Mandogalup West Local Structure Plan

APSLEY ESTATE - LOTS 3, 9013 & 9015 ET. AL. ROWLEY ROAD, MANDOGALUP

June 2025



QUBE

HATCH

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VERSION CONTROL

Version	Prepared By	Approved By	Issue Date
A	KV	DW	November 2017
B	TP	DW	May 2024
C	TP	DW	June 2025

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Hatch Pty Ltd, 2024

Cover Image: Retained Banksia Neighbourhood Park, Event Space and Adventure Playground (POS A)



Pocket Park with Childrens Play area and family BBQ facilities (POS B)

ENDORSEMENT PAGE

This structure plan is prepared under the provisions of the City of Kwinana Local Planning Scheme No.2

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

22 MARCH 2018

In accordance with Schedule 2, Part 4, Clause 28 (2) and refer to Part 1, 2. (b) of the *Planning and Development (Local Planning Schemes) Regulations 2015*.

Date of Expiry: **22 MARCH 2028**

Table of amendments

Amendment No.	Summary of the Amendment	Date Approved by WAPC
1	• Extension of the approval area over the balance of title south of Peel Main Drain • Extension of approval timeframe to 22nd March 2030 • Updates to reflect existing development to date	24 October 2025

Table of density plans

Amendment No.	Summary of the Amendment	Date Approved by WAPC
	•	

EXECUTIVE SUMMARY

This Structure plan was initially prepared for Lot 682 and Lot 52, Mandogalup and Lot 3 which contains the Peel Main Drain. The primary focus of this Amendment 1 is to include the balance of the Lot 682 south of the Peel Main Drain that has subsequently been rezoned to Urban under the MRS, together with the earlier developed portions of the Apsley Estate which contains various new title descriptions. The subject site is herein referred to as the Mandogalup West Structure plan (MWLSP).

The purpose of this Structure plan is to provide a plan for the coordination of future zoning and subdivision of the subject land to facilitate development for residential, education, recreation and local centre purposes.

The preparation of this Structure plan has been undertaken in liaison and collaboration with Satterley Group and associated project team (the adjacent landholding comprising the Mandogalup East Structure plan), The City of Kwinana and all other relevant approval authorities.

Table 1: Structure plan Summary Table

ITEM	DATA	SECTION NUMBER REFERENCED IN REPORT
Total area covered by the Structure plan	94.282 ha	1.3.2
Estimate area of each land use proposed:		
Zones		3.0
Residential	44.852 ha	
Local Centre	0.0993 ha	
Reserves		
Public Open Space	10.079 ha	
Existing Drainage Reserve	2.0407 ha	
Public Purpose -Primary School	2.0076 ha	
Road	19.889 ha	
Transmission Line Easement	14.230 ha	
Improvement Plan 47	2.4573 ha	
Estimated lot yield:	1160	3.3
Estimated number of dwellings	1160	3.3
Estimated residential site density (dwellings/site hectare):	25.59	3.3
Estimated population (@ 2.8 people per household)	3,248	3.3
Number of high schools	0	3.7
Number of primary schools	1	3.7
Estimated commercial floor space (nett lettable area):	750m2	3.8
Estimated area and percentage of public open space given over to:		
Regional open space	Nil	
District open space	1.358 ha (playing fields)	3.2
Neighbourhood parks	3.6354 ha | 2 parks	
Local parks	5.1012 ha | 8 parks	
Estimated number and area of natural area	7.52ha	3.2

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Appendix D: Local Water Management Strategy (JDA)

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Appendix F: Landscape Concept (Plan E)

Appendix G: Transport Assessment Report (Transcore)

Appendix H: Power Easement Document

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PART 1:

Implementation

1.0 Structure Plan Area

This Structure plan applies to the land contained within the inner edge of the line denoting the Local Structure plan boundary on the Structure plan map (refer Plan 1 situated at the end of Part One of this Structure plan report).

2.0 Operation

The Structure plan comes into effect on the day it is approved by the Western Australian Planning Commission (WAPC).

3.0 Staging

Development of the site will generally progress from north to south. Development will then generally progress in a southerly direction.



