ROWE GROUP DESIGN

STRUCTURE PLAN

LOT 50 (NO. 193) BARFIELD ROAD HAMMOND PARK

OUR REF: 8697 2/02/2022

DOCUMENT CONTROL

Printed xxxx 8697_20dec03R_rt

VERSION	FILE NAME	PREPARED BY	APPROVED BY	DATE
1	8697_19May02R_bs	Blair Stroud	Nathan Stewart	17/10/2019
2	8697_19Nov04R_bs	Blair Stroud	Nathan Stewart	19/12/2019
3	8697_20dec01R_rt	Rebecca Thompson	Rod Dixon	9/12/2020
4	8697_20dec02R_rt	Rebecca Thompson	Rod Dixon	15/12/2021
5	8697_20dec03R_rt	Rebecca Thompson	Rod Dixon	2/02/2022

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This structure plan is prepared under the provisions of the City of Cockburn Town Planning Scheme No. 3.

IT IS CERTIFIED THAT THIS STRUCTURE PLAN WAS APPROVED BY RESOLUTION OF THE WESTERN AUSTRALIAN PLANNING COMMISSION ON: **10 FEBRUARY 2022**

Signed for and on behalf of the Western Australian Planning Commission

_____

an officer of the Commission duly authorised by the Commission pursuant to Section 16 of *the Planning and Development Act 2005* for that purpose, in the presence of:

_____ Witness

14 February 2022 Date

10 February 2032 Date of Expiry

TABLE OF AMENDMENTS

AMENDMENT NO.	SUMMARY OF THE AMENDMENT	AMENDMENT TYPE	DATE APPROVED BY WAPC

TABLE OF DENSITY PLANS

DENSITY PLAN NO.	**AREA OF DENSITY PLAN APPLICATION**	**DATE ENDORSED BY WAPC**

EXECUTIVE SUMMARY

Rowe Group acts on behalf of the landowner of Lot 50 (No. 193) Barfield Road, Hammond Park (herein referred to as the 'subject site'). We have been instructed by our Client to prepare and lodge a Structure Plan over the subject site.

The proposed Structure Plan is located adjacent to the existing Structure Plan for the Vivente estate (currently under construction), within the Southern Suburbs (Stage 3, Hammond Park / Wattleup) District Structure Plan area.

The proposed Structure Plan seeks to facilitate the subdivision and development of the subject site for residential purposes, providing for seamless connections with the surrounding urban environment, existing and planned. Specifically, the Local Structure Plan provides:

- Residential lots, with a proposed R30 density code; and
- Public Open Space, designed in accordance with the requirements of Liveable Neighbourhoods.

The proposed Structure Plan has been prepared in accordance with the provisions of Part 4 of Schedule 2 of the Planning and Development (Local Planning Schemes) Regulations 2015 ('Planning Regulations') and provides the planning framework to guide and facilitate the urban residential development of the subject land.

The preparation of the Structure Plan has been undertaken in consultation with the City of Cockburn and other relevant stakeholders.

STRUCTURE PLAN SUMMARY

ITEM	DATA		SECTION NUMBER REFERENCED IN PART 2 OF REPORT
Total area covered by the Structure Plan	1.86 hectares		1.2.2
Area of each land use proposed: Residential	1.20 hectares	32 lots	3.3
Total estimated lot yield	32 lots		3.3
Estimated number of dwellings	32 dwellings		3.3
Estimated residential site density	26.28 dwellings per res site hectare 17.2 dwellings per gross hectare		3.3
Estimated population	96 people		3.3
Number of high schools	0 high schools		3.6
Number of primary schools	0 primary schools		3.6
Estimated commercial floor space	0 hectares		3.7
Estimated area and percentage of public open space given over to: - Regional open space - District open space - Neighbourhood parks - Local parks	 - 0 hectares, 0% - 0 hectares, 0% - 0 hectares, 0 parks - 0.20 hectares, 1 park		3.2
Estimate percentage of natural area	0 hectares, 0 %		3.2

TABLE 1: STRUCTURE PLAN SUMMARY

Note: All information and areas are approximate only and are subject to survey and detailed design.

CONTENTS

FIGURES

TABLES

TECHNICAL APPENDICES

APPENDIX NUMBER	DOCUMENT TITLE	NATURE OF DOCUMENT	REFERRAL/APPROVAL AGENCY	APPROVAL STATUS AND MODIFICATIONS
1	Certificate of Title	Supporting		
2	Bushfire Management Plan	Requires Approval	Department of Fire and Emergency Services	
3	Environmental Assessment Management Strategy	Supporting	Department of Biodiversity, Conservation and Attractions	
4	Transportation Noise Assessment	Requires Approval	Main Roads WA	
5	Indicative Landscape Concept	Supporting	City of Cockburn	
6	Engineering Servicing and Traffic Report	Supporting	City of Cockburn	
7	Local Water Management Strategy	Requires Approval	Department of Water and Environmental Regulation	Approved
8	LWMS Approval	Supporting	Department of Water and Environmental Regulation	

TABLE 2: TECHNICAL APPENDICES

PART ONE

IMPLEMENTATION

ROWE
GROUP
DESIGN

1. STRUCTURE PLAN AREA

This Structure Plan applies to Lot 50 (No. 193) Barfield Road, Hammond Park, being the land contained within the inner edge of the line denoting the Structure Plan Boundary on the Structure Plan Map (Refer Plan 1 situated at the end of Part 1 of this Structure Plan Report).

2. OPERATION

In accordance with Schedule 2, Part 4 of the *Planning and Development (Local Planning Schemes) Regulations 2015* ('Planning Regulations'), this Structure Plan shall come into operation when it is approved by the Western Australian Planning Commission ('WAPC').

Pursuant to clause 27(1) of Schedule 2 of the Planning Regulations:

> *A decision-maker for an application for development approval or subdivision approval in an area covered by a structure plan that has been approved by the Commission is to have due regard to, but is not bound by, the structure plan when deciding the application.*

Pursuant to clause 28(1) of Schedule 2 of the Planning Regulations this Structure Plan has effect for a period of 10 years, commencing on the day which the WAPC approves the plan.

3. STAGING

Given the size of the site, development within the proposed Structure Plan area is intended to occur as a single stage.

4. SUBDIVISION & DEVELOPMENT REQUIREMENTS

4.1 LAND USE PERMISSIBILITY

The Structure Plan Map (Plan 1) outlines land use, zones and reserves applicable within the Structure Plan area. The zones and reserves designated under this Structure Plan apply to the land within it as if the zones and reserves were incorporated into the *City of Cockburn Town Planning Scheme No.3*.

4.2 PUBLIC OPEN SPACE

The Structure Plan is to provide for a minimum of ten percent (10%) of the gross subdivisible area as Public Open Space in accordance with the WAPC's *Liveable Neighbourhoods* document. Public open space shall be provided generally in accordance with Plan 1 – Structure Plan Map.

4.3 RESIDENTIAL DENSITY

The residential density codes applicable to the Structure Plan shall be in accordance with those shown on the Structure Plan Map (Plan 1).

In accordance with Liveable Neighbourhoods and Directions 2031 targets, the Structure Plan area shall provide for an average minimum of 22 dwellings per residential site hectare and 15 dwellings per gross urban hectare.

5. LOCAL DEVELOPMENT PLANS

a) The WAPC may require, as a condition of subdivision approval, a Local Development Plan(s) be prepared in accordance with Part 6 of Schedule 2 of the *Planning and Development (Local Planning Schemes) Regulations 2021*, prior to the creation or development of lots:

   i. of irregular shape or less than 260m^2 in area;

   ii. affected by road or rail noise exceeding the targets set out in *State Planning Policy 5.4: Road and Rail Noise* and the associated implementation guidelines;

   iii. where vehicular access is obtained from a rear laneway, or right of way, or is otherwise constrained;

   iv. abutting areas of public open space; and/or

   v. intended to accommodate grouped or multiple dwellings.

b) Local Development Plans are to address the following matters, as required:

   i. street and boundary setbacks;

   ii. dwelling orientation;

   iii. uniform fencing requirements;

   iv. open space requirements;

   v. garage setbacks and width;

   vi. vehicular and pedestrian access;

   vii. parking requirements;

   viii. overshadowing;

   ix. visual privacy;

   x. quite house design and/or construction requirements; and

   xi. any variations to the Residential Design Codes

6. OTHER REQUIREMENTS

6.1 NOTIFICATION(S) ON TITLE

Notification(s) is/are to be placed on Title of all affected lots to advise:

a) the lot is located near a transport corridor and higher construction standards may be required to reduce transport noise to acceptable levels in accordance with *State Planning Policy 5.4: Road and Rail Noise*;

b) the lot is located within an area which has been declared bushfire prone and may be subject to a Bushfire Management Plan, and where additional construction requirements may

apply in accordance with *Australian Standard (AS3959) Construction of Buildings in Bushfire Prone Areas* (as amended).

6.2 RESTRICTIVE COVENANT

A Restrictive Covenant is to be placed on Titles of all affected lots that have been assessed as BAL-40 or BAL-Flame Zone, with a notice of this restriction to be included on the Diagram or Plan of Survey (Deposited Plan) to advise no habitable buildings are to be built within areas identified as BAL-40 or BAL-Flame Zone.

6.3 BUSHFIRE CONSTRUCTION STANDARDS

This Structure Plan is supported by a Bushfire Management Plan (April 2021). Regardless of whether the land has been formally designated as bushfire prone, any buildings to be erected on land identified as falling within 100 metres of a bushfire hazard shall comply with the requirements of *Australian Standard (AS3959) Construction of Buildings in Bushfire Prone Areas* (as amended).

6.4 DEVELOPMENT CONTRIBUTIONS

The Structure Plan area is included within Development Contribution Areas 9, 13 and 26 under the City of Cockburn Town Planning Scheme No. 3. Contribution costs are to be paid in accordance with the requirements of the Scheme at subdivision and development stage.

6.5 ENVIRONMENTAL AND HERITAGE FEATURES

A Landscape Management Plan is to be provided at the subdivision application stage, identifying any trees worthy for retention, where not affected by subdivision works.

Prior to the commencement of subdivisional works, a Tree Protection Management Plan is to be prepared and approved to ensure the protection and management of the site's environmental assets, with satisfactory arrangements being made for the implementation of the approved plan.

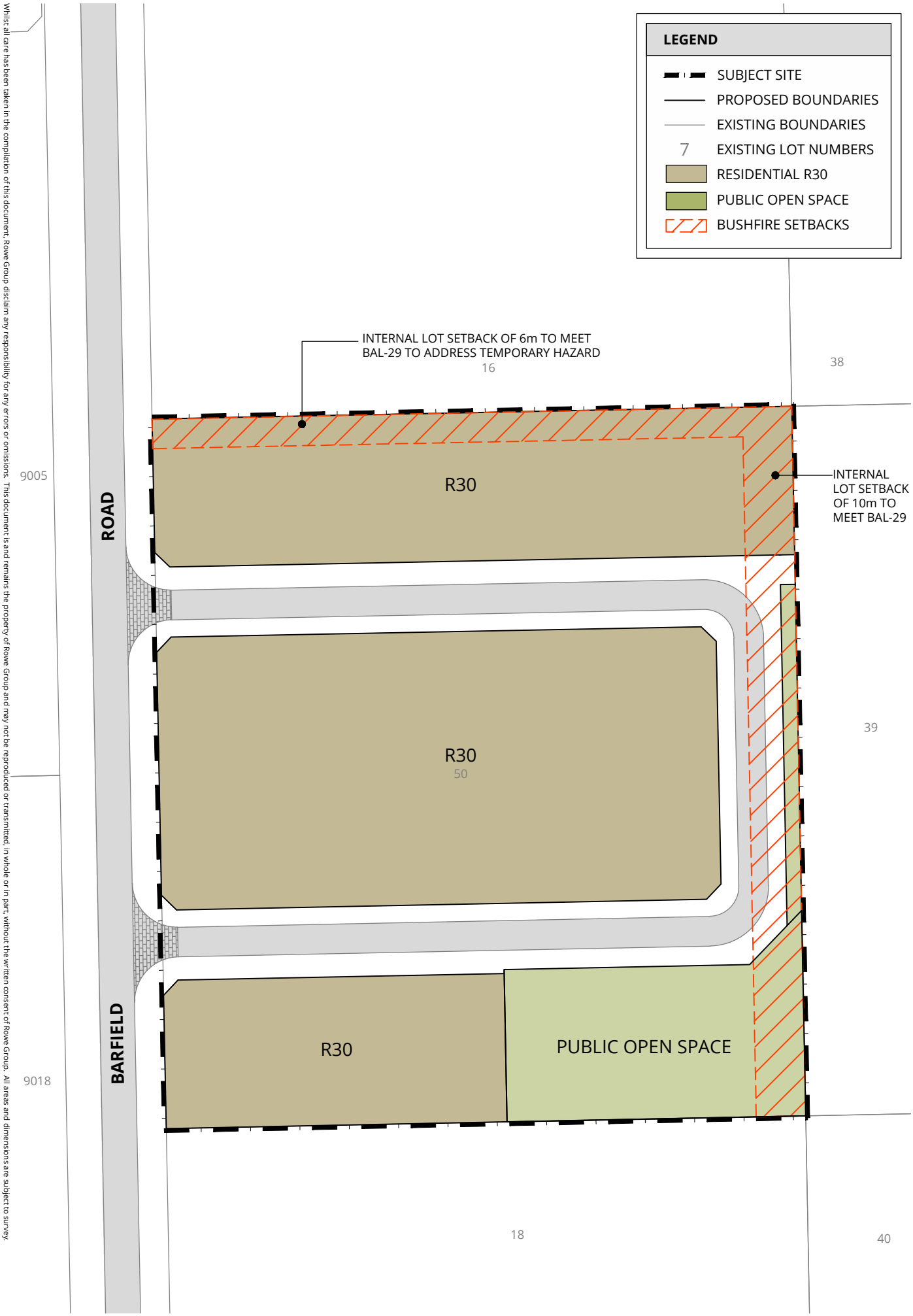
A Fauna Survey and Relocation Management Plan will be required to be undertaken at the subdivision stage.

A Bushfire Attack Level Assessment and Contour Plan will be required to be submitted with any Subdivision Application/s.

7. ADDITIONAL INFORMATION

ADDITIONAL INFORMATION	APPROVAL STAGE	CONSULTATION REQUIRED
Landscape Management Plan	Subdivision Application	City of Cockburn
Urban Water Management Plan (unless exempt)	Subdivision Application	DWER and City of Cockburn
Fauna Survey and Relocation Management Plan	Subdivision Application	DBCA and City of Cockburn
Tree Protection Management Plan	Subdivisional Works	City of Cockburn
Bushfire Attack Level Assessment and Plan	Subdivision Application	DPLH and City of Cockburn
Acoustic Assessment	Subdivision Application	Main Roads WA and City of Cockburn

TABLE 3: ADDITIONAL INFORMATION



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0 25 m

SCALE @ A4: 1:1000

N

PLAN 1

LOCAL STRUCTURE PLAN

PART TWO

EXPLANATORY SECTION

ROWE GROUP DESIGN

1. PLANNING BACKGROUND

1.1 INTRODUCTION AND PURPOSE

The purpose of this Structure Plan is to facilitate the development of the Urban zoned land comprising Lot 50 (No. 193) Barfield Road, Hammond Park ('the subject site') for residential purposes.

The following multi-disciplinary project team has been engaged by the proponent to progress the preparation of the Structure Plan:

DISCIPLINE	CONSULTANT
Acoustic	Lloyd George Acoustics
Bushfire	Emerge Associates
Civil Engineering	BPA Engineering
Environmental	Emerge Associates
Hydrological	Emerge Associates
Town Planning and Design	Rowe Group

Table 4: Project Team

Rowe Group is the primary point of contact for all matters relating to the Structure Plan submission.

1.1.1 PRE-LODGEMENT CONSULTATION

The proposed Structure Plan was lodged with the City of Cockburn in October 2019. Following a period of review, the City of Cockburn provided comments on the proposed Structure Plan and LWMS, and sought additional information to support the proposal. Since that time, there has been ongoing liaison with the City's Planning and Engineering teams in regard to the proposed layout, with specific focus on the drainage and public open space.

This Structure Plan therefore reflects a refinement of the originally lodged request, addressing the various recommendations of the City of Cockburn and providing the additional required supporting information.

1.2 LAND DESCRIPTION

1.2.1 LOCATION

The subject site is located within the municipality of the City of Cockburn, within the locality of Hammond Park. The site is situated approximately 24 kilometres south of the Perth Central Area and is accessible via the Kwinana Freeway (via Rowley Road). The Aubin Grove/ Success passenger railway station is located approximately 2.4 kilometres north east of the subject site and Cockburn Central approximately 5.5 kilometres north of the site.

The site is generally bound by Barfield Road to the west, privately held land (future residential) to the north and south, and the Western Power high voltage power line easement / Kwinana Freeway to the east.

Refer to **Figure 1** – Regional Location and **Figure 2** – Local Location.

1.2.2 AREA AND LAND USE

The subject site comprises approximately 1.86 hectares of land situated in Hammond Park, with frontage to Barfield Road.

The subject site is currently vacant, with some existing vegetation.

There is existing development to the west of the site on the opposite side of Barfield Road, comprising the Vivente estate. Land to the immediate south of the site will be developed as the final stages of that estate.

Land to the immediate north of the site is currently vacant, with no known timeframes for planning and development being undertaken on that land.

The site adjoins a Western Power high voltage power line easement on its eastern boundary. This does not impact the residential development potential for the site.

Refer **Figure 3** – Site Plan.

1.2.3 LEGAL DESCRIPTION AND OWNERSHIP

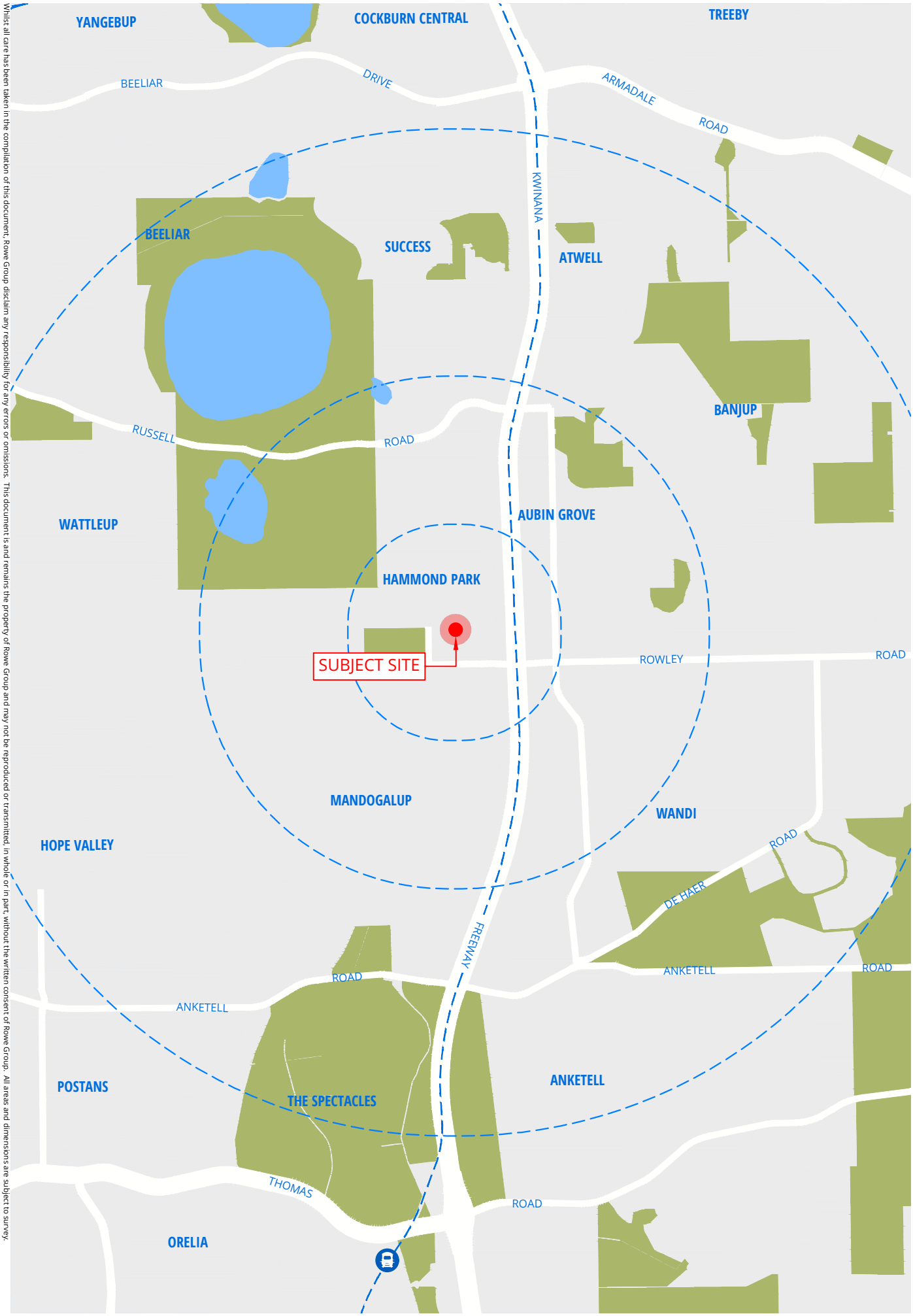
The Structure Plan comprises one land parcel, legally described as follows:

LOT NUMBER	STREET ADDRESS	DIAGRAM NO.	VOL / FOLIO	PROPRIETOR(S)
50	193 Barfield Road	65995	1678 / 32	Glenbrook Civil Engineering Contractors Pty Ltd

Table 5: OWNERSHIP DETAILS

The Structure Plan area comprises an area of approximately 1.86 hectares.

Refer to **Appendix 1** – Certificate of Title.



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SCALE @ A4: 1:50,000

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FIGURE 1

REGIONAL LOCATION

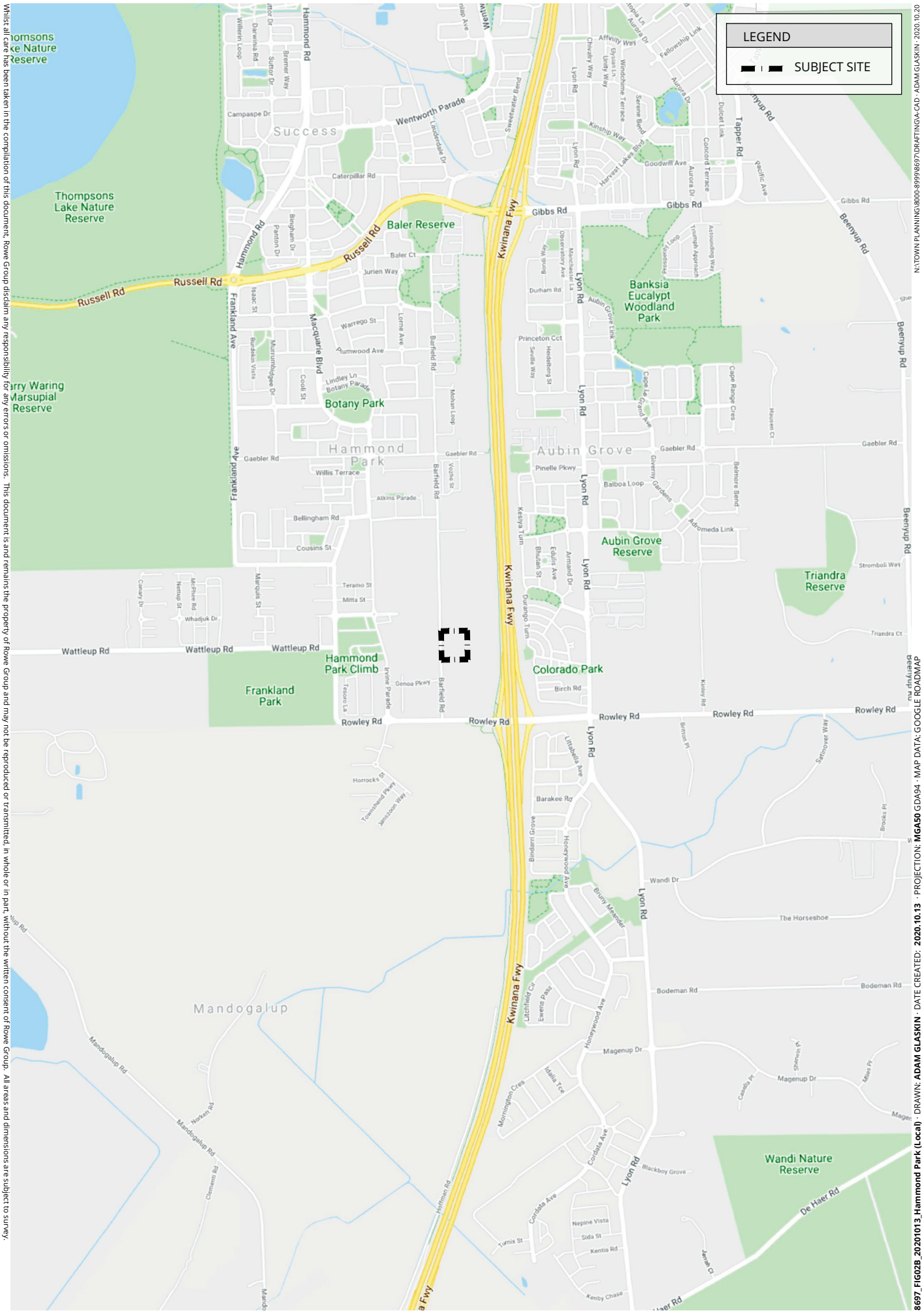

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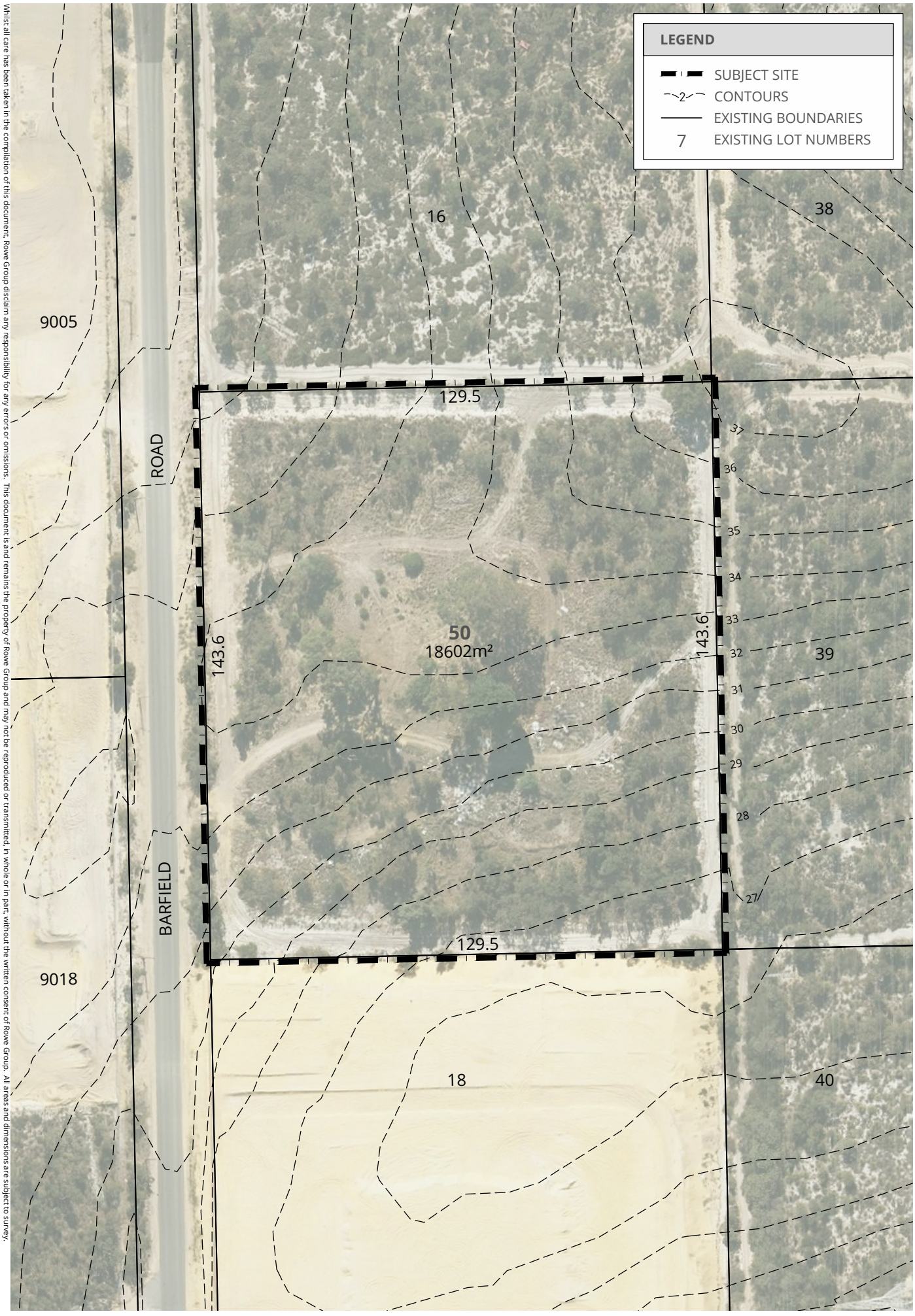
FIGURE 2

LOCAL LOCATION



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0 31.25 m

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FIGURE 3

SITE PLAN / AERIAL

1.3 PLANNING FRAMEWORK

1.3.1 ZONING AND RESERVATIONS

The subject site is zoned 'Urban' under the provisions of the Metropolitan Region Scheme (MRS), and 'Development' under the provisions of the City of Cockburn Town Planning Scheme No. 3 (TPS 3).

The objectives of the 'Development' zone, as stated in TPS 3, are:

> *To provide for future residential, industrial or commercial development to be guided by a comprehensive Structure Plan prepared under the Scheme.*

This Structure Plan has been prepared in a manner consistent with these objectives and which provides a framework for further subdivision and development at the subject site.

Refer to **Figure 4** – Metropolitan Region Scheme Zoning.

Refer to **Figure 5** – City of Cockburn Town Planning Scheme No. 3 Zoning.

1.3.2 PERTH AND PEEL @ 3.5 MILLION AND SOUTH METROPOLITAN PEEL SUB-REGIONAL PLANNING FRAMEWORK

Perth and Peel @ 3.5 Million seeks to meet the targets identified under *Directions 2031 and Beyond* ('Directions 2031') and the *State Planning Strategy 2050*. The suite of documents also includes four sub-regional planning frameworks for the Central, North-West, North-East and South Metropolitan Peel sub-regions. The four sub-regional planning frameworks detail where future homes and employment should be located, and where important environmental assets should be avoided and protected.

The subject site is located within the *South Metropolitan Peel Sub-Regional Planning Framework* (the Framework). The Framework represents a whole of State Government approach to managing the future urban form within the sub-region and identifies sufficient land to meet the increased demand for residential dwellings. Within the Framework, the City is expected to require an additional 30,120 dwellings by 2050.

Both *Perth and Peel @ 3.5 Million* and the *South Metropolitan Peel Sub-Regional Framework* identify the subject site as 'Urban', consistent with the zoning of the site under the MRS.

1.3.3 CITY OF COCKBURN SOUTHERN SUBURBS DISTRICT STRUCTURE PLAN

The *Southern Suburbs District Structure Plan* ('SSDSP') provides a framework for subdivision and development in Success, Hammond Park, Atwell and Aubin Grove. The SSDSP is now in stage 3, which is the remaining area of development and comprises the area of Hammond Park west of the Freeway and south of Gaebler Road.

The SSDSP Stage 3, comprises the following design principles:

- Provide a framework for urban land uses within the District Structure Plan area that integrates with the Sub Regional Context;
- Respond to the social and economic needs of the community in a timely way;

- Provide a framework for future Local Structure Planning and subdivision, allowing for refinement of detail and recognition of previous uses;
- Provide for a variety of housing choice through a range of densities, with higher codings being located near public open space, centres and along high frequency public transport routes;
- Define a robust road network reflecting and accommodating public and private transport priorities, responding to the Sub Regional transport network;
- Main-street based centres;
- An integrated open space, conservation and drainage network, balancing environmental, recreational and drainage objectives;
- Provide for sustainable land use and lot design that responds to solar orientation principles as well as Crime Prevention Through Environmental Design ('CPTED');
- Encourage local employment within centres, as well as through home based businesses; and
- Reflect and integrate the development area with surrounding land uses.

The subject site is identified as 'Medium Density Residential' under the SSDSP, which requires a minimum base coding of R30. The proposed Structure Plan designates a density code of R30, consistent with the SSDSP.

The SSDSP requires structure plans to achieve a minimum of 15 dwellings per gross urban zoned hectares of land and a minimum of 22 dwellings per site hectare of residential land. Based on preliminary subdivision design, it is anticipated the Structure Plan area will yield approximately 32 dwellings, with an average of 17.2 dwellings per gross urban zoned hectare and 26.28 dwellings per residential site hectare.

The Structure Plan has been designed with consideration of the surrounding road network, including intersection spacing, and the adjoining proposed lot layout, including consideration of site levels and drainage requirements.

The Structure Plan is therefore considered to be consistent with the principles of the SSDSP.

1.3.4 PLANNING POLICIES

1.3.4.1 LIVEABLE NEIGHBOURHOODS

Liveable Neighbourhoods represents the WAPC's primary policy to guide the design and assessment of residential structure plans and subdivision. The underlying objective of *Liveable Neighbourhoods* is to create safe, sustainable and attractive neighbourhoods with a strong site responsive identity that reduce dependency on private vehicles and are more energy and land efficient. As such, *Liveable Neighbourhoods* seeks to promote an urban structure based on walkable, mixed-use neighbourhoods with interconnected street patterns. It functions by drawing together key policy aspects into a single 'integrated planning and assessment policy' to provide for a performance-based approach to planning assessment. These aspects include:

- Community;
- Movement;
- Lot Layout;
- Urban Water Management;
- Public Open Space; and
- Schools.

Liveable Neighbourhoods identifies a series of objectives and requirements for structure plans that, when met, demonstrate compliance with the overall outcomes sought by *Liveable Neighbourhoods*. These objectives and requirements relate to items such as road layout, relationship of housing to open space and schools, school location/distribution, public open space layout and location, and housing densities.

Working with the site constraints, the Structure Plan has been prepared to satisfy the various objectives and requirements of *Liveable Neighbourhoods* to ensure that more detailed proposals at subdivision stage are also capable of satisfying the relevant criteria.

1.3.4.2 STATE PLANNING POLICY 3 – URBAN GROWTH AND SETTLEMENT

State Planning Policy 3 – Urban Growth and Settlement ('SPP 3') sets out the principles and considerations which apply to planning for urban growth and settlement in WA. SPP 3 recognises that:

> *The orderly planning of urban growth and settlement should be facilitated by structure plans, which should take into account the strategic and physical context of the locality, provide for the development of safe, convenient and attractive neighbourhoods which meet the diverse needs of the community, and facilitate logical and timely provision of infrastructure and services. Structure plans may consist of a hierarchy of plans ranging from broad district structure plans to more detailed plans for neighbourhoods and precincts.*
>
> *Proposals for future urban growth will be determined having regard to*
>
> - *the State Planning Strategy, relevant statements of planning policy and regional and subregional strategies in the State Planning Framework;*
> - *population projections provided by the Department for Planning and Infrastructure;*
> - *land release plans published by the Commission; and*
> - *local planning strategies prepared by local government and endorsed by the Commission.*

The proposed Local Structure Plan is consistent with the abovementioned objectives for future urban growth. Consideration of the strategic and physical context of the subject site is discussed further within this document and more detailed design provisions are to be addressed and considered at subdivision stage.

1.3.4.3 STATE PLANNING POLICY 3.7 – PLANNING IN BUSHFIER PRONE AREAS

State Planning Policy 3.7 – Planning in Bushfire Prone Areas ('SPP 3.7') seeks to guide the implementation of effective risk-based land use planning and development to preserve life and reduce the impact of bushfire on property and infrastructure. The subject site is identified by the Department of Fire and Emergency Services ('DFES') Map of Bush Fire Prone Areas as being "bushfire prone" with the mapped bushfire risk coming from the adjacent areas of remnant vegetation.

Due to the subject site being identified as 'bushfire prone", the principles and objectives of SPP 3.7 need to be considered as part of the structure planning process. A Bushfire Management Plan ('BMP') has therefore been prepared by Emerge Associates in support of the proposed Structure Plan.

Refer **Appendix 2** – Bushfire Management Plan.

1.3.4.4 STATE PLANNING POLICY 5.4 – ROAD AND RAIL NOISE

The general objectives of *State Planning Policy 5.4 - Road and Rail Noise* ('SPP 5.4') are to ensure people are protected from unreasonable levels of transport noise and to ensure new development is compatible with existing transport corridors and freight operations. Given the Kwinana Freeway (Primary Regional Road) and Perth to Mandurah Railway Line are situated to the east of the subject site, the provisions of SPP 5.4 are applicable to proposed development.

In this regard, and in accordance with SPP 5.4, a Traffic Acoustic Assessment has been prepared by Lloyd George Acoustics. The Acoustics Assessment is contained at **Appendix 4** of this report. The Traffic Acoustic Assessment demonstrates compliance with SPP 5.4.

1.3.4.5 LOCAL PLANNING POLICY

The City of Cockburn *Local Planning Policy 1.2 – Residential Design Guidelines* is to be addressed and considered through the subdivision and detailed design stages.

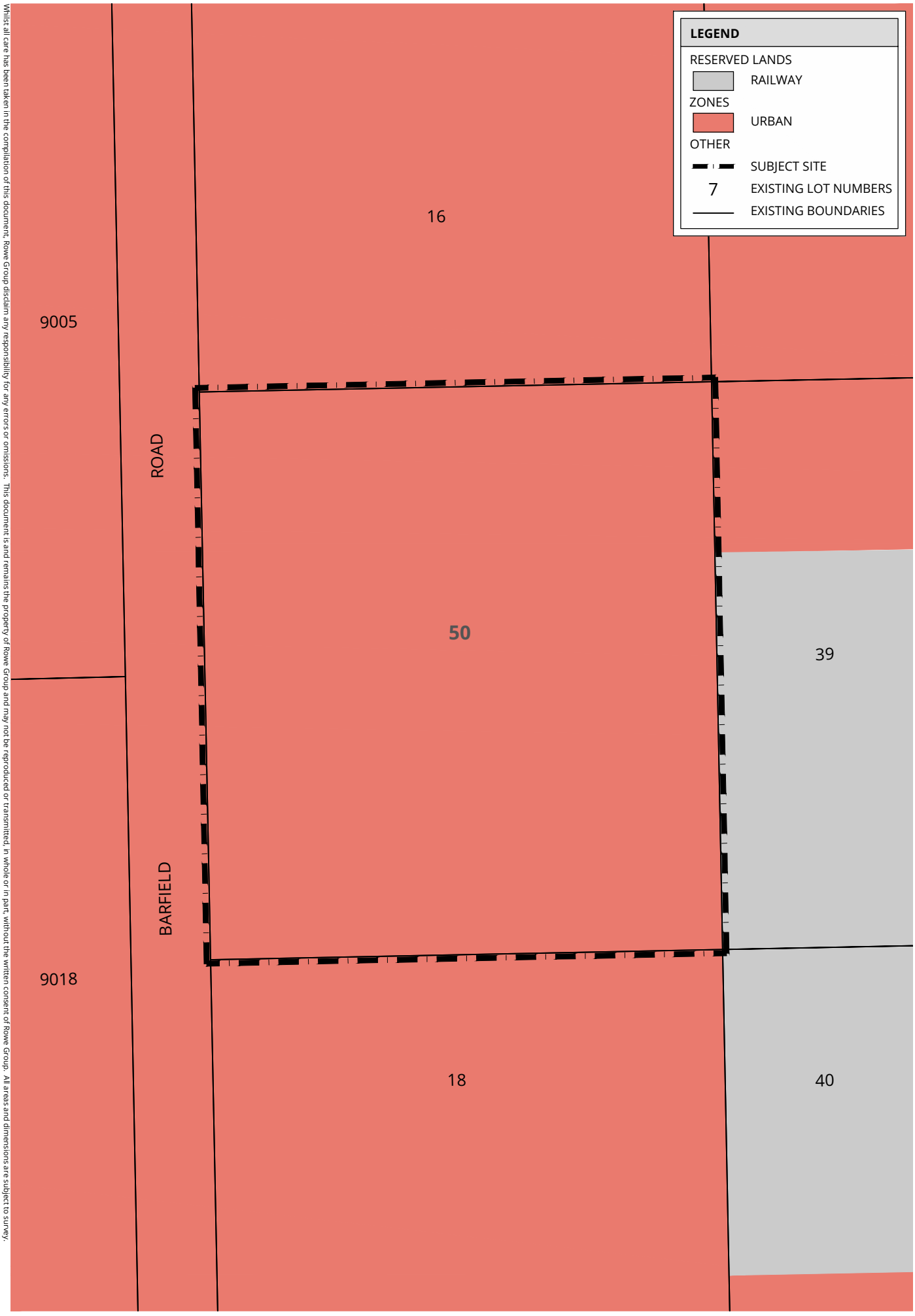

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FIGURE 4

METROPOLITAN REGION SCHEME ZONING

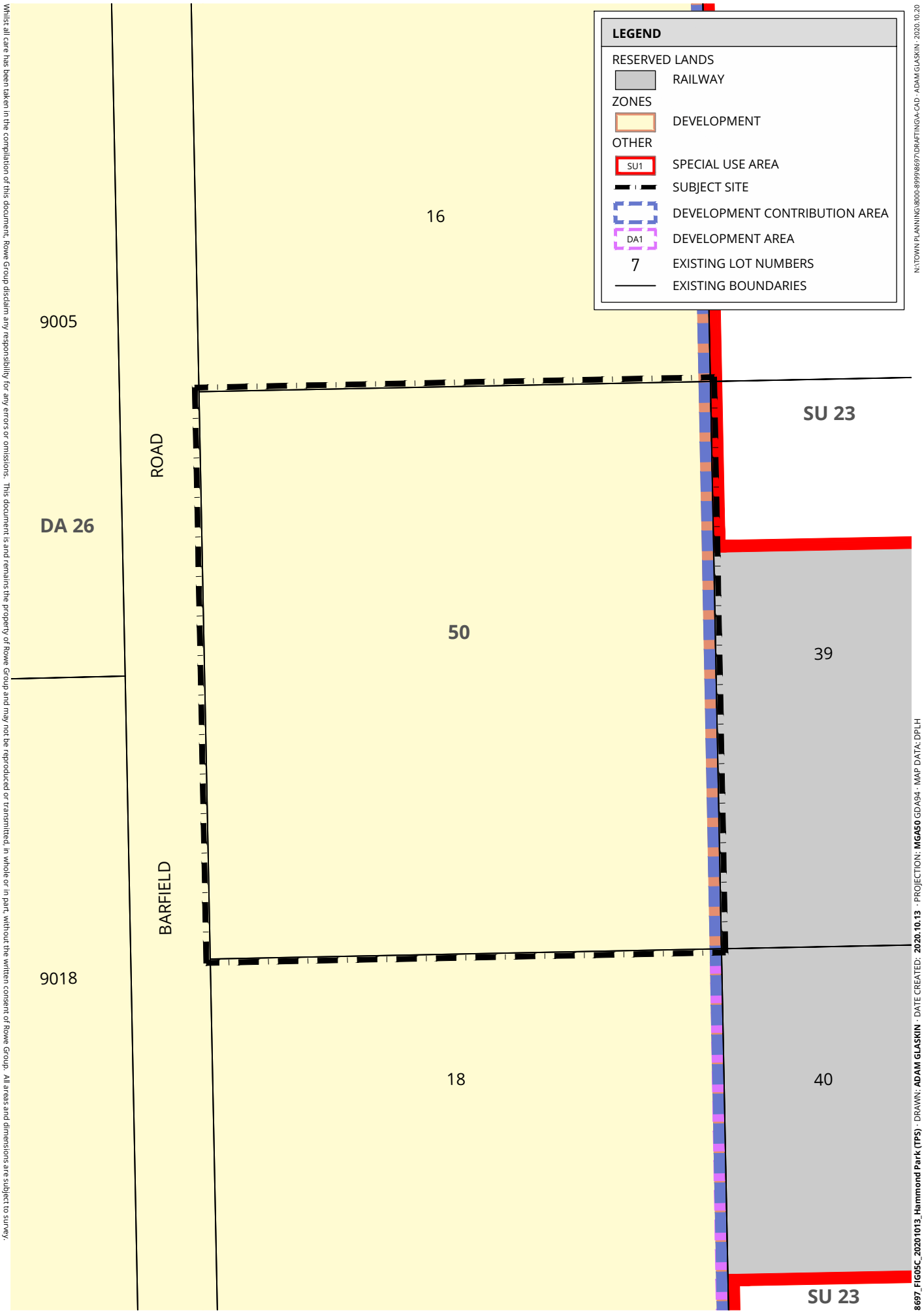

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FIGURE 5

CITY OF COCKBURN TOWN PLANNING SCHEME No. 3 ZONING

2. SITE CONDITIONS AND CONSTRAINTS

The following provides a summary of the environmental site conditions and constraints. For further detailed information, refer to the Environmental Assessment and Management Strategy contained at **Appendix 3**.

2.1 BIODIVERSITY AND NATURAL AREA ASSETS

2.1.1 FLORA AND VEGETATION

A total of 123 species were recorded during a Detailed Flora Survey undertaken in Spring 2018. Of the 123 plant species, 36 were non-native (weed) species, which is present across approximately 1.02 hectares of the subject site. One native plant community ("BaBm") was identified within the north-eastern and south-eastern edges of the site, which comprises part of a larger patch directly east of the subject site, extending north and south.

There was one declared pest on site under s22 of the *Biosecurity and Agriculture Management Act 2007*:

- *Gomphocarpus fruticosus* (Cotton Bush).

No threatened or priority flora species were recorded within the subject site. Furthermore, there were not any locally or regionally significant flora species recorded within the subject site.

Whilst the site is proposed to be cleared to facilitate the proposed development, there may be some scope for the retention of significant trees and vegetation within public open space and road reserves through translocation. This will be reviewed in further detail at the subdivision implementation stage, through the detailed civil design process, and facilitated through the preparation and implementation of a *Landscape Management Plan* and *Tree Protection Management Plan*.

2.1.2 FAUNA

A fauna survey and targeted black cockatoo habitat assessment was carried out by Emerge Associates in 2018, to determine the fauna values associated with the subject site. A total of eight native fauna species were observed within the subject site, with the majority of species recorded as common widespread bird species.

Fauna habitat values within the subject site have been compromised by historical clearing, with the remaining areas of remnant vegetation having little value for fauna.

No signs of black cockatoos were observed during the site inspection. The subject site contains a number of foraging places for black cockatoos (especially Carnaby's black cockatoo). In addition, two mature tuart trees and a planted pine tree are present in the centre of the site, within the disturbed, non-native portion of the site. Due to the size, these trees have the potential to provide some foraging values. Further site-specific investigations undertaken for these trees confirm they are not suitable for nesting.

A Fauna Survey and Relocation Management Plan will be undertaken at the subdivision stage. In addition, a Landscape Management Plan will be prepared (at the subdivision stage), identifying any trees capable and worthy of retention.

2.1.3 WETLANDS

The Department of Biodiversity Conservation and Attractions (DBCA) Wetland Mapping does not identify any wetlands within the subject site.

2.2 LANDFORM AND SOILS

2.2.1 TOPOGRAPHY

The topography of the site grades from approximately 26 metres Australian height datum ('AHD') in the south east of the site up to 37 metres AHD in the north east corner of the subject site. Gradients vary across the site from 1:12 to 1:21.

2.2.2 GEOLOGY

Regional soil association mapping indicates the subject site is within the Bassendean association, which is described as "sand plains with low dunes and occasional swamps; iron or humus podzols; areas of complex steep dunes".

2.2.3 ACID SULPHATE SOILS

The Department of Water and Environmental Regulation ('DWER') Acid Sulphate Soils ('ASS') Mapping identifies the site as having a "moderate to low" risk of ASS occurring within 3 metres of the natural soil surface. It is therefore anticipated that development of the site can be undertaken with minimal adverse future risk of ASS occurring.

Notwithstanding, any management measures required to address any potential risk from ASS will be further explored prior to subdivision, and will be subject to more detailed engineering and environmental advice at that time.

2.2.4 CONTAMINATION

The DWER Contaminated Sites Database does not list the subject site as being a known or suspected contaminated site.

2.3 GROUNDWATER AND SURFACE WATER

2.3.1 GROUNDWATER

DWER Water Register indicates the site is underlain by a multi-layered aquifer system comprised of the following resources:

- Perth – Superficial Swan (unconfined)
- Perth – Leederville (confined)
- Perth – Yarragadee North (confined)

The Department of Water Perth Groundwater Map indicates historical maximum groundwater levels across the site are approximately 21 metres AHD. Based on the topographic contours, groundwater is expected to be located within approximately 12 metres to 14 metres of the surface across the subject site. Groundwater is expected to generally flow in an east to west direction.

2.3.2 SURFACE WATER

The subject site is located within the Cockburn/Kwinana Coastal Catchment and sub-catchment, as identified through the DWER Hydrographic Catchments dataset. No surface water features occur within the site itself.

The subject site is situated north of the Peel Main Drain catchment. The Peel Main Drain is a rural drain that runs from north to south, forming a regional drainage network. It flows in a southerly direction and passes through several pools and wetlands before discharging into the Serpentine River. The development of the subject site is not expected to have any impact on the hydrology of the Peel Main Drain.

2.4 BUSHFIRE MANAGEMENT

The subject site is identified on the Department of Fire and Emergency Services (DFES) mapping as being bushfire prone. A Bushfire Management Plan has therefore been prepared for the site in support of this Structure Plan, with a copy provided at **Appendix 2**.

The BMP considers the bushfire hazards within the subject site and surrounding area, and the associated bushfire risk readily manageable through standard management responses. It is considered that on implementation of the proposed management measures, the subject site will be able to be developed with a manageable level of bushfire risk, while maintaining full compliance with the relevant controls.

A Bushfire Attack Level ('BAL') Assessment has been provided on the basis that the vegetation within the subject site will be removed and the surrounding area is to remain in its current state. In accordance with the BAL Assessment, a BAL Rating of BAL-FZ to BAL-19 has been identified along the northern and eastern boundaries of the subject site, with a majority of the western boundary identified as BAL-19.

In accordance with the BAL Assessment, majority of the subject site is capable of being developed to a BAL 12.5 standard. There are some portions of the site, along the northern and eastern boundaries, where lots will be impacted by ratings above BAL 29. To ensure development compliance, the BMP and Structure Plan has provided for the provision of Asset Protection Zones, to ensure all development occurs in areas capable of achieving BAL 29 or below.

A further BAL assessment and contour plan will be required to be submitted with any subsequent subdivision applications.

Refer **Appendix 2** – Bushfire Management Plan.

2.5 HERITAGE

2.5.1 ABORIGINAL HERITAGE

A search of the Department of Planning, Lands and Heritage Aboriginal Heritage Inquiry System identified no registered sites within the Structure Plan area or immediate surrounds.

2.5.2 EUROPEAN HERITAGE

A search of the Western Australian Register of Heritage Places identified no sites of State heritage significance within the subject site or immediate surrounds.

A search of the City of Cockburn's Municipal Heritage Inventory identified no sites of local historic significance within the subject site or immediate surrounds.

3. LAND USE AND SUBDIVISION REQUIREMENTS

3.1 LAND USE

The Structure Plan sets out land use, residential densities, public open space, public and private transport provision, environmental considerations and servicing requirements.

The Structure Plan comprises residential development with a density code of R30. The Structure Plan also comprises a single area of public open space.

The following describes the design response underpinning the Structure Plan, and addresses the relevant elements of Liveable Neighbourhoods. Please also refer to the Land Use Summary Table provided within the Executive Summary on Page IV of this report.

Refer **Plan 1: Structure Plan**.

3.2 PUBLIC OPEN SPACE

The Structure Plan makes provision for a single area of public open space, with an area of approximately 1920m^2, equating to 10.51% of the gross subdivisible area, comprising 8.4% unrestricted open space (approximately 1535.8m^2).

Refer **Figure 6** – Public Open Space Plan, and below Public Open Space Schedule.

PUBLIC OPEN SPACE SCHEDULE			
Site Area			18,602 m^2
Deductions			
1:1 year ARI Drainage	320 m^2		
Total		320 m^2	
Gross Subdivisible Area			**18282 m^2**
POS @ 10%			1828 m^2
Public Open Space Contribution			
May Comprise:			
- Min. 80% unrestricted POS		1462.56 m^2	
- Min. 20% restricted POS		365.64 m^2	
Total Required POS			**1828.20 m^2**
POS Provision	**1:1 Year ARI Drainage**	**Restricted POS Sites**	**Unrestricted POS Sites**
POS Area 1 – 1920.8 m^2	320 m^2	65 m^2	1535.8 m^2
Percentage of Gross Subdivisible Area	1.75%	0.36%	8.40%

Table 6: Public Open Space Schedule.

The public open space is proposed as a 'Local Park', in accordance with the principles of *Liveable Neighbourhoods* and provides a dual functionality, providing for passive and active recreation functions, as well local drainage. All proposed dwellings within the Structure Plan are situated within a 100 metre walkable catchment of the park.

The park is proposed to be located in the south east corner of the site. Given the various engineering constraints, specifically in regard to site levels, earthworks requirements and hydrological functions, and taking into account bushfire management requirements, there is limited opportunity to provide the open space elsewhere in the Structure Plan area.

The levels and hydrology of the site require the drainage to be located in the south east corner, and given the relatively small scale of the Structure Plan area (and therefore limited open space requirement), the most logical and appropriate outcome is to provide a combined public open space and drainage feature.

In addition, we understand the adjoining landowner to the north has no intention of progressing planning and development of their land in the foreseeable future. This reduces any scope to coordinate engineering design and undertake earthworks over the wider area to provide further opportunity for dispersing levels and retaining across the site, thereby modifying the drainage functions to facilitate an alternate public open space location.

Further, to facilitate fire management for the site, a 10 metre Asset Protection Zone (APZ) is required to provide separation to the existing bushfire hazard within the adjacent Western Power easement. This is most appropriately dealt with through the provision of public open space and road reserves, which can be readily maintained by the Crown in perpetuity. We acknowledge there are some circumstances where this separation may be taken up within private lots, however this is not ideal and should be avoided where possible. Indicative subdivision design for the site indicates only one lot will be impacted by the required APZ for the Western Power easement. Other APZ requirements for the site come from temporary hazards to the north.

The proposed public open space location is therefore considered to be the most logical and appropriate from an engineering, hydrological and fire management perspective.

3.2.1 PUBLIC OPEN SPACE DESIGN AND FUNCTION

Please refer to **Appendix 5** - Indicative Landscape Concept.

Indicative concept planning for the park provides for a vegetated drainage basin in the eastern portion of the open space, adjacent to the Western Power high voltage power line easement, providing a degree of separation and screening of the powerlines and Kwinana Freeway to the east. The basin is anticipated to be in the order of 390m^2, with 1:6 graded batters to allow access and maintenance. The basin may provide for some passive recreation opportunities, subject to detailed design at subdivision stage.

Majority of the park will comprise unrestricted open space (approximately 1535m^2), incorporating a flat kickabout space as the central feature. Indicative concept planning suggests this area may be in the order of 450m^2, to enable perimeter planting, as well as the inclusion of a footpath

network, play space and picnic facilities. The final design and layout will be subject to further discussions with the City of Cockburn at subdivision and detailed design stage.

Subject to engineering design, there may be opportunities to retain some of the existing mature trees within the open space. This will be reviewed in further detail at subdivision stage as part of the detailed civil design, and facilitated through the preparation and implementation of a Landscape Management Plan and Tree Protection Management Plan.

Given the location of the open space, the Structure Plan provides for direct frontage lots, facilitating passive visual surveillance. These lots are intended to have direct access to the open space, through the inclusion of gates and footpath connections. To ensure the passive visual surveillance of the open space, a Local Development Plan will be required for these lots, providing the following controls:

- Uniform fencing to be provided along the public open space boundary. Uniform fencing will be required to be maintained as visually permeable above 1.2 metres;
- The location of the main outdoor living area adjacent to the boundary with the open space; and
- Primary dwelling orientation (positioning of habitable rooms and external architectural design features) to address the open space.

Notwithstanding the above, to provide a level of security for the proposed lots, a degree of separation will be maintained between the dwelling and the open space through level differences (approximately 1 metre). The lots will be retained at the boundary, with the open space grading down from that point.

SURROUNDING PUBLIC OPEN SPACE CONTEXT 1:7,500

DRAINAGE CONSIDERATIONS

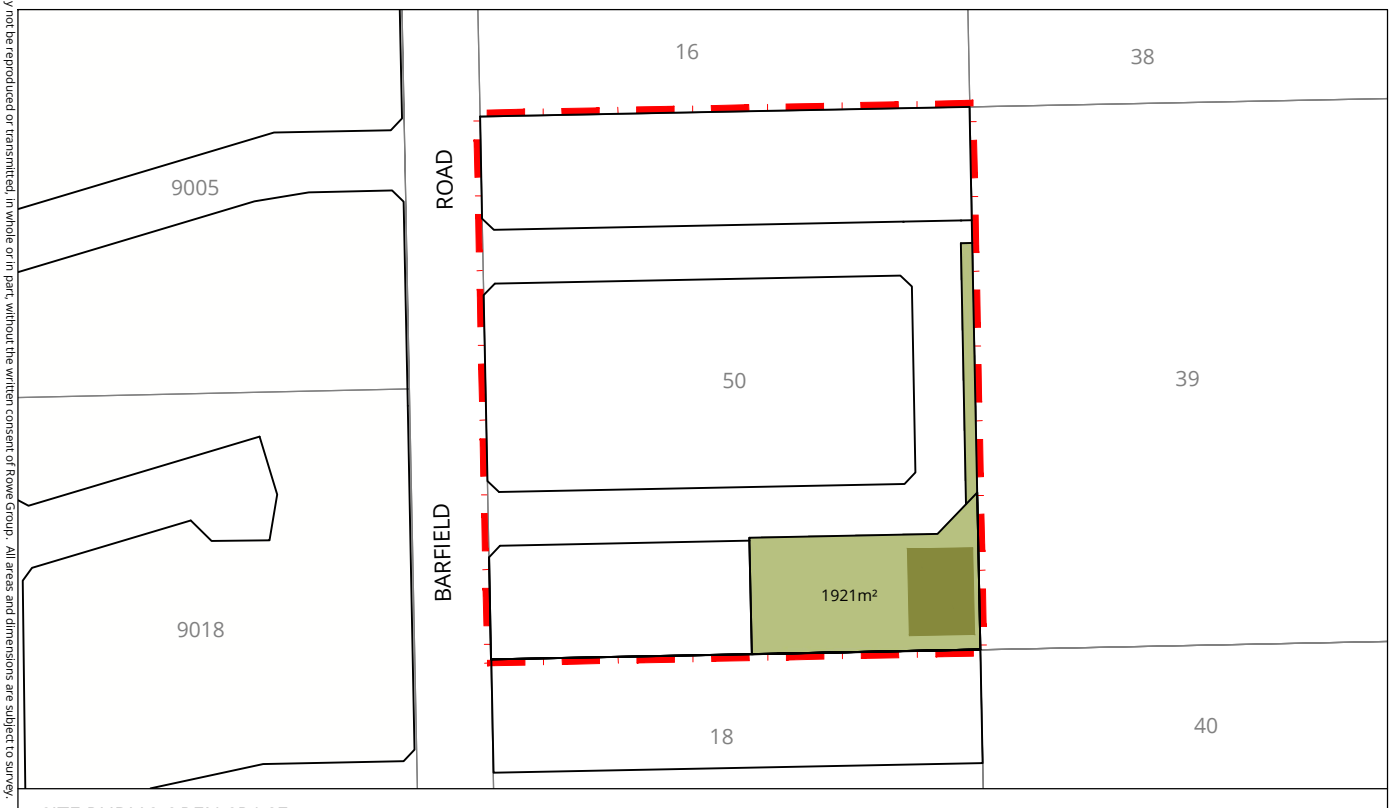
EVENT	TOP WATER LEVEL	TOP WATER LEVEL FOOTPRINT AREA
1EY (1yr ARI)*	29.9m AHD	320m²
20% AEP (approx 5yr ARI)*	30.0m AHD	385m²
1% AEP (100 yr ARI)	30.2m AHD	1089m²

*1 yr ARI event sits within the 20% AEP basin

PUBLIC OPEN SPACE PROVISION

PARK TYPE	APPROX AREA	DEDUCTION (1:1 YR ARI)	RESTRICTED POS CREDIT*	UNRESTRICTED POS CREDIT
Local Park	1920.8m²	320m²	65m²	1535.8m²

*Restricted POS credit based on 20% AEP basin area, less deduction for 1:1 yr ARI.



SITE PUBLIC OPEN SPACE 1:2000

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8697_FIG06C_20201209_Hammond Park (POS plan) - DRAWN:ADAM GLASKIN - DATE CREATED: 2020.12.09 - PROJECTION: MGA50 GDA94 - CADASTRE: LANDGATE -

FIGURE 6

PUBLIC OPEN SPACE PLAN

3.3 RESIDENTIAL

The Structure Plan allocates a residential density code of R30 across the site, consistent with the existing surrounding development, local structure planning and the SSDSP.

Based on the R30 density code and indicative concept planning undertaken for the site, the Structure Plan is anticipated to yield approximately 32 dwellings. On this basis, the site is expected to deliver an approximate density of 26.28 dwellings per residential site hectare and 17.2 dwellings per gross urban hectare. These densities are consistent with the targets set out under both Liveable Neighbourhoods and the Planning Framework, which specify a minimum average of 22 dwellings per residential site hectare and 15 dwellings per gross urban hectare.

In accordance with the Australian Bureau of Statistics 2016 census data, the average household size for Hammond Park is 3 people per household. Therefore, based on an indicative yield of 32 dwellings, the proposed Structure Plan is expected to provide a population of approximately 96 people.

Refer to **Figure 7** – Indicative Subdivision Concept.

3.3.1 LOCAL DEVELOPMENT PLANS

The WAPC may require, as a condition of subdivision approval, that a Local Development Plan(s) be prepared in accordance with Part 6 of Schedule 2 of the *Planning and Development (Local Planning Schemes) Regulations 2021*, prior to the creation or development of lots:

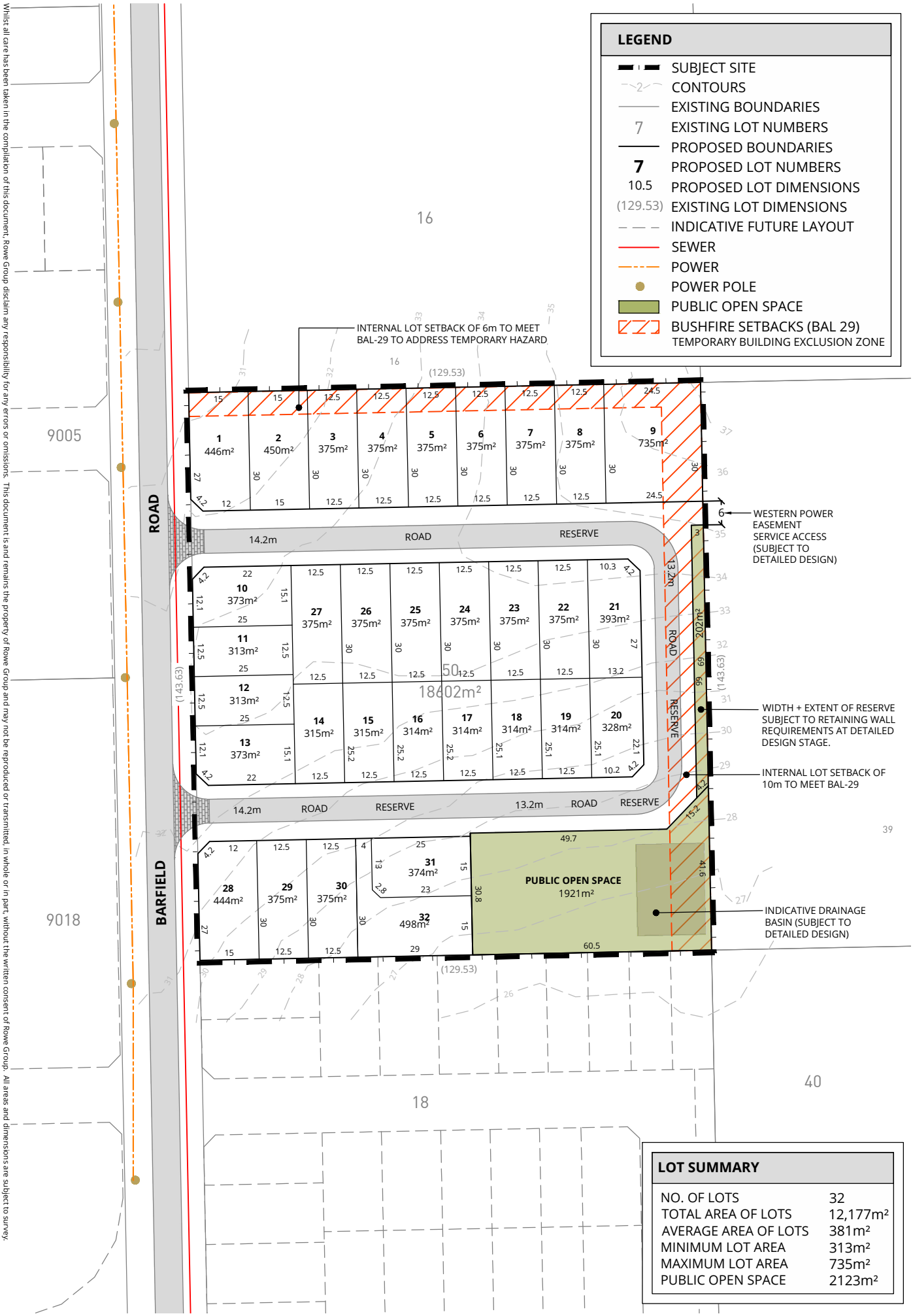
- of irregular shape or less than 260m^2 in area;
- affected by road and rail noise exceeding the targets set out in *State Planning Policy 5.4: Road and Rail Noise* and the associated implementation guidelines;
- where vehicular access is obtained from a rear laneway , or right of way, or is otherwise constrained;
- abutting areas of public open space; and/or
- intended to accommodate grouped or multiple dwellings.

Local Development Plans are to address the following matters, as required:

- street and boundary setbacks;
- dwelling orientation;
- uniform fencing requirements;
- open space requirements;
- garage setbacks and width;
- vehicular and pedestrian access;
- parking requirements;
- overshadowing;

- visual privacy;
- quiet house design and/or construction requirements; and
- any variations to the Residential Design Codes which may be required.

In preparing Local Development Plans, the design responses and interface treatments between the subject site and the adjoining Vivente estate will need to be considered to ensure an effortless transition between the two developments.



LOT SUMMARY	
NO. OF LOTS	32
TOTAL AREA OF LOTS	12,177m²
AVERAGE AREA OF LOTS	381m²
MINIMUM LOT AREA	313m²
MAXIMUM LOT AREA	735m²
PUBLIC OPEN SPACE	2123m²

0 30 m

SCALE @ A4: 1:1250

N

FIGURE 7

SUBDIVISION CONCEPT PLAN (INDICATIVE ONLY)

N:\TOWN PLANNING\8000-8999\8697\DRAFTING\A-CAD - ADAM GLASKIN - 2020.12.09

8697_FIG010B_20201112 Hammond Park (Subdivision Concept) - DRAWN:ADAM GLASKIN - DATE CREATED: 2020.12.09 - PROJECTION: MGA50 GDA94 - CADASTRE: LANDGATE -

3.4 MOVEMENT NETWORK

3.4.1 EXISTING ROAD NETWORK

Barfield Road

Barfield Road runs along the western boundary of the subject site, providing gazetted road frontage and access.

Barfield Road is classified as a 'Local Distributor Road' under the Main Roads WA Functional Road Hierarchy. However, it is understood Barfield Road will be downgraded in the future and the intersection with Rowley Road closed, to facilitate upgrades to Rowley Road as a designated freight route. Upon closure of this intersection, the primary north-south movements through the locality will be via the Neighbourhood Connector (Irvine Parade) within the Vivente estate.

3.4.2 PROPOSED ROAD NETWORK

The Structure Plan layout proposes an Access Street D loop road, intersecting with Barfield Road at two points. Consistent with Liveable Neighbourhoods, this road will be constructed to a 14.2 metre reserve width, reduced to 13.2 metres where adjoining public open space and the Western Power easement. Estimated traffic volumes for the proposed Structure Plan are anticipated to be less than 1000 vehicle movements per day, based on 10 vehicle movements per dwelling per day.

The proposed intersections with Barfield Road have been designed as such that they achieve a minimum separation distance of 20 metres between existing and planned intersections on either side of the road, in accordance with Liveable Neighbourhoods requirements.

Further information relating to traffic is contained in **Appendix 6** – Engineering Servicing and Traffic Report.

3.4.3 PUBLIC TRANSPORT

There are currently no existing public transport services operating within reasonable walking distance from the subject site. As development progresses within the surrounding area, it is recommended that the City consult with the Public Transport Authority in regard to expanding the existing bus routes and frequencies or to introduce new services to encourage use of public transport.

The closest existing bus route is number 536, approximately 800 metres to the north west of the site, generally at the intersection of Irvine Parade and Mitta Street. This route services the Aubin Grove train station.

The Aubin Grove train station is situated approximately 2.5 kilometres to the north of the site.

3.4.4 PEDESTRIAN AND CYCLE NETWORK

Footpaths are proposed on at least one side of all internal roads, in accordance with Liveable Neighbourhoods requirements.

All cycling within the Structure Plan area is proposed to be either on-road or on proposed footpaths. Internal traffic volumes are expected to be low enough such that on-road cycling will not pose a high risk to cyclists.

3.5 WATER MANAGEMENT

A Local Water Management Strategy (LWMS) has been prepared in support of the proposed Structure Plan, provided at **Appendix 7.**

The LWMS has been prepared in accordance with the design objectives outlined in *Better Urban Water Management* (2008) and proposes an integrated water cycle management approach.

The overall objective for integrated water cycle management for urban development is to minimise pollution and maintain an appropriate water balance. The design objectives presented in the LWMS for the proposed Structure Plan seek to deliver best practice outcomes using a water sensitive urban design (WSUD) approach, including detailed management objectives for:

- Water supply and conservation;
- Stormwater management; and
- Groundwater management.

The overall approach to water supply is to utilise scheme water and implement water conservation measures (e.g. water efficient fixtures, use of WSUD measures, and planting of water wise species) to reduce water requirements. Non-potable water for irrigation purposes will be supplied by groundwater.

The stormwater management plan focuses on the treatment of the small event (1 year 1 hour average recurrence interval (ARI)/63% annual exceedance probability (AEP)) and detention of the major event (100 year ARI/1% AEP) to maintain the existing hydrological regime. Small event runoff within the entire site will be treated within a bio-retention area (BRA), which is collated with a flood storage area (FSA) in the downstream public open space. Major event stormwater runoff for the majority of the site will be managed within the FSA, which is sized to retain the major (1% AEP) event. Two lots fronting Barfield road are not able to be managed within the site, hence will discharge into the Barfield road drainage network during the major event; this mimics the existing hydrological regime. Stormwater quality will be addressed through structural measures (i.e. a vegetated BRA) and non-structural measures (i.e. street sweeping, minimising fertiliser use, and provision of educational materials).

Groundwater management will include the use of imported fill to maintain sufficient clearance to groundwater in lower areas of the site. Groundwater quality will be managed through the appropriate treatment of surface runoff prior to infiltration to groundwater, and management of landscape management practices (i.e. minimising fertiliser use).

Refer **Appendix 7** – Local Water Management Strategy.

Approval for the enclosed LWMS was issued by the Department of Water and Environmental Regulation on December 8, 2020 (refer **Appendix 8**). The City of Cockburn has also previously provided comments on the LWMS, with the enclosed LWMS reflective of the City's requirements.

3.6 EDUCATION FACILITIES

In accordance with the SSDSP, no primary or high school sites are proposed within the Structure Plan area.

The subject site is in proximity to the following schools:

- Hammond Park Catholic Primary School (0.3km);
- Hammond Park Secondary College (0.5km);
- Aubin Grove Primary School (0.9km);
- Hammond Park Primary School (1.5km);
- Honeywood Primary School (2.1km);
- Success Primary School (2.8km); and
- Atwell College (3.8km).

3.7 ACTIVITY CENTRES AND EMPLOYMENT

In accordance with the SSDSP, no activity centres are proposed within the Structure Plan area.

There are existing local convenience shopping and services within relatively close proximity to the subject site within Hammond Park and Aubin Grove. There is also a planned local centre situated approximately 750 metres to the west of the site on Whadjuk Drive.

In accordance with hierarchy detailed under *State Planning Policy 4.2 - Activity Centres for Perth and Peel* ('SPP 4.2'), the closest secondary centre to the subject site is Cockburn Central, located approximately 5.5 kilometres to the north of the site. This centre offers a range of economic and community services.

The future Wandi District Centre is located approximately 3.8 kilometres to the south of the subject site on Anketell Road. The purpose of the centre will be to provide a mix of smaller scale every day uses, including food and beverage outlets, retail shops, offices and other complementary uses such as warehouse / showroom type uses.

3.7.1 COMMUNITY FACILITIES

The subject site is located in relatively close proximity to the Aubin Grove Sport and Community Facility, as well as Botany Park, which contains an AFL oval and athletic facilities with change rooms and toilets. The SSDSP also proposes three future local centres to the west of the subject site.

In this regard the subject site is considered to be well serviced in terms of existing community facilities and therefore, does not require the provision of additional facilities as a result of the proposed population increase.

3.8 INFRASTRUCTURE COORDINATION, SERVICING AND STAGING

An Engineering Service Report was prepared by BPA Engineering, assessing the servicing and infrastructure provisions for the subject site. Refer **Appendix 6**.

3.8.1 SEWER

The Structure Plan area is proposed to be serviced by gravity sewer designed and installed to the Water Corporations standards and specification. At present, there is no sewer infrastructure in the vicinity of the site.

Water Corporation planning shows that sewerage infrastructure for the subject site will be connected to the proposed wastewater reticulation being installed within the Vivente subdivision to the west of the site along Barfield Road.

Standard Water Corporation sewerage headworks will be payable on all lots as they are developed.

3.8.2 WATER

The Structure Plan area is proposed to be serviced by a reticulated water supply, designed and constructed in accordance with the Water Corporation manuals. The reticulation mains will be constructed at the developers cost.

Water Corporation planning shows the water supply for the Structure Plan area will be via a connection to the proposed reticulation being installed within the Vivente subdivision to the west of the site along Barfield Road.

The Water Corporation will impose standard headworks charges on the development on a per lot basis.

3.8.3 POWER

All power within the Structure Plan area will be underground.

Any requirements for a transformer site will be determined following receipt of a design information package from Western Power at the subdivision and detailed design stage. Initial advice indicates a new transformer and switchgear will be required for the proposed development. This will be connected to the HV network on the western side of Barfield Road.

Given the site's proximity to existing high voltage overhead transmission lines, Western Power may request a transmission EPR/LFI report be prepared to determine any specific development/ construction requirements for the site. This will be determined at subdivision stage.

The cost of the power infrastructure, including any systems charges, is payable by the developer. HV costs may be payable by the HV pool.

3.8.4 RETICULATED GAS

There are no existing WA gas network underground assets / pipes present in the vicinity of the subject site. However, gas reticulation is planned through the Vivente subdivision to the west of the site. The proposed development is expected to be serviced via a connection to that infrastructure.

Headwork costs may be applicable to extend the service to the site.

Gas reticulation within the development incurs no cost to the developer, providing the mains are laid in the same trench as the water reticulation.

3.8.5 TELECOMMUNICATIONS

Future development within the Structure Plan area will be serviced via the existing pit and pipe installed along Barfield Road.

There is a P8 connection currently servicing Lot 50. Depending on the position of the P8 relative to the intersection of the proposed road network, relocation may be necessary. This will be further investigated at the detailed design stage.

NBN headworks charges will apply.

3.9 DEVELOPER CONTRIBUTION ARRANGEMENTS

Under the provisions of TPS 3, the Structure Plan is subject to Development Contribution Area 9 ('DCA 9'). Contributions shall be made towards the following items:

- *Proportional (61.6%) cost of widening and upgrading of Hammond Road between Gaebler Road and Rowley Road including:*
    - *Construction of one carriage way comprised of two lanes for Hammond Road and where the reserve width is less than 40 metres wide, kerbing to the verge side of the carriageway shall be provided;*
    - *The purchase of land reserved for Hammond Road under the Metropolitan Region Scheme; o Full earthworks;*
    - *Dual use path (one side only);*
    - *Pedestrian crossings (where appropriate at the discretion of the local government); o Land and infrastructure associated with the drainage of Hammond Road;*
    - *Costs associated with the relocation of servicing infrastructure resulting from the implementation of this scheme, where appropriate;*
    - *Traffic management devices (traffic lights to the intersection of Hammond Rd and the realigned Wattleup Road to facilitate traffic and pedestrian/cyclist movement).*
- *Costs associated with the provision of regional drainage infrastructure;*
- *Costs to administer cost sharing arrangements – preliminary engineering design and costing's, valuations, annual reviews and audits and administration costs.*

Future residential development within the Structure Plan area will be required to pay contributions in accordance with DCA 9.

APPENDIX 1

CERTIFICATE OF TITLE

ROWE GROUP DESIGN

WESTERN AUSTRALIA

REGISTER NUMBER	
50/D65995	
DUPLICATE EDITION **3**	DATE DUPLICATE ISSUED **18/3/2010**

VOLUME **1678** FOLIO **32**

RECORD OF CERTIFICATE OF TITLE

UNDER THE TRANSFER OF LAND ACT 1893

The person described in the first schedule is the registered proprietor of an estate in fee simple in the land described below subject to the reservations, conditions and depth limit contained in the original grant (if a grant issued) and to the limitations, interests, encumbrances and notifications shown in the second schedule.

REGISTRAR OF TITLES

REGISTRAR OF TITLES WESTERN AUSTRALIA

LAND DESCRIPTION:

LOT 50 ON DIAGRAM 65995

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

GLENBROOK CIVIL ENGINEERING CONTRACTORS PTY LTD OF 27 RIMMER ROAD, LANDSDALE
(T L250668) REGISTERED 8/3/2010

LIMITATIONS, INTERESTS, ENCUMBRANCES AND NOTIFICATIONS:
(SECOND SCHEDULE)

Warning: A current search of the sketch of the land should be obtained where detail of position, dimensions or area of the lot is required.
* Any entries preceded by an asterisk may not appear on the current edition of the duplicate certificate of title.
Lot as described in the land description may be a lot or location.

----------END OF CERTIFICATE OF TITLE----------

STATEMENTS:

The statements set out below are not intended to be nor should they be relied on as substitutes for inspection of the land and the relevant documents or for local government, legal, surveying or other professional advice.

SKETCH OF LAND: 1678-32 (50/D65995)
PREVIOUS TITLE: 1289-811
PROPERTY STREET ADDRESS: 193 BARFIELD RD, HAMMOND PARK.
LOCAL GOVERNMENT AUTHORITY: CITY OF COCKBURN

CT 1678 0032 F

1678 032

Application C878950 WESTERN AUSTRALIA

Volume 1289 Folio 811

CERTIFICATE OF TITLE

UNDER THE "TRANSFER OF LAND ACT, 1893" AS AMENDED

I certify that the person described in the First Schedule hereto is the registered proprietor of the undermentioned estate in the undermentioned land subject to the easements and encumbrances shown in the Second Schedule hereto.

N. J. Smyth
REGISTRAR OF TITLES

Dated 17th October, 1984

ESTATE AND LAND REFERRED TO

Estate in fee simple in portion of Jandakot Agricultural Area Lot 194 and being Lot 50 the subject of Diagram 65995, delineated and coloured green on the map in the Third Schedule hereto, limited however to the natural surface and therefrom to a depth of 60.96 metres.

FIRST SCHEDULE (continued overleaf)

~~The State Energy Commission of Western Australia of 365 Wellington Street, Perth.~~

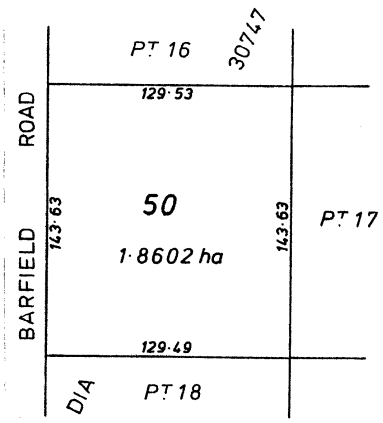
SECOND SCHEDULE (continued overleaf)

~~1. MORTGAGE C878953 to Energy Credit Union Ltd. Registered 17.10.84 at 2.32 p.m.~~

Discharged F483243 15.3.94

N. J. Smyth
REGISTRAR OF TITLES

THIRD SCHEDULE



SCALE 1: 3000

JT

NOTE: RULING THROUGH AND SEALING WITH THE OFFICE SEAL INDICATES THAT AN ENTRY NO LONGER HAS EFFECT. ENTRIES NOT RULED THROUGH MAY BE AFFECTED BY SUBSEQUENT ENDORSEMENTS.

72009/12/77–45M–S/2860

LT. 37

FIRST SCHEDULE (continued)

NOTE: RULING THROUGH AND SEALING WITH THE OFFICE SEAL INDICATES THAT AN ENTRY NO LONGER HAS EFFECT. ENTRIES NOT RULED THROUGH MAY BE AFFECTED BY SUBSEQUENT ENDORSEMENTS.

REGISTERED PROPRIETOR	INSTRUMENT NATURE	INSTRUMENT NUMBER	REGISTERED	TIME	SEAL	INITIALS
Robert William McNair, Assistant Supervisor and Anne Isobel McNair, Married Woman, both of 76,						
Connell Avenue, Kelmscott, as joint tenants.	Transfer	C878952	17.10.84	2.32		
The correct address of the registered proprietors is now Lot 50 Barfield Road, Banjup.	By	F483244	15.3.94	15.5		

SECOND SCHEDULE (continued)

NOTE: RULING THROUGH AND SEALING WITH THE OFFICE SEAL INDICATES THAT AN ENTRY NO LONGER HAS EFFECT. ENTRIES NOT RULED THROUGH MAY BE AFFECTED BY SUBSEQUENT ENDORSEMENTS.

INSTRUMENT NATURE	INSTRUMENT NUMBER	PARTICULARS	REGISTERED	TIME	SEAL	INITIALS	CANCELLATION	NUMBER	REGISTERED OR LODGED	SEAL	INITIALS
Caveat	E829778	Lodged 12.3.92 at 10.10 hrs.					Withdrawn	F483242	15.3.94		
Mortgage	F483244	to Citibank Savings Ltd.	15.3.94	15.56							

CERTIFICATE OF TITLE VOL. 1678 032

APPENDIX 2

BUSHFIRE MANAGEMENT PLAN

ROWE GROUP DESIGN

emerge ASSOCIATES
Integrated Science & Design

Bushfire Management Plan

Lot 50 Barfield Road, Hammond Park

Project No: EP18-043(03)

Prepared for Glenbrook Civil
December 2019

Document Control

Doc name:	Bushfire Management Plan Lot 50 Barfield Road, Hammond Park				
Doc no.:	EP18-043(03)--007				
Version	**Date**	**Author**		**Reviewer**	
1	July 2019	Sean Moylan	SCM	Anthony Rowe	AJR
	Report issued to client for review.				
A	December 2019	Sean Moylan	SCM	Anthony Rowe	AJR
	Report updated to reflect updated vegetation classifications, as requested by City of Cockburn. Final report issued to client.				

Disclaimer:

This document has been prepared in good faith and is derived from information sources believed to be reliable and accurate at the time of publication. Nevertheless, it is distributed on the terms and understanding that the author is not liable for any error or omission in the information sources available or provided to us, or responsible for the outcomes of any actions taken based on the recommendations contained herein. It is also expected that our recommendations will be implemented in their entirety, and we cannot be held responsible for any consequences arising from partial or incorrect implementation of the recommendations provided.

This document has been prepared primarily to consider the layout of development and/or the appropriate building construction standards applicable to development, where relevant. The measures outlined are considered to be prudent minimum standards only based on the standards prescribed by the relevant authorities. The level of bushfire risk mitigation achieved will depend upon the actions of the landowner or occupiers of the land and is not the responsibility of the author. The relevant local government and fire authority (i.e. Department of Fire and Emergency Services or local bushfire brigade) should be approached for guidance on preparing for and responding to a bushfire.

Notwithstanding the precautions recommended in this document, it should always be remembered that bushfires burn under a wide range of conditions which can be unpredictable. An element of risk, no matter how small, will always remain. The objective of the Australian Standard AS 3959:2018 is to "prescribe particular construction details for buildings to reduce the risk of ignition from a bushfire while the front passes" (Standards Australia 2018). Building to the standards outlined in AS 3959 does not guarantee a building will survive a bushfire or that lives will not be lost.

Executive Summary

Rowe Group, on behalf of the landowner Glenbrook Civil, has prepared a Local Structure Plan (LSP) for the future residential development of Lot 50 Barfield Road, Hammond Park (herein referred to as 'the site'). The LSP covers a total area of 1.86 hectares (ha), and is bound by Barfield Road to the west, future urban development to the north and south (Vivente Estate) and a Western Power transmission line corridor and Kwinana Freeway to the east.

The site is located within a 'bushfire prone area' under the state-wide Map of Bush Fire Prone Areas prepared by the Office of Bushfire Risk Management (OBRM 2019). The identification of a site within an area declared as bushfire prone necessitates that a further assessment of the determined bushfire risk affecting the site (in accordance with *Australian Standard 3959:2018 Construction of buildings in bushfire prone areas* (AS 3959)) and the satisfactory compliance of the proposal with the policy measures described in *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (SPP 3.7) (WAPC 2015) and its associated *Guidelines for Planning in Bushfire Prone Areas Version 1.3* (the Guidelines) (WAPC and DFES 2017).

The SPP 3.7 policy intent is to preserve life and reduce the impact of bushfire on property and infrastructure through effective risk-based land use planning. Importantly, it is required by SPP 3.7 that the determining (relevant) authority is to apply its consideration to the precautionary principle (clause 6.11 in SPP 3.7) and that it must be satisfied that the intent of the policy measures have been met, before approval is given.

This BMP has followed the requirements of SPP 3.7 to identify bushfire risk and identify the bushfire protection measures that will make the land suitable for its intended purpose. As part of this, a BAL assessment involving the classification and condition of vegetation within and near (150 m) of the site has been undertaken as a measure of the bushfire risk.

The site contains remnant scrub (Class D) vegetation (as classified in accordance with AS 3959) and grassland (Class G) vegetation. Scrub vegetation has been identified to the east, and west of the site, grassland vegetation has been identified to the south and west of the site, and shrubland (Class C) vegetation has been identified to the north.

In order to consider the likely bushfire risk applicable to future development within the site, a post development vegetation classification scenario has been assumed in which all classified vegetation, will be removed or managed to a 'low threat' standard. Areas of public open space will be designed to low threat in accordance with Section 2.2.3.2 of AS 3959 while achieving broader landscape management objectives.

The outcomes of this BMP demonstrate that as development progresses, it will be possible for an acceptable solution to be adopted for each of the applicable bushfire protection criteria outlined in the Guidelines. This includes:

- **Location**: future habitable buildings can be located in an area that will, on completion, be subject to a low or moderate bushfire hazard.
- **Siting and Design**: all future habitable buildings can be sited within the proposed development so that BAL-29 or less can be achieved based on the proposed structure plan through the location of public roads and public open space, or in lot setbacks.

- **Vehicular Access**: the proposed structure plan provides for an interconnected road network within the site that will connect with the existing Barfield Road. This road connection provides egress in two directions from the site, to the north and south.
- **Water**: the development will be provided with a permanent and reticulated water supply to support onsite firefighting requirements.

The measures to be implemented through this structure plan and associated future subdivision process have been outlined as part of this BMP and can be used to support future planning and development approval processes. A revised BMP is likely to be required to support any future subdivision applications, in order to address the specific bushfire risk reduction measures applicable to each proposed lot.

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Abbreviation Tables

Table A1: Abbreviations – General terms

Organisations	
AHD	Australian Height Datum
AS	Australian Standard
APZ	Asset Protection Zone
BAL	Bushfire Attack Level
BEEP	Bushfire Emergency Evacuation Plan
BMP	Bushfire Management Plan
BPAD	Bushfire Planning and Design
ESL	Emergency Services Levy
FDI	Fire Danger Index
FZ	Flame Zone

Table A2: Abbreviations – Organisations

General terms	
DBCA	Department of Biodiversity Conservation and Attractions
DoW	Department of Water (now known as Department of Water and Environment Regulation)
DFES	Department of Fire and Emergency Services
OBRM	Office of Bushfire Risk Management
SES	State Emergency Services
WAPC	Western Australian Planning Commission

Table A3: Abbreviations –Legislation and policies

Legislation	
Guidelines	*Guidelines for Planning in Bushfire Prone Areas version 1.3 (WAPC and DFES 2017)*
SPP 3.7	*State Planning Policy 3.7 Planning in Bushfire Prone Areas* (WAPC 2015)

Table A4: Abbreviations – Planning and building terms

Units of measurement	
AS 3959	*Australian Standard 3959-2018 Construction of buildings in bushfire prone areas*
LSP	Local Structure Plan
MRS	Metropolitan Region Scheme
POS	Public Open Space
TPS	Town Planning Scheme

1 Introduction

1.1 Background

Rowe Group, on behalf of the landowner Glenbrook Civil, has prepared a Local Structure Plan (LSP) for the future residential development of Lot 50 Barfield Road, Hammond Park (herein referred to as 'the site'). The LSP is provided in **Appendix A**, and covers a total area of 1.86 hectares (ha). The site is located approximately 25 kilometres south of the Perth Central Business District (CBD), within the City of Cockburn, as shown in **Figure 1**. It is bound by Barfield Road to the west, future urban development to the north and south and a Western Power transmission line corridor and Kwinana Freeway to the east.

The site is located within a 'bushfire prone area' under the state-wide *Map of Bush Fire Prone Areas* prepared by the Office of Bushfire Risk Management (OBRM 2019), as shown in **Plate 1**. The identification of a site within an area declared as bushfire prone necessitates that a further assessment of the determined bushfire risk affecting the site is undertaken using the methodology described in *Australian Standard 3959-2018 Construction of buildings in bushfire prone areas* (AS 3959) (Standards Australia 2018). The suitability of the land, for the intended land use, is then to be assessed having regard to the determined risk and its compliance with the intent and objectives of *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (SPP 3.7) (WAPC 2015) and the *Guidelines for Planning in Bushfire Prone Areas Version 1.3* (the Guidelines) (WAPC and DFES 2017).

