing south-east/south-west winds) from the market garden. Stakehill Road (20m road reserve) is the separation buffer between the market garden and school. The market garden operator has received no complaints from the school or residents.



Image 1. Market garden at corner Sixty Eight Road/Eighty Road, Baldivis which is located opposite a private high school and lifestyle village.

Lot 700 corner Lenore Road and Elliot Road, Wanneroo (**Image 2**)	Market garden located approx. 45m separation distance from residential dwellings. Dwellings are downwind (i.e. prevailing summer easterly winds) from the market garden. Dwellings are protected by a 2.0m high wall comprising 1.8m high solid fence with 200mm lattice screen on top. There is no vegetation buffer.



Image 2. Market garden at Lot 700 corner Lenore Rd /Elliot Rd, Wanneroo opposite residential dwellings.

Lots 49 & 500 East Road, Wanneroo (**Image 3**)	Market garden almost surrounded by dwellings located adjacent and across the roads from the market garden.



Image 3. Market garden at Lots 49 & 500 East Road, Wanneroo directly adjacent residential dwellings.

Lot 9003 Mary Road, Wanneroo (**Image 4**)	Market garden located approx. 47m separation distance from residential dwellings. Dwellings are downwind (i.e. prevailing summer easterly winds) from the market garden. Dwellings are protected by a 1.8m high solid fence. There is no vegetation buffer.



Image 4. Market garden at Lot 9003 Mary Street, Wanneroo located across Lenore Road from residential dwellings.

Anketell North market gardens - Treeby Road - Anketell Road (**Image 5**)	There are numerous commercial market gardens operating within Anketell North adjacent to or in close proximity to residential urban subdivision. The recently adopted 2020 *Anketell North Structure Plan* (**Image 6**) does not contain any statutory Part One provisions or notations on the structure plan map that address the issue of market garden spray drift. The market gardens currently co-exist alongside urbanisation in Anketell (and Wandi South). Note that Lot 90 Anketell Road is zoned MRS 'Rural – Water Protection' zone (along with the rear portions of Lots 37 – 39 Treeby Road) and is not identified for future urban development.



Image 5. Market gardens in Anketell North adjacent to residential land use in the Anketell North Structure Plan.



Image 6. Anketell North Structure Plan does not address the interim (transitional) impact of existing operational market gardens on staged residential development within the structure plan. Nor does the structure plan address the impacts of permanent neighbouring market gardens such as the one at Lot 90 Anketell Road.

End of technical note

MILANA FARMS

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Coogee WA 6163
E: admin@milanafarms.com.au
M: 0419184542

1 July 2021

Mr Joe Garbin
209 Stakehill Road
Karnup WA 6176

RE: Past Market Garden Practice – Lot 849 Eighty Road corner of Stakehill Road Baldivis.

I refer to our discussion where you advised of your interest in the past practices of the market garden at lot 849 Eighty Road, corner of Stakehill Road, which is situated north of your property at Lot 877 Stakehill Road.

I was a part owner of the market garden as a beneficial owner of Baldivis Farms Pty Ltd, until it was sold to the Indigenous Land & Sea Corporation in July 2020. Baldivis Farms Pty Ltd operated a market garden on the site from the year 2000 to that sale. The Indigenous Land & Sea Corporation have not operated the site since it was purchased.

During the ownership of Baldivis Farms Pty Ltd (Baldivis Farms), it was used principally to grow the following crops:

- Carrots
- Potatoes
- Cauliflower
- Broccoli
- Lettuce

During the four years from 2016 to the sale no fumigants were used on the site.

These crops are low height crops, growing up to 40cm high in general. Sprays are applied at a height of 50cm above the crop to minimise drift . Sprays are only applied in accordance with the various guidelines and best practice, to ensure compliance with the *Health (Pesticides) Regulations 2011*.

I had no complaints about spray drift from neighbours during the operation of the farm, even though I had many residents living directly opposite and adjoining this farm, including on Stakehill Road and along Eighty Road.

I currently operate another farm in the area, being lots 4 & 5 on the south west corner of Sixty Eight Road and Baldivis Road. This is directly opposite the Catholic College recently built on the north west corner of Sixty Eight and Eighty Roads. Despite being directly down wind of the farm, we receive no complaints from the Catholic College regarding spray drift.

We do not use fumigants and still spray at the above heights on our farms.