Dog Park within WP Easement POS

4.0 Subdivision and Development Requirements

4.1 Land Use Zones and Reserves

a) Land use permissibility within the structure plan area shall be in accordance with the structure plan map (Plan 1) and the corresponding zones and reserves described in the City of Kwinana Local Planning Scheme No. 2.

4.2 Residential Density

a) Plan 1 defines the broad residential density ranges that apply to specific areas within the Structure Plan. Lot specific residential densities, within the defined residential density ranges, are to be subsequently assigned in accordance with a Residential Density Code Plan approved by the WAPC.

b) A Residential Density Code Plan is to be submitted at the time of subdivision to the WAPC and shall indicate the Residential Density Coding applicable to each lot within the subdivision and shall be consistent with the Structure Plan, and the Residential Density Ranges identified on Plan 1 and locational criteria contained in Clause 4.1.1.

c) The Residential Density Code Plan is to include a summary of the proposed dwelling yield of the subdivision.

d) Approval of the Residential Density Code Plan shall be undertaken at the time of determination of the subdivision application by the WAPC. The approved Residential Density Code Plan shall then form part of the Structure Plan and shall be used for the determination of future development applications.

e) Amendments to the Residential Density Code Plan will require further approval of the WAPC in accordance with sub-clause 4.1(d) above.

f) Residential Density Code Plans are not required if the WAPC considers that the subdivision is for one or more of the following:

   i) the amalgamation of lots;

   ii) consolidation of land for “superlot” purposes to facilitate land assembly for future development;

   iii) the purposes of facilitating the provision of access, services or infrastructure;

   iv) land which by virtue of its zoning or reservation under the Structure Plan cannot be developed for residential purposes; or

   v) where a Residential Density Code Plan already exists for the subdivision area and the subdivision accords with this approved Residential Density Code Plan

g) The allocation of residential densities shall be in accordance with the following criteria:

i) A base density code of R30 shall apply to all residential lots except in the circumstances described below.

ii) An R35, R40, R50 or R60 density code may be applied to lots located within 400 metres of a school, a public transport route, a neighbourhood connector and/or public open space.

4.3 Public Open Space

The Structure plan is to provide for a minimum of 10% public open space in accordance with the WAPC's Liveable Neighbourhoods requirements. Public open space is to be provided generally in accordance with the Structure plan map.

4.4 Bushfire Management

The Structure plan is supported by a Bushfire Management Plan (BMP) (JBSG, June 2025).

It is the responsibility of the landowner/applicant to demonstrate compliance with *State Planning Policy 3.7: Bushfire* and the associated Planning for Bushfire Guidelines, at each stage of subdivision.

Notifications on certificates of title will be used to advise purchasers of land affected by a bushfire attack level of 12.5 or more that the lot is located in a bushfire prone area, may be subject to a bushfire management plan and additional planning and building requirements may apply

4.5 Notifications on Title

a) The Council shall recommend to the WAPC that a condition be imposed on the grant of subdivision approval for a notification to be placed on the Certificate of Title to suitably respond to the following: a) The BMP for lots with a Bushfire Attack Level (BAL) rating of 12.5 or higher;

b) Transport noise for lots that are the subject of noise levels exceeding the noise target as per State Planning Policy 5.4 - Road and Rail Transport Noise and Freight Considerations in Land Use Planning.

4.6 Reports and Management Plans

The Council shall recommend to the WAPC that a condition be imposed on the grant of subdivision approval to respond to the following as identified by the Structure plan:

a) A Urban Water Management Plan;

b) A Dieback Management Plan;

c) An Acid Sulfate Soils Management Plan;

d) A Fauna and Habitat Management Plan;

e) A Landscape Feature and Tree Retention Management Plan;

f) A Aborists Report (to be prepared in respect od trees to be retained in public open space areas);

g) A Mosquito and Midge Management Plan;

h) A Public Open Space Management Plan for the Western Power transmission easement; and

i) Construction Environmental Management Plan

5.0 Local Development Plans

A Local Development Plan is required in the following circumstances:

a) Lots with an area of 260 square metres or less;

b) Irregular shaped lots;

c) Lots where specific vehicle access and egress control is required;

d) Lots abutting public open space;

e) Lots with site constraints;

f) Lots abutting the Western Power High Voltage Power Line Easement;

g) Lots abutting / adjacent to the Peel Main Drain;

h) Lots that require Quiet House Design for noise attenuation through deemed-to-comply noise insulation packages, and/or lots identified as requiring specialist acoustic requirements.