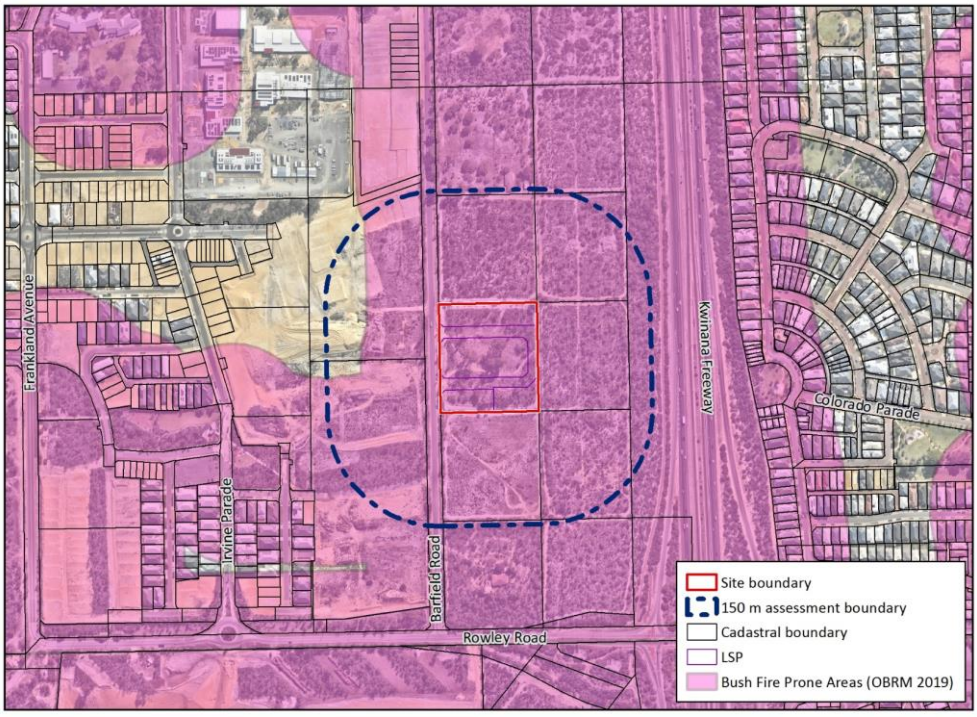

Plate 1: Areas within and surrounding the site identified as 'bushfire prone areas' (as indicated in purple) under the state-wide Map of Bush Fire Prone Areas (OBRM 2018).

1.2 Aim of this report

The purpose of this Bushfire Management Plan (BMP) is to assess bushfire hazards within the site and surrounding areas and ensure that the threat posed by any identified hazards can be appropriately mitigated and managed, and demonstrate satisfaction of clause 6.11 of SPP 3.7 (the precautionary principle). It has been prepared to support the proposed structure plan for the site and addresses the requirements of SPP 3.7 (WAPC 2015), the Guidelines (WAPC and DFES 2017) and AS 3959 (Standards Australia 2018). The document provides an assessment of the general bushfire management strategies to be considered as part of the future development of individual dwellings and includes:

- An assessment of the existing classified vegetation in the vicinity of the site (within 150 m) and consideration of bushfire hazards that will exist in the post development scenario (**Section 3**).
- Commentary on how the future development can achieve the bushfire protection criteria outlined within the Guidelines (**Section 5**).
- An outline of the roles and responsibilities associated with implementing this BMP (see **Section 6**).

1.3 Statutory policy and framework

The following key legislation, policies and guidelines are relevant to the preparation of a bushfire management plan:

- *Bush Fires Act 1954*
- *Fire and Emergency Services Act 1998*
- *Planning and Development Act 2005* and associated regulations
- *Building Act 2011* and associated regulations
- *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (WAPC 2015)
- *Guidelines for Planning in Bushfire Prone Areas version 1.3* (WAPC and DFES 2017)
- *Australian Standard AS 3959 – 2018 Construction of buildings in bushfire prone areas* (Standards Australia 2018)

1.4 Description of the proposed development

The site is proposed to be developed to allow for residential development, in accordance with the LSP provided in **Appendix A**. Development within the site is proposed to include:

- residential lots;
- public open space, including areas for drainage; and
- a public loop road which connects to the existing urban road network.

This development is in accordance with the 'Urban' zoning under the Metropolitan Region Scheme (MRS), as shown in **Plate 2**, and the 'Urban' zoning under the City of Cockburn Town Planning Scheme (TPS) No. 3.

The site is located in a developing urban area, with urban development expanding to the west of the site, and existing undeveloped land to the north and south, with a Western Power transmission line corridor located to the east of the site. The site connects to the existing road network, with Barfield Road located to the west of the site.

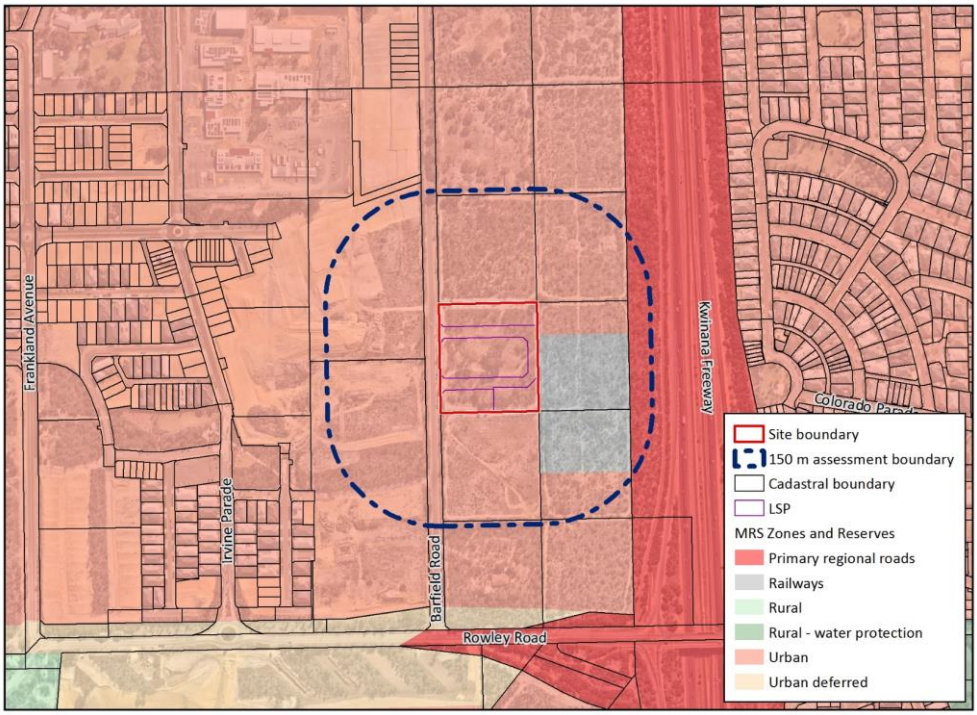

Plate 2: MRS zones and reserves within and surrounding the site.

1.5 Description of the land characteristics

The landform within the site has a south facing aspect, with elevation ranging from approximately 27 m Australian Height Datum (m AHD) in the south-east of the site up to 35 m AHD in the north-east corner of the site (DoW 2008).

The site is vacant, with the previous residential dwelling demolished in 2016. Areas of remnant native vegetation are located in the north-western, north-eastern and south-eastern portions of the site.

Land uses surrounding the site include:

- Land being developed for residential purposes to the west and south of the site, as part of Vivente Estate.
- Undeveloped 'Urban' zoned land is located to the north of the site, containing native vegetation.
- Land located to the east of the site is a Western Power transmission line corridor, with remnant vegetation across the landholdings, and the Kwinana Freeway reserve further east. Land within two lots to the east are zoned 'Railways' under the City of Cockburn TPS No.3, however under the Southern Suburbs District Structure Plan, no railway is identified to be developed in these landholdings.

2 Environmental Considerations

In accordance with the *Bushfire Management Plan – BAL Contour* template prepared by the Department of Planning, Lands and Heritage (2018), this BMP has considered whether there are any environmental values within the site or nearby that may require specific consideration through either protection, retention or revegetation. To support this, a review of publicly available databases as well as site specific information (where available) has been undertaken, with particular reference to the Shared Location Information Platform (SLIP) databases. A summary of the search results has been provided in **Table 1**.

Based on a review of publicly available aerial photography (Landgate 2019), areas of remnant vegetation within the central portion of the site have historically been cleared to support a residential dwelling on the site, which was constructed between 1983 and 1985. The dwelling was demolished between March and September 2016. Areas of remnant vegetation have historically been gradually removed from within the site since the construction of dwelling, with intact areas of remnant vegetation remaining in the north-west, north-east and south-east portions of the site.

Table 1: Summary of potential environmental considerations that may be associated with the site (based on a search of the SLIP databases)

Key environmental feature (information in brackets refers to mapping data source)	Yes/no/potentially occurring within the site	If yes/potentially, describe value that may be impacted
Conservation category wetlands and buffer (Geomorphic wetlands, Swan Coastal Plain (DBCA-019))	No	No conservation category wetlands are mapped as occurring within or nearby the site.
RAMSAR wetlands (DBCA-010)	No	No Ramsar wetlands are located within or nearby the site.
Threatened and priority flora (DBCA-036)	No	No species of threatened or priority flora are identified within the mapping as occurring within the site. Additionally, a flora and vegetation survey carried out by Emerge Associates (2018a) did not identify any threatened or priority flora within the site.
Threatened and priority fauna (DBCA-037)	No	No species of threatened or priority fauna are identified within the mapping as occurring within the site. Additionally, a fauna survey carried out by Emerge Associates (2018b) did not identify any threatened or priority fauna within the site.
Threatened ecological communities (DBCA-038)	Yes	The flora and vegetation survey carried out by Emerge Associates (2018a) identified that vegetation within the site represented one threatened ecological community (TEC), the banksia woodlands of the Swan Coastal Plain TEC, as occurring within the site. In accordance with the *Environmental Protection and Biodiversity Conservation Act 1999*, the proponent will determine if the future development within the site is to be referred to the federal Department of Environment and Energy for assessment.
Bush Forever areas (DOP-071)	No	No Bush Forever sites are located within the site. Bush Forever Site 392 is located approximately 1.1 km to the north-west of the site.

Table 1: Summary of potential environmental considerations that may be associated with the site (based on a search of the SLIP databases) (continued)

Key environmental feature (information in brackets refers to mapping data source)	Yes/no/potentially occurring within the site	If yes/potentially, describe value that may be impacted
Clearing regulations – Environmentally Sensitive Areas (DWER-046)	No	No environmentally sensitive areas (ESAs) have been identified within the site. ESAs are located to north-west and south of the site.
Swan Bioplan Regionally Significant Natural Areas 2010 (DWER-070)	No	The site is not located in a mapped Swan Bioplan Regionally Significant Natural Area.

2.1 Native vegetation – modification and clearing

Areas of the site have historically been cleared of native vegetation between 1983 and 1985 to accommodate the construction of a residential dwelling. As future development occurs within the site, the majority of native vegetation within the site will be cleared, with native vegetation in the future public open space to be opportunistically retained where possible, dependent on future servicing and design requirements.

It is relevant to note that as part of future development, that where clearing is undertaken in accordance with a subdivision approval under the *Planning and Development Act 2005*, it is exempt from requiring a clearing permit pursuant to Schedule 6 of the *Environmental Protection Act 1986.*

2.2 Revegetation and landscape plans

No revegetation is proposed at this stage of development. The area of public open space within the site is intended to be utilised for recreation and drainage purposes. The detailed design of this area will be determined in collaboration with the City of Cockburn as part of the standard development process and based on achieving the requirements of Liveable Neighbourhoods and community expectations for urban areas, and will be designed to achieve low threat vegetation in accordance with Section 2.2.3.2 of AS 3959. Ongoing management is likely to include:

- Irrigation of grass and garden beds (where required).
- Regular removal of weeds and built up dead material (such as fallen branches, leaf litter etc.)
- Low pruning of trees (branches below 2 m in height removed where appropriate).
- Application of ground/surface covers such as mulch or non-flammable materials as required.
- Regular mowing/slashing of grass to less than 100 mm in height.

The proponent will be responsible for the initial maintenance of the public open space and drainage areas within the site and following handover the City of Cockburn will be responsible for the long-term maintenance.

3 Bushfire Assessment Results

Bushfire risk for the site has been appropriately considered both in context to the site and potential impact upon the site.

Appendix Two of the Guidelines provides a description for undertaking contextual hazard level assessment using the vegetation classifications from AS 3959. The purpose is to identify at the strategic level the Bushfire Hazard Level (BHL) and the likely impact and intensity of a bushfire attack.

AS 3959 has been used to determine the impact on the site. Its objective is to reduce the risk of ignition and loss of a building to bushfire. It provides a consistent method for determining a radiant heat level (radiant heat flux) as a primary consideration of bushfire attack. It measures the Bushfire Attack Level as the radiant heat level (kWm^2) over a distance of 100 m.

AS 3959 also prescribes deemed to satisfy construction responses that can resist the determined radiant heat level at a given distance from the fire. It is based on six Bushfire Attack Level (BAL) ratings: BAL-LOW, BAL-12.5, BAL-19, BAL-29, BAL-40 and BAL-FZ.

3.1 Bushfire Attack Level (BAL) assessment

In accordance with Appendix Five of the Guidelines, a method 1 BAL assessment has been undertaken to support the proposed development of the site and determine the BAL ratings likely to be applicable to future habitable buildings. This has been based on the vegetation classifications and the effective slope under the vegetation, with the result presented on the BAL contour plan.

Not all vegetation is a classified bushfire risk. Vegetation and ground surfaces that are exempt from classification as a potential hazard are identified as low threat under Section 2.2.3.2 of AS 3959. Low threat vegetation includes the following:

a) Vegetation of any type that is more than 100 m from the site.
b) Single areas of vegetation less than 1 ha in area and not within 100 m of other areas of vegetation being classified.
c) Multiple areas of vegetation less than 0.25 ha in area and not within 20 m of the site, or each other or of other areas of vegetation being classified.
d) Strips of vegetation less than 20 m in width (measured perpendicular to the elevation exposed to the strip of vegetation) regardless of length and not within 20 m of the site or each other, or other areas of vegetation being classified.
e) Non-vegetated areas, that is, areas permanently cleared of vegetation, including waterways, exposed beaches, roads, footpaths, buildings and rocky outcrops.
f) Vegetation regarded as low threat due to factors such as flammability, moisture content or fuel load. This includes grassland managed in a minimal fuel condition, mangroves and other saline wetlands, maintained lawns, golf courses (such as playing areas and fairways), maintained public reserves and parklands, sporting fields, vineyards, orchards, banana plantations, market gardens (and other non-curing crops), cultivated gardens, commercial nurseries, nature strips and wind breaks.

3.1.1 Assessment inputs

Classifying bushfire hazards takes into account the vegetation structure within the site and surrounding area for a minimum of 100 m, in accordance with AS 3959. The assignment of the vegetation classifications is based on consideration of the fuel layers of different vegetation types. This can be broken-down into five segments as illustrated in **Plate 3** below.

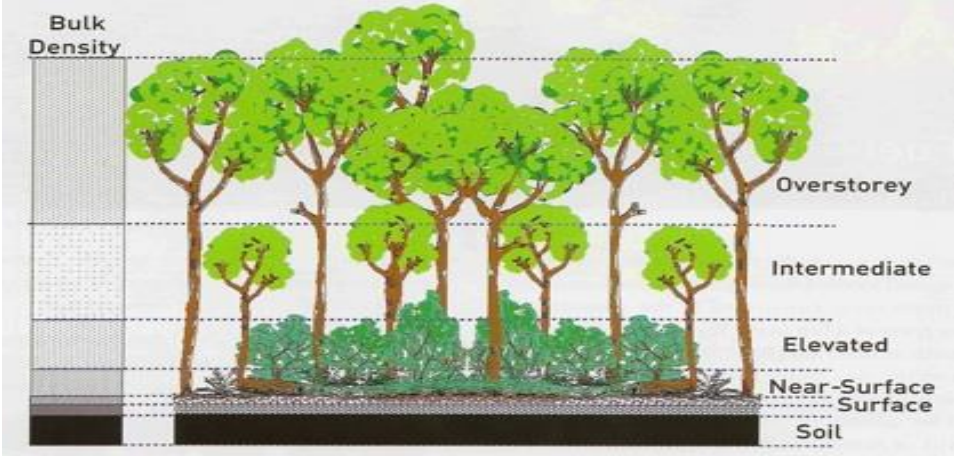

Plate 3: The five fuel layers in a forest environment that could be associated with fire behaviour (Gould et al. 2007)

Multiple assessments of existing vegetation within the site and surrounding 150 m as well as effective slope have been undertaken, with the most recent occurring on 29th May 2019 in accordance with AS 3959 and the Guidelines.

It is noted that this BMP (Version A) has been updated on the advice of the City of Cockburn to reflect that vegetation to the west and south of the site (within Vivente Estate) that was previously identified as a temporary hazard has since been removed and now does not present a bushfire risk to the site. High resolution aerial imagery (Nearmaps) has confirmed the vegetation has been removed, however no additional site photos have been provided of this recent clearing.

Table 2 below outlines:

- The existing AS 3959 vegetation classifications (and associated photo locations), which are also shown in **Figure 2.**
- The existing bushfire hazard level ratings, which are shown in **Figure 3.**
- The post-development AS 3959 vegetation classifications, which are shown in **Figure 4.**
- The effective slope for each area of classified vegetation present in the post-development scenario, which is shown in **Figure 5.**

Table 2: Vegetation classification, effective slope and future management

Pre-development (see Figure 2 and Figure 3)			Post development (see Figure 4 and Figure 5)	
Plot no.	**AS 3959 classification and bushfire hazard rating**	**Site photo/s (location points shown in Figure 2)**	**Plot no.**	**AS 3959 classification, effective slope and assumptions**
1	**AS 3959 classification (Figure 2):** Shrubland (Class C) **Bushfire hazard rating (Figure 3):** Moderate Shrubland vegetation has been identified to the north of the site. Shrubland vegetation is characterised by native shrubs growing to a height of less than 2 m, with occasional emergent *Banksia* spp. This area of vegetation is characterised by surface, near-surface, and elevated fuel layers.	 *Photo location 1: Shrubland vegetation located to the north of the site*  *Photo location 2: Shrubland vegetation located to the north of the site*  *Photo location 3: Shrubland vegetation located to the north of the site*  *Photo location 4: Shrubland vegetation located to the north of the site*	1	**AS 3959 classification (Figure 4):** Shrubland (Class C) **Effective slope (Figure 5):** Flat/upslope Shrubland vegetation located to the north of the site will not be removed as part of future development within the site, and will therefore remain a long-term bushfire hazard to the site.

Table 2: Vegetation classification, effective slope and future management (continued)

Pre-development (see Figure 2 and Figure 3)			Post development (see Figure 4 and Figure 5)	
Plot no.	**AS 3959 classification and bushfire hazard rating**	**Site photo/s (location points shown in Figure 2)**	**Plot no.**	**AS 3959 classification, effective slope and assumptions**
2 - 5	**AS 3959 classification (Figure 2):** Scrub (Class D) **Bushfire hazard rating (Figure 3):** Extreme Scrub vegetation has been identified within the north-eastern, north-western and south-eastern portions of the site. In addition, scrub vegetation has been identified growing along the northern, western and southern fence lines within the site (Plot 2). In addition, scrub vegetation has been identified to the east of the site, within the Western Power transmission line corridor and Kwinana Freeway reserve (Plot 3). Additionally, scrub vegetation is found to the west of the site within the Barfield Road reserve (Plot 4) and within a future POS area within Vivente Estate (Plot 5). This scrub vegetation is characterised by banksia woodland, dominated by *Banskia attenuata* and *Banksia menziesii*, with native midstorey and understorey species forming a continual fuel layer up to 6 m in height.	 *Photo location 5: Scrub vegetation located in the north-eastern portion of the site*  *Photo location 6: Scrub vegetation located in the north-eastern portion of the site*  *Photo location 7: Scrub vegetation located to the east of the site*  *Photo location 8: Scrub vegetation located in the south-eastern portion of the site*	3 - 5	**AS 3959 classification (Figure 4):** Scrub (Class D) **Effective slope (Figure 5):** Flat/upslope Scrub vegetation located outside of the site boundary, to the east within the Western Power transmission line corridor and the Kwinana Freeway reserve (Plot 3), and to the west within the Barfield Road reserve (Plot 4) and the future POS area within Vivente Estate (Plot 5) will be retained in the long-term. No management of this vegetation has been assumed, and therefore will remain a bushfire risk to the site.

Table 2: Vegetation classification, effective slope and future management (continued)

Pre-development (see Figure 2 and Figure 3)			Post development (see Figure 4 and Figure 5)	
Plot no.	**AS 3959 classification and bushfire hazard rating**	**Site photo/s (location points shown in Figure 2)**	**Plot no.**	**AS 3959 classification, effective slope and assumptions**
2 - 5	The areas of scrub vegetation within and surrounding the site are characterised by surface, near-surface, elevated, intermediate and low overstorey fuel layers.	 *Photo location 9: Scrub vegetation located to the east of the site*  *Photo location 10: Scrub vegetation located to the east of the site*  *Photo location 11: Scrub vegetation located to the east of the site*  *Photo location 12: Scrub vegetation located in the Barfield Road reserve to the west of the site*	9	**AS 3959 classification (Figure 4):** Non-vegetated (exclusion clause 2.2.3.2(e)) **Effective slope (Figure 5):** Not applicable The majority of the scrub vegetation within the site (Plot 2) will be removed during the proposed development to form the public road and future lots and has been identified as non-vegetated (exclusion clause 2.2.3.2(e)).

Table 2: Vegetation classification, effective slope and future management (continued)

Pre-development (see Figure 2 and Figure 3)			Post development (see Figure 4 and Figure 5)	
Plot no.	**AS 3959 classification and bushfire hazard rating**	**Site photo/s (location points shown in Figure 2)**	**Plot no.**	**AS 3959 classification, effective slope and assumptions**
2 - 5	Continued from above.	Continued from above.	10	**AS 3959 classification (Figure 4):** Low threat vegetation (exclusion clause 2.2.3.2(f)) **Effective slope (Figure 5):** Not applicable Scrub vegetation that is located in the south-eastern portion of the site (Plot 2) where future POS will be located will be removed or modified to a low threat standard (where opportunistic retention of existing vegetation occurs) as part of development. The future POS will be landscaped and managed as low threat vegetation. This POS will be the responsibility of the proponent initially, then the City of Cockburn following handover.

Table 2: Vegetation classification, effective slope and future management (continued)

Pre-development (see Figure 2 and Figure 3)			Post development (see Figure 4 and Figure 5)	
Plot no.	**AS 3959 classification and bushfire hazard rating**	**Site photo/s (location points shown in Figure 2)**	**Plot no.**	**AS 3959 classification, effective slope and assumptions**
6 - 8	**AS 3959 classification (Figure 2):** Grassland **Bushfire hazard rating (Figure 3):** Moderate Grassland vegetation has been identified within degraded portions of the site, particularly in the central portion (Plot 6). In addition, grassland vegetation has been identified to the west of the site within the Barfield Road reserve (Plot 7) and a small patch of grassland occurs within the future POS area within Vivente Estate (Plot 8). These areas of vegetation are characterised by surface and near surface fuel layers of weedy grass species.	 *Photo location 13: Grassland vegetation located within the central portion of the site*  *Photo location 14: Grassland vegetation located within the central portion of the site*  *Photo location 15: Grassland vegetation located within the central portion of the site*  *Photo location 16: Grassland vegetation located within the central portion of the site*	7 - 8	**AS 3959 classification (Figure 4):** Grassland **Effective slope (Figure 5):** Flat/upslope Grassland vegetation located to the west of the site within the Barfield Road reserve (Plot 7) and within the area of future POS in Vivente Estate (Plot 8) will not be removed as part of future development within the site, and will therefore remain a long-term bushfire hazard to the site.

Table 2: Vegetation classification, effective slope and future management (continued)

Pre-development (see Figure 2 and Figure 3)			Post development (see Figure 4 and Figure 5)	
Plot no.	**AS 3959 classification and bushfire hazard rating**	**Site photo/s (location points shown in Figure 2)**	**Plot no.**	**AS 3959 classification, effective slope and assumptions**
7 - 8	Continued from above.	Continued from above.	9	**AS 3959 classification (Figure 4):** Non-vegetated (exclusion clause 2.2.3.2(e)) **Effective slope (Figure 5):** Not applicable The majority of the grassland vegetation within the site will be removed during the proposed development to form the public road and future lots and has been identified as non-vegetated (exclusion clause 2.2.3.2(e)).
			10	**AS 3959 classification (Figure 4):** Low threat vegetation (exclusion clause 2.2.3.2(f)) **Effective slope (Figure 5):** Not applicable Grassland vegetation that is located in the south-eastern portion of the site where POS will be created will be removed as part of development. The future POS will be landscaped and managed as low threat vegetation. This POS will be the responsibility of the proponent initially, then the City of Cockburn following handover.

Table 2: Vegetation classification, effective slope and future management (continued)

Pre-development (see Figure 2 and Figure 3)			Post development (see Figure 4 and Figure 5)	
Plot no.	**AS 3959 classification and bushfire hazard rating**	**Site photo/s (location points shown in Figure 2)**	**Plot no.**	**AS 3959 classification, effective slope and assumptions**
9	**AS 3959 classification (Figure 2):** Non-vegetated (exclusion clause 2.2.3.2(e)) **Bushfire hazard rating (Figure 3):** Low. As required under the Guidelines, any areas within 100 m of moderate or extreme hazards have been shown as moderate, to reflect the potential increased risk. Within and surrounding the site, non-vegetated areas such as existing roads, firebreaks, driveways and buildings have been excluded in accordance with Clause 2.2.3.2(e) of AS 3959. The non-vegetated areas to the south and west of the site within Vivente Estate were cleared subsequent to the lodgement of the previous BMP (between May and July 2019), and this BMP reflects the updated vegetation classifications.	 *Photo location 17: Non-vegetated firebreak in the eastern portion of the site*  *Photo location 18: Non-vegetated road (Barfield Road) to the west of the site*  *Photo location 19: Non-vegetated road (Barfield Road) to the west of the site*  *Photo location 20: Non-vegetated firebreak in the eastern portion of the site*	9	**AS 3959 classification (Figure 4):** Low threat vegetation (exclusion clause 2.2.3.2(f)) **Effective slope (Figure 5):** Not applicable The existing condition and/or maintenance regimes for all existing non-vegetated areas within and surrounding the site are assumed to continue in the long-term based on current land uses and management arrangements and/or will remain low threat as development within the site is progressed.

Table 2: Vegetation classification, effective slope and future management (continued)

Pre-development (see Figure 2 and Figure 3)			Post development (see Figure 4 and Figure 5)	
Plot no.	**AS 3959 classification and bushfire hazard rating**	**Site photo/s (location points shown in Figure 2)**	**Plot no.**	**AS 3959 classification, effective slope and assumptions**
10	Continued from above.	Continued from above.	10	**AS 3959 classification (Figure 4):** Low threat vegetation (exclusion clause 2.2.3.2(f)) **Effective slope (Figure 5):** Not applicable Non-vegetated areas that are located in the south-eastern portion of the site where POS will be created will be converted to low threat vegetation as part of development. The future POS will be landscaped and managed as low threat vegetation. This POS will be the responsibility of the proponent initially, then the City of Cockburn following handover.

3.1.1.1 Post development assumptions

The BAL assessment, to determine the predicted BAL ratings applicable to the site, has assumed the following:

- **Designated FDI:** 80
- **Flame temperature:** 1090 K
- **Vegetation classification:** Shrubland (Class C), scrub (Class D) and grassland (Class G) vegetation identified within the post-development scenario, see **Figure 4**.
- **Effective slope beneath classified vegetation**: Flat/upslope (see **Figure 5**)
- **Setback distances:** as per Table 2.5 in AS 3959 with the relevant distances used to inform the BAL contour plan provided in **Figure 6** and summarised in **Table 3**.

In addition to the above, the following key assumptions have informed this assessment:

- All classified vegetation within the site will be removed or modified to achieve low threat in accordance with Section 2.2.3.2 of AS 3959. This may include:
  - Clearing of vegetation.
  - Regular maintenance including removal of weeds and dead material.
  - Low pruning of trees (branches below 2 m in height removed where appropriate).
  - Application of ground/surface covers such as mulch or non-flammable materials.
  - Where grass/turf is present, this will be regularly mowed/slashed so that grass is maintained at or below 100 mm in height.
- Classified vegetation that has been identified outside of the site has been assumed to remain in its current state (unless stated otherwise), and will therefore remain a bushfire hazard to development within the site.
- It has been assumed that existing firebreaks in surrounding lots will continue to be maintained in the long term, in accordance with the City of Cockburn Fire Control Order, which requires 3 m-wide firebreaks within the internal boundaries of the lot. Where unmanaged vegetation currently exists within this area, this vegetation has been assumed to be removed in the post development scenario as firebreaks are implemented within these lots, as enforced by the City of Cockburn.

3.1.2 Assessment outputs

The BAL assessment completed for the site indicates that a BAL rating of BAL-29 or less can be achieved for future residential buildings based on the indicated spatial layout for the structure plan (**Appendix A**). Whilst a BAL rating of BAL-FZ and BAL-40 is present within the northern and eastern portions of the site, the structure plan allows for future lots within the site to have appropriate in-lot setbacks, in order to provide separation between future residential lots in the site and the vegetation to the east and north of the site.

Table 3 provides a summary of the setback distances necessary from the identified classified vegetation to achieve the indicated BAL ratings, with the BAL Contour Plan (**Figure 6**) being a visual representation of these distances. The setback distances are based on the post-development classified vegetation (**Figure 4**), effective slope (**Figure 5**) and are taken from Table 2.5 of AS 3959.

Table 3: Setback distances based on vegetation classification and effective slope and Table 2.5 of AS 3959, as determined by the method 1 BAL assessment

Post development plot number (see Figure 4)	Vegetation classification (see Figure 4)	Effective slope (see Figure 5)	Distance to vegetation	BAL rating (see Figure 6)
Plot 1	Shrubland	Flat/upslope	< 7 m	BAL-FZ
			7 - < 9 m	BAL-40
			9 - < 13 m	BAL-29
			13 - < 19 m	BAL-19
			19 - < 100 m	BAL-12.5
			> 100 m	BAL-LOW
Plot 3 – 5	Scrub	Flat/upslope	< 10 m	BAL-FZ
			10 - < 13 m	BAL-40
			13 - < 19 m	BAL-29
			19 - < 27 m	BAL-19
			27 - < 100 m	BAL-12.5
			> 100 m	BAL-LOW
Plot 7 – 8	Grassland	Flat/upslope	< 6 m	BAL-FZ
			6 - < 8 m	BAL-40
			8 - < 12 m	BAL-29
			12 - < 17 m	BAL-19
			17 - < 50 m	BAL-12.5
			> 50 m	BAL-LOW

4 Identification of Bushfire Hazard Issues

From a bushfire hazard management perspective, the key issues that are likely to require management and/or consideration as part of future development within the site include:

- Provision of appropriate separation distance from bushfire hazards surrounding the site to ensure a BAL rating of BAL-29 or less can be achieved at future habitable buildings (built form). This will include provision of in-lot setbacks at future planning stages.
- Ensuring that future areas of public open space (POS) are appropriately designed and managed to achieve low threat standards where indicated (i.e. low threat areas identified in **Figure 4**), in accordance with AS 3959 and the requirements of the City of Cockburn.

These issues are considered further in **Section 5.**

5 Assessment against the Bushfire Compliance Criteria

This BMP provides an outline of the mitigation strategies that will ensure that as planning and development is progressed within the site, an acceptable solution and/or performance-based system of control can be adopted for each of the bushfire protection criteria detailed within Appendix Four of the Guidelines (WAPC and DFES 2017). The bushfire protection criteria identified in the Guidelines and addressed as part of this BMP are:

- Element 1: Location of the development
- Element 2: Siting and design of the development
- Element 3: Vehicular access
- Element 4: Water supply.

As part of future development, it is likely that an 'acceptable solution' will be able to address the intent of all four bushfire protection criteria as part of future development within of the site. A summary of how this can be achieved and an associated compliance statement for each has been provided in **Table 4**.

Table 4: Summary of bushfire protection criteria and compliance statement

Bushfire protection criteria	Intent	Method of compliance		Proposed bushfire management strategies	Compliance statement
		Acceptable solution	Performance principle		
Element 1: Location	To ensure that strategic planning proposals, subdivision and development applications are located in areas with the least possible risk of bushfire to facilitate the protection of people, property and infrastructure.	A1.1 Development location		Based on the bushfire hazard level assessment (**Figure 3**), the site is currently located in an area of moderate and extreme bushfire hazard level. As development progresses within the site, the vegetation contributing the moderate and extreme hazard level will be removed, and the site will be located in an area of low and moderate hazard level. The acceptable solution can be satisfied.	Based on the outlined management measures, future development would be able to comply with and meet the intent of Element 1: Location.
		Yes.	N/A		
Element 2: Siting and design	To ensure the siting and design of development minimises the level of bushfire impact.	A2.1 Asset Protection Zone		One of the most important bushfire protection measures influencing the safety of people and property is to create an Asset Protection Zone (APZ) around buildings. The APZ is a low fuel area immediately surrounding a building, and can include non-flammable features such as irrigated landscapes, gardens, driveways, public roads and managed public open space. Classified vegetation will be retained to the north, west, east and south of the site. Based on the BAL assessment and the BAL Contour Plan (see **Figure 6**), development (i.e. future habitable buildings) within the central portion of the site will be able to achieve a BAL rating of BAL-29 or less. Development located along the northern (adjacent to shrubland vegetation) and eastern (adjacent to scrub vegetation) boundaries of the site will be subject to BAL ratings exceeding BAL-29 (BAL-40 and BAL-FZ). However, these areas of the site are appropriately sized to accommodate a future building envelope that will not be exposed to a BAL rating exceeding BAL-29, ensuring that future habitable buildings won't be subject to a BAL rating of BAL-FZ or BAL-40. Overall, the acceptable solution can be satisfied. Class 1, 2 and 3 buildings, where located within a designated bushfire prone area and an area subject to a BAL rating of BAL-12.5 or higher will need to satisfy higher construction standards in accordance with AS 3959.	Based on the outlined management measures, future development would be able to comply with and meet the intent of Element 2: Siting and design.
		Yes	N/A		

Table 4: Summary of bushfire protection criteria and compliance statement (continued)

Bushfire protection criteria	Intent	Method of compliance		Proposed bushfire management strategies	Compliance statement
		Acceptable solution	Performance principle		
Element 3: Vehicular access	To ensure vehicular access serving a subdivision/ development is available and safe during a bushfire event.	A3.1 Two access routes		The proposed structure plan provides for a public loop road within the site that will provide two connections to the existing Barfield Road to the west of the site (see **Appendix A**). The existing Barfield Road provides access to the north and south of the site, connecting to Rowley Road to the south (approximately 290 m to the south of the site), which provides further egress options to the east and west of the site, including Kwinana Freeway.	Based on the outlined management measures, future development would be able to comply with and meet the intent of Element 3: Vehicular access.
		Yes.	N/A		
		A3.2 Public road		Existing public roads surrounding the site, as well as proposed new public roads can and will comply with the minimum standards outlined in Appendix Four of the Guidelines (WAPC and DFES 2017) or as agreed with the City of Cockburn and includes a minimum 6 m-wide trafficable surface.	
		Yes	N/A		
		A3.3 Cul-de-sac (including dead-end-road)		No permanent cul-de-sacs are proposed within the site. Whilst staged development as part of future subdivision within the site is unlikely, if temporary cul-de-sacs are required, these cul-de-sacs will be provided with suitable turn around areas and will be able to comply with Appendix Four of the Guidelines.	
		N/A	N/A		
		A3.4 Battle-axe		Not applicable. No battle-axe properties are proposed as part of structure plan.	
		N/A	N/A		
		A3.5 Private driveway longer than 50 m		Not applicable. No private driveways longer than 50 m are proposed as part of the structure plan or likely based on the proposed urban development.	
		N/A	N/A		
		A3.6 Emergency access way		Given the proposed structure plan accommodates various access routes, emergency access ways are not required as part of the proposed development of the site.	
		N/A	N/A		
		A3.7 Fire service access routes (perimeter roads)		Future development within the site will be provided with appropriate vehicular access, as outlined above, and therefore fire service access routes are not required.	
		N/A	N/A		

Table 4: Summary of bushfire protection criteria and compliance statement (continued)

Bushfire protection criteria	Intent	Method of compliance		Proposed bushfire management strategies	Compliance statement
		Acceptable solution	Performance principle		
Continued from above.	Continued from above.	A3.8 Firebreak width		Once development is progressed within the site, in accordance with the City of Cockburn Fire Control Order (or as specified by the City of Cockburn in accordance with Section 33 of the *Bush Fires Act 1954*), firebreaks are unlikely to be required. Instead landholdings will be required to manage landholdings clear of all flammable material.	Continued from above.
		Yes.	N/A		
Element 4: Water	To ensure water is available to the subdivision, development or land use to enable people, property and infrastructure to be defended from bushfire.	A4.1 Reticulated areas		Development is located within an Emergency Services Levy (ESL) Category 1 area, which indicates that bushfire events are responded to by a network of career Fire and Rescue Service stations and the State Emergency Service. Fire response services require ready access to an adequate water supply during bushfire emergencies. The site will connect with a reticulated water supply and will include fire hydrants installed by the developer to meet the specifications of Water Corporation (Design Standard DS 63) (or similar standard, as agreed with the relevant water authority) and DFES. There is one existing hydrant located within 200 m of the site, on Genoa Parkway to the west of the site.	Based on the outlined management measures, future development would be able to comply with and meet the intent of Element 4: Water.
		Yes.	N/A		
		A4.2 Non-reticulated areas		Not applicable.	
		N/A	N/A		
		A4.3 Individual lots within non-reticulated areas (only for use if creating 1 additional lot and cannot be applied cumulatively)		Not applicable.	
		N/A	N/A		

5.1 Additional management strategies

5.1.1 Future approval considerations

The BAL assessment within this document is considered to be a conservative assessment of potential bushfire risk posed to future habitable buildings within the site based on the assumptions outlined in **Section 3**.

The measures to be implemented through this structure plan and associated future subdivision process have been outlined as part of this BMP and can be used to support future planning and development approval processes. A revised BMP is likely to be required to support any future subdivision applications, particularly if the development layout detail is different to that outlined within this document, and will need to respond to the subdivision design (and/or the stage of development).

5.1.2 Landscape management

5.1.2.1 Within the site

One public open space area is proposed to be developed within the site for recreation and drainage purposes.

The design and construction of public open space areas is generally a condition of subdivision approval. The detailed design of the public open space areas within the site will be determined in collaboration with the City of Cockburn as part of the standard development process and it is assumed that these will be designed to achieve low threat vegetation in accordance with Section 2.2.3.2 of AS 3959, and in line with City of Cockburn requirements. Ongoing management of these areas is likely to include:

- Irrigation of grass and garden beds (where required)
- Regular removal of weeds and built up dead material (such as fallen branches, leaf litter etc.)
- Low pruning of trees.
- Application of ground/surface covers such as mulch or non-flammable materials as required.
- Regular mowing/slashing of grass to less than 100 mm in height.

The proponent will be responsible for the initial maintenance of these areas, and following handover the City of Cockburn will be responsible for the long-term maintenance of the public open space areas to a low threat standard.

5.1.2.2 Surrounding the site

Within private landholdings

The private landholdings surrounding the site are assumed to be managed by the applicable landowners in accordance with the City of Cockburn Fire Control Order in perpetuity and/or in accordance with existing maintenance regimes, including the maintenance of a 3 m-wide firebreak within the internal boundary of each lot.

Within Western Power transmission line corridor

Vegetation to the east of the site, within the Western Power transmission line corridor is assumed to remain in its existing state in the long-term, with the lots assumed to be managed in accordance with the City of Cockburn Fire Control Order, including the maintenance of a 3 m-wide firebreak along the internal boundaries of the lots.

5.1.3 City of Cockburn Fire Control Order

The City of Cockburn releases a fire control order annually (or as required) to provide a framework for bushfire management within the City. The City of Cockburn is able to enforce this order in accordance with Section 33 of the *Bush Fires Act 1954* and landowners will need to ensure compliance with the fire control notice, as published, or any direction provided by the City of Cockburn.

All landowners of future lots will be required to comply with the Fire Control Order as published, which for residential lots is likely to include ensuring that the property is cleared of all flammable material, except for living standing trees, and ensuring that grass height is no longer than 5 cm.

As discussed above, surrounding landowners are required to maintain their landholdings in accordance with the City of Cockburn Fire Control Order. This includes maintaining a 3 m-wide firebreak within the internal boundary of each lot. Where surrounding landowners do not comply with the Fire Control Order, the City of Cockburn are able to enforce compliance.

5.1.4 Vulnerable or high-risk land uses

No vulnerable or high-risk land uses are proposed as part of the future residential development of the site.

5.1.5 Public education and preparedness

Community bushfire safety is a shared responsibility between individuals, the community, government and fire agencies. DFES has an extensive Community Bushfire Education Program including a range of publications, a website and Bushfire Ready Groups. The DFES publication '*Prepare. Act. Survive.'* (DFES 2014) provides excellent advice on preparing for and surviving the bushfire season. Other downloadable brochures are available from http://www.dfes.wa.gov.au/safetyinformation/fire/bushfire/pages/publications.aspx

The City of Cockburn provides bushfire safety advice to residents available from their website https://www.cockburn.wa.gov.au/Health-and-Safety/Fire-and-Emergency-Management. Professional, qualified consultants also offer bushfire safety advice and relevant services to residents and businesses in high risk areas in addition to that provided in this BMP.

In the case of a bushfire in the area, advice would be provided to residents by DFES, Department of Biodiversity Conservation and Attractions (DBCA) and/or the City of Cockburn on any specific recommendations with regard to responding to the bushfire, including evacuation if required. However, it is highly recommended that future residents make themselves aware of their responsibilities with regard to preparing for and responding to a potential bushfire that may impact them, their family and property, regardless of the BAL rating their properties are subject to.

6 Responsibilities for Implementation and Management of Bushfire Measures

Table 5 outlines the future responsibilities of the proponent/developer and the City of Cockburn associated with implementing this BMP with reference to ongoing bushfire risk mitigation measures for existing land uses (through compliance with the City of Cockburn Fire Control Order) or future mitigation measures to be accommodated as part of future subdivision (in particular, consideration of spatial layout requirements). These responsibilities will need to be considered as part of the subsequent planning process.

Additional bushfire mitigation responsibilities will be outlined as part of future BMP/s prepared to support detailed subdivision for the site, including responsibilities for future lot owners.

Table 5: Responsibilities for the implementation of this BMP

Management action	Timing
Developer/landowner	
Provide a copy of this BMP to the relevant decision makers to support approval of the proposed local structure plan.	To support the local structure plan approval process.
Prepare a new/revised BMP in accordance with SPP 3.7, the Guidelines and AS 3959 to support future subdivision applications, based on the proposed detailed layout and in consideration of existing bushfire hazards or those that will be present following development. In addition, if the assumptions regarding the treatment to POS change as part of future detailed design stages, a revised BMP will be required.	To support each future subdivision application.
Where required, and based on the outcomes this BMP or subsequent BMP/s, make spatial provision within the subdivision layout/design to accommodate: • A suitable public road network that provides access to at least two different destinations. Public roads should be at least 6 m-wide and consider the minimum requirements of Appendix Four in the Guidelines (or as agreed with the City of Cockburn). The proposed local structure plan currently supports this requirement. • Where possible avoid cul-de-sacs and battle axe lots, or where utilised ensure these consider the general requirements outlined in **Table 4** and Appendix Four of the Guidelines, or as agreed with the City of Cockburn. • Ensure future habitable buildings are able to be located so that BAL-29 or less applies. Separation distances should be in accordance with the minimum distances outlined in **Table 3** of this BMP for the corresponding vegetation plot/classification, or as determined in subsequent BMPs/BAL assessments. This may include the provision of public roads and/or managed public open space between habitable buildings and bushfire hazards, or by ensuring lots are an adequate depth or width to ensure BAL-29 is not exceeded at future habitable buildings.	To support each future subdivision application.
Comply with the City of Cockburn Fire Control Order until subdivision progresses, including which for residential land greater than 4,047 m^2, provide firebreaks of at least 3 m-wide and keep grass fuels short.	At all times, where applicable.

Table 5: Responsibilities for the implementation of this BMP (continued)

Management action	Timing
City of Cockburn	
Maintaining fuel loads in existing public road reserves and public open space (under their management) to appropriate standards to minimise fuel loads (as per current maintenance regimes)	Ongoing, as required.
Monitoring vegetation fuel loads in private landholdings against the requirements of the City's Fire Control Order (and/or existing maintenance regimes outlined in this BMP) and liaising with relevant stakeholders to maintain fuel loads at minimal/appropriate fuel levels.	Ongoing, as required.

7 Applicant Declaration

7.1 Accreditation

This BMP has been prepared by Emerge Associates who have been providing bushfire risk management advice for more than six years, undertaking detailed bushfire assessments (and associated approvals) to support the land use development industry.

Anthony Rowe is a Fire Protection Association of Australia (FPAA) Level 3 Bushfire Planning and Design (BPAD) accredited practitioner (BPAD no. 36690) with over nine years' experience and is supported by a number of team members who have undertaken BPAD Level 1 and Level 2 training and are in the processing of gaining formal accreditation.

7.2 Declaration

I declare that the information provided is true and correct to the best of my knowledge.

Signature:

Name: Anthony Rowe

Company: Emerge Associates

Date: 13 December 2019

BPAD Accreditation: Level 3 BPAD no. 36690

8 References

8.1 General references

The references listed below have been considered as part of preparing this document.

Department of Fire and Emergency Services (DFES) 2014, *Prepare. Act. Survive.*, Perth. August 2014.

Emerge Associates 2018a, *Detailed Flora and Vegetation Survey - Lot 50 Barfield Road*, EP18-043(02)--005, revision 1.

Emerge Associates 2018b, *Level 1 Fauna Assessment and Targeted Black Cockatoo Survey - Lot 50 Barfield Road, Hammond Park*, EP18-043(05)--006 MS, Version 1.

Gould, J., McCaw, W., Cheney, N., Ellis, P. and Matthews, S. 2007, *Field Guide: Fuel Assessment and Fire Behaviour Prediction in Dry Eucalypt Forest*, CSIRO and Department of Environment and Conservation, Perth, Western Australia.

Standards Australia 2018, *AS 3959-2018 Construction of buildings in bushfire-prone areas*, Sydney.

Western Australian Planning Commission (WAPC) 2015, *State Planning Policy 3.7 Planning in Bushfire Prone Areas*, Perth.

Western Australian Planning Commission and Department of Fire and Emergency Services (WAPC and DFES) 2017, *Guidelines for Planning in Bushfire Prone Areas Version 1.3*, Western Australia. December 2017.

8.2 Online references

Department of Water 2008, *LIDAR derived 1 m elevation contours* dataset, Government of Western Australia.

Landgate 2019, *Map Viewer*, viewed June 2019, https://www0.landgate.wa.gov.au/maps-and-imagery/interactive-maps/map-viewer

Office of Bushfire Risk Management (OBRM) 2019, Map of Bush Fire Prone Areas, viewed June 2019, https://maps.slip.wa.gov.au/landgate/bushfireprone/

Figures

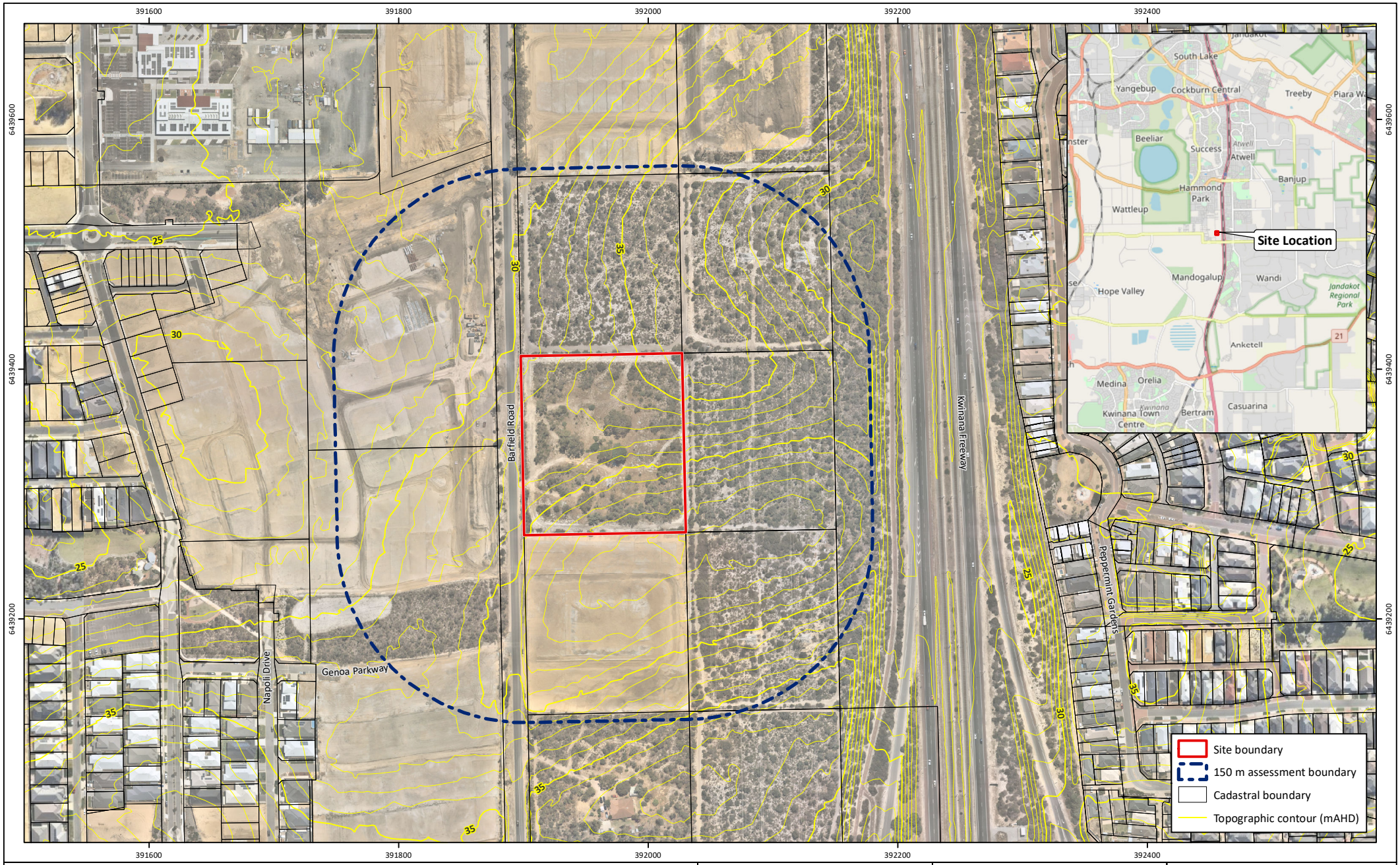

Figure 1: Site Location and Topographic Contours

Project:	Bushfire Management Plan Lot 50 Barfield Road, Hammond Park
Client:	Glenbrook Civil

Plan Number:
EP18-043(03)--F19a

Drawn:	GAR
Date:	11/12/2019
Checked:	SCM
Approved:	AJR
Date:	13/12/2019

N

0 50 100
Metres

Scale: 1:4,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

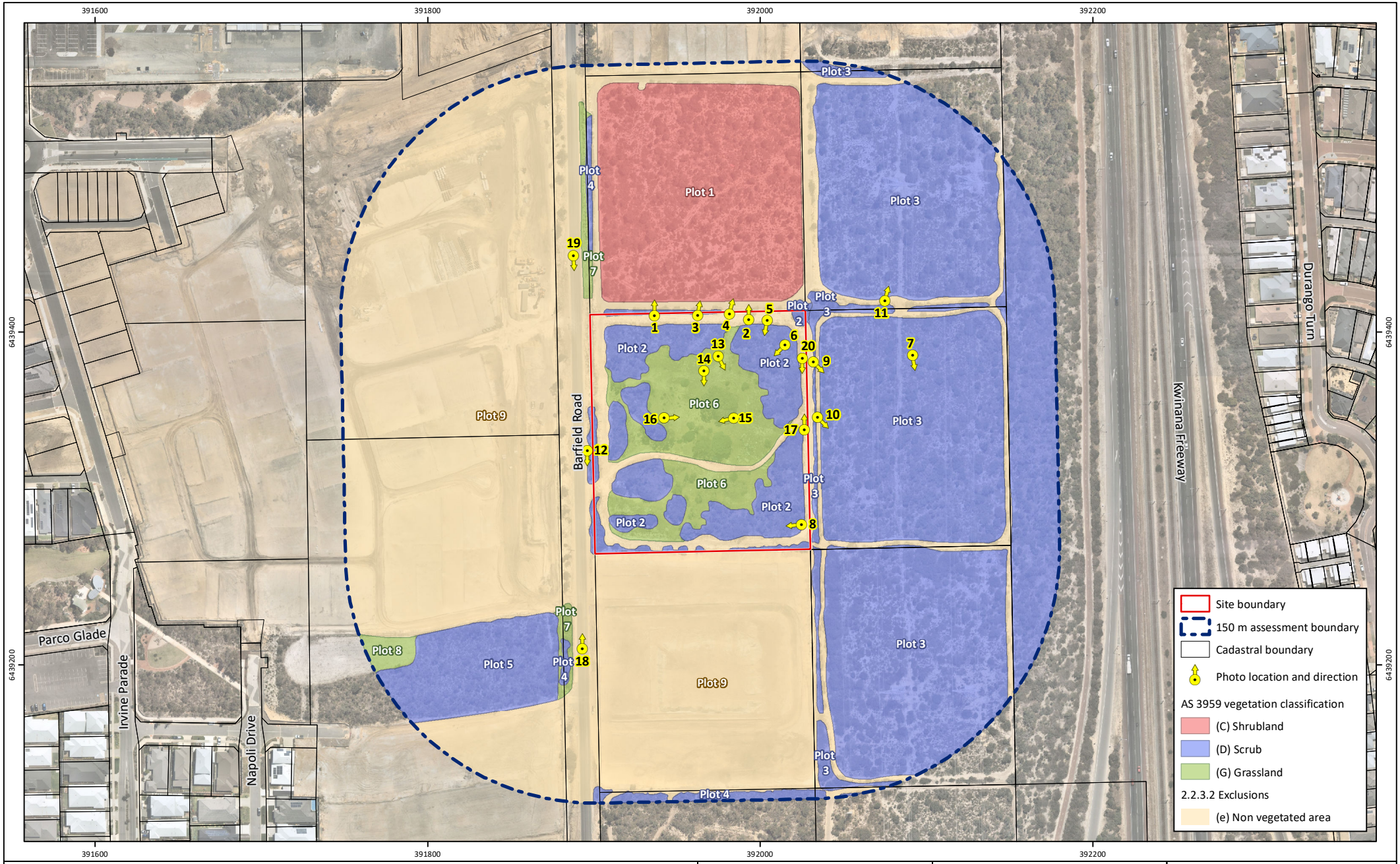

Figure 2: Existing Site Conditions – AS 3959 Vegetation Classification

Project: Bushfire Management Plan
Lot 50 Barfield Road, Hammond Park
Client: Glenbrook Civil

Plan Number:
EP18-043(03)--F20a
Drawn: GAR
Date: 11/12/2019
Checked: SCM
Approved: AJR
Date: 13/12/2019

N

0 50 100
Metres
Scale: 1:3,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

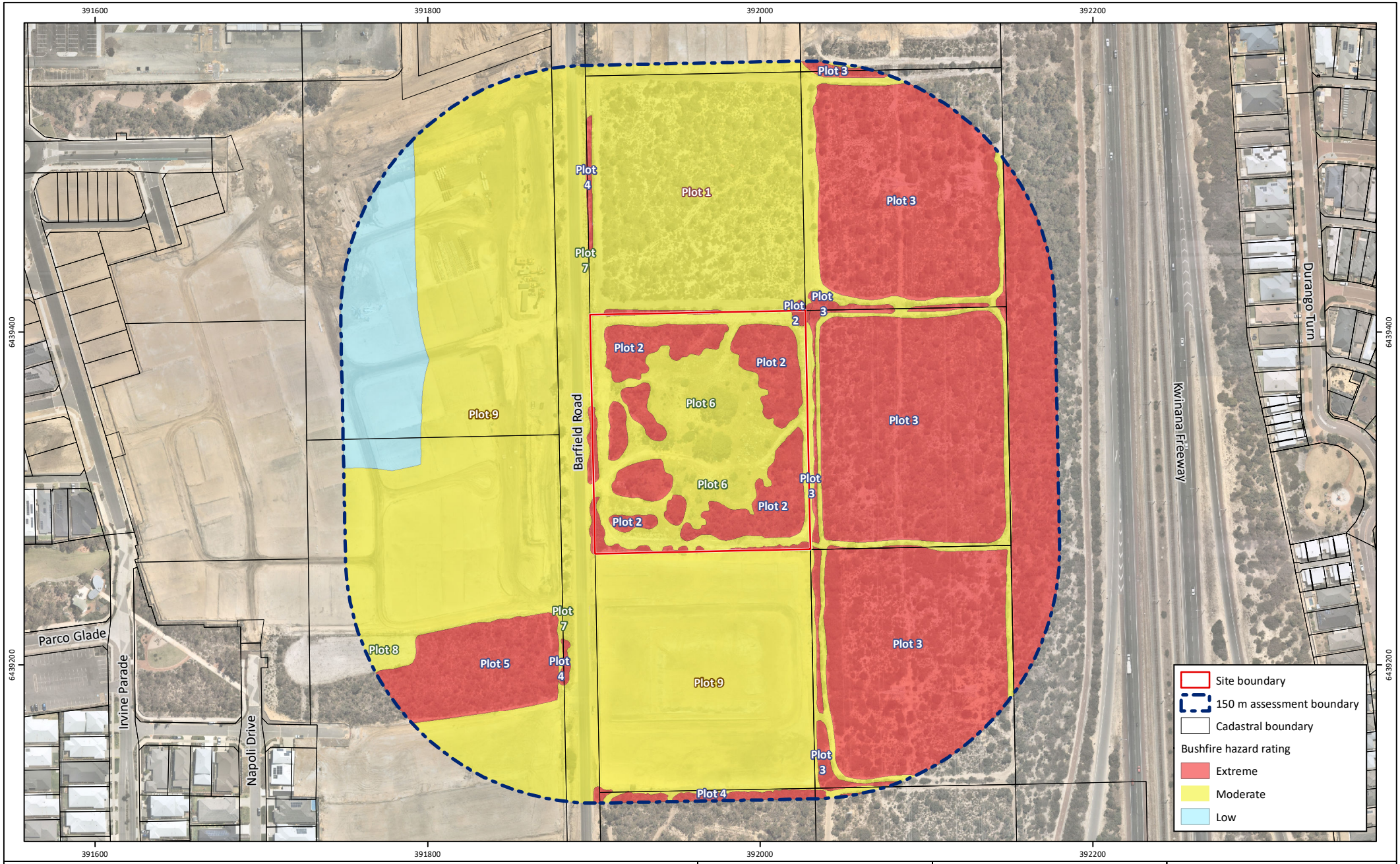

Figure 3: Existing Site Conditions – Bushfire Hazard Level

Project: Bushfire Management Plan
Lot 50 Barfield Road, Hammond Park
Client: Glenbrook Civil

Plan Number:
EP18-043(03)--F21a
Drawn: GAR
Date: 11/12/2019
Checked: SCM
Approved: AJR
Date: 13/12/2019

N

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Metres
Scale: 1:3,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

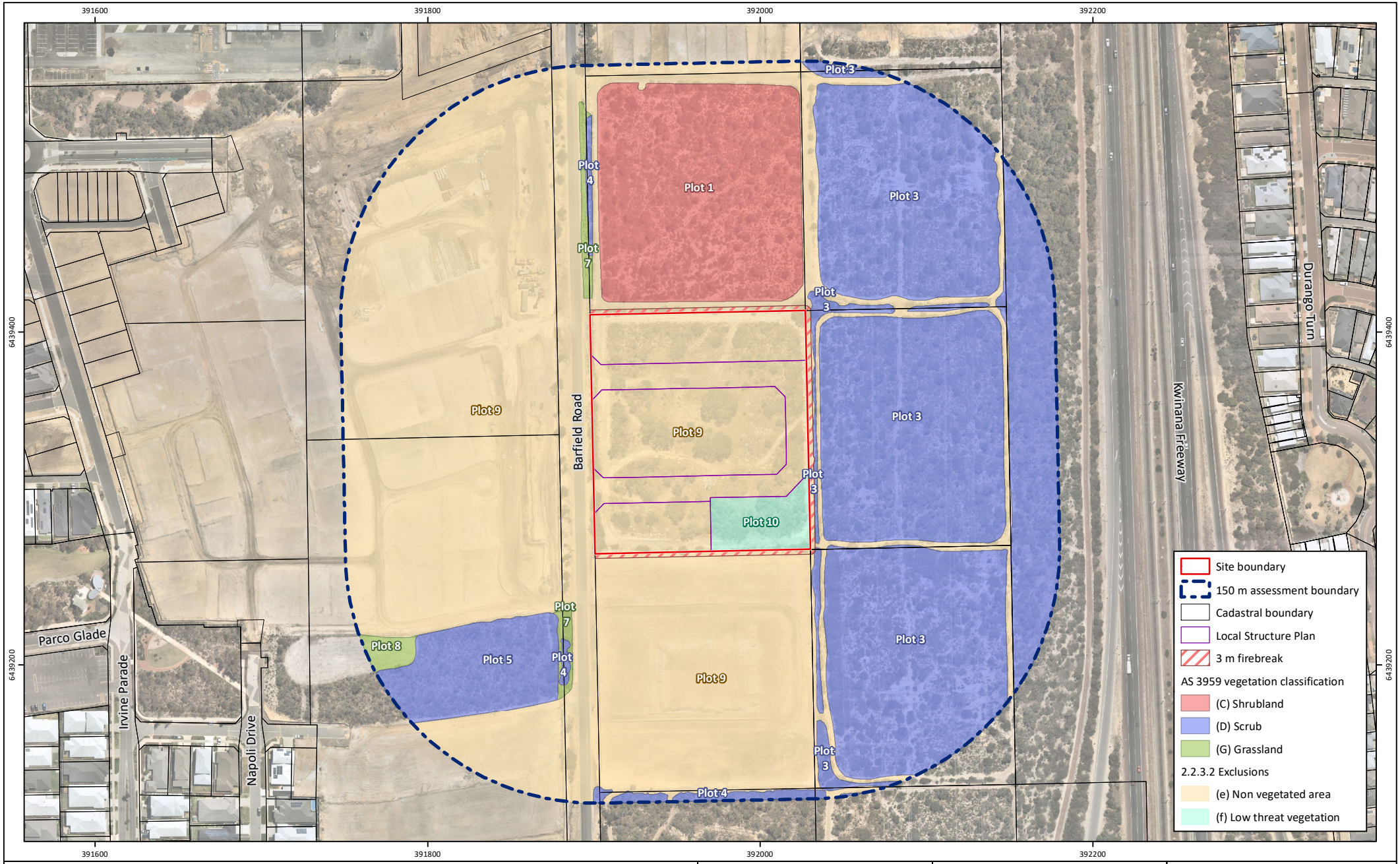

Figure 4: Post Development Site Conditions – AS 3959 Vegetation Classification

Project: Bushfire Management Plan
Lot 50 Barfield Road, Hammond Park
Client: Glenbrook Civil

Plan Number:
EP18-043(03)--F22a
Drawn: GAR
Date: 11/12/2019
Checked: SCM
Approved: AJR
Date: 13/12/2019

N

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Metres
Scale: 1:3,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

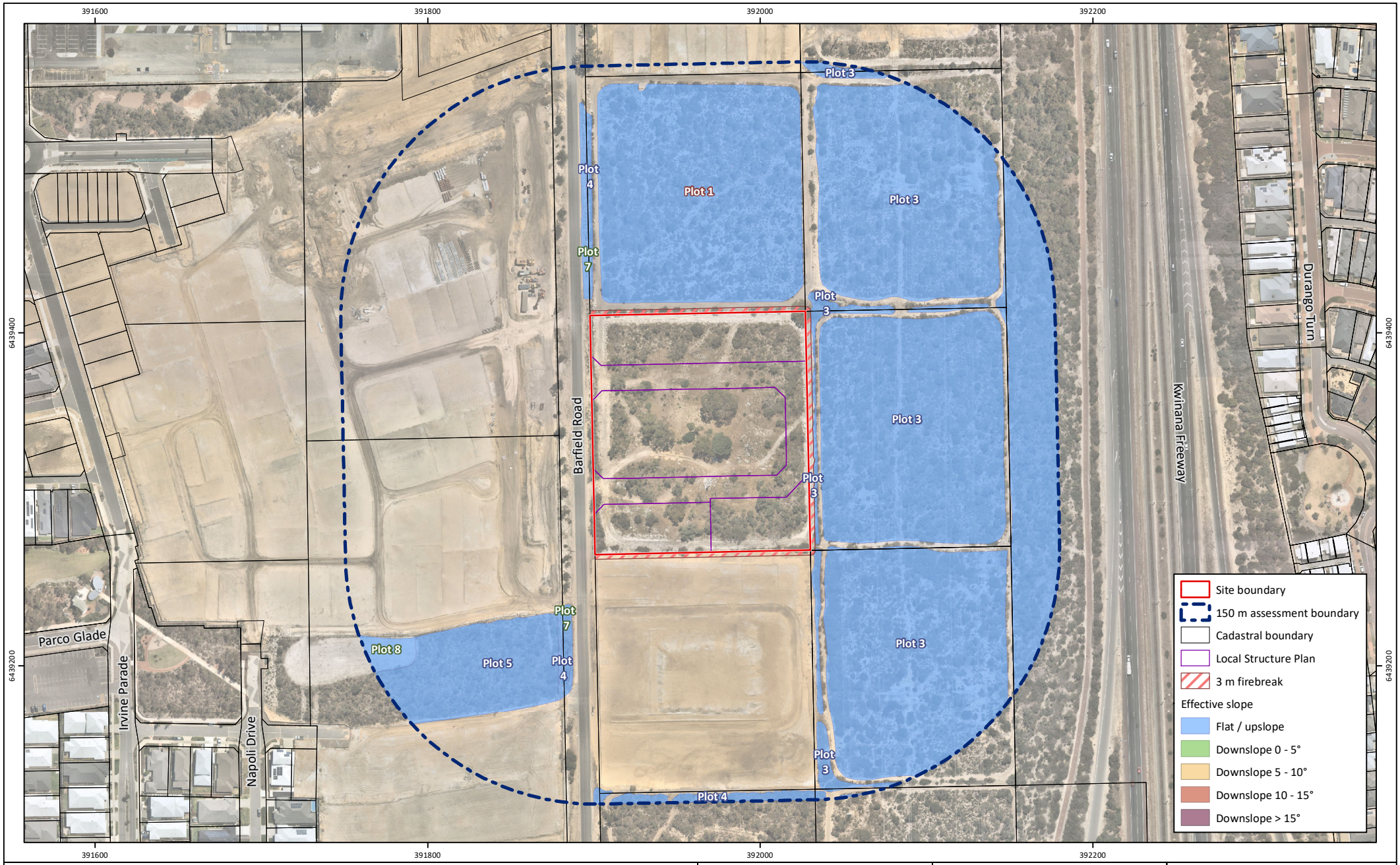


Figure 5: Post Development Site Conditions – Effective Slope

Project: Bushfire Management Plan
Lot 50 Barfield Road, Hammond Park
Client: Glenbrook Civil

Plan Number:
EP18-043(03)--F23a
Drawn: GAR
Date: 11/12/2019
Checked: SCM
Approved: AJR
Date: 13/12/2019

N

0 50 100
Metres
Scale: 1:3,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

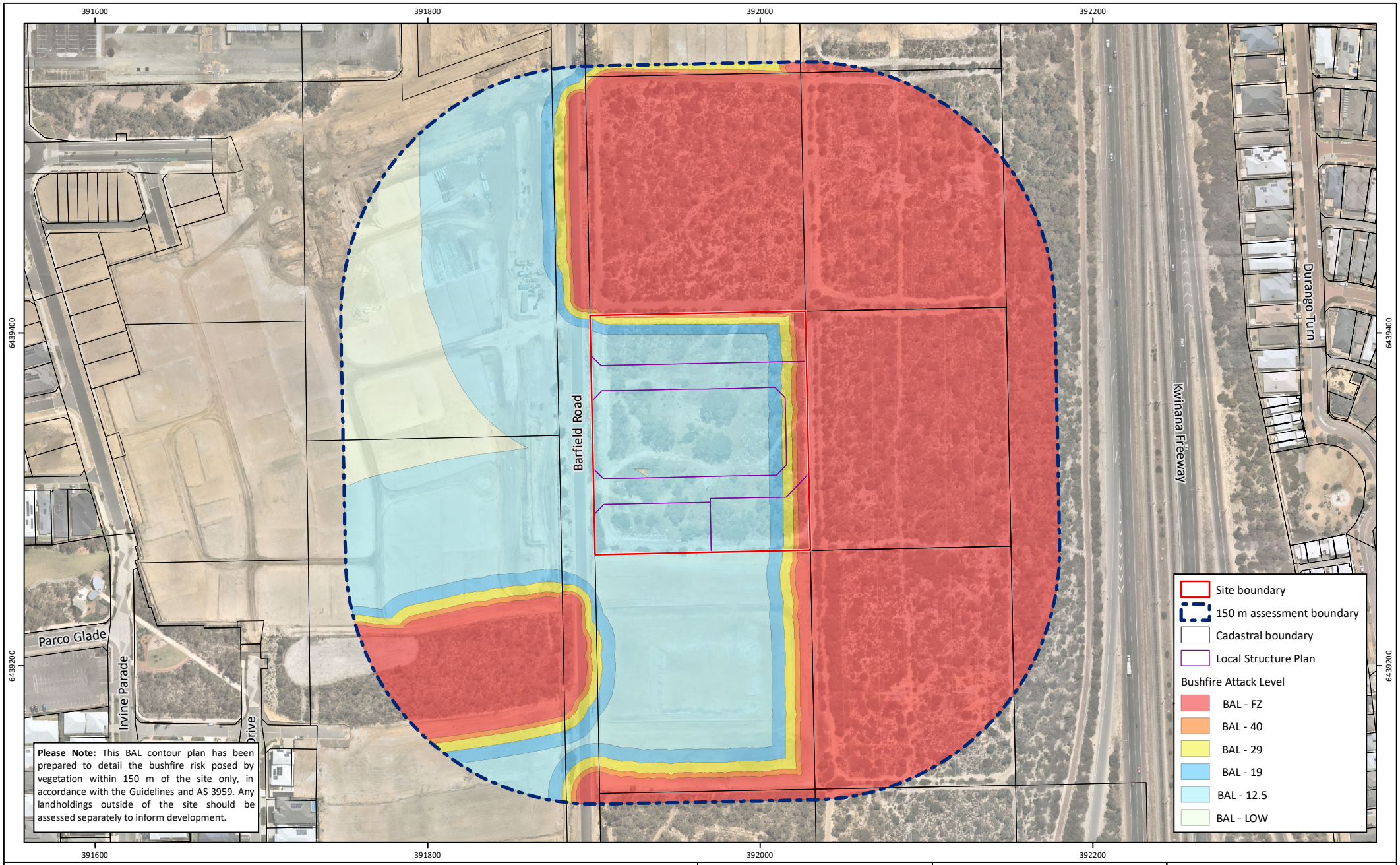


Figure 6: Bushfire Attack Level Contour Plan

Project: Bushfire Management Plan
Lot 50 Barfield Road, Hammond Park
Client: Glenbrook Civil

Plan Number:
EP18-043(03)--F24a
Drawn: GAR
Date: 12/12/2019
Checked: SCM
Approved: AJR
Date: 13/12/2019

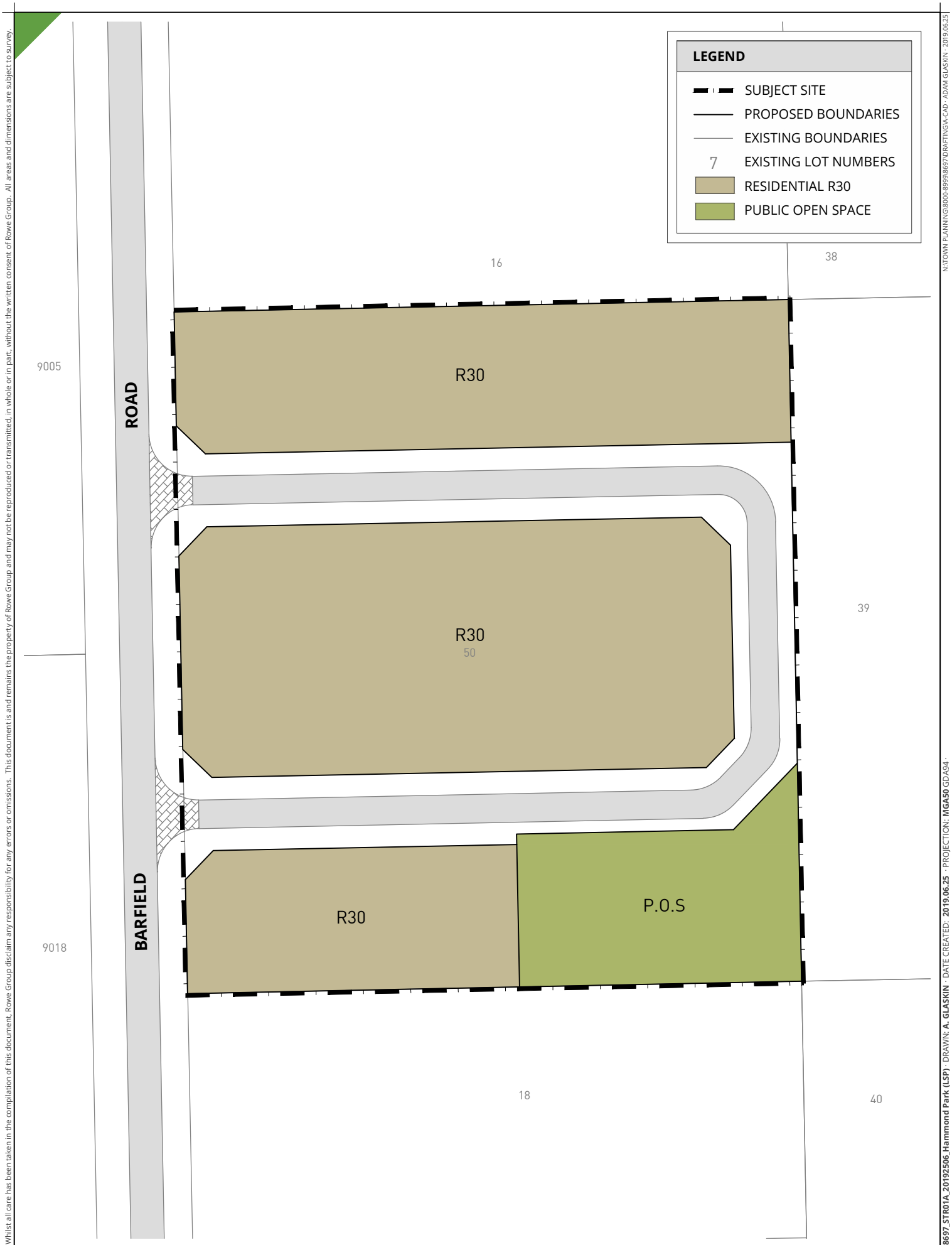
N

0 50 100
Metres
Scale: 1:3,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

Appendix A

Lot 50 (No. 193) Barfield Road, Hammond Park Local Structure Plan



N:\TOWN PLANNING\8000-8999\8697\DRAFTING\A-CAD - ADAM GLASKIN - 2019.06.25

8697_STR01A_20192506_Hammond Park (LSP) · DRAWN: A. GLASKIN · DATE CREATED: 2019.06.25 · PROJECTION: MGA50 GDA94 ·

LOCAL STRUCTURE PLAN

LOT 50 (No. 193) BARFIELD ROAD
HAMMOND PARK

NORTH

0 25 m
SCALE @ A4: 1:1000

8697-STR-01-A

ROWE GROUP DESIGN

APPENDIX 3

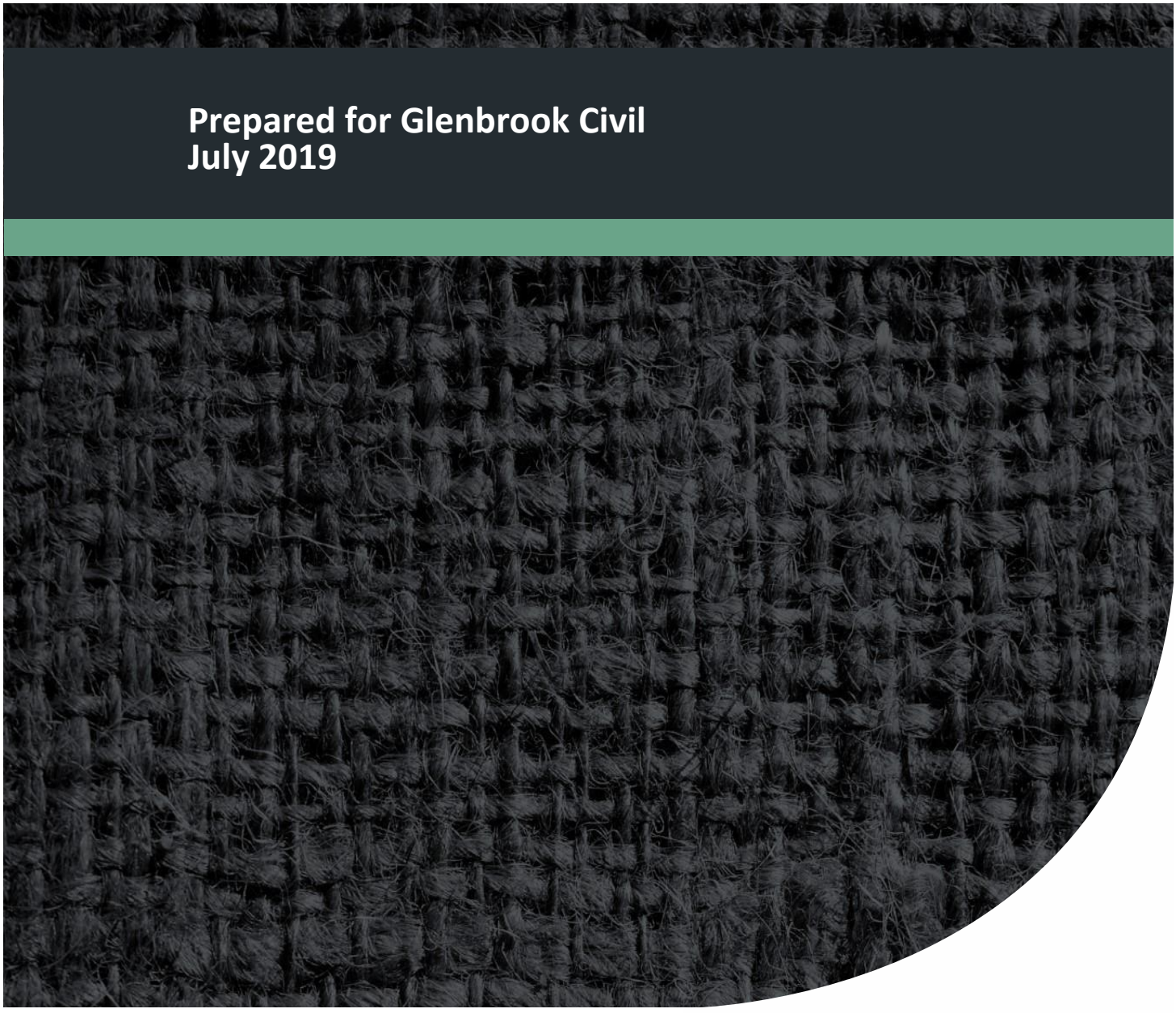
ENVIRONMENTAL ASSESSMENT MANAGEMENT STRATEGY

ROWE GROUP DESIGN

Environmental Assessment and Management Strategy

Lot 50 Barfield Road, Hammond Park

Project No: EP18-043(04)



Prepared for Glenbrook Civil
July 2019

Document Control

Doc name:	Environmental Assessment and Management Strategy Lot 50 Barfield Road, Hammond Park				
Doc no.:	**EP18-043(04)--001**				
Version	**Date**	**Author**		**Reviewer**	
1	July 2019	Jessica Lisle	JHL	Ashley Bird	ALB
		Sean Moylan	SCM	Andreas Biddiscombe	ADB
	Prepared for client review				

Executive Summary

This *Environmental Assessment and Management Strategy* (EAMS) has been prepared on behalf of Glenbrook Civil for Lot 50 Barfield Road, Hammond Park, within the City of Cockburn (herein referred to as the site). Rowe Group is progressing the Lot 50 (No. 193) Barfield Road Local Structure Plan (Barfield Road LSP) (as provided in **Appendix A**) on behalf of Glenbrook Civil, which will provide a planning framework for future residential development of the site.

This EAMS has been prepared to support the preparation and implementation of the structure plan, as required by the Western Australian Planning Commission's (WAPC) *Structure Plan Framework* (WAPC 2015). The EAMS provides a synthesis of information from a range of sources regarding the environmental features, attributes and values of the site.

The site comprises a total area of 1.86 hectares (ha), and is zoned 'Urban' under the Metropolitan Region Scheme (MRS), and 'Urban' under the City of Cockburn Local Planning Scheme (LPS) No. 3. The site is generally bound by undeveloped 'Urban' zoned land to the north, south and west, and a Western Power transmission corridor to the east.

The relevant environmental attributes and values of the site are summarised as follows:

- Portions of the site have historically been cleared to allow for the construction of a residential dwelling. Native remnant vegetation remains in the north-western, north-eastern and south-eastern portions of the site.
- The landform within the site has a south facing aspect, with elevation ranging from approximately 27 m Australian height datum (m AHD) in the south-east of the site up to 35 m AHD in the north-east corner of the site.
- The entire site is classified as having a moderate to low risk of acid sulfate soils (ASS) occurring within 3 m of the natural soil surface.
- Given historic clearing, flora and vegetation within the site has been modified within the site, with approximately 54% of the site identified as being in 'completely degraded' condition in accordance with the Keighery (1994) vegetation condition scale.
- One native plant community, '**BaBm'** was identified within the site, ranging in condition from 'very good' to 'degraded'.
- One threatened ecological community (TEC) was identified within the site, the federally listed 'banksia woodlands of the Swan Coastal Plain' TEC. Vegetation representative of this TEC within the site forms parts of a much larger patch of the TEC located directly east of the site, which extends to the north and south. The area of TEC within the site contributes to a small proportion of the total TEC patch area and is also situated on the outer edge of the wider patch.
- No threatened or priority flora species have been identified within the site, nor are any considered likely to occur given targeted searches have been completed.
- Due to the degraded nature of vegetation within the site, the extent of functional fauna habitat within the site is limited and generally only associated with the areas of retained native vegetation. This vegetation provides some potential black cockatoo habitat values, however no evidence of black cockatoo usage of habitat within the site has been observed. Vegetation in nearby, adjacent land is considered to provide higher fauna habitat values than that within the site.

- No wetlands occur within the site.
- No registered Aboriginal heritage sites are mapped within the site.
- Due to the historical residential activities that have occurred across the site, no significant potential contamination risks have been identified within the site.

The LSP design has responded to site-specific environmental considerations where necessary and possible, including accommodation of stormwater management requirements consistent with the Local Water Management Strategy. The LSP design does not specifically provide for the future retention of existing flora, vegetation or fauna habitat values, due to the determined significance of these values through detailed surveys and also given the bulk earthworks requirements to facilitate future residential development, which limit any such opportunities.

This document provides an environmental management strategy to be implemented across the site for future subdivision and development stages. The key components of this management strategy are summarised as follows:

- Acid sulfate soils: completion of an ASS self-assessment form and if necessary, the preparation of an Acid Sulfate Soil and Dewatering Management Plan (ASSBDMP). However, given the high clearance to groundwater, ASS investigations and management measures are considered unlikely to be ultimately required.
- Native vegetation: completing a detailed analysis of the final development design and bulk earthworks requirements, to confirm any potential retention opportunities. Where clearing of vegetation is proposed, a clearing permit will need to be attained pursuant to Part V of the *Environmental Protection Act 1986* (unless a valid exemption applies) and the potential requirement for an EPBC Act referral will need to be considered.
- Native fauna: completing a detailed analysis of the final development design and bulk earthworks requirements, to confirm any potential retention opportunities. Where clearing of potential black cockatoo habitat is proposed, the potential requirement for an EPBC Act referral will need to be considered. Fauna management protocols and actions will also need to be implemented prior to and during clearing activities, potentially through implementation of a Fauna Management Plan.
- Hydrology: preparation of an Urban Water Management Plan (UWMP) for each stage of future subdivision.

Overall, the environmental attributes and values of the site can be suitably accommodated within the structure plan design, or can be appropriately managed through the future subdivision and development phases in line with the relevant state and local government legislation, policies and guidelines and best management practices.

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List of Abbreviations

Table A1: Abbreviations – General terms

General terms	
AHD	Australian Height Datum
AHIS	Aboriginal Heritage Inquiry System
ASS	Acid Sulfate Soil
ASSDMP	Acid Sulfate Soil and Dewatering Management Plan
BBC	Baudin's black cockatoo
CBC	Carnaby's black cockatoo
DBH	Diameter at Breast Height
EAMS	Environmental Assessment and Management Strategy
ESA	Environmentally Sensitive Area
FRTBC	Forest red-tailed black cockatoo
IBRA	Interim Biogeographic Regionalisation of Australia
LWMS	Local Water Management Strategy
PEC	Priority Ecological Community
PF	Priority Flora
PDWSA	Public Drinking Water Source Area
TEC	Threatened Ecological Community
TF	Threatened Flora
UWMP	Urban Water Management Plan

Table A2: Abbreviations – Legislation and policies

Legislation and policies	
AH Act	*Aboriginal Heritage Act 1972*
BC Act	*Biodiversity Conservation Act 2016*
EP Act	*Environmental Protection Act 1986*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*

Table A3: Abbreviations – Organisations

Organisations	
DBCA	Department of Biodiversity Conservation and Attractions
DoEE	Department of Environment and Energy
DoW	Department of Water (now known as Department of Water and Environmental Regulation)
DPAW	Department of Parks and Wildlife (now known as Department of Biodiversity Conservation and Attractions)
DPLH	Department of Planning, Lands and Heritage
DWER	Department of Water and Environmental Regulation
EPA	Environmental Protection Authority
WAPC	Western Australian Planning Commission

Table A4: Abbreviations – Planning and building terms

Planning and building terms	
LSP	Local Structure Plan
MRS	Metropolitan Region Scheme
TPS	Town Planning Scheme

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1 Introduction

1.1 Background

Rowe Group, on behalf of the landowner Glenbrook Civil, has prepared a Local Structure Plan (LSP) for the future residential development of Lot 50 Barfield Road, Hammond Park (herein referred to as 'the site') (see **Appendix A**), which covers a total area of 1.86 hectares (ha). The site is located approximately 25 kilometres south of the Perth Central Business District (CBD), within the City of Cockburn, as shown in **Figure 1**. It is bound by Barfield Road to the west, land zoned for future urban development to the north and south and a Western Power transmission corridor and Kwinana Freeway to the east.

The site is zoned 'Urban' under the Metropolitan Regional Scheme (MRS), as shown in **Figure 2** and 'Urban' under the City of Cockburn Town Planning Scheme No. 3 (TPS No. 3). A small parcel of land to the east of the site is zoned 'Railway' under the MRS and TPS No. 3, which according to the *Southern Suburbs District Structure Plan – Stage 3* was identified as a possible future rail station that has now been located further south.

1.2 Purpose of this report

The purpose of this Environmental Assessment and Management Strategy (EAMS) is to provide a synthesis of information regarding the environmental values and attributes of the site. Specifically, this report:

- Identifies the existing environmental values and attributes of the site (**Section 2**).
- Discusses the land use and environmental planning context for the structure plan area (**Section 3**).
- Discusses how the structure plan layout responds to the existing environmental features and values, and future environmental management requirements as part of the future planning and development process (**Section 4**).
- Provides an implementation strategy for future environmental management requirements as part of the future planning and development process (**Section 5**).

The EAMS is the key supporting environmental document for the LSP. It facilitates consideration of relevant environmental issues by the City of Cockburn and State Government authorities during advertising, agency referrals, assessment and ultimately to approval. It is consistent with the requirements for environmental assessment as outlined in the Western Australian Planning Commission's *Structure Plan Framework* (WAPC 2015).

1.3 Assessment scope

Emerge Associates (Emerge) was engaged to undertake this environmental assessment to document the existing environmental attributes and values of the site and ensure that any relevant environmental values can be accommodated within the structure plan, and/or managed through future stages of planning and development of the site. This involved utilising a range of information sources including local and regional reports, databases, and mapping.

Emerge has conducted a number of site-specific investigations (outlined below), as well as a comprehensive desktop review of the available information on environmental conditions within and surrounding the site. The outcomes of these findings have provided context for the following within the site:

- Landforms, topography and soils.
- Flora and vegetation.
- Terrestrial fauna.
- Surface and groundwater hydrology.
- Aboriginal and non-indigenous heritage.
- Historical and existing land uses within and surrounding the site.
- Bushfire hazards.

In addition to this EAMS, Emerge has prepared or commissioned the following to support the proposed structure plan:

- Detailed Flora and Vegetation Survey (provided in **Appendix B**).
- Level 1 Fauna Assessment and Targeted Black Cockatoo Survey (provided in **Appendix C**).
- Bushfire Management Plan (provided separately).

2 Existing Environment

2.1 General location and site context

The site is located on the central Swan Coastal Plain, approximately 25 km south of the Perth CBD. It is located in an area that has historically supported native vegetation and market gardens, although recently urban development has begun to predominate the broader area. Areas of remnant vegetation within the site have historically been cleared to support a residential dwelling on the site, which was constructed between 1983 and 1985. The dwelling was demolished between March and September 2016. Remnant vegetation has historically been removed from within the site since the construction of dwelling, with intact areas of remnant vegetation remaining in the north-west, north-east and south-east portions of the site.

2.2 Landform and soils

2.2.1 Topography

The landform within the site has a south facing aspect, with elevation ranging from approximately 27 m Australian height datum (m AHD) in the south-east of the site up to 35 m AHD in the north-east corner of the site (DoW 2008), as shown in **Figure 3**.

2.2.2 Landform, soils and geology

Regional soil association mapping indicates that the site is within the Bassendean association (Churchward and McArthur 1980). The Bassendean association is described as 'sand plains with low dunes and occasional swamps; iron or humus podzols; areas of complex steep dunes'. Regional landform mapping by Gozzard (2011) places the site within the Bassendean dune system.

The Geological Survey of Western Australia, as documented in *Perth Metropolitan Region 1: 50,000 Environmental Geology Series Perth Sheet 2034 II & Part of 2034 III & 2134 III* (Gozzard 1986) indicates the following soil unit within the site, and is shown in **Figure 4**:

- **Sand (S8)** which is described as 'white to pale grey at the surface, yellow at depth, fine to medium grained, moderately sorted sub-angular to sub-rounded, minor heavy minerals of eolian origin'.

2.2.3 Acid sulfate soils

Acid sulfate soils (ASS) is the name commonly given to naturally occurring soils and sediment containing iron sulphide (iron pyrite) materials. In their natural state, ASS are generally present in waterlogged and/or anoxic conditions and do not present any risk to the environment. ASS can pose issues when oxidised, producing sulphuric acid, which can present a range of risks for the surrounding environment, infrastructure and human health.

The Department of Water and Environment Regulation (DWER) provides broad-scale mapping indicating areas of potential ASS risk (DWER 2019b). A review of the DWER mapping indicates that the entire site is classified as having a 'moderate to low risk' of ASS occurring within 3 m of the natural soil surface, as shown in **Figure 5**.

2.3 Biodiversity and natural area assets

2.3.1 Flora and vegetation

2.3.1.1 Regional context

Native vegetation can be described and mapped at different scales or units in order to illustrate general patterns in its distribution. At a continental scale the *Interim Biogeographic Regionalisation of Australia* (IBRA) divides the Swan Coastal Plain into two floristic subregions, the Perth Plateau and the Dandaragan Plateau (Environment Australia 2000).