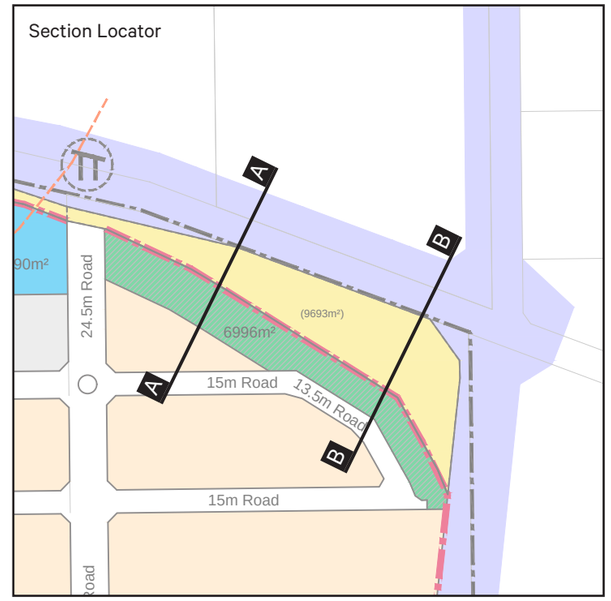
Yours sincerely,

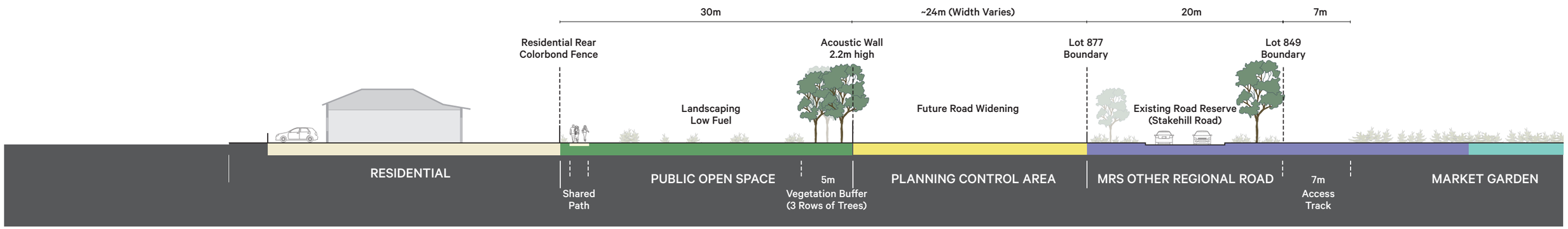
Charlie Blogna

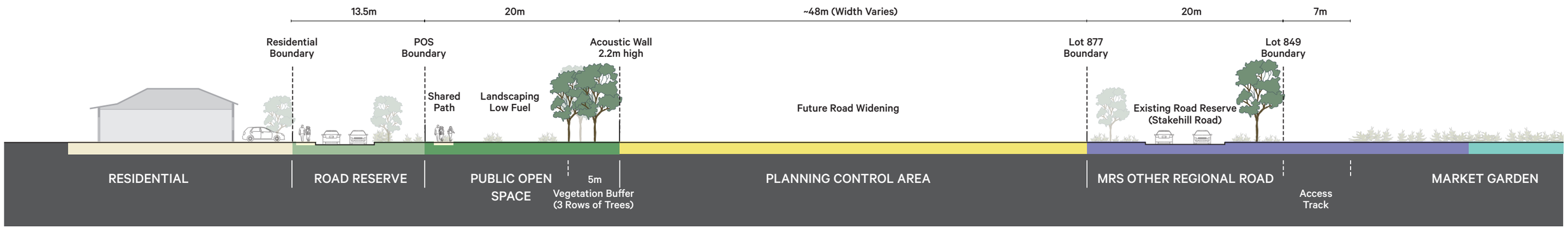
Milana Farms Pty Ltd

Appendix 14

Vegetation Buffer Plan







Road Cross Sections

Stakehill Road, Karnup

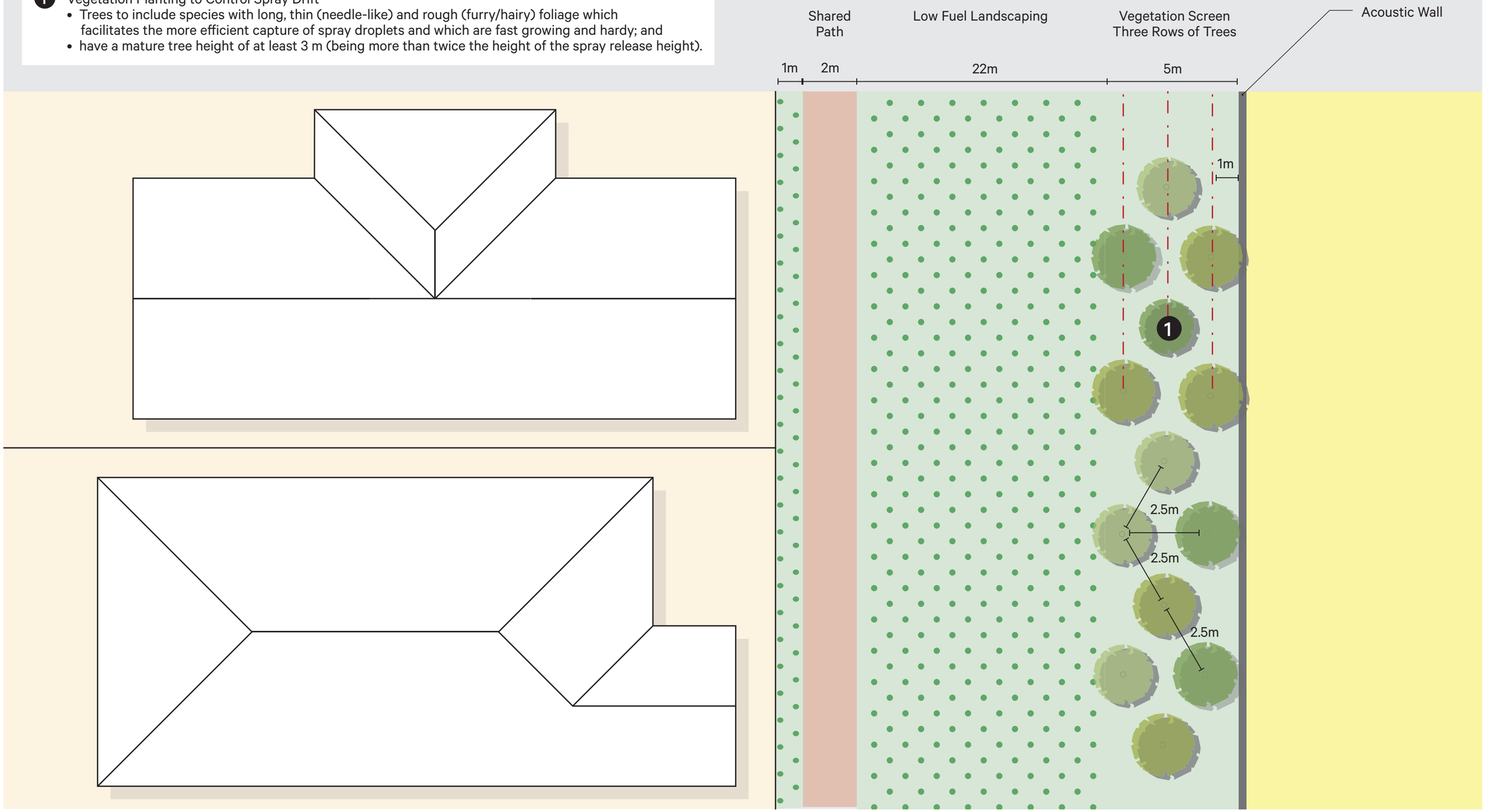
Date: 10 Dec 2024 Scale: NTS @ A3 NTS @ A1 File: **24-174 ST-1** Staff: JP GW Checked: JP

element.

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NOTE:

1. Vegetation Planting to Control Spray Drift
   - Trees to include species with long, thin (needle-like) and rough (furry/hairy) foliage which facilitates the more efficient capture of spray droplets and which are fast growing and hardy; and
   - have a mature tree height of at least 3 m (being more than twice the height of the spray release height).



Vegetation Buffer Plan

Stakehill Road, Karnup

Date: 10 Dec 2024 Scale: NTS @A3 File: **24-174 VBP-01 Vegetation Buffer** Staff: WJ Checked: JP

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