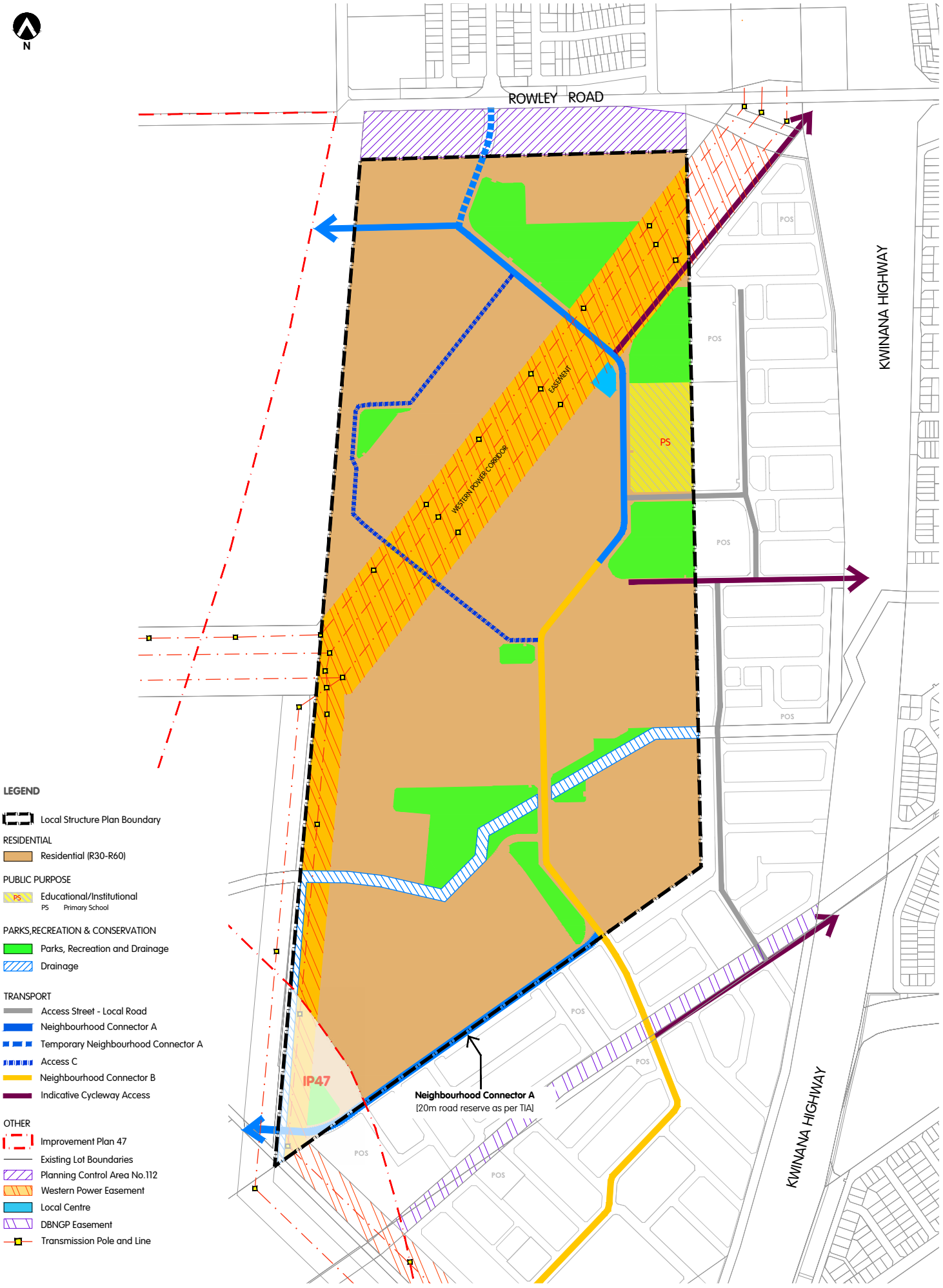
6.0 Other requirements

6.1 Developer Contribution Arrangements

Under the City of Kwinana Town Planning Scheme No.2, the following development contribution arrangements apply and/or are contemplated:

a) Development Contribution Area 8 for the funding of community infrastructure; and

b) Development Contribution Area 6 for traditional 'hard' infrastructure.