The site is located within the Perth subregion of the Swan Coastal Plain, which is characterised as mainly containing *Banksia* low woodland on leached sands with *Melaleuca* swamps where ill-drained; and woodland of *Eucalyptus gomphocephala* (tuart), *E. marginata* (jarrah) and *Corymbia calophylla* (marri) on less leached soils (Beard 1990).

At a regional scale, vegetation complex mapping undertaken by Heddle *et al.* (1980) indicates the site occurs within the Bassendean Complex – Central and South, the description of which is described as "woodland of *Eucalyptus marginata - Allocasuarina fraseriana - Banksia* spp. to low woodland of *Melaleuca* spp. and sedgelands on the moister sites". In 2015, there was estimated to be 26.1% of the pre-European extent of the Southern River Complex remaining on the Swan Coastal Plain, with 21.3% remaining in the Perth – Peel region (EPA 2015).

2.3.1.2 Site specific surveys and investigations

Botanists from Emerge visited the site and undertook a reconnaissance flora and vegetation survey on 15 May 2018, with a detailed spring survey undertaken on 28 September 2018. The site was traversed on foot and the vegetation was sampled using three non-permanent 10 m x 10 m quadrats. The results of the survey are summarised below and the survey report is provided in **Appendix B**.

2.3.1.3 Vegetation communities

Based on the findings from the flora and vegetation survey (Emerge Associates 2018a), one native plant community was recorded in the site, as described in **Table 1** and shown in **Figure 6**. Plant community **BaBm** exists in a number of patches around the edges of the site and extends over a total area of 0.84 ha. The remainder of the site (1.02 ha) contains non-native vegetation with bare soil, weeds or planted vegetation including **Pinus pinaster* (pine tree), **Eucalyptus* sp. and **Corymbia citriodora* (lemon scented gum). Two tuart trees are located in the centre of the site and appear to also have been planted, based on available historical aerial photography. Representative photos of each plant community are provided below in **Plate 1** to **Plate 2**.

Table 1: Vegetation communities recorded within the site

Plant community	Description	Area (ha)
BaBm	Sparse woodland of *Eucalyptus marginata* and *Allocasuarina fraseriana* over low woodland of *Banksia menziesii* and *Banksia attenuata* over low shrubland of *Xanthorrhoea preissii, Allocasuarina humilis, Stirlingia latifolia, Eremaea* spp. and *Hibbertia hypericoides* over forbland of *Chordifex sinuosus, Lepidosperma squamatum, Patersonia occidentalis, Stylidium* spp., *Lomandra* spp. (**Plate 1**).	0.84
Non-native/planted vegetation	Heavily disturbed areas comprising weeds with planted vegetation and occasional native species (**Plate 2**)**.**	1.02

*Plate 1: Plant community **BaBm** in very good condition.*

Plate 2: Non-native/planted vegetation throughout the centre of the site.

2.3.1.4 Vegetation condition

Vegetation condition within the site was assessed by Emerge Associates (2018a) using methods from Keighery (1994). The vegetation within the site was determined to range in condition from 'very good' to 'completely degraded' condition, as shown in **Figure 7**. The majority of the site (approximately 54%) was determined to be in 'completely degraded' condition due to historical clearing. The most intact native vegetation was located in the north-eastern and south-eastern portions of the site, which was mapped as being in 'very good' condition, as it retains the structure expected of a banksia woodland community. The north-western portion of the site was mapped as being in 'good' - 'very good' condition, whilst vegetation surrounding the centre of the site and on the western half of the site were mapped as being in 'degraded' condition.

The extent of vegetation by condition category is detailed in **Table 2** and shown in **Figure 7.**

Table 2: Area of vegetation condition categories within the site

Condition category (Keighery 1994)	Area (ha)
'Pristine'	0
'Excellent'	0
'Very good'	0.26
'Very good – good'	0.13
'Good'	0.13
'Degraded'	0.32
'Completely degraded'	1.02

2.3.1.5 Threatened and Priority Ecological Communities

Generally, ecological communities can be described as vegetation communities that are assemblages of species that occur together in a particular type of habitat. An ecological community's structure, composition and distribution are determined by a range of environmental factors. 'Threatened ecological communities' (TECs) are ecological communities that are recognised as rare or under threat and therefore warrant special protection.

Selected TECs are afforded statutory protection at a Commonwealth level under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). TECs listed under the EPBC Act are categorised as either 'critically endangered', 'endangered' or 'vulnerable'. Any action likely to have a significant impact on a TEC listed under the EPBC Act (either critically endangered or endangered TECs) requires approval from the Commonwealth Minister for the Environment.

Within Western Australia, state-listed threatened flora and TECs are statutorily protected through the *Biodiversity Conservation Act 2016* (BC Act), and licences (or similar) may be required where these values are proposed to be disturbed or modified.

An ecological community under consideration for listing as a TEC in Western Australia, but which does not yet meet survey criteria or has not been adequately defined, or which is rare but not currently threatened, is referred to as a 'priority ecological community' (PEC). Whilst PECs are not afforded statutory protection in Western Australia, they are considered during the approval process.

Known locations of TECs and PECs within 10 km of the site were searched for using the publicly available *Weed and native flora dataset* (Keighery *et al.* 2012), *Protected Matters Search Tool* (DoEE 2018) and DBCA's threatened and priority ecological communities' database. These search results indicate that 11 TECs (five of these are PECs at the State level) and one PEC occur within 10 km of the site.

The vegetation survey undertaken by Emerge Associates (2018a) determined that the observed 0.84 ha of plant community **BaBm** within the site is part of a larger patch of 'banksia woodlands of the Swan Coastal Plain' TEC located directly east of the site, which extends to the north and south. The vegetation within the site contributes a small proportion of the total patch area and is situated on the outer edge of the patch.

The 'banksia Woodlands of the Swan Coastal Plain' TEC, herein referred to as the 'banksia woodland TEC'), is listed as 'endangered' under the EPBC Act. This community also represents the state listed 'banksia dominated woodlands of the Swan Coastal Plain IBRA region' PEC.

Whether a patch of vegetation is considered to represent the banksia woodland TEC depends on a number of diagnostic criteria including geographic location, soils, landform, structure, composition, condition and patch size (DoEE 2016). The full assessment against these criteria completed for vegetation within the site is detailed in the flora and vegetation survey (Emerge Associates 2018a), which is provided in **Appendix B**.

2.3.1.6 Significant flora

Certain flora species that are considered to be rare or under threat warrant special protection under Commonwealth and/or State legislation. At a Commonwealth level, flora species may be listed as 'threatened' pursuant to the EPBC Act and any action likely to have a significant impact on a listed threatened species requires approval from the Commonwealth Minister for the Environment.

At a State level, plant species may also be classed as 'threatened' under the BC Act. Species which are potentially rare or threatened, or meet the criteria for near threatened, or have recently been removed from the threatened species list are classed as 'priority' flora species. However, priority flora species are not afforded statutory protection.

A search was conducted for threatened and priority flora within a 5 km radius of the site using the *Protected Matters Search Tool* (DoEE 2019b), *NatureMap* (DBCA 2019) and DBCA's threatened and priority flora database (reference no. 03-0714FL). A total of nine threatened and 19 priority flora species were identified as potentially occurring in the wider local area.

A targeted search for threatened and priority flora identified to potentially occur within the wider local area was completed across the site (Emerge Associates 2018a). No threatened or priority flora species were observed to occur within the site, and the degraded habitat is considered unsuitable to support any threatened or priority species.

2.3.2 Bush Forever

There are no Bush Forever sites within the site. The closest Bush Forever site located approximately 1.1 kilometres to the north-west of the site (Bush Forever Site 392 *Harry Waring Marsupial Reserve*), as shown in **Figure 8**.

2.3.3 Ecological linkages

There are no mapped ecological linkages within the site. A linkage is located to the west of the site connecting Bush Forever Site 392 to the north-west of the site to *Bush Forever* sites and remnant vegetation to the north-east and south-west of the site. In addition, the Western Power transmission line (located to the east of the site) is recognised in the City of Cockburn *Natural Area Management Strategy (2012-2022)* as a possible ecological linkage subject to the vegetation height restrictions associated with the easement use.

2.3.4 Environmentally Sensitive Areas

No 'environmentally sensitive areas' (ESAs) occur within the site. ESAs are located to the north-west and south of the site, as shown in **Figure 8.**

2.3.5 Terrestrial fauna

The site is located in the central area of the Swan Coastal Plain, which is typically characterised by areas largely cleared of remnant vegetation to facilitate urban land uses, transitioning away from historic agricultural (market garden uses). Notwithstanding, the region does contain some large areas of remnant vegetation, in addition to other environmental features such as mature trees, waterways and wetlands, all of which provide fauna habitat values.

A range of conservation significant fauna species are known to occur within the broader region encompassing the site. This includes three species of threatened black cockatoo, namely Carnaby's black cockatoo (CBC), forest red-tailed black cockatoo (FRTBC) and Baudin's black cockatoo (BBC).

Regional scale habitat mapping published by the Department of Planning (2011) delineates likely CBC habitat used for feeding, night roosts and breeding areas across the Swan Coastal Plain. The regional mapping indicates that the site does contain areas of vegetation identified as potentially suitable black cockatoo foraging habitat.

Records of black cockatoo roosting sites across south-west Western Australia are maintained by Birdlife Australia, and are based on annual community surveys as part of the *Great Cocky Count* (GCC). Based on the most recently published 2018 GCC report, the site does not contain any confirmed black cockatoo roosting sites. The nearest known roost, as identified in the GCC is located approximately 1.7 km to the south-east of the site. The nearest breeding habitat, as identified in the Department of Planning data, is approximately 21 km to the north-east of the site.

2.3.5.1 Site specific surveys and investigations

A fauna survey and targeted black cockatoo habitat assessment was carried out by Emerge Associates in 2018, to determine the fauna values associated with the site. The survey report is provided in **Appendix B.** A total of eight native fauna species were observed within the site (or positively identified through foraging evidence, scats, tracks, skeletons or calls) during the survey. The majority of the recorded fauna species are common, widespread bird species.

Based on the findings of the fauna assessment, it was concluded that fauna habitat values within the site have been compromised by historical vegetation clearing. The remaining areas of remnant vegetation within the site represent the highest value fauna habitat when compared to the degraded areas of the site, which lack significant native groundcover/shrubs or microhabitats such as hollow logs.

In consideration of the observed site characteristics, the overall diversity of native fauna in the site is expected to be well below pre-disturbance levels (Emerge Associates 2018b). Due to historical clearing and degradation of native vegetation, the majority of the site has limited natural values, and it is likely to be only utilised by generally common and widespread fauna species (Emerge Associates 2018b).

2.3.5.2 Species of conservation significance

Certain fauna species that are considered to be rare or under threat warrant special protection under state and/or federal legislation. At a federal level, fauna species may be listed as 'threatened' pursuant to the EPBC Act and any action likely to have a significant impact on a listed threatened species requires approval from the Commonwealth Minister for the Environment.

At a state level, fauna species could formerly be classed as 'threatened' under the BC Act. In addition to this, DBCA maintains a list of priority fauna species which, while not considered threatened under the BC Act and therefore not protected directly, elicit some concern over their long-term survival. **Appendix B** provides detailed descriptions as to the definitions and categories of threatened and priority fauna species.

Based on the results of the fauna assessment (Emerge Associates 2018b), no fauna species of conservation significance were positively identified as utilising the site, either through direct observation or secondary evidence such as, foraging evidence, scats, tracks, skeletons or calls.

The targeted black cockatoo habitat assessment determined that some flora species identified within the site (generally within the **BaBm** plant community) represent potential black cockatoo habitat. However, these resources were considered relatively small and less significant than the foraging resource present in adjacent land parcels and across the wider local area.

The assessment also concluded the site has limited potential black cockatoo roosting habitat, given only six larger trees occur within the site. In addition, substantial potential roosting habitat is located within the wider area, thus the trees within the site are considered unlikely to provide any important roosting habitat.

The assessment identified five endemic trees within the site as potential breeding habitat trees due to their size (diameter at breast height (DBH) > 500 mm) and species. Of these, one jarrah tree was observed to contain a hollow suitably sized to potentially support black cockatoo nesting, situated approximately 3m above the ground. The remaining four trees was observed to either contain unsuitable or no hollows.

Further details of potential black cockatoo habitat values within the site is provided in the Fauna Assessment (**Appendix C**).

2.4 Groundwater and surface water

2.4.1 Groundwater

Information on the regional groundwater resources obtained from the Department of Water and Environmental Regulation Water Register (DWER 2019c) indicates that the site is underlain by a multi-layered aquifer system comprised of the following resources:

- Perth - Superficial Swan (unconfined).
- Perth - Leederville (confined).
- Perth - Yarragadee North (confined).

The Department of Water *Perth Groundwater Map* (DWER 2019b) indicates historical maximum groundwater levels across the site are approximately 21 m AHD. Based on the topographic contours, groundwater is expected to be located within approximately 12m to 13m of the surface across the site. Groundwater is expected to generally flow in an east to west direction.

For the purpose of future groundwater allocation and licensing requirements, the site is found within the Jandakot Groundwater Area and the Success and Jandakot Confined Groundwater Sub-areas.

2.4.2 Surface water

The site is located within the Cockburn/Kwinana Coastal Catchment and sub-catchment as identified through the DWER *Hydrographic Catchments* dataset. No surface water features occur within the site itself.

The site is situated just to the north of the Peel Main Drain catchment. The Peel Main Drain is a rural drain that runs from north to south, forming a regional drainage network. It flows in a southerly direction and passes through several pools and wetlands before discharging into the Serpentine River.

2.4.3 Wetlands

Based on a review of DBCA's *Geomorphic Wetlands of the Swan Coastal Plain* database, no wetlands have been identified within the site.

2.4.4 Public Drinking Water Sources Areas

The site is not located within a proclaimed Public Drinking Water Source Area.

2.5 Heritage

2.5.1 Indigenous heritage

In accordance with the *Aboriginal Heritage Due Diligence Guidelines* (DAA 2013), a search of the Aboriginal Heritage Inquiry System online database (DPLH 2019) was undertaken. No Registered Aboriginal Heritage Sites or Other Heritage Places have been identified within the site.

Although no Aboriginal heritage sites were identified within the site, if during construction Aboriginal artefacts or sites are uncovered, these will be protected under the *Aboriginal Heritage Act 1972* and works should cease and a suitably qualified expert should be brought in to survey the potential site. If required based on the outcome of the survey, permission under the *Aboriginal Heritage Act 1972* to manage and disturb sites should be sought.

2.5.2 Non-indigenous heritage

A desktop search of the Australian Heritage Database (DoEE 2019a), the State Heritage Office database (Heritage Council 2019) and the City of Cockburn Local Government Inventory (City of Cockburn 2014) indicated that the site contains no registered heritage sites.

2.6 Other land use considerations

2.6.1 Existing and historical land uses

Based on a review of publicly available historic aerial imagery (Landgate 2019), the site was relatively undisturbed until 1985. Between the period of 1983 and 1985, remnant vegetation within the central portion of the site was cleared to support a dwelling and associated access road. Remnant vegetation in the south west portion of the site was cleared in 1995. During 2016 the dwelling and associated sheds were removed, leaving patches of vegetation and mature trees.

2.6.2 Potential site contamination

A review of the Department of Environment Regulation *Contaminated Sites Database* (DWER 2019a) indicates that the site is not registered as a contaminated site pursuant to the *Contaminated Sites*

Act 2003, nor are any other registered sites located nearby. The historic residential land uses within the site are considered unlikely to present any significant contamination risk.

2.6.3 Surrounding land uses

Land to the north, west and south of the site is predominantly zoned 'Urban' under the MRS and 'Urban' under the City of Cockburn TPS No 3 and is currently undergoing staged development by respective landowners. Situated between the site and the Kwinana Freeway is a small section of land zoned 'Railway' under the MRS and TPS No.3.

Directly adjacent to the east of the site is a Western Power transmission corridor and Kwinana Freeway road reserve.

There are no land uses identified surrounding the site that would be incompatible with the proposed future residential development within the site.

3 Planning Framework and Proposal

3.1 Historical planning and environmental assessment context

The site is currently zoned 'Urban' under the Metropolitan Region Scheme (MRS) and 'Urban' under the City of Cockburn TPS No. 3. The site is located within the Southern Suburbs District Structure Plan (DSP) area, within the Stage 3 boundary. For future development to occur within the DSP area an LSP is required to support development, which is the basis for the preparation of the Lot 50 (No. 193) Barfield Road Local Structure Plan.

No significant environmental values were recognised within the site as part of the Southern Suburbs DSP planning process.

Under the general notes of the Southern Suburbs DSP, a local structure plan requires the following plans to be prepared to support the preparation of the LSP:

- Detailed Local Water Management Strategy (LWMS) based upon Regional Drainage Study.
- Detailed Noise Management Strategy where LSP adjoins Rowley Road.
- Fire Management Plan where LSP is located near Regional Open Space (ROS) or significant POS.
- Flora and Fauna Management Plan.
- Traffic Management Plan.
- Contaminated Sites and Acid Sulfate Soils Management Plan where required.
- Heritage Study where LSP includes former historic tramway.
- Transition and/or interface strategy in respect of existing rural uses.
- Neighbourhood Centre Concept Plan and detailed area plan where included within LSP area.
- Neighbourhood Node Concept Plan and detailed area plan.

The following documents have been prepared to satisfy the environmental components of the above:

- Environmental Assessment and Management Strategy (Emerge Associates 2019)
- Bushfire Management Plan (Emerge Associates 2019)
- Local Water Management Strategy (BPA Engineering 2019).

3.2 Proposed Local Structure Plan

The Lot 50 (No. 193) Barfield Road Local Structure Plan has been prepared for the site on behalf of Glenbrook Civil by Rowe Group, and is included in **Appendix A**.

The LSP design incorporates the inputs from a multi-disciplinary project team and the outcomes of a range of site-specific technical studies and investigations. The LSP proposes a number of land uses including:

- areas of residential development
- a public open space (POS) reserve
- a public loop road, connecting to Barfield Road at two locations.

3.3 Future approval process

3.3.1 State process

Subject to approval and endorsement of the structure plan by the City of Cockburn and the WAPC, urban development of the site would be progressed through subdivision and/or development approvals (collectively referred to as 'future planning stages').

The key environmental values and attributes that will require some consideration as part of future planning stages have been outlined in **Section 4** of this report and include:

- acid sulfate soils
- native vegetation
- native fauna
- hydrology.

The WAPC can impose conditions on subdivision applications to ensure subdivision incorporates all the appropriate environmental management measures. These conditions are usually determined in accordance with WAPC's *Model Subdivision Conditions Schedule 2019* and include those relating to environmental considerations. It is envisaged that there would be future subdivision conditions applied for any subdivision within the site, that would deal with environmental, hydrological and bushfire related requirements.

3.3.2 Federal process

The **BaBm** vegetation community within the site represents the banksia woodlands TEC, which is afforded protection under the EPBC as a threatened ecological community. Additionally, the EPBC Act also provides protection for listed 'threatened' species, including black cockatoos, relating to potential impacts on foraging, breeding and roosting habitat. Any proposed action which is considered likely to result in a 'significant' impact upon threatened species and ecological communities identified by the DoEE as Matters of National Environmental Significance (MNES), should be referred to the Commonwealth Department of Environment and Energy.

In accordance with the provisions of the EPBC Act, the proponent will consider whether potential future impacts to MNES habitat within the site will require referral to the Department of Environment and Energy, prior to any clearing being undertaken within the site to facilitate future urban development proposed in the structure plan.

4 Environmental Assessment and Management Strategy

This section outlines any layout considerations within the structure plan to respond to environmental attributes and values within the site, and any future environmental management requirements that will need to be accommodated within future planning and development stages. Only those environmental values and attributes that require specific consideration based on their presence within the site, and/or the applicable legislation and policy requirements have been included in this section.

4.1 Acid sulfate soils

4.1.1 Policy framework, site context and management objectives

The Department of Water and Environmental Regulation (DWER), through the WAPC, ensures ASS are adequately managed during the land use planning and development process. The objective of the DWER's ASS policy framework is to manage ASS appropriately to prevent the release of metals, nutrients and acidity into the soil and groundwater system that may adversely affect the natural and built environment and human health.

No site-specific investigations have occurred within the site previously. However, the regional mapping produced by DWER indicates that the site is located within an area that is identified as a 'moderate – low' threat of ASS occurring within 3 m of the natural soil surface.

The principal management objective for acid sulfate soils within the site is to ensure that any future development that may disturb acid sulfate soils is appropriately managed to avoid impacts on the environment.

4.1.2 Structure plan layout considerations for acid sulfate soils

ASS management does not require any spatial consideration within the structure plan, and any ASS risk can be appropriately managed in future planning stages.

4.1.3 Future acid sulfate soils management requirements

Where relevant, the WAPC includes a standard condition relating to ASS management on subdivision approvals (model subdivision condition EN8, WAPC 2019) which states:

An acid sulphate soils self-assessment form and, if required as a result of the self-assessment an acid sulphate soils report and an acid sulphate soils management plan shall be submitted to and approved by the Department of Water and Environmental Regulation (DWER) before any subdivision works or development are commenced.

Where an acid sulphate soils management plan is required to be submitted, all subdivision works shall be carried out in accordance with the approved management plan (Department of Water and Environmental Regulation).

Given the depth to groundwater within the site, ASS investigations and management considerations for the site are unlikely to be required at subdivision. However, this will be determined at future development stages. If further assessment is required, this is likely to require the preparation of an Acid Sulfate Soil and Dewatering Management Plan (ASSDMP).

4.2 Flora and vegetation

4.2.1 Policy framework, site context and management objectives

In the context of environmental impact assessment, the EPA objective for flora and vegetation is '*to protect flora and vegetation so that biological diversity and ecological integrity are maintained*'. Where a proposal may potentially impact upon flora and vegetation values, the following mitigation hierarchy should be applied to minimise potential impacts:

1. **Avoid** impacts.
2. **Minimise** impacts.
3. **Offset** impacts.

Whilst portions of the site are completely cleared of vegetation, some portions of intact vegetation remain in the north-western, north-eastern and south-eastern portions of the site. These areas of intact vegetation are identified as being representative of the banksia woodland TEC. The vegetation within the site is small in area, and varies in condition from 'very good' to 'degraded', with areas of better-quality banksia woodland TEC vegetation located to the immediate east of the site, and in the broader area to the west and south of the site.

Opportunities to facilitate the retention of vegetation within the site are limited due to bulk earthworks requirements, given the variable topography of the site and adjacent land parcels.

4.2.2 Structure plan layout considerations for flora and vegetation

No specific spatial response to the existing vegetation within the site has been provided for in the structure plan.

4.2.3 Future flora and vegetation management requirements

Opportunities to retain vegetation or trees within the site (and specifically within public open space) are unlikely to be feasible due to earthworks requirements. However, any such opportunities will be considered as part of the detailed civil design process, to determine if they are possible and practical.

This will also likely be required to address future subdivision approval conditions, specifically model subdivision condition EN2 (WAPC 2019), which requires:

Measures being taken to ensure the identification and protection of any vegetation on the site worthy of retention that is not impacted by subdivisional works, prior to commencement of subdivisional works. (Local Government)

Should bulk earthworks or any other works be commenced within the site that requires clearing of native vegetation before subdivision approvals are gained, a clearing permit pursuant to Part V of the EP Act will be required. Otherwise, subdivision approval and associated authorised subdivision works

will provide an exemption from the requirements for a clearing permit. In addition, the requirements of the EPBC Act will need to be adhered to by the proponent of development, as discussed in **Section 3.3.2**.

4.3 Native fauna

4.3.1 Policy framework, site context and management objectives

In the context of environmental impact assessment, the EPA's objective for terrestrial fauna is *'to protect fauna so that biological diversity and ecological integrity are maintained'.* The application of the mitigation hierarchy should be applied to avoid or minimise impacts to terrestrial fauna where possible.

The EPBC Act also provides protection for listed 'threatened' species, including black cockatoos, which may potentially use habitat within the site. Any proposed action which is considered likely to result in a 'significant' impact upon these species, identified by the DoEE as Matters of National Environmental Significance (MNES), should be referred to the Commonwealth Department of Environment and Energy.

Based on the degraded condition of vegetation within the site, there are limited fauna habitat values remaining, restricted to areas of intact vegetation. One potential habitat tree with hollows has been identified within the site, however no roosting or breeding activity has been identified.

Opportunities to facilitate the retention of fauna habitat within the site are limited due to bulk earthworks requirements, given the variable topography of the site and adjacent land parcels.

4.3.2 Structure plan layout considerations for fauna

Due to the cleared and degraded nature of vegetation within the site, limited fauna habitat values exist. No specific spatial response to fauna habitat values within the site has been provided for in the structure plan.

4.3.3 Future terrestrial fauna management requirements

Given the limited fauna habitat values within the site it is unlikely that a formal Fauna Management Plan will be required for this site at the time of subdivision. However, in order to reduce the impact of future construction works on any fauna within the site standard civil construction fauna management measures are recommended. Depending on the need (based on the size and extent of civil construction works), these management measures can include:

- Pre-clearing inspection of trees with hollows to ensure that they are not being used by fauna.
- Use of a fauna spotter to direct and manage clearing works to avoid impacts to fauna wherever possible and to rescue trans-locatable fauna that are disturbed during clearing works to assist them to disperse safely or capture them for later translocation as appropriate.
- Application of correct fauna handling procedures to reduce stress on any captured animals.

Given development of site will likely involve impacts to potential habitat for black cockatoos listed under the EPBC Act, the requirements of the EPBC Act will need to be adhered to by the proponent of development, as discussed in **Section 3.3.2**.

4.4 Hydrology

4.4.1 Policy framework, site context and management objectives

In the context of environmental impact assessment, the EPA's objective for inland waters is *'to maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected'.*

Due to the lack of existing sensitive receptors in the site, the principal management objective for hydrology in the site is to ensure that groundwater and surface water is appropriately infiltrated and treated so as to not impact on the broader area.

4.4.2 Structure plan layout considerations for hydrology

A Local Water Management Strategy (LWMS) has been prepared by BPA Engineering (2019) to support the preparation of the structure plan, and provides a framework for the future delivery of a best practice approach to integrated water cycle management utilising WSUD principles. The structure plan has been designed to accommodate the stormwater management requirements outlined in the LWMS.

4.4.3 Future hydrology management requirements

The LWMS provides for the environmental management framework for groundwater and surface water within the site.

It is anticipated that environmental condition D2 of the WAPC's *Model Subdivision Conditions Schedule* 2019 will be attached to all subdivision approvals, requiring the preparation of an Urban Water Management Plan (UWMP) which states:

Prior to the commencement of subdivisional works, an urban water management plan is to be prepared and approved, in consultation with the Department of Water, consistent with any approved Local Water Management Strategy. (Local Government).

Generally, an UWMP will address the following considerations:

- The detailed drainage design.
- Imported fill specifications and requirements.
- Implementation of water conservation strategies.
- Non-structural water quality improvement measures.
- Management and maintenance requirements.
- Construction period management strategy.
- Monitoring and evaluation program.
- Status of groundwater abstraction license.

5 Implementation

A summary of how the structure plan responds to the environmental values and attributes within the site is provided in **Table 3**. The table also outlines the proposed management strategy that will inform the subdivision and development process.

Table 3: Environmental management strategy implementation table

Factor	Structure plan phase (completed)	Subdivision phase	Part of development works
Acid sulfate soils	• Consider ASS Risk mapping published by DWER. No spatial response in LSP required.	• Completion of ASS self-assessment for and preparation of an Acid Sulfate Soil and Dewatering Management Plan, if required.	• Implementation of an Acid Sulfate Soil and Dewatering Management Plan, if required
Native vegetation:	• Assessment of flora and vegetation values and preliminary consideration of potential retention opportunities.	• Detailed analysis of final subdivision layout and bulk earthworks requirements to determine potential retention opportunities. • Consideration of potential requirement for Clearing Permit and/or EPBC Act referral.	• If areas of retention are proposed, accommodate these as part of construction and landscaping works.
Native fauna	• Assessment of fauna habitat and preliminary consideration of potential retention opportunities.	• Detailed analysis of final subdivision layout and bulk earthworks requirements to determine potential habitat retention opportunities. • Preparation of a Fauna Management Plan, if required.	• If areas of retention are proposed, accommodate these as part of construction and landscaping works. • Implementation of pre-clearance checks to ensure fauna is not present within the site. • Implementation of fauna management actions, if required.
Hydrology	• Preparation of a Local Water Management Strategy.	• Preparation of an Urban Water Management Plan.	• Implementation of the UWMP.

6 Conclusions

Rowe Group, on behalf of the Glenbrook Civil, has prepared the Lot 50 (No. 193) Barfield Road Local Structure Plan which outlines the proposed urban development of the site (see **Appendix A**). This EAMS has been prepared to support the Local Structure Plan, together with:

- Local Water Management Strategy (BPA Engineering 2019)
- Bushfire Management Plan (Emerge Associates 2019).

The LSP design has responded to site-specific environmental considerations where necessary and possible, including accommodation of stormwater management requirements consistent with the LWMS. The LSP design does not specifically provide for the future retention of existing flora, vegetation or fauna habitat values, due to the determined significance of these values through detailed surveys and also given the bulk earthworks requirements to facilitate future residential development, which limit any such opportunities.

This document provides an environmental management strategy to be implemented across the site for future subdivision and development stages. The key components of this management strategy are summarised as follows:

- Acid sulfate soils: completion of an ASS self-assessment form and if necessary, the preparation of an Acid Sulfate Soil and Dewatering Management Plan (ASSBDMP). However, given the high clearance to groundwater, ASS investigations and management measures are considered unlikely to be ultimately required.
- Native vegetation: completing a detailed analysis of the final development design and bulk earthworks requirements, to confirm any potential retention opportunities. Where clearing of vegetation is proposed, a clearing permit will need to be attained pursuant to Part V of the *Environmental Protection Act 1986* (unless a valid exemption applies) and the potential requirement for an EPBC Act referral will need to be considered.
- Native fauna: completing a detailed analysis of the final development design and bulk earthworks requirements, to confirm any potential retention opportunities. Where clearing of potential black cockatoo habitat is proposed, the potential requirement for an EPBC Act referral will need to be considered. Fauna management protocols and actions will also need to be implemented prior to and during clearing activities, potentially through implementation of a Fauna Management Plan.
- Hydrology: preparation of an Urban Water Management Plan (UWMP) for each stage of future subdivision.

Overall, the environmental attributes and values of the site can be suitably accommodated within the structure plan design, or can be appropriately managed through the future subdivision and development phases in line with the relevant state and local government legislation, policies and guidelines and best management practices.

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Figures

Figure 1: Site Locality

Project:	Environmental Assessment and Management Strategy Lot 50 Barfield Road, Hammond Park
Client:	Glenbrook Civil

Plan Number:
EP18-043(04)--F10

Drawn:	KNM
Date:	24/06/2019
Checked:	ADB
Approved:	ALB
Date:	04/07/2019

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Scale: 1:4,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

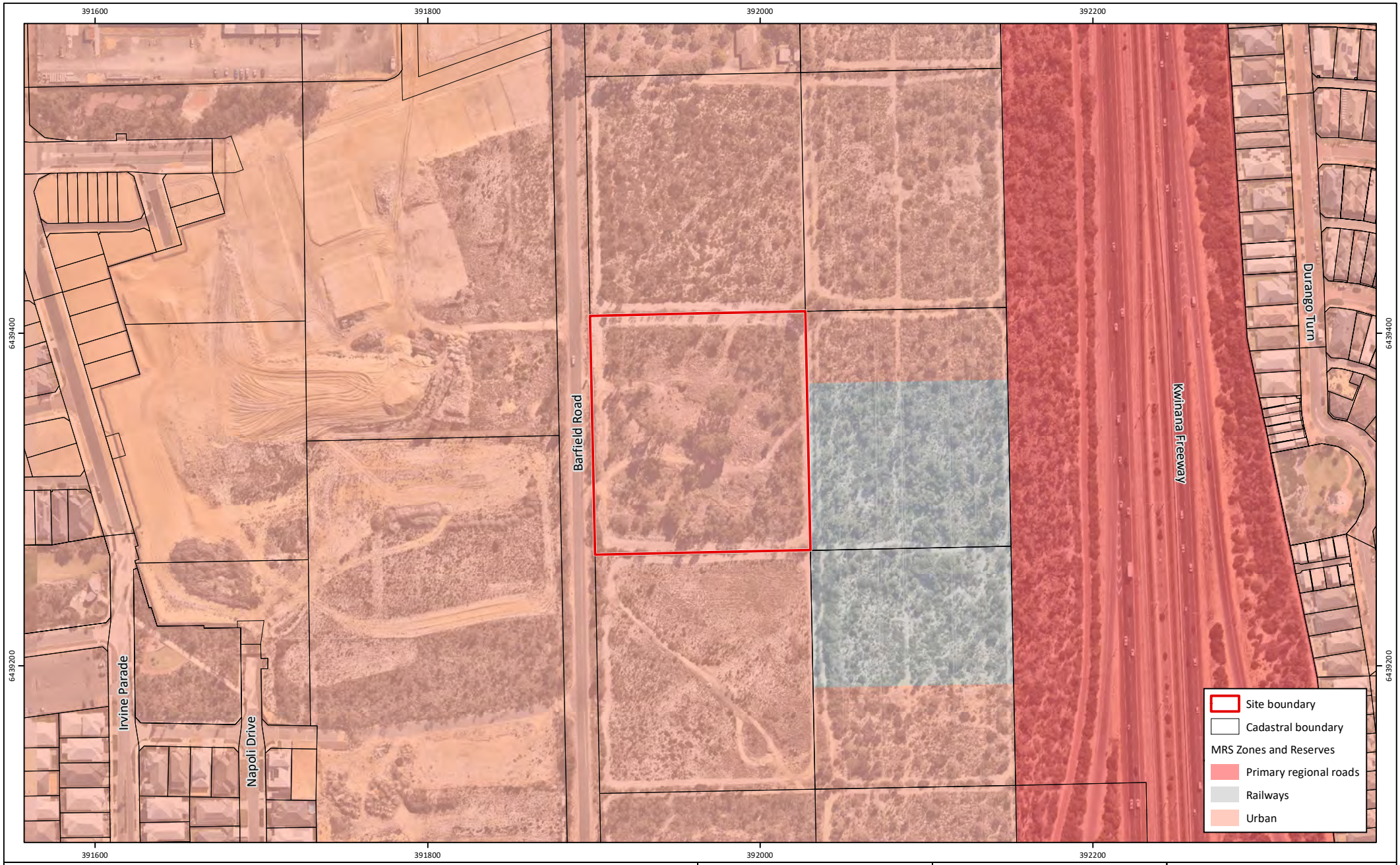

Figure 2: MRS Zones and Reserves

Project: Environmental Assessment and Management Strategy
Lot 50 Barfield Road, Hammond Park
Client: Glenbrook Civil

Plan Number:
EP18-043(04)--F11
Drawn: KNM
Date: 24/06/2019
Checked: ADB
Approved: ALB
Date: 04/07/2019

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Metres
Scale: 1:3,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

Figure 3: Topographic Contours

Project:	Environmental Assessment and Management Strategy Lot 50 Barfield Road, Hammond Park
Client:	Glenbrook Civil

Plan Number:
EP18-043(04)--F12

Drawn:	KNM
Date:	24/06/2019
Checked:	ADB
Approved:	ALB
Date:	04/07/2019

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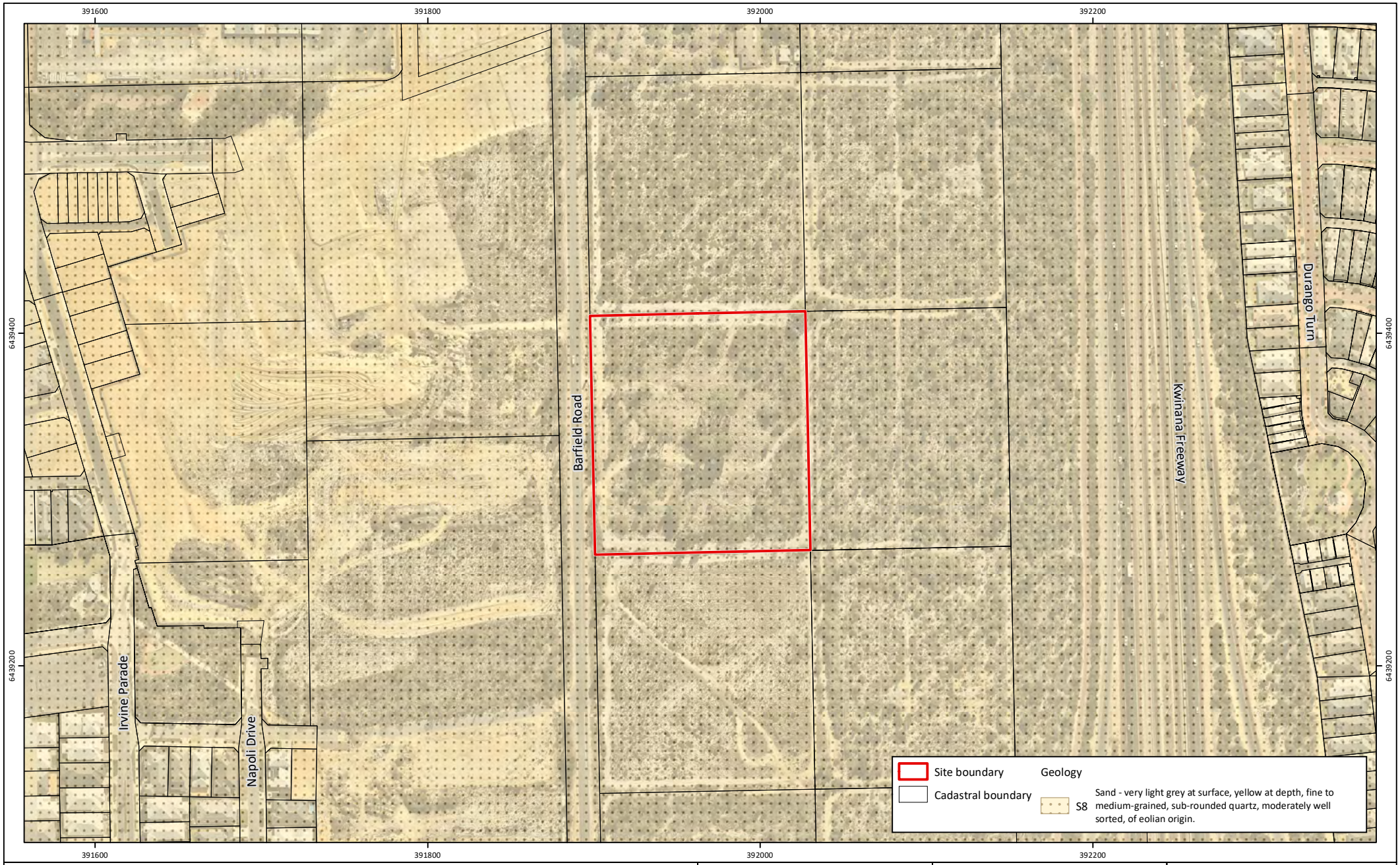

Figure 4: Environmental Geology

Project:	Environmental Assessment and Management Strategy Lot 50 Barfield Road, Hammond Park
Client:	Glenbrook Civil

Plan Number:
EP18-043(04)--F13

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Date:	24/06/2019
Checked:	ADB
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Date:	04/07/2019

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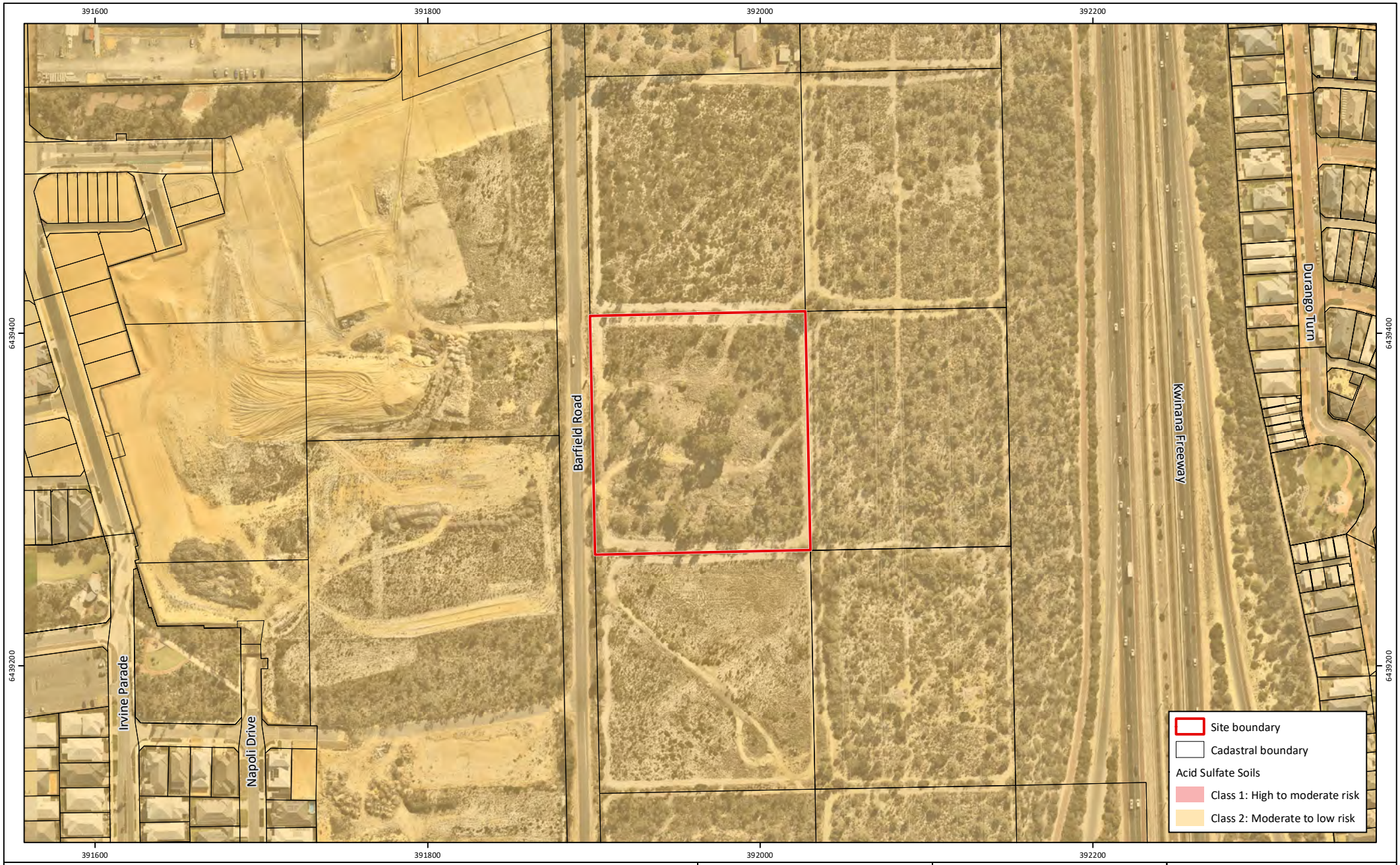

Figure 5: Acid Sulfate Soil Mapping

Project: Environmental Assessment and Management Strategy
Lot 50 Barfield Road, Hammond Park
Client: Glenbrook Civil

Plan Number:
EP18-043(04)--F14
Drawn: KNM
Date: 24/06/2019
Checked: ADB
Approved: ALB
Date: 04/07/2019

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Metres
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GDA 1994 MGA Zone 50

emerge ASSOCIATES

Figure 6: Vegetation Communities and Potential Breeding Habitat Trees

Project: Environmental Assessment and Management Strategy
Lot 50 Barfield Road, Hammond Park
Client: Glenbrook Civil

Plan Number:
EP18-043(04)--F15
Drawn: KNM
Date: 24/06/2019
Checked: ADB
Approved: ALB
Date: 04/07/2019

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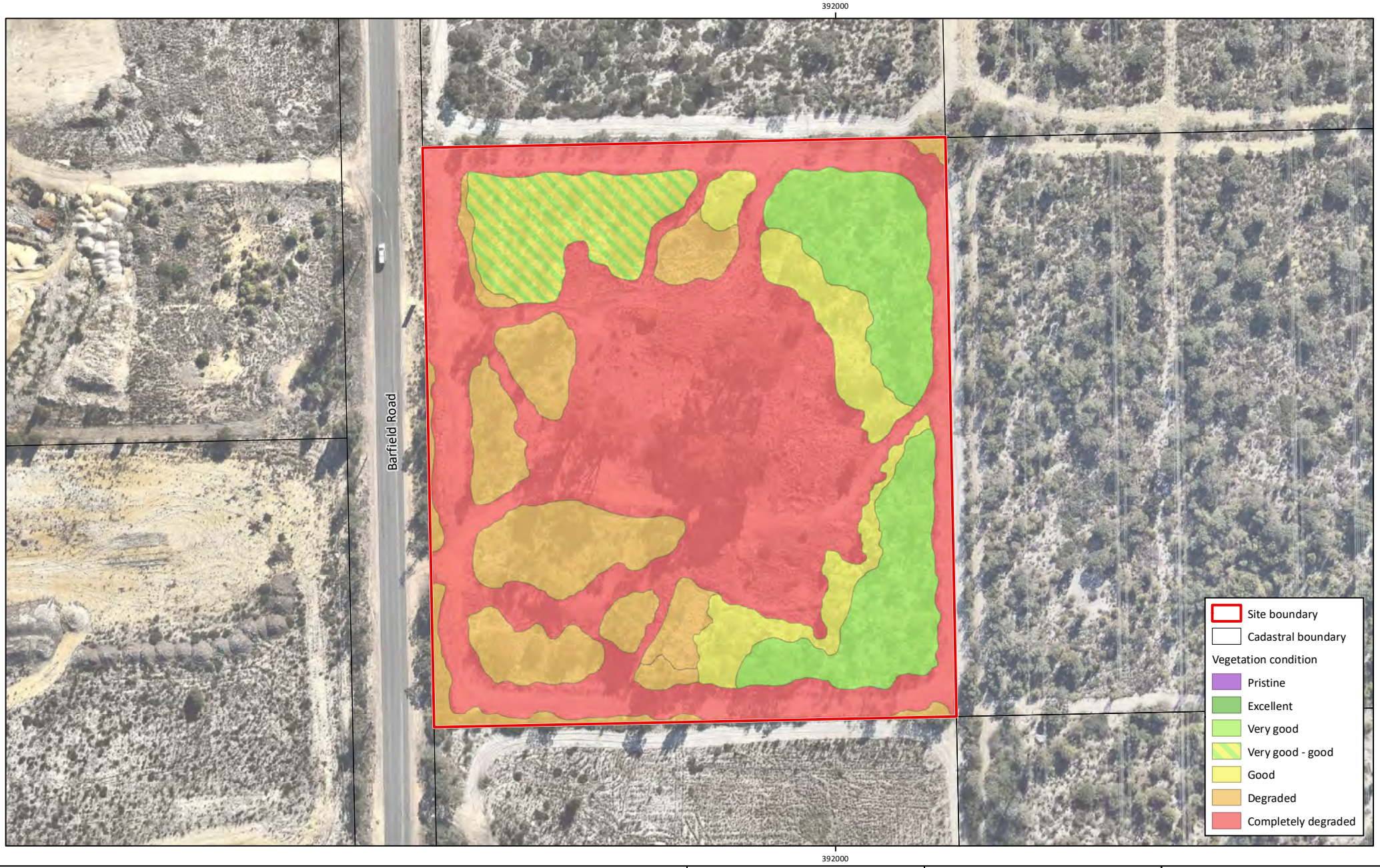

Figure 7: Vegetation Condition

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Lot 50 Barfield Road, Hammond Park
Client: Glenbrook Civil

Plan Number:
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Date: 24/06/2019
Checked: ADB
Approved: ALB
Date: 04/07/2019

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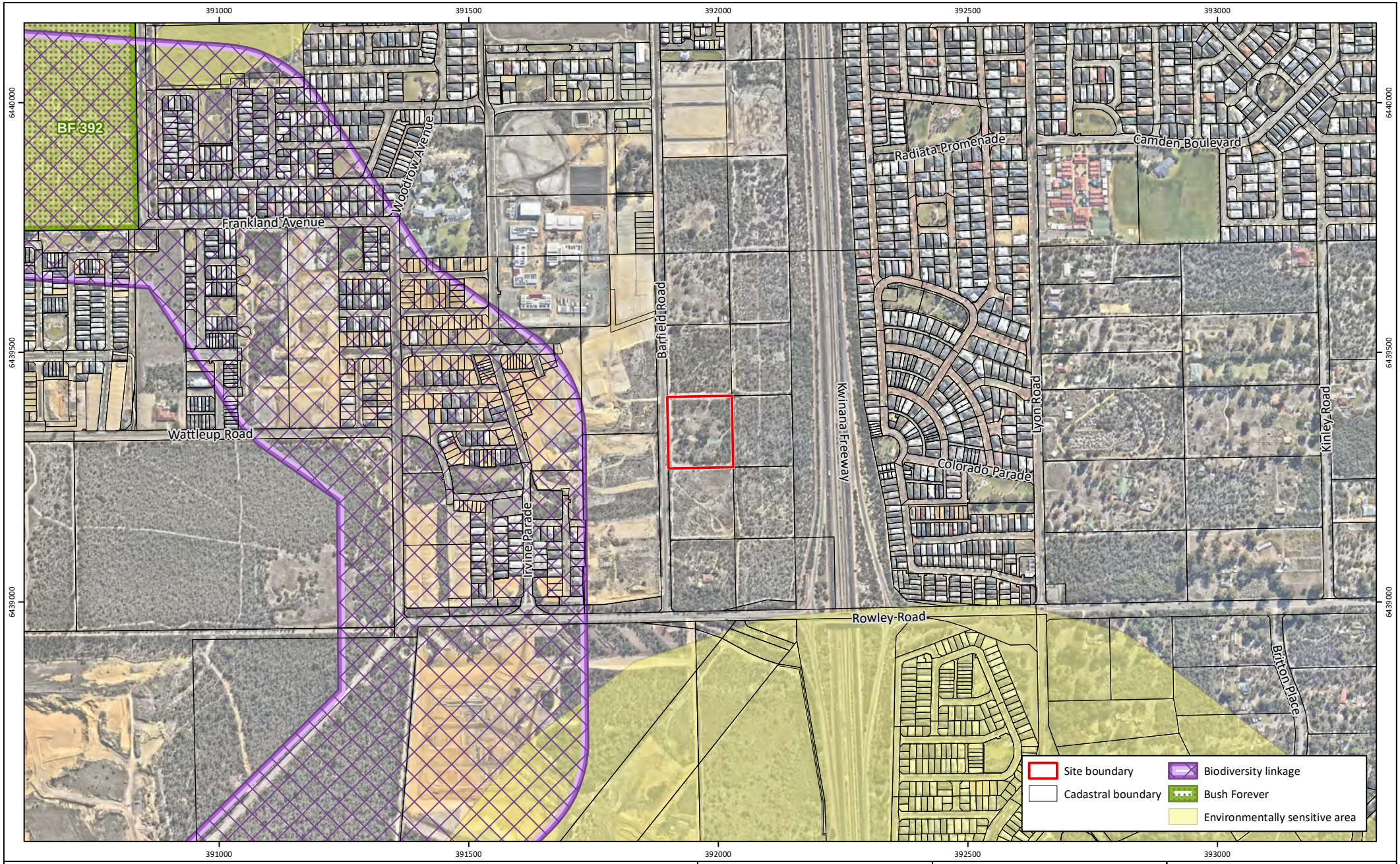

Figure 8: **Bush Forever, Environmentally Sensitive Areas and Regional Ecological Linkages**

Project: Environmental Assessment and Management Strategy
Lot 50 Barfield Road, Hammond Park
Client: Glenbrook Civil

Plan Number:
EP18-043(04)--F17
Drawn: KNM
Date: 24/06/2019
Checked: ADB
Approved: ALB
Date: 04/07/2019

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emerge ASSOCIATES

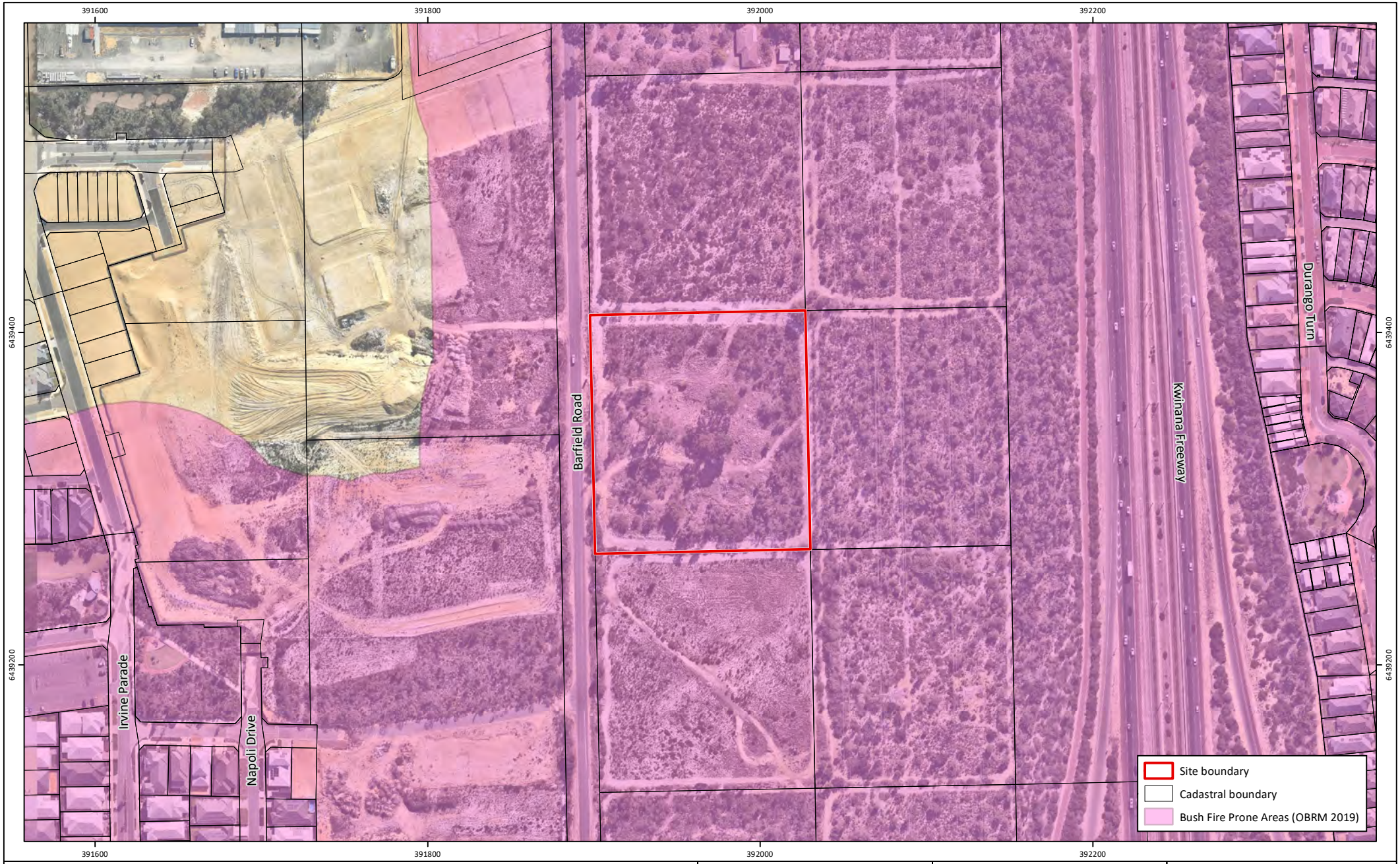

Figure 9: Bushfire Considerations

Project: Environmental Assessment and Management Strategy
Lot 50 Barfield Road, Hammond Park
Client: Glenbrook Civil

Plan Number:
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Date: 24/06/2019
Checked: ADB
Approved: ALB
Date: 04/07/2019

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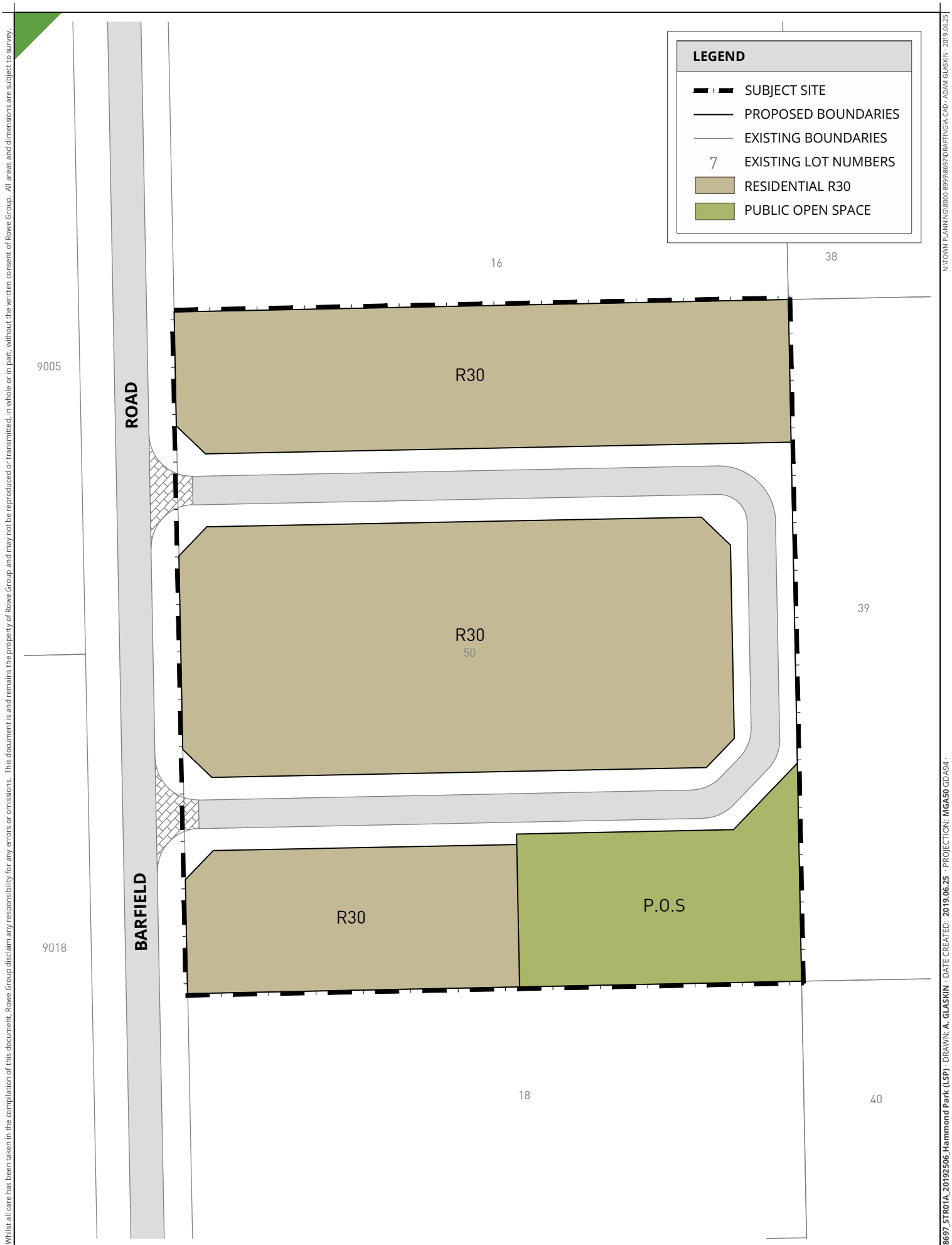
GDA 1994 MGA Zone 50

emerge ASSOCIATES

Appendix A

Lot 50 (No. 193) Barfield Road Local Structure Plan



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8697_STR01A_20192506_Hammond Park (LSP) · DRAWN: A. GLASKIN · DATE CREATED: 2019.06.25 · PROJECTION: MGA50 GDA94 ·

LOCAL STRUCTURE PLAN

LOT 50 (No. 193) BARFIELD ROAD
HAMMOND PARK

NORTH

0 25 m
SCALE @ A4: 1:1000

8697-STR-01-A

ROWE GROUP DESIGN

Appendix B

Detailed Flora and Vegetation Survey (Emerge Associates 2019)

Detailed Flora and Vegetation Survey

Lot 50 Barfield Road, Hammond Park

Project No: EP18-043(02)

Prepared for Glenbrook Civil
December 2018

Document Control

Doc name:	Detailed Flora and Vegetation Survey Lot 50 Barfield Road, Hammond Park				
Doc no.:	EP18-043(02)--005				
Version	Date	Author		Reviewer	
1	December 2018	Sarah Paul	SKP	Tom Atkinson	TAA
	Report for client review				

Executive Summary

Glenbrook Civil engaged Emerge Associates (Emerge) to undertake a detailed flora and vegetation survey within Lot 50 Barfield Road in Hammond Park (referred to herein as 'the site'). The site is approximately 1.86 ha in size and zoned 'urban' under both the Metropolitan Regional Scheme (MRS) and the City of Cockburn Town Planning Scheme No. 3 (TPS No. 3).

A botanist from Emerge Associates visited the site on 15 May and 28 September 2018 and undertook detailed flora and vegetation surveys. During the surveys an assessment was made on the type, condition and values of vegetation across the site.

Outcomes of the survey include the following.

- Historic disturbance has occurred across the site, including some vegetation clearing and the construction of a residence and associated structures.
- Non-native vegetation is present across 1.02 ha of the site.
- Remnant native vegetation is present across 0.84 ha of the site in varying levels of condition.
- A total of 87 native and 36 non-native (weed) species were recorded in the site.
- No threatened or priority flora species were recorded.
- The native vegetation within the site was classified as plant community **BaBm,** that is present in 'very good', 'very good to good', 'good' and 'degraded' condition. Plant community **BaBm** showed high similarity to a number of 'floristic community types' (FCTs) but was considered most likely to represent FCT 23a 'Central *Banksia attenuata – B. menziesii* woodlands'.
- The previously disturbed areas containing non-native and planted vegetation are in 'completely degraded' condition and too degraded to assign to an FCT.
- Based on the relevant criteria, the plant community **BaBm** represents the 'banksia woodlands of the Swan Coastal Plain' threatened ecological community, which is listed as 'endangered' under the *Environment Protection and Biodiversity Conservation Act 1999*. The 0.84 ha of banksia woodland within the site connects to a larger patch of banksia woodland located directly to the east of the site and extending to the north and south. The **BaBm** community also represents the State listed priority ecological community 'banksia dominated woodlands of the Swan Coastal Plain IBRA region'.

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Abbreviation Tables

Table A1: Abbreviations – Organisations

Organisations	
EPA	Environmental Protection Authority
DBCA	Department of Biodiversity, Conservation and Attractions
DoW	Department of Water (now DWER)
DWER	Department of Water and Environmental Regulation
DPaW	Department of Parks and Wildlife (now DBCA)
WALGA	Western Australia Local Government Association

Table A2: Abbreviations – General terms

General terms	
CCW	Conservation category wetland
ESA	Environmentally sensitive area
FCT	Floristic community type
IBRA	Interim Biogeographic Regionalisation of Australia
MUW	Multiple use wetland
NVIS	National Vegetation Inventory System (ESCAVI 2003)
P1	Priority 1
P2	Priority 2
P3	Priority 3
P4	Priority 4
P5	Priority 5
PEC	Priority ecological community
REW	Resource enhancement wetland
T	Threatened
TEC	Threatened ecological community
UFI	Unique feature identifier

Table A3: Abbreviations –Legislation

Legislation	
BAM Act	*Biosecurity and Agriculture Management Act 2007*
EP Act	*Environmental Protection Act 1986*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
WC Act	*Wildlife Conservation Act 1950*

Table A4: Abbreviations – planning

Planning terms	
MRS	Metropolitan region scheme
TPS	Town planning scheme

Table A5: Abbreviations – units of measurement

Units of measurement	
cm	Centimetre
ha	Hectare
m	Metre
m^2	Square metre
m AHD	m in relation to the Australian height datum
mm	Millimetre

1 Introduction

1.1 Project background

Rowe Group, on behalf of the landowner Glenbrook Civil, has prepared a local structure plan (LSP) for the future residential development of Lot 50 Barfield Road, Hammond Park (herein referred to as 'the site'). The site is located approximately 25 kilometres south of the Perth Central Business District, within the City of Cockburn (CoC) and is zoned 'urban' under the Metropolitan Regional Scheme (MRS) and 'urban' under the City of Cockburn Town Planning Scheme No. 3 (TPS No. 3).

The site is approximately 1.86 hectares (ha) in size and is bound by Barfield Road to the west, future urban development to the north and south and a Western Power easement and Kwinana Freeway to the east. The location and extent of the site is shown in **Figure 1.**

1.2 Purpose and scope of work

Emerge Associates (Emerge) were engaged by Glenbrook Civil to provide environmental consultancy services to support the structure planning process for the site. The purpose of this survey is to provide information on the flora and vegetation values within the site to inform this process.

The scope of work was specifically to undertake a flora and vegetation assessment to the standard required of a detailed survey in accordance with the Environmental Protection Authority's (EPA's) *Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA and DPaW 2015).

As part of this scope of work, the following tasks were undertaken:

- Desktop review of relevant background information pertaining to the site and surrounds, including database searches for threatened flora species and ecological communities.
- Compilation of a list of flora species recorded as part of the field survey.
- Mapping of plant communities and vegetation condition.
- Identification of conservation significant flora and vegetation.
- Documentation of the desktop assessment, survey methodology and results into a report.

2 Background

2.1 Environmental context

2.1.1 Climate

Climate has a strong influence on the types of vegetation that grow in a region and the life cycles of the flora present. It is therefore critical for a flora and vegetation survey to respond appropriately to climatic conditions to ensure that surveys are conducted during times when flora species are easiest to detect and identify.

The south west of Western Australia experiences a Mediterranean climate of hot dry summers and cool wet winters. In Mediterranean type climates some flora species will typically spend part of their life-cycle as either underground storage organs or as seed. This is an adaptation to unfavourable environmental conditions such as excessive heat and drought that occur over the summer period. These species, known as 'geophytes' or 'annuals', tend to re-emerge during winter when favourable conditions return and are most visible during spring, which is the flowering period for a majority of plant species. Therefore, spring is the optimal time to complete flora and vegetation surveys in the south west of WA.

An average of 745.5 millimetres (mm) of rainfall is recorded annually from the Medina Research Centre, which is the closest weather station, located approximately 7.5 km from Hammond Park. The majority of this rainfall is received between the months of May and August. Mean maximum temperatures at the Medina research station range from 18.3^{o}C in July to 31.5^{o}C in February, while mean minimum temperatures range from 8.2^{o}C in July and August to 17.6^{o}C in February (BoM 2017).

2.1.2 Geomorphology and soils

Landform and soils influence vegetation types at regional and local scales. The site occurs on the Swan Coastal Plain, which is the geomorphic unit that characterises much of the Perth metropolitan region.

The Swan Coastal Plain is approximately 500 km long and 20 to 30 km wide and is roughly bound by the Indian Ocean to the west and the Darling Scarp to the east. Broadly the Swan Coastal Plain consists of two sedimentary belts of different origin. Its' eastern side has formed from the deposition of alluvial material washed down from the Darling Scarp, while it's western side is comprised of three dune systems that run roughly parallel to the Indian Ocean coastline (Seddon 2004). These dune systems, referred to as Quindalup, Spearwood and Bassendean associations, represent a succession of coastal deposition that has occurred since the late Quaternary period (approximately two million years ago) (Kendrick *et al.* 1991) and, as a result, they contain soils at different stages of leaching and formation.

Examination of broad scale mapping places the site within the Bassendean association (Churchward and McArthur 1980). Finer scale mapping by Gozzard (2011) places the majority of the site in the 'Bassendean B1 Phase' land unit, which is broadly defined as 'extremely low to very low relief dunes, undulating sand plain and discrete sand rises with deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at depths greater than 2m'. A small section in the

south-west of the site is mapped as the 'Spearwood S1b Phase' land unit which is broadly defined as 'dune ridges with deep siliceous yellow brown sands or pale sands with yellow-brown subsoil and slopes up to 15%'.

The environmental geology of the site has been mapped by the Geological Survey of Western Australia (Gozzard 1986). The site consists of 'S8' sand which is described as 'white to pale grey at the surface, yellow at depth, fine to medium grained, moderately sorted sub-angular to sub-rounded, minor heavy minerals of eolian origin'.

During the survey the soils were recorded as a thin layer of light grey over brown sands, consistent with the Bassendean dune system. Due to its location, the site is likely somewhat transitional between the Bassendean and Spearwood dune systems. The site is not known to contain any restricted landforms or unique geological features.

2.1.3 Topography

The landform within the site has a south facing aspect, with elevation ranging from 27 m in relation to the Australian height datum (mAHD) in the south-east of the site up to 35 mAHD in the north-east corner of the site (DoW 2008) (**Figure 2**).

2.1.4 Hydrology and wetlands

Wetlands include "areas of seasonally, intermittently or permanently waterlogged soils or inundated land, whether natural or otherwise, fresh and saline, e.g. waterlogged soils, ponds, billabongs, lakes, swamps, tidal flats, estuaries, rivers and their tributaries" (Wetlands Advisory Committee 1977). Wetlands can further be recognised by the presence of vegetation associated with waterlogging or the presence of hydric soils such as peat, peaty sand or carbonate mud (Hill *et al*. 1996).

Wetlands of national or international significance may be afforded special protection under Commonwealth or international agreements. The following lists of important wetlands were checked as part of this assessment:

- *Ramsar List of Wetlands of International Importance* (DBCA 2017)
- *A Directory of Important Wetlands in Australia* (DBCA 2018a).

No Ramsar or listed 'important wetlands' are located within the site. The 'Forrestdale and Thomsons Lakes' Ramsar site is located 2.2 km to the north-west of the site. A portion of the 'Gibbs Road Swamp System' is located 370 m to the south of the site. This system is recognised as a large network of formerly extensive swamps covering 5800 ha but is highly disturbed throughout much of its area. The locations of the Ramsar and important wetlands near the site is shown on **Figure 2**.

Examination of the Department of Water and Environmental Regulation (DWER) hydrography dataset shows no wetland or water related features within the site.

On the Swan Coastal Plain the geomorphic wetland classification system of Semeniuk (1987) is used to classify wetlands based on the landform shape and water permanence (hydro-period). The Department of Biodiversity, Conservation and Attractions (DBCA) maintains the *Geomorphic Wetlands of the Swan Coastal Plain* dataset (DBCA 2018b), which further categorises geomorphic wetland features into specific management categories to guide land use and conservation. Note that

as this dataset was drafted at a regional scale the boundaries of mapped wetland features are often inconsistent with physical wetland boundaries. Further information on geomorphic wetland types and their management categories is provided in **Appendix A**.

A review of DBCA's *Geomorphic Wetlands of the Swan Coastal Plain* dataset indicated that no wetlands are located in or close to the site.

2.1.5 Regional vegetation

Native vegetation is described and mapped at different scales in order to illustrate patterns in its distribution. At a continental scale the *Interim Biogeographic Regionalisation of Australia* (IBRA) divides the Swan Coastal Plain into two floristic subregions (Environment Australia 2000). The site is contained within the 'SWA02' or Perth subregion, which is characterised as mainly containing *Banksia* low woodland on leached sands with *Melaleuca* swamps where ill-drained; and woodland of *Eucalyptus gomphocephala* (tuart), *E. marginata* (jarrah) and *Corymbia calophylla* (marri) on less leached soils (Beard 1990). This subregion is recognised as a biodiversity hotspot and contains a wide variety of endemic flora and vegetation types.

Variations in native vegetation within the site can be further classified based on regional vegetation associations. Beard *et al.* (2013) mapping shows the site as comprising vegetation association 'Bassendean_1001'. This association is described as 'medium very sparse woodland; jarrah, with low woodland; banksia & casuarina' (Beard *et al.* 2013). The Bassendean_1001 association has 22.3 % of its pre-European extent remaining on the Swan Coastal Plain with 2.8 % protected for conservation purposes (Government of Western Australia 2018).

Heddle *et al.* (1980) mapped the site as comprising the 'Bassendean central and south complex', which is described as vegetation ranging from woodland of *Eucalyptus marginata - Allocasuarina fraseriana - Banksia* spp. to low woodland of *Melaleuca* spp. and sedgelands on the moister sites. This complex was determined to have 27.7% remaining in 2013 (PBP 2013), of which 2.6 % is under formal protection.

Studies have indicated that the loss of biodiversity caused by habitat fragmentation is significantly greater once a habitat type falls below 30% of its original extent (Miles 2001). The national objectives and targets for biodiversity conservation (Environment Australia 2001) established an objective of retaining 30% of the original extent of each vegetation complex. However, a lower objective of 10% is applied in 'constrained urban areas' such as the Swan Coastal Plain (Ministry for Planning 1995). The percentage protected for conservation of both the 'Bassendean_1001' association and the 'Bassendean central and south complex' fall below the 30% retention objective but above the 10% retention objective.

2.1.6 Historic land use

Review of historical images available from 1953 (WALIA 2018) onwards, shows that the majority of the site was largely undisturbed prior to 1985. Between 1983-1985 a residence was built in the western portion of the site. The remainder of the site was maintained as native vegetation. By 1995 the south-western corner and additional areas in the western half adjacent to the dwelling were cleared. Clearing surrounding the dwelling was continued in 2016, and the dwelling was removed by September 2016.

2.2 Significant flora and vegetation

2.2.1 Threatened and priority flora

Certain flora taxa that are considered to be rare or under threat warrant special protection under Commonwealth and/or State legislation. At a Commonwealth level, flora taxa may be listed as 'threatened' pursuant to Schedule 1 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Any action likely to have a significant impact on a taxon listed under the EPBC Act requires approval from the Commonwealth Minister for the Environment and Energy.

In Western Australia flora species may also be classed as 'threatened' under the *Wildlife Conservation Act 1950* (WC Act). Threatened flora species are gazetted under subsection 2 of section 23F of the WC Act and it is an offence to "take" or damage rare ('threatened') flora without Ministerial approval.

Flora species that do not currently meet the criteria for listing as threatened but are potentially rare or threatened may be added to the DBCA's *Priority Flora List*. These species are classified into 'priority' levels based on level of threat. Whilst priority species are not under direct statutory protection, they are considered during State approval processes.

Further information on threatened and priority species and their categories is provided in **Appendix A**.

A search was conducted for threatened and priority flora within a 10 km radius of the site using the *Protected Matters Search Tool* (DoEE 2018a), *NatureMap* (DBCA 2018) and DBCA's threatened and priority flora database (reference no. 03-0714FL). Nine threatened and 19 priority flora species were identified as potentially occurring in the wider local area as listed in **Table 1**. None of the records were located within or near the site.

Of the flora species potentially occurring in the local area, only those with habitat preferences of dry elevated sandy soils and were deemed likely to occur in the site.

On this basis three threatened flora species (*Caladenia huegelii, Drakaea elastica* and *Drakaea micrantha*) and four priority flora species (Austrostipa mundula (P2), *Phlebocarya pilosissima* subsp. *pilosissima* (P3), *Thelymitra variegata* (P3) and *Dodonaea hackettiana* (P4)) were identified as having potential to occur within the site (shaded green in **Table 1**).

Table 1: Significant flora species known or likely to occur within 10 km of the site

Species	Level of significance		Life strategy	Habitat	Flowering period	Likelihood of occurrence
	State	EPBC Act				
Andersonia gracilis	T	E	P	White/grey sand, sandy clay, gravelly loam. Winter-wet, near swamps.	Sept-Nov	Unlikely
Caladenia huegelii	T	E	PG	Grey or brown sand, clay loam.	Sept-Oct	Possible
Centrolepis caespitosa	T	E	A	White sand, clay.	Oct-Dec	Unlikely
Darwinia foetida	T	CE	P	Peaty, sandy clay.	Oct-Nov	Unlikely
Diuris micrantha	T	V	PG	Brown loamy clay.	Sept-Oct	Unlikely
Diuris purdiei	T	E	PG	Grey-black sand, moist.	Sept-Oct	Unlikely
Drakaea elastica	T	E	PG	White or grey sand.	Oct-Nov	Possible
Drakaea micrantha	T	V	PG	White-grey sand.	Sept-Oct	Possible
Lepidosperma rostratum	T	E	P	Peaty sand, clay.	May-Aug	Unlikely
Acacia lasiocarpa var. bracteolata long peduncle variant (G.J. Keighery 5026)	P1	-	P	Grey or black sand over clay. Swampy areas, winter wet lowlands.	May or Aug	Unlikely
Austrostipa mundula	P2	-	P	Sands often over limestone. Plains, coastal dunes and cliffs.	(Aug) Sep-Oct (Nov)	Possible
Byblis gigantea	P3	-	P	Sandy-peat swamps. Seasonally wet areas.	Sep-Dec (Jan)	Unlikely
Cyathochaeta teretifolia	P3	-	P	Grey sand, sandy clay. Swamps, creek edges.	Sep-Jan	Unlikely
Jacksonia gracillima	P3	-	P	Grey/brown/black sand, loam and clays. Dry flats, winter wet swamps (or adjacent to).	(Jun) Oct-Nov	Unlikely
Phlebocarya pilosissima subsp. *pilosissima*	P3	-	P	White or grey sand, lateritic gravel.	Aug-Oct	Possible
Pimelea calcicola	P3	-	P	Sand. Outcropping limestone.	Sept-Nov	Unlikely
Pithocarpa corymbulosa	P3	-	P	Gravelly or sandy loam. Amongst granite outcrops.	Jan-Apr	Unlikely
Stylidium longitubum	P3	-	A	Sandy clay, clay. Seasonal wetlands.	Oct-Dec	Unlikely
Stylidium paludicola ms	P3	-	P	Peaty sand over clay. Winter wet habitats. Marri and Melaleuca woodland, Melaleuca shrubland.	Oct-Dec	Unlikely
Thelymitra variegata	P3	-	Pg	Sandy clay, sand, laterite.	Jun-Sep	Possible
Aponogeton hexatepalus	P4	-	A	Mud. Freshwater: ponds, rivers, claypans.	Jul-Oct	Unlikely

Table 1: Significant flora species known or likely to occur within 10 km of the site (cont.)

Species	Level of significance		Life strategy	Habitat	Flowering period	Likelihood of occurrence
	State	EPBC Act				
Dodonaea hackettiana	P4	-	P	Sand.	Jul-Oct	Possible
Grevillea olivacea	P4	-	P	White or grey sand. Coastal dunes, limestone rocks.	Jun-Sep	Unlikely
Microtis quadrata	P4	-	Pg	Peaty sands, clays and loams. Wet flat, swamps, water on surface common.	Oct-Dec	Unlikely
Stylidium ireneae	P4	-	P	Sandy loam. Valleys near creek lines, woodland, often with Agonis.	Oct-Dec	Unlikely
Tripterococcus paniculatus	P4	-	P	Grey, black or peaty sand. Winter-wet flats.	Oct-Nov	Unlikely
Verticordia lindleyi subsp. Lindleyi	P4	-	P	Sand, sandy clay. Winter-wet depressions.	May or Nov-Dec (Jan)	Unlikely

Note: T=threatened, CE=critically endangered, E=endangered, V=vulnerable, P1=Priority 1, P2=Priority 2, P3=Priority 3, P4=Priority 4, P=perennial, PG=perennial geophyte, A=annual. Species considered to potentially occur within the site are shaded green.

2.2.2 Threatened and priority ecological communities

An ecological community is a naturally occurring group of native plants, animals and other organisms that are interacting in a unique habitat. An ecological community's structure, composition and distribution are determined by environmental factors such as soil type, position in the landscape, altitude, climate and water availability (DoEE 2018b). 'Threatened ecological communities' (TECs) are ecological communities that are recognised as rare or under threat and therefore warrant special protection.

Selected TECs are afforded statutory protection at a Commonwealth level under section 181 of the EPBC Act. Any action likely to have a significant impact on a community listed under the EPBC Act requires approval from the Commonwealth Minister for the Environment and Energy. TECs are also listed within Western Australia but are currently are not afforded direct statutory protection at a State level. Nonetheless their significance is acknowledged through other State environmental approval processes such as 'environmental impact assessment' pursuant to Part IV of the *Environmental Protection Act 1986* (EP Act) and the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*.

A plant community that is under consideration for listing as a TEC in Western Australia, but does not yet meet survey criteria or has not been adequately defined, may be listed as a 'priority ecological community' (PEC). Listing as a PEC is similarly considered during State approval processes. Further information on categories of TECs and PECs is provided in **Appendix A**.

Known locations of TECs and PECs within 10 km of the site were searched for using the publicly available *Weed and native flora dataset* (Keighery *et al.* 2012), *Protected Matters Search Tool* (DoEE 2018) and DBCA's threatened and priority ecological communities' databases. These search results

indicate no TECs or PECs are known to occur within the site, but that ten TECs and PECs occur within 10 km of the site as listed in **Table 2**.

Table 2: TECs and PECs known to occur within 10 km of the site.

Code	Community name	TEC/PEC	Level of significance	
			State	EPBC Act
SCP 19b	Woodlands over sedgelands in Holocene dune swales of the southern Swan Coastal Plain	TEC	Critically Endangered	Endangered
Mound Springs SCP	Communities of Tumulus Springs (Organic Mound Springs, Swan Coastal Plain)	TEC	Critically Endangered	Endangered
SCP 26a	*Melaleuca huegelii-Melaleuca acerosa* (currently *M. systena*) shrublands on limestone ridges	TEC	Endangered	-
SCP 10a	Shrublands on dry clay flats	TEC	Endangered	-
SCP 08	Herb rich shrublands in clay pans	TEC	Vulnerable	-
SCP 30a	*Callitris preissii* (or *Melaleuca lanceolata*) forests and woodlands, Swan Coastal Plain	TEC	Vulnerable	-
SCP 21c	Low lying *Banksia attenuata* woodlands or shrublands	TEC/PEC	Priority 3	Endangered (Banksia woodlands of the Swan Coastal Plain)
SCP 22	*Banksia ilicifolia* woodlands	TEC/PEC	Priority 3	
FCT 23a	Central *Banksia attenuata – B. menziesii* woodlands	TEC/PEC	Priority 3	
SCP 24	Northern Spearwood shrublands and woodlands	TEC/PEC	Priority 3	
FCT 28	Spearwood *Banksia attenuata* or *Banksia attenuata – Eucalyptus* woodlands	TEC/PEC	Priority 3	
SCP 25	Southern *Eucalyptus gomphocephala-Agonis flexuosa* woodlands	PEC	Priority 3	-

*Communities considered to be potentially present within the site shaded green.

The following communities are considered to potentially occur in the site, based geomorphology, soils and regional vegetation patterns:

- 'banksia woodlands of the Swan Coastal Plain' TEC (endangered under EPBC Act). This TEC includes SCP 21c, SCP 22, FCT 23a, SCP 24 and FCT 28, as listed in **Table 2**.
- 'banksia dominated woodlands of the Swan Coastal Plain IBRA region' PEC. This PEC includes SCP 21c, SCP 22, FCT 23a, SCP 24 and FCT 28, as listed in **Table 2**.

2.2.3 Local and regional significance

Flora species and ecological communities may be significant for a number of reasons irrespective of whether they have special protection under policy or legislation.

One key reason that vegetation within the site may be significant is the vegetation has potential value as habitat for threatened or priority fauna species including, in particular, Carnaby's black cockatoo and the forest red-tailed black cockatoo, which are listed as 'endangered' and 'vulnerable' respectively under the EPBC Act and 'endangered' under the WC Act (DoEE 2012).

2.2.4 Weeds

The term 'weed' can refer to any plant that requires some form of action to reduce its effect on the economy, the environment, human health and amenity. Many non-native flora species and some native species are considered to be weeds.

A particularly invasive or detrimental weed species may be listed as a 'declared pest' pursuant to the Western Australia's *Biosecurity and Agriculture Management Act 2007* (BAM Act), indicating that it warrants special management to limit its spread. Further information on categories of declared pests is provided in **Appendix A.**

Due to historical disturbance weed species are expected to be present at the site.

2.3 Land use planning considerations

A range of legislation, regulations and polices are relevant to the evaluation of vegetation in Western Australia. Key considerations applicable to the site are described below and also shown in **Figure 2.**

2.3.1 Bush Forever

The Government of Western Australia's *Bush Forever* policy is a strategic plan for conserving regionally significant bushland within the Swan Coastal Plain portion of the Perth Metropolitan Region. The objective of *Bush Forever* is to protect comprehensive representations of all original ecological communities by targeting a minimum of 10% of each vegetation complex for protection (Government of WA 2000). *Bush Forever* sites are representative of regional ecosystems and habitat and have a key role in the conservation of Perth's biodiversity.

No *Bush Forever* sites occur within the site. Bush Forever Site Number 392 - *Harry Waring Marsupial Reserve, Wattleup* is located approximately 1.1 kilometres to the north-west. The location of Bush Forever Site 392 is shown in **Figure 2.**

2.3.2 Environmentally sensitive areas

'Environmentally sensitive areas' (ESAs) are prescribed under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* and have been identified to protect native vegetation values of areas surrounding significant, threatened or scheduled flora, vegetation communities or ecosystems. Within an ESA none of the exemptions under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* apply. However, exemptions under Schedule 6 of the EP Act still apply, including any clearing in accordance with a subdivision approval under the *Planning and Development Act 2005* (a recognised exemption under the Schedule 6 of the EP Act).

No ESAs have been mapped across the site.

2.3.3 Ecological linkages

Ecological linkages are linear landscape elements that allow the movement of fauna, flora and genetic material between areas of remnant habitat. The movement of fauna and the exchange of genetic material between vegetation remnants improve the viability of those remnants by allowing greater access to breeding partners and food sources, refuge from disturbances such as fire and

maintenance of genetic diversity of plant communities and populations. Ecological linkages are ideally continuous or near-continuous as the more fractured a linkage is, the less ease flora and fauna have in moving within the corridor (Alan Tingay and Associates 1998).

The Perth Biodiversity Project, supported by the Western Australia Local Government Association (WALGA), have identified and mapped regional ecological linkages within the Perth Metropolitan Region (WALGA and PBP 2004). This study was extended beyond the Perth Metropolitan Region through the South West Biodiversity Project, resulting in the identification and mapping of the South West regional ecological linkages (Molloy *et al.* 2009).

No ecological linkages have been mapped across the site. A linkage is located to the west of the site connecting Bush Forever Site Number 392 to the north-west of the site to *Bush Forever* sites and remnant vegetation to the north-east and south-west of the site. In addition, the Western Power transmission line (located to the east of the site) is recognised in the City of Cockburn *Natural Area Management Strategy (2012-2022)* as a possible ecological linkage subject to the vegetation height restrictions associated with the easement use.

2.4 Previous flora surveys

No flora and vegetation assessments are known to have occurred over the site.

3 Methods

3.1 Field survey

A detailed survey was undertaken across the site in 2017. This included a reconnaissance survey in autumn and a detailed spring survey to sample vegetation via plots, map vegetation and conduct targeted searches for conservation significant flora species.

One botanist and an environmental consultant from Emerge visited the site on 15 May and 28 September 2018.

3.1.1 Vegetation

The site was traversed on foot and the composition and condition of vegetation was recorded. A targeted search was conducted on 28 September 2018 to look for conservation significant flora species.

Detailed sampling of the vegetation was undertaken using non-permanent 10 x 10 m quadrats. A total of three locations were sampled. The position of each sample location was recorded with a hand-held GPS unit, as shown on **Figure 3** and **Figure 4.**

The data recorded within each sample included:

- site details (site name, site number, observers, date, location)
- environmental information (slope, aspect, bare-ground, rock outcropping soil type and colour class, litter layer, topographical position, time since last fire event)
- biological information (vegetation structure and condition, degree of disturbance and species present).

The species percentage 'foliage projective cover' (FPC) was also recorded within each quadrat. Additional plant taxa not observed within sampling points were recorded opportunistically as the botanist traversed the site. Photographs were taken throughout the field visit to show particular site conditions.

All plant specimens collected during the field survey were dried, pressed and then named in accordance with requirements of the Western Australian Herbarium. Identification of specimens occurred through comparison with named material and through the use of taxonomic keys. Flora species not native to Western Australia are denoted by an asterisk ('*') in text and raw data.

Vegetation condition was assigned at each sample point and changes in vegetation condition were also noted and mapped across the site. The condition of the vegetation was assessed using methods from Keighery (1994). For vegetation in the site containing *Banksia* spp., the condition scale provided in the conservation advice for the 'Banksia Woodlands of the Swan Coastal Plain TEC' (DoEE 2016) was applied in addition to the Keighery scale (as shown in **Table 3**).

Table 3: Vegetation condition scale applied during the field assessment

Condition category	Definition (Keighery 1994)	Indicator (DoEE 2016)	
		Typical native vegetation composition	Typical weed cover
Pristine	Pristine or nearly so, no obvious signs of disturbance.	Native plant species diversity fully retained or almost so	Zero or close to
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.	High native plant species diversity	Less than 10%
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	Moderate native plant species diversity	5-20%
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbances. 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.	Low native plant species diversity	5-50%
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.	Very low native plant species diversity	20-70%
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 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.	Very low to no native species diversity	Greater than 70%

3.1.2 Threatened and priority flora

Areas of suitable habitat for threatened and priority flora species with potential to occur in the site were identified during the reconnaissance survey.

Searches were conducted within a suitable season to detect the species (within the flowering season for the majority of species). The majority of threatened and priority flora species with potential to occur in the site flower during spring.

3.2 Mapping and data analysis

3.2.1 Plant community identification and description

The local plant communities within the site were identified from the sample data collected during the field survey. The vegetation was described according to the dominant species present using the

structural formation descriptions of the *National Vegetation Inventory System* (NVIS) (ESCAVI 2003). The identified plant community was then mapped on aerial photography (1:1,000) from the sample points and boundaries were interpreted from aerial photography and notes taken in the field. Vegetation condition was mapped on aerial photography (1:1,000) based on the locations recorded during the field survey to define areas with differing condition.

3.2.2 Floristic community type assignment

The identified plant communities were then compared to the regional 'floristic community type' (FCT) dataset *A floristic survey of the southern Swan Coastal Plain* by Gibson *et al.* (1994). The sample data (presence/absence) was reconciled with Gibson *et al*. (1994) by standardising the names of taxa with those used in the earlier study. This was necessary due to changes in nomenclature in the intervening period. Taxa that were only identified to genus level were excluded, while some infra-species that have been identified since 1994 were reduced to species level. The combined dataset was then imported into the statistical analysis package Primer-6 (Clarke and Gorley 2006). As data from a localised survey is often spatially correlated, data for each sample point was compared to Gibson *et al*. (1994) separately. This removed the influence of spatial correlation when assigning a FCT. Classification was then undertaken using a group-average hierarchical clustering technique using the Bray-Curtis distance measure (as described above for plant community determination).

Where the sample tended to cluster with a grouping of different FCTs, individual sample point similarity was assessed separately to differentiate between FCTs. Ultimately the cluster analysis, as well as contextual information relating to the soils, landforms and known locations of FCTs within the region, was considered in the final determination of an FCT for vegetation within the site.

3.2.3 Threatened and priority ecological communities

Areas of native vegetation potentially representing a TEC were assessed against key diagnostic characteristics and, if available, size and/or vegetation condition thresholds provided in the following document:

- *Approved Conservation Advice (incorporating listing advice) for the Banksia Woodlands of the Swan Coastal Plain ecological community (TSSC 2016)*

3.2.4 Species accumulation curve

A species accumulation curve was plotted from sample data by generating a trendline (log) in Microsoft Excel. The trendline was forecast to locate the asymptote of the curve (the point at which the curve flattens), which provides an indication of amount of sampling that would be required before it can be assumed few species remain undetected. PRIMER v6 also offers a range of estimators to predict minimum species richness (Clarke and Gorley 2006). Both the Jacknife1 and Chao2 non-parametric estimators are reported, as these are known to perform well in comparison to simulated and real data sets and are also recommended for small sample sizes (Gotelli and Colwell 2011). Comparison between actual and estimated species accumulation assists in evaluating the adequacy of sampling effort.

3.3 Survey limitations

It is important to note the specific constraints imposed on surveys and the degree to which these may have limited survey outcomes. An evaluation of the survey methodology against standard constraints outlined in the EPA document *Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA 2016) is provided in **Table 4**.

Table 4: Evaluation of survey methodology against standard constraints outlined in EPA Technical Guidance – Flora and Vegetation Surveys for Environmental Impact Assessment

Constraint	Degree of limitation	Details
Availability of contextual information	No limitation	The broad scale contextual information described in **Section 2** is adequate to place the site and vegetation in context.
	No limitation	Regarding assignment of FCTs, the authoritative Gibson *et al* 1994 dataset was derived from a necessarily limited sample of vegetation from largely publicly owned land which is now more than 20 years out of date. Consequently, it is unknown to what degree official FCTs are appropriate reference to biodiverse vegetation across the Swan Coastal Plain. Furthermore, Gibson *et al.* (1994) collected data in the spring main flowering period and in many cases sampled plots multiple times to provide a complete species list. This survey included both autumn and spring assessment of quadrats and so is considered comparable.
Experience level of personnel	No limitation	This flora and vegetation assessment was undertaken by a qualified botanist with seven years of botanical experience in Western Australia. Technical review was undertaken by a senior environmental consultant with 15 years' experience in environmental science in Western Australia.
Suitability of timing	No limitation	The survey was conducted in May and September, thus with survey effort within the main flowering season.
Temporal coverage	Minor limitation	Comprehensive flora and vegetation assessments can require multiple visits, at different times of year, and over a period of a number of years, to enable observation of all species present. The survey was visited multiple times in 2018, including the main flowering period. Therefore, this survey is considered to meet the requirements of a detailed survey following the guidelines provided by the EPA (2016).
Spatial coverage and access	No limitation	Site coverage was comprehensive (track logged).
	No limitation	All parts of the site could be accessed as required.
Sampling intensity	No limitation	A total of 123 species were recorded, of which 93 were recorded from three sample locations and 30 were recorded opportunistically. An adequate degree of sampling was undertaken, given the degree of disturbance and the small area of intact vegetation.
Influence of disturbance	Minor limitation	The vegetation within the site showed evidence of fire within the last 5-10 years (scars on trunks, resprouting). Therefore, short-lived species more common soon after fire may not have been visible.
	No limitation	Historical ground disturbance was evident throughout much of the site. The disturbance history of the site was considered when undertaking field sampling.
Adequacy of resources	No limitation	All resources required to perform the survey were available.

4 Results

4.1 General site conditions

The site comprises a south facing slope, with intact remnant vegetation concentrated around the north, eastern and southern edges. The centre of the site previously contained a house, sheds and associated driveways. These structures were removed in 2016, leaving the area cleared with some remaining debris, and a number of planted native (including two *Eucalyptus gomphocephala* (tuart) trees) and exotic trees and shrubs (**Plate 1**). Weeds are also widespread throughout the cleared portions of the site. The soils within the site comprised a thin layer of light grey sand over deeper brown sands.

Plate 1: Cleared area in the centre of the site, with planted trees.

4.2 Flora

A total of 87 native and 36 non-native (weed) species were recorded within the site during the field survey, representing 46 families and 93 genera. The dominant families containing native taxa were Fabaceae (12 native taxa and six weed taxa) and Myrtaceae (eight native taxa and two weed taxa). The most common genera were *Acacia* (five taxa), *Banksia, Lomandra* and *Stylidium* (four taxa each) and *Conostylis, Eucalyptus*, *Schoenus* and **Trifolium* (three taxa each). Of the species recorded 93 were present in sample locations and 30 were recorded opportunistically. A complete species list is provided in **Appendix B** and sampled data in **Appendix C**.

4.2.1 Threatened and priority flora

No threatened or priority flora species were recorded within the site.

4.2.2 Locally and regionally significant flora

No locally or regionally significant flora species were recorded within the site.

4.2.3 Declared pests

One species, **Gomphocarpus fruticosus* (cotton bush), listed as declared pests (C3) pursuant to the BAM Act were recorded within the site. A small number of individuals of this species were recorded scattered sporadically in the south-western portion of the site.

4.3 Vegetation

4.3.1 Plant communities

One native plant community was identified within the site. Plant community **BaBm** exists in a number of patches around the edges of the site and extends over 0.84 ha. The remainder of the site (1.02 ha) contains non-native vegetation with bare soil, weeds or planted vegetation including **Pinus pinaster* (pine tree), **Eucalyptus* sp. and **Corymbia citriodora* (lemon scented gum). Two tuart trees are located in the centre of the site and appear to also have been planted, based on available historical aerial photography.

A description and the area of the plant communities is provided in **Table 5** and representative photographs are provided in **Plate 2** to **Plate 3**. The extent of each plant community is shown on **Figure 3.**

Table 5: Plant communities identified within the site

Plant community	Description	Area (ha)
BaBm	Sparse woodland of *Eucalyptus marginata* and *Allocasuarina fraseriana* over low woodland of *Banksia menziesii* and *Banksia attenuata* over low shrubland of *Xanthorrhoea preissii, Allocasuarina humilis, Stirlingia latifolia, Eremaea* spp. and *Hibbertia hypericoides* over forbland of *Chordifex sinuosus, Lepidosperma squamatum, Patersonia occidentalis, Stylidium* spp., *Lomandra* spp. (**Plate 2**).	0.84
Non-native/planted vegetation	Heavily disturbed areas comprising weeds with planted vegetation and occasional native species (**Plate 3**)**.**	1.02

*Plate 2: Plant community **BaBm** in very good condition, taken at Q3.*

Plate 3: Non-native/planted vegetation throughout the centre of the site.

4.3.2 Vegetation condition

The most intact native vegetation was located in the north-eastern and south-eastern corners of the site. This vegetation was mapped as being in very good condition as it retains the structure expected of a banksia woodland community and has moderate native species diversity and less than 20% weed cover.

The north-western patch of plant community **BaBm** was mapped as being in good-very good condition, as it had higher weed cover (40-50%) but still retained moderate native species diversity. A number of small patches of plant community **BaBm** surrounding the centre of the site and on the

western half of the site were mapped as being in degraded condition due to lower native species diversity and high weed cover. These patches have been subject to greater disturbance through adjacent historical clearing when the centre of the site housed a residence and related disturbances.

Remaining areas in the site are 'completely degraded' and consist of non-native species such as *Conyza sumatrensis*, pasture grasses, *Asphodelus fistulosus* (onion weed) and planted trees and shrubs. Sandy tracks within the site were also mapped as being in 'completely degraded' condition.

The extent of vegetation by condition category is detailed in **Table 6** and shown on **Figure 4.**

Table 6: Size of vegetation condition categories within the site

Condition category (Keighery (1994))	Size (ha)
Pristine	0
Excellent	0
Very Good	0.26
Very Good – Good	0.13
Good	0.13
Degraded	0.32
Completely Degraded	1.02

4.3.3 Floristic community type assignment

Plant community **BaBm** was considered most likely to represent FCT 23a 'Central *Banksia attenuata* – *B. mensiezii* woodlands'. This FCT is listed as 'well reserved' and 'low risk' by Gibson *et al. (1994).* The cluster analysis showed high similarities to a number of banksia woodland FCTs, and the quadrats clustered with two different FCTs. Quadrats 1 and 2 both grouped with FCT 28 in the cluster analysis but were most similar to a Gibson *et al. (1994)* plot representing FCT 23a with 54% and 50% similarity respectively (**Table 7**). Quadrat 3 grouped with FCT 23a in the cluster analysis with 59% similarity and also showed the highest similarity to a FCT 23a plot (WAND-1, with 55% similarity) (**Table 7**). The Gibson *et al.* (1994) plot WAND-1 is located 3 km to the south east of the site and shared a high similarity with all three quadrats within the site. Gibson *et al.* 1994 HURST03 also showed high similarity to all three quadrats within the site and is located 12 kms north east of the site. The relevant portions of the cluster dendrograms showing Quadrat 1-3 are provided in **Appendix D**.

Table 7: Plant community and likely FCT represented within the site for each sample point

Plant community	Sample unit	Most similar Gibson *et al.* (1994) sites	Similarity (%)	Most likely Floristic community type (FCT)	Reservation and conservation status (Gibson *et al.* 1994).
BaBm	**Q1**	HURST03 (23a) KING-2 (FCT 28) YULE-2 (FCT 23a) WAND-1 (FCT 23a)	54 49 48 48	FCT 23a – Central Banksia attenuata – B. menziesii woodlands	Well reserved and low risk
	Q2	HURST03 (23a) AUSTRA-1 (FCT 21a) FL-5 (FCT 21c) LOW01 (FCT 21c) BANK-3 (FCT 23a)	50 47 46 46 46		
	Q3	WAND-1 (FCT 23a) NINE-2 (FCT 21a) HURST03 (FCT 23a)	55 54 52		

4.3.4 Threatened and priority ecological communities

The structure and composition of plant community **BaBm** indicates that it represents the 'banksia woodlands of the Swan Coastal Plain' TEC. This TEC, herein referred to as the 'banksia woodland TEC', is listed as 'endangered' under the EPBC Act. Whether a patch of vegetation is considered to represent the banksia woodland TEC depends on a number of diagnostic criteria including geographic location, soils, landform, structure, composition, condition and patch size (DoEE 2016). As outlined in **Table 8,** the mapped 0.84 ha of **BaBm** vegetation within the site satisfies the criteria to be considered a patch of the 'banksia woodland TEC', as it is contiguous with larger areas of banksia woodland vegetation to the east. The inferred extent of this is shown on **Figure 5**.

Table 8: Criteria for determining presence of Banksia Woodlands of the Swan Coastal Plain TEC adapted from DoEE (2016)

Criteria	Requirements for meeting criteria	Site implications
1. Must meet key diagnostic characteristics	A variety of factors relating to: • Location • Soils • Structure • Composition	• Site meets location and soils criteria. • The **BaBm** vegetation includes the key diagnostic feature of a tree layer of *Banksia attenuata* and *Banksia menziesii*. • The **BaBm** vegetation within site also meets structure and composition criterion. FCT 23a identified as one FCT of the banksia woodland TEC.
2. Must meet condition thresholds	• A patch should at least meet the 'good' condition category.	• The **BaBm** vegetation is present in 'very good', 'very good-good', 'good', 'good-degraded' and 'degraded' condition, which meets this criterion. The conservation advice indicates that a single patch may include areas of variable condition, meaning parts of the **BaBm** vegetation in 'good-degraded' and 'degraded' condition may still be considered the TEC.

Table 8: Criteria for determining presence of Banksia Woodlands of the Swan Coastal Plain TEC adapted from DoEE (2016) (cont.)

Criteria	Requirements for meeting criteria	Site implications
3. Must meet minimum patch size	Minimum size of patch: • Pristine=no minimum size • Excellent=0.5 ha • Very Good=1 ha • Good=2 ha	• The **BaBm** vegetation in 'good' or better condition collectively comprises a total of 0.52 ha and does not independently meet this criterion. • However, the adjoining **BaBm** vegetation in 'good to degraded' and 'degraded' condition would be viewed as contiguous and part of the same patch, thus the site comprises a total of 0.84 ha of banksia woodland. • Furthermore, Banksia woodland vegetation also exists to the east of the site, extending south past Rowley Road and to the north to Russell Road. As gaps no greater than 30 m wide exist between these patches they would also be viewed as contiguous. Therefore the mapped 0.84 ha of **BaBm** vegetation within the site, when combined with the banksia woodland vegetation to the east does comprise a patch of the TEC.
4. Must incorporate surrounding context	• Breaks (e.g. tracks) < 30 m do not separate vegetation into separate patches • Buffer zones may apply (20-50 m recommended from patch edge) • The site should be thoroughly sampled (2 surveys in same spring). • Survey timing should be appropriate. • Surrounding environment should be considered (e.g. connectivity, conservation values, fauna habitat)	• A number of tracks and other disturbed areas exist within the patch. • Land surrounding the patch is a combination of future residential and native vegetation. • This survey was conducted in May and September. Whilst a second survey in the same spring was not undertaken, the surveys were sufficient to determine the extent of the banksia woodland TEC conclusively. • The survey was undertaken in the appropriate season (spring). • Intact native vegetation that is likely to meet criteria as banksia woodland exists directly to the west and north of the site.

The plant community **BaBm** also represents the 'banksia dominated woodlands of the Swan Coastal Plain IBRA region' PEC (P3).

No other TECs or PECs occur within the site.

The area of the banksia woodland TEC and PEC within the site is outlined in **Figure 5.**

4.3.5 Locally and regionally significant vegetation

Plant community **BaBm** contains a number of foraging species for black cockatoos (especially Carnaby's black cockatoo). In addition, two mature planted tuart trees (diameter at breast height larger than 500 mm) and a planted pine tree are present in the centre of the site, within the disturbed, non-native portion of the site. Due to their size these trees have the potential to provide some foraging, roosting and nesting values for black cockatoos, along with other ecological services. However, site-specific fauna investigations would be required to confirm habitat values within the site.

4.4 Species richness and sampling adequacy

A total of 93 species were recorded from three samples. A species accumulation curve derived from sample data is presented in **Plate 4**. After three samples the curve is still increasing and has not reached its asymptote. This indicates that a proportion of species likely remain undetected by sampling.

Species richness was estimated in PRIMER v6 to be between 121 (Jacknife1) and 140 (Chao2). Based on the trend of the species accumulation curve approximately 10 to 14 samples would be required to capture that many species. However, including the 30 additional species recorded opportunistically, a total of 123 species was recorded in the site. This indicates that between 87% and 100% of the estimated 121-140 species in the site were recorded. As such, the survey effort was considered to be adequate to prepare a representative species inventory.

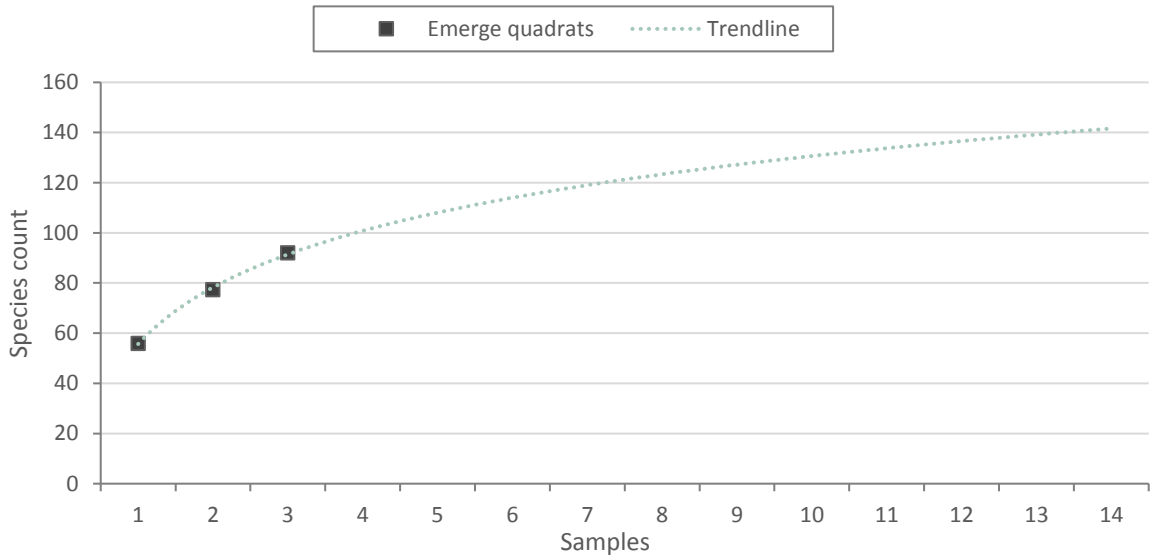

Plate 4: Species accumulation curve derived from sample data (y =32.554ln(x) + 55.668, R^2 = 0.9981).

5 Discussion

The vegetation within the site has been subject to past disturbance and over half of the site is covered by non-native vegetation in completely degraded condition. The most intact native vegetation exists in the north and eastern portion of the site where the **BaBm** plant community is present.

The composition of vegetation in the site reflects the sites location on the boundary between the Spearwood and Bassendean dune systems but based on the floristic analysis, appears to align more closely with the Bassendean dune system. Plant community **BaBm** was considered most likely to represent FCT 23a which is a banksia woodland community commonly associated with the Bassendean dune system.

There were a small number of species recorded that could indicate the site is more closely aligned with the Spearwood dune system than the Bassendean system (tuart and the sedge species *Mesomelaena pseudostygia*). Tuart is recorded from near coastal areas and is more common on the Spearwood dune system than on the Bassendean dune system. However, from the available historical aerial photography, it seems that the two tuart trees in the site were most likely planted around the time that the dwelling was built and there is only a small possibility that these are remnant trees that were not visible on the historical aerials. *M. pseudostygia* is a common understorey species associated with the Spearwood system and further east on the Pinjarra Plain but does not tend to occur on the Bassendean dune system (pers. comm. B. Keighery). This species was only recorded in low densities in one location within the site and its presence is likely a product of natural heterogeneity of native vegetation and its presence likely the product of natural heterogeneity of native vegetation.

The **BaBm** vegetation in the north-eastern and south-eastern corners of the site is in very good condition, as it retains a woodland structure and a moderate level of native species diversity. However, the vegetation includes notable weed cover, ranging from 10-50% and is surrounded by a fringe of more disturbed vegetation. From aerial photography it was determined that most of this disturbed vegetation is regrowth. The **BaBm** vegetation was also found to represent a patch of the EPBC Act listed banksia woodland TEC (refer to **Section 3.3**).

5.1 Threatened and priority flora

No threatened or priority flora species were recorded within the site. The absence of the larger perennial species such as *Dodonaea hackettiana* was relatively easy to confirm. However, due to their size and seasonal lifeform, smaller geophytic species such as *Caladenia huegelii, Drakaea elastica, D. micrantha* and *Thelymitra variegata* can be more difficult to detect.

The survey included targeted searches in the main flowering season for conservation significant species. The areas of plant community **BaBm** were traversed thoroughly (walking lines approximately 5 m apart) to search for these species. Should these species have been present it is likely that they would have been recorded. The timing was appropriate to record spring flowering perennial geophytic species, as evidenced by the presence of other orchid species in flower (*Caladenia flava, Caladenia longicauda* subsp. *calcigena* and *Thelymitra macrophylla*).

5.2 Vegetation condition

Assigning condition using a categorical scale is always most difficult when vegetation qualities are close to the boundary between two categories. Categorical schemes may also invariably yield different results when applied by different assessors, because of differences in skill levels or personal bias. The method applied to assess vegetation condition was robust, as it combined the standard qualitative, categorical scheme of Keighery (1994), with the additional indicators for diversity and weed cover outlined in DoEE (2016).

A vegetation condition score has the greatest implications when the condition of vegetation is close to the boundary between 'good' and 'degraded'. This is because 'good' condition is typically accepted as the threshold for conservation significance, while 'degraded' condition implies a low conservation requirement. Separating these two condition categories is further complicated by the fact that good condition is more correctly understood to mean 'average' condition. Applying the Keighery (1994) condition scale, good condition vegetation can be expected to be significantly altered, with very obvious disturbance and the presence of aggressive weeds at high density. Therefore, good does not literally mean "good" as the label implies.

One compound condition category ('good to very good') was included in the results of this survey for patches of plant community **BaBm** that comprised characteristics from more than one of the DoEE (2016) indicators (shown in **Table 3**). For example, the north-western patch comprised a moderate species diversity (indicative of very good condition) but a higher weed cover at 40-50% (indicative of good condition).

5.3 Threatened and priority ecological communities

Identifying the **BaBm** plant community as a 'banksia woodland' was relatively straightforward. The **BaBm** vegetation includes the key diagnostic feature of a tree layer of *Banksia attenuata* and *B. menziesii*. It was also considered most likely to represent 'FCT 23a - Central *Banksia attenuata – B. menziesii* woodlands', which is one of the regional FCTs identified in the banksia woodland TEC conservation advice (DoEE 2016). The sampling data showed high similarities to Gibson et al. (1994) sites comprising FCT 23a.

In addition to the above characteristics, to be considered the banksia woodland TEC a patch of banksia vegetation must also meet thresholds for condition and minimum patch size (refer to **Table 8**). The DoEE (2016) conservation advice states that a patch of banksia woodland vegetation in very good condition must be greater than 1 ha in size for it to be considered the TEC. The conservation advice also states that a patch may include areas of variable condition and that the condition that is most representative should be used to assign overall condition of a patch.

For the **BaBm** community, 0.26 ha was mapped as very good, 0.13 ha was mapped as good to very good, 0.13 ha was mapped as good, 0.18 ha was mapped as good to degraded and 0.14 ha was mapped as degraded, totaling 0.84 ha. As there are no breaks of 30 m or more to separate the areas of varying condition vegetation, these areas were understood as a single patch. The mapped 0.84 ha of **BaBm** vegetation within the site does not in itself satisfy the criteria to be considered a patch of the 'banksia woodland TEC' (which would require 2ha in good condition or 1 ha in very good condition). However, when considered as contiguous with the banksia woodland vegetation to the

east, it does meet these criteria. Whilst this wider patch has not been assessed or quantified in detail, the banksia vegetation potentially stretches south past Rowley Road and north to Russell Road, comprising at least 60 ha. Therefore, it is possible to conclude that vegetation in the site is part of a larger patch of the banksia woodlands of the SCP TEC without further information or survey.

Due to the presence of *Banksia attenuata* and *B. menziesii,* on deep sands, the **BaBm** community also represents the State listed PEC 'Banksia dominated woodlands of the Swan Coastal Plain IBRA region'. Conservation advice for PECs is less specific, but it is likely that only the area of **BaBm** vegetation in very good and good condition would be consider to represent this PEC.

5.4 Local and regional significance

The banksia woodland within the site is expected to provide potential foraging habitat for endangered black cockatoo species. In addition, the tuart and pine trees also provide potential foraging habitat and may also be used for roosting and nesting purposes. Given the small size of the site, these are not likely to be of regional significance, but may be of local significance. However, further assessment by a fauna specialist would be required to confirm these values.

6 Conclusions

Over half of the site is highly disturbed and modified, with approximately 1.02 ha of the site containing completely degraded, non-native vegetation. The remaining 0.84 ha of the site includes native vegetation that is present in degraded to very good condition.

No threatened or priority flora species were recorded within the site.

The site contains 0.84 ha of banksia woodland vegetation. This vegetation itself does not meet the threshold minimum patch size of the EPBC Act listed banksia woodlands TEC (which also represents the State listed PEC 'Banksia dominated woodlands of the Swan Coastal Plain IBRA region'). However, the banksia woodland in the site is contiguous with vegetation in adjacent land to the east and so is considered to be part of larger patch of the banksia woodlands of the SCP TEC.

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Figure 1: Site Location

Project: Detailed Flora and Vegetation Assessment
Lot 50 Barfield Road, Hammond Park

Client: Glenbrook Civil

Plan Number:
EP18-043(02)--F02a

Drawn:	KNM
Date:	24/10/2018
Checked:	SKP
Approved:	TAA
Date:	24/10/2018

N

0 50 100
Metres

Scale: 1:3,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

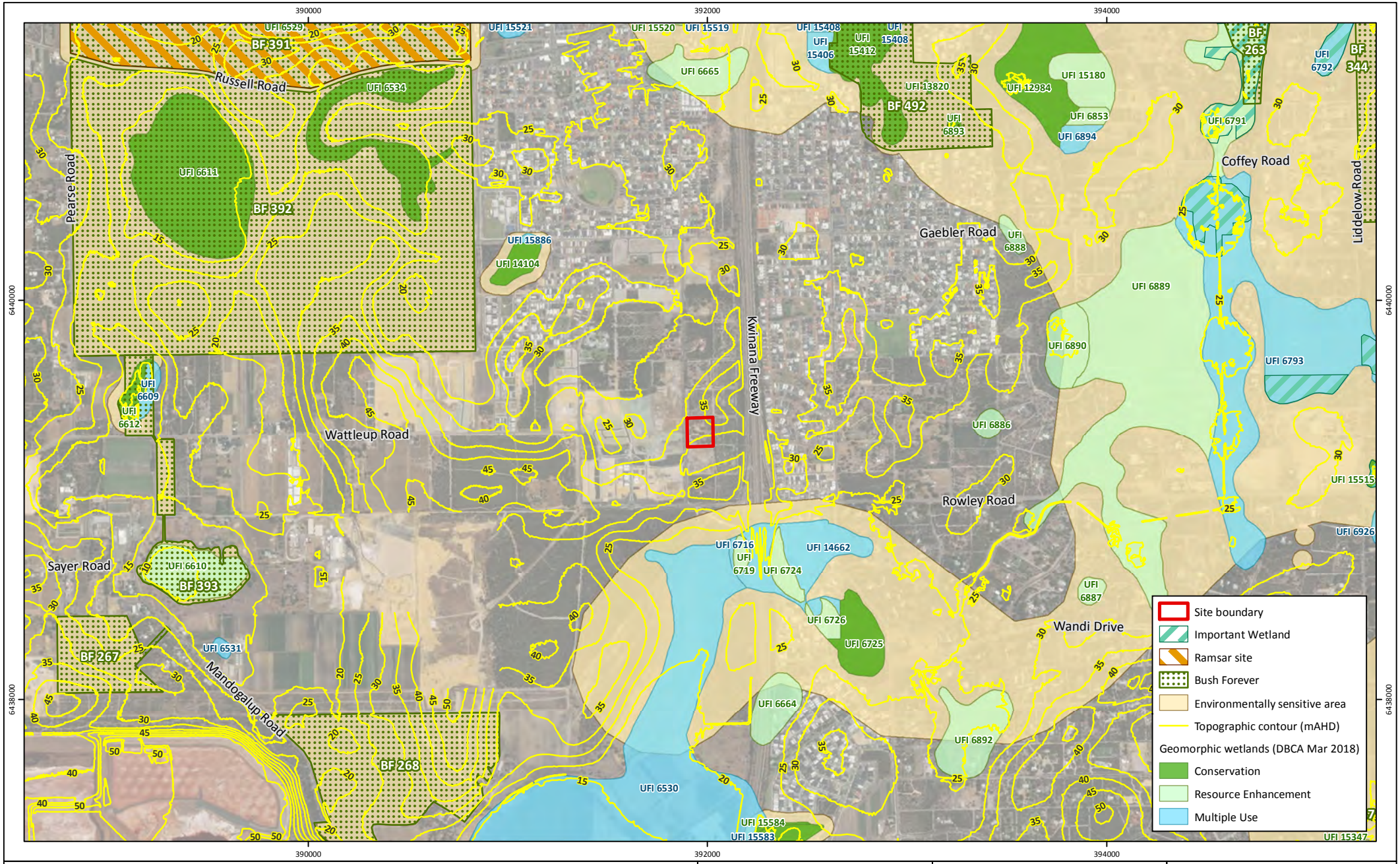

Figure 2: Environmental Features

Project:	Detailed Flora and Vegetation Assessment Lot 50 Barfield Road, Hammond Park
Client:	Glenbrook Civil

Plan Number:
EP18-043(02)--F03a

Drawn:	KNM
Date:	24/10/2018
Checked:	SKP
Approved:	TAA
Date:	24/10/2018

N

0 400 800
Metres

Scale: 1:25,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

Figure 3: Plant Communities

Project:	Detailed Flora and Vegetation Assessment Lot 50 Barfield Road, Hammond Park
Client:	Glenbrook Civil

Plan Number:
EP18-043(02)--F04a

Drawn:	KNM
Date:	24/10/2018
Checked:	SKP
Approved:	TAA
Date:	24/10/2018

N

0 20 40
Metres

Scale: 1:1,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

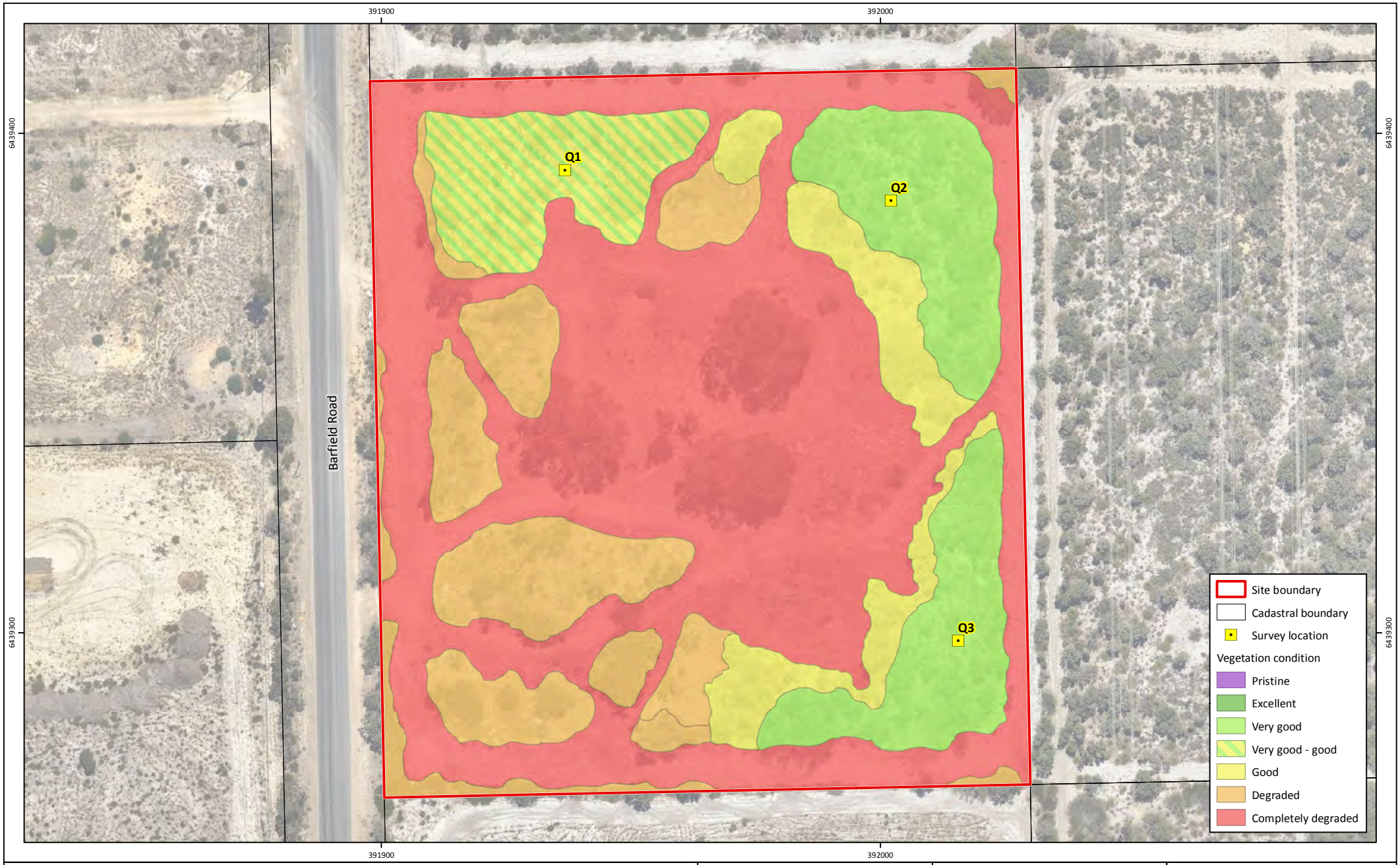

Figure 4: Vegetation Condition

Project: Detailed Flora and Vegetation Assessment
Lot 50 Barfield Road, Hammond Park
Client: Glenbrook Civil

Plan Number:
EP18-043(02)--F05a
Drawn: KNM
Date: 24/10/2018
Checked: SKP
Approved: TAA
Date: 24/10/2018

N

0 20 40
Metres
Scale: 1:1,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

Figure 5: Threatened Ecological Communities

Project: Detailed Flora and Vegetation Assessment
Lot 50 Barfield Road, Hammond Park
Client: Glenbrook Civil

Plan Number:
EP18-043(02)--F06a

Drawn:	RAO
Date:	06/11/2018
Checked:	SKP
Approved:	TAA
Date:	06/11/2018

N

0 20 40
Metres

Scale: 1:1,000@A4

GDA 1994 MGA Zone 50

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Appendix A

Additional Background Information

Conservation Significant Flora and Vegetation

Threatened and priority flora

Flora species considered rare or under threat warrant special protection under Commonwealth and/or State legislation. At the Commonwealth level, flora species can be listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Flora species considered 'threatened' pursuant to Schedule 1 of the EPBC Act are assigned categories according to their conservation status, as outlined in **Table 1**.

In Western Australia, plant taxa may be classed as 'threatened' under the *Wildlife Conservation Act 1950* (WC Act) which is enforced by Department of Biodiversity Conservation and Attractions (DBCA). Threatened flora species are gazetted under subsection 2 of section 23F of the WC Act and therefore it is an offence to "take" or damage threatened flora without Ministerial approval. Section 23F of the Act defines "to take" as "… to gather, pluck, cut, pull up, destroy, dig up, remove or injure the flora to cause or permit the same to be done by any means". The definition of threatened flora under the WC Act is provided in **Table 1**.

Flora species that may be threatened or near threatened but lack sufficient information to be listed under the WC Act may be added to the DBCA's *Priority Flora List* (DBCA 2018). Priority flora species are considered during State approval processes. Priority flora categories and definitions are listed in **Table 1**.

Note that the WC Act is expected to be repealed some time in 2018 and will be replaced by the Biodiversity Conservation Act 2016 (BC Act). The BC Act includes updated provisions for the management of threatened flora along with increased penalties and requirements for reporting, management programmes and recovery plans. The BC Act was granted Royal assent on 21 September 2016 but most of the provisions of the BC Act have not come into effect and until they do, the WC Act will continue to guide the management of threatened flora in Western Australia.

Table 1: Definitions of conservation significant flora species pursuant to the EPBC Act and WC Act and on DBCA's Priority Flora List (DBCA 2018)

Conservation code	Description
EX†	Threatened Flora – Presumed Extinct Taxa which have not been collected, or otherwise verified, over the past 50 years despite thorough searching, or of which all known wild populations have been destroyed more recently, and have been gazetted as such.
T^†	Threatened Flora – Extant Taxa which are declared to be likely to become extinct or is rare, or otherwise in need of special protection.
CR^	Threatened Flora – Critically Endangered Taxa which are considered to be facing an extremely high risk of extinction in the wild.
EN^	Threatened Flora – Endangered Taxa which are considered to be facing a very high risk of extinction in the wild.
VU^	Threatened Flora – Vulnerable Taxa which are considered to be facing a high risk of extinction in the wild.
P1	Priority One – Poorly Known Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat e.g. road verges, urban areas, farmland, active mineral leases etc., or the plants are under threat, e.g. from disease, grazing by feral animals etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declaration as 'rare flora', but are in urgent need of further survey.
P2	Priority Two – Poorly Known Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under immediate threat (i.e. not currently endangered). Such taxa are under consideration for declaration as 'rare flora', but urgently need further survey.
P3	Priority Three – Poorly Known Taxa which are known from several populations, and the taxa are not believed to be under immediate threat (i.e. not currently endangered), either due to the number of known populations (generally >5), or known populations being large, and either widespread or protected. Such taxa are under consideration for declaration as 'rare flora' but needs further survey.
P4	Priority Four – Rare Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5-10 years.

^pursuant to the EPBC Act, †pursuant to the WC Act, on DBCA's *Priority Flora List*

Threatened and priority ecological communities

'Threatened ecological communities' (TECs) are recognised as ecological communities that are rare or under threat and therefore warrant special protection. Selected TECs are afforded statutory protection at a Commonwealth level under section 181 of the EPBC Act. TECs nominated for listing under the EPBC Act are considered by the Threatened Species Scientific Committee and a final decision is made by the Commonwealth Minister for the Environment and Energy. Once listed under the EPBC Act, communities are categorised as either 'critically endangered', 'endangered' or 'vulnerable' as defined in **Table 2**. Any action likely to have a significant impact on a community listed under the EPBC Act requires approval from the Minister for the Environment and Energy.

Within Western Australia TECs are determined by the Western Australian Threatened Ecological Communities Scientific Advisory Committee (WATECSAC) and endorsed by the State Minister for the Environment. The WATECSAC is an independent group comprised of representatives from organisations including tertiary institutions, the Western Australian Museum and DBCA. TECs are assigned to one of the categories outlined in **Table 2** according to their status (in relation to the level of threat). Currently TECs are not afforded direct statutory protection at a state level and their significance is acknowledged through other state environmental approval processes such as 'environmental impact assessment' pursuant to Part IV of the *Environmental Protection Act 1986* (EP Act) and the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*.

Table 2: Categories of threatened ecological communities (English and Blyth 1997; DEC 2009).

Conservation code	Description
PD	Presumably Totally Destroyed An ecological community that has been adequately searched for but for which no representative occurrences have been located.
CE	Critically Endangered An ecological community that has been adequately surveyed and is found to be facing an extremely high risk of total destruction in the immediate future.
E	Endangered An ecological community that has been adequately surveyed and is not critically endangered but is facing a very high risk of total destruction in the near future.
V	Vulnerable An ecological community that has been adequately surveyed and is not critically endangered or endangered but is facing a high risk of total destruction or significant modification in the medium to long-term future.

An ecological community that is under consideration for listing as a TEC, but does not yet meet survey criteria or has not been adequately defined ay be listed as a 'priority ecological community' (PEC). PECs are categorised as priority category 1, 2 or 3 as described in **Table 3**. Ecological communities that are adequately known and are rare but not threatened, or meet criteria for 'near threatened', or that have been recently removed from the threatened list, are placed in 'priority 4'. These ecological communities require regular monitoring. Conservation dependent ecological communities are placed in 'priority 5' (DEC 2009).

Note the BC Act, previously introduced in **Section 1**, includes provisions for the management of TECs, penalties for impacting TECS, and requirements for reporting, management programmes and recovery plans. The provisions of the BC Act relating to TECs have not yet come into effect and until they do the management of TECs will continue to be guided by existing environmental approval processes.

Table 3: Categories of priority ecological communities (DEC 2009).

Priority code	Description
P1	Priority One Ecological communities with apparently few, small occurrences, all or most not actively managed for conservation (e.g. within agricultural or pastoral lands, urban areas, active mineral leases) and for which current threats exist. Communities may be included if they are comparatively well-known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under immediate threat from known threatening processes across their range.
P2	Priority Two Communities that are known from few small occurrences, all or most of which are actively managed for conservation (e.g. within national parks, conservation parks, nature reserves, State forest, unallocated Crown land, water reserves, etc.) and not under imminent threat of destruction or degradation. Communities may be included if they are comparatively well known from one or more localities but do not meet adequacy of survey requirements, and/or are not well defined, and appear to be under threat from known threatening processes.
P3	Priority Three Communities that are known from several to many occurrences, a significant number or area of which are not under threat of habitat destruction or degradation or: (i) communities known from a few widespread occurrences, which are either large or within significant remaining areas of habitat in which other occurrences may occur, much of it not under imminent threat, or; (ii) communities made up of large, and/or widespread occurrences, that may or not be represented in the reserve system, but are under threat of modification across much of their range from processes such as grazing by domestic and/or feral stock, and inappropriate fire regimes. Communities may be included if they are comparatively well known from several localities but do not meet adequacy of survey requirements and/or are not well defined, and known threatening processes exist that could affect them.
P4	Priority Four Ecological communities that are adequately known, rare but not threatened or meet criteria for Near Threatened or that have been recently removed from the threatened list. These communities require regular monitoring.
P5	Priority Five Ecological communities that are not threatened but are subject to a specific conservation program, the cessation of which would result in the community becoming threatened within five years.

Weeds

A number of legislative and policy documents exist in relation to weed management at state and national levels. The *Biosecurity and Agriculture Management Act 2007* (BAM Act) is the principle legislation guiding weed management in Western Australia and lists declared pest species. At a national level, the Australian government has compiled a list of 32 Weeds of National Significance (WoNS), of which many are also listed under the BAM Act.

Declared Pests

Part 2.3.23 of the BAM Act requires a person must not; "*a) keep, breed or cultivate the declared pest; b) keep, breed or cultivate an animal, plant or other thing that is infected or infested with the declared pest; c) release into the environment the declared pest, or an animal, plant or other thing that is infected or infested with the declared pest; or d) intentionally infect or infest, or expose to infection or infestation, a plant, animal or other thing with a declared pest*".

Under the BAM Act, all declared pests are placed in one of three categories, namely C1 (exclusion), C2 (eradication) or C3 (management). These categories are described further in **Table 4**. The Western Australian Organism List (WAOL) provides the status of organisms which have been categorised under the BAM Act (DAFWA 2016).

Table 4: Categories of declared pest species under the BAM Act (DAFWA 2016).

Category	Description
C1	Exclusion Not established in Western Australia and control measures are to be taken, including border checks, in order to prevent them entering and establishing in the State.
C2	Eradication Present in Western Australia in low enough numbers or in sufficiently limited areas that their eradication is still a possibility.
C3	Management Established in Western Australia but it is feasible, or desirable, to manage them in order to limit their damage. Control measures can prevent a C3 pest from increasing in population size or density or moving from an area in which it is established into an area which currently is free of that pest.

Wetland Habitat

Geomorphic wetland types

The geomorphic wetland classification system of Semeniuk (1987) is a recognised classification system for the south west of Western Australia. The Semeniuk system uses the landform shape and water permanence (hydro-period) to categorise wetlands as described in **Table 5**.

Table 5: Wetland types defined within the global geomorphic classification system (DEC 2007).

Level of inundation	Basin	Flat	Channel	Slope
Permanently inundated	Lake	-	River	-
Seasonally inundated	Sumpland	Floodplain	Creek	-
Seasonally waterlogged	Dampland	Palusplain	-	Paluslope

Wetland management categories

DBCA maintains the *Geomorphic Wetland of the Swan Coastal Plain* dataset, which also categorises individual wetlands into specific management categories as described in **Table 6**.

Table 6: Geomorphic Wetlands of the Swan Coastal Plain management categories (Hill et al. 1996).

Management category	Description of wetland	Management objectives
Conservation (CCW)	Support high levels of attributes	Preserve wetland attributes and functions through reservation in national parks, crown reserves and state owned land. Protection provided under environmental protection policies.
Resource enhancement (REW)	Partly modified but still supporting substantial functions and attributes	Restore wetland through maintenance and enhancement of wetland functions and attributes. Protection via crown reserves, state or local government owned land, environmental protection policies and sustainable management on private properties.
Multiple use (MUW)	Few wetland attributes but still provide important hydrological functions	Use, development and management considered in the context of water, town and environmental planning through land care.

The management categories of wetland features are determined based on hydrological, biological and human use features. The DBCA document *A methodology for the evaluation of specific wetland types on the Swan Coastal Plain, Western Australia* (DPaW 2016) details the methodology by which wetlands on the Swan Coastal Plain are assigned management categories based on a two tiered evaluation system, with preliminary and secondary evaluation stages. The preliminary evaluation aims to identify any features of conservation significance that would immediately place the wetland within the CCW management category. Examples of these significant features include presence on significant wetland lists, presence of TECs or PECs (Priority 1 and 2), presence of threatened flora and over 90% of vegetation in good or better condition based on the Keighery (1994) scale. If such

environmental values are identified the wetland would be categorised as CCW without further evaluation.

Should the preliminary evaluation indicate that no such features occur, the secondary evaluation and site assessment are then applied. In the secondary evaluation, an appropriate management category is determined through the assessment of a range of environmental attributes, functions and values.

Wetland reclassification

DBCA have a protocol for proposing changes to the wetland boundaries and management categories of the existing geomorphic wetland dataset (DEC 2007). The procedure involves a wetland desktop evaluation and site assessment which culminates in a recommended management category. Relevant information should be obtained in the optimal season for vegetation condition and water levels, which is usually spring (DEC 2007). In the case of larger wetlands that have undergone a degree of disturbance, a separate management category may be assigned to parts of the wetland in order to reflect the current values.

References

General references

Department of Environment and Conservation (DEC) 2007, Protocol for proposing modifications to the Geomorphic Wetlands Swan Coastal Plain dataset, Perth.

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Department of Parks and Wildlife (DPaW) 2016, A methodology for the evaluation of wetlands on the Swan Coastal Plain, Wetlands Section , Department of Parks and Wildlife and Urban Water Branch, Department of Water, Perth.

English, V. and Blyth, J. 1997, Identifying and Conserving Threatened Ecological Communities in the South West Botanical Province, ANCA National Reserves System Cooperative Program, Project Number N702, Perth.

Hill, A. L., Semeniuk, C. A., Semeniuk, V. and Del Marco, A. 1996, Wetlands of the Swan Coastal Plain: Volume 2A - Wetland Mapping, Classification and Evaluation, Water and Rivers Commission and the Department of Environmental Protection, Perth.

Keighery, B. 1994, Bushland Plant Survey: A guide to plant community survey for the community, Wildflower Society of WA (Inc), Nedlands.

Semeniuk, C. A. 1987, Wetlands of the Darling System - a geomorphic approach to habitat classification, Journal of the Royal Society of Western Australia, 69: 95-112.

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Department of Agriculture and Food (DAFWA) 2016, *The Western Australian Organism List* (WAOL), <https://www.agric.wa.gov.au/bam/western-australian-organism-list-waol>.

Department of Biodiversity, Conservation and Attractions (DBCA) 2018, *Threatened and Priority Flora and Fauna Lists*, < https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities>.

Appendix B

Species List

Lot 50 Barfield Road, Hammond Park - Flora Taxa List

Note: * denotes introduced weed species.

Family	Species
Aizoaceae	
	* *Carpobrotus edulis*
Anarthriaceae	
	Lyginia imberbis
Apiaceae	
	Xanthosia huegelii
Apocynaceae	
	* *Gomphocarpus fruticosus*
Araliaceae	
	Trachymene pilosa
Arecaceae	
	* Arecaceae sp.
Asparagaceae	
	Chamaescilla corymbosa
	Laxmannia squarrosa
	Lomandra caespitosa
	Lomandra hermaphrodita
	Lomandra nigricans
	Lomandra preissii
	Sowerbaea laxiflora
	Thysanotus manglesianus
Asphodelaceae	
	* *Asphodelus fistulosus*
Asteraceae	
	* *Arctotheca calendula*
	* *Conyza sumatrensis*
	* *Hypochaeris glabra*
	* *Osteospermum ecklonis*
	* *Sonchus oleraceus*
	* *Ursinia anthemoides*
Brassicaceae	
	* *Raphanus raphanistrum*
Caryophyllaceae	
	* *Petrorhagia dubia*

Lot 50 Barfield Road, Hammond Park - Flora Taxa List

Note: * denotes introduced weed species.

Family	Species
Casuarinaceae	
	Allocasuarina fraseriana
	Allocasuarina humilis
Colchicaceae	
	Burchardia congesta
Crassulaceae	
	Crassula colorata var. colorata
Cyperaceae	
	Lepidosperma squamatum
	Mesomelaena pseudostygia
	Schoenus clandestinus
	Schoenus curvifolius
	Schoenus pedicellatus
Dasypogonaceae	
	Dasypogon bromeliifolius
Dilleniaceae	
	Hibbertia hypericoides
	Hibbertia racemosa
Droseraceae	
	Drosera erythrorhiza
	Drosera menziesii
	Drosera pallida
Ericaceae	
	Astroloma pallidum
	Conostephium pendulum
	Leucopogon conostephioides
Euphorbiaceae	
	* *Euphorbia terracina*
	* *Ricinus communis*
Fabaceae	
	* *Acacia iteaphylla*
	Acacia pulchella var. *glaberrima*
	Acacia saligna
	Acacia stenoptera
	Acacia willdenowiana
	Bossiaea eriocarpa
	* *Chamaecytisus palmensis*
	Daviesia nudiflora
	Daviesia triflora

Lot 50 Barfield Road, Hammond Park - Flora Taxa List

Note: * denotes introduced weed species.

Family	Species
Fabaceae	*Gastrolobium capitatum*
	Gompholobium tomentosum
	Hovea trisperma
	Jacksonia furcellata
	Kennedia prostrata
	* *Lupinus cosentinii*
	* *Trifolium angustifolium*
	* *Trifolium campestre*
	* *Trifolium hirtum*
Geraniaceae	
	* *Pelargonium capitatum*
Goodeniaceae	
	Dampiera linearis
	Scaevola canescens
Haemodoraceae	
	Anigozanthos humilis
	Anigozanthos manglesii
	Conostylis aculeata
	Conostylis juncea
	Conostylis setigera subsp. setigera
	Phlebocarya ciliata
Hemerocallidaceae	
	Caesia occidentalis
	Dianella revoluta
	Tricoryne elatior
Iridaceae	
	* *Freesia alba × leichtlinii*
	* *Gladiolus caryophyllaceus*
	Patersonia occidentalis
Lamiaceae	
	Hemiandra pungens
Loranthaceae	
	Nuytsia floribunda
Myrtaceae	
	Calytrix flavescens
	Calytrix fraseri
	* *Corymbia citriodora*
	Eremaea asterocarpa subsp. *asterocarpa*
	Eremaea pauciflora var. *pauciflora*

Lot 50 Barfield Road, Hammond Park - Flora Taxa List

Note: * denotes introduced weed species.

Family	Species
Myrtaceae	*Eucalyptus gomphocephala*
	Eucalyptus marginata
	* *Eucalyptus* sp.
	Hypocalymma robustum
	Kunzea glabrescens
Orchidaceae	
	Caladenia flava subsp. f*lava*
	Caladenia longicauda subsp. *calcigena*
	Elythranthera brunonis
	Thelymitra macrophylla
Oxalidaceae	
	* *Oxalis pes-caprae*
Papaveraceae	
	* *Fumaria capreolata*
Pinaceae	
	* *Pinus pinaster*
Plantaginaceae	
	* *Plantago lanceolata*
Poaceae	
	Amphipogon turbinatus
	* *Avena barbata*
	* *Briza maxima*
	* *Ehrharta calycina*
Proteaceae	
	Adenanthos cygnorum
	Banksia attenuata
	Banksia dallanneyi var. *dallanneyi*
	Banksia ilicifolia
	Banksia menziesii
	Petrophile linearis
	Stirlingia latifolia
Restionaceae	
	Alexgeorgea nitens
	Chordifex sinuosus
	Desmocladus flexuosus
	Hypolaena exsulca
Rosaceae	
	* Rosaceae sp.

Lot 50 Barfield Road, Hammond Park - Flora Taxa List

Note: * denotes introduced weed species.

Family		Species
Rubiaceae		
		Opercularia vaginata
Rutaceae		
		Philotheca spicata
Santalaceae		
		Leptomeria empetriformis
Scrophulariaceae		
	*	*Dischisma arenarium*
Solanaceae		
	*	*Solanum nigrum*
Stylidiaceae		
		Stylidium brunonianum
		Stylidium piliferum
		Stylidium repens
		Stylidium schoenoides
Tropaeolaceae		
	*	*Tropaeolum majus*
Xanthorrhoeaceae		
		Xanthorrhoea preissii

Appendix C

Sample Data

Site Details							
Project ID.	EP18-043	Site name	Lot 50 Barfield Road				
Date	15/05/2018, 28/09/2018			Recorder	SKP		
Survey type	Detailed	Sampl. unit	Quadrat		Permanent?	N	
Geographic and habitat data - GDA 94 MGA 50							
Plot ID.	**1**	Easting:	**391938**	Northing	**6439391**	Altitude	
Photo No.		Photo dir.		Slope	gentle	Aspect	**W**
Landform	sandy slope			Hydrology	Dry		
Soil type	sand			Soil col.	light grey	Subsoil col.	brown
Disturbance	weeds			Time since disturbance			
				Time since fire			>5 years
Notes: Weeds throughout understorey. Some dead large banksia. Planted eucs on edges of patch.				**Abiotic/detrital components**			**% Cover**
				Surf. rock	NA		0
				Bground.			5
				Litter 1	leaf/dead grass		20
				Litter 2	twig/log		5

NVIS Canopy stratum		Major species and other observations	Av.Ht	% Cover
U1- Upper	4-8 m	Banksia spp., Jarrah, Allo fras		25
U2- Sub-canopy				
U3- Lower tree				
M1- Tall shrub				
M1- Mid shrub	1-2 m	Allo hum, Xanthorrhoea, Acacia saligna, J furc		15
M1- Low shrub	0.5-1 m	Hibbertia, Eremaea, Stirlingia		25
G1 - Tall ground	0.5	Dianella, Patersonia, Sedges		10
G - Ground				
G3- Low ground	0.1	Stylidum brunonianum, Laxmannia		5

Vegetation description	Condition
Low woodland of *Banksia* spp., *Allocasuarina fraseriana* and *Eucalyptus marginata* over open shrubland *Xanthorrhoea preissii* and *Allocasuarina humilis* over low shrubland *Hibbertia hypericoides, Eremaea pauciflora* and *Stirlingia latifolia* over forb/sedgeland of *Patersonia occidentalis, Stylidium brunonianum, Chordifex sinuosus, Lomandra* spp	VG- G. Moderate diversity, c. 40% weed cover

Flora Species:	ID. No.	Life stg.	No. indv.	Av. Ht.	% Cover
Banksia attenuata					5
Banksia menziesii					10
Eucalyptus marginata					3
Alllocasuarina fraseriana					2
Allocasuarina humilis					7
Stirlingia latifolia					3
Hibbertia hypericoides					10
Amphipogon turbinatus					3
Hypocalymma robustum					3
Eremaea pauciflora subsp. pauciflora					4
Daviesia triflora					1
Calytrix flavescens					2
Petrophile linearis					2
Laxmannia squarrosa					1
Patersonia occidentalis					3
Leucopogon conostephioides					2
Kunzea glabrescens					2
Dianella revoluta					1
Stylidium brunonianum					1
Lepidosperma squamatum					3

Flora Species:	ID. No.	Life stg.	No. indv.	Av. Ht.	% Cover
Schoenus clandestinus					1
Burchardia congesta					1
Chordifex sinuosus					4
Lomandra hermaphrodita					2
Lomandra sp.					1
Gastrolobium capitatum					2
Leptomeria empetriformis					2
Acacia willdenowiana					3
Thysanotus sp.					1
Ehrharta calycina					40
Gladiolus caryophylleus					2
Gompholobium tomentosum					1
Desmocladus flexuosus					1
Conostylis aculeata					2
Pelargonium capitatum					1
Ursinia anthemoides					2
Conostephium pendulum					1
Dasypogon bromeliifolius					1
Scaevola canescens					1
Acacia saligna					1
Xanthorrhoea preissii					5
Jacksonia furcellata					1
Eucalyptus sp.					opp

Site Details							
Project ID.	EP18-043	Site name	Lot 50 Barfield Road				
Date	15/05/2018, 28/09/2018			Recorder	SKP		
Survey type	Detailed	Sampl. unit	Quadrat		Permanent?	N	
Geographic and habitat data - GDA 94 MGA 50 WP273							
Plot ID.	**2**	Easting:	**392002**	Northing	**6439386**	Altitude	
Photo No.		Photo dir.		Slope	gentle/mod	Aspect	**SW**
Landform	slope			Hydrology	dry		
Soil type	sand			Soil col.	light grey	Subsoil col.	brown
Disturbance	weeds			Time since disturbance			
				Time since fire			<5 years
Notes: less dense weeds than Q1, same community. Lots of 1-2 m high banksia juveniles, some dead large old banksia				**Abiotic/detrital components**			**% Cover**
				Surf. rock	<type>		
				Bground.	<type>		
				Litter 1	<type>		
				Litter 2	<type>		

NVIS Canopy stratum		Major species and other observations	Av.Ht	% Cover
U1- Upper	4-8 m	Banksia spp., Jarrah, Allo fras		25
U2- Sub-canopy				
U3- Lower tree				
M1- Tall shrub				
M1- Mid shrub	1-2 m	Allo hum, Xanthorrhoea, Acacia saligna, J furc		15
M1- Low shrub	0.5-1 m	Hibbertia, Hypocalymma, Leucopogon		25
G1 - Tall ground	0.5	Dianella, Patersonia, sedges		10
G - Ground				
G3- Low ground	0.1	Hemiandra		4

Vegetation description	Condition
Low woodland of *Banksia* spp. and *Allocasuarina fraseriana* over open shrubland *Xanthorrhoea preissii* and *Allocasuarina humilis* over low shrubland *Hibbertia hypericoides, Eremaea pauciflora* and *Stirlingia latifolia* over forb/sedgeland of *Patersonia occidentalis, Chordifex sinuosus, Lomandra* spp	VG moderate diversity, low/mod weed cover

Flora Species:	ID. No.	Life stg.	No. indv.	Av. Ht.	% Cover
Banksia menziesii					10
Banksia attenuata					10
Jacksonia furcellata					5
Xanthorrhoea preissii					5
Kunzea glabrescens					3
Eucalyptus marginata					opp
Conostylis setigera subsp. setigera					2
Opercularia vaginata					1
Stirlingia latifolia					4
Hypocalymma robustum					5
Leptomeria empetriformis					2
Leucopogon conostephioides					2
Gompholobium tomentosum					2
Hibbertia hypericoides					4
Hemiandra pungens					2
Burchardia congesta					1
Patersonia occidentalis					3
Lepidosperma squamatum					3
Lomandra sp.					2
Petrophile linearis					3

Flora Species:	ID. No.	Life stg.	No. indv.	Av. Ht.	% Cover
Lyginia imberbis					4
Laxmannia squarrosa					2
Dianella revoluta					1
Amphipogon turbinatus					2
Chordifex sinuosus					4
Calytrix flavescens					2
Desmocladus flexuosus					2
Chamaecytisus palmensis					1
Gladiolus caryophylleus					1
Briza maxima					3
Ehrharta calycina					12
Acacia willdenowiana					3
Conostylis aculeata					1
Acacia pulchella var. glaberrima					2
Mesomelaena pseudostygia					1
Gastrolobium capitatum					2
Drosera sp.					1
Hibbertia racemosa					2
Euphorbia terracina					2
Anigozanthos manglesii					1
Calytrix fraseri					1
Tricoryne elatior					opp
Carpobrotus edulis					opp
Pinus pinaster					opp
Corymbia citreodora					opp
Arecaceae sp.					opp
Nuytsia floribunda					opp
Adenanthos cygnorum					opp
Asphodelus fistulosus					opp
Xanthosia huegelii					opp
Caladenia longicauda supsp. calcigena					opp
Anigozanthos humilis					1

Anigozanthos manglesii					2
Stylidium piliferum					1
Stylidium brunonianum					opp
Sowerbaea laxiflora					2
Thelymitra macrophylla					opp
Laxmannia squarrosa					2
Caladenia flava subsp. flava					1
Lomandra ?caespitosa					1
Phlebocarya ciliata					1
Amphipogon turbinatus					1
Drosera pallida					1
Drosera menziesii					1
Drosera erythrorhiza					3
Trachymene pilosa					0.5
Chamaescilla corymbosa					3

Site Details							
Project ID.	EP18-043	Site name	Lot 50 Barfield Road				
Date	15/05/2018, 28/09/2018			Recorder	SKP		
Survey type	Detailed	Sampl. unit	Quadrat		Permanent?	N	
Geographic and habitat data - GDA 94 MGA 50 WP274							
Plot ID.	**3**	Easting:	**392015**	Northing	**6439298**	Altitude	
Photo No.		Photo dir.		Slope	moderate	Aspect	**S**
Landform	slope			Hydrology			
Soil type	sand			Soil col.	white	Subsoil col.	brown
Disturbance	Weeds, not dominant			Time since disturbance			
				Time since fire			<5 years
Notes: Young banksias, some dead older banksia.				**Abiotic/detrital components**			**% Cover**
				Surf. rock	<type>		0
				Bground.	<type>		
				Litter 1	<type>		
				Litter 2	<type>		

NVIS Canopy stratum		**Major species and other observations**	**Av.Ht**	**% Cover**
U1- Upper	4-8 m	Banksia spp., Nuytsia, Allocasuarina fras		35
U2- Sub-canopy				
U3- Lower tree				
M1- Tall shrub				
M1- Mid shrub	1-2 m	Allo hum, Xanthorrhoea		15
M1- Low shrub	0.5-1 m	Gompholobium, Stirlingia, Acacia, Eremaea		25
G1 - Tall ground	0.5	Dianella, Patersonia, Lyginia, sedges		10
G - Ground				
G3- Low ground	0.1	Stylidium repens		4

Vegetation description	**Condition**
Low woodland of *Banksia* spp., *Nuytsia floribunda* and *Allocasuarina fraseriana* over open shrubland *Xanthorrhoea preissii* and *Allocasuarina humilis* over low shrubland *Hibbertia hypericoides, Eremaea pauciflora* and *Stirlingia latifolia* over forb/sedgeland of *Patersonia occidentalis, Lyginia imberbis, Stylidium repens, Chordifex sinuosus, Lomandra* spp	VG moderate diversity, low/mod weed cover

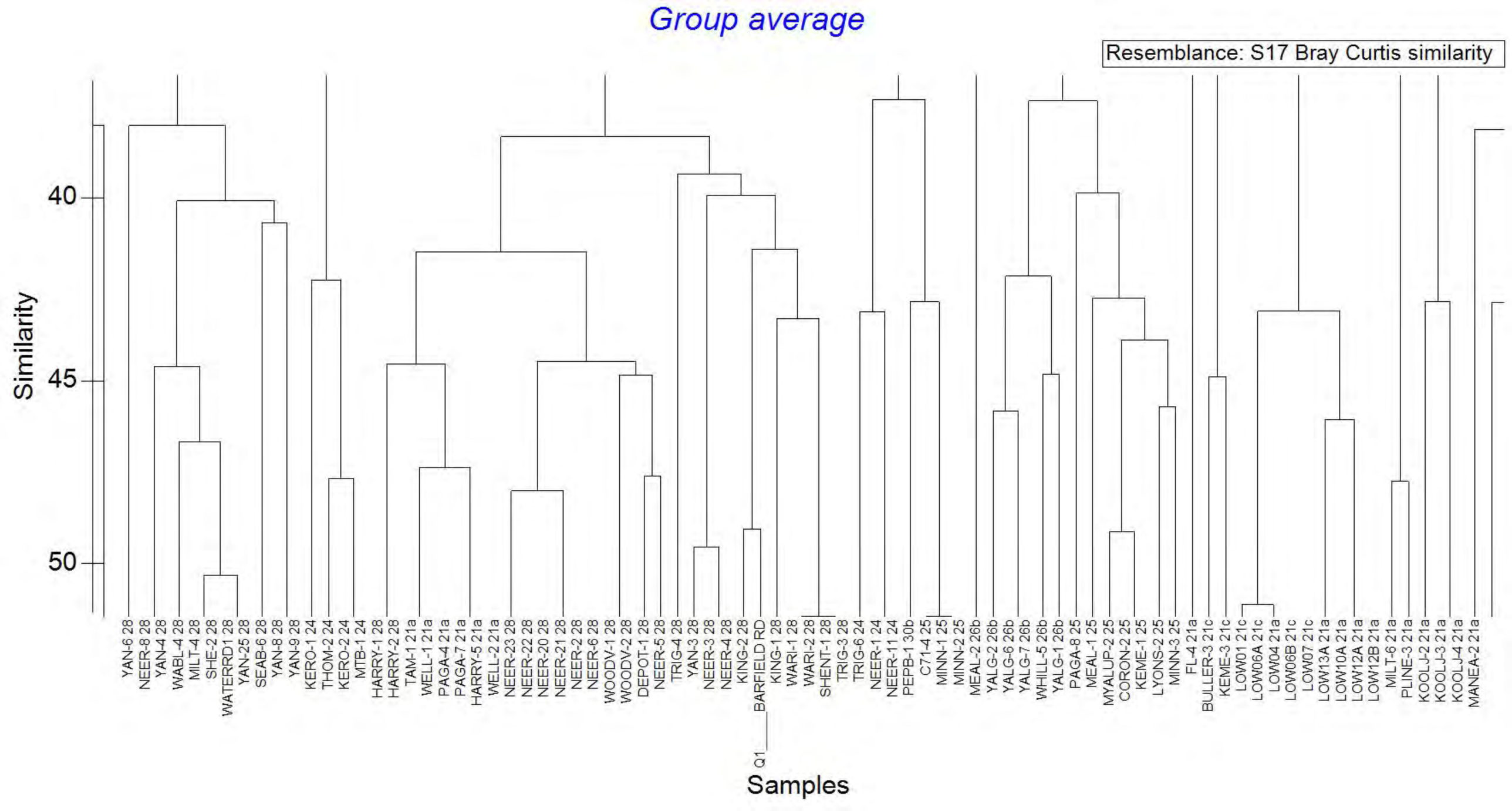
Flora Species:	**ID. No.**	**Life stg.**	**No. indv.**	**Av. Ht.**	**% Cover**
Banksia attenuata					15
Banksia menziesii					10
Nuytsia floribunda					10
Allocasuarina fraseriana					5
Allocasuarina humilis					10
Xanthorrhoea preissii					6
Gompholobium tomentosum					2
Stirlingia latifolia					4
Acacia stenoptera					2
Acacia willdenowiana					2
Chordifex sinuosus					4
Calytrix flavescens					2
Amphipogon turbinatus					3
Patersonia occidentalis					3
Conostephium pendulum					2
Desmocladus flexuosus					2
Eremaea asterocarpa subsp. asterocarpa					2
Acacia stenoptera					2
Bossiaea eriocarpa					1
Stylidium repens					2
Burchardia congesta					1

Flora Species:	ID. No.	Life stg.	No. indv.	Av. Ht.	% Cover
Lyginia imberbis					3
Gladiolus caryophylleus					2
Petrophile linearis					2
Daviesia triflora					2
Lepidosperma squamatum					3
Ehrharta calycina					7
Hypolaena exsulca					2
Kunzea glabrescens					2
Gastrolobium capitatum					2
Banksia ilicifolia					2
Lomandra nigricans					1
Briza maxima					2
Hibbertia racemosa					2
Acacia pulchella var. glaberrima					3
Caladenia flava subsp. flava					1
Chamaescilla corymbosa					3
Drosera erythrorhiza					2
Schoenus curvifolius					2
Conostylis juncea					1
Conostylis aculeata subsp. aculeata					3
Conostylis setigera subsp. setigera					2
Lomandra preissii					1
Jacksonia furcellata					2
Phlebocarya ciliata					2
Hypocalymma robustum					2
Schoenus pedicellatus					1
Philotheca spicata					1
Amphipogon turbinatus					2
Stylidium schoenoides					1
Hovea trisperma					1
Trachymene pilosa					1
Elythranthera brunonis					1

Drosera menziesii					1
Dianella revoluta					1
Stylidium brunonianum					1
Drosera pallida					1
Alexgoergea nitens					opp
Dampiera linearis					opp
Sowerbaea laxiflora					opp
Eremaea pauciflora var. pauciflora					opp
Eucalyptus gomphocephala					opp
Solanum nigrum					opp
Oxalis pes-caprae					opp
Kennedia prostrata					opp
Lupinus cosentii					opp
Hypochaeris glabra					opp
Euphorbia terracina					opp
Osteospermum ecklonis					opp
Trifolium angustifolium					opp
Gomphocarpus fruticosus					opp
conyza sumatrensis					opp
Plantago lanceolata					opp
Acacia iteaphylla					opp
Avena barbata					opp
Pinus pinaster					opp
Astroloma pallidum					opp
Eucalyptus sp.					opp
Rosaceae sp.					opp
Chamaecytisus palmensis					opp
Trifolium campestre					opp
Carpobrotus edulis					opp
Crassula colorata					opp
Dischisma arenarium					opp
Tropaeolum majus					opp
Arctotheca calendula					opp
Trifolium angustifolium					opp
Trifolium hirtum					opp
Fumaria capreolata					opp
Gladiolus caryophylleus					opp
Sonchus oleraceus					opp
Oxalis pes-caprae					opp
Raphanus raphanistrum					opp
Asphodelus fistulosus					opp
Ricinus communis					opp

Appendix D

Cluster Dendrograms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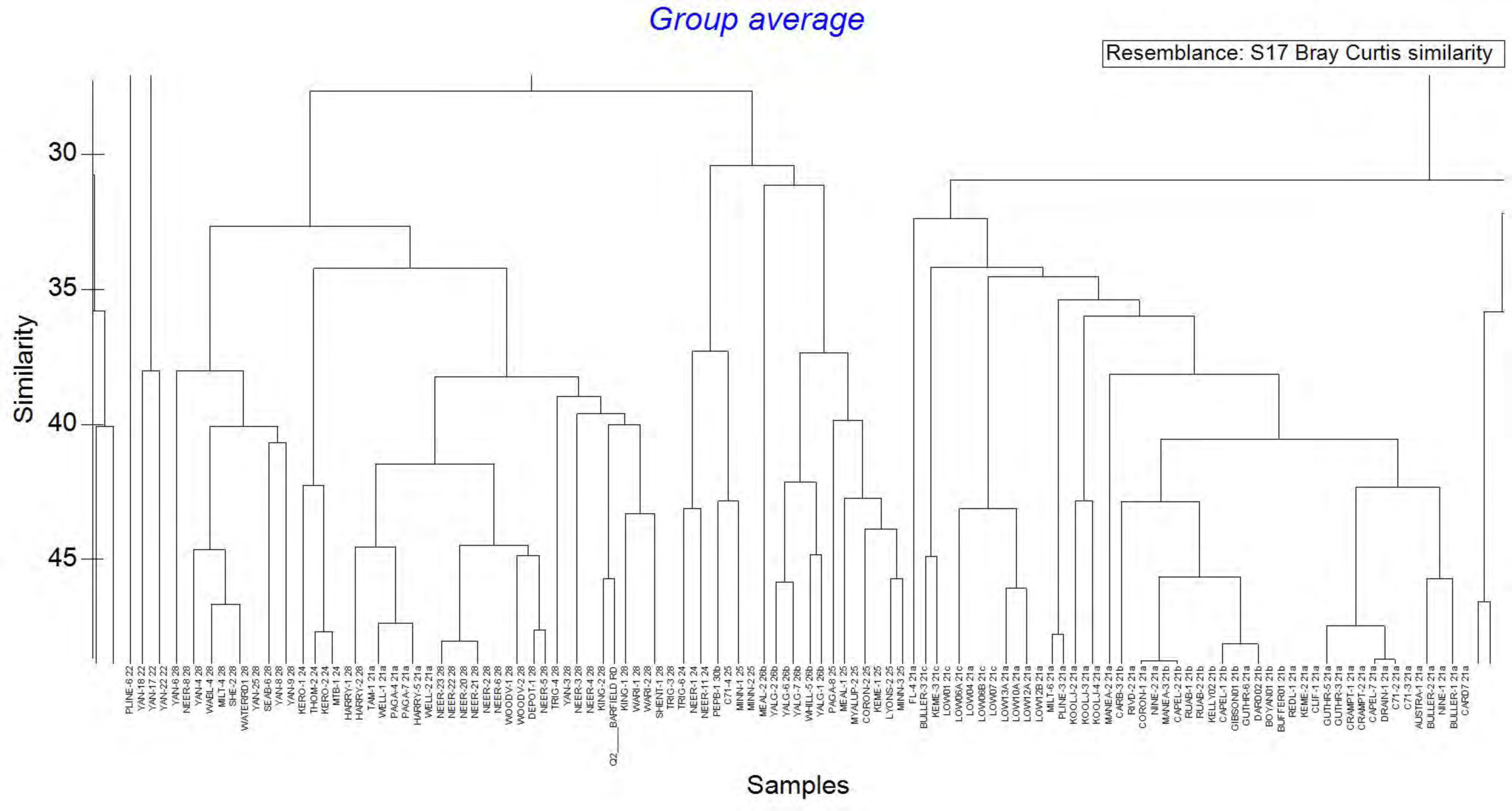
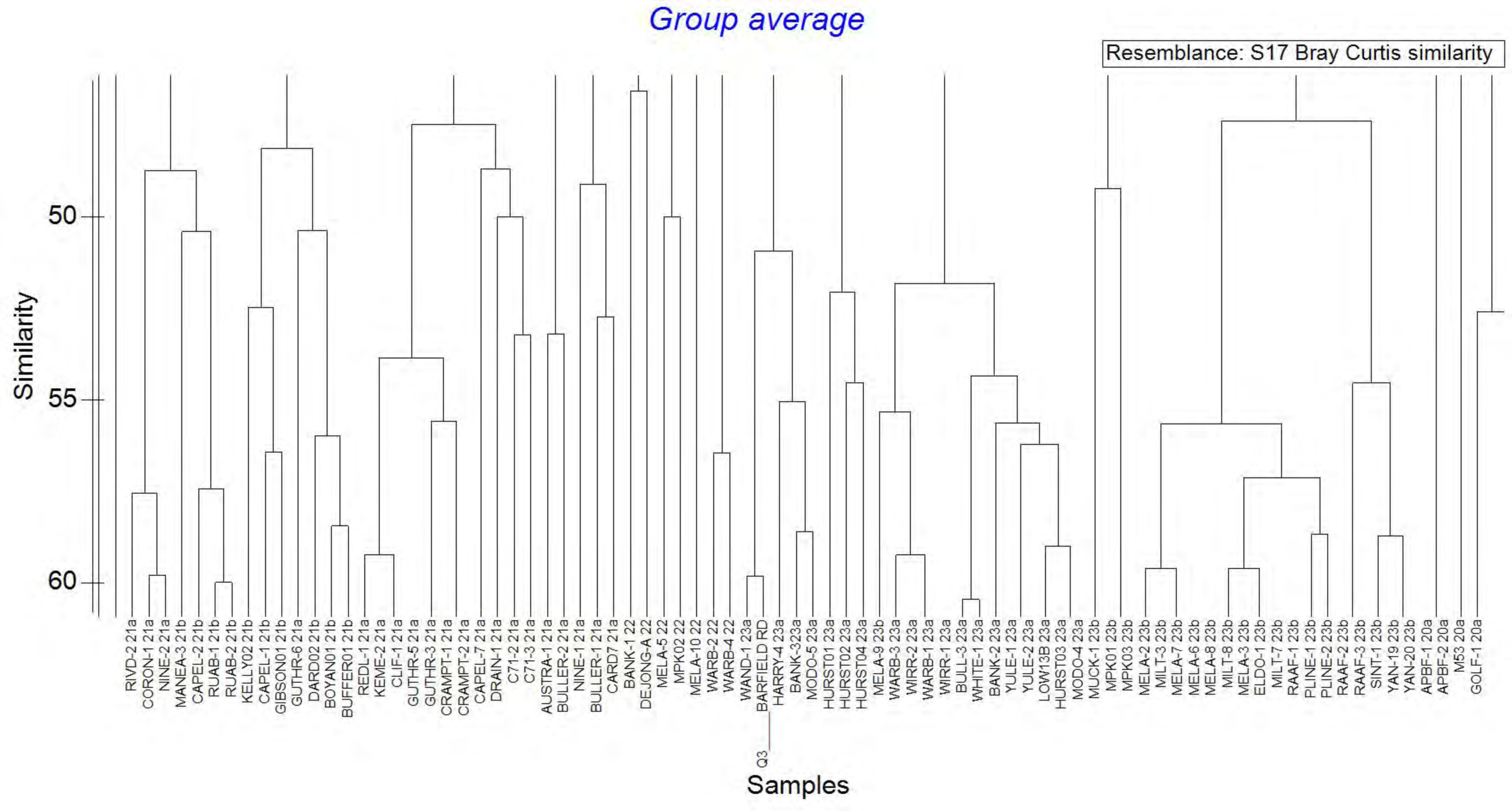
Resemblance: S17 Bray Curtis similarity
Similarity
40
45
50
YAN-6 28
NEER-8 28
YAN-4 28
WABL-4 28
MILT-4 28
SHE-2 28
WATERRD1 28
YAN-25 28
SEAB-6 28
YAN-8 28
YAN-9 28
KERO-1 24
THOM-2 24
KERO-2 24
MTB-1 24
HARRY-1 28
HARRY-2 28
TAM-1 21a
WELL-1 21a
PAGA-4 21a
PAGA-7 21a
HARRY-5 21a
WELL-2 21a
NEER-23 28
NEER-22 28
NEER-20 28
NEER-21 28
NEER-2 28
NEER-6 28
WOODV-1 28
WOODV-2 28
DEPOT-1 28
NEER-5 28
TRIG-4 28
YAN-3 28
NEER-3 28
NEER-4 28
KING-2 28
Q1___BARFIELD RD
KING-1 28
WARI-1 28
WARI-2 28
SHENT-1 28
TRIG-3 28
TRIG-6 24
NEER-1 24
NEER-11 24
PEPB-1 30b
C71-4 25
MINN-1 25
MINN-2 25
MEAL-2 26b
YALG-2 26b
YALG-6 26b
YALG-7 26b
WHILL-5 26b
YALG-1 26b
PAGA-8 25
MEAL-1 25
MYALUP-2 25
CORON-2 25
KEME-1 25
LYONS-2 25
MINN-3 25
FL-4 21a
BULLER-3 21c
KEME-3 21c
LOW01 21c
LOW06A 21c
LOW04 21a
LOW06B 21c
LOW07 21c
LOW13A 21a
LOW10A 21a
LOW12A 21a
LOW12B 21a
MILT-6 21a
PLINE-3 21a
KOOLJ-2 21a
KOOLJ-3 21a
KOOLJ-4 21a
MANEA-2 21a
Samples


Group average
Resemblance: S17 Bray Curtis similarity
Similarity
30
35
40
45
Samples
PLINE-6 22
YAN-18 22
YAN-17 22
YAN-22 22
YAN-6 28
NEER-8 28
YAN-4 28
WABL-4 28
MILT-4 28
SHE-2 28
WATERRD1 28
YAN-25 28
SEAB-6 28
YAN-8 28
YAN-9 28
KERO-1 24
THOM-2 24
KERO-2 24
MTB-1 24
HARRY-1 28
HARRY-2 28
TAM-1 21a
WELL-1 21a
PAGA-4 21a
PAGA-7 21a
HARRY-5 21a
WELL-2 21a
NEER-23 28
NEER-22 28
NEER-20 28
NEER-21 28
NEER-2 28
NEER-6 28
WOODV-1 28
WOODV-2 28
DEPOT-1 28
NEER-5 28
TRIG-4 28
YAN-3 28
NEER-3 28
NEER-4 28
KING-2 28
BARFIELD RD
Q2
KING-1 28
WARI-1 28
WARI-2 28
SHENT-1 28
TRIG-3 28
TRIG-6 24
NEER-1 24
NEER-11 24
PEPB-1 30b
C71-4 25
MINN-1 25
MINN-2 25
MEAL-2 26b
YALG-2 26b
YALG-6 26b
YALG-7 26b
WHILL-5 26b
YALG-1 26b
PAGA-8 25
MEAL-1 25
MYALUP-2 25
CORON-2 25
KEME-1 25
LYONS-2 25
MINN-3 25
FL-4 21a
BULLER-3 21c
KEME-3 21c
LOW01 21c
LOW06A 21c
LOW04 21a
LOW06B 21c
LOW07 21c
LOW13A 21a
LOW10A 21a
LOW12A 21a
LOW12B 21a
MILT-6 21a
PLINE-3 21a
KOOLJ-2 21a
KOOLJ-3 21a
KOOLJ-4 21a
MANEA-2 21a
CARB-3 21b
RIVD-2 21a
CORON-1 21a
NINE-2 21a
MANEA-3 21b
CAPEL-2 21b
RUAB-1 21b
RUAB-2 21b
KELLY02 21b
CAPEL-1 21b
GIBSON01 21b
GUTHR-6 21a
DARD02 21b
BOYAN01 21b
BUFFER01 21b
REDL-1 21a
KEME-2 21a
CLIF-1 21a
GUTHR-5 21a
GUTHR-3 21a
CRAMPT-1 21a
CRAMPT-2 21a
CAPEL-7 21a
DRAIN-1 21a
C71-2 21a
C71-3 21a
AUSTRA-1 21a
BULLER-2 21a
NINE-1 21a
BULLER-1 21a
CARD7 21a


Group average
Resemblance: S17 Bray Curtis similarity
Similarity
50
55
60
RIVD-2 21a
CORON-1 21a
NINE-2 21a
MANEA-3 21b
CAPEL-2 21b
RUAB-1 21b
RUAB-2 21b
KELLY02 21b
CAPEL-1 21b
GIBSON01 21b
GUTHR-6 21a
DARD02 21b
BOYAN01 21b
BUFFER01 21b
REDL-1 21a
KEME-2 21a
CLIF-1 21a
GUTHR-5 21a
GUTHR-3 21a
CRAMPT-1 21a
CRAMPT-2 21a
CAPEL-7 21a
DRAIN-1 21a
C71-2 21a
C71-3 21a
AUSTRA-1 21a
BULLER-2 21a
NINE-1 21a
BULLER-1 21a
CARD7 21a
BANK-1 22
DEJONG-A 22
MELA-5 22
MPK02 22
MELA-10 22
WARB-2 22
WARB-4 22
WAND-1 23a
BARFIELD RD
Q3
HARRY-4 23a
BANK-323a
MODO-5 23a
HURST01 23a
HURST02 23a
HURST04 23a
MELA-9 23b
WARB-3 23a
WIRR-2 23a
WARB-1 23a
WIRR-1 23a
BULL-3 23a
WHITE-1 23a
BANK-2 23a
YULE-1 23a
YULE-2 23a
LOW13B 23a
HURST03 23a
MODO-4 23a
MUCK-1 23b
MPK01 23b
MPK03 23b
MELA-2 23b
MILT-3 23b
MELA-7 23b
MELA-6 23b
MELA-8 23b
MILT-8 23b
MELA-3 23b
ELDO-1 23b
MILT-7 23b
RAAF-1 23b
PLINE-1 23b
PLINE-2 23b
RAAF-2 23b
RAAF-3 23b
SINT-1 23b
YAN-19 23b
YAN-20 23b
APBF-1 20a
APBF-2 20a
M53 20a
GOLF-1 20a
Samples

Appendix C

Level 1 Fauna Assessment and Targeted Black Cockatoo Survey (Emerge Associates 2018)

Level 1 Fauna Assessment and Targeted Black Cockatoo Survey

Lot 50 Barfield Road, Hammond Park

Project No: EP18-043(05)

Prepared for Glenbrook Civil
October 2018

Document Control

Doc name:	Level 1 Fauna Assessment and Targeted Black Cockatoo Survey Lot 50 Barfield Road, Hammond Park				
Doc no.:	**EP18-043(05)--006**				
Version	**Date**	**Author**		**Reviewer**	
1	October 2018	Melanie Schubert	MS	Tom Atkinson	TAA
	Submitted for client review				

Executive Summary

Rowe Group, on behalf of the landowner Glenbrook Civil, has prepared a local structure plan (LSP) for the future residential development of Lot 50 Barfield Road, Hammond Park. This lot is approximately 1.86 hectares (ha) in size and is bound by Barfield Road to the west, future urban development to the north and south and a Western Power easement and Kwinana Freeway to the east.

Emerge Associates (Emerge) were engaged by Glenbrook Civil to provide environmental consultancy services to support the structure planning process for the site. As part of this, Emerge undertook a fauna assessment to the standard required of a 'level 1' survey (desktop assessment and site inspection) and targeted (black cockatoo) survey in accordance with the Environmental Protection Authority's (EPA's) *Technical Guidance – Terrestrial fauna Surveys* (EPA 2016).

As part of this scope of work the following tasks were undertaken:

- Desktop review of background information regarding fauna species relevant to the site and surrounds.
- Compilation of a list of fauna species opportunistically recorded as part of the field survey.
- Identification of potential habitat for conservation significant fauna species and likelihood of occurrence.
- A targeted black cockatoo survey including a roost survey at dusk.
- Documentation of the desktop assessment, survey methodology and results into a report.

A total number of 8 native fauna species were recorded within the site, of which none are threatened or priority species.

No signs of black cockatoos were observed during the site inspection. The site has limited value as habitat for black cockatoos including five habitat trees and a relatively small extend of roosting and foraging habitat.

The site may provide habitat for a range of common and widespread native fauna species but it is unlikely to provide important habitat for black cockatoos or any other conservation significant fauna species.

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Abbreviation Tables

Table A1: Abbreviations – Organisations

Organisations	
EPA	Environmental Protection Authority
DBCA	Department of Biodiversity, Conservation and Attractions
DPaW	Department of Parks and Wildlife (now DBCA)
DoEE	Department of Environment and Energy

Table A2: Abbreviations – General terms

General terms	
VU	Vulnerable
EN	Endangered
S	Specially protected fauna
CD	Conservation depended
CE	Critically endangered
IA	International agreement
MI	Migratory fauna
P1	Priority 1
P2	Priority 2
P3	Priority 3
P4	Priority 4
P5	Priority 5

Table A3: Abbreviations –Legislation

Legislation	
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
WC Act	*Wildlife Conservation Act 1950*

Table A4: Abbreviations – planning

Planning terms	
LSP	Local structure plan
MRS	Metropolitan region scheme
TPS	Town planning scheme

Table A5: Abbreviations – units of measurement

Planning terms	
ha	Hectare
km	Kilometre
mm	Millimetre

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1 Introduction

1.1 Project background

Rowe Group, on behalf of the landowner Glenbrook Civil, has prepared a local structure plan (LSP) for the future residential development of Lot 50 Barfield Road, Hammond Park (herein referred to as 'the site'). The site is located approximately 25 kilometres south of the Perth Central Business District, within the City of Cockburn (CoC) and is zoned 'urban' under the Metropolitan Regional Scheme (MRS) and 'urban' under the City of Cockburn Town Planning Scheme No. 3 (TPS No. 3).

The site is approximately 1.86 hectares (ha) in size and is bound by Barfield Road to the west, future urban development to the north and south and a Western Power easement and Kwinana Freeway to the east. The location and extent of the site is shown in **Figure 1.**

1.2 Purpose and scope of work

Emerge Associates (Emerge) were engaged by Glenbrook Civil to provide environmental consultancy services to support the structure planning process for the site. As part of this, Emerge undertook a fauna assessment to the standard required of a 'level 1' survey (desktop assessment and site inspection) and targeted (black cockatoo) survey in accordance with the Environmental Protection Authority's (EPA's) *Technical Guidance – Terrestrial fauna Surveys* (EPA 2016).

As part of this scope of work the following tasks were undertaken:

- Desktop review of background information regarding fauna species relevant to the site and surrounds.
- Compilation of a list of fauna species opportunistically recorded as part of the field survey.
- Identification of potential habitat for conservation significant fauna species and likelihood of occurrence.
- A targeted black cockatoo survey including a roost survey at dusk.
- Documentation of the desktop assessment, survey methodology and results into a report.

2 Methods

2.1 Desktop assessment

2.1.1 Database searches

A variety of different databases were accessed to source information on fauna species with potential to occur within the site.

Sources of information included:

- DPaW's *NatureMap* Database Search (combined data from DPaW, Western Australian Museum, Birds Australia and consultants' reports) (DPaW 2017a)
- *Protected Matters Search Tool* (DoEE 2017a)
- DBCA's threatened and priority fauna database.

Database searches were conducted within a 10 km radius of the site.

The search results were reviewed and fauna species with no potential to occur within the site due to lack of habitat (e.g. marine mammal species) were removed.

A total number of species with potential to occur within the site was calculated by adding the total count of non-conservation significant species provided by *NatureMap* to the combined number of conservation significant species received from *NatureMap* and *Protected Matters Search Tool*.

2.1.2 Taxonomy and nomenclature

Taxonomy and nomenclature for vertebrate fauna species was taken from the *WA Museum Checklist of the Terrestrial Vertebrate Fauna of Western Australia* (Western Australian Museum 2018).

2.2 Reconnaissance survey

An ecologist from Emerge visited the site on the 28 and of September 2018 to undertake a reconnaissance survey in conjunction with a targeted black cockatoo survey. During the survey the following tasks were undertaken:

- Where possible, transects were traversed across the site, during the day, while searching microhabitats such as logs, rocks and leaf litter.
- Secondary evidence of species presence such as tracks, scats, skeletal remains, foraging evidence or calls was collected.
- A black cockatoo habitat assessment, identifying habitat trees (DBH > 500mm), roosting and foraging habitat was undertaken. A dusk survey was undertaken, involving listening and looking out for incoming flocks of black cockatoos. Secondary evidence of roosting activity such as branch clippings, droppings and moulted feathers were also noted.

- A vertebrate fauna list was compiled and fauna habitat values were described, with particular reference to 'threatened' and 'priority' fauna species with potential to occur within the site[1].

2.3 Fauna habitat assessment

The native plant communities identified during the flora and vegetation survey (Emerge 2018), supplemented with observations during the reconnaissance survey, has been used as a basis for categorizing areas within the site into broad fauna habitat types.

As part of the desktop assessment, available information on specific habitat requirements for conservation significant vertebrate fauna species listed as having potential to occur within the site were compiled. This information was used to determine whether these fauna species are likely to be utilising the site.

2.4 Survey limitations

It is important to note the specific constraints imposed on surveys and the degree to which these may have limited survey outcomes. An evaluation of the survey methodology against standard constraints outlined in the EPA document *Technical Guidance – Terrestrial Fauna Surveys* (EPA 2016) is provided in **Table 1**.

Table 1: Survey limitations.

Constraint	Degree of limitation	Details
Level of survey	No limitation	A level 1 (desktop study and site inspection) survey was appropriate due to the relatively small scale of the site, the relatively low habitat values within the site and the generally good availability of fauna information for the region.
Scope	No limitation	The survey focused on vertebrate fauna and habitat values, with particular focus on conservation significant taxa with potential to occur within the site.
Proportion of fauna identified, recorded and/or collected.	No limitation	All observed vertebrate fauna were identified.
Sources of information e.g. previously available information (whether historic or recent) as distinct from new data.	No limitation	Adequate information was available from database searches and previous surveys in the region.
The proportion of the task achieved and further work which might be needed.	No limitation	The task was achieved in its entirety.

[1] Invertebrate taxa were not assessed and no evaluation of the potential for invertebrate taxa to occur within the site is provided.

Table 1 (cont): Survey limitations.

Constraint	Degree of limitation	Details
Experience level of personnel	Minor limitation	This fauna assessment was undertaken by a qualified, early career ecologist. The ecologist is experienced in conducting fauna surveys but is relatively new to Western Australia. Technical review was undertaken by a senior environmental consultant with 15 years' experience in environmental science in Western Australia.
Suitability of timing	No limitation	Survey timing is not considered to be of great importance for Level 1 assessments. The weather conditions were excellent for identifying fauna species.
Completeness	No limitation	The desktop assessment and site inspection components of the survey were completed.
Spatial coverage and access	No limitation	Site coverage was comprehensive (track logged).
	No limitation	All parts of the site could be accessed as required.
Survey intensity	No limitation	The intensity of the survey was adequate given the size of the site and the relatively low habitat value present.
Influence of disturbance	No limitation	The site is highly modified due to historical disturbance. However, no recent disturbance was noted that may have affected outcomes of the survey.
Adequacy of resources	No limitation	All resources required to perform the survey were available.

3 Results

3.1 Desktop Assessment

A search was conducted for fauna species within a 10 km radius of the site using *the Protected Matters Search Tool* (DoEE 2017a), *Nature Map* (DPaW 2017a) and DBCA's threatened and priority fauna database (reference no. 5802). A total number of 408 fauna species (native and non-native) were identified as having potential to occur within the site or the wider local area. This includes 36 threatened, one conservation depended, one other specially protected and 17 priority fauna species as shown in **Table 2**. A full list of fauna species is provided in **Appendix C**.

Table 2: Summary of conservation significant fauna species known or likely to occur within 10 km of the site.