CADASTRAL INFORMATION
SOURCE:MNG
YYMMDD: 250519
DWG REF: 96755lots-9999bj-MGA94z50
PROJECTION: MGA94z50

HATCH

SIZE A3 1:6000

0 metres 60 120 180 240 300

REV	DESCRIPTION	YYMMDD	DRAWN	APPR'D
D	UPDATE POS AREAS	250605	SB	DW
C	UPDATE POS AREAS	240411	SB	DW
B	INCREASE 'POS K'	240318	SB	DRAFT
A	FIRST ISSUE	240315	SB	DRAFT

LOCAL STRUCTURE PLAN
Mandogalup
City of Kwinana

JOB CODE	DRAW NO.	REV.
QUB MAN	**RD1 508**	**D**

DISCLAIMER: ISSUED FOR DESIGN INTENT ONLY. ALL AREAS AND DIMENSIONS ARE SUBJECT TO DETAIL DESIGN AND SURVEY

PART 2:

Explanatory

1.0 Planning Background

1.1 Introduction and Purpose

The purpose of the Structure plan is to provide a plan for the coordination of future subdivision and development of the subject land. The subject land relates to the Urban zoned land within Lot 3 (Peel Main Drain), Lots 9013 and 9015 (formally Lots 52 and 682) and subsequent various new residential and POS titles created as part of the development of the Apsley Estate, Mandogalup. This area is herein referred to as the Mandogalup West Structure plan or MWLSP.

Subdivision and development of the subject land in accordance with this Structure plan represents a logical progression of the development front from the north (Hammond Park), initially development stages within MWLSP and MELSP as well as the eastern side of the Kwinana Freeway (Wandi).

The primary purpose of Amendment 1 is to accommodate the southern expansion of Aspley Estate over additional Urban zoned land. This document largely retains the reporting content and techical appendices of the existing approved MWLSP, with additional reporting and technical addendums to address the additional land in the south where relevant.



Nature play space and retained Banksia Woodland (POS A)

1.1.1 Project Team

The following multi-disciplinary project team have been engaged to progress the preparation of the MWLSP:

ROLE	COMPANY
Landowner and Project Manager	Qube Property on behalf of the Mandogalup Development Joint Venture
Urban Design and Planning	Hatch
Engineering	Cossill and Webley
Landscape	Plan E
Hydrology	JDA
Environmental and Bushfire	JBSG
Traffic	Transcore
Retail	Taktics 4
Acoustic	Llyod George Acoustics

1.1.2 Mandogalup East Structure plan

The MWLSP is adjoined on its eastern boundary by land comprising the Mandogalup East Local Structure plan (MELSP). The updated MELSP is currently being progressed by Satterley Property Group, and will be assessed and determined concurrently with the MWLSP.

Ongoing collaboration between the relevant landowners and project consultant teams for the MWLSP and MELSP has taken place to ensure coordination between the two Structure plan areas. In particular, the concept subdivision designs ensure the alignment of local roads, distribution of public open space, residential property boundaries, shared Primary Schools, service provision and staging.

The proposed northern primary school and local playing fields have been sited within the MWLSP and MELSP to ensure equitable pro rata provision of the required land area, as well as in consultation with the Department of Education and City of Kwinana to ensure appropriate location within the catchment and surrounding land use context. In accordance with consultation with the Department of Education a second Primary School site has been located further south within the amended MELSP.

1.2 Land Description

1.2.1 Location

The MWLSP area is located within the metropolitan south-west corridor, in the municipality of the City of Kwinana. The site is situated approximately 25 kilometres south of the Perth Central Area, and is accessible via the Kwinana Freeway. The Kwinana Town Centre is located approximately 9 kilometres south of the site and Cockburn Central approximately 6 kilometres north of the site (refer Figure 1: Regional Context).

The MWLSP area is generally bound by Rowley Road to the north, Kwinana Freeway to the east and the Western Power Easement to the West. Land to the immediate east and south is zoned Urban and forms part of the Satterley MELSP. (refer Figure 2: Local Context).

Figure 1: Regional Context



Figure 2: Local Context



1.2.2 Area and Land Use

The MWLSP has a total land area of approximately 99.75 hectares. It is traversed by a 132 kv and 330 kv power line easement running north-east to south-west, totalling 16.83 hectares in area. An existing drainage reserve, being the Peel Main Drain, also runs east west through the southern portion of the site, totaling approximately 2.04 ha.

The MWLSP area is largely either developed as residential housing or undergoing civil works for the creation of residential lots. Extensive remnant bushland has been retained in earlier public open space areas. (refer Figure 3 – Aerial Photo).

1.2.3 Legal Description and Ownership

The MWLSP area comprises of Lot 3 (Peel Main Drain) which is Crown Land vested in Water Corporation pending transfer to eth City of Kwinana, balance of the original parent titles being lots 9013 and 9015 (formerly Lots 52 and 682), Rowley Road, Mandogalup, owned by Mandogalup Development Joint Venture, and various new privately owned residential lots and POS areas.

Figure 3: Aerial Photo



1.3 Planning Framework

1.3.1 Zoning and Reservations

1.3.1.1 Metropolitan Region Scheme

The majority of the MWLSP area is zoned "Urban" under the Metropolitan Region Scheme (MRS), with the exception of the area adjacent to Rowley Road, which is within Planning Control Area No. 112 (PCA No. 112) for the purposes of future road widening. The land also overlaps the Improvement Plan 47 (IP47) area to the south west corner.

The Western Australian Planning Commission (WAPC) initiated MRS Amendment 1114/33 in June 2006 to rezone approximately 352ha of land in Mandogalup from the "Rural" zone to the "Urban Deferred" zone. This was one of a group of amendments in the district to facilitate the urbanisation of land as prescribed by the Jandakot Structure Plan (JSP)

The amendment was recommended for final approval by the WAPC but held in abeyance following objections from Alcoa regarding potential dust impacts from the Alcoa residue storage area located to the west of the landholding. The "Review of the Kwinana Air Quality Buffer – Position Paper (WAPC 2008)" identified an area 1km from the nearest residue disposal area (Area F) as "subject to further investigation" due to potential impacts of dust, noise and visual amenity arising from the operation of the residue storage area.

Amendment 1114/33 was approved and became effective in November 2009, in a modified form, transferring approximately 181ha (of the original 352ha of land) outside the 1km "subject to further investigation" area to the "Urban Deferred" zone.

The south-western boundary of the MWLSP area and the extent of the "Urban" zoned land was previously defined by the outer edge of the Revised Kwinana Industrial (including air quality) Buffer (here in referenced to as KIB), as of 21 September 2010.

In proposing the reduced amendment area, the Minister for Planning directed the WAPC under Section 17 of the Planning and Development Act 2005 as follows:

No decision to transfer land in the Mandogalup locality from the Rural or Urban Deferred zone to the Urban zone is to be made without the approval of Cabinet and the Minister responsible at the time of the Metropolitan Region Scheme and amendments or changes proposed to be made to it.

No such decision will be made until the Kwinana Air Quality Buffer has been finalised, clearly indicating what land is within a buffer and should remain in the Rural or Urban Deferred zone and what land is outside a buffer area and therefore could be transferred to the Urban zone, subject to whatever other planning circumstances may apply to the subject land at the time.

In September 2010, the WAPC reviewed its position following completion of dust monitoring and modelling studies undertaken by Alcoa. The WAPC, on advice from the Kwinana Buffer Review Committee, resolved to retain the 1km buffer and an additional 500m residential development and sensitive use restriction area to be referenced in public documents and Memorials on Certificates of Titles.

In May 2011, the WAPC resolved to confirm the 1km buffer and the additional 500m residential development and sensitive use restriction area, but with the specific acknowledgement that the extent of the buffer and restriction area will be reviewed in five years (May 2017).