Species	Common name	Level of significance		Habitat	Likelihood of occurrence within the site
		State	EPBC Act		
Birds					
Anous tenuirostris melanops	Australian lesser noddy	EN	VU	Very common in blue-water seas around the Abrolhos (endemic to this area, accidental occurrences on lower west coast of Australia) (Johnstone and Storr 1998).	Unlikely
Botaurus poiciloptilus	Australasian bittern	EN	EN	Beds of tall dense *Typha*,spp., *Baumea* spp. and sedges in freshwater swamps.	Unlikely
Calidris canatus	Red knot	VU (IA)	CR (MI)	Mud and sand flats in estuaries and on sheltered coasts. Also near-coastal saltlakes, including saltwork ponds.	Unlikely
Calidris ferruginea	Curlew sandpiper	VU (IA)	CR (MI)	Mainly shallows of estuaries and near-coastal saltlakes (including saltwork ponds) and drying near-coastal freshwater lakes and swamps. Also beaches and near-coastal sewage ponds.	Unlikely
Calidris tenuirostris	Great knot	VU (IA)	CR (MI)	Mud or sand flats in estuaries and on sheltered coasts. Also near-coastal saltlakes, including saltwork ponds.	Unlikely
Calyptorhynchus banksii naso	Forest red-tailed black cockatoo	VU	VU	Eucalypt forests. Attracted to seeding *Corymbia calophylla*, *Eucalyptus marginata*, *E. patens*, *E. staeri*, *E. diversicolor*, *Allocasuarina fraseriana* and *Persoonia longifolia* (Johnstone and Storr 1998).	Possible

Table 2 (cont): Summary of conservation significant fauna species known or likely to occur within 10 km of the site.

Species	Common name	Level of significance		Habitat	Likelihood of occurrence within the site
		State	EPBC Act		
Birds					
Calyptorhynchus baudinii	Baudin's cockatoo	EN	EN	Mainly eucalypt forests. Attracted to seeding *Corymbia calophylla*, *Banksia* spp., *Hakea* spp., *Erodium botyrs*, and to fruiting apples and pears (Johnstone and Storr 1998).	Unlikely
Calyptorhynchus latirostris	Carnaby's cockatoo	EN	EN	Mainly proteaceous scrubs and heaths and adjacent eucalypt woodlands and forests; also plantations of *Pinus* spp. Attracted to seeding *Banksia*, *Dryandra*, *Hakea*, *Eucalyptus*, *Corymbia*, *Grevillea*, *Pinus* and *Allocasuarina* spp. Roosting in flat-topped yates *Eucalyptus occidentalis* (Johnstone and Storr 1998).	Possible
Chardadrius leschenaultii	Greater sand plover	VU (IA)	VU (MI)	Mainly bare margins of fresh or brackish waters, however small (river pools, lagoons, claypans, swamps, rockholes, ephemeral waters, roadside puddles, farm dams, reservoir and sewage ponds). Occasionally edge of saltlakes and estuaries (Johnstone and Storr 1998).	Unlikely
Diomedea amsterdamensis	Amsterdam albatross	CR (IA)	EN (MI)	The Amsterdam Albatross is a marine, pelagic seabird. It nests in open patchy vegetation (among tussocks, ferns or shrubs) near exposed ridges or hillocks (Weimerskirch *et al.* 1985). It sleeps and rests on ocean waters when not breeding (Marchant and Higgins 1990).	Unlikely

Table 2 (cont): Summary of conservation significant fauna species known or likely to occur within 10 km of the site.

Species	Common name	Level of significance		Habitat	Likelihood of occurrence within the site
		State	EPBC		
Birds					
Diomedea dabbenena	Tristan albatross	CR (IA)	EN (MI)	The Tristan albatross is a marine, pelagic seabird. It forages in open water in the Atlantic Ocean near the Cape of Good Hope, South Africa. It sleeps and rests on ocean waters when not breeding (Marchant and Higgins 1990).	Unlikely
Diomedea epomophora	Southern royal albatross	VU (IA)	VU (MI)	Rare visitor to Western Australian seas; it breeds on subantarctic islands south of New Zealand (Johnstone and Storr 1998).	Unlikely
Diomedea exulans	Wandering albatross	VU (IA)	VU (MI)	Marine, pelagic and aerial species. It breeds on Macquarie Island and feeds in Australian portions of the Southern Ocean (Doe 2018).	Unlikely
Diomedea sanfordi	Northern royal albatross	EN (IA)	EN (MI)	Marine, pelagic and aerial species. Its habitat includes subantarctic, subtropical, and occasionally Antarctic waters (Marchant and Higgins 1990).	Unlikely
Falco peregrinus	Peregrine falcon	OS	-	Mainly found around cliffs along coasts, rivers, ranges and around wooded watercourses and lakes (Johnstone and Storr 1998).	Unlikely (fly over possible)
Ixobrychus dubius	Australian little bittern	P4	-	Dense vegetation surrounding/within freshwater pools, swamps and lagoons, well screened with trees. Shelters in dense beds of Typha spp., Baumea spp. and tall rushes in freshwater swamps around lakes and along rivers (Johnstone and Storr 1998).	Unlikely
Leipoa ocellata	Mallefowl	VU	VU	Scrubs and thickets of *Eucalyptus* spp., *Melaleuca ianceolata* and *Acacia linophylla*; also other dense litter-forming shrublands. Attracted to fallen wheat in stubbles and along roads (Johnstone and Storr 1998).	Unlikely (locally extinct)
Limosa lapponica baueri	Bar-tailed godwit	VU (IA)	VU or CR (MI)	Estuarine sand and mudflats and sandy beaches with loads of seaweed; also reef flats and near-coastal saltlakes (including saltwork ponds) (Johnstone and Storr 1998).	Unlikely

Table 2 (cont): Summary of conservation significant fauna species known or likely to occur within 10 km of the site.

Species	Common name	Level of significance		Habitat	Likelihood of occurrence within the site
		State	EPBC		
Birds					
Limosa lapponica menzbieri	Bar-tailed godwit	VU (IA)	CR (MI)		Unlikely
Macronectes giganteus	Southern giant-petrel	- (IA)	EN (MI)	Breeds on southern subantartic and antarctic islands. May visit Western Australian waters from February to December (mostly June to September) (Johnstone and Storr 1998).	Unlikely
Macronectes halli	Northern giant petrel	- (IA)	VU (MI)	Breeds on subantartic islands. May visit Western Australian water from February to September (Johnstone and Storr 1998).	Unlikely
Ninox connivens	Barking owl	P3	-	Dense vegetation, especially forests and thickets of cajuput *Melaleuca leucadendra* and other waterside melaleucas; also mangroves, rainforests and deciduous vine scrubs (Johnstone and Storr 1998).	Unlikely
Numenius madagascariensis	Eastern curlew	VU (IA)	CR (MI)	Mainly tidal mudflats; also reef flats, sandy beaches and rarely near-coastal lakes (including saltwork ponds) (Johnstone and Storr 1998).	Unlikely
Oxyura australis	Blue-billed duck	P4	-	Mainly deeper freshwater swamps and lakes; occasionally saltlakes and estuaries freshened by flood waters (Johnstone and Storr 1998).	Unlikely
Pachyptila turtur	Fairy prion	-	VU	Breeds on subantarctic islands and is presumed to frequent subtropical waters during non-breeding period (TSSC 2015).	Unlikely
Phaethon rubricauda	Red-tailed tropicbird	P4 (IA)	- (MI)	Spend most of their lives at sea and rarely venture near land. This bird is normally found in tropical and subtropical seas around northern Australia. Though rarely seen in colder areas, a few pairs breed on Sugarloaf Rock, south of Cape Naturaliste (DPAW 2017b).	Unlikely
Rostratula australis	Australian painted snipe	EN	EN	Mainly shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans (Marchant and Higgins 1993).	Unlikely

Table 2 (cont): Summary of conservation significant fauna species known or likely to occur within 10 km of the site.

Species	Common name	Level of significance		Habitat	Likelihood of occurrence within the site
		State	EPBC		
Birds					
Rostratula benghalensis	Painted snipe	-	EN	Well vegetated shallows and margins of wetlands, dams, sewerage ponds, wet pastures, marshy areas, irrigation systems, lignum, tea tree scrub, open timber. Requires dense low cover (Morcombe 2004).	Unlikely
Sternula nereis nereis	Australian fairy tern	VU	VU	Sheltered blue-water seas close to land, estuaries (when free of silt) and near-coastal lakes (Johnstone and Storr 1998).	Unlikely
Thalassarche cauta cauta	Shy albatross	VU (IA)	VU (MI)	Scarce visitor (late May to mid-October) to southwestern and western seas. Breeds on islands off Tasmania and south New Zealand (Johnstone and Storr 1998).	Unlikely
Thalassarche cauta steadi	White-capped albatross	VU (IA)	VU (MI)	Scarce visitor (late May to mid-October) to southwestern and western seas. Breeds on islands off Tasmania and south New Zealand (Johnstone and Storr 1998).	Unlikely
Thalassarche impavida	Campbell albatross	VU	VU	Scarce visitor to south western and western seas. Breeds on Campbell island.	Unlikely
Thalassarche melanophris	Black-browed albatross	EN (IA)	VU (MI)	Seas of south and west coasts. Visitor to Western Australian mainland from January to early November (mostly May to September). Breeds on southern subantartic and antarctic islands (Johnstone and Storr 1998).	Unlikely
Thinornis rubricollis	Hooded plover	P4	-	Margins and shallows of saltlakes, sandy and seaweedy beaches and estuaries; also dams (Johnstone and Storr 1998).	Unlikely
Tringa brevipes	Grey-tailed tattler	P4	-	Tidal mud and reef flats, sheltered rocky coasts, stony and seaweedy beaches and sandpits, dry coral ridges (Abrolhos) and pebbly shores of near-coastal saltlakes (including saltwork ponds) (Johnstone and Storr 1998).	Unlikely

Table 2 (cont): Summary of conservation significant fauna species known or likely to occur within 10 km of the site.

Species	Common name	Level of significance		Habitat	Likelihood of occurrence within the site
		State	EPBC		
Birds					
Tyto novaehollandiae novaehollandiae	Masked owl	P3	-	Forests, woodlands, timbered waterways and open country on the fringe of these areas (BirdLife Australia 2018).	Unlikely
Mammals					
Bettongia penicillata ogilbyi	Woylie	CR	EN	Woodlands and adjacent heaths with a dense understorey of shrubs, particularly *Gastrolobium* spp (TSSC 2018).	Unlikely (locally extinct)
Dasyurus geoffroii	Chuditch	VU	VU	Wide range of habitats from woodlands, dry sclerophyll forests, riparian vegetation, beaches and deserts. Appears to utilise native vegetation along road sides in the wheatbelt (DEC 2012b).	Unlikely
Falsistrellus mackenziei	Western false pipistrelle	P4	-	High rainfall forests dominated by jarrah, karri, marri, and tuart. Occupies hollow logs for breeding and resting (Van Dyck and Strahan 2008). Also known to utilise Banksia woodland on the Swan Coastal Plain (Hosken and O'Shea 1995).	Unlikely (locally extinct)
Hydromys chrysogaster	Rakali	P4	-	Areas with permanent water, fresh, brackish or marine. Likely to occur in all major rivers and most of the larger streams as well as bodies of permanent water in the lower south west (Christensen et al. 1985).	Unlikely
Isoodon fusciventer	Quenda	P4	-	Dense scrubby, often swampy, vegetation with dense cover up to one metre high (DEC 2012a)	Possible
Myrmecobius fasciatus	Numbat	EN	EN	Forests that are generally dominated by E*ucalyptus* spp. that provide hollow logs and branches for shelter and termites for food (van Dyck & Strahan 2008).	Unlikely (locally extinct)
Notamacropus eugenii derbianus	Tammar wallaby	P4	-	Dry sclerophyll forest, *Banksia* spp. woodlands and shrublands, typically favouring dense low vegetation that provides dense cover (Christensen and Strahan 1983).	Unlikely (locally extinct)

Table 2 (cont): Summary of conservation significant fauna species known or likely to occur within 10 km of the site.

Species	Common name	Level of significance		Habitat	Likelihood of occurrence within the site
		State	EPBC		
Mammals					
Notamacropus irma	Western brush wallaby	P4	-	Open forest or woodland, particularly favouring open, seasonally wet flats with low grasses and open scrubby thickets. Also occurs in some areas of mallee and heathland.	Unlikely
Phascogale tapoatafa wambenger	South-western brush-tailed phascogale	CD	-	Dry sclerophyll forests and open woodlands that contain hollow-bearing trees but a sparse ground cover (Triggs 2003).	Possible
Pseudocheirus occidentalis	Western ringtail possum	CR	VU	On the Swan Coastal Plain in *Agonis flexuosa* woodlands and *Agonis flexuosa/ Eucaluptus gomphocephala* forests. Also *Eucalyptus marginata* forests (DBCA 2017).	Unlikely (locally extinct)
Setonix brachyurus	Quokka	VU	VU	On the mainland mostly dense streamside vegetation or shrubland and heath areas, particularly around swamps (Cronin 2007).	Unlikely (locally extinct)
Reptiles					
Lerista lineata	Perth Slider	P3	-	Sandy coastal heath and low scrubland. *Banksia* spp. woodland, E*ucalyptus gomphocephala* open woodland over deep sands, and coastal dunes immediately adjacent to the beach (Wilson and Swan 2017).	Unlikely
Neelaps calonotos	Black-striped snake	P3	-	Coastal and near-coastal dunes, sandplains supporting heathlands and Banksia spp. woodlands (Bush *et al.* 2002).	Unlikely
Insects					
Leioproctus contrarius	a short-tongued bee	P3	-	Unknown	Not assessed
Leioproctus douglasiellus	a short-tongued bee	EN	CR	Life history and habits are poorly documented/ unknown. It has been recorded only on the flowers of *Gompholobium aristatum* on which it may be dependent.	Not assessed

Table 2 (cont): Summary of conservation significant fauna species known or likely to occur within 10 km of the site.

Species	Common name	Level of significance		Habitat	Likelihood of occurrence within the site
		State	EPBC		
Insects					
Neopasiphae simplicior	a short-tongued bee	EN	CR	This species of native bee has been collected on flowers of *Goodenia filiformis*, *Lobelia tenulor*, *Angianthus preissianus* and *Velleia* sp. (Houston 2000).	Not assessed
Synemon gratiosa	Graceful sunmoth	P4	-	Coastal heathland on Quindalup dunes where it is restricted to secondary sand dunes due to the abundance of the preferred host plant *Lomandra maritima*. Banksia woodland on Spearwood and Bassendean dunes, where the second known host plant *L. hermaphrodita* is widespread (DEC 2011).	Not assessed
Throscodectes xiphos	Stylet Bush Cricket	P1	-	Unknown.	Not assessed
Molluscs					
Westralunio carteri	Carter's freshwater mussel	VU	VU	Occurs in greatest abundance in slower flowing streams with stable sediments that are soft enough for burrowing amongst woody debris and exposed tree roots. Salinity tolerance quite low (Morgan et al. 2011).	Not assessed

Detailed information on conservation codes are provided in **Appendix A.**

3.2 Reconnaissance survey

3.2.1 General site conditions

The site comprises a south facing slope with intact remnant vegetation concentrated around the north, eastern and southern edges. The centre of the site previously contained a house, sheds and associated driveways. These structures were removed in 2016, leaving the area cleared with some remaining debris, and a number of planted native (including two *Eucalyptus gomphocephala* (tuart) trees) and exotic trees and shrubs. Weeds are also widespread throughout the cleared portions of the site.

3.2.2 Species inventory

A total of 8 native fauna species were recorded during the site inspection as shown in **Table 3**. Fauna species were identified from sightings and calls.

Table 3: Vertebrate fauna species recorded within the site.

Species	Common name	Level of significance		Record type
		State	EPBC	
Birds				
Cacatua roseicapilla	Galah	-	-	Sighting
Corvus coronoides	Australian raven	-	-	Sighting
Elanus caeruleus	Black-shouldered kite	-	-	Sighting
Gavicalis virescens	Singing honeyeater	-	-	Sighting, call
Phylidonyris novaehollandiae	New holland honeyeater	-	-	Sighting, call
Rhipidura leucophrys	Willie wagtail	-	-	Sighting
Zonarius semitorquatus	Twenty-eight parrot	-	-	Sighting
Mammals				
Macropus fuliginosus melanops	Western grey kangaroo	-	-	Sighting

3.2.3 Habitat assessment

Historical disturbance and previous land use has strongly influenced habitat values within the site. Due to historical disturbance approximately half of pre-existing native vegetation has been removed within the site. Vegetation now predominantly comprises cleared areas, dominated by non-native and weed species with scattered or patches of native and non-native trees. Two broad fauna habitat types are identified within the site that correspond with native plant community **BaBm** and '**non-native/planted vegetation**' identified in (Emerge 2018).

A description and the area of each habitat type is provided in **Table 4** and representative photographs of each are provided in **Plate 1** to **Plate 4**. The location of each habitat type is shown on **Figure 2.**

The highest natural habitat values are associated with plant community **BaBm** throughout the edges of the site. Where this vegetation remains in good or better condition, it in particular provides a cover of native trees and shrubs, as well as, microhabitats such as logs, rocks and leaves.

Table 4: Broad fauna habitat types identified within the site.

Plant community	Description	Area (ha)
BaBm	Sparse woodland of *Eucalyptus marginata* and *Allocasuarina fraseriana* over low woodland of *Banksia menziesii* and *Banksia attenuata* over low shrubland of *Xanthorrhoea preissii, Allocasuarina humilis, Stirlingia latifolia, Eremaea* spp. and *Hibbertia hypericoides* over forbland of *Chordifex sinuosus, Lepidosperma squamatum, Patersonia occidentalis, Stylidium* spp., *Lomandra* spp. (**Plate 2**).	0.84
Non-native/planted vegetation	Heavily disturbed areas comprising weeds with planted vegetation and occasional native species (**Plate 3**).	1.02

Five potential black cockatoo habitat trees[2] were observed within the site. The location of these trees is shown in **Figure 3**. One of these potential habitat trees contains a hollow that is large enough that it may be suitable for use by black cockatoos. Two additional trees contain one or more small hollows that are currently not suitable for use by black cockatoos.

No black cockatoos were observed to be roosting within or adjacent to the site during the dusk survey and no evidence of historical roosting was observed.

The site provides several patches of black cockatoo foraging habitat, comprising jarrah, banksia, tuart, lemon scented gum and pine trees.

Plate 1: Plant community BaBm in very good condition. Ground cover and understorey largely intact and some microhabitats such as logs, rocks and leaf litter present.

[2] Native eucalypt trees with a diameter at breast height (DBH) > 500mm.

Plate 2: Plate 3: Non-native/planted vegetation throughout the centre of the site. Few large planted trees and non-native grass ground cover.

4 Discussion

4.1 Fauna assessment

The site has been subject to significant past disturbance and as a result approximately half of the vegetation within the site has been cleared. Information obtained from desktop assessment and site inspection indicates that fauna habitat values are greatest with respect to patches of native plant community **BaBm** and scattered native and non-native trees that are present throughout the site. **BaBm** provides an intact layer of native tree canopy, shrubs and ground cover. It also contains several microhabitats including logs, rocks and leaf litter. Given that there is only a small area (0.84 ha) of remnant native vegetation within the site, it is unlikely to be important habitat, but it may nonetheless be utilized by a range of common and widespread native fauna species.

4.2 Black cockatoo habitat assessment

No black cockatoo individuals and no secondary evidence of recent or past use of the site by black cockatoo species was revealed during the site visit.

There are five potential black cockatoo habitat trees located within the site. Three of these trees contain one or more hollows. To be suitable for species of breeding black cockatoos hollows must have an opening with a diameter of at least 10 cm (Groom 2010). One hollow within a jarrah tree in the far north eastern corner of the site meets this criteria and is therefore considered potentially suitable for use as breeding habitat by black cockatoos. This hollow occurs approximately 3 m above ground. No signs of use such as chew marks or feeding debris were observed and no assessment was made of its internal dimensions during the site inspection.

The site has limited potential to provide roosting habitat for black cockatoos, as there are only six larger trees (10 - 15 m) located within the site. Given that substantial potential roosting habitat is located within the wider area the trees within the site are unlikely to provide important roosting habitat. No black cockatoos were observed to be roosting within or adjacent to the site during the dusk survey and no evidence of historical roosting was observed.

Several small patches of native vegetation within plant community **BaBm**, scattered individual native trees (mostly consisting of jarrah, banksia and tuart), as well as, non-native trees such as lemon scented gums and pine trees, may provide a foraging resource for black cockatoo species. This resources is relatively small and less significant than the foraging resource present in adjacent land parcels and across the wider local area.

5 Conclusions

A total number of 8 native fauna species were recorded within the site, of which none are threatened or priority species.

No signs of black cockatoos were observed during the site inspection. The site has limited value as habitat for black cockatoos including five habitat trees and a relatively small extend of roosting and foraging habitat.

The site may provide habitat for a range of common and widespread native fauna species but it is unlikely to provide important habitat for black cockatoos or any other conservation significant fauna.

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Figures

Figure 1: Site Location

Project:	Level 1 Fauna Assessment and Targeted Black Cockatoo Survey Lot 50 Barfield Road, Hammond Park
Client:	Glenbrook Civil

Plan Number:
EP18-043(05)--F07

Drawn:	RAO
Date:	18/10/2018
Checked:	TAA
Approved:	TAA
Date:	27/11/2018

N

0 50 100
Metres

Scale: 1:210,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

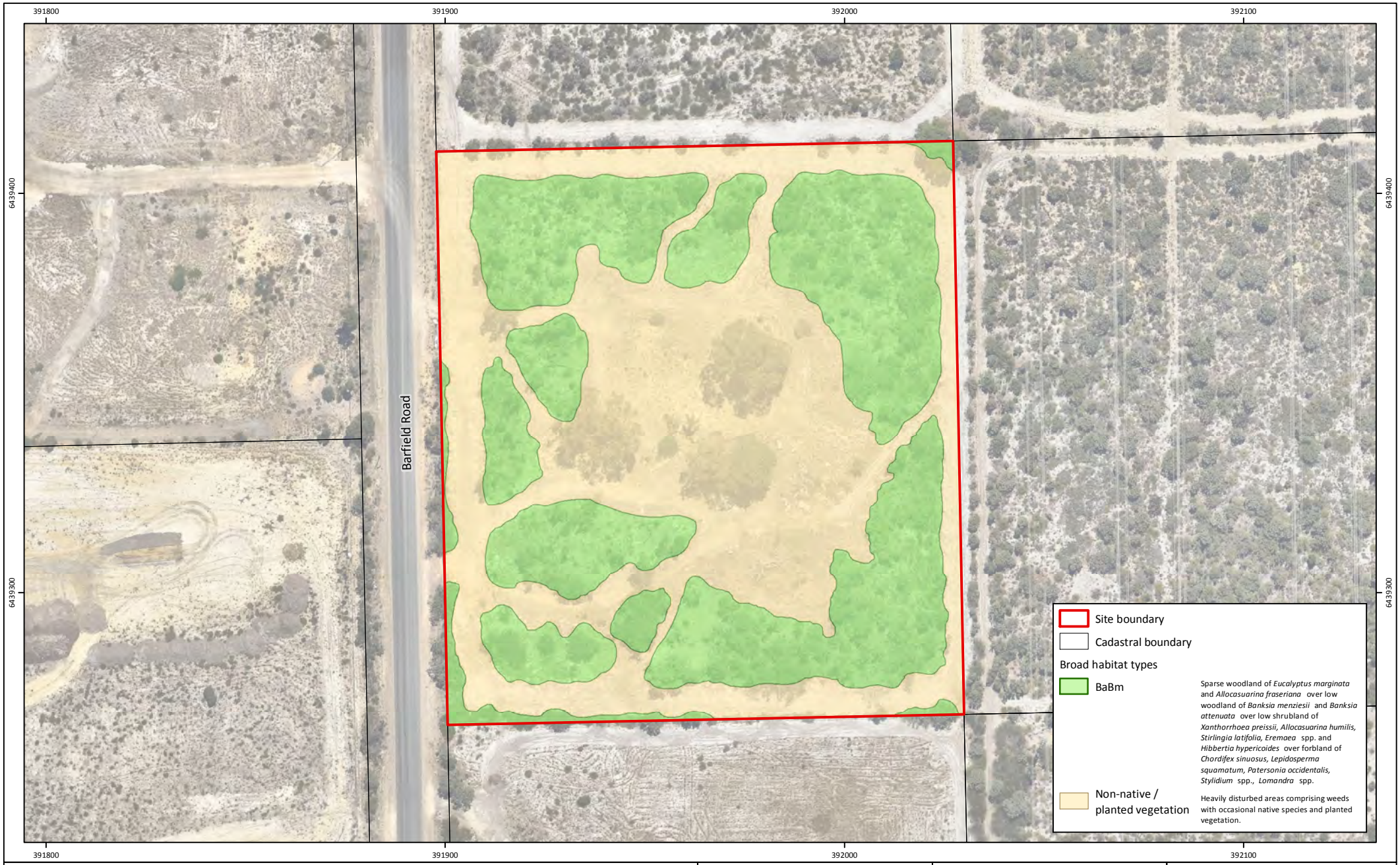

Figure 2: Broad Habitat Types

Project: Level 1 Fauna Assessment and Targeted Black Cockatoo Survey
Lot 50 Barfield Road, Hammond Park
Client: Glenbrook Civil

Plan Number:
EP18-043(05)--F08
Drawn: RAO
Date: 18/10/2018
Checked: TAA
Approved: TAA
Date: 27/11/2018

N

0 25 50
Metres
Scale: 1:1,250@A4
GDA 1994 MGA Zone 50

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Figure 3: Black Cockatoo Habitat

Project: Level 1 Fauna Assessment and Targeted Black Cockatoo Survey
Lot 50 Barfield Road, Hammond Park
Client: Glenbrook Civil

Plan Number:
EP18-043(05)--F09
Drawn: RAO
Date: 18/10/2018
Checked: TAA
Approved: TAA
Date: 27/11/2018

N

0 25 50
Metres
Scale: 1:1,250@A4
GDA 1994 MGA Zone 50

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Appendix A

Conservation categories

Conservation Significant Fauna

Fauna species considered rare or under threat warrant special protection under Commonwealth and/or State legislation. At the Commonwealth level, fauna species can be listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Migratory birds may be recognised under international treaties including:

- *Japan Australia Migratory Bird Agreement 1981* (JAMBA)
- *China Australia Migratory Bird Agreement 1998* (CAMBA)
- *Republic of Korea-Australia Migratory Bird Agreement 2007* (ROKAMBA)
- *Bonn Convention 1979* (The Convention on the Conservation of Migratory Species of Wild Animals).

All migratory bird species listed in the annexes to these bilateral agreements are protected in Australia as 'matters of national environmental significance' (MNES) under the EPBC Act. Fauna species considered 'threatened' pursuant to Schedule 1 of the EPBC Act are assigned categories as outlined in **Table 1**.

Table 1: Definitions of conservation significant fauna species pursuant to the EPBC Act

Conservation Code	Category
X	Threatened Fauna –Extinct There is no reasonable doubt that the last member of the species has died.
EW[#]	Threatened Fauna –Extinct in the Wild Taxa which are known only to survive in cultivation, captivity or as a naturalised population outside its past range, or taxa which have not been recorded in its known and/or expected habitat despite appropriate exhaustive surveys.
CR[#]	Threatened Fauna – Critically Endangered Taxa which are considered to be facing an extremely high risk of extinction in the wild.
EN[#]	Threatened Fauna – Endangered Taxa which are considered to be facing a very high risk of extinction in the wild.
VU[#]	Threatened Fauna – Vulnerable Taxa which are considered to be facing a high risk of extinction in the wild.
Migratory[#]	Migratory Fauna All migratory species that are: (i) native species; and (ii) from time to time included in the appendices to the Bonn Convention; and (b) all migratory species from time to time included in annexes established under JAMBA, CAMBA and ROKAMBA; and All native species from time to time identified in a list established under, or an instrument made under, an international agreement approved by the Minister.
Ma	Marine Fauna Species in the list established under s248 of the EPBC Act

[#]matters of national environmental significance (MNES) under the EPBC Act

In Western Australia, fauna taxa may be classed as 'specially protected' under the *Wildlife Conservation Act 1950* (WC Act) which is enforced by Department of Biodiversity Conservation and Attractions (DBCA). Specially protected fauna species are gazetted under subsection 4 of section 14F of the WC Act and are listed under Schedules 1 to 7 according to their conservation status. The definitions of these Schedules are provided in **Table 2**.

Table 2: Definitions of specially protected fauna schedules under the WC Act.

Conservation Code	Definition
CR	Schedule 1 – Critically Endangered Threatened species considered to be facing an extremely high risk of extinction in the wild.
EN	Schedule 2 – Endangered Threatened species considered to be facing a very high risk of extinction in the wild.
VU	Schedule 3 – Vulnerable Threatened species considered to be facing a high risk of extinction in the wild.
EX	Schedule 4 – Presumed extinct Species which have been adequately searched for and there is no reasonable doubt that the last individual has died.
IA	Schedule 5 – Migratory birds protected under an international agreement 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.
CD	Schedule 6 – Fauna of special conservation need as conservation dependent fauna Fauna of special conservation need being species dependent on ongoing conservation intervention to prevent it becoming eligible for listing as threatened.
OS	Schedule 7 – Other specially protected fauna. Fauna otherwise in need of special protection to ensure their conservation.

Fauna species that may be threatened or near threatened but lack sufficient information to be legislatively listed may be added to the DBCA's *Priority Fauna List* (DBCA 2018). Priority fauna species are considered during State approval processes. Priority fauna categories and definitions are listed in **Table 3**.

Table 3: Definitions of priority fauna categories on DBCA's Priority Fauna List

Conservation Code	Category
P1	Priority 1 – Poorly known 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.
P2	Priority 2 – Poorly known 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.
P3	Priority 2 – Poorly known 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.
P4	(a) Priority 4 – Rare species 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) Priority 4 – Near Threatened Species that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. (c) Priority 4 – Other Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

References

General references

Department of Biodiversity, Conservation and Attractions (DBCA) 2018, *Threatened and Priority Fauna List 15 February 2018*, Perth.

Online references

Department of Agriculture and Food (DAFWA) 2018, *The Western Australian Organism List* (WAOL), <https://www.agric.wa.gov.au/bam/western-australian-organism-list-waol>.

Department of Environment and Energy (DoEE) 2018, Weeds of National Significance, <http://www.environment.gov.au/biodiversity/invasive/weeds/weeds/lists/wons.html>.

Appendix B

Literature used for identifying fauna species

Literature used for identification of fauna species

Table 1: Standard literature for identifying fauna species.

Conservation Code	Category
Birds	Johnstone and Storr (1998b), Johnstone and Storr (1998a), Pizzey and Knight (2012), Slater *et al.* (2003)
Mammals	Menkhorst and Knight (2011), Triggs (2003)
Amphibia	Tyler and Doughty (2009), Bush *et al.* (2002)
Reptiles	Bush *et al.* (2002)

1 References

Bush, B., Maryan, B., Browne-Cooper, R. and Robinson, D. 2002, *Reptiles and Frogs of the Perth Region*, UWA Press, Crawley.

Johnstone, R. E. and Storr, G. M. 1998a, *Handbook of Western Australian Birds. Volume 2 - Passerines (Blue-Winged Pitta to Goldfinch)*, Western Australian Museum, Perth.

Johnstone, R. E. and Storr, T. 1998b, *Handbook of Western Australian Birds: Volume 1 - Non-passerines (Emu to Dollarbird)*, Western Australian Museum, Perth.

Menkhorst, P. and Knight, F. 2011, *Field guide to the mammals of Australia (Third edition)*, Oxford University Press Australia & New Zealand, Melbourne, VIC, Australia.

Pizzey, G. and Knight, F. 2012, *The Fieldguide to the Birds of Australia*, Harper Collins Publishers, Sydney, Australia.

Slater, P., Slater, P. and Slater, R. 2003, *The Slater Field Guide to Australian Birds*, Reed New Holland, Australia.

Triggs, B. 2003, *Tracks, Scats and Other Traces A Field Guide to Australian Mammals*, Oxford University Press Australia, Melbourne, Victoria.

Tyler, M. J. and Doughty, P. 2009, *Field Guide to Frogs of Western Australia*, Western Australian Museum, Perth, Western Australia.

Appendix C

NatureMap and *Protected Matters Search Tool* results

NatureMap
Mapping Western Australia's biodiversity

NatureMap Species Report

Created By Guest user on 26/09/2018

Kingdom Animalia
Current Names Only Yes
Core Datasets Only Yes
Method 'By Circle'
Centre 115° 51' 15" E,32° 10' 39" S
Buffer 10km

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
1.	24260	*Acanthiza apicalis (Broad-tailed Thornbill, Inland Thornbill)*			
2.	24261	*Acanthiza chrysorrhoa (Yellow-rumped Thornbill)*			
3.	24262	*Acanthiza inornata (Western Thornbill)*			
4.	24560	*Acanthorhynchus superciliosus (Western Spinebill)*			
5.	25535	*Accipiter cirrocephalus (Collared Sparrowhawk)*			
6.	25536	*Accipiter fasciatus (Brown Goshawk)*			
7.	24282	*Accipiter fasciatus subsp. fasciatus (Brown Goshawk)*			
8.	42368	*Acritoscincus trilineatus (Western Three-lined Skink)*			
9.	25755	*Acrocephalus australis (Australian Reed Warbler)*			
10.	24831	*Acrocephalus australis subsp. gouldi (Australian Reed Warbler)*			
11.	41323	*Actitis hypoleucos (Common Sandpiper)*		IA	
12.		*Afraflacilla huntorum*			Y
13.		*Afurcagobius suppositus*			
14.		*Allothereua maculata*			
15.		*Aname mainae*			
16.		*Aname tepperi*			
17.	24310	*Anas castanea (Chestnut Teal)*			
18.	24312	*Anas gracilis (Grey Teal)*			
19.	24313	*Anas platyrhynchos (Mallard)*			
20.		*Anas platyrhynchos subsp. domesticus*			
21.	24315	*Anas rhynchotis (Australasian Shoveler)*			
22.	24316	*Anas superciliosa (Pacific Black Duck)*			
23.	47414	*Anhinga novaehollandiae (Australasian Darter)*			
24.	44629	*Anilios australis*			
25.		*Anser anser*			
26.	24561	*Anthochaera carunculata (Red Wattlebird)*			
27.	24562	*Anthochaera lunulata (Western Little Wattlebird)*			
28.	24991	*Aprasia repens (Sand-plain Worm-lizard)*			
29.	25554	*Apus pacificus (Fork-tailed Swift, Pacific Swift)*		IA	
30.	24285	*Aquila audax (Wedge-tailed Eagle)*			
31.		*Arachnura higginsi*			
32.		*Araneus cyphoxis*			
33.		*Araneus eburneiventris*			
34.		*Araneus senicaudatus*			
35.	24337	*Ardea garzetta subsp. nigripes (Little Egret)*			
36.	25558	*Ardea ibis (Cattle Egret)*			
37.	25559	*Ardea intermedia (Intermediate Egret)*			
38.	41324	*Ardea modesta (great egret, white egret)*			
39.	24340	*Ardea novaehollandiae (White-faced Heron)*			
40.	24341	*Ardea pacifica (White-necked Heron)*			
41.	25736	*Arenaria interpres (Ruddy Turnstone)*		IA	
42.		*Argiope protensa*			
43.	25566	*Artamus cinereus (Black-faced Woodswallow)*			
44.	24352	*Artamus cinereus subsp. melanops (Black-faced Woodswallow)*			
45.	24353	*Artamus cyanopterus (Dusky Woodswallow)*			
46.		*Artema atlanta*			
47.		*Artoria flavimana*			
48.		*Artoria linnaei*			
49.		*Artoria taeniifera*			
50.		*Artoriopsis expolita*			
51.		*Austracantha minax*			
52.	24318	*Aythya australis (Hardhead)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
53.		*Backobourkia brounii*			
54.		*Backobourkia heroine*			
55.		*Badumna insignis*			
56.		*Ballarra longipalpus*			
57.		*Barnardius zonarius*			
58.		*Bianor maculatus*			
59.	24319	*Biziura lobata (Musk Duck)*			
60.	24345	*Botaurus poiciloptilus (Australasian Bittern)*		T	
61.	42381	*Brachyurophis semifasciatus (Southern Shovel-nosed Snake)*			
62.	25713	*Cacatua galerita (Sulphur-crested Cockatoo)*			
63.	25714	*Cacatua pastinator (Western Long-billed Corella)*			
64.	25715	*Cacatua roseicapilla (Galah)*			
65.	25716	*Cacatua sanguinea (Little Corella)*			
66.	24729	*Cacatua tenuirostris (Eastern Long-billed Corella)*	Y		
67.	25598	*Cacomantis flabelliformis (Fan-tailed Cuckoo)*			
68.	42307	*Cacomantis pallidus (Pallid Cuckoo)*			
69.	24779	*Calidris acuminata (Sharp-tailed Sandpiper)*		IA	
70.	24780	*Calidris alba (Sanderling)*		IA	
71.	25738	*Calidris canutus (Red Knot, knot)*		IA	
72.	24784	*Calidris ferruginea (Curlew Sandpiper)*		T	
73.	24786	*Calidris melanotos (Pectoral Sandpiper)*		IA	
74.	24787	*Calidris minuta (Little Stint)*			
75.	24788	*Calidris ruficollis (Red-necked Stint)*		IA	
76.	24789	*Calidris subminuta (Long-toed Stint)*		IA	
77.	24790	*Calidris tenuirostris (Great Knot)*		T	
78.	25717	*Calyptorhynchus banksii (Red-tailed Black-Cockatoo)*			
79.	24731	*Calyptorhynchus banksii subsp. naso (Forest Red-tailed Black Cockatoo)*		T	
80.	24733	*Calyptorhynchus baudinii (Baudin's Cockatoo, White-tailed Long-billed Black Cockatoo)*		T	
81.	24734	*Calyptorhynchus latirostris (Carnaby's Cockatoo, White-tailed Short-billed Black Cockatoo)*		T	
82.	48400	*Calyptorhynchus sp. (white-tailed black cockatoo)*		T	
83.	25335	*Caretta caretta (Loggerhead Turtle)*		T	
84.		*Cercophonius sulcatus*			
85.	24186	*Chalinolobus gouldii (Gould's Wattled Bat)*			
86.	25574	*Charadrius dubius (Little Ringed Plover)*		IA	
87.	25575	*Charadrius leschenaultii (Greater Sand Plover)*		IA	
88.	24377	*Charadrius ruficapillus (Red-capped Plover)*			
89.	43380	*Chelodina colliei (South-western Snake-necked Turtle)*			
90.	24321	*Chenonetta jubata (Australian Wood Duck, Wood Duck)*			
91.	47909	*Cheramoeca leucosterna (White-backed Swallow)*			
92.	33939	*Cherax cainii (Marron)*			
93.		*Cherax destructor*			
94.		*Cherax preissii*			
95.		*Cherax quinquecarinatus*			
96.		*Cherax sp.*			
97.	41332	*Chlidonias leucopterus (White-winged Black Tern, white-winged tern)*		IA	
98.	24980	*Christinus marmoratus (Marbled Gecko)*			
99.		*Chroicocephalus novaehollandiae*			
100.	25601	*Chrysococcyx lucidus (Shining Bronze Cuckoo)*			
101.	24288	*Circus approximans (Swamp Harrier)*			
102.	24289	*Circus assimilis (Spotted Harrier)*			
103.	24774	*Cladorhynchus leucocephalus (Banded Stilt)*			
104.		*Clynotis albobarbatus*			
105.	25675	*Colluricincla harmonica (Grey Shrike-thrush)*			
106.	24399	*Columba livia (Domestic Pigeon)*	Y		
107.	25568	*Coracina novaehollandiae (Black-faced Cuckoo-shrike)*			
108.		*Cormocephalus aurantiipes*			
109.		*Cormocephalus novaehollandiae*			
110.		*Cormocephalus rubriceps*			
111.	24416	*Corvus bennetti (Little Crow)*			
112.	25592	*Corvus coronoides (Australian Raven)*			
113.	24417	*Corvus coronoides subsp. perplexus (Australian Raven)*			
114.	24671	*Coturnix pectoralis (Stubble Quail)*			
115.	25701	*Coturnix ypsilophora (Brown Quail)*			
116.	24673	*Coturnix ypsilophora subsp. australis (Brown Quail)*			
117.	24420	*Cracticus nigrogularis (Pied Butcherbird)*			
118.	25595	*Cracticus tibicen (Australian Magpie)*			
119.	24422	*Cracticus tibicen subsp. dorsalis (White-backed Magpie)*			
120.	25596	*Cracticus torquatus (Grey Butcherbird)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
121.	25398	*Crinia georgiana (Quacking Frog)*			
122.	25399	*Crinia glauerti (Clicking Frog)*			
123.	25400	*Crinia insignifera (Squelching Froglet)*			
124.		*Crustulina bicruciata*			
125.	30893	*Cryptoblepharus buchananii*			
126.	25020	*Cryptoblepharus plagiocephalus*			
127.		*Cryptoerithus quobba*			
128.	30899	*Ctenophorus adelaidensis (Southern Heath Dragon, Western Heath Dragon)*			
129.	25027	*Ctenotus australis*			
130.	25039	*Ctenotus fallens*			
131.	25040	*Ctenotus gemmula (Jewelled South-west Ctenotus (Swan Coastal Plain subpop P3), skink)*			
132.		*Cyclosa trilobata*			
133.	24322	*Cygnus atratus (Black Swan)*			
134.	24323	*Cygnus olor (Mute Swan)*	Y		
135.		*Cyrtophora parnasia*			
136.	30901	*Dacelo novaeguineae (Laughing Kookaburra)*	Y		
137.	25673	*Daphoenositta chrysoptera (Varied Sittella)*			
138.	24687	*Daption capense (Cape Petrel)*			
139.	24092	*Dasyurus geoffroii (Chuditch, Western Quoll)*		T	
140.	25766	*Delma fraseri (Fraser's Legless Lizard)*			
141.	24999	*Delma grayii*			
142.	25296	*Demansia psammophis subsp. reticulata (Yellow-faced Whipsnake)*			
143.	25346	*Dermochelys coriacea (Leatherback Turtle)*		T	
144.	25607	*Dicaeum hirundinaceum (Mistletoebird)*			
145.		*Dingosa serrata*			
146.	25100	*Egernia napoleonis*			
147.		*Egretta garzetta*			
148.		*Egretta novaehollandiae*			
149.		*Elanus axillaris*			
150.	25250	*Elapognathus coronatus (Crowned Snake)*			
151.	47937	*Elseyornis melanops (Black-fronted Dotterel)*			
152.		*Eodelena convexa*			
153.		*Eolophus roseicapillus*			
154.	24652	*Eopsaltria georgiana (White-breasted Robin)*			
155.	24567	*Epthianura albifrons (White-fronted Chat)*			
156.		*Eriophora biapicata*			
157.		*Erythracarus decoris*			
158.	24379	*Erythrogonys cinctus (Red-kneed Dotterel)*			
159.	24368	*Eurostopodus argus (Spotted Nightjar)*			
160.	25621	*Falco berigora (Brown Falcon)*			
161.	25622	*Falco cenchroides (Australian Kestrel, Nankeen Kestrel)*			
162.	25623	*Falco longipennis (Australian Hobby)*			
163.	25624	*Falco peregrinus (Peregrine Falcon)*		S	
164.	24189	*Falsistrellus mackenziei (Western False Pipistrelle, Western Falsistrelle)*		P4	
165.	24041	*Felis catus (Cat)*	Y		
166.	25727	*Fulica atra (Eurasian Coot)*			
167.	24761	*Fulica atra subsp. australis (Eurasian Coot)*			
168.	24791	*Gallinago hardwickii (Latham's Snipe, Japanese snipe)*		IA	
169.	25729	*Gallinula tenebrosa (Dusky Moorhen)*			
170.	24763	*Gallinula tenebrosa subsp. tenebrosa (Dusky Moorhen)*			
171.	25730	*Gallirallus philippensis (Buff-banded Rail)*			
172.	24959	*Gehyra variegata*			
173.	47954	*Gelochelidon nilotica (Gull-billed Tern)*		IA	
174.	24401	*Geopelia cuneata (Diamond Dove)*			
175.	25530	*Gerygone fusca (Western Gerygone)*			
176.	47962	*Glyciphila melanops (Tawny-crowned Honeyeater)*			
177.	24443	*Grallina cyanoleuca (Magpie-lark)*			
178.	25627	*Haematopus fuliginosus (Sooty Oystercatcher)*			
179.	24487	*Haematopus longirostris (Pied Oystercatcher)*			
180.	24293	*Haliaeetus leucogaster (White-bellied Sea-Eagle)*			
181.	24295	*Haliastur sphenurus (Whistling Kite)*			
182.		*Hasarius adansoni*			
183.	25410	*Heleioporus eyrei (Moaning Frog)*			
184.	25119	*Hemiergis quadrilineata*			
185.	24961	*Heteronotia binoei (Bynoe's Gecko)*			
186.		*Heurodes turritus*			
187.	47965	*Hieraaetus morphnoides (Little Eagle)*			
188.	25734	*Himantopus himantopus (Black-winged Stilt)*			
189.	24775	*Himantopus himantopus subsp. leucocephalus (Black-winged Stilt)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
190.	24491	*Hirundo neoxena (Welcome Swallow)*			
191.		*Hogna crispipes*			
192.		*Holasteron perth*			
193.		*Holoplatys dejongi*			
194.	24215	*Hydromys chrysogaster (Water-rat, Rakali)*		P4	
195.	25366	*Hydrophis elegans (Elegant Seasnake, Bar-bellied Seasnake)*			
196.	42410	*Hydrophis ornatus (Ornate Reef Seasnake, Sea Snake)*			
197.	43384	*Hydrophis platurus (Yellow-bellied Seasnake)*			
198.	48587	*Hydroprogne caspia (Caspian Tern)*		IA	
199.		*Idiommata blackwalli*			
200.	48588	*Isoodon fusciventer (Quenda, southwestern brown bandicoot)*		P4	
201.		*Isopeda leishmanni*			
202.	47975	*Ixobrychus dubius (Australian Little Bittern)*		P4	
203.		*Kangarosa properipes*			
204.		*Lampona cylindrata*			
205.	24511	*Larus novaehollandiae subsp. novaehollandiae (Silver Gull)*			
206.		*Latrodectus hasseltii*			
207.	33982	*Leioproctus contrarius (a short-tongued bee)*		P3	
208.	33983	*Leioproctus douglasiellus (a short-tongued bee)*		T	
209.	25128	*Lerista christinae*			
210.	25131	*Lerista distinguenda*			
211.	25133	*Lerista elegans*			
212.	25147	*Lerista lineata (Perth Slider, Lined Skink)*		P3	
213.	25005	*Lialis burtonis*			
214.	25661	*Lichmera indistincta (Brown Honeyeater)*			
215.	24582	*Lichmera indistincta subsp. indistincta (Brown Honeyeater)*			
216.	25415	*Limnodynastes dorsalis (Western Banjo Frog)*			
217.	25741	*Limosa limosa (Black-tailed Godwit)*		IA	
218.	25378	*Litoria adelaidensis (Slender Tree Frog)*			
219.	25388	*Litoria moorei (Motorbike Frog)*			
220.	25683	*Lonchura castaneothorax (Chestnut-breasted Mannikin)*			
221.		*Longepi woodman*			
222.		*Lophoictinia isura*			
223.		*Lycosa ariadnae*			
224.		*Lycosa australicola*			
225.		*Lycosa gilberta*			
226.	24690	*Macronectes giganteus (Southern Giant Petrel)*		IA	
227.	24132	*Macropus fuliginosus (Western Grey Kangaroo)*			
228.	24326	*Malacorhynchus membranaceus (Pink-eared Duck)*			
229.	25650	*Malurus elegans (Red-winged Fairy-wren)*			
230.	25651	*Malurus lamberti (Variegated Fairy-wren)*			
231.	25654	*Malurus splendens (Splendid Fairy-wren)*			
232.	24552	*Malurus splendens subsp. splendens (Splendid Fairy-wren)*			
233.	24583	*Manorina flavigula (Yellow-throated Miner)*			
234.		*Maratus pavonis*			
235.	25758	*Megalurus gramineus (Little Grassbird)*			
236.	47997	*Melanodryas cucullata (Hooded Robin)*			
237.	25663	*Melithreptus brevirostris (Brown-headed Honeyeater)*			
238.	24587	*Melithreptus chloropsis (Western White-naped Honeyeater)*			
239.	24736	*Melopsittacus undulatus (Budgerigar)*			
240.	25184	*Menetia greyii*			
241.	24598	*Merops ornatus (Rainbow Bee-eater)*			
242.		*Microcarbo melanoleucos*			
243.	25693	*Microeca fascinans (Jacky Winter)*			
244.	25542	*Milvus migrans (Black Kite)*			
245.		*Missulena granulosa*			
246.		*Missulena occatoria*			
247.		*Mituliodon tarantulinus*			
248.		*Mitzoruga insularis*			
249.	25191	*Morethia lineoocellata*			
250.	25192	*Morethia obscura*			
251.	48008	*Morus serrator (Australasian Gannet)*			
252.	24223	*Mus musculus (House Mouse)*	Y		
253.	25610	*Myiagra inquieta (Restless Flycatcher)*			
254.	25420	*Myobatrachus gouldii (Turtle Frog)*			
255.	24146	*Myrmecobius fasciatus (Numbat, Walpurti)*		T	
256.		*Nanometa gentilis*			
257.	25248	*Neelaps bimaculatus (Black-naped Snake)*			
258.	25249	*Neelaps calonotos (Black-striped Snake, black-striped burrowing snake)*		P3	
259.	33984	*Neopasiphae simplicior (a short-tongued bee)*		T	

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
260.	24738	*Neophema elegans (Elegant Parrot)*			
261.	24739	*Neophema petrophila (Rock Parrot)*			
262.		*Nephila edulis*			
263.		*Nicodamus mainae*			
264.	25747	*Ninox connivens (Barking Owl)*			
265.	48024	*Notamacropus eugenii subsp. derbianus (Tammar Wallaby, Tammar)*		P4	
266.	48022	*Notamacropus irma (Western Brush Wallaby)*		P4	
267.	25252	*Notechis scutatus (Tiger Snake)*			
268.	25564	*Nycticorax caledonicus (Rufous Night Heron)*			
269.	24194	*Nyctophilus geoffroyi (Lesser Long-eared Bat)*			
270.	24742	*Nymphicus hollandicus (Cockatiel)*			
271.		*Ocrisiona parmeliae*			
272.	24407	*Ocyphaps lophotes (Crested Pigeon)*			
273.		*Ommatoiulus moreletii*			
274.	24085	*Oryctolagus cuniculus (Rabbit)*	Y		
275.	24328	*Oxyura australis (Blue-billed Duck)*		P4	
276.	25680	*Pachycephala rufiventris (Rufous Whistler)*			
277.	48591	*Pandion cristatus (Osprey, Eastern Osprey)*		IA	
278.	25253	*Parasuta gouldii*			
279.	25681	*Pardalotus punctatus (Spotted Pardalote)*			
280.	24626	*Pardalotus punctatus subsp. xanthopyge (Yellow-rumped Pardalote)*			
281.	25682	*Pardalotus striatus (Striated Pardalote)*			
282.	24642	*Passer montanus (Eurasian Tree Sparrow)*	Y		
283.	24648	*Pelecanus conspicillatus (Australian Pelican)*			
284.	48060	*Petrochelidon ariel (Fairy Martin)*			
285.	48061	*Petrochelidon nigricans (Tree Martin)*			
286.	48066	*Petroica boodang (Scarlet Robin)*			
287.	24659	*Petroica goodenovii (Red-capped Robin)*			
288.	24663	*Phaethon rubricauda (Red-tailed Tropicbird)*		P4	
289.	25697	*Phalacrocorax carbo (Great Cormorant)*			
290.	24665	*Phalacrocorax fuscescens (Black-faced Cormorant)*			
291.	25698	*Phalacrocorax melanoleucos (Little Pied Cormorant)*			
292.	24667	*Phalacrocorax sulcirostris (Little Black Cormorant)*			
293.	25699	*Phalacrocorax varius (Pied Cormorant)*			
294.	24409	*Phaps chalcoptera (Common Bronzewing)*			
295.	25587	*Phaps elegans (Brush Bronzewing)*			
296.		*Phenasteron longiconductor*			
297.	24802	*Philomachus pugnax (Ruff, reeve)*		IA	
298.		*Phryganoporus candidus*			
299.	48071	*Phylidonyris niger (White-cheeked Honeyeater)*			
300.	24596	*Phylidonyris novaehollandiae (New Holland Honeyeater)*			
301.		*Pinkfloydia harveii*			
302.	24841	*Platalea flavipes (Yellow-billed Spoonbill)*			
303.	24842	*Platalea regia (Royal Spoonbill)*			
304.	25720	*Platycercus icterotis (Western Rosella)*			
305.	24747	*Platycercus spurius (Red-capped Parrot)*			
306.	25721	*Platycercus zonarius (Australian Ringneck, Ring-necked Parrot)*			
307.	24750	*Platycercus zonarius subsp. semitorquatus (Twenty-eight Parrot)*			
308.	24843	*Plegadis falcinellus (Glossy Ibis)*		IA	
309.	25509	*Pletholax gracilis (Keeled Legless Lizard)*			
310.	25007	*Pletholax gracilis subsp. gracilis (Keeled Legless Lizard)*			
311.	24382	*Pluvialis fulva (Pacific Golden Plover)*		IA	
312.	24383	*Pluvialis squatarola (Grey Plover)*		IA	
313.	25703	*Podargus strigoides (Tawny Frogmouth)*			
314.	25704	*Podiceps cristatus (Great Crested Grebe)*			
315.		*Podykipus collinus*			
316.	25510	*Pogona minor (Dwarf Bearded Dragon)*			
317.	24907	*Pogona minor subsp. minor (Dwarf Bearded Dragon)*			
318.	24681	*Poliocephalus poliocephalus (Hoary-headed Grebe)*			
319.	25722	*Polytelis anthopeplus (Regent Parrot)*			
320.	25731	*Porphyrio porphyrio (Purple Swamphen)*			
321.	24767	*Porphyrio porphyrio subsp. bellus (Purple Swamphen)*			
322.	24769	*Porzana fluminea (Australian Spotted Crake)*			
323.	25732	*Porzana pusilla (Baillon's Crake)*			
324.	24770	*Porzana pusilla subsp. palustris (Baillon's Crake)*			
325.	24771	*Porzana tabuensis (Spotless Crake)*			
326.		*Prionosternum scutatum*			
327.	25511	*Pseudonaja affinis (Dugite)*			
328.	25259	*Pseudonaja affinis subsp. affinis (Dugite)*			
329.	42416	*Pseudonaja mengdeni (Western Brown Snake)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
330.	25433	*Pseudophryne guentheri (Crawling Toadlet)*			
331.	48085	*Psittacula krameri (Indian Ringnecked Parrot, Rose-ringed Parakeet)*	Y		
332.		*Pterygotrigla polyommata*			
333.		*Purpureicephalus spurius*			
334.	25008	*Pygopus lepidopodus (Common Scaly Foot)*			
335.	24243	*Rattus fuscipes (Western Bush Rat)*			
336.	24245	*Rattus rattus (Black Rat)*	Y		
337.		*Raveniella cirrata*			
338.		*Raveniella peckorum*			
339.	24776	*Recurvirostra novaehollandiae (Red-necked Avocet)*			
340.	48096	*Rhipidura albiscapa (Grey Fantail)*			
341.	25614	*Rhipidura leucophrys (Willie Wagtail)*			
342.	48237	*Rostratula australis (Australian Painted Snipe)*		T	
343.		*Scolopendra laeta*			
344.	25534	*Sericornis frontalis (White-browed Scrubwren)*			
345.		*Servaea melaina*			
346.		*Servaea spinibarbis*			
347.	24145	*Setonix brachyurus (Quokka)*		T	
348.		*Simaetha tenuior*			
349.	25266	*Simoselaps bertholdi (Jan's Banded Snake)*			
350.	25267	*Simoselaps littoralis (West Coast Banded Snake)*			
351.		*Smeringopus natalensis*			
352.	30948	*Smicrornis brevirostris (Weebill)*			
353.		*Steatoda capensis*			
354.		*Steatoda grossa*			
355.	24516	*Stercorarius longicaudus (long-tailed jaeger, long-tailed skua)*		IA	
356.	24528	*Sterna hybrida subsp. javanica (Whiskered Tern)*			
357.	48594	*Sternula nereis (Fairy Tern)*			
358.	24329	*Stictonetta naevosa (Freckled Duck)*			
359.	25597	*Strepera versicolor (Grey Currawong)*			
360.	25589	*Streptopelia chinensis (Spotted Turtle-Dove)*	Y		
361.	25590	*Streptopelia senegalensis (Laughing Turtle-Dove)*	Y		
362.	30950	*Streptopelia senegalensis subsp. senegalensis (Laughing Turtle-Dove)*	Y		
363.	24942	*Strophurus spinigerus subsp. spinigerus*			
364.		*Supunna funerea*			
365.		*Supunna picta*			
366.	24259	*Sus scrofa (Pig)*	Y		
367.	33992	*Synemon gratiosa (Graceful Sunmoth)*		P4	
368.		*Synothele michaelseni*			
369.	25705	*Tachybaptus novaehollandiae (Australasian Grebe, Black-throated Grebe)*			
370.	24682	*Tachybaptus novaehollandiae subsp. novaehollandiae (Australasian Grebe, Black-throated Grebe)*			
371.	24207	*Tachyglossus aculeatus (Short-beaked Echidna)*			
372.	25552	*Tadorna radjah (Radjah Shelduck)*			
373.	24331	*Tadorna tadornoides (Australian Shelduck, Mountain Duck)*			
374.		*Tamopsis distinguenda*			
375.		*Tamopsis perthensis*			
376.	24167	*Tarsipes rostratus (Honey Possum, Noolbenger)*			
377.		*Tetragnatha valida*			
378.	48597	*Thalasseus bergii (Crested Tern)*		IA	
379.	48135	*Thinornis rubricollis (Hooded Plover, Hooded Dotterel)*		P4	
380.	24845	*Threskiornis spinicollis (Straw-necked Ibis)*			
381.	33994	*Throscodectes xiphos (Stylet Bush Cricket, Stylet Throsco (Jandakot))*		P1	Y
382.	25203	*Tiliqua occipitalis (Western Bluetongue)*			
383.	25519	*Tiliqua rugosa*			
384.	25204	*Tiliqua rugosa subsp. aspera*			
385.	25207	*Tiliqua rugosa subsp. rugosa*			
386.		*Tinytrema yarra*			
387.	25549	*Todiramphus sanctus (Sacred Kingfisher)*			
388.	24309	*Todiramphus sanctus subsp. sanctus (Sacred Kingfisher)*			
389.	48141	*Tribonyx ventralis (Black-tailed Native-hen)*			
390.	25723	*Trichoglossus haematodus (Rainbow Lorikeet)*			
391.	25521	*Trichosurus vulpecula (Common Brushtail Possum)*			
392.	24158	*Trichosurus vulpecula subsp. vulpecula (Common Brushtail Possum)*			
393.	24803	*Tringa brevipes (Grey-tailed Tattler)*		P4	
394.	24806	*Tringa glareola (Wood Sandpiper)*		IA	
395.	24808	*Tringa nebularia (Common Greenshank, greenshank)*		IA	
396.	24809	*Tringa stagnatilis (Marsh Sandpiper, little greenshank)*		IA	
397.	48147	*Turnix varius (Painted Button-quail)*			
398.	24851	*Turnix velox (Little Button-quail)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
399.	24069	*Tursiops truncatus (Bottlenose Dolphin)*			
400.	24852	*Tyto alba subsp. delicatula (Barn Owl)*			
401.	24855	*Tyto novaehollandiae subsp. novaehollandiae (Masked Owl (southwest))*		P3	
402.		*Urodacus novaehollandiae*			
403.	25577	*Vanellus miles (Masked Lapwing)*			
404.	24386	*Vanellus tricolor (Banded Lapwing)*			
405.	25218	*Varanus gouldii (Bungarra or Sand Monitor)*			
406.	25225	*Varanus rosenbergi (Heath Monitor)*			
407.		*Venator immansueta*			
408.		*Venatrix pullastra*			
409.	24206	*Vespadelus regulus (Southern Forest Bat)*			
410.	24040	*Vulpes vulpes (Red Fox)*	Y		
411.	34113	*Westralunio carteri (Carter's Freshwater Mussel)*		T	
412.	41351	*Xenus cinereus (Terek Sandpiper)*		IA	
413.		*Zebraplatys fractivittata*			
414.	25765	*Zosterops lateralis (Grey-breasted White-eye, Silvereye)*			

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.

Australian Government
Department of the Environment and Energy

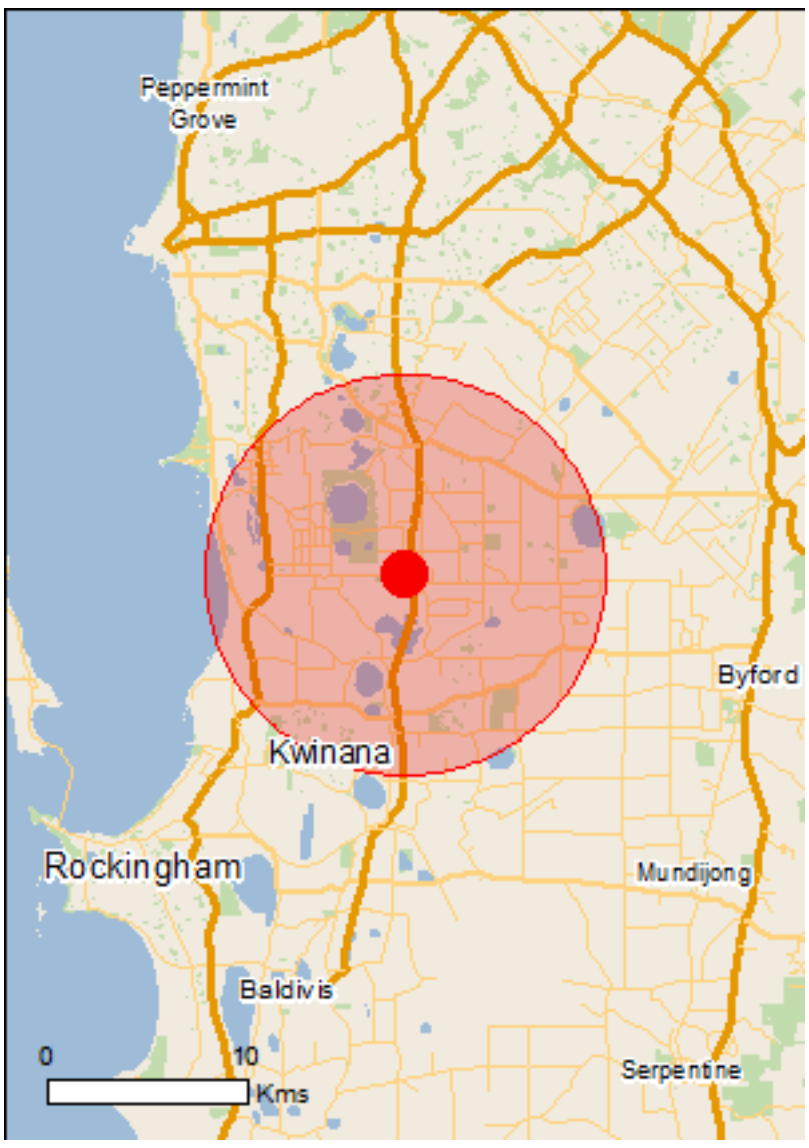
EPBC Act Protected Matters Report

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: 26/09/18 12:49:47



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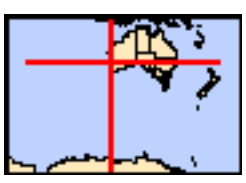
Coordinates

Buffer: 10.0Km



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:	56
Listed Migratory Species:	52

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:	80
Whales and Other Cetaceans:	12
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:	12
Regional Forest Agreements:	None
Invasive Species:	42
Nationally Important Wetlands:	4
Key Ecological Features (Marine)	None

Details

Matters of National Environmental Significance

Wetlands of International Importance (Ramsar) [Resource Information]

Name	Proximity
Forrestdale and thomsons lakes	Within Ramsar site
Peel-yalgorup system	30 - 40km 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
Clay Pans of the Swan Coastal Plain	Critically Endangered	Community likely to occur within area

Listed Threatened Species [Resource Information]

Name	Status	Type of Presence
Birds		
Anous tenuirostris melanops Australian Lesser Noddy [26000]	Vulnerable	Species or species habitat may occur within area
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	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 known 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	Roosting known to occur within area
Calyptorhynchus latirostris Carnaby's Cockatoo, Short-billed Black-Cockatoo [59523]	Endangered	Species or species habitat known to occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat may occur within area
Diomedea dabbenena Tristan Albatross [66471]	Endangered	Species or species habitat may occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or

Name	Status	Type of Presence
		related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely 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
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat likely to occur within area
Pachyptila turtur subantarctica Fairy Prion (southern) [64445]	Vulnerable	Species or species habitat known to occur within area
Rostratula australis Australian Painted-snipe, Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area
Sternula nereis nereis Australian Fairy Tern [82950]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Thalassarche cauta cauta Shy Albatross, Tasmanian Shy Albatross [82345]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche cauta steadi White-capped Albatross [82344]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Insects		
Leioproctus douglasiellus a short-tongued bee [66756]	Critically Endangered	Species or species habitat likely to occur within area
Neopasiphae simplicior A native bee [66821]	Critically Endangered	Species or species habitat likely to occur within area
Mammals		

Name	Status	Type of Presence
Balaenoptera musculus Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Bettongia penicillata ogilbyi Woylie [66844]	Endangered	Species or species habitat may occur within area
Dasyurus geoffroii Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat known to occur within area
Eubalaena australis Southern Right Whale [40]	Endangered	Breeding known to occur within area
Megaptera novaeangliae Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Neophoca cinerea Australian Sea-lion, Australian Sea Lion [22]	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
Setonix brachyurus Quokka [229]	Vulnerable	Species or species habitat may occur within area
Other		
Westralunio carteri Carter's Freshwater Mussel, Freshwater Mussel [86266]	Vulnerable	Species or species habitat likely 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 known to occur within area
Diuris micrantha Dwarf Bee-orchid [55082]	Vulnerable	Species or species habitat known to occur within area
Diuris purdiei Purdie's Donkey-orchid [12950]	Endangered	Species or species habitat known 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 known to occur within area
Eleocharis keigheryi Keighery's Eleocharis [64893]	Vulnerable	Species or species habitat may occur within area
Eucalyptus x balanites Cadda Road Mallee, Cadda Mallee [87816]	Endangered	Species or species habitat likely to occur within area
Grevillea curviloba subsp. incurva Narrow curved-leaf Grevillea [64909]	Endangered	Species or species habitat may occur within area

Name	Status	Type of Presence
[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
[Thelymitra dedmaniarum](#) Cinnamon Sun Orchid [65105]	Endangered	Species or species habitat may occur within area
Reptiles		
[Caretta caretta](#) Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
[Chelonia mydas](#) Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
[Dermochelys coriacea](#) Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
[Natator depressus](#) Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Sharks		
[Carcharias taurus (west coast population)](#) Grey Nurse Shark (west coast population) [68752]	Vulnerable	Species or species habitat likely to occur within area
[Carcharodon carcharias](#) White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
[Rhincodon typus](#) Whale Shark [66680]	Vulnerable	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		
[Anous stolidus](#) Common Noddy [825]		Species or species habitat may occur within area
[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
[Diomedea amsterdamensis](#) Amsterdam Albatross [64405]	Endangered	Species or species habitat may occur within area
[Diomedea dabbenena](#) Tristan Albatross [66471]	Endangered	Species or species habitat may occur within area

Name	Threatened	Type of Presence
Diomedea epomophora		
Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans		
Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi		
Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Hydroprogne caspia		
Caspian Tern [808]		Foraging, feeding or related behaviour known to occur within area
Macronectes giganteus		
Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli		
Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may occur within area
Onychoprion anaethetus		
Bridled Tern [82845]		Foraging, feeding or related behaviour likely to occur within area
Sterna dougallii		
Roseate Tern [817]		Foraging, feeding or related behaviour likely to occur within area
Thalassarche cauta		
Tasmanian Shy Albatross [89224]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida		
Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area
Thalassarche melanophris		
Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi		
White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Migratory Marine Species		
Balaena glacialis australis		
Southern Right Whale [75529]	Endangered*	Breeding known to occur within area
Balaenoptera edeni		
Bryde's Whale [35]		Species or species habitat may occur within area
Balaenoptera musculus		
Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
Caperea marginata		
Pygmy Right Whale [39]		Species or species habitat may occur within area
Carcharodon carcharias		
White Shark, Great White Shark [64470]	Vulnerable	Species or species habitat known to occur within area
Caretta caretta		
Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area

Name	Threatened	Type of Presence
Chelonia mydas		
Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea		
Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Lamna nasus		
Porbeagle, Mackerel Shark [83288]		Species or species habitat may occur within area
Manta alfredi		
Reef Manta Ray, Coastal Manta Ray, Inshore Manta Ray, Prince Alfred's Ray, Resident Manta Ray [84994]		Species or species habitat may occur within area
Manta birostris		
Giant Manta Ray, Chevron Manta Ray, Pacific Manta Ray, Pelagic Manta Ray, Oceanic Manta Ray [84995]		Species or species habitat may occur within area
Megaptera novaeangliae		
Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
Natator depressus		
Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Orcinus orca		
Killer Whale, Orca [46]		Species or species habitat may occur within area
Rhincodon typus		
Whale Shark [66680]	Vulnerable	Species or species habitat may 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]		Roosting 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 known to occur within area
Calidris melanotos		
Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis		
Red-necked Stint [860]		Roosting known to occur within area
Calidris subminuta		
Long-toed Stint [861]		Roosting known to occur within area
Charadrius dubius		
Little Ringed Plover [896]		Roosting known to occur within area
Gallinago megala		
Swinhoe's Snipe [864]		Roosting likely to occur within area

Name	Threatened	Type of Presence
Gallinago stenura		
Pin-tailed Snipe [841]		Roosting likely to occur within area
Limosa lapponica		
Bar-tailed Godwit [844]		Species or species habitat known to occur within area
Limosa limosa		
Black-tailed Godwit [845]		Roosting known to occur within area
Numenius madagascariensis		
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat likely to occur within area
Numenius minutus		
Little Curlew, Little Whimbrel [848]		Roosting likely to occur within area
Pandion haliaetus		
Osprey [952]		Species or species habitat known to occur within area
Philomachus pugnax		
Ruff (Reeve) [850]		Roosting known to occur within area
Tringa glareola		
Wood Sandpiper [829]		Roosting known to occur within area
Tringa nebularia		
Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis		
Marsh Sandpiper, Little Greenshank [833]		Roosting known 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		
Actitis hypoleucos		
Common Sandpiper [59309]		Species or species habitat known to occur within area
Anous stolidus		
Common Noddy [825]		Species or species habitat may occur within area
Anous tenuirostris melanops		
Australian Lesser Noddy [26000]	Vulnerable	Species or species habitat may 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]		Breeding known to occur within area

Name	Threatened	Type of Presence
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Roosting 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 known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area
Calidris subminuta Long-toed Stint [861]		Roosting known to occur within area
Charadrius dubius Little Ringed Plover [896]		Roosting known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Roosting known to occur within area
Diomedea amsterdamensis Amsterdam Albatross [64405]	Endangered	Species or species habitat may occur within area
Diomedea dabbenena Tristan Albatross [66471]	Endangered	Species or species habitat may occur within area
Diomedea epomophora Southern Royal Albatross [89221]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea exulans Wandering Albatross [89223]	Vulnerable	Foraging, feeding or related behaviour likely to occur within area
Diomedea sanfordi Northern Royal Albatross [64456]	Endangered	Foraging, feeding or related behaviour likely to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area
Himantopus himantopus Pied Stilt, Black-winged Stilt [870]		Roosting known to occur within area
Larus pacificus Pacific Gull [811]		Foraging, feeding or related behaviour may occur within area
Limosa lapponica Bar-tailed Godwit [844]		Species or species habitat known to occur within area

Name	Threatened	Type of Presence
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Macronectes giganteus Southern Giant-Petrel, Southern Giant Petrel [1060]	Endangered	Species or species habitat may occur within area
Macronectes halli Northern Giant Petrel [1061]	Vulnerable	Species or species habitat may 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 likely to occur within area
Numenius minutus Little Curlew, Little Whimbrel [848]		Roosting likely to occur within area
Pachyptila turtur Fairy Prion [1066]		Species or species habitat known to occur within area
Pandion haliaetus Osprey [952]		Species or species habitat known to occur within area
Philomachus pugnax Ruff (Reeve) [850]		Roosting known to occur within area
Puffinus assimilis Little Shearwater [59363]		Foraging, feeding or related behaviour known to occur within area
Puffinus carneipes Flesh-footed Shearwater, Fleshy-footed Shearwater [1043]		Species or species habitat likely to occur within area
Recurvirostra novaehollandiae Red-necked Avocet [871]		Roosting known to occur within area
Rostratula benghalensis (sensu lato) Painted Snipe [889]	Endangered*	Species or species habitat may occur within area
Sterna anaethetus Bridled Tern [814]		Foraging, feeding or related behaviour likely to occur within area
Sterna caspia Caspian Tern [59467]		Foraging, feeding or related behaviour known to occur within area
Sterna dougallii Roseate Tern [817]		Foraging, feeding or related behaviour likely to occur within area
Thalassarche cauta Tasmanian Shy Albatross [89224]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Thalassarche impavida Campbell Albatross, Campbell Black-browed Albatross [64459]	Vulnerable	Species or species habitat may occur within area

Name	Threatened	Type of Presence
Thalassarche melanophris Black-browed Albatross [66472]	Vulnerable	Species or species habitat may occur within area
Thalassarche steadi White-capped Albatross [64462]	Vulnerable*	Foraging, feeding or related behaviour likely to occur within area
Thinornis rubricollis Hooded Plover [59510]		Species or species habitat known to occur within area
Tringa glareola Wood Sandpiper [829]		Roosting known to occur within area
Tringa nebularia Common Greenshank, Greenshank [832]		Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]		Roosting known to occur within area
Fish		
Acentronura australe Southern Pygmy Pipehorse [66185]		Species or species habitat may occur within area
Campichthys galei Gale's Pipefish [66191]		Species or species habitat may occur within area
Heraldia nocturna Upside-down Pipefish, Eastern Upside-down Pipefish, Eastern Upside-down Pipefish [66227]		Species or species habitat may occur within area
Hippocampus angustus Western Spiny Seahorse, Narrow-bellied Seahorse [66234]		Species or species habitat may occur within area
Hippocampus breviceps Short-head Seahorse, Short-snouted Seahorse [66235]		Species or species habitat may occur within area
Hippocampus subelongatus West Australian Seahorse [66722]		Species or species habitat may occur within area
Histiogamphelus cristatus Rhino Pipefish, Macleay's Crested Pipefish, Ring-back Pipefish [66243]		Species or species habitat may occur within area
Lissocampus caudalis Australian Smooth Pipefish, Smooth Pipefish [66249]		Species or species habitat may occur within area
Lissocampus fatiloquus Prophet's Pipefish [66250]		Species or species habitat may occur within area
Lissocampus runa Javelin Pipefish [66251]		Species or species habitat may occur within area
Maroubra perserrata Sawtooth Pipefish [66252]		Species or species habitat may occur within area
Mitotichthys meraculus Western Crested Pipefish [66259]		Species or species habitat may occur within area
Nannocampus subosseus Bonyhead Pipefish, Bony-headed Pipefish [66264]		Species or species

Name	Threatened	Type of Presence
		habitat may occur within area
Phycodurus eques Leafy Seadragon [66267]		Species or species habitat may occur within area
Phyllopteryx taeniolatus Common Seadragon, Weedy Seadragon [66268]		Species or species habitat may occur within area
Pugnaso curtirostris Pugnose Pipefish, Pug-nosed Pipefish [66269]		Species or species habitat may occur within area
Solegnathus lettiensis Gunther's Pipehorse, Indonesian Pipefish [66273]		Species or species habitat may occur within area
Stigmatopora argus Spotted Pipefish, Gulf Pipefish, Peacock Pipefish [66276]		Species or species habitat may occur within area
Stigmatopora nigra Widebody Pipefish, Wide-bodied Pipefish, Black Pipefish [66277]		Species or species habitat may occur within area
Urocampus carinirostris Hairy Pipefish [66282]		Species or species habitat may occur within area
Vanacampus margaritifer Mother-of-pearl Pipefish [66283]		Species or species habitat may occur within area
Vanacampus phillipi Port Phillip Pipefish [66284]		Species or species habitat may occur within area
Vanacampus poecilolaemus Longsnout Pipefish, Australian Long-snout Pipefish, Long-snouted Pipefish [66285]		Species or species habitat may occur within area
Mammals		
Arctocephalus forsteri Long-nosed Fur-seal, New Zealand Fur-seal [20]		Species or species habitat may occur within area
Neophoca cinerea Australian Sea-lion, Australian Sea Lion [22]	Vulnerable	Species or species habitat known to occur within area
Reptiles		
Caretta caretta Loggerhead Turtle [1763]	Endangered	Foraging, feeding or related behaviour known to occur within area
Chelonia mydas Green Turtle [1765]	Vulnerable	Foraging, feeding or related behaviour known to occur within area
Dermochelys coriacea Leatherback Turtle, Leathery Turtle, Luth [1768]	Endangered	Foraging, feeding or related behaviour known to occur within area
Disteira kingii Spectacled Seasnake [1123]		Species or species habitat may occur within area
Natator depressus Flatback Turtle [59257]	Vulnerable	Foraging, feeding or related behaviour known to occur within area

Whales and other Cetaceans		[Resource Information]
Name	Status	Type of Presence
Mammals		
[Balaenoptera acutorostrata](#) Minke Whale [33]		Species or species habitat may occur within area
[Balaenoptera edeni](#) Bryde's Whale [35]		Species or species habitat may occur within area
[Balaenoptera musculus](#) Blue Whale [36]	Endangered	Species or species habitat likely to occur within area
[Caperea marginata](#) Pygmy Right Whale [39]		Species or species habitat may occur within area
[Delphinus delphis](#) Common Dophin, Short-beaked Common Dolphin [60]		Species or species habitat may occur within area
[Eubalaena australis](#) Southern Right Whale [40]	Endangered	Breeding known to occur within area
[Grampus griseus](#) Risso's Dolphin, Grampus [64]		Species or species habitat may occur within area
[Megaptera novaeangliae](#) Humpback Whale [38]	Vulnerable	Species or species habitat known to occur within area
[Orcinus orca](#) Killer Whale, Orca [46]		Species or species habitat may occur within area
[Stenella attenuata](#) Spotted Dolphin, Pantropical Spotted Dolphin [51]		Species or species habitat may occur within area
[Tursiops aduncus](#) Indian Ocean Bottlenose Dolphin, Spotted Bottlenose Dolphin [68418]		Species or species habitat likely to occur within area
[Tursiops truncatus s. str.](#) Bottlenose Dolphin [68417]		Species or species habitat may occur within area

Extra Information

State and Territory Reserves	[Resource Information]
Name	State
Banksia	WA
Forrestdale Lake	WA
Gibbs Road	WA
Harry Waring Marsupial Reserve	WA
Modong	WA
Piara	WA
Thomsons Lake	WA
Unnamed WA39584	WA
Unnamed WA39752	WA
Unnamed WA48291	WA

Name	State
Unnamed WA49561	WA
Wandi	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 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

Name	Status	Type of Presence
		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		
Anredera cordifolia Madeira Vine, Jalap, Lamb's-tail, Mignonette Vine, Anredera, Gulf Madeiravine, Heartleaf Madeiravine, Potato Vine [2643]		Species or species habitat likely to occur within area
Asparagus aethiopicus Asparagus Fern, Ground Asparagus, Basket Fern, Sprengi's Fern, Bushy Asparagus, Emerald Asparagus [62425]		Species or species habitat likely to occur within area
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Asparagus plumosus Climbing Asparagus-fern [48993]		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 linifolia Flax-leaved Broom, Mediterranean Broom, Flax Broom [2800]		Species or species habitat likely to occur within area
Genista monspessulana Montpellier Broom, Cape Broom, Canary Broom, Common Broom, French Broom, Soft Broom [20126]		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
Lycium ferocissimum African Boxthorn, Boxthorn [19235]		Species or species habitat likely to occur within area

Name	Status	Type of Presence
Olea europaea Olive, Common Olive [9160]		Species or species habitat may occur within area
Opuntia spp. Prickly Pears [82753]		Species or species habitat likely to occur within area
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
Sagittaria platyphylla Delta Arrowhead, Arrowhead, Slender Arrowhead [68483]		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
Solanum elaeagnifolium Silver Nightshade, Silver-leaved Nightshade, White Horse Nettle, Silver-leaf Nightshade, Tomato Weed, White Nightshade, Bull-nettle, Prairie-berry, Satansbos, Silver-leaf Bitter-apple, Silverleaf-nettle, Trompillo [12323]		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

Nationally Important Wetlands	[Resource Information]
Name	State
Forrestdale Lake	WA
Gibbs Road Swamp System	WA
Spectacles Swamp	WA
Thomsons Lake	WA

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

-32.17742 115.85403

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

TRANSPORT NOISE ASSESSMENT

ROWE GROUP DESIGN

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Transportation Noise Assessment

Lot 50 (#193) Barfield Road, Hammond Park

Reference: 19105234-02a

Prepared for:
Glenbrook Civil Engineering

Report: 19105234-02a

Lloyd George Acoustics Pty Ltd

ABN: 79 125 812 544

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Date:	Rev	Description	Prepared By	Verified
10-Nov-21	0	Issued to Client	Terry George	Matt Moyle
9-Dec-21	A	Updated noise mitigation recommendations	Terry George	-

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Appendices

1 INTRODUCTION

It is proposed to subdivide Lot 50 (#193) Barfield Road, Hammond Park into 36 residential lots. The location of the overall lot is shown in *Figure 1-1*, with the proposed subdivision plan shown in *Figure 1-2*. A transport noise assessment was originally prepared in November 2019 for the subject site, with this report updated in October 2020[1] with a new layout and finished lot levels. This earlier work utilised information on file for the adjoining Vivente Estate, which includes Lot 18 to the immediate south and the large parcel of land on the west side of Barfield Road and north of Rowley Road.

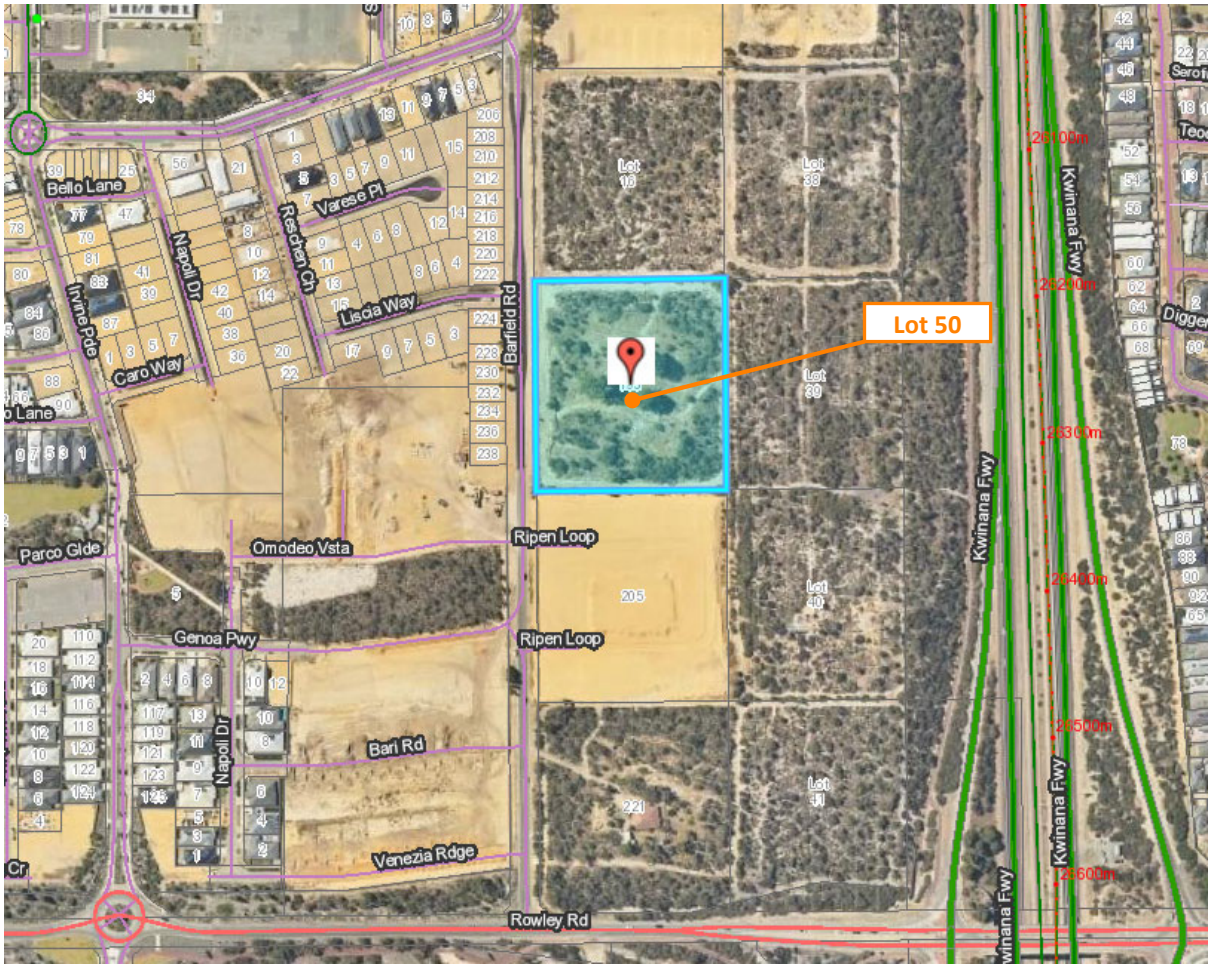


Figure 1-1 Proposed Subdivision Location

As described, the October 2020 report was based on file information. Following review of this report by Main Roads WA, it was requested the noise monitoring be updated as well as the forecast traffic volumes, being the subject of this report.

Appendix B contains a description of some of the terminology used throughout this report.

[1] *Transportation Noise Assessment, Lot 50 (No. 193) Barfield Road, Hammond Park*; Reference: 19105234-01b

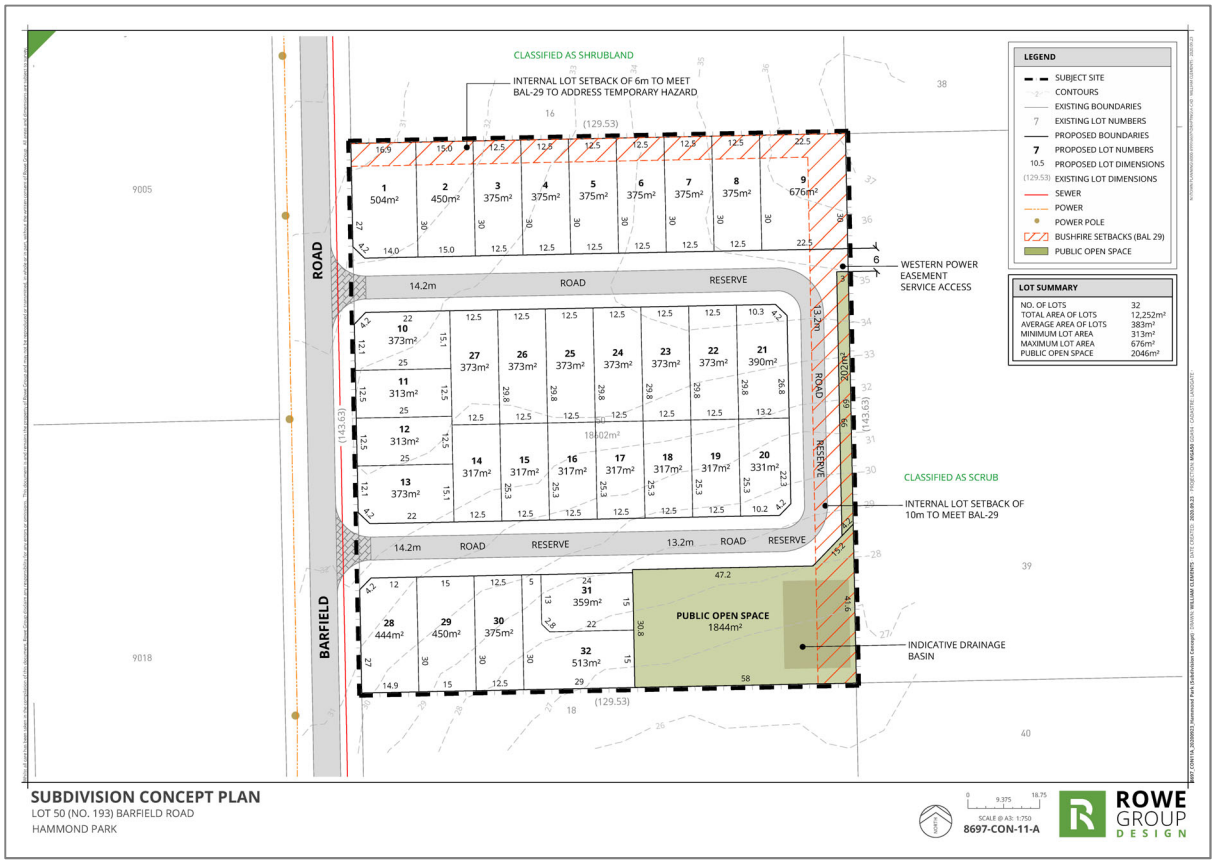


Figure 1-2 Proposed Subdivision Concept Plan (Rowe Group)

2 CRITERIA

The criteria relevant to this assessment is provided in *State Planning Policy No. 5.4 Road and Rail Noise* (hereafter referred to as SPP 5.4) produced by the Western Australian Planning Commission (WAPC). The objectives of SPP 5.4 are to:

- Protect the community from unreasonable levels of transport noise;
- Protect strategic and other significant freight transport corridors from incompatible urban encroachment;
- Ensure transport infrastructure and land-use can mutually exist within urban corridors;
- Ensure that noise impacts are addressed as early as possible in the planning process; and
- Encourage best practice noise mitigation design and construction standards

Table 2-1 sets out noise targets that are to be achieved by proposals under which SPP 5.4 applies. Where the targets are exceeded, an assessment is required to determine the likely level of transport noise and management/mitigation required.

Table 2-1 Noise Targets for Noise-Sensitive Land-Use

Outdoor Noise Target		Indoor Noise Target	
55 dB $L_{Aeq(Day)}$	50 dB $L_{Aeq(Night)}$	40 dB $L_{Aeq(Day)}$ (Living and Work Areas)	35 dB $L_{Aeq(Night)}$ (Bedrooms)

Notes:

- Day period is from 6am to 10pm and night period from 10pm to 6am.
- The outdoor noise target is to be measured at 1-metre from the most exposed, habitable[2] facade of the noise sensitive building.
- 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.
- Outdoor targets are to be met at all outdoor areas as far as is reasonable and practicable to do so using the various noise mitigation measures outlined in the Guidelines.

The application of SPP 5.4 is to consider anticipated traffic volumes for the next 20 years from when the noise assessment is undertaken.

In the application of the noise targets, the objective is to achieve:

- indoor noise levels specified in *Table 2-1* in noise-sensitive areas (e.g. 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 childcare 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.

[2] A habitable room is defined in State Planning Policy 3.1 as a room used for normal domestic activities that includes a bedroom, living room, lounge room, music room, sitting room, television room, kitchen, dining room, sewing room, study, playroom, sunroom, gymnasium, fully enclosed swimming pool or patio.

3 METHODOLOGY

Noise measurements and modelling have been undertaken generally in accordance with the requirements of SPP 5.4 and associated Guidelines[3] as described in *Section 3.1* and *Section 3.2*.

3.1 Site Measurements

Noise monitoring was undertaken alongside Kwinana Freeway in order to:

- Quantify the existing noise levels;
- Determine the differences between different acoustic parameters ($L_{A10,18hour}$, $L_{Aeq(Day)}$ and $L_{Aeq(Night)}$); and
- Calibrate the noise model for existing conditions.

The instrument used was an ARL Type 316 noise data logger (S/N: 15-301-468), located 25 metres from the edge of the northbound on-road, with the microphone 1.4 metres above ground level (refer *Figure 3-1*). The logger was programmed to record hourly L_{A1}, L_{A10}, L_{A90}, and L_{Aeq} levels. This instrument complies with the instrumentation requirements of *Australian Standard 2702-1984 Acoustics – Methods for the Measurement of Road Traffic Noise*. The logger was field calibrated before and after the measurement session and found to be accurate to within +/- 1 dB. Lloyd George Acoustics also holds current laboratory calibration certificate for the loggers.

Figure 3-1 Photograph and Location of Noise Logger

[3] Road and Rail Noise Guidelines, September 2019

3.2 Noise Modelling

The computer programme *SoundPLAN 7.3* was utilised incorporating the *Calculation of Road Traffic Noise* (CoRTN) algorithms, modified to reflect Australian conditions. The modifications included the following:

- Vehicles were separated into heavy (Austroads Class 3 upwards) and non-heavy (Austroads Classes 1 & 2) with non-heavy vehicles having a source height of 0.5 metres above road level and heavy vehicles having two sources, at heights of 1.5 metres and 3.6 metres above road level, to represent the engine and exhaust respectively. By splitting the noise source into three, allows for less barrier attenuation for high level sources where barriers are to be considered;
- Note that a -8.0 dB correction is applied to the exhaust and -0.8 dB to the engine (based on Transportation Noise Reference Book, Paul Nelson, 1987), so as to provide consistent results with the CoRTN algorithms for the no barrier scenario;
- Adjustments of -0.8 dB and -1.7 dB have been applied to the predicted levels for the 'free-field' and 'at facade' cases respectively, based on the findings of *An Evaluation of the U.K. DoE Traffic Noise Prediction*; Australian Road Research Board, Report 122 ARRB – NAASRA Planning Group (March 1983).

Predictions are made at heights of 1.4 m above ground floor level, representing single storey houses. The noise is predicted at 1.0 metre from an assumed building facade resulting in a +2.5 dB correction due to reflected noise.

Various input data are included in the modelling such as ground topography, road design, traffic volumes etc. These model inputs are discussed in the following sections.

3.2.1 Ground Topography

Topographical and road design data for this project was on file from the previous projects in the area.

Buildings have also been included as these can provide barrier attenuation when located between a source and receiver, in much the same way as a hill or wall provides noise shielding. All buildings are assumed to be single storey with a height of 3.5 metres.

Finished lot levels were provided by BPA Engineering as shown in *Figure 3-2* and have been incorporated into the noise model.

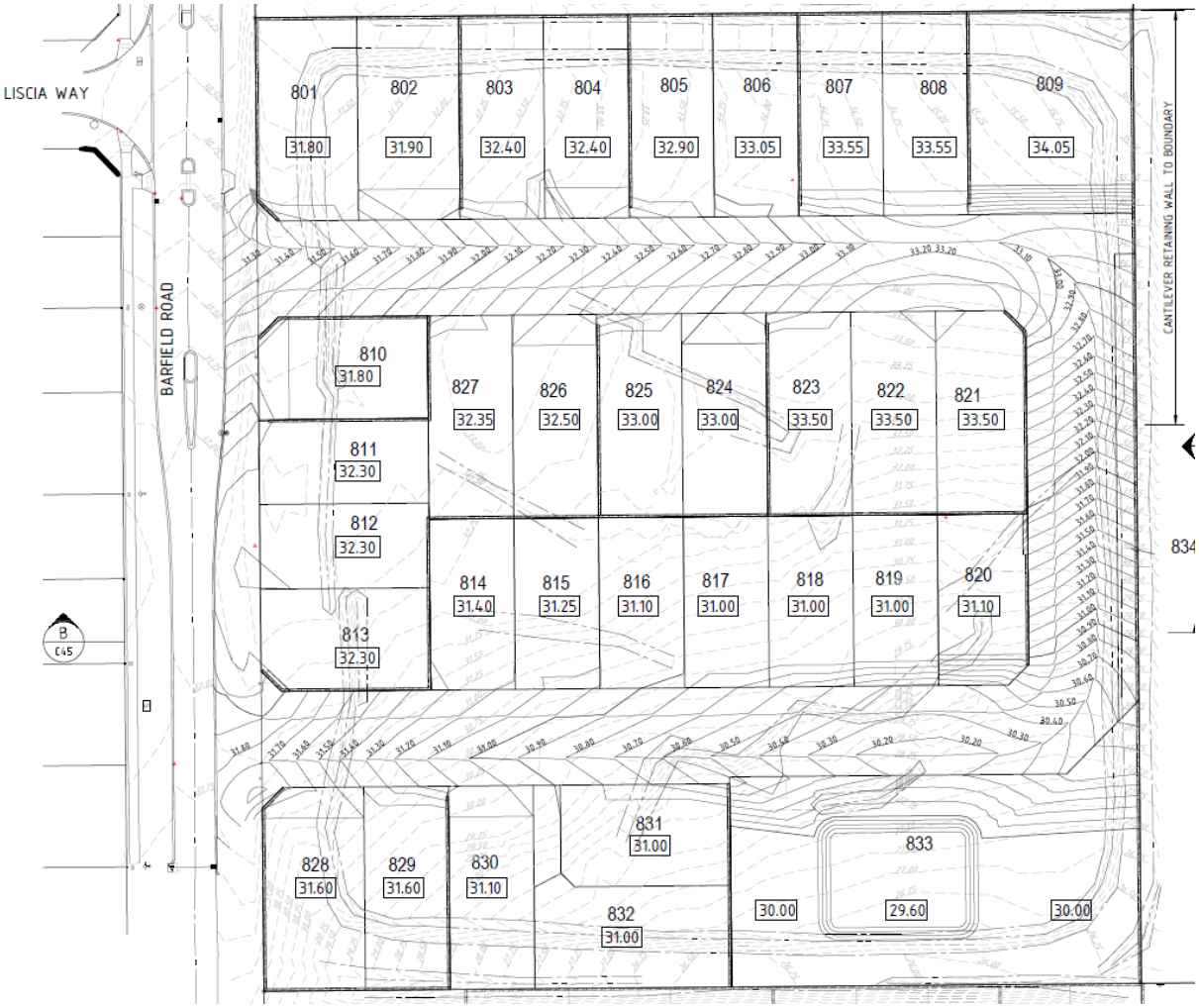


Figure 3-2 Finished Lot Levels

3.2.2 Traffic Data

Traffic data includes:

- Road Surface – The noise relationship between different road surface types is shown in *Table 3-1*.

Table 3-1 Noise Relationship Between Different Road Surfaces

Road Surfaces							
Chip Seal				Asphalt			
14mm	10mm	5mm	Slurry	Dense Graded	Novachip	Stone Mastic	Open Graded
+3.5 dB	+2.5 dB	+1.5 dB	+1.0 dB	0.0 dB	-0.2 dB	-1.5 dB	-2.5 dB

The existing and future road surface for Kwinana Freeway is open graded asphalt and is expected to remain unchanged into the future.

- Vehicle Speed – The existing and future posted speeds for the main carriageways of Kwinana Freeway are 100km/hr. The ramps are modelled as progressively changing from 60km/hr up to 100km/hr.

- Traffic Volumes – Existing (2016) and forecast (2041) traffic volumes were provided by Main Roads WA (Thomas Ng, Traffic Modelling Analyst, Reference: #42030). More recent traffic data was also obtained from the Main Roads WA Traffic Map site. *Table 3-2* provides the traffic volume input data in the model.

Table 3-2 Traffic Information Used in the Modelling

Road	Scenario			
	Existing - 2020/21		Future - 2041	
	Northbound	Southbound	Northbound	Southbound
Kwinana Freeway – north of ramps	50,773 (16.0)	49,803 (12.5)	78,300 (11.0)	82,700 (10.0)
Kwinana Freeway – south of ramps	45,428 (13.6)	45,614 (13.1)	72,400 (9.0)	74,100 (9.0)
Ramps – north of Rowley Road	5,345 (36.4)	4,189 (6.0)	5,900 (25.0)	8,600 (20)

Numbers in brackets are % heavy vehicles.

3.2.3 Ground Attenuation

Ground absorption values vary from 0 to 1, with 0 representing hard, reflective surfaces such as water or bitumen and 1 representing absorptive surfaces such as grass. The ground attenuation has been assumed to be 0.2 (20%) within the road reserve, and 0.6 (60%) elsewhere across the study area, except for public open space, which was set to 1.00 (100%).

4 RESULTS

4.1 Noise Measurements

The results of the noise monitoring are summarised in *Table 4-1* and shown graphically in *Figure 4-1*.

Table 4-1 Measured Average Noise Levels

Date	Average Weekday Noise Level, dB			
	$L_{A10,18hour}$	$L_{Aeq,24hour}$	$L_{Aeq\ (Day)}$	$L_{Aeq\ (Night)}$
Wednesday 13 October 2021	*72.0*	*70.5*	*70.9*	*69.7*
Thursday 14 October 2021	70.4	68.3	69.1	66.4
Friday 15 October 2021	70.9	68.7	69.6	65.9
Saturday 16 October 2021	*69.7*	*66.7*	*67.8*	*63.0*
Sunday 17 October 2021	*69.0*	*66.1*	*67.5*	*60.5*
Monday 18 October 2021	69.9	67.7	68.6	65.4
Tuesday 19 October 2021	*72.9*	*70.8*	*71.4*	*69.5*
Wednesday 20 October 2021	*72.1*	*69.5*	*70.3*	*67.1*
Thursday 21 October 2021	70.6	68.6	69.2	67.3
Weekday Average	**70.4**	**68.3**	**69.1**	**66.2**

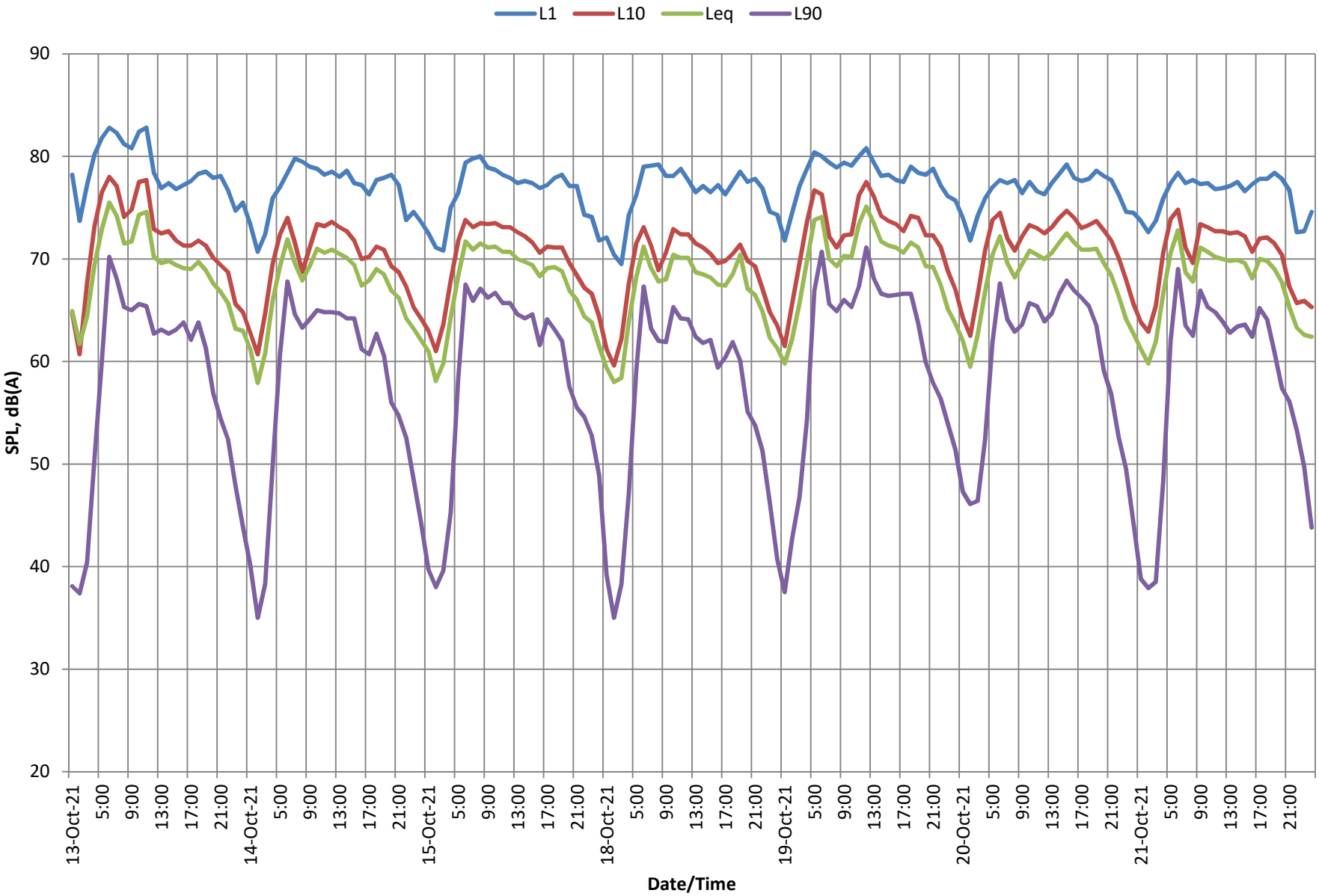
* Those shown in shaded italics are not used in average due to poor weather or not being a weekday.

The average difference between the weekday $L_{Aeq(Day)}$ and $L_{Aeq(Night)}$ is 2.9 dB and this conversion has been used in the modelling. This same difference has been assumed to exist in future years. As such, it is the $L_{Aeq(Night)}$ noise levels that will dictate compliance, since these are within 5 dB of the daytime levels.

4.2 Noise Modelling

The noise model is initially set-up and calibrated for existing conditions. It is then updated to reflect future conditions incorporating the proposed development and future traffic volumes with the results provided in *Figure 4-2* as an $L_{Aeq(Night)}$ noise level contour plot.

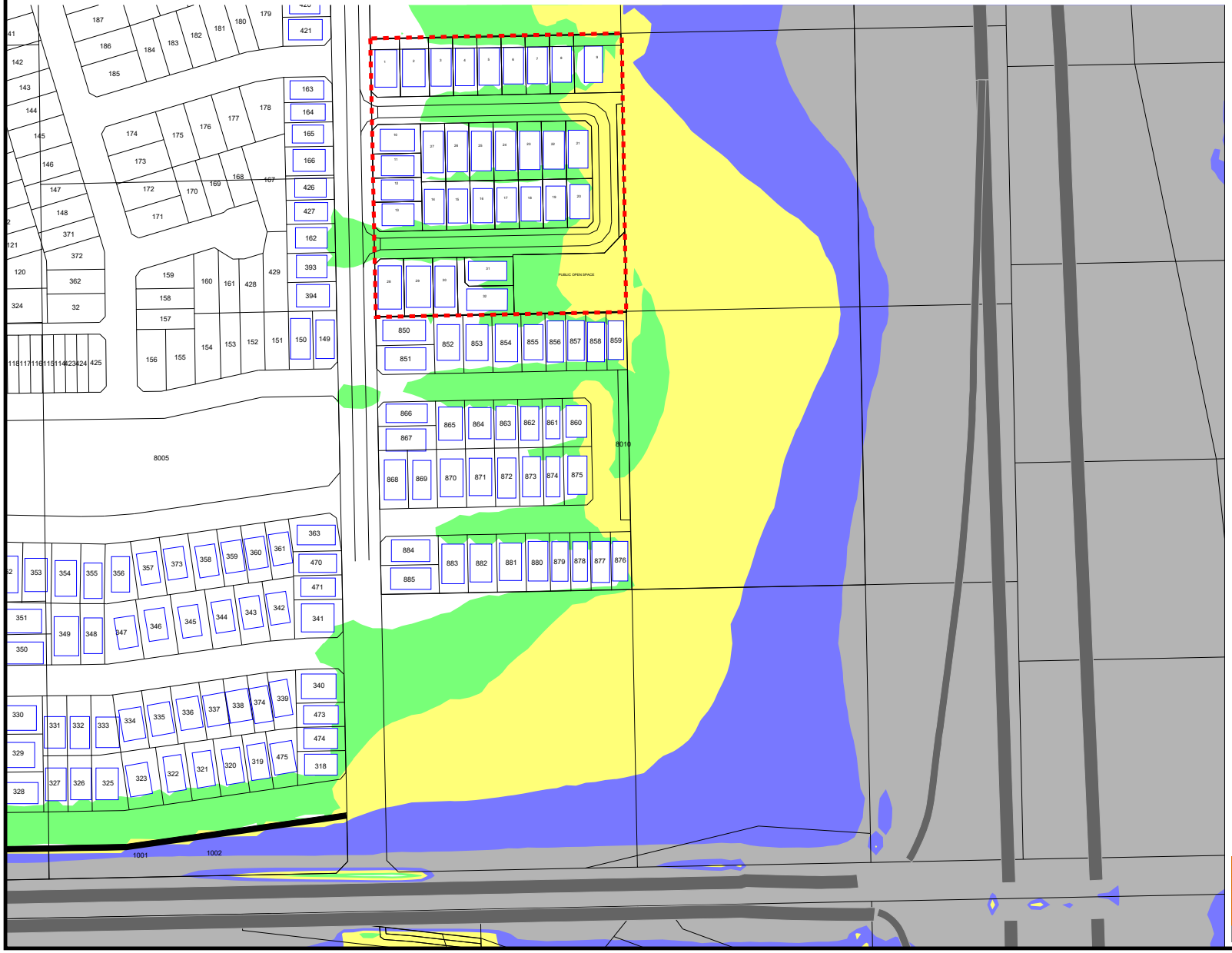
Figure 4-1: Noise Monitoring Alongside Kwinana Freeway



Lot 50 Proposed Subdivision

LAeq(Night) Noise Level Contours - Future

Figure 4-2



Noise levels

$L_{Aeq(night)}$ dB

<=	50	
<=	51	Exposure A
<=	52	
<=	53	
<=	54	Exposure B
<=	55	
<=	56	
<=	57	
<=	58	Exposure C
<=	59	
<=	60	
<=	61	
>	61	Exposure D+

N

Signs and symbols

- Road Lanes
- Building
- Subject Site

6 November 2021

Length Scale 1:3000

0 15 30 60 90 120 m

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5 ASSESSMENT

The objectives of SPP 5.4 are to achieve:

- indoor noise levels specified in *Table 2-1* in noise-sensitive areas (e.g. bedrooms and living rooms of houses and school classrooms); and
- a reasonable degree of acoustic amenity for outdoor living areas on each residential lot.

Where the outdoor noise targets of *Table 2-1* are achieved, no further controls are necessary.

With reference to the predicted noise levels in *Section 4.2*, it is evident the outdoor noise target will be exceeded at some lots. As such, the following is recommended:

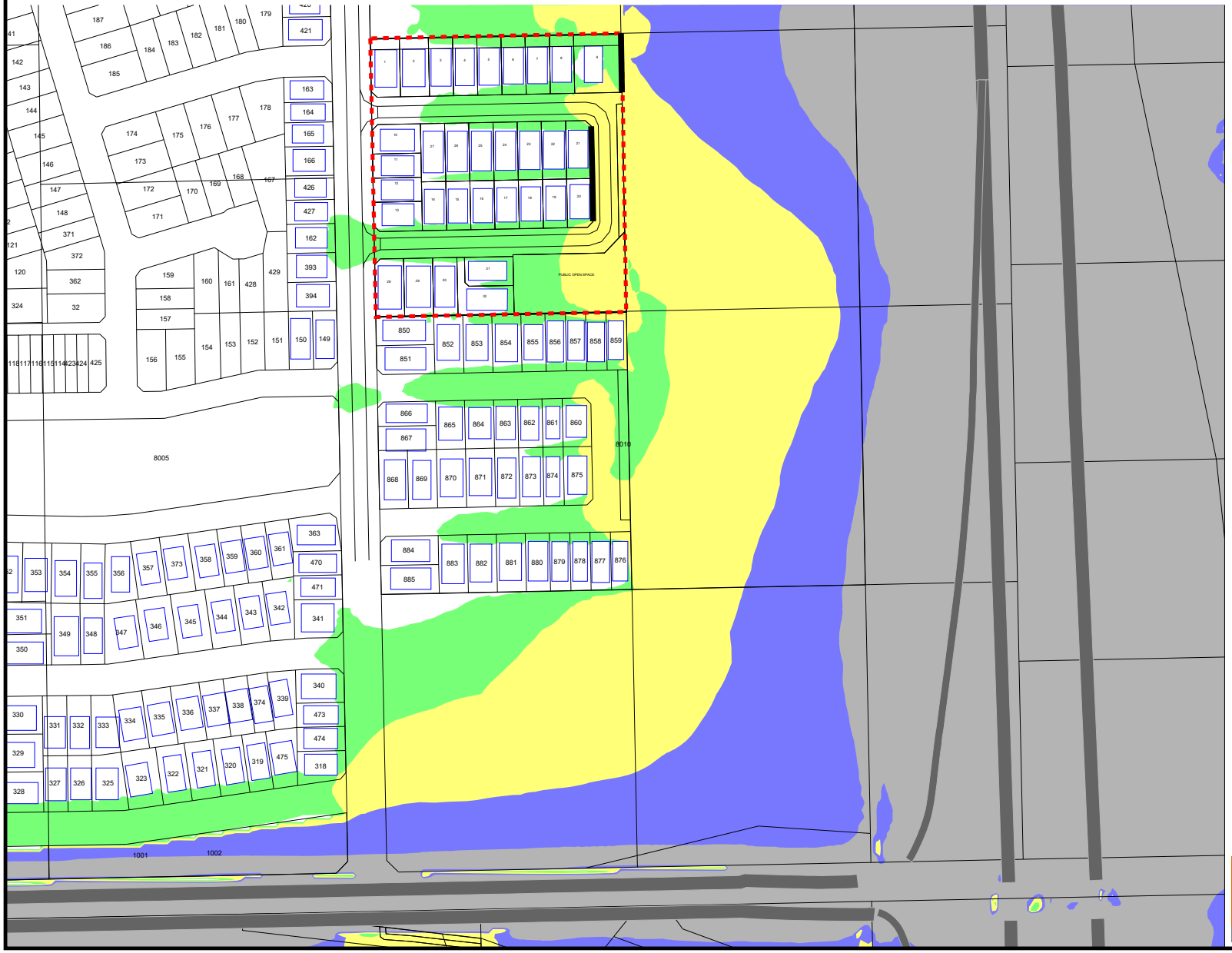
- Construct a noise wall alongside Lots 9, 20 and 21. The wall is to be 2.4 metres high (relative to finished lot level) and have a minimum surface mass of 15 kg/m^2. The noise contour plot with the noise wall is provided in *Figure 5-1*.
- Where lots are above the outdoor noise target (refer *Figure 5-1*), the following Packages (refer *Appendix A*) are required:
    - Package A where noise levels are between 51 dB and 53 dB $L_{Aeq(Night)}$;
    - Package B where noise levels are between 54 dB and 57 dB $L_{Aeq(Night)}$;

      Alternative constructions from the deemed to satisfy packages may be acceptable if supported by a report undertaken by a suitably qualified acoustical consultant (member from of the Association of Australasian Acoustical Consultants (AAAC)), once the lots specific building plans are available.
- All affected lots are to have notifications on lot titles as per SPP 5.4 requirements – refer *Appendix A*.
- Where a dwelling is to be more than one storey, a specific house assessment is to be undertaken by a suitably qualified acoustical consultant.

Lot 50 Proposed Subdivision

LAeq(Night) Noise Level Contours - Future with 2.4m Noise Wall

Figure 5-1



Noise levels

$L_{Aeq(night)}$ dB

<= 50		
<= 51		Exposure A
<= 52		
<= 53		
<= 54		Exposure B
<= 55		
<= 56		
<= 57		
<= 58		Exposure C
<= 59		
<= 60		
<= 61		
> 61		Exposure D+

N

Signs and symbols

- Road Lanes
- Building
- Subject Site
- 2.4m Wall

9 December 2021

Length Scale 1:3000

0 15 30 60 90 120 m

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Lot 50 Proposed Subdivision

Proposed Noise Mitigation

Figure 5-2

Signs and symbols

- Road Lanes
- Subject Site
- 2.4m High Wall
- Package A (Kwinana Fwy)
- Package B (Kwinana Fwy)

9 December 2021

Length Scale 1:3000

0 15 30 60 90 120 m

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Appendix A

Quiet House Packages

The packages and information provided on the following pages are taken from *Road and Rail Noise Guidelines* (September 2019).

Where outdoor and indoor noise levels received by a noise-sensitive land-use and/or development exceed the policy's noise target, implementation of quiet house requirements is an acceptable solution.

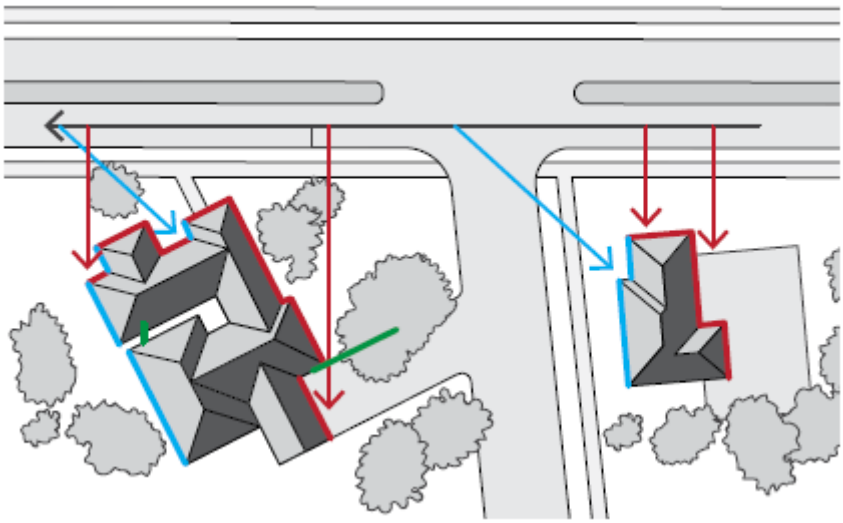
The quiet house packages are not the only solution to achieving acceptable internal transport noise levels. A suitably qualified acoustical engineer or consultant may also determine more tailored acoustic design requirements for buildings in a transport noise corridor by carrying out acoustic design in accordance with relevant industry standards. This includes the need to meet the relevant design targets specified in AS/NZS 2107:2016 for road traffic noise.

With regards to the packages, the following definitions are provided:

- **Facing** the transport corridor (red): Any part of a building façade is 'facing' the transport corridor if any straight line drawn perpendicular (at a 90 degree angle) to its nearest road lane or railway line intersects that part of the façade without obstruction (ignoring any fence).

- **Side-on** to transport corridor (blue): Any part of a building façade that is not 'facing' is 'side-on' to the transport corridor if any straight line, at any angle, can be drawn from it to intersect the nearest road lane or railway line without obstruction (ignoring any fence).

- **Opposite** to transport corridor (green): Neither 'side on' nor 'facing', as defined above.



Quiet House Package A

56-58 dB $L_{Aeq(Day)}$ & 51-53 dB $L_{Aeq(Night)}$

Element	Orientation	Room	
		Bedroom	Indoor Living and Work Areas

External Windows	Facing	• Up to 40% floor area ($R_w + C_{tr} \geq 28$):
		  ○ Sliding or double hung with minimum 10mm single or 6mm-12mm-10mm double insulated glazing;
		  ○ Sealed awning or casement windows with minimum 6mm glass.
		• Up to 60% floor area ($R_w + C_{tr} \geq 31$):
		  ○ Sealed awning or casement windows with minimum 6mm glass.
			• Up to 40% floor area ($R_w + C_{tr} \geq 25$):
			  ○ Sliding or double hung with minimum 6mm single or 6mm-12mm-6mm double insulated glazing;
			• Up to 60% floor area ($R_w + C_{tr} \geq 28$);
			• Up to 80% floor area ($R_w + C_{tr} \geq 31$).

	Side On	As above, except $R_w + C_{tr}$ values may be 3 dB less or max % area increased by 20%.	
	Opposite	No specific requirements	

External Doors	Facing	• Fully glazed hinged door with certified $R_w + C_{tr} \geq 28$ rated door and frame including seals and 6mm glass.	• Doors to achieve $R_w + C_{tr} \geq 25$:
			  ○ 35mm Solid timber core hinged door and frame system certified to R_w 28 including seals;
			  ○ Glazed sliding door with 10mm glass and weather seals.

	Side On	As above, except $R_w + C_{tr}$ values may be 3 dB less.	
	Opposite	No specific requirements	

External Walls	All	• $R_w + C_{tr} \geq 45$:
		  ○ Two leaves of 90mm thick clay brick masonry with minimum 20mm cavity; or
		  ○ Single leaf of 150mm brick masonry with 13mm cement render on each face; or
		  ○ One row of 92mm studs at 600mm centres with:
		  ▪ Resilient steel channels fixed to the outside of the studs; and
		  ▪ 9.5mm hardboard or fibre cement sheeting or 11mm fibre cement weatherboards fixed to the outside;
		  ▪ 75mm thick mineral wool insulation with a density of at least 11kgkg/m^3; and
		  ▪ 2 x 16mm fire-rated plasterboard to inside.	

Roofs and Ceilings	All	• $R_w + C_{tr} \geq 35$: ○ Concrete or terracotta tile or metal sheet roof with sarking and at least 10mm plasterboard.	
Outdoor Living Areas		Where practicable, located outdoor living area on side of house opposite to corridor.	

Quiet House Package B

59-62 dB $L_{Aeq(Day)}$ & 54-57 dB $L_{Aeq(Night)}$

Element	Orientation	Room	
		Bedroom	Indoor Living and Work Areas
External Windows	Facing	• Up to 40% floor area ($R_w + C_{tr} \geq 31$): ○ Fixed sash, awning or casement with minimum 6mm glass or 6mm-12mm-6mm double insulated glazing. • Up to 60% floor area ($R_w + C_{tr} \geq 34$): ○ Fixed sash, awning or casement with minimum 10mm glass or 6mm-12mm-10mm double insulated glazing.	• Up to 40% floor area ($R_w + C_{tr} \geq 28$): ○ Sliding or double hung with 6mm-12mm-10mm double insulated glazing; ○ Sealed awning or casement windows with minimum 6mm glass. • Up to 60% floor area ($R_w + C_{tr} \geq 31$); • Up to 80% floor area ($R_w + C_{tr} \geq 34$).
	Side On	As above, except $R_w + C_{tr}$ values may be 3 dB less or max % area increased by 20%.	
	Opposite	As above, except $R_w + C_{tr}$ values may be 6 dB less or max % area increased by 20%.	
External Doors	Facing	• Fully glazed hinged door with certified $R_w + C_{tr} \geq 31$ rated door and frame including seals and 10mm glass.	• Doors to achieve $R_w + C_{tr} \geq 28$: ○ 40mm Solid timber core hinged door and frame system certified to R_w 32 including seals; ○ Fully glazed hinged door with certified $R_w + C_{tr} \geq 28$ rated door and frame including seals and 6mm glass.
	Side On	As above, except $R_w + C_{tr}$ values may be 3 dB less or max % area increased by 20%.	
	Opposite	As above, except $R_w + C_{tr}$ values may be 6 dB less or max % area increased by 20%.	
External Walls	All	• $R_w + C_{tr} \geq 50$: ○ Two leaves of 90mm thick clay brick masonry with minimum 50mm cavity between leaves and 25mm glasswool or polyester (24kg/m^3). Resilient ties used where required to connect leaves. ○ Two leaves of 110mm clay brick masonry with minimum 50mm cavity between leaves and 25mm glasswool or polyester insulation (24kg/m^3). ○ Single leaf of 220mm brick masonry with 13mm cement render on each face. ○ 150mm thick unlined concrete panel or 200mm thick concrete panel with one layer of 13mm plasterboard or 13mm cement render on each face. ○ 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 glasswool or polyester insulation (11kg/m^3) between studs; and ▪ One layer of 10mm plasterboard fixed to the inside face.	
Roofs and Ceilings	All	• $R_w + C_{tr} \geq 35$: ○ Concrete or terracotta tile or metal sheet roof with sarking and at least 10mm plasterboard ceiling with R3.0+ fibrous insulation.	
Outdoor Living Areas		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 2.4 metres height above ground level.	

Mechanical Ventilation requirements

In implementing the acceptable treatment packages, the following mechanical ventilation / air-conditioning considerations are required:

- Acoustically rated openings and ductwork to provide a minimum sound reduction performance of R_w 40 dB into sensitive spaces;
- Evaporative systems require attenuated ceiling air vents to allow closed windows;
- Refrigerant based systems need to be designed to achieve National Construction Code fresh air ventilation requirements;
- Openings such as eaves, vents and air inlets must be acoustically treated, closed or relocated to building sides facing away from the corridor where practicable.

Notification

Notifications on title advise prospective purchasers of the potential for noise impacts from major transport corridors and help with managing expectations.

The Notification is to state as follows:

This lot is in the vicinity of a transport corridor and is affected, or may in the future be affected, by road and rail transport noise. Road and rail transport noise levels may rise or fall over time depending on the type and volume of traffic.

Appendix B

Terminology

The following is an explanation of the terminology used throughout this report.

Decibel (dB)
The decibel is the unit that describes the sound pressure and sound power levels of a noise source. It is a logarithmic scale referenced to the threshold of hearing.

A-Weighting
An A-weighted noise level has been filtered in such a way as to represent the way in which the human ear perceives sound. This weighting reflects the fact that the human ear is not as sensitive to lower frequencies as it is to higher frequencies. An A-weighted sound level is described as L_A dB.

L_1
An L_1 level is the noise level which is exceeded for 1 per cent of the measurement period and is considered to represent the average of the maximum noise levels measured.

L_{10}
An L_{10} level is the noise level which is exceeded for 10 per cent of the measurement period and is considered to represent the "*intrusive*" noise level.

L_{90}
An L_{90} level is the noise level which is exceeded for 90 per cent of the measurement period and is considered to represent the "*background*" noise level.

L_{eq}
The L_{eq} level represents the average noise energy during a measurement period.

$L_{A10,18hour}$
The $L_{A10,18\ hour}$ level is the arithmetic average of the hourly L_{A10} levels between 6.00 am and midnight. The *CoRTN* algorithms were developed to calculate this parameter.

$L_{Aeq,24hour}$
The $L_{Aeq,24\ hour}$ level is the logarithmic average of the hourly L_{Aeq} levels for a full day (from midnight to midnight).

$L_{Aeq,8hour}$ / $L_{Aeq\ (Night)}$
The $L_{Aeq\ (Night)}$ level is the logarithmic average of the hourly L_{Aeq} levels from 10.00 pm to 6.00 am on the same day.

$L_{Aeq,16hour}$ / $L_{Aeq\ (Day)}$
The $L_{Aeq\ (Day)}$ level is the logarithmic average of the hourly L_{Aeq} levels from 6.00 am to 10.00 pm on the same day. This value is typically 1-3 dB less than the $L_{A10,18hour}$.

Noise-sensitive land use and/or development
Land-uses or development occupied or designed for occupation or use for residential purposes (including dwellings, residential buildings or short-stay accommodation), caravan park, camping ground, educational establishment, child care premises, hospital, nursing home, corrective institution or place of worship.

About the Term 'Reasonable'

An assessment of reasonableness should demonstrate that efforts have been made to resolve conflicts without comprising on the need to protect noise-sensitive land-use activities. For example, have reasonable efforts been made to design, relocate or vegetate a proposed noise barrier to address community concerns about the noise barrier height? Whether a noise mitigation measure is reasonable might include consideration of:

- The noise reduction benefit provided;
- The number of people protected;
- The relative cost vs benefit of mitigation;
- Road conditions (speed and road surface) significantly differ from noise forecast table assumptions;
- Existing and future noise levels, including changes in noise levels;
- Aesthetic amenity and visual impacts;
- Compatibility with other planning policies;
- Differences between metropolitan and regional situations and whether noise modelling requirements reflect the true nature of transport movements;
- Ability and cost for mobilisation and retrieval of noise monitoring equipment in regional areas;
- Differences between Greenfield and infill development;
- Differences between freight routes and public transport routes and urban corridors;
- The impact on the operational capacity of freight routes;
- The benefits arising from the proposed development;
- Existing or planned strategies to mitigate the noise at source.

About the Term 'Practicable'

'Practicable' considerations for the purposes of the policy normally relate to the engineering aspects of the noise mitigation measures under evaluation. It is defined as "reasonably practicable having regard to, among other things, local conditions and circumstances (including costs) and to the current state of technical knowledge" (*Environmental Protection Act 1986*). These may include:

- Limitations of the different mitigation measures to reduce transport noise;
- Competing planning policies and strategies;
- Safety issues (such as impact on crash zones or restrictions on road vision);
- Topography and site constraints (such as space limitations);
- Engineering and drainage requirements;
- Access requirements (for driveways, pedestrian access and the like);
- Maintenance requirements;
- Bushfire resistance or BAL ratings;
- Suitability of the building for acoustic treatments.

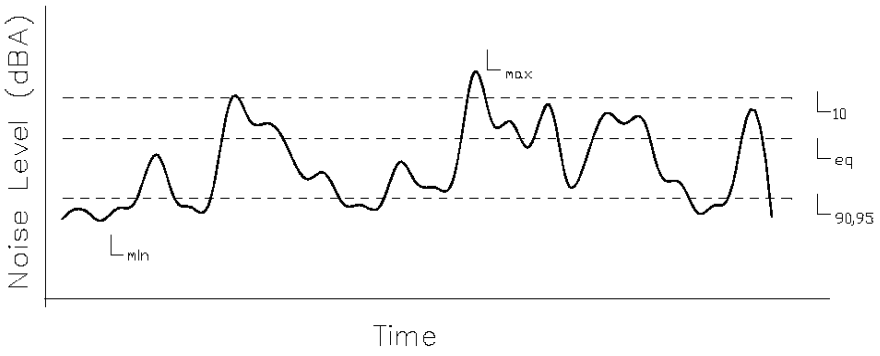
R_w

This is the weighted sound reduction index and is similar to the previously used STC (Sound Transmission Class) value. It is a single number rating determined by moving a grading curve in integral steps against the laboratory measured transmission loss until the sum of the deficiencies at each one-third-octave band, between 100 Hz and 3.15 kHz, does not exceed 32 dB. The higher the R_w value, the better the acoustic performance.

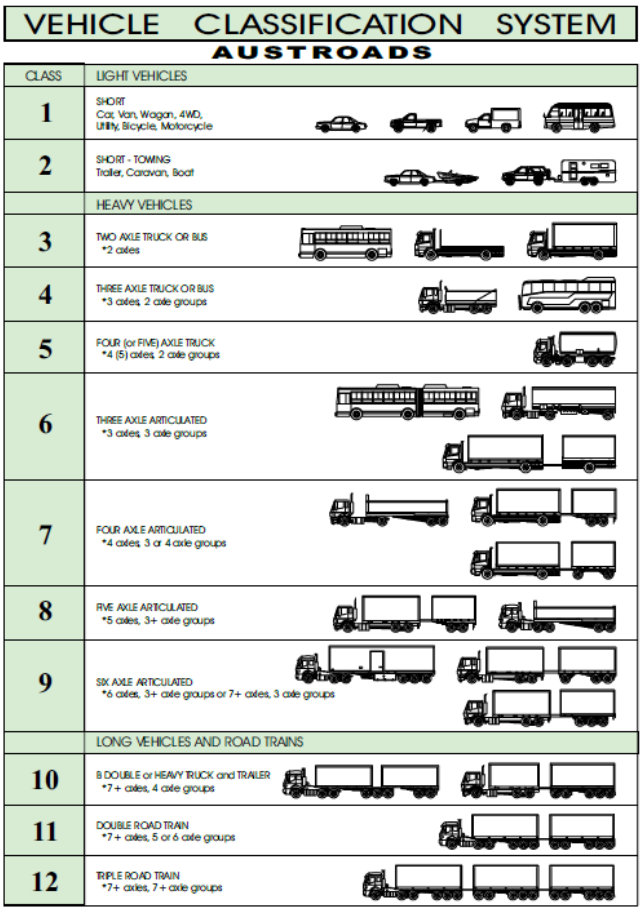
C_{tr}

This is a spectrum adaptation term for airborne noise and provides a correction to the R_w value to suit source sounds with significant low frequency content such as road traffic or home theatre systems. A wall that provides a relatively high level of low frequency attenuation (i.e. masonry) may have a value in the order of –4 dB, whilst a wall with relatively poor attenuation at low frequencies (i.e. stud wall) may have a value in the order of -14 dB.

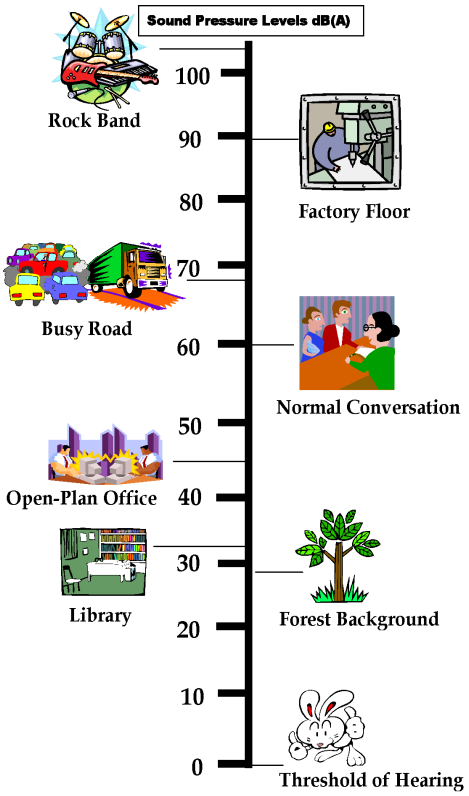
Chart of Noise Level Descriptors



Austroads Vehicle Class



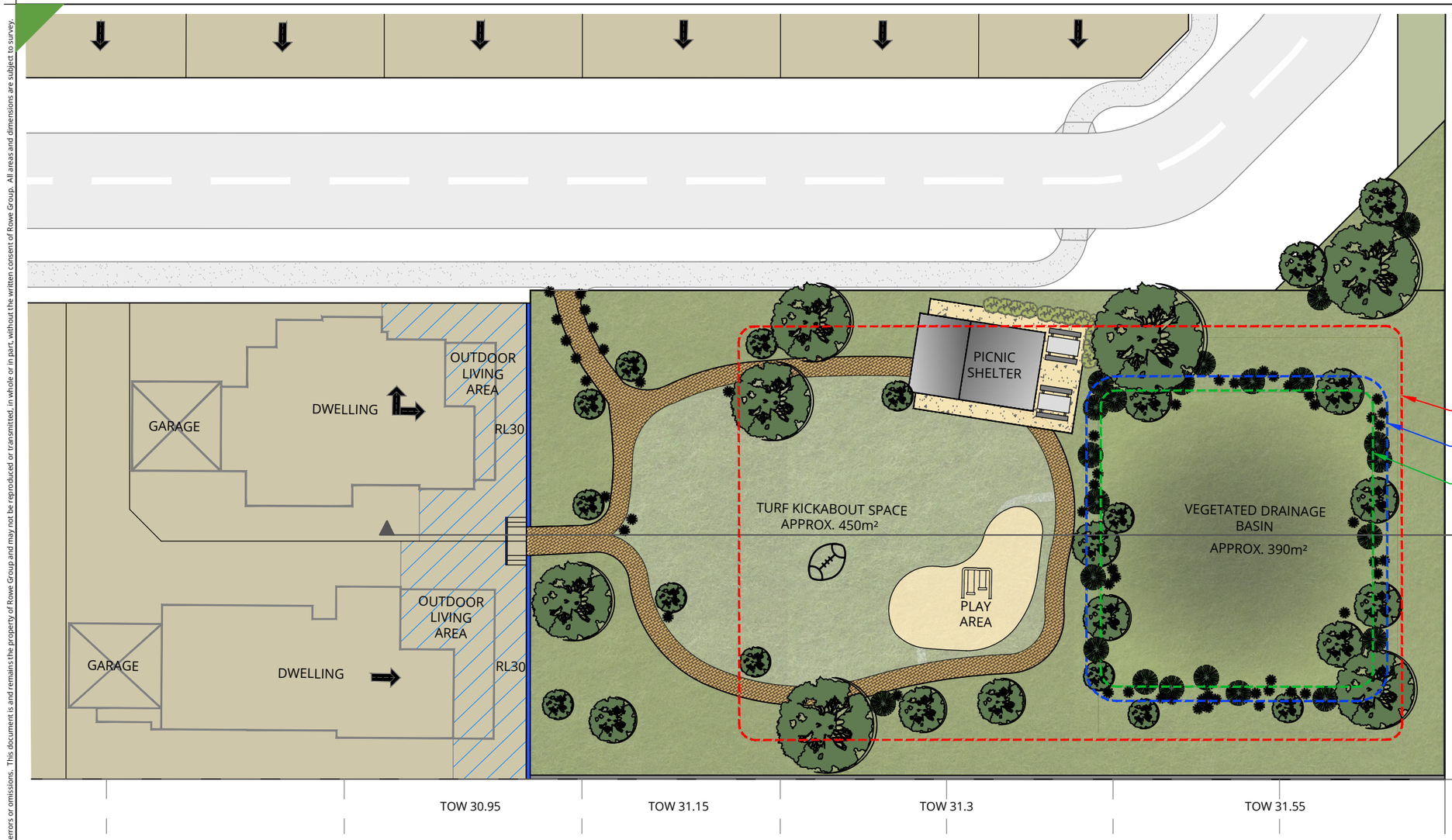
Typical Noise Levels



APPENDIX 5

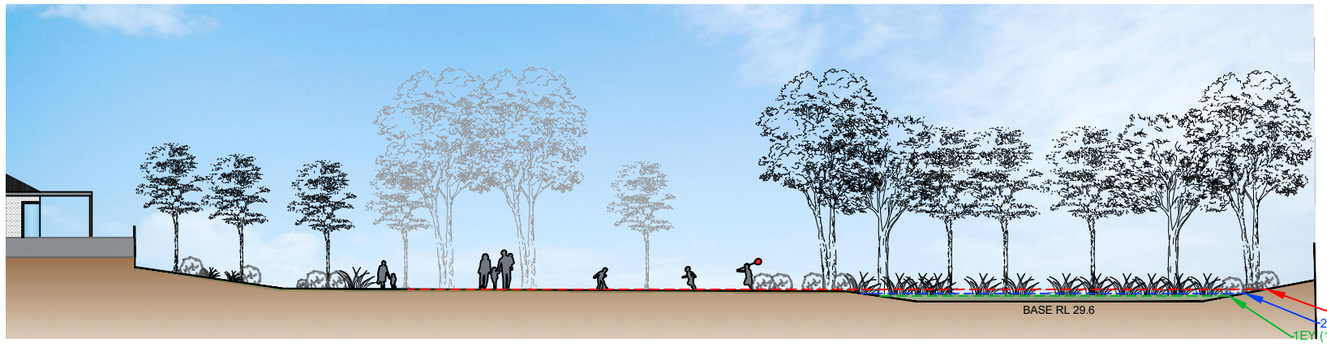
INDICATIVE LANDSCAPE CONCEPT

ROWE GROUP DESIGN



LEGEND

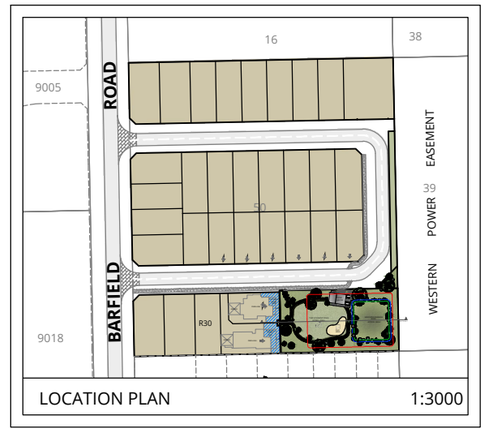
- UNIFORM FENCING (VISUALLY PERMEABLE ABOVE 1.2m)
- BOUNDARY FENCE
- GATE/ ACCESS
- OUTDOOR LIVING AREA OVERLOOKING POS
- PRIMARY DWELLING ORIENTATION
- FOOTPATH
- TREES (SPECIES TO BE DETERMINED IN CONSULTATION WITH CITY OF COCKBURN)
- PLAY AREA
- PICNIC AREA
- VEGETATED BASIN
- LEVEL KICKABOUT SPACE (TURF)
- LANDSCAPED BATTERS (MIX OF VEGETATION, TREES, TURF AND MULCH)
- INDICATIVE DWELLING FOOTPRINT



SECTION 1 1:750

* ALL PLANT SPECIES TO BE DETERMINED IN CONSULTATION WITH CITY OF COCKBURN AT DETAILED DESIGN STAGE

* ALL ELEMENTS ARE INDICATIVE ONLY AND AREA SUBJECT TO DETAILED DESIGN AND AGREEMENT WITH CITY OF COCKBURN



INDICATIVE CONCEPT LANDSCAPE PLAN

LOT 50 BARFIELD ROAD

HAMMOND PARK

NORTH

0 7.5 m

SCALE @ A3: 1:300

8697-FIG-08-F

ROWE GROUP DESIGN

N:\TOWN PLANNING\8000-8999\8697\DRAFTING\CAD - ADAM GLASKIN - 2020.11.25

8697_FIG08F_20201125 Hammond Park (Landscape Concept) - DRAWN: **ADAM GLASKIN** - DATE CREATED: **2020.11.25** - PROJECTION: **MGA50** GDA94 -

APPENDIX 6

ENGINEERING SERVICING AND TRAFFIC REPORT

ROWE GROUP DESIGN

BPA Engineering
Civil & Structural Consultants

PROPOSED SUBDIVISION OF LOT 50 (#193) BARFIELD ROAD HAMMOND PARK

FOR

GLENBROOK CIVIL ENGINEERING

LOCAL STRUCTURE PLAN – ENGINEERING REPORT ON STORMWATER DRAINAGE, EARTHWORKS, SERVICING AND TRAFFIC CONSIDERATIONS.

C03617
7 October 2019

BPA ENGINEERING

DOCUMENT CONTROL

Title:	Proposed Subdivision of Lot 50 (#193) Stormwater Management Plan
Author(s):	Richard Williams
File Name:	C03617
Phone:	08 9382 8008
Email:	richard@bpaeng.com.au
Client:	Glenbrook Civil Engineering

Revision	Description	Date	By	Approved
1	Issued for review	07.10.19	RW	ARW
2	100yr Basin info and traffic considerations updated.	19.12.19	RW	ARW

CONTENTS

0.0 INTRODUCTION

This report has been prepared by BPA Engineering (BPA) on behalf of Glenbrook Civil in support of a Local Structure Plan for Lot 50 Barfield Road Hammond Park.

BPA reviewed the services and infrastructure requirements and investigated the development opportunities and constraints for the following works of the proposed residential subdivision development;

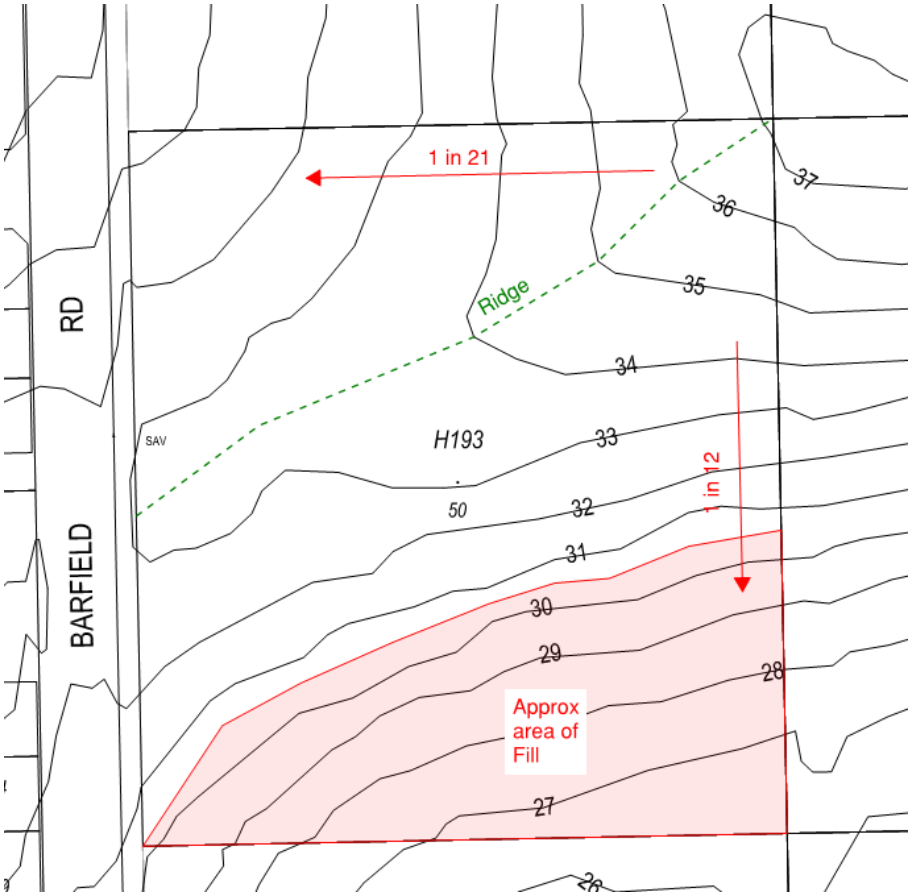
1) Bulk earthworks
2) Stormwater drainage management
3) Servicing
4) Traffic Consideration

1.0 BULK EARTHWORKS

1.1 Site Topographical Evaluation

The site is located on the east side of Barfield Road, nearest intersection is Rowley Road to the south The site area is rectangular and approximately 1.86ha in area (129.5m x 143.6M)

Surface levels fall to the south and west with varying gradients of approximately 1 in 12 to 1 in 21. Levels range from approximately 37.0m AHD to 26.2m



1.2 Site Geology & Geotechnical Investigation

Reference to the published information for the area of Hammond Park by the Geological Survey of Western Australia indicates subsurface conditions comprise well drained Bassendean sand.

1.3 Groundwater Level

The Perth Groundwater Atlas indicates natural groundwater levels are approximately AHD +23.5m, which is a separation between 13.5m and 2.7m below ground level.

1.4 Bulk Earthworks

The site is to be filled in the south east corner to facilitate servicing of wastewater reticulation. The fill will be designed to coordinate with the development to the south. Cut may be required in the North East corner to lower levels relative to the proposed road. Retaining will be installed as required.

Preparatory works should be limited to the following:

- Clearing and grubbing shall be carried out over the entire site to remove all vegetation and roots.
- Upon completion of the earthworks and re-spreading of the topsoil on the lots, verges and POS, the site will be temporarily stabilized with hydromulch.

2.0 CONCEPT STORMWATER DRAINAGE MANAGEMENT PLAN

Based on the subdivision size, proposed development and City of Cockburn feedback a Concept Stormwater Management Plan has been prepared to accompany the Local Structure Plan for planning approval. Pipe layouts, hydraulic calculations and detail drawings will be provided for approval separately to complement this plan prior construction. The stormwater drainage will be designed and constructed in accordance with City of Cockburn's requirements, design guidelines and standards.

2.1 Summary and Site Characteristics

Pre-development conditions comprise sandy soil with sparse vegetation. The area is surrounded by predominantly vacant lots, rural land and other land development projects at various stages of completion.

Since there is no available geotechnical report to confirm permeability rates across the site runoff coefficients will be used at the concept stage.

The Dept. of water Groundwater maps indicate the following characteristics:

Groundwater salinity:	<250 mg/L
Surface Geology Type:	Bassendean Sand: quartz sand (dunes)|Qpb
Iron Staining Risk:	Low risk
Acid Sulfate Class:	Moderate to low risk

The above data indicates that the site is well suited for structural controls using infiltration of stormwater.

The proposed development consists of residential lots, new internal roads and a new public open space.

To maintain post-development flows at pre-development level, detention storage and infiltration will be provided in a basin within the POS. Water quality will be managed through sand and bio-retention filtration and non-structural controls such as regular cleaning and maintenance.

More in depth hydraulic system sizing will be provided at the detailed design stage.

The below catchment information is based on Rowe Group Subdivision Concept Plan document number 8697-CON-08-B.

Catchment Information

		Pre-development		Post Development	
Description	Runoff Coefficient (C)	Actual Area	Equivalent Impervious Area	Actual Area	Equivalent Impervious Area
		m^2	m^2	m^2	m^2
Sand and sparse vegetation	0.2	18,604	3,721	0	0
Residential Lots	0.8	0	0	12,012	9,610
Road Reserve	0.9	0	0	4,582	4,124
POS/Soft Landscaping	0.2	0	0	2,010	402
Total		18,604	3,721	18,604	14,135

2.2 Policies and Guidelines

The concept stormwater management plan is based on the following documents:

Department of Water – Stormwater Management Manual for Western Australia

WAPC - Better Urban Water Management 2008

Department of Water - Urban water management plans: Guidelines for preparing plans and for complying with subdivision conditions

Note that this plan is intending to use the above guidelines to achieve objectives in the State Planning Policy 2.9 Water Resources (Government of WA, 2006) only as relevant for the proposed subdivision works.

2.3 Stormwater and Groundwater Management

Based on the WA floodplain mapping service the site is not located in a floodplain. No permanent water bodies are located on the lot. Stormwater will be managed at source per the below strategy to satisfy Water Sensitive Urban Design Principles.

Key elements of Water Sensitive Urban Design (WSUD) such as flood protection, management of frequent events and quality of groundwater are considered below as part of the stormwater management strategy.

2.4 Quantity Management

2.5 Quantity Management Objectives

BPA have been advised that the design criteria is as follows:

- Post development runoff to be equal or less than predevelopment
- Lots to retain 20-year 5min storm event. This is an approximate equivalent of 1 m3 per 80 m2.
- A runoff coefficient of 0.9 will be used for the road reserve catchment (refer catchments table above). Piped drainage system will be designed for the 5-year ARI.
- Frequent storm events up to an average recurrence interval (ARI) of 1 in 20-years will be retained on site using structural controls such as soakwells, underground storage and infiltration tanks, this is based on the site sandy soil conditions where infiltration of these events over a reasonable duration is feasible.
- Infrequent storm events over an ARI of 1 in 20-year will be managed within the subdivision area by overland flow into the road reserve and ultimately discharged into basin for infiltration.
- Local Govt. Guidelines for Subdivisional Development to be considered in design

The stormwater drainage detailed design will be based on Australian Rainfall and Runoff (ARR) 1987.

2.6 BOM Data

Rainfall data was obtained from the Bureau of Meteorology Design Rainfall Data System 2016, please refer Appendix 1.

2.7 Stormwater Modelling

Stormwater flows have been modelled using a combination of the Rational Formula and proprietary software PCSump for basin design. Preliminary calculations have been carried out based on the simplified volume-area ratio for residential lots.

Modelling was carried out for all standard duration storms ranging from 1 year events to 100 year events.

Please refer to C03617 SWMP for the subdivision layout, catchments and flow directions.

For major infrequent storms (in excess of 1 in 20-year ARI), it is proposed that the catchment areas are split as follows:

Catchment Summary

Catchment	Description	Equivalent Impervious Area	Destination
Northern Catchment	Lots, Road Reserve	3,955 m2	Soakwells or Underground tanks
Southern Catchment	Lots, Road Reserve, POS	7,563 m2	Road reserve and POS Basin
Barfield Road Discharge		981 m2	Discharge to Barfield Road reserve

Note lots nominated to discharge to Barfield Road are deemed not to be suitable for interallotment drainage, these flows will be maintained at pre-development levels.

PC Sump Summary for 100 year basin

Project Details	
Project	Barfield Road
Job Number	C03617
Task	100 Year Basin Sizing
Designer	AB

Catchment Area Details				
Land Form	Area (m2)	Runoff Coeff	Aimp (m2)	Comments
Road Reserve	2766	0.9	2489	
POS	2010	0.9	1809	
Lots	4672	0.4	1869	
TOTAL	9448		6167	

INPUT DATA		
Location	Cockburn	
$A_{impervious}$	0.6167	ha
GWL	23.500	m AHD
Depth to GWL from base	6.500	m
Max Allowable TWL	30.600	m AHD
Sump Base Level	30.000	m AHD
Sump Width at base	26.6	m
Sump Length at base	51.1	m
Side Slope	7.0	1 in --
Soil Permeability, K	8.6	m/d
Permeability Clogged Layer	0.15	m/d
Thickness of Clogged Layer	200	mm
Reduction Factor - Shallow	0.800	
Reduction Factor - Deep	0.333	
Reduction Factor - Clogged	1.000	

SUMMARY OUTPUT

ARI (years)	Duration (hours)	Rainfall Intensity (mm/h)	Total Inflow (m3)	Infiltration q0 (m3/day)	Total Outflow (m3)	Storage Required (m3)	Water Depth, H (m)	TWL (m AHD)	Freeboard (m)	Critical Model	Comments
100	18	6.68	742	388.28	291	450	0.295	30.295	0.305	Clogged base model	

2.8 Lot Drainage

Individual residential lot drainage will be designed to cater for events of up to 1 in 20-year interval. It is proposed that this will generally be achieved through the use of soakwells and/or underground infiltration tanks.

Storms in excess of the above criteria will be provided with an overland flow path towards the road reserve from where detention and conveyance towards the POS basin is provided. Overland flow paths are to be confirmed during the detailed design stage once bulk earthworks have been resolved.

2.9 Road Drainage Network

A system of pits and pipes is proposed to cater for the road reserve catchments and will be sized to cater for the 1 in 5-year critical storm. Hydraulic modelling to be confirmed at the detailed design stage.

2.10 Flood Management

During rare events such as the 1 in 100-year flood, stormwater is directed towards the POS infiltration basin for detention and infiltration. Events with flows exceeding the 100-year storm will be allowed to discharge external to the site via overland flow. All lots will be a minimum 300mm above the 100-year flood level in the basin. Final lot levels and basin information to be confirmed during detailed design.

2.11 Quality Management

Stormwater quality objectives are based on WSUD principles where the conveyed flows are pre-treated prior infiltration to groundwater.

There following are proposed methods for treatment:

- Soakwells or underground tanks – sand filtration and gross pollutant capture
- Bioretention swale – multi-layer media filtration and gross pollutant capture.

Road reserve catchments are prone to accumulating debris, rubbish, gross pollutants, and particles from vehicle emissions, and as such require treatment. The 1 year 1 hour “first flush” event will be conveyed towards the a section of the POS where it will be detained and treated within a bio-retention swale to facilitate cleansing prior infiltration. Detailed design of the bio-retention swale will be provided prior construction as the development progresses.

Proposed lot catchments will be treated locally using soakwells or underground tanks through sand filtration.

3.0 SERVICING REPORT

The following servicing report is presented with the knowledge that further development within the Structure Area will most likely proceed prior to the development of Lot and therefore the current infrastructure will be upgraded and extended to closer proximity to the site. The servicing requirements are to be reviewed at the time of development.

4.0 SEWER RETICULATION

The development is to be serviced by gravity sewer designed and installed to the Water Corporations standards and specification. At present there is no sewer infrastructure in the vicinity of the site.

Water Corporation planning shows that sewer will be connected to the proposed wastewater reticulation being installed within the Vivente subdivision to the West of and along Barfield Road.

Standard Water Corporation sewerage headworks will be payable on all lots as they are developed.

5.0 WATER SUPPLY

The water supply reticulation will be designed and constructed in accordance with the Water Corporation manuals. The reticulation mains will be constructed at the developers cost.

Water Corporation planning shows that water supply will be connected to the proposed reticulation being installed within the Vivente subdivision to the West of and along Barfield Road.

The Water Corporation will impose standard headworks charges on the development on a per lot basis.

6.0 GAS SUPPLY

There is no gas presently in Barfield Road however will be reticulated through the Vivente subdivision to the West. Connection is expected from this reticulation in the future.

Headwork costs may be applicable to extend the service to the site.

Gas reticulation within the development is at no cost to the developer providing the mains are laid in the same trench as the water reticulation.

7.0 TELECOMMUNICATIONS

This subdivision will be serviced via the existing pit and pipe installed along Barfield Road.

There is a P8 in the ground currently servicing lot 50. Depending on the position of the P8 relative to the intersection of the subdivision plan, we may need a separate application to Telstra/NBN to relocate the pit to a new position. This will be investigated during the design of this job.

NBN charges $600/ lot in 2019 for headworks

8.0 UNDERGROUND POWER

All power within the site will be underground and the requirements for a transformer site will be determined following receipt of a design information package from Western Power and a final design being produced. Initial advice is that a new transformer and switchgear will be required for the development. This will be connected to the HV network on the West side of Barfield Road.

Western Power may request a transmission EPR/LFI report as the development is in close proximity to overhead transmission lines.

The cost of the power infrastructure plus a systems charge is payable by the developer however the HV costs may be covered by the HV pool.

9.0 STREET LIGHTS

Street lights would be installed to Western Power and City Of Cockburn requirements and standards to provide a well lit safe environment. Street lights would be of a high quality in keeping with the standard of the development and would be standard Western Power lights possibly from the decorative range.

Liaison with neighbouring developers will ensure that a common standard of lighting was maintained from development to development.

10.0 ROADWORKS

All internal subdivision roads will be designed and constructed in accordance with City of Cockburn and Austroads requirements and specification.

Roads will be constructed with an asphalt pavement possibly coloured red and mountable kerbs. One way cross fall and flush kerb will be installed on roads adjacent POS, MUC and swales.

Roads will be designed with longitudinal falls to suit the proposed earthworked levels.

Roads and reserve widths have been designed in accordance with City of Cockburn requirements and Liveable Neighbourhoods recommendations. In general road widths will be 6.0m within a 15.4m reserve with a 13.2m reserve adjacent the POS and Lot 39 to the East. The proposed reserve widths will accommodate standard subdivision servicing and reticulation.

11.0 FOOTPATHS

Footpaths will be constructed to City of Cockburn standard in locations as required to provide an integrated pedestrian network.

12.0 TRAFFIC CONSIDERATIONS

The structure plan provides for 36 lots (R30) on a total site of 1.86Ha with 0.66 Ha being POS.

The Structure Plan is bound by Barfield Road to the west, private property to the North and South and land owned by WAPC to the east.

The Structure Plan allows for a loop road entering and exiting onto Barfield Road with a separation of approximately 68m between centerlines which is an acceptable separation for Access Streets in accordance with Liveable Neighbourhoods Table 5 Junction Spacing.

The closest proposed intersection on the west side of Barfield Road is offset by approximately 26.3m to the North which is an acceptable stagger distance for Access Streets in accordance with Liveable Neighbourhoods Table 5 Junction Spacing.

Proposed internal road will be 2 way 6.0m wide within a 15.4m road reserve (13.2m when adjacent a POS). Speed limit will be 50km/h.

A pedestrian footpath will be provided to one side of the road reserve.

An estimate of traffic volumes generated from the Structure Plan will be 360 vehicles per day based on 10 movements per day per lot. This is less than 1000vpd which is in keeping with the Access Street Type D – Narrow Yield Street in accordance with Liveable Neighbourhoods guidelines.

City of Cockburn traffic counts (2014+ refer attached Plan) for Barfield Road indicate an Average Weekday Traffic of 3112 vehicles just North of this Structure Plan with 4.6% heavy vehicles. It is expected that traffic numbers on Barfield Road in the vicinity of the Structure Plan will reduce with the closure of the intersection with Rowley Road.

All intersections and internal radii are designed to have full unrestricted movement of design vehicles to and from the Structure Plan area. Intersections are priority controlled.

Local Road Network consists of Barfield Road running along the western boundary of the structure plan which is a two lane 6.0m wide Urban Local Road/Access Road in a 20.4m road reserve. Future planning is showing that the intersection of Barfield Road and Rowley Road is to be closed to the south.

Traffic generated from this Structure Plan is expected to be for either trips related to employment, shopping, education or social/recreational. It is expected that most trips will require travel north along Barfield Road and either continue North to Russell Road or head West along Whadjuk Drive then

along Frankland Ave/Rowley Road to gain access to the Kwinana Freeway for trips to the City of Perth and possibly south. Local trips within the City of Cockburn are expected for shopping, education and recreation.

Sight distances on Barfield Road appear sufficient however this is to be confirmed at detailed civil design stage.

13.0 DEVELOPMENT CONSTRAINTS

BPA Engineering Pty Ltd have found no major servicing constraints on the development other than the need for Water Corporation and gas infrastructure to be constructed in closer proximity to the site to allow connection.

14.0 REFERENCES

1. Department of Water – Stormwater Management Manual for Western Australia, Department of Environment 2004

2. WAPC - Better Urban Water Management 2008

3. Department of Water - Urban water management plans: Guidelines for preparing plans and for complying with subdivision conditions, August 2008

4. City of Cockburn – Guidelines and Standards for the Design, Construction and Handover of Subdivision within the Municipality, July 2019

Appendix 1
BOM Rainfall Data

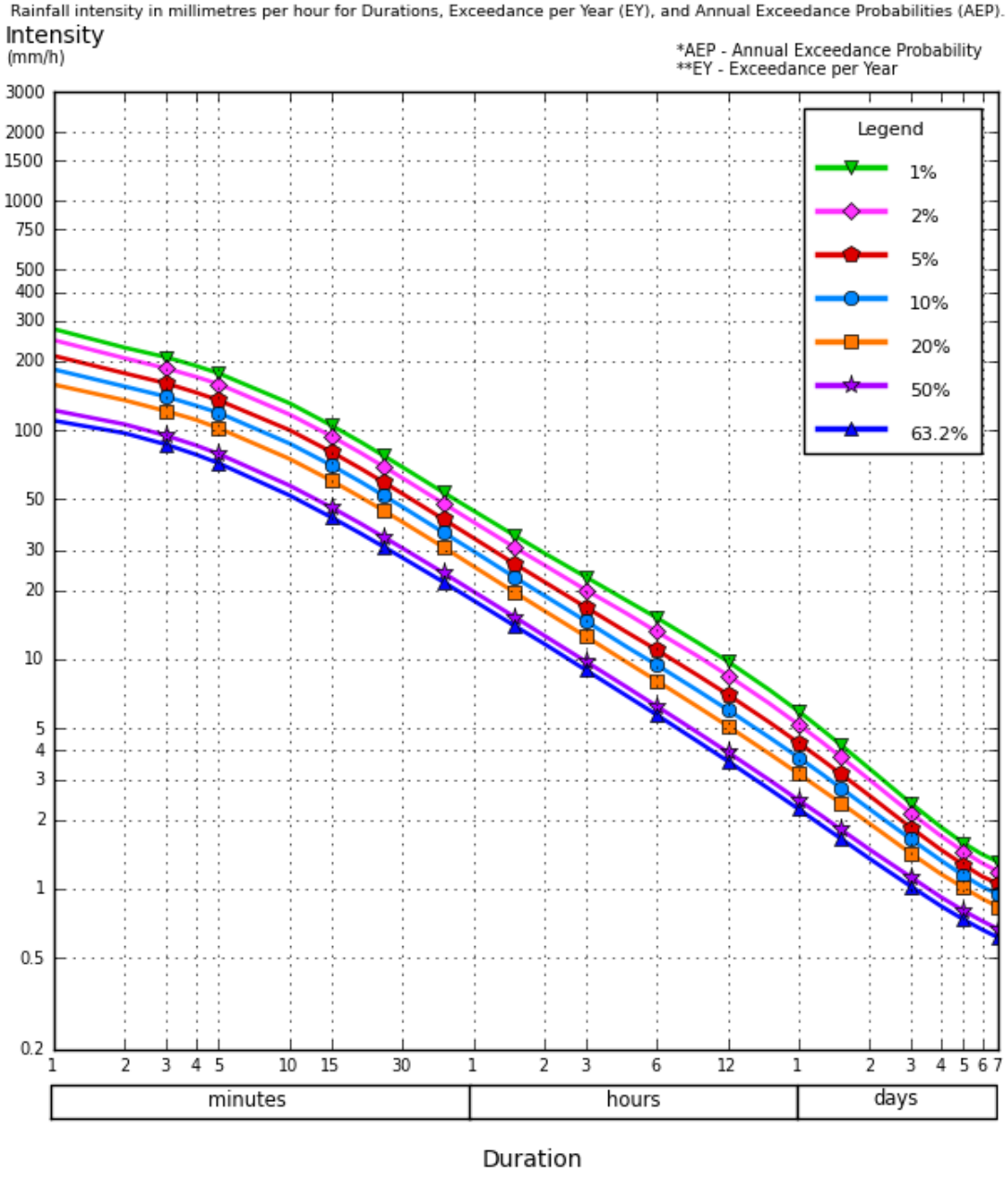
Label:Barfield

Requested coordinate	Latitude: -32.1772	Longitude: 115.8537
Nearest grid cell	Latitude: 32.1875 (S)	Longitude: 115.8625 (E)

IFD Design Rainfall Intensity (mm/h)

Issued: 06 October 2019

Rainfall intensity in millimetres per hour for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).



Appendix 2

STORMWATER DRAINAGE CONCEPT PLAN

CLASSIFIED AS SHRUBLAND

INTERNAL LOT SETBACK OF 6m TO MEET BAL-29 TO ADDRESS TEMPORARY HAZARD

4 No Lots fronting Barfield Road to retain 1 in 20yr ARI on site. Major storm to overflow to Barfield Road (predevelopment flow).

ROAD

BARFIELD

15.4m ROAD RESERVE

13.2m ROAD RESERVE

1 300m² | 2 282m² | 3 375m² | 4 375m² | 5 375m² | 6 315m² | 7 375m² | 8 375m² | 9 375m² | 10 720m²

11 329m² | 12 330m² | 13 277m² | 14 277m² | 15 277m² | 16 277m² | 17 330m² | 18 319m² | 19 303m² | 20 303m² | 21 317m²

22 329m² | 23 277m² | 24 277m² | 25 277m² | 26 277m² | 27 330m² | 28 329m² | 29 313m² | 30 313m² | 31 282m² | 32 300m² | 33 375m² | 34 375m² | 35 375m² | 36 375m²

PUBLIC OPEN SPACE & DRAINAGE 2010m²

18602m²

(129.53)

(143.63)

9005 | 9018

CLASSIFIED AS WOODLAND

INTERNAL LOT SETBACK OF 11m TO MEET BAL-29

1hy 1hr bio retention area for cleansing of first flush.

INTERNAL LOT SETBACK OF 5m TO MEET BAL-29 TO ADDRESS TEMPORARY HAZARD

CLASSIFIED AS GRASSLAND

LEGEND

- SUBJECT SITE
- CONTOURS
- EXISTING BOUNDARIES
- 7 EXISTING LOT NUMBERS
- PROPOSED BOUNDARIES
- 7 PROPOSED LOT NUMBERS
- 10.5 PROPOSED LOT DIMENSIONS
- (129.53) EXISTING LOT DIMENSIONS
- SEWER
- POWER
- POWER POLE
- BUSHFIRE SETBACKS

LOT SUMMARY

NO. OF LOTS	36
TOTAL AREA OF LOTS	12012m²
AVERAGE AREA OF LOTS	334m²
MINIMUM LOT AREA	277m²
MAXIMUM LOT AREA	720m²
PUBLIC OPEN SPACE	2010m²

Legend

Proposed side entry pit connected to underground tank.

Stormwater flow direction

SUBDIVISION CONCEPT PLAN

LOT 50 (NO. 193) BARFIELD ROAD

HAMMOND PARK

NORTH

0 9.375 18.75

SCALE @ A3: 1:750

8697-CON-08-B

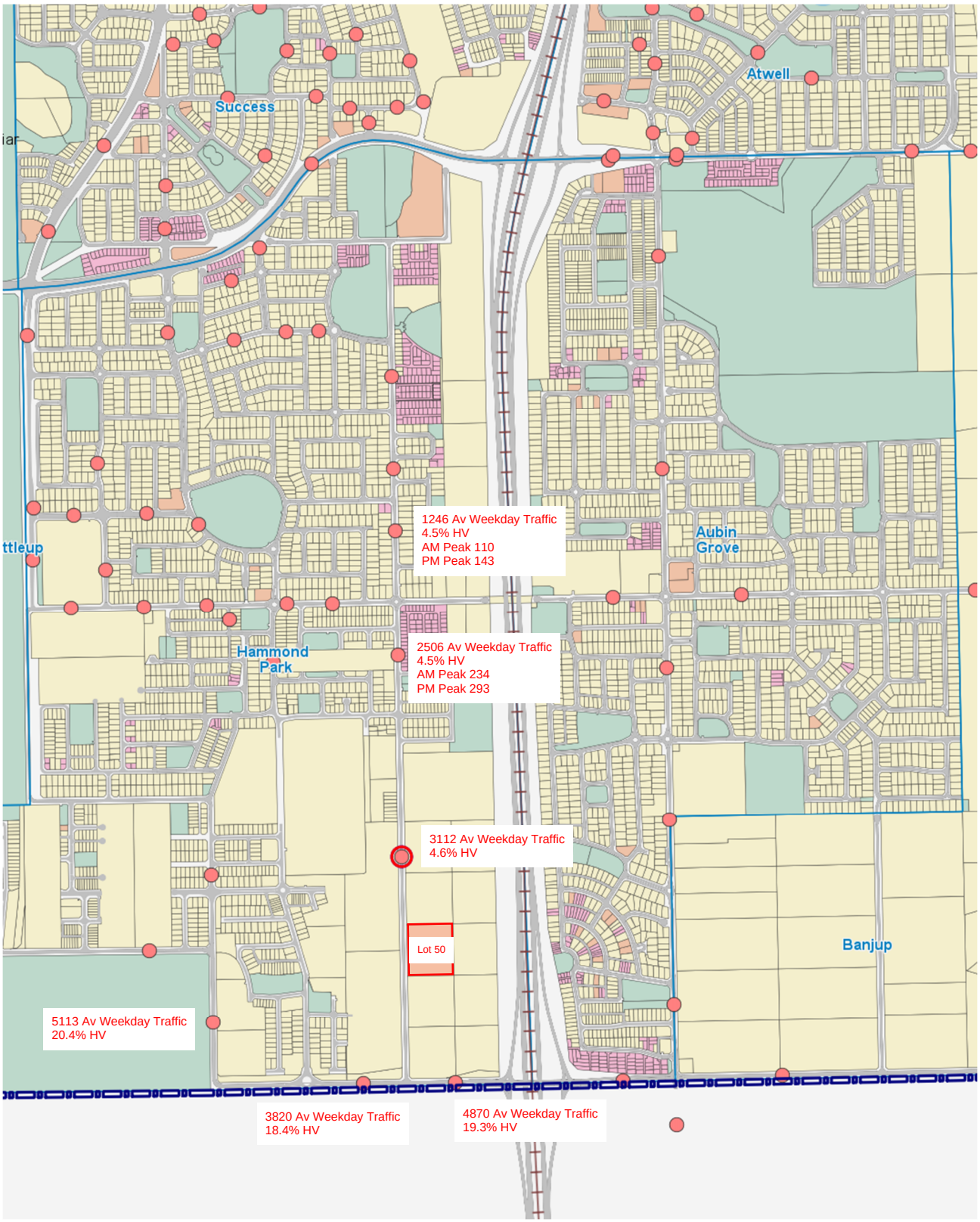
ROWE GROUP DESIGN

N:\TOWN PLANNING\8600-8999\8697\DRAFTING\A-CAD - WILLIAM CLEMENTS - 2019.05.21

8697_CON08B_20190521_Hammond Park (Subdivision Concept) - DRAWN: **WILLIAM CLEMENTS** - DATE CREATED: **2019.05.21** - PROJECTION: **MGA50** GDA94 - CADASTRE: LANDGATE -

Appendix 3

Traffic Counts and Expected Traffic Flows



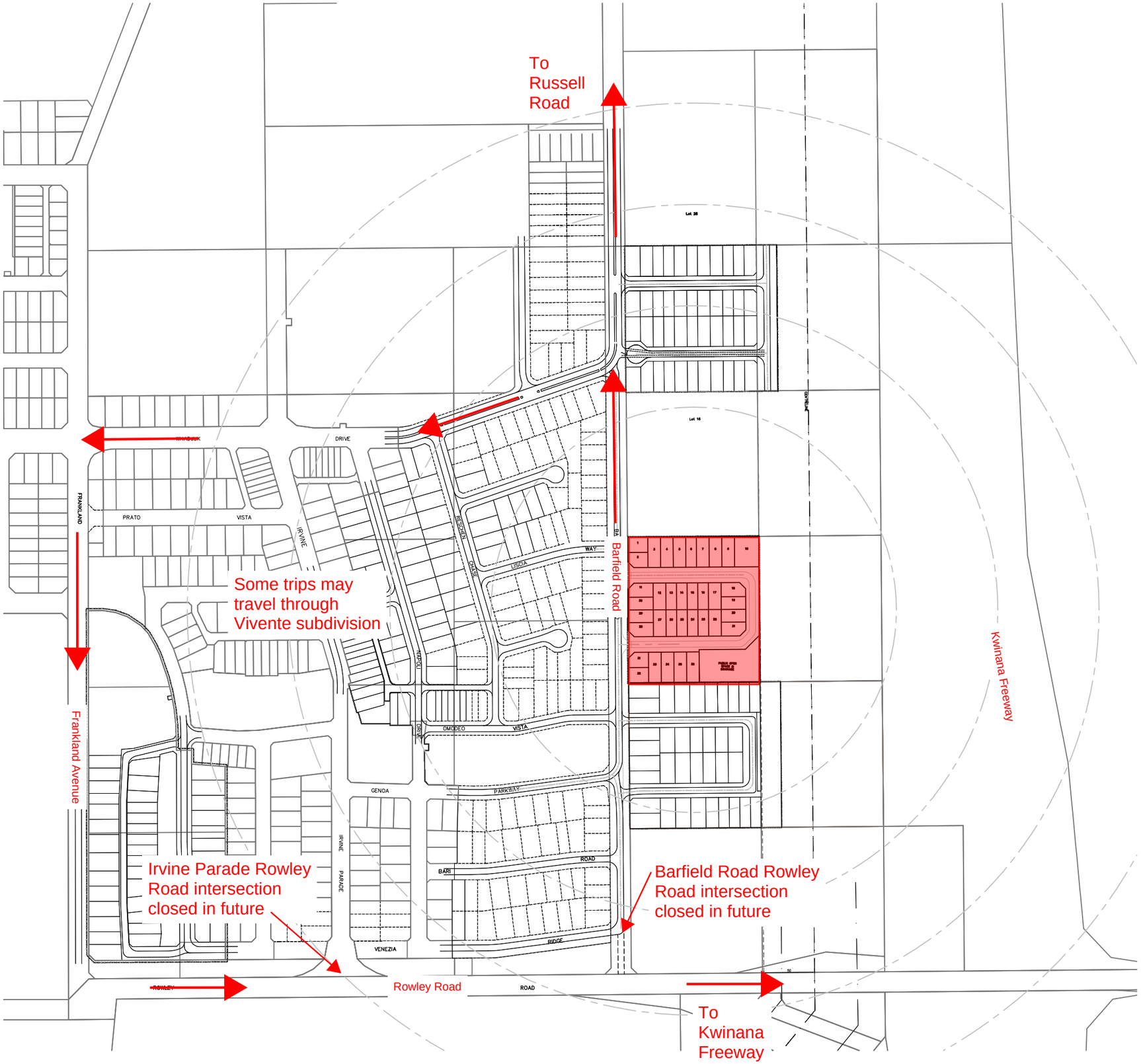
City of Cockburn
G.I.S Services Department

Traffic Counts 2014+

PRINTED ON: 19/12/2019

SCALE = 1:15000

NORTH



Lot 50 (#193) Barfield Road Hammond Park Estimated Traffic Movements

APPENDIX 7

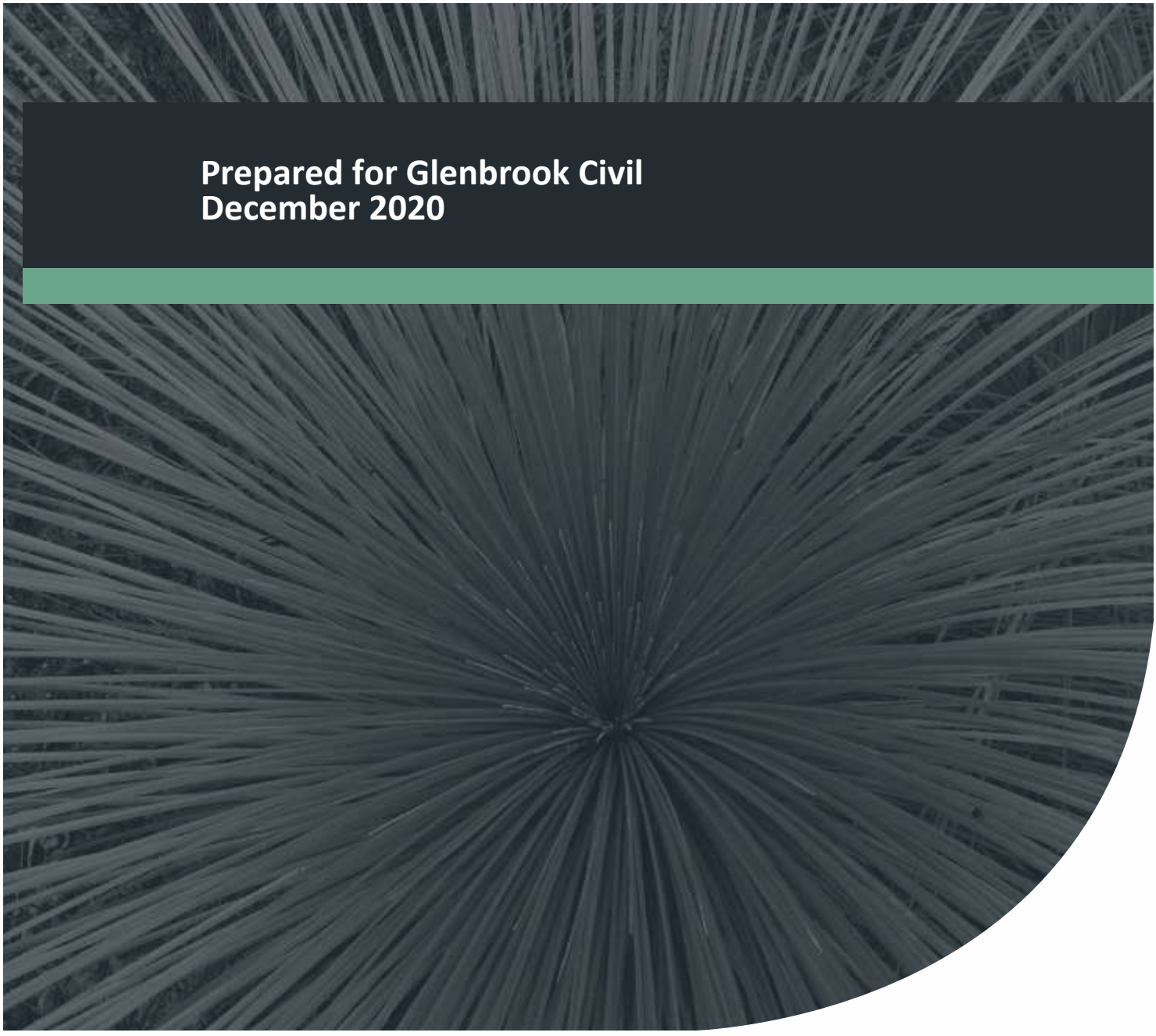
LOCAL WATER MANAGEMENT STRATEGY

ROWE GROUP DESIGN

Local Water Management Strategy

Lot 50 Barfield Road, Hammond Park

Project No: EP18-043(06)



Prepared for Glenbrook Civil
December 2020

Document Control

Doc name:	**Local Water Management Strategy Lot 50 Barfield Road, Hammond Park**				
Doc no.:	**EP18-065(02)—002B TEM**				
Version	**Date**	**Author**		**Reviewer**	
1	June 2020	Tess McAllister	TEM	Rachel Evans	RLE
	For inclusion with structure plan				
A	November 2020	Tess McAllister	TEM	Rachel Evans	RLE
	Update in response to City of Cockburn and DWER comments				
B	December 2020	Tess McAllister	TEM	Rachel Evans	RLE
	Update in response to City of Cockburn comments				

Executive Summary

Glenbrook Civil (the proponent) propose to develop Lot 50 (No. 193) Barfield Road, Hammond Park ('the site') for residential purposes. The site is located approximately 25 kilometres south of the Perth Central Business District, within the City of Cockburn (CoC). The site is approximately 1.86 hectares (ha) in size and is bounded by Barfield Road to the west, and undeveloped lots to the north, east and south. The site is currently zoned 'Urban' under the Metropolitan Region Scheme (MRS) and 'Urban' under the City of Cockburn TPS No. 3.

Emerge Associates have been engaged by Rowe group on behalf of Glenbrook Civil to prepare a local water management strategy (LWMS) to support the local structure plan (LSP) process for the site. This LWMS details the water management approach in accordance with the requirement of *Better Urban Water Management* (BUWM) (WAPC 2008) and other guidelines and policies relevant to the site.

Water will be managed using an integrated water cycle management approach. The first step in applying integrated water cycle management in urban catchments is to establish agreed environmental values for receiving waters and their ecosystems. In summary, the environmental investigations conducted to date indicate that:

- The site receives an average of 745.5 mm of rainfall annual.
- Average maximum temperatures throughout the site range from 18.3^{o}C to 31.5^{o}C and average minimum temperatures range from 8.2^{o}C to 17.6^{o}C.
- Topography throughout the site ranges from 27 m Australian height datum (AHD) in the south-east to 35 m AHD in the north-east.
- Regional geological mapping shows the site is underlain by Bassendean sand.
- Geotechnical investigations at ten locations found soils beneath the site to be loose Bassendean sand up to 3 m BGL.
- Infiltration testing at two locations found permeability to be >25 m/day. The phosphorous retention index (PRI) of the soils was found to be 2.2 and 5.2.
- The site is classified as having a 'moderate to low risk' of acid sulfate soils (ASS) occurring within 3 m of the natural soil surface.
- The site is located within the Cockburn/Kwinana coastal catchment and sub-catchment as identified through the DWER *Hydrographic Catchments* dataset. No surface water features occur within the site itself.
- Rainfall will infiltrate at source considering the sandy nature of the site, however shallow sheet flow may occur following major events. Discharge volume of 47.3 m^3 towards the north-west is expected due to local topography.
- There are no Bush Forever sites within the boundaries of the site.
- There are no wetlands located in or close to the site.
- Groundwater beneath the site is a multi-layered system comprised of the Perth Superficial Swan aquifer and the Perth-Yarragadee North aquifer.
- A groundwater allocation of 21, 480kL for irrigation and construction purposes has been attained for the site.
- Maximum groundwater level (MGL) across the site are between 21 m and 23 m AHD. Depth to MGL across the site is between 3 m and 14 m.

- There is no groundwater quality data available for the site.

The overall objective for integrated water cycle management for urban development is to minimise pollution and maintain an appropriate water balance. The design objectives presented in this LWMS seek to deliver best practice outcomes using a water sensitive urban design (WSUD) approach, including detailed management objectives for:

- Water supply and conservation
- Stormwater management
- Groundwater management.

The overall approach to water supply is to utilise scheme water and implement water conservation measures (e.g. water efficient fixtures, use of WSUD measures, and planting of water wise species) to reduce water requirements. Non-potable water for irrigation purposes will be supplied by groundwater.