In May 2011, Hatch on behalf of Qube Property Group and Satterley Property Group lodged an application with the WAPC to lift the "Urban Deferred" zone over the portion of land outside the KIB. Subsequently the WAPC approved the inclusion of the land in the "Urban" zone in March 2014 under MRS Amendment 1260/27.

In August 2017 the EPA published s16(e) confirming the suitability of the subject site for residential development (Area A), removed the requirement for a fixed buffer and suggested areas B, C and D undergo further consideration of appropriate transitional land use. Land use within Areas B, C and D has subsequently been resolved through IP 47 with a range of residential and industrial uses..

In March 2018 a further MRS amendment was lodged to lift the "Urban Deferred" between the previous 1km and 1.5km buffer lines covering the area subject of the MWLSP and MELSP Amendment 1. This Amendment 1350/27 was endorsed in April 2019.

The site is surrounded by "Urban" zoned land to the north, east and south and "IP47" land to the west. Further east of the site is the "Primary Regional Road" reserve associated with the Kwinana Freeway.

The land within the MWLSP boundary is largely zoned "Urban", the northern strip is zoned "Urban Deferred" and forms part of PCA No.112 held for the design and resolution of Rowley Road as well as a small portion of land in the SW corner which is within IP47.

This land within IP47 has been included in the subject site, associated concept design and POS calculations to enable a coordinated residential development. This is consistent with the Urban designations under IP47, however, it is acknowledged that the subdivision and development of this land will need to occur under the jurisdiction of IP47 and the associated Improvement Scheme provisions currently being finalised.

The current MRS zonings and IP47 are shown on Figure 4.

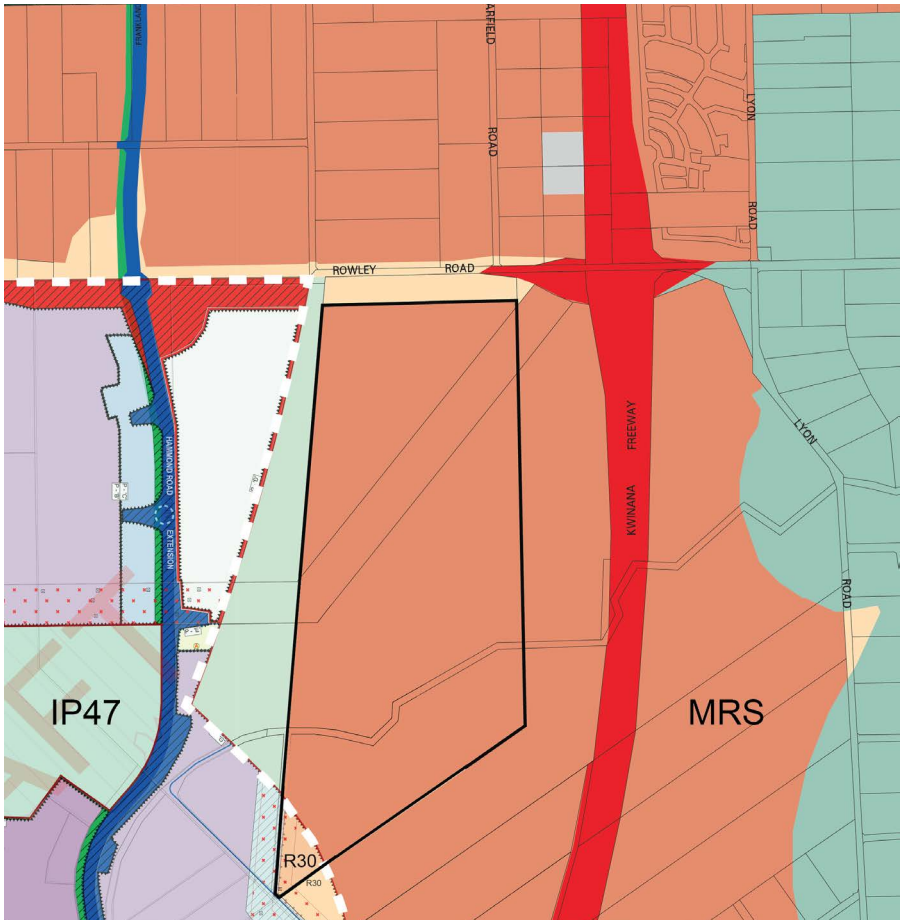


Figure 4: MRS Zoning

LEGEND
Structure Plan Boundary

METROPOLITAN REGION SCHEME RESERVES
Primary Regional Roads
Other Regional Roads

ZONES
Urban
Urban Deferred
Rural

IMPROVEMENT PLAN 47
ZONES
General Industry
Light Industry
Residential
Service Commercial
Composite