The stormwater management plan focuses on the treatment of the small event (1 year 1 hour average recurrence interval (ARI)/63% annual exceedance probability (AEP)) and detention of the major event (100 year ARI/1% AEP) to maintain the existing hydrological regime. Small event runoff within the entire site will be treated within a bio-retention area (BRA), which is collated with a flood storage area (FSA) in the downstream public open space (POS). Major event stormwater runoff for the majority of the site will be managed within the FSA, which is sized to retain the major (1% AEP) event. Two lots fronting Barfield road are not able to be managed within the site, hence will discharge into the Barfield road drainage network during the major event; this mimics the existing hydrological regime. Stormwater quality will be addressed through structural measures (i.e. a vegetated BRA) and non-structural measures (i.e. street sweeping, minimising fertiliser use, provision of educational materials).

Groundwater management will include the use of imported fill to maintain sufficient clearance to groundwater in lower areas of the site. Groundwater quality will be managed through the appropriate treatment of surface runoff prior to infiltration to groundwater, and management of landscape management practices (i.e. minimising fertiliser use).

The water management design criteria identified for the site, and the manner in which they are proposed to be achieved are presented in **Table E1**. This table provides a readily auditable summary of the required outcomes which can be used in the future detailed design stage to demonstrate that the agreed objectives for water management for the development have actually been achieved. This LWMS demonstrates that, by following the recommendations detailed in the report, the site is capable of being developed.

Table E1 Water management criteria and compliance summary

Management Aspect	Criteria number	Criteria description	Manner in which compliance will be achieved	Responsibility for implementation	When implemented
Water Conservation	WC1	Use fit for purpose water sources.	Rainwater tanks can be utilised for non-potable uses	Lot owner	At lot owner's discretion
			A reticulated potable water supply will service the site	Proponent	Civil design
			Groundwater will be utilised to irrigate POS areas	Proponent	Landscape implementation
	WC2	Consumption target for water of 100 kL/person/year, including not more than 40-60 kL/person/year scheme water.	Promotion of WWG practices	Proponent	Landscape implementation
			Use of WWG practices	Lot owner	Ongoing
			Promotion of water efficient appliances	Proponent	At Point of sale
			Use of water efficient appliances	Lot owner	Ongoing
			Use of water efficient fittings	Lot owner	Ongoing
	WC3	POS areas will be limited to an average water use of 7,500 kL/ha/year	Use of WWG in POS	Proponent	Landscape implementation

Table E1 Water management criteria and compliance summary (continued)

Management Aspect	Criteria number	Criteria description	Manner in which compliance will be achieved	Responsibility for implementation	When implemented
Stormwater management	SW1	Retain and treat small rainfall event runoff as close to source as possible	Lots will retain and treat runoff within soakwells and pervious garden areas of the lots	Proponent	Detailed drainage design
			Road reserve runoff will be retained and treated within a BRA within the downstream POS	Proponent	Detailed drainage design
	SW2	Runoff discharged from site following the major event should not exceed the pre-development volume.	Pre development discharge from site equates to 47.3 m^3. Post development discharge from site equates to 2.4 m^3	Proponent	Detailed drainage design
	SW3	Provide stormwater flow pathways for runoff from the major event.	The road network within the southern catchment will be graded towards the POS and drainage areas, providing a flow path for major storm event runoff	Proponent	Detailed drainage design
			Major stormwater runoff will be conveyed via a gutter and pipe network, both sized for the major event, to the FSA		
	SW4	Finished floor levels of lots must have a minimum of 300 mm clearance from the major event flows being conveyed within road reserves	Finished floor levels will be maintained with adequate clearance from dynamic flows in the road network	Proponent	Detailed drainage design

Table E1 Water management criteria and compliance summary (continued)

Management Aspect	Criteria number	Criteria description	Manner in which compliance will be achieved	Responsibility for implementation	When implemented
Stormwater management	SW5	Minor roads are to remain passable in a minor event	The pipe network for the site will be sized to cater for the minor (5 year ARI) event	Proponent	Detailed drainage design
	SW6	Design infiltration areas to avoid creating mosquito habitat	Stormwater infrastructure will be designed to ensure all runoff is infiltrated within 96 hours	Proponent	Detailed drainage design
	SW7	Inverts of infiltration structures (i.e. BRA and FSA) must be at least 500 mm above MGL	The FSA invert will sit at 29.6 m AHD and groundwater beneath the site is approximately 21 - 23 m AHD, leaving a 6.6 - 8.6 m clearance	Proponent	Detailed drainage design
	SW8	Surface runoff treatment areas to be sized to at least 2% of the total connected impervious area	The total size of the surface treatment system (i.e. BRA) equates to 3.5% of the total connected impervious area	Proponent	Detailed drainage design
	SW9	Apply non-structural measures to reduce nutrient loads	Utilise WWG practices in POS	Proponent	Landscape implementation
			Maintenance of POS and drainage areas	Proponent	Landscape contractors for first three years then CoM
			Street sweeping	Proponent	Landscape contractors for first two years then CoM
			Education of residents on use of WWG and fertilisers.	Proponent	Point of sale

Table E1 Water management criteria and compliance summary (continued)

Management Aspect	Criteria number	Criteria description	Manner in which compliance will be achieved	Responsibility for implementation	When implemented
Groundwater management	GW1	Maintain 1.2 m between habitable floor levels and MGL	A minimum of 1.2 m clearance will be provided between habitable floor levels and MGL	Proponent	Detailed drainage design
	GW2	Use water sensitive design approaches to recharge the superficial Swan aquifer	Runoff will be able to recharge the superficial swan with the use of a FSA	Proponent	Detailed drainage design
	GW3	Maintain groundwater quality onsite	Direct small event runoff to the BRA. Treatment is provided through interaction with vegetation and adsorption of nutrients to soil particles through infiltration	Proponent	Detailed drainage design
			Minimise fertiliser use in POS and road verges	Proponent	Landscape implementation
			Use roll-on, drought tolerant turf species	Proponent	Landscape implementation
			Education of residents on use of WWG and fertiliser use	Proponent	Point of sale

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Appendices

Abbreviation Tables

Table A1: Abbreviations – Organisations

Organisations	
ANZECC	Australian and New Zealand Environment and Conservation Council
DWER	Department of Water and Environmental Regulation

Table A2: Abbreviations – units of measurement

Units of measurement	
cm	Centimetre
ha	Hectare
kL/person/year	Kiloliters per person per year
kL/year	Kiloliters per year
m	Metre
m^2	Square metre
m3	Cubic metres
m AHD	m in relation to the Australian height datum
m/day	Metres per day
mm	Millimetre
m/s	Metres per second
%	Percentage

Terminology Tables

Table A3: AEP – ARI equivalence

Rainfall event	Annual exceedance probability (AEP)	Annual recurrence interval (ARI)	Depth (mm)
Small	63%	1	15
Minor	20 %	5	-
	10 %	10	-
Major	1 %	100	-

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1 Introduction

1.1 Background

Glenbrook Civil (the proponent)propose to develop Lot 50 (No. 193) Barfield Road, Hammond Park ('the site') for residential purposes, as indicated in the Local Structure Plan (LSP) provided in **Appendix A**. The site is located approximately 25 kilometres south of the Perth Central Business District, within the City of Cockburn (CoC). The site is approximately 1.86 hectares (ha) in size and is bounded by Barfield Road to the west and undeveloped lots to the north, east and south. Future urban development is located to the north, a Western Power easement is located to the south and Kwinana Freeway is located to the east. The location and extent of the site is shown in **Figure 1**.

1.2 Purpose

It is important that the manner in which stormwater runoff from urban zoned areas is to be managed to avoid flooding and protect the environment is clearly documented early in the planning process. This approach provides the framework for actions and measures to achieve the desired outcomes at subdivision and development stages.

This local water management strategy (LWMS) details the water management approach to support the development of Lot 50 Barfield Road and is intended to satisfy the requirement to prepare a LWMS in accordance with *Better Urban Water Management* (WAPC 2008), and expectations of the Department of Water and Environmental Management (DWER) and CoC.

1.3 Policy framework

There are a number of Local and State Government policies of relevance to the development. These policies include:

- *A State Water Strategy for Western Australia* (Government of WA 2003)
- *State Water Plan* (Government of WA 2007)
- *State Planning Policy 2.9 Water Resources* (WAPC 2006)
- *Liveable Neighbourhoods Edition 4 (Update 2)* (WAPC 2009a)
- *Guidance Statement No. 33: Environmental Guidance for Planning and Development* (EPA 2008)
- *Planning Bulletin No. 64: Acid Sulfate Soils* (WAPC 2009b).

In addition to the above policies, there are a number of published guidelines and standards available that provide direction regarding the water discharge characteristics that developments should aim to achieve. These are key inputs that relate either directly or indirectly to the development and include:

- *Australian Rainfall and Runoff (Ball J 2019)*
- *Australian Runoff Quality* (Engineers Australia 2006)
- *Better Urban Water Management* (WAPC 2008)

- *Developing a Local Water Management Strategy* (DoW 2008a)
- *Decision Process for Stormwater Management in Western Australia (DWER 2017)*
- *National Water Quality Management Strategy* (NWQMS) (ANZECC and ARMCANZ 2000)
- *Stormwater Management Manual for Western Australia* (DoW 2007)
- *POS development guide* (CoC 2020)
- *Subdivision within the Municipality* (CoC 2019).

1.4 Previous studies

A number of studies have been conducted across the site to inform the LWMS and structure plan. Studies include:

- *Level 1 Fauna Assessment and Targeted Black Cockatoo Survey* (Emerge Associates 2018b)
- *Environmental Assessment and Management* Strategy (Emerge Associates 2018a)
- *Reconnaissance Flora and Vegetation Survey* (Emerge Associates 2019).

1.5 LWMS objectives

This LWMS has been developed in consideration of the objectives and principles detailed in *Better Urban Water Management* (WAPC 2008). It is intended to support the development within the site and is based on the following major objectives:

- Maintain the existing hydrological regime.
- Provide a broad level stormwater management framework to support future urban development.
- Develop a water conservation strategy for the site that will ensure the efficient use of all water resources.
- Minimise construction costs for the LSP, which will result in reduced land costs for future home owners.
- Incorporate appropriate best management practices (BMPs) into the drainage system that address the environmental and stormwater management issues identified.
- Ensure that sufficient land area is set aside in the LSP to manage urban runoff.
- Minimise ongoing operation and maintenance costs for the land owners and CoC.
- Gain support from DWER and CoC for the proposed method to manage stormwater within the site.

Detailed objectives for water management within the site are further discussed in **Section 4**.

2 Proposed Development

The Lot 50 (No. 193) Barfield Road LSP covers approximately 1.86 ha and will allow for the creation of 32 lots. The LSP includes areas of residential development with a public loop road connecting to Barfield Road at two locations. A downstream public open space (POS) is proposed which is intended as a community focal area with space for active play as well as integration of drainage for the site. The LSP also proposes the possibility to retain significant trees within the POS and road reserve, which will be further investigated during subdivision stage.

The LSP and landscape concept design were prepared by Rowe Group and are attached in **Appendix A.**

3 Existing environment

3.1 Sources of information

The following sources of information were used to provide a broad regional environmental context to the site:

- *Weather and Climate Statistics* (BoM 2020)
- *LIDAR elevation dataset, Swan Coastal Plain* (DoW 2008b)
- *Geological survey of Western Australia* (Gozzard 1986a)
- *Acid sulfate soils (ASS) risk mapping* (DWER 2020c)
- *Geomorphic wetlands of the Swan Coastal Plain database* (DBCA 2020)
- *Perth groundwater map* (DWER 2020b)
- *Water register* (DWER 2020e)
- *Landgate Aerial Photography* (WALIA 2020).

3.2 Existing and historical land use

Review of historical images available from 1953 (WALIA 2020) onwards, shows that the majority of the site was largely undisturbed prior to 1985. Between 1983-1985 a residence was built in the western portion of the site, with the remainder of the site maintained as native vegetation. By 1995 the south-western corner and additional areas in the western half adjacent to the dwelling were cleared. Clearing surrounding the dwelling was continued in 2016, though the dwelling was removed by September 2016.

3.3 Climate

The south west of Western Australia experiences a Mediterranean climate of hot dry summers and cool wet winters. An average of 745.5 millimetres (mm) of rainfall is recorded annually from the closest weather station (Medina Research Centre), which is located approximately 7.5 km from Hammond Park. The majority of the rainfall is received between the months of May and August. Mean maximum temperatures range from 18.3^{o}C in July to 31.5^{o}C in February, while mean minimum temperatures range from 8.2^{o}C in July and August to 17.6^{o}C in February (BoM 2020).

3.4 Geotechnical conditions

3.4.1 Topography

The topography of the site is generally southward facing, with elevations ranging from 27 m Australian height datum (AHD) in the south-east up to 35 m AHD in the north-east corner (DoW 2008b). Topographic contours across the site are shown in **Figure 2**.

3.4.2 Regional geology

Regional soil association mapping indicates that the site is within the Bassendean association (Churchward and McArthur 1980). The Bassendean association is described as 'sand plains with low dunes and occasional swamps; iron or humus podzols; areas of complex steep dunes'. Regional landform mapping by Gozzard (2011) places the site within the Bassendean dune system.

The Geological Survey of Western Australia (Gozzard 1986b) indicates the following soil unit within the site:

- **Sand (S8)** which is described as 'white to pale grey at the surface, yellow at depth, fine to medium grained, moderately sorted sub-angular to sub-rounded, minor heavy minerals of eolian origin'.

The site is not known to contain any restricted landforms or unique geological features. Geological soil mapping is shown in **Figure 3**.

3.4.3 Local geology and Soils

A geotechnical investigation was conducted by Douglas Partners (2020) which included ten boreholes (BHs) as shown in **Figure 3**. BHs were drilled to a target depth of 3 m below ground level (BGL).

Loose sand was encountered beneath the site to depths of between 0.3 m and 1.5 m BGL. A summary of the ground conditions encountered during the geotechnical investigations include:

- **Sandy topsoil** – 50 mm thick, fine to medium grained, grey-brown, with silt, roots and rootlets and trace gravel, at BH 1-3, 5, 6 and 10. The topsoil at BH 6 was recorded as sandy gravel (fill) fine to medium sized basalt gravel, grey-brown, with silt and rootlets.
- **Sandy and gravelly fill** – dense to very dense, grey-brown, fine to medium grained, fine to coarse sized basalt gravel, with silt, at test location 6 underlying the topsoil to a depth 0.5 m BGL.
- **Bassendean Sand** – generally very loose to loose, becoming medium dense with depth, yellow-grey-brown, fine to medium grained, trace silt, at all test locations to a maximum test termination depth of 3 m BGL.

Based on the investigation soils are considered excellent for drainage purposes. The geotechnical report is provided in **Appendix B**.

3.4.3.1 Infiltration rates

Two in situ infiltration tests (IFT) were conducted during the geotechnical investigation by Douglas Partners (2020), at depths of 0.9 to 1 m BGL as shown in **Figure 3**. Both locations derived a soil permeability >25 m/day. Phosphorous retention index (PRI) was also recorded at the two IFT locations (IFT09, IFT10) and was found to be 5.2 and 2.2, respectively.

To allow for variations in soil fines content and densification of the natural sand during site formation and construction, a preliminary design permeability for the natural sand of approximately 8 m/day was utilised for modelling by BPA Engineering (discussed further in **Section 6.2.3**).

3.4.4 Acid sulfate soil

Acid sulfate soil (ASS) risk mapping (DWER 2020b) indicates that the entire site is classified as having a 'moderate to low risk' of ASS occurring within 3 m of the natural soil surface, as shown in **Figure 4**.

3.5 Surface water

3.5.1 Surface water features

No surface water bodies or channels are observed within the site. Surface water is assumed to infiltrate freely across the site due to the high sand content (detailed in **Section 3.4.2**) and presumed high permeability, however shallow sheet flow may occur following major rainfall events. The natural topography of the site will lead to the majority of runoff being retained on site within localised low points, however the north-west corner is likely to discharge a portion of runoff to the north-west in major events. Calculations provided by BPA Engineering indicates an approximate discharge volume of 47.3 m^3 is likely following the major rainfall event (detailed in **Appendix C**).

3.5.2 Wetlands

A review of DBCA's *Geomorphic Wetlands of the Swan Coastal Plain* dataset (DBCA 2020) indicates that there are no wetlands located in or in close proximity to the site.

No Ramsar or wetlands listed as 'important wetlands' are located within the site. The 'Forrestdale and Thomsons Lakes' Ramsar site is located 2.2 km to the north-west of the site. A portion of the 'Gibbs Road Swamp System' is located 370 m to the south of the site. This system is recognised as a large network of formerly extensive swamps covering 5800 ha but is highly disturbed throughout much of its area (Emerge Associates 2019).

3.6 Groundwater

3.6.1 Groundwater resources

The *Water Register* (DWER 2020e) indicates that the site is located in the Jandakot groundwater area. Aquifers beneath the site comprise of the following.

- Perth-Superficial Swan (unconfined)
- Perth-Yarragadee North (confined).

At the time of preparing this report (March 2020), the Yarragadee North was fully allocated with no available resources, and the Superficial Swan has a total of 197, 305 kL available (DWER 2020e).

Glenbrook Civil have attained a groundwater licence of 21, 480 kL for irrigation of the POS (0.2 ha) and construction purposes.

3.6.2 Groundwater levels

The *Perth Groundwater Map* (DWER 2020b) indicates that current maximum groundwater levels (MGL) across the site are between 21 m AHD and 23 m AHD. Therefore, depth to groundwater is approximately between 3 m and 14 m BGL. Groundwater level contours are shown in **Figure 2**.

No groundwater was observed during geotechnical investigations by Douglas Partners (2020) up to 3 m BGL on 28 August 2020.

3.6.3 Groundwater quality

There is no groundwater quality data available for the site. Broad information taken from the *Water Information Reporting Portal* (DWER 2020a) shows groundwater salinity as <250 mg/L and low iron staining risk.

3.7 Summary of existing environment

- The site receives an average of 745.5 mm of rainfall annual.
- Average maximum temperatures throughout the site range from 18.3^{o}C to 31.5^{o}C and average minimum temperatures range from 8.2^{o}C to 17.6^{o}C.
- Topography throughout the site ranges from 27 m Australian height datum (AHD) in the south-east to 35 m AHD in the north-east.
- Regional geological mapping shows the site is underlain by Bassendean sand.
- Geotechnical investigations at ten locations found soils beneath the site to be loose Bassendean sand up to 3 m BGL.
- Infiltration testing at two locations found permeability to be >25 m/day. The PRI of the soils was found to be 2.2 and 5.2.
- The site is classified as having a 'moderate to low risk' of acid sulfate soils (ASS) occurring within 3 m of the natural soil surface.
- The site is located within the Cockburn/Kwinana coastal catchment and sub-catchment as identified through the DWER *Hydrographic Catchments* dataset. No surface water features occur within the site itself.
- Surface water is expected to infiltrate, however during major events will be seen as sheet flow with 47.3 m^3 approximately discharging from site towards the north-west.
- There are no Bush Forever sites within the boundaries of the site.
- There are no wetlands located in or close to the site.
- Groundwater beneath the site is a multi-layered system comprised of the Perth Superficial Swan aquifer and the Perth-Yarragadee North aquifer.
- A groundwater allocation of 21, 480kL for irrigation and construction purposes has been attained for the site.
- Maximum groundwater level (MGL) across the site are between 21 m and 23 m AHD. Depth to MGL across the site ranges between 3 m to 14 m.
- There is no groundwater quality data available for the site.

4 Design Criteria and Objectives

This section outlines the objectives and design criteria that this LWMS and future management plans must achieve. The water management strategy includes water conservation, groundwater management and stormwater management.

4.1 Integrated water cycle management

The *State Water Strategy* (Government of WA 2003) and *Better Urban Water Management* (WAPC 2008) endorses the promotion of total water cycle management and application of water sensitive urban design (WSUD) principles to provide improvements in the management of stormwater, and to increase the efficient use of other existing water supplies.

The key principles of integrated water cycle management include:

- Considering all water sources, including wastewater, stormwater and groundwater.
- Integrating water and land use planning.
- Allocating and using water sustainably and equitably.
- Integrating water use with natural water processes.
- Adopting a whole catchment integration of natural resource use and management.

Integrated water cycle management addresses not only physical and environmental aspects of water resource use and planning, but also integrates other social and economic concerns. Stormwater management design objectives should therefore seek to deliver better outcomes in terms of:

- Potable water consumption
- Flood mitigation
- Stormwater quality management
- Groundwater management.

The first step in applying integrated water cycle management in urban catchments is to establish agreed environmental values for receiving environments. The existing environmental context of the site has been discussed in **Section 3** of this document. Guidance regarding environmental values and criteria is provided by a number of National and State policies and guidelines and site-specific studies undertaken in and around the site. These were detailed in **Section 1.3** and **Section 1.4** respectively.

The overall objective for preparing integrated water cycle management plans for proposed residential developments is to minimise pollution and maintain the hydrological regime. This objective is central to the water management approach for the Lot 50 Barfield Road LSP.

4.2 Water conservation

The water conservation design criteria proposed are consistent with the guidelines presented in *Better Urban Water Management* (WAPC 2008) and *Developing a Local Water Management Strategy* (DoW 2008a). This LWMS proposes the following water conservation criteria:

Criteria WC1 Use fit for purpose water sources.

Criteria WC2 Consumption target for water of 100 kL/person/year, including not more than 40-60 kL/person/year scheme water.

Criteria WC3 POS areas will be limited to an average water use of 7, 500 kL/ha/year.

The manner in which this objective will be achieved is further detailed in **Section 5**.

4.3 Stormwater management

Stormwater quantity design criteria include:

Criteria SW1 Retain and treat the small rainfall event as close to source as possible.

Criteria SW2 Runoff discharged from site following the major event should not exceed the pre-development volume.

Criteria SW3 Provide stormwater flow pathways for runoff from the major event.

Criteria SW4 Finished floor levels of lots must have a minimum of 300 mm clearance from the major event flows being conveyed within road reserves.

Criteria SW5 Minor roads are to remain passable in the minor event.

Criteria SW6 Design infiltration areas to avoid creating mosquito habitat.

Criteria SW7 Inverts of infiltration structures (i.e. BRA and FSA) must be at least 500 mm above MGL.

Criteria SW8 Surface runoff treatment areas to be sized to at least 2% of the total connected impervious area.

Criteria SW9 Apply non-structural measures to reduce nutrient loads.

The manner in which these objectives will be achieved is further detailed in **Section 7**.

4.4 Groundwater management

The principle behind the groundwater management strategy is to maintain the existing groundwater hydrology. The groundwater management criteria for the site include:

Criteria GW1 Treat small event stormwater runoff before infiltration to groundwater.

Criteria GW2 Use WSUD approaches to recharge the superficial Swan aquifer.

Criteria GW3 Maintain groundwater quality onsite.

The manner in which the groundwater management objectives will be achieved is further detailed in **Section 8**.

5 Water Conservation Strategy

5.1 Fit for purpose water use

Conservation of water through fit-for-purpose use and best management practices is encouraged so that scheme water is not wasted. Fit-for-purpose describes the use of water that is of a quality suitable for the required use of the water. Fit-for-purpose principles have been utilised in the water conservation strategy for the site and will achieve **Criteria WC1**.

5.1.1 Scheme water supply

Water Corporation planning shows that water supply will be connected to the proposed reticulated supply network being installed within the Vivente subdivision to the West of, and along Barfield Road (BPA 2019).

5.1.2 Groundwater supply

Groundwater can be used for irrigation of the POS area instead of utilising scheme water. Turf areas typically require 7,500 kL/ha/year, therefore the 2,010 m^2 of POS will require a maximum of 1,508 kL/year.

As discussed in **Section 3.6.1**, Glenbrook Civil have obtained a groundwater licence of 21,480 kL for irrigation of the POS and construction purposes.

The above measures will assist in achieving **Criteria WC3**.

5.1.3 Rainwater harvesting

Collection of runoff from roof surfaces can be undertaken, with this water stored within rainwater tanks (RWT) for later use. This water is of high quality, however in urban environments this water is considered non-potable. Stored rainwater may be used for some irrigation requirements however this will need to be supplemented with scheme water during the lower rainfall months. During the higher rainfall months, the majority of the stored rainwater can be used to supplement internal building non-potable uses. The water efficiency strategy recommends that rainwater is used in washing machines, toilets and hot water systems.

RWTs will not be mandated for the development however will be promoted to lot owners at point of sale.

The use of RWTs will assist in achieving **Criteria WC1 and WC2**.

5.2 Water conservation measures

The development will utilise water wise garden (WWG) principles (WC 2003) for lot scale gardens and within estate landscaping, and water efficient fixtures and appliances (WEFA) to ensure that the development minimises the use of water. These measures are further discussed in the following Sections.

5.2.1 Water efficient fixtures and appliances

Significant reductions in in-house water uses can be achieved with the use of WEFA. The water conservation strategy proposes that all dwellings use WEFA. Water efficient fittings are mandated as part of the building approvals process, while uptake of water efficient appliances can be encouraged through education from the proponent at point of sale.

The use of WEFA will assist in achieving **Criteria WC2**.

5.2.2 Water wise gardens

Reductions in water use for irrigation (by employing water efficiency measures) can significantly reduce the total water usage (WC 2003). The following water efficiency measures will be used:

- Retain native vegetation and trees within the POS, where possible.
- Where required, soil shall be improved with soil conditioner certified to Australian Standard AS4454 to a minimum depth of 150 mm where turf is to be planted and a minimum depth of 300 mm for garden beds.
- Garden beds to be mulched to 75 mm with a product certified to Australian Standard AS4454.
- Implementation of hydrozoning design practices, which will group plant species with similar/ same irrigation requirements.
- Irrigation systems will have emitters which disperse coarse droplets to minimise losses to evaporation.
- Irrigation will not be utilised during winter months and rain sensors will be utilised.
- The adoption of xeriscaped gardens (garden beds are landscaped using ‘waterwise plants’, which are local native species that require less water).
- Minimising turf areas where possible.
- Educating the community to increase awareness of water conservation.

The above measures will assist in achieving **Criteria WC3**.

5.2.3 Community awareness and education programs

The proponent can provide educational material to lot purchasers on water efficiency and quality protection measures that they can implement within lots. Specific water conservation and protection topics that should be addressed include:

- Reducing water use behaviours
- Water efficient technologies
- Plant species
- Fertiliser and pesticide use
- WWG practices.

Example educational materials are provided in **Appendix D**.

5.3 Water Use Analysis

5.3.1 Estate scale water use analysis

The water usage at the estate scale has been determined by the amount of POS provided and any additional areas which will require ongoing irrigation. There is 2,010 m^2 of proposed POS (as shown in **Appendix A**) which will incorporate native shrub planting and small pockets of turf.

The POS will be irrigated at a maximum rate of 7,500 kL/ha/year, therefore a total volume of 1, 508 kL/year will be required. A detailed irrigation schedule will be provided in future urban water management plans (UWMP) and/or landscape concept designs to demonstrate how the allocation will be utilised. A temporary allocation for dust suppression will also be required for construction purposes, the total of which will be confirmed at UWMP stage, and for the relevant construction area. As discussed in **Section 5.1.2**, a groundwater allocation has been obtained for the development.

5.4 Wastewater management

The development will be serviced by gravity sewer designed and installed to the Water Corporations standards and specification (BPA Engineering 2019). Water Corporation planning shows that sewer will be connected to the proposed wastewater reticulation being installed within the Vivente subdivision to the west of, and along Barfield Road. The site is also proposed to be filled in the south east corner to facilitate the servicing of this wastewater reticulation (BPA 2019).

5.5 Water conservation criteria compliance summary

A summary of the proposed water conservation design criteria and how these are addressed within the site is provided in **Table 1** below.

Table 1: Water conservation compliance summary

Criteria number	Criteria description	Manner in which compliance will be achieved
WC1	Use fit for purpose water sources	A reticulated potable water supply will service the site
		Groundwater will be utilised to irrigate POS areas
WC2	Consumption target for water of 100 kL/person/year, including not more than 60 kL/person/year of scheme water	Use of WEFA by lot owners
		Adoption of WWG practices by lot owners
		Education regarding water conservation provided to lot purchasers
WC3	POS areas will be limited to an average water use of 7,500 kL/ha/year	Landscape design that follows WWG practices

5.5.1 Lot scale water use analysis

A water use analysis has been undertaken to estimate the expected total lot water use by the proposed development, and demonstrate the effectiveness of the water conservation strategy proposed for residential lot-scale measures. The water use analysis has been based on the rates and calculation methodology presented in the Water Corporation (2011) spreadsheet AltWaterSupply_Water_Use_Model.xls. This spreadsheet has been adapted to model the effects of using the water conservation measures proposed.

A number of key assumptions were made to carry out the lot scale water use calculations including:

- Total lot area has been based on the Lot 50 Barfield Road SP (see **Appendix A**).
- Average residency of 2.6 people per single lot dwelling. This value has been calculated from data provided by Australian Bureau of Statistics (ABS) for new housing developments in Perth (ABS 2014).
- Assumed up-take rates have been derived from data supplied by the ABS (2013) and include:
  - 100% uptake of water efficient fittings
  - 40% uptake of water efficient appliances
  - 7.5% uptake of rainwater tanks
  - 55% uptake of WWG principles.

If households across the site adopt WWG and WEFA at typical rates, then households will use (on average) 42.9 kL/year/person of scheme water. A total lot scale consumption of 4.02 ML/year is estimated under the proposed water conservation strategy. This achieves the water target of no more than 60 kL/year/person of scheme water, and satisfies **Criteria WC2.** Without the adoption of WWG and WEFA measures, lots are estimated to use 77.6 kL/year/person of scheme water.

6 Stormwater Management

The principle behind the stormwater management strategy for the site is to retain and treat the small rainfall event as close to source as possible, and to maintain the existing hydrological regime. All stormwater management assets will also be designed and constructed in accordance with CoC requirements, design guidelines and standards (CoC 2019). Due to the existing environmental conditions (See **Section 3.4**), the site is presumed to be well suited for structural controls utilising infiltration of stormwater. WSUD measures utilised in the stormwater management strategy include:

- Soakwells
- Bio-retention area (BRA)
- Flood storage area (FSA).

These components and the WSUD measures that will be implemented as a part of these components are described in the following sections. The stormwater management concept plan is provided in the engineering technical note provided in **Appendix E**, and replicated in **Figure 5**.

6.1 Lot drainage

All lots will manage the minor event (20 year ARI/5% AEP, 5-minute duration) on lot in accordance with CoC requirements (CoC 2019). Based on current intensity-frequency-duration tables for the area this equates to a rainfall depth of 11.2 mm for the site (BoM 2020a). It is proposed that this storage will be achieved through the use of soakwells and pervious garden areas on lots. The total volumetric requirements for the minor event for soakwells was determined to be 62 m3 as calculated by BPA Engineering (refer to Appendix E) with overflow from the soakwells to be routed to the downstream FSA (discussed in **Section 6.2.3**).

The design, installation and maintenance of soakwells is the responsibility of the lot owner. The measures discussed above will assist in achieving **Criteria SW1**.

6.2 Development drainage

6.2.1 Pipe network

Stormwater runoff up to the major 100 year ARI/1% AEP event will be piped into the FSA (described in **Section 6.2.3**) for treatment and retention. Major stormwater runoff from the northern catchment (refer to **Figure 5**) not retained on lots will flow west via a road network gutter towards Barfield road. While the earthworks will result in road grades towards Barfield road (east to west), the pipe network will be graded in the opposite direction (west to east) to enable flows to be directed to the FSA (refer to Appendix C in the technical note provided in **Appendix E**). Flow directions are further illustrated in **Figure 5**.

Runoff from within the southern catchment (refer to **Figure 5**) not retained on lots will be conveyed west via overland flow and this pipe network into the FSA. Both the gutter and the pipe will be sized to cater for the 100 year ARI/1% AEP rainfall event (E. Aguiar [BPA Engineering] 2020, *pers. comm.*, 30 October), with sufficient freeboard in junction (150 mm) and gully pits (300 mm) (E. Aguiar [BPA Engineering] 2020, *pers. comm.*, 5 November), hence achieving **Criteria SW3** and **SW5**.

6.2.2 Bio-retention areas

A BRA will accept runoff from both the northern and southern catchments via the pipe network where the runoff will be treated in the vegetated BRA located in the downstream POS, as shown in **Figure 5**.

The BRA will be designed with 1:6 side slopes, a width of 15.6 m, a top water level (TWL) of 29.86 m AHD and a total area of 385 m^2 (refer to the cross section provided in **Appendix E**). The BRA will be collocated within the FSA (as is discussed in **Section 6.2.3**) and a design infiltration rate of 3.5 m/day has been utilised for the BRA (BPA Engineering 2020).

BRAs will be vegetated with plant species suitable for nutrient uptake, consistent with the *Vegetation guidelines for stormwater biofilters in the South West of Western Australia* (Monash University 2014) and be underlain with a 300 mm layer of soil with PRI >10 to allow for the absorption of phosphorous species. Additional treatment will be provided through adsorption of nutrients to sand particles through infiltration.

The use and design of the BRA will assist in achieving **Criteria SW1**, **SW8**, **GW1**, **GW2 and GW3**.

6.2.3 Flood storage areas

Major event runoff will be conveyed via the pipe network and overland flow into the FSA located within the downstream POS area. As discussed in **Section 6.2.2**, the FSA will be collocated with the BRA.

Due to the high infiltration rate of filter media and parent soils, the BRA will not be inundated for prolonged periods, and hence the vegetation can remain in good health. Further design optimisation of the FSA and POS area will be completed at subdivision to ensure the POS area more effectively integrates the drainage requirements and usability for the local community.

The FSA will have varied side slopes between 1:6 and 1:200, a width of 20.4 m, a TWL of 30.16 m AHD, and a total area of 1,180 m^2. A design infiltration rate of 8 m/day for the FSA has been utilised in the modelling (refer **Appendix E**). The FSA invert will sit at 29.6 m AHD and as discussed in **Section 3.6.2**, groundwater beneath the site is approximately 21-23 m AHD, leaving a 6.6-8.6 m clearance. The depth to groundwater along with high infiltration rates of soils will allow prompt infiltration of runoff thus ensuring the basin empties within the maximum 96 hours required to avoid creating mosquito breeding habitat.

The measures described above will assist in achieving **Criteria SW1**, **SW2**, **SW6**, **SW7 and GW3**.

6.2.4 Stormwater management design

6.2.4.1 Storage volumes

Calculations to support the concept stormwater management approach for the site have been completed by BPA Engineering and are attached in **Appendix E**. The modelling of the site was conducted using the software DRAINS utilising the BoM 2016 IFD data.

A summary of the storage volumes provided across each asset and event is provided in **Table 2**.

Table 2: Stormwater storage requirements

Rainfall event		Total Volume Required (m^3)	Inundated Area (m^2)	TWL (m AHD)
Small (63% AEP)	BRA	70	385	29.86
Minor (20% AEP)	FSA	129	395	30.02
Major (1% AEP)		255	1180	30.16

6.2.4.2 Stormwater treatment

The volume required for the small rainfall event in the surface BRA is shown to be 70 m^3 with an inundated area of 385 m^2 (see **Table 2**). The total connected impervious area is 10, 910 m^2 (refer to Table 3 of **Appendix E**). This equates to an equivalent treatment area of 3.5% which achieves **Criteria SW8**.

6.2.5 Discharge from site

As discussed in **Section 3.5.1**, the site is expected to discharge a portion of runoff towards Barfield Road following a major rainfall event in the existing environment.

Two lots fronting Barfield road (as shown in the LSP provided in **Appendix A**), will retain the minor event as stipulated by the CoC (discussed in **Section 6.1**). Major event runoff from these lots are unable to be managed within the internal site drainage system due to levels, and will instead be discharged into the Barfield road reserve at a lower rate than pre-development flow rates.

The calculation of post-development discharge volumes, and comparison to the existing site conditions, is provided in **Appendix E** and summarised in **Table 3**. This calculation is based on the 100 year ARI/1% AEP, 1-hour duration storm event which equates to a depth of 44.6 mm.

Table 3: Pre and post development discharge volumes from site

Catchment	Scenario	Total catchment area (m^2)	Major event runoff Coefficient	Runoff retained on site (m^3)	Total volume discharged from site (m^3)	Peak flow rate (m^3/s)
Barfield Road	Pre development	5, 316	0.2	-	47.3	0.060
	Post development	625	0.4	56.4	2.4	0.014

As shown in **Table 3**, the post development discharge volumes do not exceed the existing conditions and therefore **Criteria SW2** will be achieved.

6.3 Non-structural measures

Runoff from lots and road reserves can often accumulate debris, gross pollutants and sediments which enter the stormwater system. Regular maintenance of the proposed structural elements of water quality treatment (i.e. BRA) is important to ensure the ongoing effectiveness of these assets. Additional management measures required to reduce the risk of contamination from surface runoff includes:

- Ongoing use of WWG practices in POS and road verges
- Maintenance of POS and drainage areas
- Street sweeping
- Education of residents on use of WWG and appropriate fertilser use.

On this basis **Criteria SW9** will be achieved.

6.4 Stormwater design criteria compliance

A summary of the proposed water conservation design criteria and how these are addressed within LSP is provided below.

Table 4: Stormwater management compliance summary

Criteria number	Criteria description	Manner in which compliance will be achieved
SW1	Retain and treat the small rainfall event as close to the source as possible.	Lots will retain and treat runoff within soakwells and pervious garden areas of the lots.
		Road reserve runoff will be retained and treated within a BRA within the downstream POS.
SW2	Runoff discharged from site following the major event should not exceed the pre-development volume.	Pre development discharge from site equates to 47.3 m^3. Post development discharge from site equates to 2.4 m^3.
SW3	Provide stormwater flow pathways for runoff from the major rainfall event.	The road network in the southern catchment will be graded towards the POS and drainage areas, providing a flow path for major storm event runoff.
		Major stormwater runoff will be conveyed via a gutter and pipe network to the FSA, sized for the major event.
SW4	Finished floor levels of lots must have a minimum of 300 mm clearance from the major rainfall event flows being conveyed within road reserves.	Finished floor levels will be maintained with adequate clearance from dynamic flows in the road network.

Table 4: Stormwater management compliance summary (continued)

Criteria number	Criteria description	Manner in which compliance will be achieved
SW5	Minor roads are to remain passable in a 5 year ARI event.	The pipe network for the site will be sized to cater for the minor (5 year ARI) event.
SW6	Design infiltration areas to avoid creating mosquito habitat.	The site has a high infiltration rate and the depth to groundwater from the FSA invert is approximately 6.6-8.8 m.
SW7	Inverts of infiltration structures (i.e. BRA and FSA) must be at least 500 mm above MGL	The FSA invert will sit at 29.6 m AHD with a clearance to groundwater of 6.6-8.6 m.
SW8	Surface runoff treatment areas to be sized to at least 2% of the total connected impervious area.	The total size of the BRA, achieved through at-source retention storage equates to 3.5% of the total connected impervious area.
SW9	Apply non-structural measures to reduce nutrient loads.	Utilise WWG practices in POS.
		Maintenance of POS and drainage areas.
		Street sweeping.
		Education of residents on use of WWG and fertilisers.

7 Groundwater Management

The principles behind groundwater management are to maintain the existing hydrology across the site, recharge the superficial aquifer and maintain the existing groundwater quality.

7.1 Groundwater level management

As discussed in **Section 3.6.2**, groundwater beneath the site is approximately 21-23 m AHD. Fill is proposed in the south-eastern portion of the site which will ensure adequate clearance of lots and inverts of all stormwater management structures from MGL. The FSA invert will sit at 29.6 m AHD leaving a 6.6-8.6 m clearance (including fill). Groundwater level management measures are therefore somewhat passive and the focus of groundwater management is on water quality.

7.2 Groundwater quality management

The main objective for the management of groundwater quality is to maintain the existing quality. This can be achieved by treating surface runoff prior to infiltration via application of appropriate WSUD measures, thereby reducing the total nutrient load into the groundwater that originates from the development.

The reduction of nutrient load to the groundwater will be achieved by:

- Directing stormwater to vegetated BRA within POS (detailed in **Section 5.5.1**).
- The BRA will be underlain with a 300 mm layer of soil with PRI >10 to allow for the absorption of phosphorous species.
- Street sweeping on a regular basis.
- Maintenance of WSUD features.
- Minimising fertiliser use to establish and maintain vegetation within POS and landscaped areas (e.g. within verge, lot etc).
- Utilising drought tolerant plant species that require minimal water and nutrients.
- Turf species should be drought tolerant and require minimal water and nutrients.
- Education of lot owners, residents and tenants regarding fertiliser application and the use of nutrient absorbing vegetation.

The above measures will improve the quality of the water prior to it infiltrating into the underlying groundwater, and will assist in achieving **Criteria GW1, GW2 and GW3**.

7.3 Groundwater design criteria compliance

A summary of the proposed groundwater management design criteria and how these are addressed within the site is provided in **Table 5**.

Table 5: Groundwater management compliance summary

Criteria number	Criteria description	Manner in which compliance will be achieved
GW1	Treat stormwater runoff before infiltration to groundwater	A minimum of 1.2 m clearance will be provided between habitable floor levels and MGL
GW2	Use water sensitive design approaches to recharge the superficial Swan aquifer	Runoff will be able to recharge the superficial swan with the use of a BRA and FSA.
GW3	Maintain groundwater quality onsite	Direct small event runoff to the BRA. Treatment is provided through interaction with vegetation and adsorption of nutrients to soil particles through infiltration.
		Minimise fertiliser use in POS and road verges
		Use roll-on, drought tolerant turf species
		Education of residents on use of WWG and fertiliser use

8 Subdivision and Urban Water Management Plans

The requirement to undertake preparation of more detailed water management plans to support subdivision is generally imposed as a condition of subdivision. The development of any future UWMP should follow the guidance provided in *Urban Water Management Plans: Guidelines for Preparing Plans and for Complying with Subdivision Conditions* (DoW 2008c).

While strategies have been provided within this LWMS that address planning for water management within the site, it is a logical progression that future subdivision designs and the supportive UWMP will clarify details not provided within the LWMS. The main areas that will require further clarification within future UWMPs include:

- ASS investigations
- Imported fill specifications
- Modelling of local road drainage network
- Infiltration basin area configurations
- Implementation of water conservation strategies
- Non-structural water quality improvement measures
- Management and maintenance requirements
- Construction period management strategy
- Monitoring and evaluation program.

These are further detailed in the following sections.

8.1 ASS investigation

The site is mapped as having a 'moderate to low risk' of ASS being found within 3 m of the natural surface. An investigation is required to determine the actual presence or otherwise of actual ASS or potential ASS. If ASS are found within the areas that are proposed to be developed or detailed designs indicate that ASS is likely to be disturbed due to excavation for installation of services, then an appropriate management plan will be a likely requirement of future development. These requirements will be clarified and/or summarised at UWMP stage once detailed earthworks designs and depths of trenching/excavation are known.

8.2 Imported fill specifications

Fill is proposed within the southern catchment required to allow at least 500 mm clearance to groundwater, however the final levels will be confirmed at UWMP stage.

8.3 Modelling of local road drainage network

It is acknowledged that the drainage strategies documented in this LWMS are based upon broad-scale assumptions and regional data. These assumptions are considered adequate for development of the proposed stormwater management structure sizing and are of an appropriate level of detail; however verification of proposed subdivision drainage designs within the LSP area will be undertaken by modelling the catchments serviced by the piped drainage network.

Such modelling will allow verification that the development undertaken within the LSP area is consistent with this LWMS. The design of the drainage system to date has been undertaken at an appropriate level for local structure planning and modelling of the stormwater drainage system will be reviewed once detailed drainage design has commenced for the area. It is anticipated that this will occur during the subdivision design process and be detailed within the future UWMPs.

The exception to the requirement to revise the surface runoff modelling is if the catchment details and basin designs are consistent with the assumptions made in this LWMS. If this were the case it would be acceptable to provide design calculations for the pipe network and retention areas to demonstrate compliance with the LWMS.

8.4 Stormwater storage configurations and structures

The exact location and shape of infiltration structures will still need to be specified and presented within the future UWMP. It is expected that the civil drainage designs will be progressed to a level that provides detailed cross-sections, sizes of storage areas, pipe sizes, inverts, etc. to confirm the design meets the requirements of this LWMS.

8.5 Implementation of water conservation strategies

A number of potential measures to conserve water have been presented within this LWMS (see **Section 5.2**). These water conservation strategies will be incorporated into the design and the ongoing maintenance of all POS areas. Landscape design measures that will be incorporated into the water conservation strategy will be further detailed within the future UWMP produced for the development. The manner in which the developer intends to promote water conservation measures discussed in this LWMS to future lot owners will also be discussed within the future UWMP.

8.6 Non-Structural water quality improvement measures

Guidance for the development and implementation of non-structural water quality improvement measures is provided within the *Stormwater Management Manual for Western Australia* (DoW 2007). Some measures will be more appropriately implemented at a local government level, such as street sweeping, however many can be implemented relatively easily within the design and maintenance of the subdivision and the POS areas. It is expected that the future UWMP will provide reference to measures such as public education (through measures such as signage that may be implemented to raise awareness).

8.7 Management and maintenance requirements

The management measures to be implemented to address surface water quality, such as the use of vegetation within BRAs and the POS will require ongoing maintenance. It is therefore expected that the future UWMP will provide detailed management and maintenance plans that will set out maintenance actions (e.g. gross pollutant removal), timing (e.g. how often it will occur), locations (e.g. exactly where it will occur) and responsibilities (e.g. who will be responsible for carrying out the actions). Given that approval from the CoC and DWER will be sought for the proposed measures, it is anticipated that consultation with these agencies will be undertaken and referral to guiding policies and documents will be made.

8.8 Construction period management strategy

It is anticipated that the construction stage will require some management of various aspects (e.g. dust, surface runoff, noise, traffic etc.). The management measures undertaken for construction management will be addressed either in the future UWMP or a separate Construction Management Plan (CMP).

8.9 Monitoring and evaluation program

It will be necessary to confirm that the management measures that are implemented are able to fulfil their intended management purpose, and are in a satisfactory condition at a point of management hand-over to the CoC. A post-development monitoring program will be developed to provide this confirmation, and it will include details of objectives of monitoring, relevant issues and information, proposed methodology, monitoring frequency and reporting obligations. These will be further detailed at the UWMP stage.

It is proposed that the overall condition of the development will be monitored on a bi-annual basis. This monitoring will be implemented after the completion of the civil and landscaping works and will continue for a period of two years.

A visual assessment will be undertaken to monitor the overall condition of the development, with the aim to ascertain that the maintenance activities are achieving the overall management objectives for the development. The parameters that will be monitored include:

- Gross Pollutants
- Terrestrial Weeds
- Irrigation
- Vegetation density
- Paths, benches, walkways and other infrastructure.

The management and maintenance objectives will be detailed within future UWMPs along with details of the corresponding groundwater monitoring program.

9 Implementation

The LWMS is a key supportive document for the LSP. The development of the LWMS has been undertaken with the intention of providing a structure within which subsequent development can occur consistent with an integrated water cycle management approach. It is also intended to provide overall guidance to the general stormwater management principles for the area and to guide the development of the future UWMP.

9.1 Roles and Responsibility

The LWMS provides a framework that the proponent can utilise to assist in establishing stormwater management methods that have been based upon site-specific investigations, are consistent with relevant State and Local Government policies and have been endorsed by the CoC. The responsibility for working within the framework established within the LWMS rests with the subdivider, although it is anticipated that the future UWMP will be developed in consultation with the CoC and DWER and in consideration of other relevant policies and documents.

9.2 Funding

As the site constitutes a single landholding, the management strategies outlined in this LWMS will be borne solely by the proponent, with the exception of lot soakwells which will be borne by the lot purchaser.

9.3 Review

It is not anticipated that this LWMS will be reviewed, unless additional land parcels/lots are added to the LSP area prior to subdivision, or the LSP undergoes significant change post-lodgement of the LWMS. If additional areas are required to be covered by the LWMS it is most likely that an addendum to cover these areas could be prepared. If the LSP is substantially modified, surface runoff modelling undertaken for this LWMS will need to be reviewed and the criteria proposed revised to ensure that all are still appropriate.

The next stages of water management are anticipated to be lot planning through subdivision. Subdivision approvals will be supported by a UWMP. The UWMP is largely an extension of the LWMS, as it should provide detail to the designs proposed within this LWMS, and will demonstrate compliance with the criteria proposed in **Section 4**.

In addition to the issues detailed in **Section 8**, the UWMP will address:

- Compliance with design objectives within the LWMS
- Detailed stormwater management design
- Specific structural and non-structural methods to be implemented and their manner of implementation
- Details of proposed roles and responsibilities for the above measures.

The next stage of development following the UWMP is single lot or multiple dwelling developments. It is recognised that certain elements of the LWMS and the UWMP will not be implemented until this stage, and that there is little or no statutory control that can be applied to ensure the implementation of any remaining measures. While the remaining measures are unlikely to be enforced at this stage, their implementation could be encouraged by the CoC through policy (or modification of these where necessary), building licence or awareness programs (such as the Water Corporation's Waterwise program

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10.1 General references

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Figures

Figure 1: Site Location

Project: Local Water Management Strategy
Lot 50 Barfield Road, Hammond Park
Client: Glenbrook Civil

Plan Number:
EP18-043(06)--F27
Drawn: GAR
Date: 18/03/2020
Checked: TEM
Approved: RLE
Date: 12/06/2020

N

0 50 100
Metres
Scale: 1:4,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

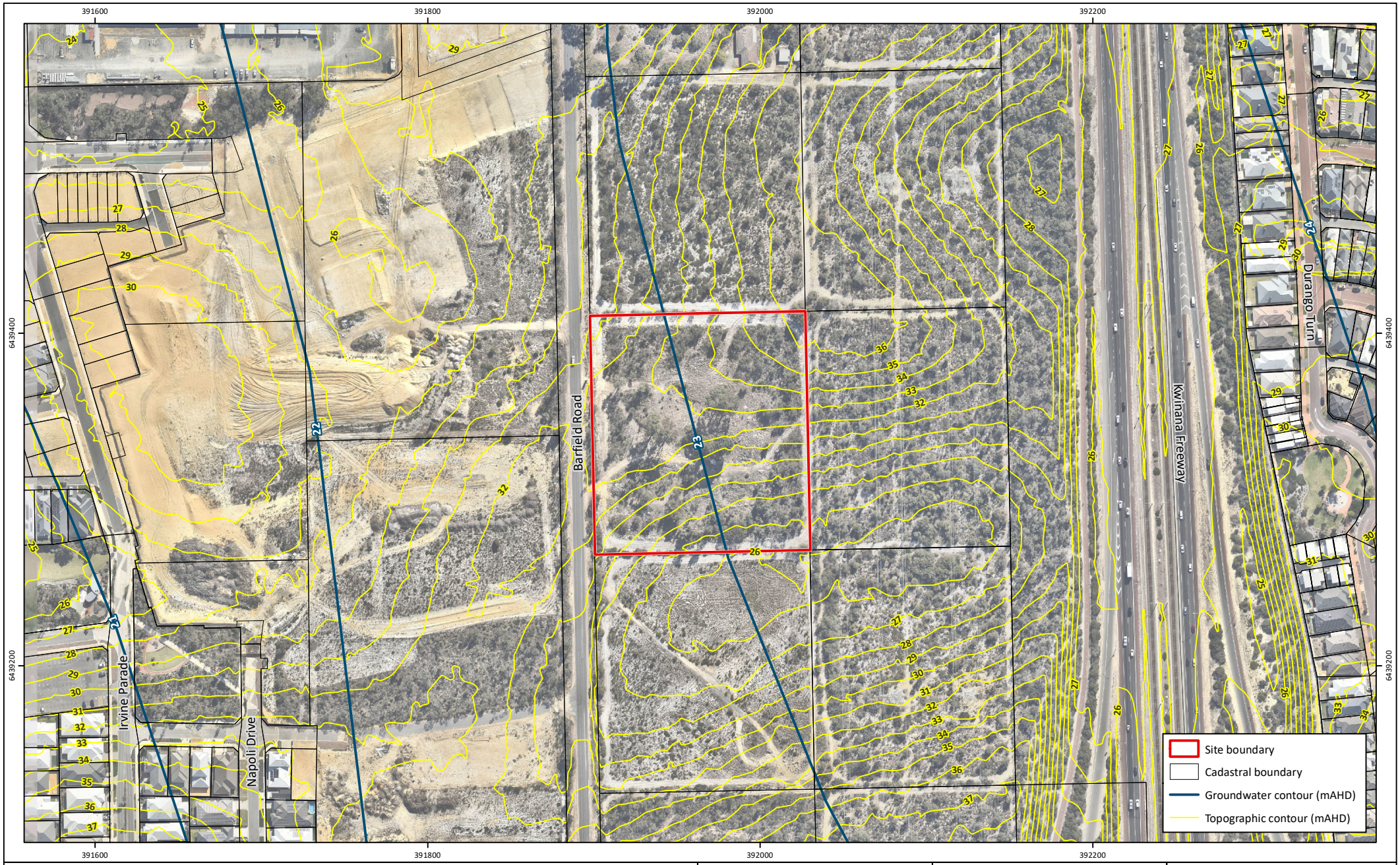


Figure 2: Topographic Contours and Maximum Groundwater Level Contours

Project: Local Water Management Strategy
Lot 50 Barfield Road, Hammond Park
Client: Glenbrook Civil

Plan Number:
EP18-043(06)--F28
Drawn: GAR
Date: 18/03/2020
Checked: TEM
Approved: RLE
Date: 12/06/2020

N

0 50 100
Metres
Scale: 1:3,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

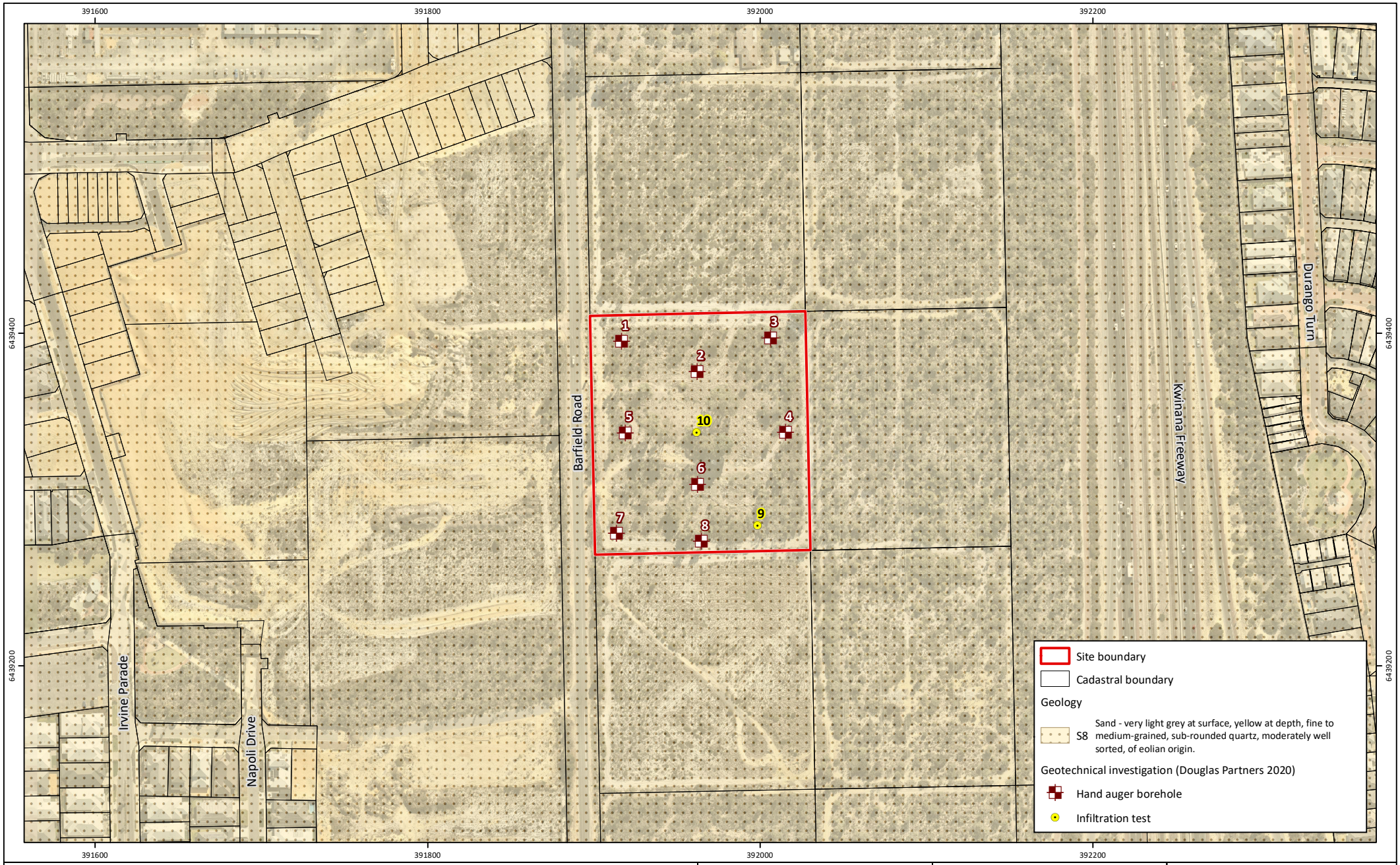


Figure 3: Environmental Geology

Project: Local Water Management Strategy
Lot 50 Barfield Road, Hammond Park
Client: Glenbrook Civil

Plan Number:
EP18-043(06)--F29a

Drawn:	GAR
Date:	28/10/2020
Checked:	TEM
Approved:	RLE
Date:	28/10/2020

N

0 50 100
Metres

Scale: 1:3,000@A4

GDA 1994 MGA Zone 50

emerge ASSOCIATES

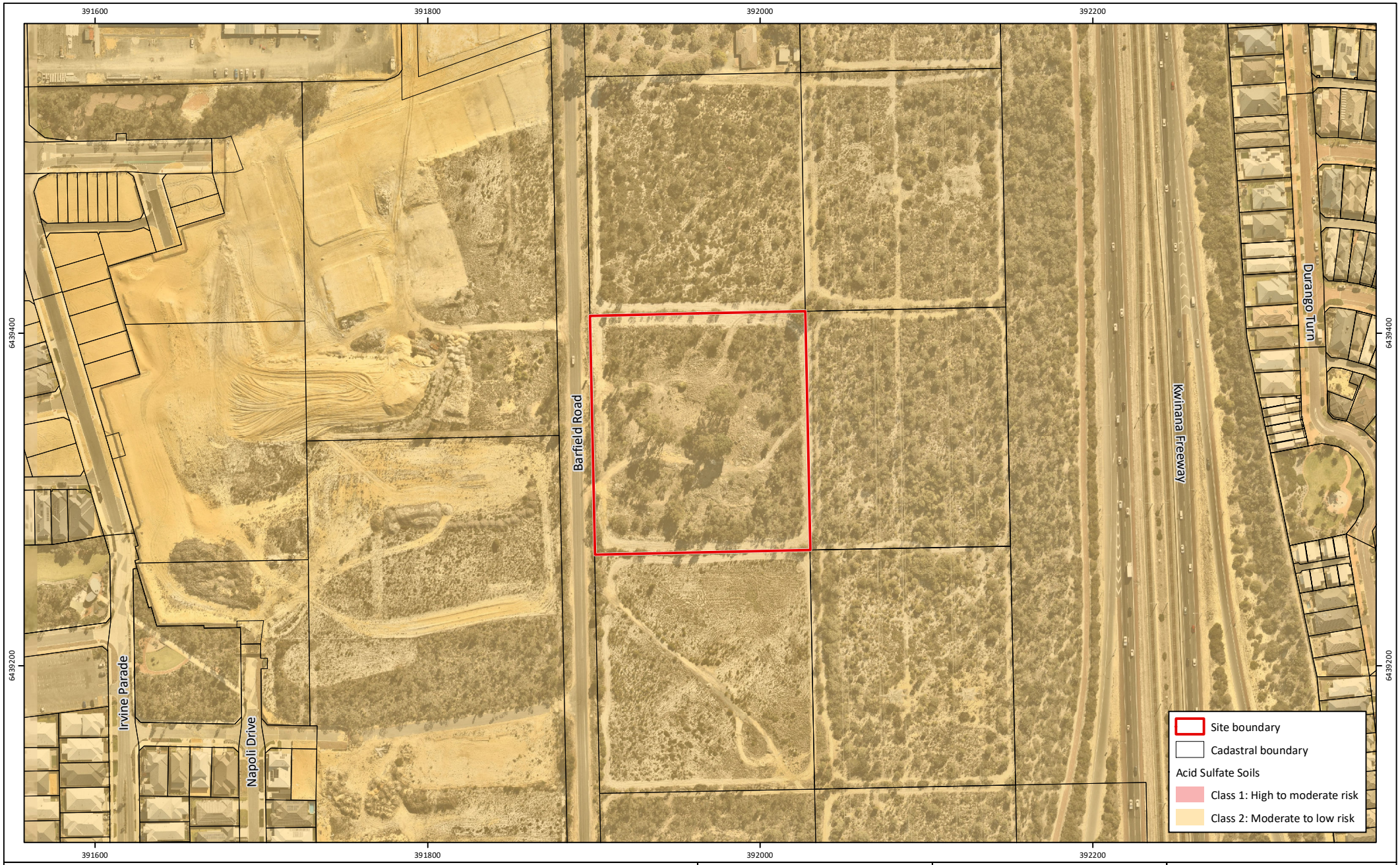


Figure 4: Acid Sulfate Soil Mapping

Project: Local Water Management Strategy
Lot 50 Barfield Road, Hammond Park
Client: Glenbrook Civil

Plan Number:
EP18-043(06)--F30
Drawn: GAR
Date: 18/03/2020
Checked: TEM
Approved: RLE
Date: 12/06/2020

N

0 50 100
Metres
Scale: 1:3,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

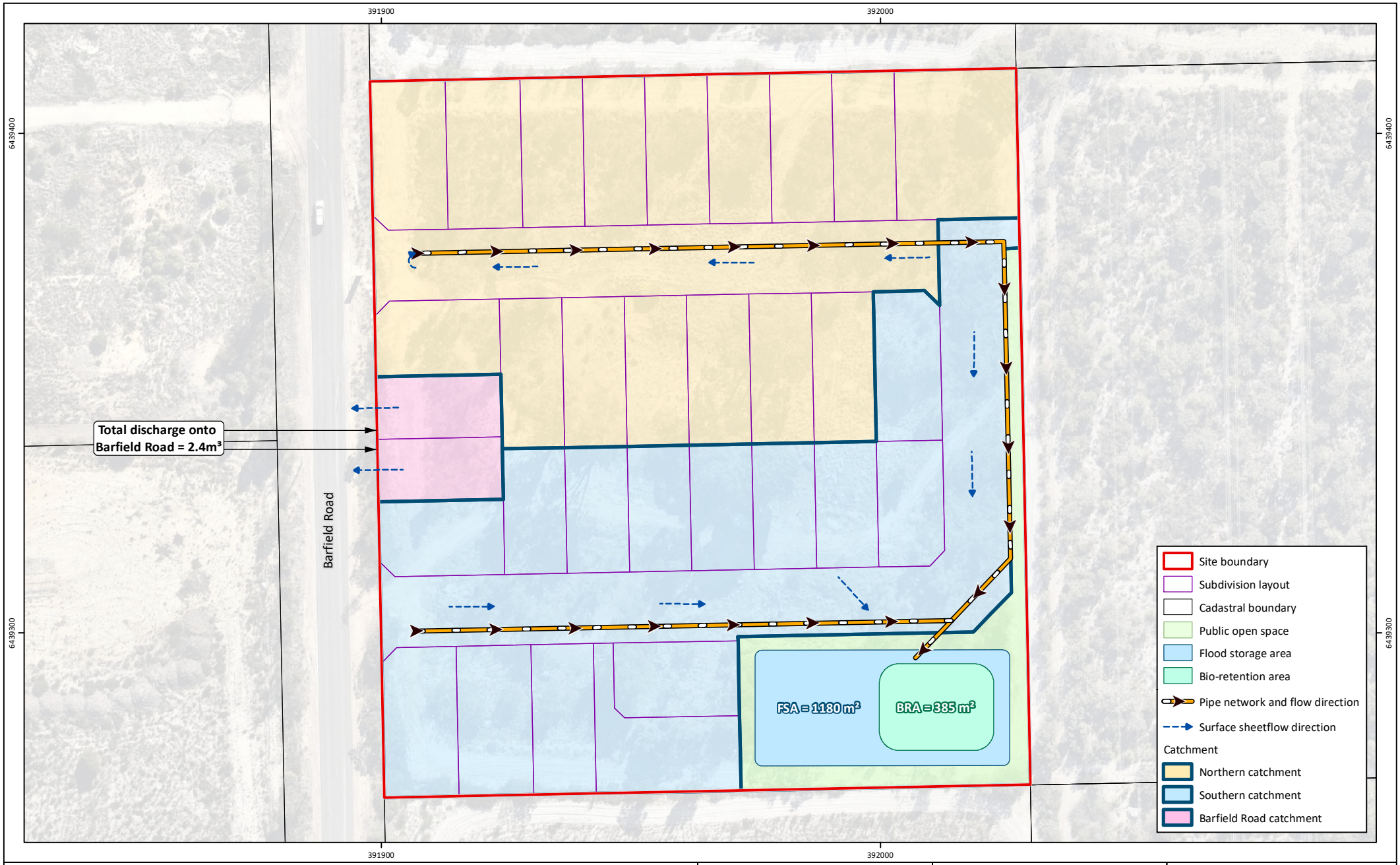


Figure 5: Stormwater Management Plan

Project: Local Water Management Strategy
Lot 50 Barfield Road, Hammond Park
Client: Glenbrook Civil

Plan Number:
EP18-043(06)--F31a
Drawn: GAR
Date: 04/11/2020
Checked: TEM
Approved: RLE
Date: 12/11/2020

N

0 20 40
Metres
Scale: 1:1,000@A4
GDA 1994 MGA Zone 50

emerge ASSOCIATES

Appendix A

Subdivision and landscaping concept plan

Prepared by Rowe Group (2020)

INTERNAL LOT SETBACK OF 6m TO MEET BAL-29 TO ADDRESS TEMPORARY HAZARD

WESTERN POWER EASEMENT SERVICE ACCESS (SUBJECT TO DETAILED DESIGN)

WIDTH + EXTENT OF RESERVE SUBJECT TO RETAINING WALL REQUIREMENTS AT DETAILED DESIGN STAGE.

INTERNAL LOT SETBACK OF 10m TO MEET BAL-29

INDICATIVE DRAINAGE BASIN (SUBJECT TO DETAILED DESIGN)

LEGEND

- SUBJECT SITE
- CONTOURS
- EXISTING BOUNDARIES
- 7 EXISTING LOT NUMBERS
- PROPOSED BOUNDARIES
- **7** PROPOSED LOT NUMBERS
- 10.5 PROPOSED LOT DIMENSIONS
- (129.53) EXISTING LOT DIMENSIONS
- INDICATIVE FUTURE LAYOUT
- SEWER
- POWER
- POWER POLE
- PUBLIC OPEN SPACE
- BUSHFIRE SETBACKS (BAL 29) TEMPORARY BUILDING EXCLUSION ZONE

LOT SUMMARY

NO. OF LOTS	32
TOTAL AREA OF LOTS	12,252m²
AVERAGE AREA OF LOTS	383m²
MINIMUM LOT AREA	313m²
MAXIMUM LOT AREA	735m²
PUBLIC OPEN SPACE	2046m²

SUBDIVISION CONCEPT PLAN (INDICATIVE ONLY)

LOT 50 (NO. 193) BARFIELD ROAD
HAMMOND PARK

NORTH

0 9.375 18.75

SCALE @ A3: 1:750

8697-CON-11-B

ROWE GROUP DESIGN

N:\TOWN PLANNING\8000-8999\8697\DRAFTING\A-CAD - WILLIAM CLEMENTS - 2020.09.29
8697_CON11B_20200929_Hammond Park (Subdivision Concept) - DRAWN: WILLIAM CLEMENTS - DATE CREATED: 2020.09.29 - PROJECTION: MGA50 GDA94 - CADASTRE: LANDGATE -

Appendix B

Geotechnical investigation

Prepared by Douglas Partners (2020)

Douglas Partners
Geotechnics / Environment / Groundwater

Integrated Practical Solutions

Report on
Geotechnical Investigation

Proposed Residential Subdivision
Lot 50 (193) Barfield Road, Hammond Park, WA

Prepared for
Glenbrook Civil Engineering Contractors Pty Ltd

Project 96711.00
September 2020

Douglas Partners
Geotechnics / Environment / Groundwater

Document History

Document details

Project No.	96711.00	Document No.	R.001.Rev0
Document title	Report on Geotechnical Investigation Proposed Residential Subdivision		
Site address	Lot 50 (193) Barfield Road, Hammond Park, WA		
Report prepared for	Glenbrook Civil Engineering Contractors Pty Ltd		
File name	96711.00.R.001.Rev0.Proposed Residential Subdivision, Lot 50 (193) Barfield Road, Hammond Park, WA		

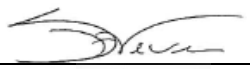
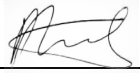
Document status and review

Status	Prepared by	Reviewed by	Date issued
Rev0	Sergio Neves	Dan Reaveley	8 September 2020

Distribution of copies

Status	Electronic	Paper	Issued to
Rev0	1	0	John Rooney, Glenbrook Civil Engineering Contractors Pty Ltd

The undersigned, on behalf of Douglas Partners Pty Ltd, confirm that this document and all attached drawings, logs and test results have been checked and reviewed for errors, omissions and inaccuracies.

	Signature	Date
Author		8 September 2020
Reviewer		8 September 2020

bsi. ISO 9001 Quality Management
FS 604853

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Douglas Partners
Geotechnics / Environment / Groundwater

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Report on Geotechnical Investigation
Proposed Residential Subdivision
Lot 50 (193) Barfield Road, Hammond Park, WA

1. Introduction

This report presents the results of a geotechnical investigation undertaken for a proposed residential subdivision at Lot 50 (193) Barfield Road in Hammond Park, WA. The investigation was commissioned in an email dated 24 August 2020 by Richard Williams of BPA Engineering on behalf of Glenbrook Civil Engineering Contractors Pty Ltd and was undertaken in accordance with Douglas Partners' proposal referenced PER200292 and dated 20 August 2020.

It is understood that the proposed development will comprise the subdivision of the site into 36 individual lots, together with associated access roads and a drainage basin at the south eastern corner of the site.

The aim of the geotechnical investigation was to assess the sub surface conditions across the development area and subsequently provide comments on:

- The geotechnical suitability of the site for the proposed development;
- The subsurface conditions including identification of any areas of foundation risk, such as areas of uncontrolled fill, compressible layers or any other problematic ground conditions, if encountered, and make suggestions in terms of recommended strategies to address any identified risks;
- Provide a site classification in accordance with AS 2870-2011 and measures that could be adopted to improve this classification, if required;
- Recommendations in terms of site preparation, including comments on possible re-use, placement and compaction of existing materials as controlled fill and specification for any imported fill;
- Provide comments on excavation conditions;
- Suitable safe batter slopes for any proposed temporary and permanent excavations;
- Recommendations on suitable foundation systems (including individual pad or strip footings or piles), and provision of geotechnical parameters for foundation design including allowable bearing pressures for pad and strip footings founded at 0.5 m and 1 m below finished floor levels;
- Estimated short and long-term settlements associated with the recommended founding systems, including potential differential settlements across the proposed structure;
- Provide recommendations in relation to external pavements, including indicative subgrade pavement CBR based on field observations and Douglas Partners experience;
- Provide geotechnical parameters for retaining wall design calculations;
- The permeability of the encountered soils and provide comments on suitable stormwater disposal methods and site drainage;
- Assess the groundwater level beneath the site at the time of investigation, if encountered, and estimate the annual average maximum groundwater level (AAMGL) and the maximum groundwater level for the site;

- Assess the soil Phosphorous Retention Index, in particular at the location of the proposed drainage basin at the south eastern corner of the site; and
- Assess the risk of acid sulfate soils based upon a review of readily available desktop information, to inform on the requirement for further acid sulfate soils investigation.

Douglas Partners scope included the drilling of ten boreholes, Perth sand penetrometer (PSP) testing adjacent to each borehole, two infiltration tests and laboratory testing of selected soils samples.

2. Site Description

At the time of investigation, the site comprised a vacant portion of land (bushland), with several sand tracks crossing the site in an east to west direction and along each boundary (see Photo 1 below).

Photo 1: View of the site from test location 4 looking southwest.

Rubbish and fly-tipped waste was also observed scattered across parts of the site, including between test locations 4, 6, 9 and 10 (see Photo 1 above).

The site is bound to the north and east by bushland, to the west by Barfield Road and to the south by a residential development which is under construction.

Based on a level survey plan provided by the client, the site slopes from a high point at approximately RL 38 m at the north eastern corner, to a low point at approximately RL 27 m at the south eastern corner.

The Fremantle 1:50,000 Geology Sheet indicates that the subsurface conditions beneath the site comprises Bassendean Sand.

The Perth Groundwater Atlas indicates that the groundwater level in May 2003, was at approximately RL 21 m (i.e. approximately 6 m below the lowest site level).

Published acid sulfate soil risk mapping indicates that the site is located within an area of "moderate to low risk of acid sulfate soils within 3 m of natural soil surface".

3. Field Work Methods

The field work was carried out on 26 August 2020 and comprised the drilling of ten boreholes (test locations 1 to 10) together with Perth sand penetrometer (PSP) tests adjacent to the boreholes, and two in situ infiltration tests (test locations 9 and 10).

The boreholes were drilled using a 110 m diameter hand auger, to target depths of 1 m (at the in situ infiltration test locations) and 3 m depth elsewhere.

Perth sand penetrometer testing was carried out adjacent to each test pit location in accordance with AS 1289.6.3.3, to assess the in situ density of the subgrade.

The infiltration tests were performed using the falling head method at depths of 0.9 m and 1 m below existing ground level. The location, depth of testing and results are outlined in Section 4.3.

Test locations were determined using a hand-held GPS and site features and are marked on Drawing 1 in Appendix B. Surface elevations at the test locations were extrapolated from a level survey plan provided by the client. Levels on the borehole logs in Appendix C are quoted relative to the Australian Height Datum (AHD).

4. Field Work Results

4.1 Ground Conditions

Detailed logs of the ground conditions are presented in Appendix C, and should be read in conjunction with the notes defining descriptive terms and classification methods provided in Appendix A.

A summary of the ground conditions encountered at the test locations is given below:

- **SANDY TOPSOIL (SAND SP-SM) –** 50 mm thick, fine to medium grained, grey-brown, with silt, roots and rootlets and trace gravel, at test locations 1 to 3, 5, 6 and 10.

  The topsoil was recorded as Sandy GRAVEL (FILL) GP-GM: fine to medium sized basalt gravel, grey-brown, with silt and rootlets, at test location 6.
- **Unit 1: SANDY AND GRAVELLY FILL (SAND SP-SM and Sandy GRAVEL GP-GM) –** dense to very dense, grey-brown, fine to medium grained, fine to coarse sized basalt gravel, with silt, at test location 6 underlying the topsoil to a depth 0.5 m below existing ground level.
- **Unit 2: Bassendean Sand (SAND SP) –** generally very loose to loose, becoming medium dense with depth, yellow-grey-brown, fine to medium grained, trace silt, at all test locations to a maximum

test termination depth of 3 m below existing ground levels. The sand is typically loose across the site, to depths of between 0.3 m and 1.5 m below surface level, with the depths and levels to the base of the loose sand summarised in Table 1 below.

Table 1: Summary of Very Loose to Loose Zones

Test Location	Surface Level (m AHD)[1]	Very Loose to Loose Zones			
		Depth (m)		Depth (m)	
		From	From	From	From
1	31.8	GL	1.5	31.8	30.3
2	33.8	GL	0.3	33.8	33.5
		0.9	1.35	32.9	32.45
3	35.8	GL	1.2	35.8	34.6
4	32.0	GL	0.45	32.0	31.55
5	33.0	GL	1.05	33.0	31.95
7	30.0	GL	0.6	30.6	29.4
8	27.1	GL	0.3	27.1	26.8
9	27.2	GL	0.9	27.2	26.3
10	33.1	GL	0.45	33.1	32.65
		0.9	>1.2	32.2	<31.9

Notes [1]: Surface elevation extrapolated from a level survey plan provided by the client.
GL: Existing ground surface level.

4.2 Groundwater

No free groundwater was observed in the boreholes to a maximum depth of 3 m below existing ground levels (approximate RL 24.1 m), on 28 August 2020. The boreholes were immediately backfilled following sampling, which precluded any longer-term monitoring of groundwater levels.

It should be noted that groundwater levels are potentially affected by various factors such as climatic conditions and land usage and will therefore vary with time.

As described in Section 2, the Perth Groundwater Atlas (2004) indicates that the regional groundwater level beneath the site in May 2003, was at approximately RL 21 m.

The Perth Groundwater Atlas (1997) indicates that the maximum regional groundwater level beneath the site, was at approximately RL 23 m. Available data from the Department of Water and Environmental Regulation (DWER) indicates the presence of 20 historical bores within an approximate 1 km radius of the site.

From the abovementioned historical bores, records for four bores contain long term groundwater monitoring data (various data ranges between 1973 and 1996). These boreholes (Bores ID reference 61410100, 61410104, 61410099 and 61419636) are located approximately 460 m, 670 m, 680 m and 820 m to the southwest, east, southeast and northeast of the site, respectively. The available information from the DWER indicates that the boreholes monitor the Perth Superficial Aquifer (i.e. the groundwater aquifer observed beneath the site, with the groundwater monitoring results shown in Figures 1 to 4 next pages).

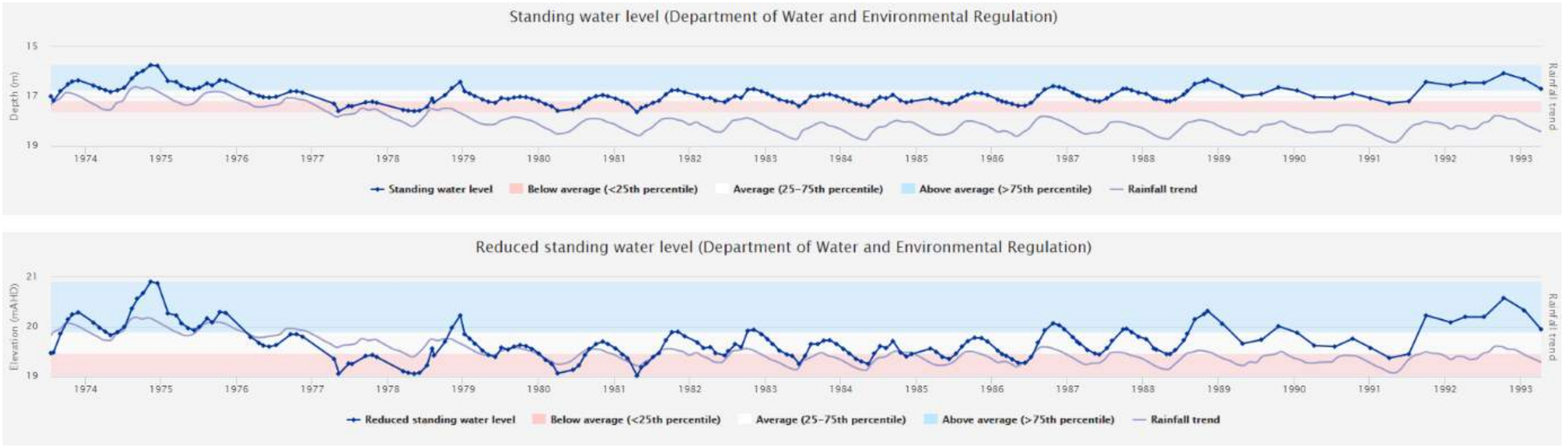


Figure 1: Extract from the Department of Water and Environmental Regulation (DWER) Bore (ID reference 61410100) Groundwater Monitoring

Figure 2: Extract from the Department of Water and Environmental Regulation (DWER) Bore (ID reference 61410104) Groundwater Monitoring

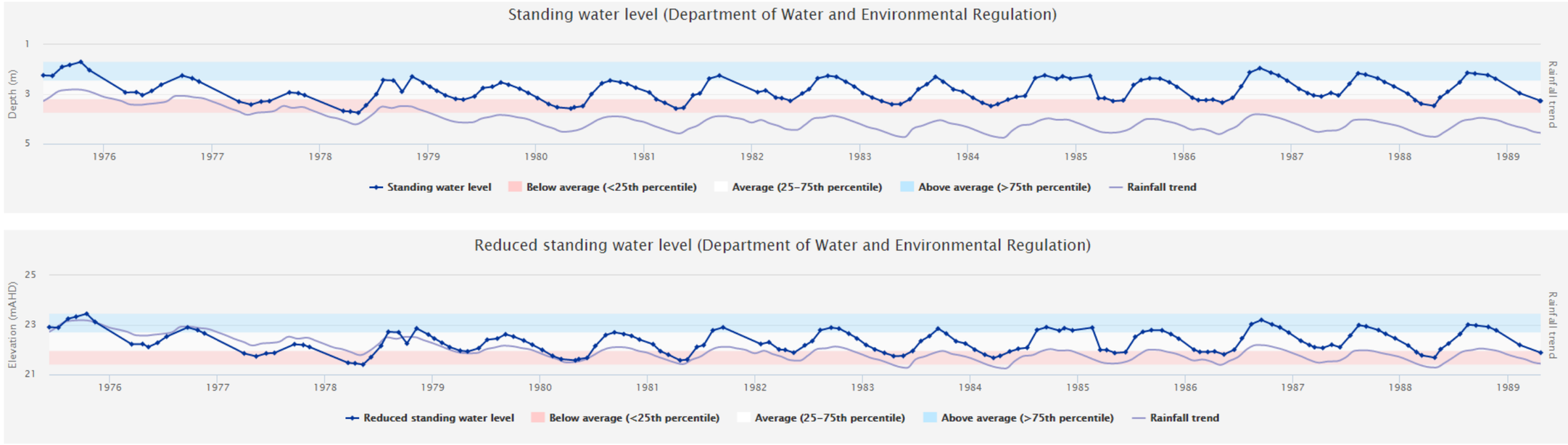


Figure 3: Extract from the Department of Water and Environmental Regulation (DWER) Bore (ID reference 61410099) Groundwater Monitoring

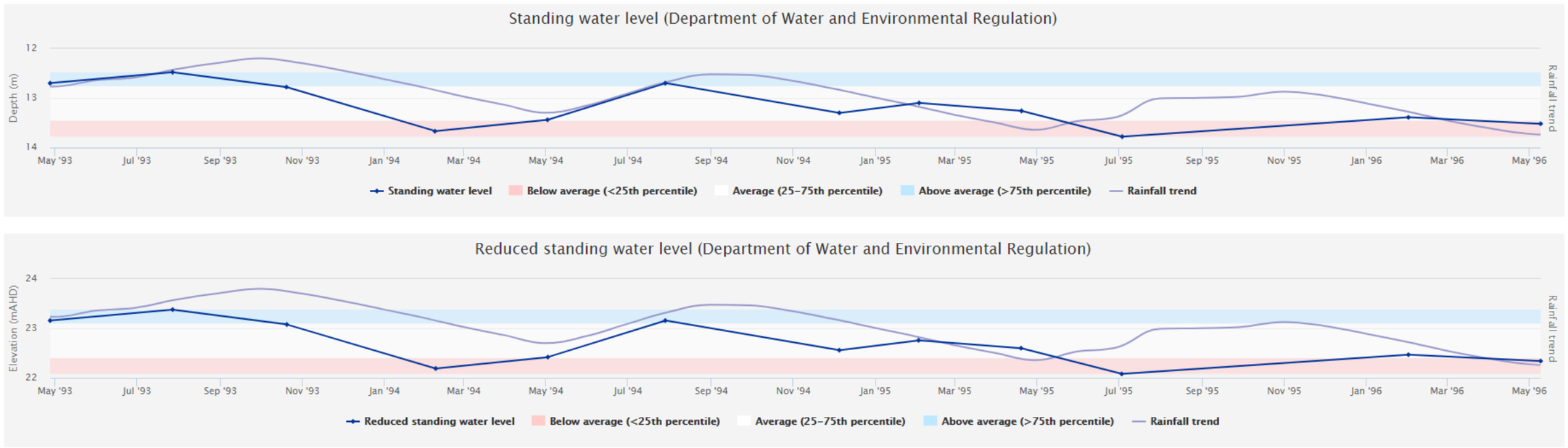


Figure 4: Extract from the Department of Water and Environmental Regulation (DWER) Bore (ID reference 61419636) Groundwater Monitoring

Review of the available data for the monitoring bores mentioned in the previous pages, indicates groundwater levels with minimum and maximum level fluctuations of between 0.8 m and 1.2 m.

Based on our experience, the abovementioned seasonal fluctuations from minimum to maximum groundwater levels is within a typical range for the Superficial Regional Aquifer in this part of the Perth Coastal Plain.

The groundwater measurements also indicate that the lowest groundwater levels occur between March and May, and the highest groundwater levels occur between August and October.

Based on the available groundwater information, a maximum groundwater level of RL 23.5 m (i.e. approximately 3.5 m below the lowest existing site level), is suggested for the site, based on:

- Groundwater information from the Perth Groundwater Atlas (1997 and 2004); and
- The groundwater readings within the monitoring bores located approximately 460 m, 670 m, 680 m and 820 m to the southwest, east, southeast and northeast of the site (Bore ID references 61410100, 61410104, 61410099 and 61419636).

4.3 Results of Infiltration Testing

Two in situ infiltration tests were carried out at test locations 9 and 10 using the falling head method, at depths of 0.9 m and 1 m below existing ground levels. Field permeability values were estimated using a method derived from a calculation by Hvorslev (1951). Permeability can also be estimated from particle size distribution test results from samples taken from the same depths at infiltration test locations, using the Hazen's formula. The Hazen's formula provides an indication of the permeability for clean sand with rounded particle shape in loose conditions. Table 2 below summarises the permeability results.

Table 2: Summary of Permeability Analysis

Test Location	Depth (m)	Measured Permeability		Derived Permeability[1]		In situ Conditions of Tested Material
		(m/s)	(m/day)	(m/s)	(m/day)	
9	0.9	1.5×10^{-3}	>25	6.3×10^{-4}	>25	SAND SP trace silt, loose
10	1.0	1.8×10^{-3}	>25	6.3×10^{-4}	>25	SAND SP trace silt, loose

Note: [1]: Hazen's formula (assumes sand in loose condition, with rounded sand particles).

5. Laboratory Testing

A geotechnical laboratory testing programme has been scheduled with a National Association of Testing Authorities (NATA) registered laboratory, and comprised the determination of the particle size distribution and the phosphorous retention index (PRI) of two samples.

The detailed test certificates are presented in Appendix D, with the results summarised in Table 3 below.

Table 3: Summary of Laboratory Testing for Soil Characterisation

Test Location	Depth (m)	Fines (%)	Sand (%)	Gravel (%)	D_{10}	D_{60}	Phosphorous Retention Index	Material
9	0.9 – 1.0	1	99	0	0.25	0.52	5.2	SAND SP trace silt
10	0.9 – 1.0	2	98	0	0.25	0.52	2.2	SAND SP trace silt

Notes: Fines are particles smaller than 75 µm.
Sand is particles larger than 75 µm and smaller than 2.36 mm.
Gravel is particles larger than 2.36 mm and smaller than 63 mm.
A D_{10} of 0.25 mm means that 10% of the sample particles are less than 0.25 mm.
A D_{60} of 0.52 mm means that 60% of the sample particles are less than 0.52 mm.

6. Proposed Development

It is understood that the proposed development will comprise the subdivision of the site into 36 residential lots, together with associated access roads and a drainage basin at the south eastern corner of the site.

It is also understood that cut and fill operations will be undertaken across the site, in particular at the location of the proposed drainage basin (south eastern corner of the site), where site levels are proposed to be raised by around 4 m.

7. Comments

7.1 Site Suitability

The results of the investigation indicate that ground conditions across the site generally comprise shallow loose sand materials of Unit 2 (Refer to Section 4.1), becoming medium dense with depth.

No free groundwater was observed in the boreholes to a maximum depth of 3 m below existing ground levels (approximate RL 24.1 m), on 28 August 2020.

Based on the available information, a minor geotechnical constraint likely to be imposed on the proposed residential subdivision by the soil conditions include the occurrence of shallow loose materials that could result in ground settlement from the densification of such materials, by loads imposed by possible proposed fill and structures.

From a geotechnical standpoint, the land is considered to be physically capable of development provided the abovementioned ground constraint is addressed in the following sections of this report.

7.2 Site Classification

The site should be classified as 'Class A' in accordance with AS2870, following suitable site preparation as described in Section 7.3.

It is noted that AS 2870 applies to single houses, townhouses and the like classified as Class 1 and 10a under the Building Code of Australia. It also applies to light industrial and commercial buildings if they are similar in size, loading and superstructure flexibility to those designs included in AS 2870.

7.3 Site Preparation

It is recommended that all site works be undertaken under the supervision of an experienced geotechnical engineer.

All topsoil, vegetation and rubbish materials should be stripped from the site area. Topsoil was recorded over thicknesses of 50 mm. Any areas of deeper organic materials encountered during stripping should be removed. The possible re-use of topsoil following blending, is discussed in Section 7.7.

Tree roots, if any, remaining from any clearing operations should be completely removed, and the excavations backfilled with material of similar geotechnical properties to the surrounding ground and compacted to achieve a dry density ratio of not less than 95% relative to modified compaction.

It is recommended that following site stripping, the subgrade be assessed by a geotechnical engineer to determine whether previous natural topsoil, rubbish, vegetation or roots remain. Any such materials will require removal and the excavations backfilled with material of similar geotechnical properties to the surrounding ground.

As described in Section 4.1, loose sand was recorded at all test locations, with the exception of test location 6, to depths of between 0.3 m and 1.5 m. It is understood that cut and fill operations will be undertaken across the site, and thus the majority of the loose materials are likely to be removed within areas where deep cut (say more than 0.5 m) is proposed. Loose sand remaining below house lots and pavements, following any cut and prior to any fill, is required to be compacted to achieve medium dense conditions.

Therefore, following stripping and cutting of site levels, and prior to placement of any fill, it is recommended that the site is proof compacted using a medium vibrating smooth drum roller. Any areas that show signs of excessive deformation during compaction should be continually compacted until deformation ceases or, alternatively, the poor quality material could be excavated and replaced with suitable structural fill compacted to achieve a dry density ratio of not less than 95% relative to modified compaction. Verification of the compaction of the loose sand across the site should be undertaken by a geotechnical engineer.

During construction, some loosening of the surface sands in the foundation excavations is expected. Therefore, the top 300 mm in the base of any foundation excavations should be re-compacted using a vibratory plate compactor prior to construction of the footings.

Compaction control in sand could be carried out using a Perth sand penetrometer (PSP) test in accordance with test method AS 1289.6.3.3. It is suggested that the sand subgrade should be

compacted to achieve a minimum blow count of 8 blows per 300 mm rod penetration to a depth of not less than 1 m below foundation level. It should be noted that this compaction level has not been directly correlated to a dry density of 95% relative to modified compaction. Lower blow counts than the above level may be acceptable provided that a correlation between Perth sand penetrometer (PSP) test and dry density ratio has been established by a NATA accredited laboratory and following review by a geotechnical engineer.

7.4 Excavation Conditions, Batter Slopes and Groundwater

Based on the ground conditions described in Section 4.1, excavations associated with bulk earthworks, service trenches and foundations are anticipated to be undertaken through dense to very dense fill, where present and medium dense natural sand following site preparation as described in Section 7.3.

Excavations should therefore be readily achieved using typical earthmoving equipment (i.e. excavators, loaders and scrapers).

During construction, it is recommended that batter slopes not steeper than 1.5H:1V (horizontal : vertical) be adopted for temporary excavations not deeper than 3 m in sand.

As mentioned in Section 4.2, groundwater was not observed in the boreholes drilled on 26 August 2020, to a depth of 3 m, and is not anticipated within 3.5 m of the lowest site level (see Section 4.2 for suggested maximum groundwater level at the site). Therefore, groundwater is unlikely to impact the proposed excavations to these depths.

7.5 Design Parameters for Earth Retaining Systems

Design parameters for temporary and permanent earth retaining structures for the soils encountered at the site, are presented in Table 4 below.

Table 4: Suggested Soil Parameters for Retaining Wall Design

Unit	Soil Type	Drained Angle of Friction Φ (degrees)	Soil Unit Weight above Water γ (kN/m³)	Elastic Modulus E' (MPa)	Coefficient of Earth Pressure[1]		
					K_0	K_p[1]	K_a
Units 1 and 2	Very loose to loose sand[2]	28	16	5	0.53	2.8	0.36
	Medium dense and denser sand and sandy gravel fill, compacted fill and natural sand.	32	18	30	0.47	3.2	0.31

Note: [1] Ultimate values. A reduction factor not greater than 0.5 is suggested to derive a design value.
[2] Only valid if no compaction undertaken as part of site preparation.

7.6 Re-use of Excavated Material and Imported Fill

The encountered sand and sandy gravel fill and naturally occurring sand excavated from the site or imported sand fill, if required, should be suitable for re-use as structural fill, provided it comprises free

draining cohesionless sand with less than 5% by weight of particles passing a 0.075 mm sieve. The material should be free from organic matter and particles greater than 150 mm in size.

If re-used as structural fill, the sand and sandy gravel materials should be placed in layers within 2% of the standard optimum moisture content. Each layer should be compacted to achieve a dry density ratio of not less than 95% relative to modified compaction.

Compaction control could be carried out using a PSP, as described in Section 7.3. In accordance with AS1289, the use of PSP is limited to granular soils with a maximum particle size not exceeding 2 mm. It is recommended that verification of the compaction works be undertaken by an experienced geotechnical engineer.

7.7 Re-use of Topsoil

Sandy topsoil was recorded over a thickness of 50 mm within the boreholes undertaken at the site. Topsoil could be considered for re-use as fill, provided that:

- The bulk of the large organic particles are removed from the material by passing it through a screen with minimum aperture size of 25 mm, or by initially stripping off the bulk of the vegetation and root mass using a grader to limit the quantity of organic material within the underlying topsoil; and
- It is blended at a suitable ratio with clean sand. A suitable blending ratio of approximately 2:1 (clean sand : topsoil) is tentatively suggested at this stage, but this blending ratio should be refined following assessment of the material resulting from the screening operations. Results of the assessment will indicate any opportunities to favourably adjust the blending ratio (i.e. increasing the topsoil fraction and decreasing the sand fraction) based on the performance of the screening operations.

The contractor should develop a suitable method for the appropriate blending of the topsoil and clean sand on site. It is suggested that small scale blending could be undertaken by turning the materials using an excavator or loader bucket a sufficient number times to form a homogenous blended material. On a large scale, the use of a scraper to pick up, blend and place the materials is suggested. Alternatively, suitable blending should be achievable by placement of a 100 mm thick layer of topsoil and a 200 mm thick layer of clean sand, followed by raking through the two material types with dozer or grader tynes and blades.

The suitability of the screened material should also be regularly assessed by a geotechnical engineer (including the determination of organic content, particle size gradings and modified maximum dry density) for approval prior to use as fill, which may also result in optimisation of the blending ratio.

Blended fill materials typically have a reduced permeability in comparison with clean sand, and therefore verification of the permeability of the blended material is suggested, prior to use. Any material considered unsuitable for use as fill by the geotechnical engineer should be removed from the site, or used in non-structural areas.

7.8 Foundation Design

Shallow foundation systems comprising slab, pad and strip footings should be suitable to support the proposed buildings. Footings of buildings covered by AS 2870-2011 should be designed to satisfy the requirements of this standard for 'Class A' conditions, provided that site preparation is carried out as outlined in Section 7.3.

It should be noted that AS 2870-2011 is applicable to residential structures and "other forms of construction including some light industrial, commercial and institutional buildings if they are similar to houses in size, loading and superstructure flexibility". For structures not covered by AS 2870-2011, shallow pad footings, strip footings and slabs founded at a depth of at least 0.5 m into medium dense or denser materials, are considered suitable to support the proposed structures. The design of such foundation systems can be based on the maximum allowable bearing pressures and associated settlement summarised in Table 5 below.

The allowable bearing pressures in Table 5 below are suggested, provided that site preparation is carried out as outlined in Section 7.3.

Table 5: Estimated Settlements of Square Pad and Strip Footings

Footing Size (m)		Founding Depth Below Existing Site Levels (m)	Allowable Bearing Pressure (kPa)	Estimated Total Settlement (mm)
Pad	1.0	0.5	210	5 - 10
	2.0			10 - 15
Strip	0.5		160	<5
	1.0			5 - 10
Pad	1.0	1.0	300	10 - 15
	2.0			20 - 25
Strip	0.5		250	5 - 10
	1.0			10 - 15

The majority of the settlement is anticipated to occur as loads are applied during construction. Long-term settlements are likely to be 10% to 20% of the total settlement and as such, are likely to be less than 5 mm.

7.9 Pavement Design Parameters

Based on field observations and Douglas Partners' experience, it is recommended that a subgrade CBR of 12% be used for the design of flexible pavements on the natural sand subgrade encountered at the site. Such CBR value is recommended, provided that such subgrade is compacted to achieve a dry density ratio of not less than 95% relative to modified compaction, as determined by AS 1289.5.2.1.

The subgrade for the proposed pavement is also likely to comprise sand fill, within areas where the site surface is proposed to be raised. If the materials excavated from site are re-used to raise site levels, then the above CBR value is recommended for such materials, provided that such materials are compacted to achieve a dry density ratio of not less than 95% relative to modified compaction, as determined by AS 1289.5.2.1.

However, in the event that imported granular fill is used to raise site levels, the pavement should be designed using an appropriate CBR of the material. A presumptive design CBR value of 12% is also suggested for such imported fill. However, such presumptive CBR value should be confirmed prior to pavement construction, once the imported fill material is known and its CBR has been assessed.

It is recommended that subgrade be inspected by a suitably experienced geotechnical engineer prior to placement of the pavement layers to identify unsuitable subgrade materials, if any.

7.10 Soil Permeability and Stormwater Disposal

The shallow ground conditions beneath the site generally comprise loose sand becoming medium dense with depth.

The results of the infiltration testing summarised in Section 4.3 indicates permeability values of between 6.3×10^{-4} m/s (>25 m/day) and 1.8×10^{-3} m/s (>25 m/day), for the shallow loose natural sand, in its in-situ condition.

To allow for possible variations in soil fines content and densification of the natural sand during site formation and construction, a preliminary design permeability for the natural sand of approximately 1.0×10^{-4} m/s (approximately 8 m/day) is suggested.

As described in Section 6 site levels at the location of the proposed drainage basin (south eastern corner of the site), are proposed to be raised by around 4 m. The above suggested preliminary design permeability could be adopted at the proposed drainage basin location, provided the natural sand at the site is re-used to raise site levels.

However, in the event that imported granular fill is used to raise site levels at this location, verification of the permeability of the imported fill is suggested, prior to use. Douglas Partners would be pleased to assist with such matter.

Observed ground conditions and permeability results indicate that on-site stormwater disposal using soakwells or the proposed drainage basin is feasible.

The infiltration capability commonly reduces over time due to silt build up at the base of soakwells and therefore the soakwells must be cleaned and maintained on a regular basis. Soakwells should be positioned at a distance from all buildings, retaining walls and boundaries by not less than 2 m.

7.11 Acid Sulfate Soil Risk

Published acid sulfate soil risk mapping for the area indicates that the site is located in an area of “moderate to low risk of acid sulfate soils occurring within 3 m of natural soils surface”. This level of risk

generally corresponds to the areas of Bassendean Sand as depicted by the published geological mapping.

The natural ground conditions encountered during the geotechnical investigation appear to be in broad agreement with the published geological mapping (i.e. Bassendean Sand). Thus, the level of acid sulfate soil risk assigned to such sands is considered to be supported by the encountered ground conditions.

Consequently, further detailed investigations for acid sulfate soils at this site are not considered to be warranted on the provision that dewatering for construction is not required.

8. References

1. Australian Standard AS2870-2011, 'Residential Slabs and Footings', April 2011, Standards Australia
2. Australian Standard AS 1289-2000, Methods of Testing Soils for Engineering Purposes.
3. Australian Standard AS 1289.6.3.3-1999, Soil Strength and Consolidation Tests-Determination of the Penetration Resistance of a Soil – Perth Sand Penetrometer Test.
4. Australian Standard AS 1726-1996, Geotechnical Site Investigation.
5. Department of Environment, Perth Groundwater Atlas, Second Edition, December 2004.
6. Department of Environment, Perth Groundwater Atlas, October 1997.

9. Limitations

Douglas Partners has prepared this report for the proposed residential subdivision at Lot 50 (193) Barfield Road in Hammond Park, WA, in accordance with Douglas Partners' proposal referenced PER200292 and dated 20 August 2020, and acceptance received from Mr Richard Williams of BPA Engineering on behalf of Glenbrook Civil Engineering Contractors Pty Ltd in an email dated 24 August 2020. The work was carried out under Douglas Partners' Conditions of Engagement. This report is provided for the exclusive use of Glenbrook Civil Engineering Contractors Pty Ltd for this project only and for the purposes as described in the report. It should not be used by or relied upon for other projects or purposes on the same or other site or by a third party. Any party so relying upon this report beyond its exclusive use and purpose as stated above, and without the express written consent of Douglas Partners, does so entirely at its own risk and without recourse to Douglas Partners for any loss or damage. In preparing this report Douglas Partners has necessarily relied upon information provided by the client and/or their agents.

The results provided in the report are indicative of the sub-surface conditions on the site only at the specific sampling and/or testing locations, and then only to the depths investigated and at the time the work was carried out. Subsurface conditions can change abruptly due to variable geological processes and also as a result of human influences. Such changes may occur after Douglas Partners' field testing has been completed.

Douglas Partners' advice is based upon the conditions encountered during this investigation. The accuracy of the advice provided by Douglas Partners in this report may be affected by undetected variations in ground conditions across the site between and beyond the sampling and/or testing locations.

This report must be read in conjunction with all of the attached and should be kept in its entirety without separation of individual pages or sections. Douglas Partners cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion stated in this report.

This report, or sections from this report, should not be used as part of a specification for a project, without review and agreement by Douglas Partners. This is because this report has been written as advice and opinion rather than instructions for construction.

The contents of this report do not constitute formal design components such as are required, by the Health and Safety Legislation and Regulations, to be included in a Safety Report specifying the hazards likely to be encountered during construction and the controls required to mitigate risk. This design process requires risk assessment to be undertaken, with such assessment being dependent upon factors relating to likelihood of occurrence and consequences of damage to property and to life. This, in turn, requires project data and analysis presently beyond the knowledge and project role respectively of Douglas Partners. Douglas Partners may be able, however, to assist the client in carrying out a risk assessment of potential hazards contained in the Comments section of this report, as an extension to the current scope of works, if so requested, and provided that suitable additional information is made available to Douglas Partners. Any such risk assessment would, however, be necessarily restricted to the geotechnical components set out in this report and to their application by the project designers to project design, construction, maintenance and demolition.

Douglas Partners Pty Ltd

Appendix A

About This Report

About this Report

Douglas Partners

Introduction

These notes have been provided to amplify DP's report in regard to classification methods, field procedures and the comments section. Not all are necessarily relevant to all reports.

DP's reports are based on information gained from limited subsurface excavations and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Copyright

Borehole and Test Pit Logs

The borehole and test pit logs presented in this report are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling or excavation. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable or possible to justify on economic grounds. In any case the boreholes and test pits represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes or pits, the frequency of sampling, and the possibility of other than 'straight line' variations between the test locations.

Groundwater

Where groundwater levels are measured in boreholes there are several potential problems, namely:

- In low permeability soils groundwater may enter the hole very slowly or perhaps not at all during the time the hole is left open;
- A localised, perched water table may lead to an erroneous indication of the true water table;
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report; and
- The use of water or mud as a drilling fluid will mask any groundwater inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water measurements are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Reports

The report has been prepared by qualified personnel, is based on the information obtained from field and laboratory testing, and has been undertaken to current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal, the information and interpretation may not be relevant if the design proposal is changed. If this happens, DP will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface conditions, discussion of geotechnical and environmental aspects, and recommendations or suggestions for design and construction. However, DP cannot always anticipate or assume responsibility for:

- Unexpected variations in ground conditions. The potential for this will depend partly on borehole or pit spacing and sampling frequency;
- Changes in policy or interpretations of policy by statutory authorities; or
- The actions of contractors responding to commercial pressures.

If these occur, DP will be pleased to assist with investigations or advice to resolve the matter.

About this Report

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, DP requests that it be immediately notified. Most problems are much more readily resolved when conditions are exposed rather than at some later stage, well after the event.

Information for Contractual Purposes

Where information obtained from this report is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. DP would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The company will always be pleased to provide engineering inspection services for geotechnical and environmental aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are generally based on Australian Standard AS1726:2017, Geotechnical Site Investigations. In general, the descriptions include strength or density, colour, structure, soil or rock type and inclusions.

Soil Types

Soil types are described according to the predominant particle size, qualified by the grading of other particles present:

Type	Particle size (mm)
Boulder	>200
Cobble	63 - 200
Gravel	2.36 - 63
Sand	0.075 - 2.36
Silt	0.002 - 0.075
Clay	<0.002

The sand and gravel sizes can be further subdivided as follows:

Type	Particle size (mm)
Coarse gravel	19 - 63
Medium gravel	6.7 - 19
Fine gravel	2.36 – 6.7
Coarse sand	0.6 - 2.36
Medium sand	0.21 - 0.6
Fine sand	0.075 - 0.21

Definitions of grading terms used are:

- Well graded - a good representation of all particle sizes
- Poorly graded - an excess or deficiency of particular sizes within the specified range
- Uniformly graded - an excess of a particular particle size
- Gap graded - a deficiency of a particular particle size with the range

The proportions of secondary constituents of soils are described as follows:

In fine grained soils (>35% fines)

Term	Proportion of sand or gravel	Example
And	Specify	Clay (60%) and Sand (40%)
Adjective	>30%	Sandy Clay
With	15 – 30%	Clay with sand
Trace	0 - 15%	Clay with trace sand

In coarse grained soils (>65% coarse)
- with clays or silts

Term	Proportion of fines	Example
And	Specify	Sand (70%) and Clay (30%)
Adjective	>12%	Clayey Sand
With	5 - 12%	Sand with clay
Trace	0 - 5%	Sand with trace clay

In coarse grained soils (>65% coarse)
- with coarser fraction

Term	Proportion of coarser fraction	Example
And	Specify	Sand (60%) and Gravel (40%)
Adjective	>30%	Gravelly Sand
With	15 - 30%	Sand with gravel
Trace	0 - 15%	Sand with trace gravel

The presence of cobbles and boulders shall be specifically noted by beginning the description with 'Mix of Soil and Cobbles/Boulders' with the word order indicating the dominant first and the proportion of cobbles and boulders described together.

Soil Descriptions

Cohesive Soils

Cohesive soils, such as clays, are classified on the basis of undrained shear strength. The strength may be measured by laboratory testing, or estimated by field tests or engineering examination. The strength terms are defined as follows:

Description	Abbreviation	Undrained shear strength (kPa)
Very soft	VS	<12
Soft	S	12 - 25
Firm	F	25 - 50
Stiff	St	50 - 100
Very stiff	VSt	100 - 200
Hard	H	>200
Friable	Fr	-

Cohesionless Soils

Cohesionless soils, such as clean sands, are classified on the basis of relative density, generally from the results of standard penetration tests (SPT), cone penetration tests (CPT) or dynamic penetrometers (PSP). The relative density terms are given below:

Relative Density	Abbreviation	Density Index (%)
Very loose	VL	<15
Loose	L	15-35
Medium dense	MD	35-65
Dense	D	65-85
Very dense	VD	>85

Soil Origin

It is often difficult to accurately determine the origin of a soil. Soils can generally be classified as:

- Residual soil - derived from in-situ weathering of the underlying rock;
- Extremely weathered material – formed from in-situ weathering of geological formations. Has soil strength but retains the structure or fabric of the parent rock;
- Alluvial soil – deposited by streams and rivers;
- Estuarine soil – deposited in coastal estuaries;
- Marine soil – deposited in a marine environment;
- Lacustrine soil – deposited in freshwater lakes;
- Aeolian soil – carried and deposited by wind;
- Colluvial soil – soil and rock debris transported down slopes by gravity;
- Topsoil – mantle of surface soil, often with high levels of organic material.
- Fill – any material which has been moved by man.

Moisture Condition – Coarse Grained Soils

For coarse grained soils the moisture condition should be described by appearance and feel using the following terms:

- Dry (D) Non-cohesive and free-running.
- Moist (M) Soil feels cool, darkened in colour.
  Soil tends to stick together.
  Sand forms weak ball but breaks easily.
- Wet (W) Soil feels cool, darkened in colour.
  Soil tends to stick together, free water forms when handling.

Moisture Condition – Fine Grained Soils

For fine grained soils the assessment of moisture content is relative to their plastic limit or liquid limit, as follows:

- 'Moist, dry of plastic limit' or 'w <PL' (i.e. hard and friable or powdery).
- 'Moist, near plastic limit' or 'w ≈ PL (i.e. soil can be moulded at moisture content approximately equal to the plastic limit).
- 'Moist, wet of plastic limit' or 'w >PL' (i.e. soils usually weakened and free water forms on the hands when handling).
- 'Wet' or 'w ≈LL' (i.e. near the liquid limit).
- 'Wet' or 'w >LL' (i.e. wet of the liquid limit).

Symbols & Abbreviations

Douglas Partners

Introduction

These notes summarise abbreviations commonly used on borehole logs and test pit reports.

Drilling or Excavation Methods

C	Core drilling
R	Rotary drilling
SFA	Spiral flight augers
NMLC	Diamond core - 52 mm dia
NQ	Diamond core - 47 mm dia
HQ	Diamond core - 63 mm dia
PQ	Diamond core - 81 mm dia

Water

▷	Water seep
▽	Water level

Sampling and Testing

A	Auger sample
B	Bulk sample
D	Disturbed sample
E	Environmental sample
U_{50}	Undisturbed tube sample (50mm)
W	Water sample
pp	Pocket penetrometer (kPa)
PID	Photo ionisation detector
PL	Point load strength Is(50) MPa
S	Standard Penetration Test
V	Shear vane (kPa)

Description of Defects in Rock

The abbreviated descriptions of the defects should be in the following order: Depth, Type, Orientation, Coating, Shape, Roughness and Other. Drilling and handling breaks are not usually included on the logs.

Defect Type

B	Bedding plane
Cs	Clay seam
Cv	Cleavage
Cz	Crushed zone
Ds	Decomposed seam
F	Fault
J	Joint
Lam	Lamination
Pt	Parting
Sz	Sheared Zone
V	Vein

Orientation

The inclination of defects is always measured from the perpendicular to the core axis.

h	horizontal
v	vertical
sh	sub-horizontal
sv	sub-vertical

Coating or Infilling Term

cln	clean
co	coating
he	healed
inf	infilled
stn	stained
ti	tight
vn	veneer

Coating Descriptor

ca	calcite
cbs	carbonaceous
cly	clay
fe	iron oxide
mn	manganese
slt	silty

Shape

cu	curved
ir	irregular
pl	planar
st	stepped
un	undulating

Roughness

po	polished
ro	rough
sl	slickensided
sm	smooth
vr	very rough

Other

fg	fragmented
bnd	band
qtz	quartz

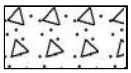
Symbols & Abbreviations

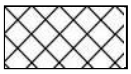
Graphic Symbols for Soil and Rock

General


Asphalt


Road base


Concrete


Filling

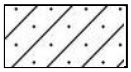
Soils


Topsoil

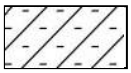

Peat

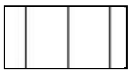

Clay

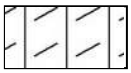

Silty clay

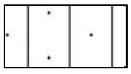

Sandy clay

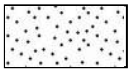

Gravelly clay


Shaly clay

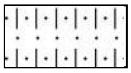

Silt


Clayey silt


Sandy silt

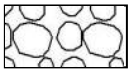

Sand

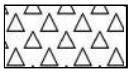

Clayey sand


Silty sand


Gravel

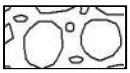

Sandy gravel


Cobbles, boulders

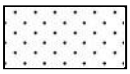

Talus

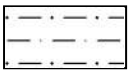
Sedimentary Rocks

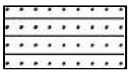

Boulder conglomerate

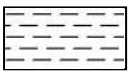

Conglomerate


Conglomeratic sandstone

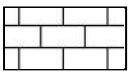

Sandstone


Siltstone

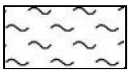

Laminite

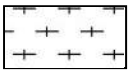

Mudstone, claystone, shale

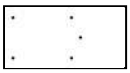

Coal


Limestone

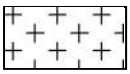
Metamorphic Rocks

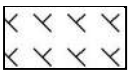

Slate, phyllite, schist

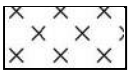

Gneiss

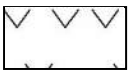

Quartzite

Igneous Rocks


Granite


Dolerite, basalt, andesite


Dacite, epidote


Tuff, breccia


Porphyry

Sampling Methods

Douglas Partners

Sampling

Sampling is carried out during drilling or test pitting to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing it to obtain a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Test Pits

Test pits are usually excavated with a backhoe or an excavator, allowing close examination of the in-situ soil if it is safe to enter into the pit. The depth of excavation is limited to about 3 m for a backhoe and up to 6 m for a large excavator. A potential disadvantage of this investigation method is the larger area of disturbance to the site.

Large Diameter Augers

Boreholes can be drilled using a rotating plate or short spiral auger, generally 300 mm or larger in diameter commonly mounted on a standard piling rig. The cuttings are returned to the surface at intervals (generally not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube samples.

Continuous Spiral Flight Augers

The borehole is advanced using 90-115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in clays and sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are disturbed and may be mixed with soils from the sides of the hole. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively low reliability, due to the remoulding, possible mixing or softening of samples by groundwater.

Non-core Rotary Drilling

The borehole is advanced using a rotary bit, with water or drilling mud being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from the rate of penetration. Where drilling mud is used this can mask the cuttings and reliable identification is only possible from separate sampling such as SPTs.

Continuous Core Drilling

A continuous core sample can be obtained using a diamond tipped core barrel, usually with a 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in weak rocks and granular soils), this technique provides a very reliable method of investigation.

Standard Penetration Tests

Standard penetration tests (SPT) are used as a means of estimating the density or strength of soils and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, Methods of Testing Soils for Engineering Purposes - Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of, say, 4, 6 and 7 as:

  4,6,7
  N=13

- In the case where the test is discontinued before the full penetration depth, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm as:

  15, 30/40 mm

The results of the SPT tests can be related empirically to the engineering properties of the soils.

Dynamic Cone Penetrometer Tests / Perth Sand Penetrometer Tests

Dynamic penetrometer tests (DCP or PSP) are carried out by driving a steel rod into the ground using a standard weight of hammer falling a specified distance. As the rod penetrates the soil the number of blows required to penetrate each successive 150 mm depth are recorded. Normally there is a depth limitation of 1.2 m, but this may be extended in certain conditions by the use of extension rods. Two types of penetrometer are commonly used.

- Perth sand penetrometer - a 16 mm diameter flat ended rod is driven using a 9 kg hammer dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands and is mainly used in granular soils and filling.
- Cone penetrometer - a 16 mm diameter rod with a 20 mm diameter cone end is driven using a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). This test was developed initially for pavement subgrade investigations, and correlations of the test results with California Bearing Ratio have been published by various road authorities.

Appendix B

Drawing

Douglas Partners Geotechnics / Environment / Groundwater	**Test Location Plan** **Proposed Residential Subdivision** **Lot 50 Barfield Road, Hammond Park, WA**	PROJECT: 96711.00 Drawing No: 1 REV: 0
	CLIENT: Glenbrook Civil Engineering Contractors Pty Ltd	DATE: 27/8/2020

Appendix C

Field Work Results

BOREHOLE LOG

CLIENT: Glenbrook Civil Engineering Contractors Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: Lot 50 Barfield Road, Hammond Park, WA

SURFACE LEVEL: 31.8 m AHD*
EASTING: 391917
NORTHING: 6439395
DIP/AZIMUTH: 90°/--

BORE No: 1
PROJECT No: 96711.00
DATE: 26/8/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
31	0.05	TOPSOIL/SAND SP-SM: fine to medium grained, grey-brown, with silt and rootlets, moist.							
	1	SAND SP: fine to medium grained, light yellow-brown, trace silt, moist, loose.		D	1.3				
30	2	- becoming medium dense from 1.5 m depth.							
29	3	3.0 Bore discontinued at 3.0m (Target depth)							

RIG: 110 mm diameter hand auger **DRILLER:** YC **LOGGED:** YC **CASING:**

TYPE OF BORING: Hand auger

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level extrapolated from a survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Glenbrook Civil Engineering Contractors Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: Lot 50 Barfield Road, Hammond Park, WA

SURFACE LEVEL: 33.8 m AHD*
EASTING: 391963
NORTHING: 6439377
DIP/AZIMUTH: 90°/--

BORE No: 2
PROJECT No: 96711.00
DATE: 26/8/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
33	0.05	TOPSOIL/SAND SP-SM: fine to medium grained, dark grey-brown, with silt and rootlets, moist.							
	1	SAND SP: fine to medium grained, grey-brown, trace silt, moist, loose. - becoming medium dense from 0.3 m depth. - becoming yellow-brown from 0.4 m depth. - becoming loose between 0.9 m to 1.35 m depth.							
32	2								
31	3 3.0	Bore discontinued at 3.0m (Target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm diameter hand auger **DRILLER:** YC **LOGGED:** YC **CASING:**

TYPE OF BORING: Hand auger

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level extrapolated from a survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Glenbrook Civil Engineering Contractors Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: Lot 50 Barfield Road, Hammond Park, WA

SURFACE LEVEL: 35.8 m AHD*
EASTING: 392007
NORTHING: 6439398
DIP/AZIMUTH: 90°/--

BORE No: 3
PROJECT No: 96711.00
DATE: 26/8/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
35	0.05	TOPSOIL/SAND SP-SM: fine to medium grained, dark grey-brown, with silt and rootlets, moist.							
		SAND SP: fine to medium grained, grey-brown, trace silt and roots, moist, very loose to loose.		D	0.4				
	1	- becoming light grey-brown from 1.0 m depth.							
		- becoming medium dense from 1.2 m depth.							
34		- becoming light yellow-brown from 1.5 m depth.							
	2								
33	3	3.0 Bore discontinued at 3.0m (Target depth)							

RIG: 110 mm diameter hand auger **DRILLER:** YC **LOGGED:** YC **CASING:**

TYPE OF BORING: Hand auger

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level extrapolated from a survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Glenbrook Civil Engineering Contractors Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: Lot 50 Barfield Road, Hammond Park, WA

SURFACE LEVEL: 32.0 m AHD*
EASTING: 392015
NORTHING: 6439341
DIP/AZIMUTH: 90°/--

BORE No: 4
PROJECT No: 96711.00
DATE: 26/8/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
32	0	SAND SP: fine to medium grained, grey-brown, trace silt, moist, loose.							
		- becoming light yellow-brown, medium dense from 0.45 m depth.		D	0.5				
31	1								1
		- becoming yellow-brown from 1.5 m depth.							
30	2								2
29	3	3.0 Bore discontinued at 3.0m (Target depth)							3

RIG: 110 mm diameter hand auger **DRILLER:** YC **LOGGED:** YC **CASING:**

TYPE OF BORING: Hand auger

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level extrapolated from a survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Glenbrook Civil Engineering Contractors Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: Lot 50 Barfield Road, Hammond Park, WA

SURFACE LEVEL: 33.0 m AHD*
EASTING: 391919
NORTHING: 6439340
DIP/AZIMUTH: 90°/--

BORE No: 5
PROJECT No: 96711.00
DATE: 26/8/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
33	0.05	TOPSOIL/SAND SP-SM: fine to medium grained, grey-brown, with silt and rootlets, moist.							
		SAND SP: fine to medium grained, grey-brown, trace silt, moist, loose.		D	0.3				
		- becoming yellow-brown from 0.5 m depth.							
32	1	- becoming medium dense from 1.05 m depth.							1
31	2								2
30	3	3.0 Bore discontinued at 3.0m (Target depth)							3

RIG: 110 mm diameter hand auger **DRILLER:** YC **LOGGED:** YC **CASING:**

TYPE OF BORING: Hand auger

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level extrapolated from a survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Glenbrook Civil Engineering Contractors Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: Lot 50 Barfield Road, Hammond Park, WA

SURFACE LEVEL: 30.2 m AHD*
EASTING: 391963
NORTHING: 6439309
DIP/AZIMUTH: 90°/--

BORE No: 6
PROJECT No: 96711.00
DATE: 26/8/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
30	0.05	TOPSOIL/Sandy GRAVEL GP-GM: fine to medium sized basalt gravel, grey-brown, with silt and rootlets, moist. Sand is fine to medium grained.							
	0.1								
	0.3	FILL/Sandy GRAVEL GP-GM: fine to medium sized basalt gravel, grey-brown, with silt, moist, dense. Sand is fine to medium grained.							
	0.5	FILL/Sandy GRAVEL GP-GM: fine to coarse sized limestone gravel, light brown, with silt, moist, dense. Sand is fine to medium grained.		D	0.8				
29	1	FILL/SAND SP-SM: fine to medium grained, dark grey-brown, with silt, trace gravel, moist, very dense.							
		SAND SP: fine to medium grained, light grey, trace silt, moist, dense to very dense.							
		- becoming medium dense from 1.05 m depth.							
28	2	- becoming light yellow-brown from 2.0 m depth.							
	3	3.0 Bore discontinued at 3.0m (Target depth)							
27									

RIG: 110 mm diameter hand auger **DRILLER:** YC **LOGGED:** YC **CASING:**

TYPE OF BORING: Hand auger

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level extrapolated from a survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Glenbrook Civil Engineering Contractors Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: Lot 50 Barfield Road, Hammond Park, WA

SURFACE LEVEL: 30.0 m AHD*
EASTING: 391914
NORTHING: 6439279
DIP/AZIMUTH: 90°/--

BORE No: 7
PROJECT No: 96711.00
DATE: 26/8/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
30		SAND SP: fine to medium grained, light grey-brown, trace silt, moist, very loose to loose.							
		- becoming medium dense from 0.6 m depth.							
29	1								1
		- becoming yellow-brown from 1.4 m depth.							
28	2								2
		- trace of very weakly cemented sand gravel from 2.5 m depth.							
27	3	3.0 Bore discontinued at 3.0m (Target depth)							3

RIG: 110 mm diameter hand auger **DRILLER:** YC **LOGGED:** YC **CASING:**

TYPE OF BORING: Hand auger

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level extrapolated from a survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Glenbrook Civil Engineering Contractors Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: Lot 50 Barfield Road, Hammond Park, WA

SURFACE LEVEL: 27.1 m AHD*
EASTING: 391965
NORTHING: 6439275
DIP/AZIMUTH: 90°/--

BORE No: 8
PROJECT No: 96711.00
DATE: 26/8/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
27	0	SAND SP: fine to medium grained, grey-brown, with rootlets to 0.05 m depth, trace silt, moist, loose.							
		- becoming light yellow-brown, medium dense from 0.3 m depth.							
26	1	- becoming yellow-brown from 1.2 m depth.							
25	2								
	3								
24	3.0	Bore discontinued at 3.0m (Target depth)							

Dynamic Penetrometer Test (blows per 150mm): 5, 10, 15, 20

RIG: 110 mm diameter hand auger **DRILLER:** YC **LOGGED:** YC **CASING:**

TYPE OF BORING: Hand auger

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level extrapolated from a survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Glenbrook Civil Engineering Contractors Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: Lot 50 Barfield Road, Hammond Park, WA

SURFACE LEVEL: 27.2 m AHD*
EASTING: 391999
NORTHING: 6439285
DIP/AZIMUTH: 90°/--

BORE No: 9
PROJECT No: 96711.00
DATE: 26/8/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
27	0.5	SAND SP-SM: fine to medium grained, dark grey-brown, with silt, with roots, moist, very loose to loose.							
		SAND SP: fine to medium grained, light yellow-brown, trace silt, moist, loose.							
26	1.0	- becoming medium dense from 0.9 m depth.		D	0.9				1
		Bore discontinued at 1.0m (Target depth)			1.0				
25	2								
24	3								

Dynamic Penetrometer Test (blows per 150mm): 5 10 15 20

RIG: 110 mm diameter hand auger **DRILLER:** YC **LOGGED:** YC **CASING:**

TYPE OF BORING: Hand auger

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level extrapolated from a survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

BOREHOLE LOG

CLIENT: Glenbrook Civil Engineering Contractors Pty Ltd
PROJECT: Proposed Residential Subdivision
LOCATION: Lot 50 Barfield Road, Hammond Park, WA

SURFACE LEVEL: 33.1 m AHD*
EASTING: 391962
NORTHING: 6439341
DIP/AZIMUTH: 90°/--

BORE No: 10
PROJECT No: 96711.00
DATE: 26/8/2020
SHEET 1 OF 1

RL	Depth (m)	Description of Strata	Graphic Log	Sampling & In Situ Testing: Type	Depth	Sample	Results & Comments	Water	Dynamic Penetrometer Test (blows per 150mm)
33	0.05	TOPSOIL/SAND SP-SM: fine to medium grained, brown, with silt and rootlets, moist.							
		SAND SP: fine to medium grained, brown, trace silt, moist, loose.							
		- becoming yellow-brown, medium dense from 0.45 m depth.							
				D	0.9				
32	1 1.0	- becoming loose from 0.9 m depth.			1.0				1
		Bore discontinued at 1.0m (Target depth)							
31	2								
30	3								

RIG: 110 mm diameter hand auger **DRILLER:** YC **LOGGED:** YC **CASING:**

TYPE OF BORING: Hand auger

WATER OBSERVATIONS: No free groundwater observed

REMARKS: * Surface level extrapolated from a survey plan provided by the client.

☒ Sand Penetrometer AS1289.6.3.3
☐ Cone Penetrometer AS1289.6.3.2

SAMPLING & IN SITU TESTING LEGEND

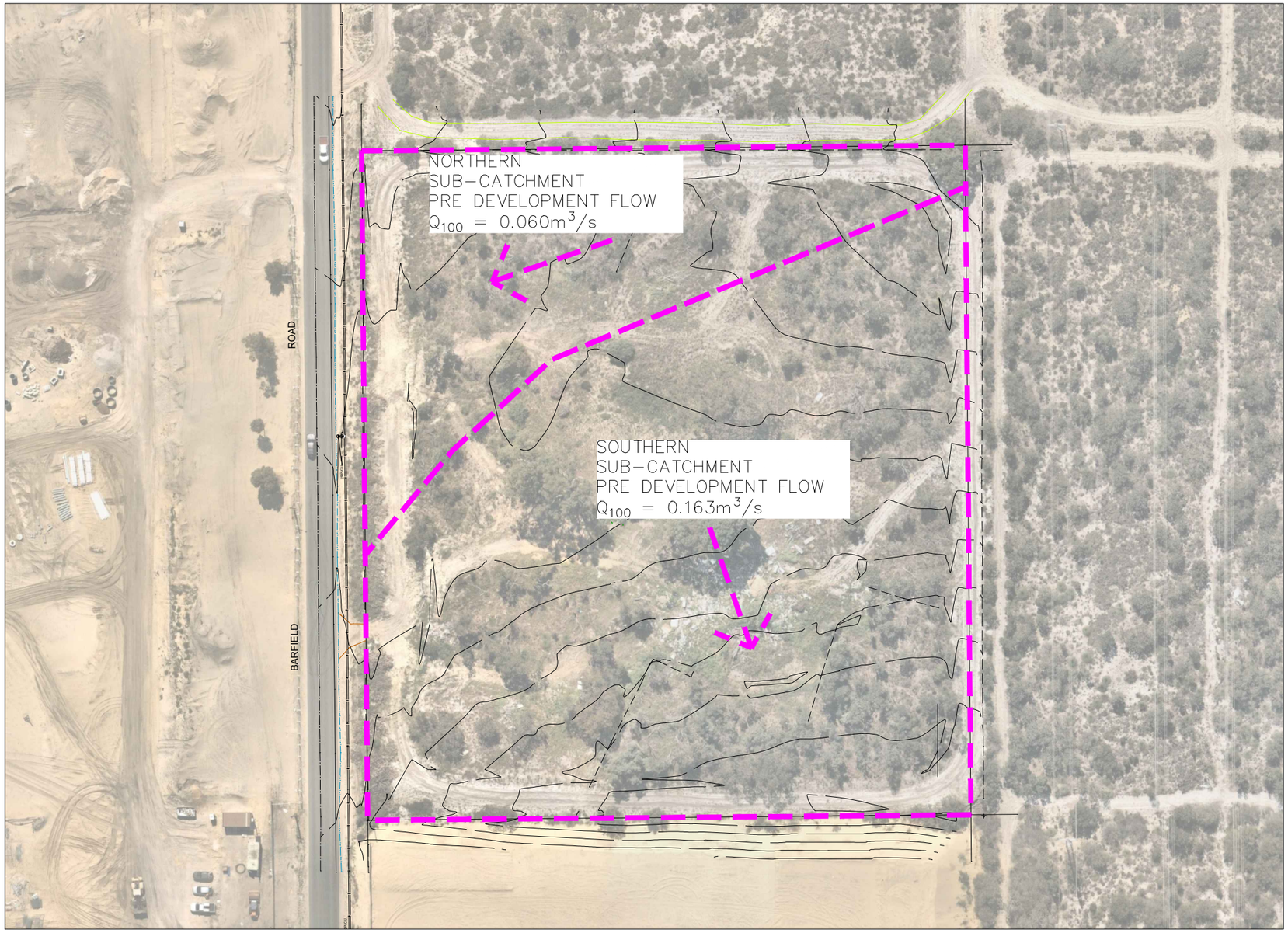
A	Auger sample	G	Gas sample	PID	Photo ionisation detector (ppm)
B	Bulk sample	P	Piston sample	PL(A)	Point load axial test Is(50) (MPa)
BLK	Block sample	U_x	Tube sample (x mm dia.)	PL(D)	Point load diametral test Is(50) (MPa)
C	Core drilling	W	Water sample	pp	Pocket penetrometer (kPa)
D	Disturbed sample	▷	Water seep	S	Standard penetration test
E	Environmental sample	▼	Water level	V	Shear vane (kPa)

Douglas Partners
Geotechnics / Environment / Groundwater

Appendix C

Pre-development flow towards Barfield Road

Prepared by BPA Engineering (2020)



LOCATION PLAN
SCALE 1:1000

DESIGNED	.		CHECKED	DATE						
DRAWN	.		APPROVED	DATE						
FILE NAME	-C00300 .DWG				No.	DATE	REVISION	BY	APP'D	

BPA Engineering
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APPENDIX A
PRE-DEVELOPED CATCHMENT PLAN

PLAN & PROFILE

DRAWING No. —
REV 1

Appendix D

Education materials

Planning your planting

Create 'watering zones' in your garden by grouping plants with similar watering needs. This will allow you to make more efficient use of your garden water by ensuring that no plants are over or under watered.

The Waterwise 'Drop Zone' system makes it easy to identify a plant's water requirements. This system divides plants into one of three groups depending on their watering needs. 'Three Drop' plants require the most watering (usually every second day in summer), whereas 'Two Drop' and 'One Drop' plants require less watering respectively.

It's also important to reticulate only once on your allocated days, either before 9am or after 6pm. Look for the Waterwise 'Drop Zone' system at your local Waterwise garden centre. To find the centre closest to you, visit www.watercorporation.com.au or call the Waterwise Helpline on 13 10 39.

Remember, a small amount of planning now can save plenty of water in the future.

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Government of **Western Australia**
Department of **Water**

Planting a local native garden

Looking after all our water needs

In an era of rising temperatures and decreasing rainfall it is important to look at how we use water in our gardens.

Did you know?

About half of the water typically used in our homes is actually used to water the garden (and of that almost all is used to water lawns).

Many of us water lawns that we simply don't use, or water more than we need to. Similarly, often the plant species in our gardens are exotic and not entirely suitable to our climate – needing more water to survive.

Why go native?

- Local native plants are best suited to the local climate, conditions and soil. Therefore they require minimal inputs such as water, fertiliser and maintenance.
- They attract local wildlife, insects and birds and provide corridors of biodiversity in developed areas.
- They have minimal impact on the environment – unlike many introduced species, which have become bushland weeds and prove difficult and expensive to eradicate.
- They represent local heritage, teaching us about nature and our local identity.

Mulch. Mulch. Mulch.

If everyone fully utilised mulch in the garden, a much lower percentage of household water usage would end up on the garden.

The even better news is that mulching is very easy! Raw materials like woodchips and tree clippings are best, but any organic mulch will suffice. Simply spread at least 50mm of mulch over the whole planting area, leaving a small amount of breathing space at the base of the stem. This mulch won't need to be topped up again until autumn. Be sure not to turn or disturb the mulch as this will break the fine feeder roots that develop between the mulch and the soil.

In addition to mulch, a wetting agent can help overcome water repellence in soils, allowing water to penetrate the soil more quickly and in larger amounts. You can find wetting agents at your local nursery or garden centre.

Want to know more?

The Department of Water is committed to making sure that the water needs of Western Australia are met now, and in the future. Small steps we each take can make a big difference to the sustainability of our precious water supply. If you would like to know more, visit the Department of Water website – www.water.wa.gov.au.

Key tips for reducing groundwater use

- Design gardens and landscaping to enhance absorption of rain into the ground and to minimise evaporation – by using local native garden beds, mulch and subsurface irrigation etc.
- Keep planted areas dense and group plants with similar water needs together and make use of windbreaks.
- Prepare the soil before planting to ensure that plants can make the most of the water they need.
- Re-use water from the home in the garden – this includes bucketing greywater from the laundry and bathroom as well as water from downpipes connected to your house gutters. You can also install a subsurface greywater reuse system. For further information, contact your local council or visit www.water.wa.gov.au

Water quality

The quality of groundwater can be affected in many ways.

- The use of lawn and garden fertilisers heavy in phosphate is a major issue in Perth. Phosphates easily soak through the sand plain into the aquifer, rivers, ocean, creeks and swamps. This results in aquatic life dying and the growth of dangerous algae in freshwater lakes and rivers.
- Oils, paint thinners, various workshop chemicals – if poured into the sandy soil – will soak through to the aquifer and create long-term pollution issues.
- Heavy metal particles are dangerous to our health, as are hydrocarbons. These come from vehicle fuel systems, brake linings and exhaust systems. When vehicles are parked on private driveways and carports, such material will wash into your private soak wells and eventually into the aquifer. Remember to clean out your soak wells annually, to remove any leaf and pollutant build-up. This will also aid in the efficiency of your soak wells and reduce internal flooding problems.

Groundwater – the situation

Over two-thirds of Perth's water supply comes from groundwater. The Perth region has an underground geology which includes large areas of deep sand and limestone. Rain falling over this area and running off the hills builds up underground as a shallow semi-freshwater aquifer, which is available for household bores in some areas.

The freshwater aquifer is renewed each year with rainfall. With rainfall continuing to decline in Perth, and more homes being equipped with bores, the draw on the aquifer is increasing, thus creating a threat to ongoing bore water supply.

Groundwater recharge

Traditionally, stormwater run-off from roofs and roads and other surfaces has been collected in drainage pipes and exported into the ocean or waterways.

This 'lost' water can be a valuable resource to recharge a shallow groundwater aquifer. Sandy soils are extremely permeable and well suited to infiltration of stormwater to increase groundwater levels.

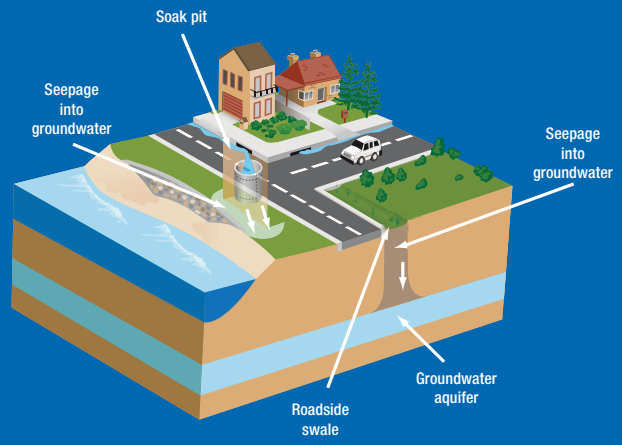
Recharging the groundwater aquifer with stormwater helps manage the local water cycle balance and prevents problems associated with increased bore water extraction, acid sulphate soils, salinity and waterlogging.

Managing local stormwater

'Stormwater' is a term used to describe the water which runs off surfaces such as houses and driveways and flows down into drains and stormwater pipes.

Poor stormwater management can damage not only individual properties but the environment in general. Local councils invest significant amounts of money into operating and maintaining the stormwater network.

Maximising infiltration of stormwater into groundwater can be achieved by replacing traditional drainage pipes with infiltration devices such as soakage pits and bioretention swales, as illustrated below.



Government of Western Australia
Department of Water

Looking after all our water needs

Water sensitive urban design

Rainwater storage and reuse systems

Summary

Rainwater storage systems are a simple method of capturing rainwater, traditionally from roofs, for use as an alternative water supply source and to reduce consumption of scheme water. When installed and maintained in accordance with recommended guidelines, they can provide a high quality source of water.

This brochure is part of a series that explain various aspects of water sensitive urban design. Please see *Water sensitive urban design in Western Australia* for background information on water sensitive urban design.

Main benefits

- Rainwater storage systems reduce the demand on potable water supplies.
- More rainwater is harvested when the tank is plumbed inside the house for uses such as toilet flushing. This creates a consistent drawdown on the tank supply, so there is always space to collect rainwater.
- They reduce the amount of directly connected impervious areas.
- They reduce stormwater peak flow rates and volumes.
- They reduce water supply peak flow rates and volumes.
- They can be retrofitted in houses and other buildings, including in high density urban areas.
- They can provide a water supply for (water sensitive) urban gardens and reduce the heat island effect in high density urban landscapes.

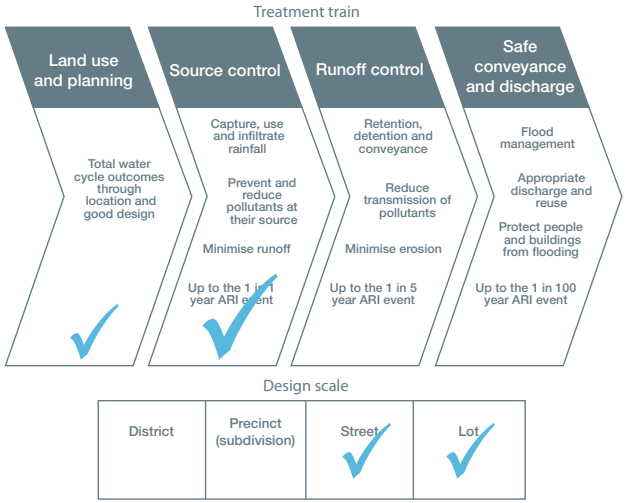
Design factors

- Put 'first flush' devices and mesh screens over all inlets and outlets to minimise maintenance requirements and preserve water quality.
- Designs for stormwater management include an air gap with trickle feed discharge level control and may include an infiltration trench or soakwell, depending on site characteristics.
- Storage can be above or below ground.
- Match storage size to collection area, end use, rainfall quantity and seasonal variability.
- Larger storage sizes are required where rainfall is unreliable and alternative supplies are not available.

Target pollutants

Rainwater storage systems are not designed to achieve direct improvements in stormwater quality.

Where they can be used in the water sensitive urban design process



Concrete underground tank

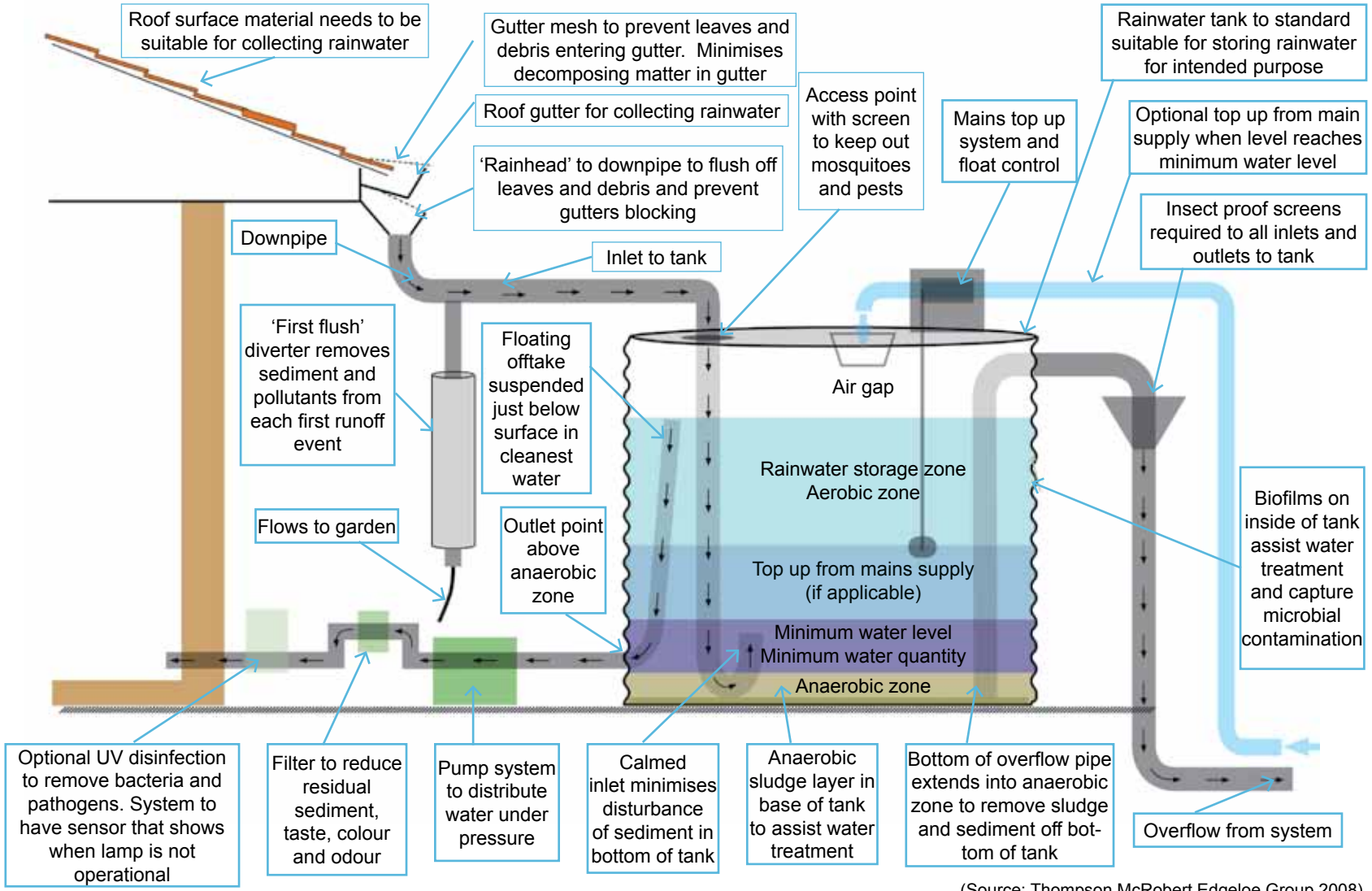
Slimline domestic rainwater tank

Poly domestic rainwater tanks

Water sensitive urban design

Rainwater storage and reuse systems

Example of above ground rainwater tank



(Source: Thompson McRobert Edgeloe Group 2008)

Required reading

Australian runoff quality: a guide to water sensitive urban design, 2006, Engineers Australia, available at <www.arq.org.au>.

Rainwater tank design and installation handbook, 2008, HB230-2008, Standards Australia.

Stormwater management manual for Western Australia, 2004–07, Department of Water, available at <www.water.wa.gov.au>. See Section 2.1 of Chapter 9 – Structural controls.

Testing of products for use in contact with drinking water, 2005, AS/NZS 4020:2005, Standards Australia.

Urban rainwater collection guidelines, Department of Health, Western Australia.

The department acknowledges the past project contributions of the Leschenault Catchment Council.

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June 2011
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Government of **Western Australia**
Department of **Water**

Saving water in the garden.

Did you know?

Pot plants use a lot more water than plants in the ground. They're more exposed to the sun and wind, only store a small amount of water and dry out faster, so you water them more.

- Reduce your lawn cover. Most of the water used in our homes goes on the lawn.
- Plant local natives. They require less water and fertiliser.
- Mulch. Organic mulches reduce evaporation and restrict weed growth.
- Collect rainwater. This will save scheme water.
- Water deeply. Watering slower, for longer, less often encourages deep root growth.
- Use greywater. Re-use your laundry and bathroom water on your garden.
- Install a drip irrigation system. This will deliver water straight to the root system.
- Landscape. Group plants to suit watering needs. Keep high water use plants together.
- Use a pool cover. It will reduce evaporation by up to 97%, saving water and money.
- Maintain. Check taps and reticulation regularly for leaks and blockages.

Government of **Western Australia**
Department of **Water**

Grow local native plants and save water.

Did you know?

About half the water typically used in our homes is used to water the garden, generally lawns. Many of us water a large lawn and only use part of that lawn. Some of us overwater even those parts of the lawn we do use regularly. Think about the areas of lawn you use regularly and whether you can reduce the amount of watering. Similarly, often the plant species in our gardens are exotic and not suitable to our climate, needing more water to survive. These can be regrouped together and more waterwise plants put in their place.

- Local native plants are best suited to the local climate, conditions and soil.
- They require less water, fertiliser and maintenance.
- They attract local wildlife, insects and birds.
- They have minimal impact on the environment, unlike some introduced species which have become bushland weeds.
- Local plants represent local heritage, teaching us about nature and our local identity.

Government of **Western Australia**
Department of **Water**

Protect and maintain our local water supplies. FertiliseWISE.

Did you know?

Fertilisers are a major contributor to surface and groundwater contamination. They run off into the stormwater system through roadside drains, collect in sumps and leach into the groundwater system. They also wash into the rivers and sea, creeks and swamps where they can do major damage to reefs and aquatic life.

WHAT YOU CAN DO TO HELP

• Minimise lawn areas and use plants that don't use fertiliser • Grow local native plants – they require less water and fertiliser • Where possible, use organic fertilisers • If you must use a chemical fertiliser, look for one that is phosphorus free. Use a nitrogen to phosphorus to potassium (N:P:K) ratio of 10:0:6. • Use a slow release fertiliser • Only apply in spring or early autumn, not in winter or summer • Fertilise only when symptoms of deficiency occur (e.g. yellowing) • Use liquid fertiliser if you have a subsurface irrigation system • Compost your garden waste • Don't fertilise near waterways or road verges • Don't let grass clippings or leaves go down the drain • Wash your car on the lawn (if you have any) not on the driveway • Pick up after your dog • Use phosphorus-free detergents (always read the labels)

Top 5 tips for saving water in the kitchen

Did you know the kitchen is a major consumer of water in the home using around 10 per cent of total household water for consumption for cooking, cleaning, washing or drinking?

If you follow these simple tips you can reduce your use dramatically.

- If you have a leaking tap, replace the washer or other components as required. Dripping taps can waste 30 – 200 litres of water per day.
- Look for dishwashers that have a National Water Conservation or WELS Label. The best water rating achieved by dishwashers is 5 stars.
- To avoid wasting warm water from a running tap when you first turn it on, collect it in a bottle or a jug and store it in the fridge until it is cool enough to drink.
- Only use dishwashers when you have full load.
- When boiling vegetables, use enough water to cover them and keep the lid on the saucepan. Your vegetables will boil quicker and it will save you water and power.

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Government of **Western Australia**
Department of **Water**

WATER SAVING TIPS

Saving water in the home

Looking after all our water needs

In southern Western Australia, water resources are under pressure due to reduced rainfall, increased population and other factors.

With the current pressure on Western Australia's water resources, it's time for us all to do our bit to protect and maintain them.

Did you know?

In the typical house, the use of showers, clothes washing machines and toilets can consume more than three quarters of all indoor water use. In the majority of homes, all of this quality drinking water is used once then goes to the sewer. There are now simple, low cost ways of reducing this water use whilst saving on your water costs.

Water use in the home and garden

Consider the following to reduce water use:

- Don't use drinking quality water to water your garden. Use bore water and/or water recycled from showers and clothes washing machines (grey water).
- Use covers on swimming pools and spas, to reduce evaporation. Evaporation can remove more water from a pool per year than toilet use in a home.
- A home can be cooled in summer using good orientation, window shading, natural ventilation and fans. This could remove the need for an air conditioner, particularly evaporative, where large amounts of water are used.
- All new houses must adhere to the criteria of 5 Star Plus for water efficiency, but the guidelines can also be used when renovating to help create a more waterwise home.
- Install flow control aerators on taps. They are inexpensive and can reduce water flow by 50 per cent.

Find out more

For information on greywater use and systems visit the Department of Health website at www.health.wa.gov.au
For waterwise tips see the Water Corporation website at www.watercorporation.com.au and follow the "Being Waterwise" links.
To find out more visit www.water.wa.gov.au

What you can do to help?

- **Buy and install water smart fittings and appliances in the kitchen, bathroom and laundry.** Low flow showers and taps, systems that store colder water while the hot tap is reaching the desired temperature, toilets with lower flush volumes, waterless toilets, front loading washing machines etc are all modern ways of saving on water use and cost.
- **Consider installing rainwater tanks.** The stored water can be used in a number of ways, even in Perth where there are less summer rain events. Such water can be plumbed into toilets and reduce the use of high-quality treated scheme water for flushing.
- **Install a waterwise garden and/or irrigation system.** The garden and irrigation system can be designed to minimize water use.

Use products and services with the Smart Approved WaterMark label. This is a water saving program for outdoor water use and ensures any product bearing the label will save water.

Visit www.smartwatermark.org for more information

Appendix E

Engineering technical note

Prepared by BPA Engineering (2020)

The following additional assumptions have been made during this assessment:

- Design rainfall and storm ensembles are based on ARR 2019;
- Groundwater is assumed to be sufficiently low to not influence the results of hydrologic and hydraulic analysis based on the Geotechnical Investigation carried out by Douglas Partners (September 2020).

BPA have queried and clarified the design hydraulic permeability for the bio-retention and flood storage areas with CoC (September 2020), the agreed rates were as follows:

- Bio Retention Area: 3.5 m/day
- Flood Storage Area: 8 m/day

Hydrologic Model

Model Setup

To assess the surface area, the topographical survey was imported into 12d software. The existing surface was generated from the elevation points within the survey file.

A desktop study was carried out to determine sub-catchment areas. Closed polygons, delineating each catchment were drawn around the ridges within the study area upstream of significant drainage points within Lot 50 Barfield Road, Hammond Park. These catchments were imported into DRAINS during the model development phase.

Model Selection

The ILSAX hydrological model was assessed within the DRAINS model to determine the corresponding flow rates for the pre and post developed scenarios. Table 1 summarises the parameters used for the ILSAX model:

Table 1: ILSAX Type Hydrological Model

Parameter	Value	Notes
Impervious Depression Storage	1 mm	Depth of rainfall assumed to be retained in depressions or puddles in impervious areas, DRAINS suggested value.
Pervious Depression Storage	5 mm	Depth of rainfall assumed to be retained in depressions or puddles in pervious areas, DRAINS suggested value
Soil Type	1	Low runoff potential, high infiltration rates (sands and gravels)

DRAINS Modelling Assumptions

The following assumptions have been made with the DRAINS models:

- Time of concentration of 6 mins in accordance with CoC subdivision guidelines.
- The time of concentration for all sub catchments is calculated using the Kinematic wave equation.
- No allowance is made for climate change.

Downstream Conditions

There are no existing main channels that the study area connects into, therefore the site is assumed to be under a free draining condition. To verify stormwater containment within the site a dummy overland flow route was incorporated into the model to assess whether the basin could facilitate all storm events up to and including the 1% AEP. As there was no overflow registered from the basin (storage) no dynamic downstream conditions need to be considered.

Pre-Development Catchment Flows

The catchment flows were simulated in DRAINS software. Peak flow for the major storm event is presented in Table 2. A plan of the pre-development hydrology plan is shown in Appendix A.

Table 2: Major event pre-development catchment flows

Catchment ID	Peak Flow (m3/s)	Due to Storm
Pre-development North	0.060	1% AEP, 10min burst, storm 9
Pre-development South	0.163	1% AEP, 10min burst storm 9

Post Development Model

The post development model was based on the subdivision concept plan prepared by Rowe Group (October 2020). The concept plan shows a mixture of residential lots, road reserve including an internal paved asphalt ring road and public open space.

Table 3 shows the summary of Lot, Road Reserve and POS Catchment Areas:

Table 3: Post development catchment study

Catchment ID	Area (ha)	Impervious (%)	Pervious (%)
Lot Catchment Only	1.16	40	60
Hammond Cat (Road Reserve and POS consolidated)	0.66	95	5

The post-developed model was carried out as a lumped analysis exercise involving the combined storage of all soakwells within the development, the storage was calculated using the CoC formula (On Site Drainage Requirements for Residential Lots) of V = A/80. The total volumetric requirements for soakwells was determined to be 61m3.

Overflow from the soakwells is then routed to the basin which incorporates incoming runoff from road reserve and POS areas. The lumped model is shown in Appendix B.

Post development results

Post-Development Catchment Results

The DRAINS model when run for the post development scenario shows that the flow and volumetric run off does not exceed the pre-development scenario. Results of the post-development scenario is shown in Appendix C and in the raw DRAINS output.

The following table summarises the top water level in the basin for the relevant stormwater design criteria.

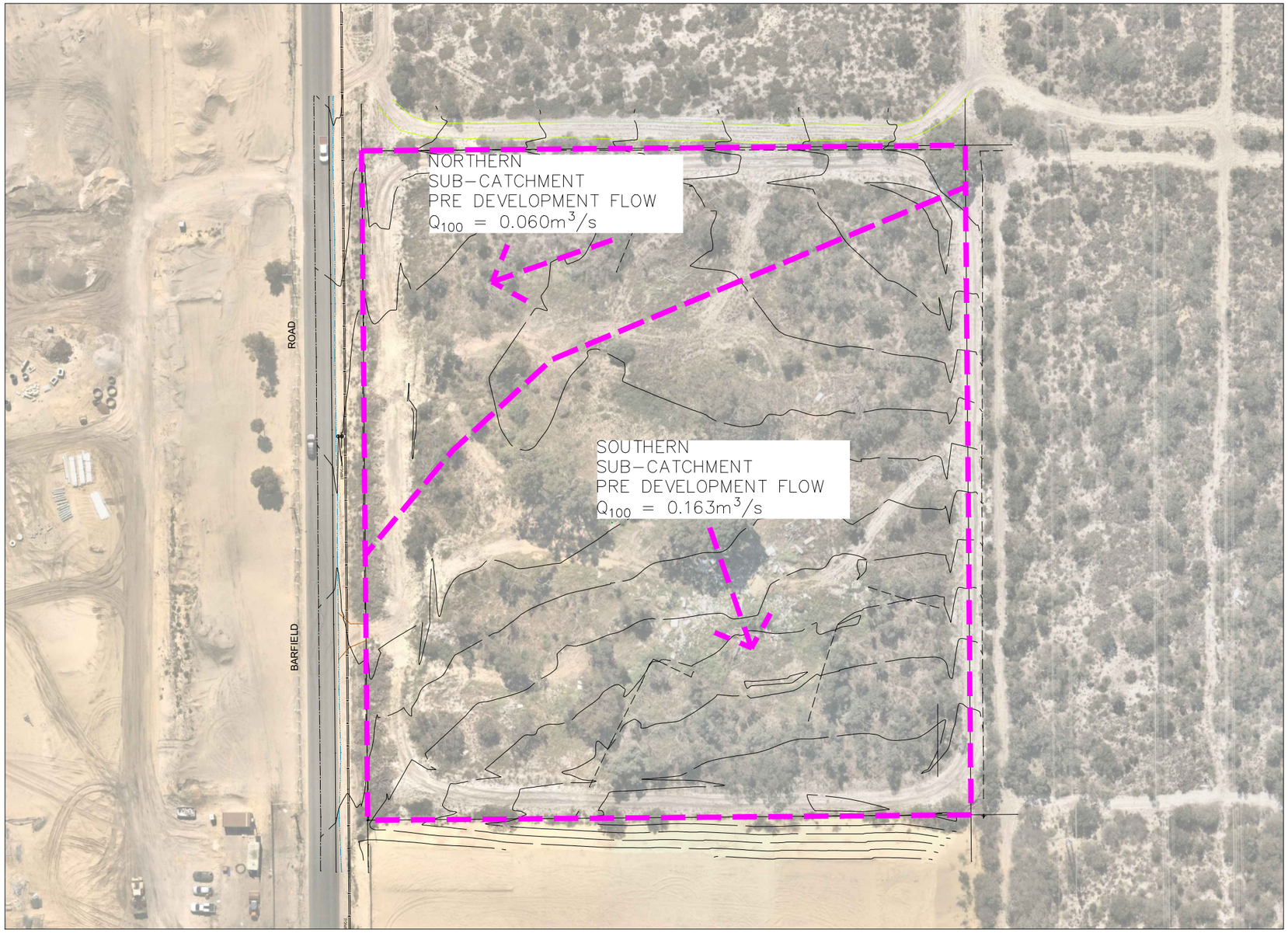
catchment flows for the post development condition.

Table 4: Basin Storage Results

Design Storm	Top Water Level (m AHD)	Critical Storm
1EY	29.86	1 hours burst, Storm 9
20% AEP	30.02	2 hour burst, Storm 4
1% AEP	30.16	2 hour burst, Storm 2

Proposed Drainage Strategy

Future development within Lot 50 Barfield Rd will result in an increase in impervious catchment area. All lots will have soakwells to manage the 1 in 20 ARI (4.48% AEP) for the 5-minute duration. Storms over and above the on-site drainage requirements for residential lots are managed internally by piping stormwater into the basin located at the south-east corner of the development. The 1% AEP event is conveyed in combination of both gutter and piped flow towards the basin. Analysis with DRAINS software shows that the basin can hold the 1EY, 20% AEP and 1% AEP events.



LOCATION PLAN
SCALE 1:1000

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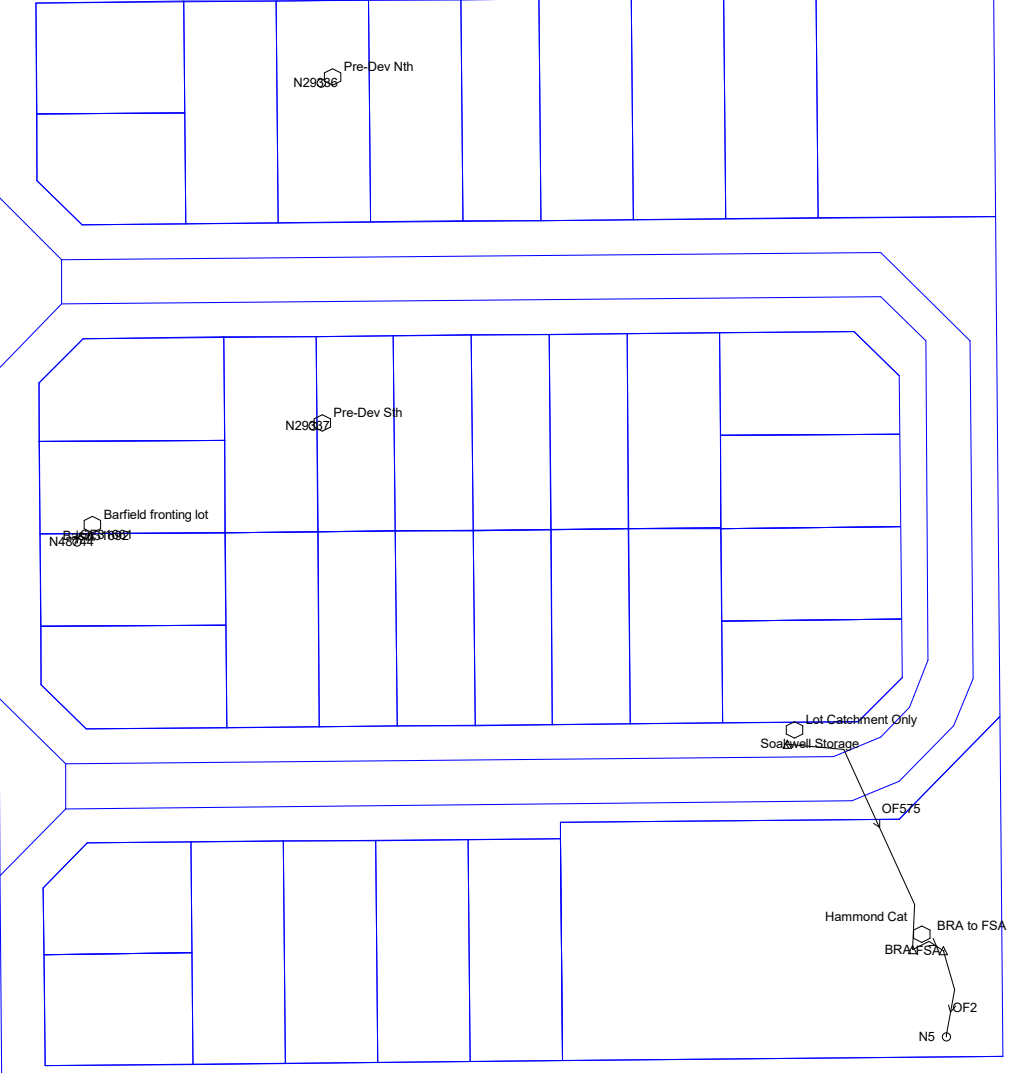
APPENDIX A
PRE-DEVELOPED CATCHMENT PLAN

PLAN & PROFILE

DRAWING No. —
REV 1



APPENDIX B
LOT 50 BARFIELD RD
HAMMOND PARK

DRAINS results prepared from Version 2020.036

PIT / NODE DETAILS

Name	Max HGL	Max Pond HGL	Max Surfac Flow Arrivi (cu.m/s)	Version 8 Max Pond Volume (cu.m)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
Hammond Cat	0.097	0.097	0	6	6	5	1EY AEP, 10 min burst, Storm 10
Lot Catchment Only	0.068	0.068	0	6	6	5	1EY AEP, 10 min burst, Storm 10
Pre-Dev Nth	0	0	0	6	6	2	1EY AEP, 5 min burst, Storm 1
Pre-Dev Sth	0	0	0	6	6	2	1EY AEP, 5 min burst, Storm 1

PIPE DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Max U/S HGL (m)	Max D/S HGL (m)	Due to Storm

CHANNEL DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Due to Storm

OVERFLOW ROUTE DETAILS

Name	Max Q U/S	Max Q D/S	Safe Q	Max D	Max DxV	Max Width	Max V	Due to Storm
BRA to FSA	0	0	0.287	0	0	0	0	
OF575	0	0.097	0.097	0.149	0.06	4.09	0.38	1EY AEP, 10 min burst, Storm 10
OF2	0	0	0.287	0	0	0	0	

DETENTION BASIN DETAILS

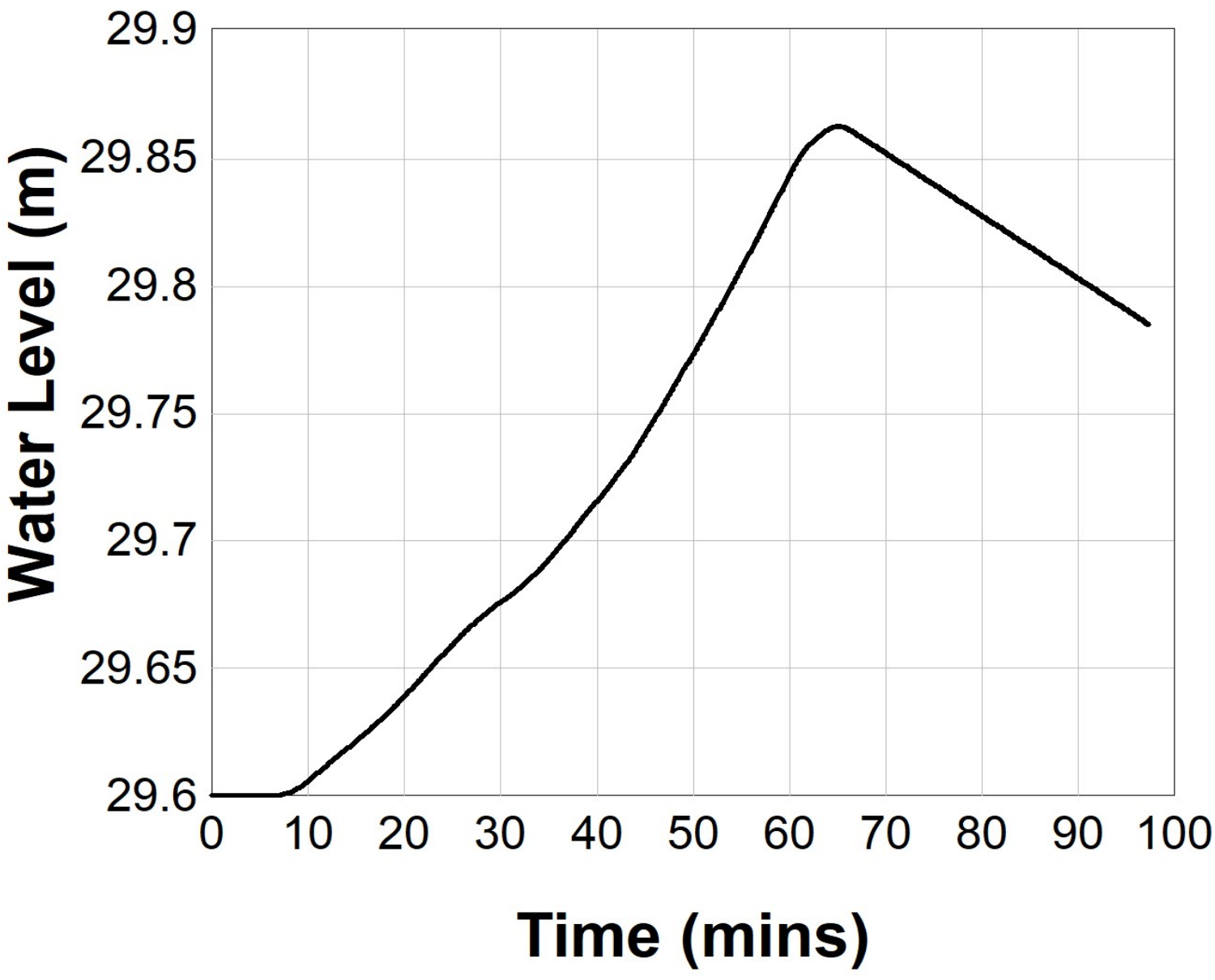
Name	Max WL	MaxVol	Max Q Total	Max Q Low Level	Max Q High Level
BRA	29.86	69.6	0	0	0
Soakwell Storage	30.83	56.4	0	0	0
FSA	30	0	0	0	0

Run Log for C03617 Lot 50 Barfield Rd Hammond Park with WSUD run at 16:41:12 on 20/10/2020 using version 2020.036

The maximum water level in these storages exceeds the maximum elevation you specified: Soakwell Storage.
DRAINS has extrapolated the Elevation vs Storage table to a higher Elevation. Please provide accurate values for higher elevations.

Flows were safe in all overflow routes.

IGNORE THESE WARNINGS AT YOUR OWN PERIL.\cf1



DRAINS results prepared from Version 2020.036

PIT / NODE DETAILS Version 8

Name	Max HGL	Max Pond HGL	Max Surfac Flow Arrivi (cu.m/s)	Max Pond Volume (cu.m)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
Hammond Cat	0.141	0.141	0	6	6	5	20% AEP, 10 min burst, Storm 9
Lot Catchment Only	0.104	0.104	0	6	6	5	20% AEP, 10 min burst, Storm 9
Pre-Dev Nth	0	0	0	6	6	2	20% AEP, 5 min burst, Storm 1
Pre-Dev Sth	0	0	0	6	6	2	20% AEP, 5 min burst, Storm 1
Barfield fronting lot	0.006	0.006	0	6	6	5	20% AEP, 10 min burst, Storm 9

PIPE DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Max U/S HGL (m)	Max D/S HGL (m)	Due to Storm

CHANNEL DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Due to Storm

OVERFLOW ROUTE DETAILS

Name	Max Q U/S	Max Q D/S	Safe Q	Max D	Max DxV	Max Width	Max V	Due to Storm
BRA to FSA	0.067	0.067	0.287	0.071	0.02	4	0.3	20% AEP, 2 hour burst, Storm 3
OF575	0	0.141	0.097	0.169	0.07	4.83	0.4	20% AEP, 10 min burst, Storm 9
OF2	0	0	0.287	0	0	0	0	
OF31661	0.003	0.003	0.097	0.049	0.01	0.75	0.21	20% AEP, 45 min burst, Storm 3

DETENTION BASIN DETAILS

Name	Max WL	MaxVol	Max Q Total	Max Q Low Level	Max Q High Level
BRA	30.02	125.8	0.067	0	0.067
Soakwell Storage	30.86	61.6	0	0	0
FSA	30	2.6	0	0	0
Basin31692	30.81	3.2	0.003	0	0.003

Run Log for C03617 Lot 50 Barfield Rd Hammond Park with WSUD run at 16:14:24 on 21/10/2020 using version 2020.036

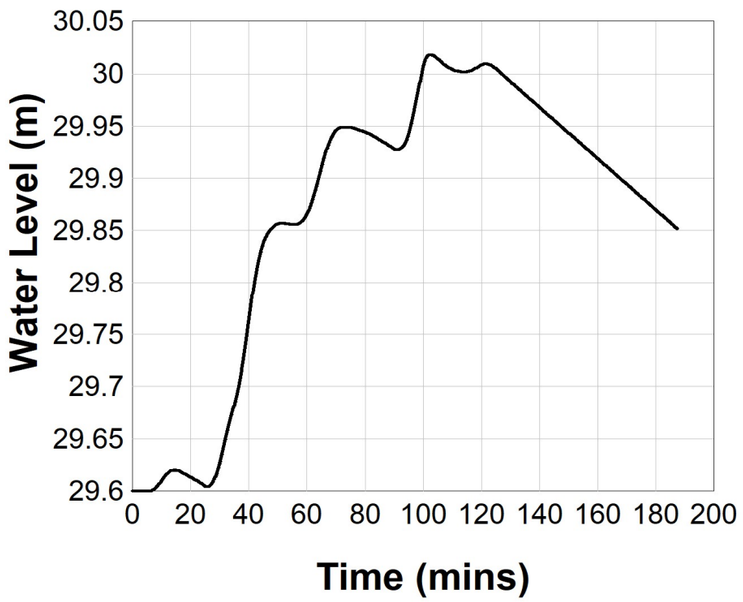
The maximum water level in these storages exceeds the maximum elevation you specified: Basin31692, Soakwell Storage, BRA.

DRAINS has extrapolated the Elevation vs Storage table to a higher Elevation. Please provide accurate values for higher elevations.

The maximum flow in these overflow routes is unsafe: OF575

These overflow routes carried water uphill (adding energy): BRA to FSA. These results may be invalid. This is likely due to either incorrect surface levels specified at pits or high downstream tailwater levels which the Standard Hydraulic model cannot handle. Analysing the latter requires solving the full unsteady flow equations in overflow routes using the Premium Hydraulic model.

IGNORE THESE WARNINGS AT YOUR OWN PERIL.\cf1



DRAINS results prepared from Version 2020.036

PIT / NODE DETAILS

Name	Max HGL	Max Pond HGL	Max Surface Flow Arriving (cu.m/s)	Version 8 Max Pond Volume (cu.m)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
Hammond Cat	0.249	0.247	0.004	6	6	5	1% AEP, 10 min burst, Storm 4
Lot Catchment Only	0.254	0.196	0.078	6	6	5	1% AEP, 10 min burst, Storm 6
Pre-Dev Nth	0.06	0	0.06	6	6	2	1% AEP, 10 min burst, Storm 9
Pre-Dev Sth	0.163	0	0.163	6	6	2	1% AEP, 10 min burst, Storm 9
Barfield fronting lot	0.014	0.011	0.004	6	6	5	1% AEP, 10 min burst, Storm 6

PIPE DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Max U/S HGL (m)	Max D/S HGL (m)	Due to Storm

CHANNEL DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Due to Storm

OVERFLOW ROUTE DETAILS

Name	Max Q U/S	Max Q D/S	Safe Q	Max D	Max DxV	Max Width	Max V	Due to Storm
BRA to FSA	0.325	0.325	0.954	0.16	0.09	4	0.56	1% AEP, 15 min burst, Storm 6
OF575	0.219	0.423	0.831	0.238	0.14	6.56	0.57	1% AEP, 10 min burst, Storm 5
OF2	0	0	0.954	0	0	0	0	
OF31661	0.013	0.013	0.831	0.077	0.02	1.69	0.26	1% AEP, 10 min burst, Storm 2

DETENTION BASIN DETAILS

Name	Max WL	MaxVol	Max Q Total	Max Q Low Level	Max Q High Level
BRA	30.05	139.7	0.325	0	0.325
Soakwell Storage	30.96	67.4	0.219	0	0.219
FSA	30.16	114.7	0	0	0
Basin31692	30.82	3.2	0.013	0	0.013

Run Log for C03617 Lot 50 Barfield Rd Hammond Park with WSUD run at 16:08:25 on 21/10/2020 using version 2020.036

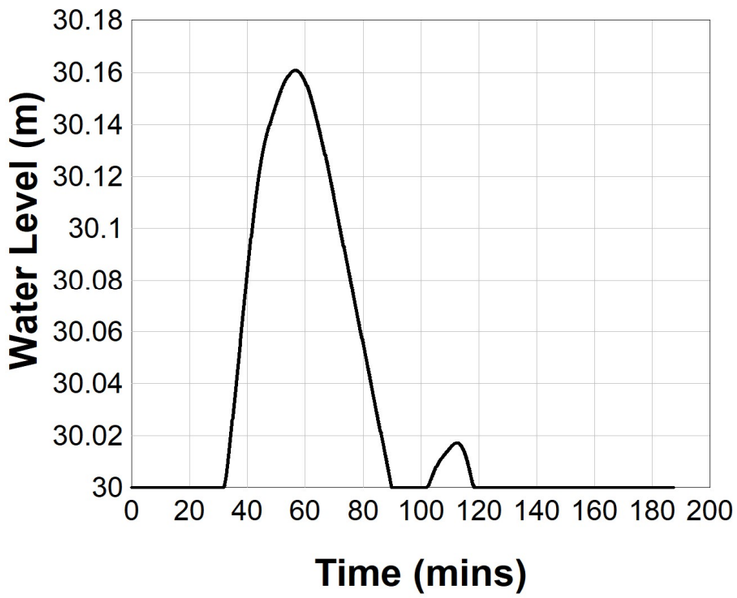
The maximum water level in these storages exceeds the maximum elevation you specified: Basin31692, Soakwell Storage, BRA.

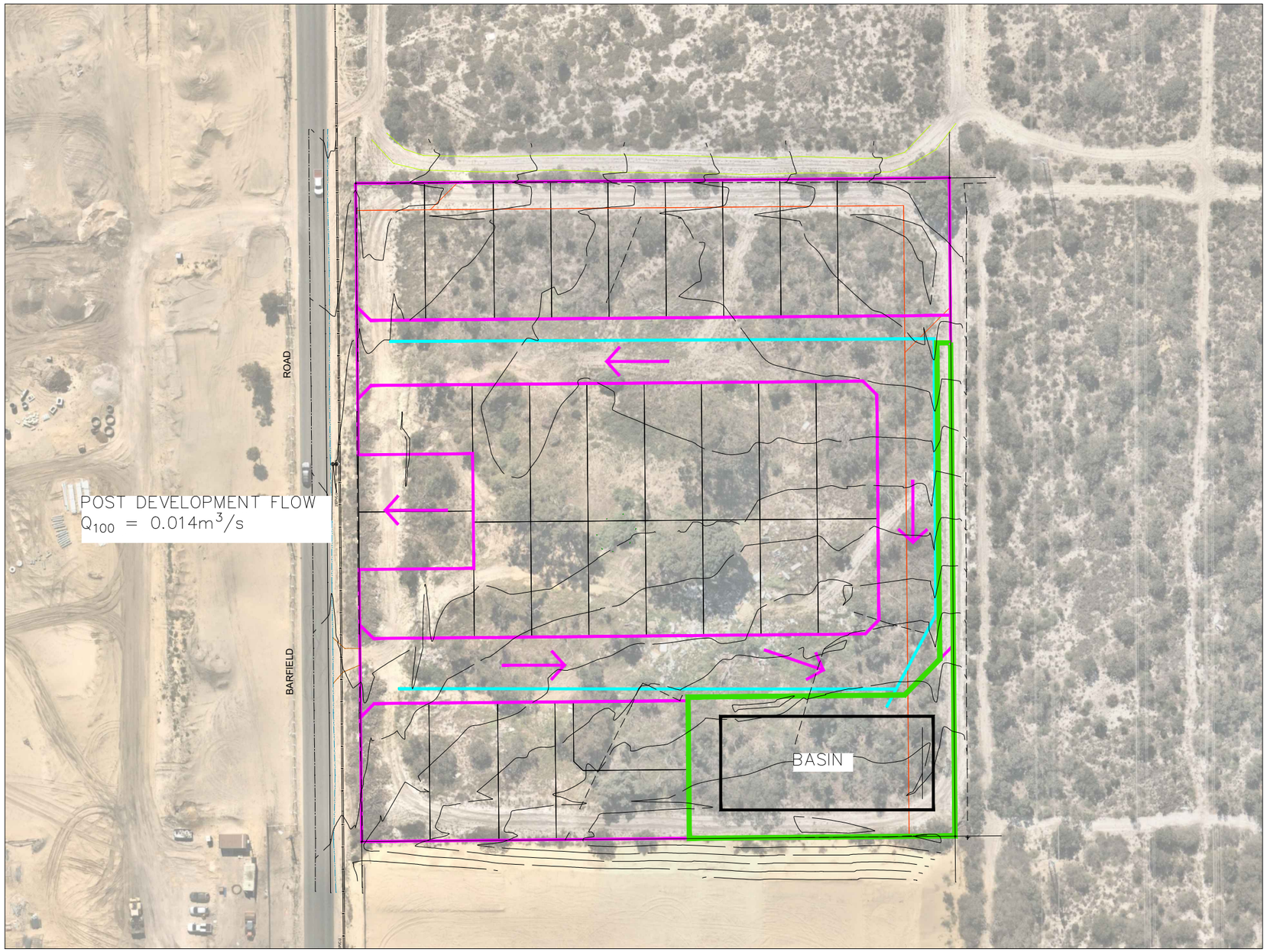
DRAINS has extrapolated the Elevation vs Storage table to a higher Elevation. Please provide accurate values for higher elevations.

Flows were safe in all overflow routes.

These overflow routes carried water uphill (adding energy): BRA to FSA. These results may be invalid. This is likely due to either incorrect surface levels specified at pits or high downstream tailwater levels which the Standard Hydraulic model cannot handle. Analysing the latter requires solving the full unsteady flow equations in overflow routes using the Premium Hydraulic model.

IGNORE THESE WARNINGS AT YOUR OWN PERIL.\cf1





LOCATION PLAN
SCALE 1:1000

DESIGNED	.		CHECKED	DATE						
DRAWN	.		APPROVED	DATE						
FILE NAME	-C00300 .DWG				No.	DATE	REVISION	BY	APP'D	

BPA Engineering
Civil And Structural Consultants
460 Roberts Road Subiaco, Western Australia 6008
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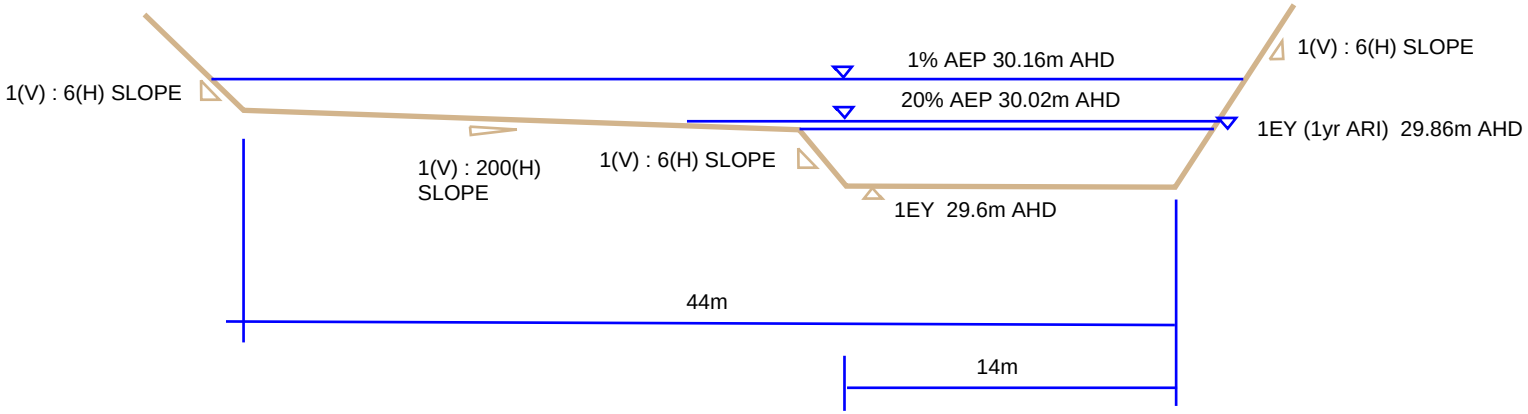
E-mail: bpa@bpaeng.com.au
CONSULT AUSTRALIA Member Firm

APPENDIX C
POST DEVELOPMENT SCENARIO

PLAN & PROFILE

DRAWING No. —
REV 1



BIO RETENTION BASE WIDTH = 15.6m

FLOOD STORAGE AREA BASE WIDTH = 20.4m

APPENDIX 8

DWER APPROVAL LETTER

ROWE GROUP DESIGN

Government of Western Australia
Department of Water and Environmental Regulation

Your ref: EP18-065(02)—002A TEM
Our ref: DWERT1208, PA038839
Enquiries: Jane Sturgess, Ph 9550 4228

Emerge Associates
U4 26 Railway Road
Subiaco WA 6008

Attention: Tessa McAllister

Dear Tessa

LOT 50 BARFIELD ROAD HAMMOND PARK LOCAL WATER MANAGEMENT STRATEGY - AMENDED

Thank you for providing the amended local water management strategy (LWMS) received 1 December 2020 for the Department of Water and Environmental Regulation (Department) to assess.

Version A of the *Lot 50 Barfield Road Hammond Park Local Water Management Strategy* dated November 2020 meets the requirements of the Department.

In the event there are modifications to the proposal that may have implications on aspects of water management, the Department should be notified to enable the implications to be assessed.

Should you require any further information on the comments please contact Jane Sturgess on 9550 4228.

Yours sincerely

Brett Dunn
Program Manager – Planning Advice
Kwinana Peel Region

08 / 12 / 2020

Cc Sabbir Hussain
Senior Development Engineer
City of Cockburn

Kwinana Peel Region
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