RESERVES
District Distributor Road
Primary Distributor Road
Regional Parks & Recreation
Drainage/Waterways

OTHER
IP47 Subject Area

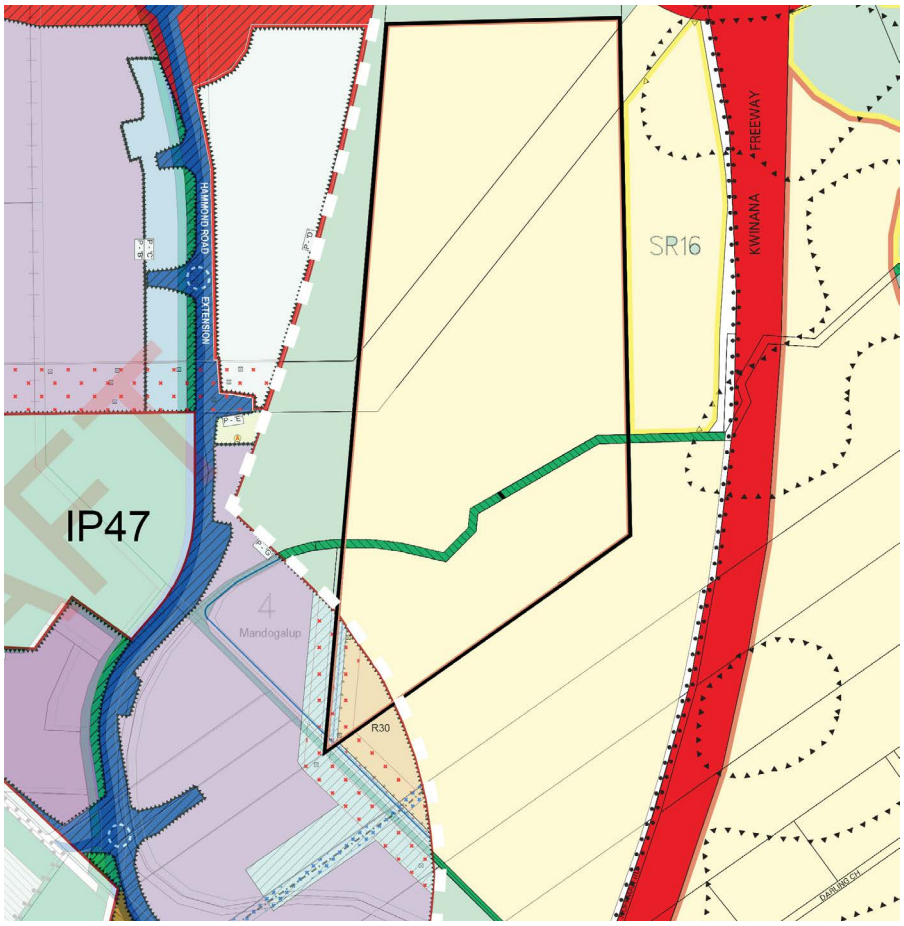


Figure 5: Town Planning Zoning

LEGEND
Structure Plan Boundary

METROPOLITAN REGION SCHEME RESERVES
Primary Regional Roads
Other Regional Roads

LOCAL SCHEME RESERVES
Park Recreation and Drainage

ZONES
Development
Rural A
Special Rural

OTHER
Local Government Boundary
Scheme Boundary
Area of Landscape Protection
SR2 Special Rural Area (see scheme text)
Policy Area (see scheme text)
No Zone

IMPROVEMENT PLAN 47
ZONES
General Industry
Light Industry
Residential
Service Commercial
Composite

RESERVES
District Distributor Road
Primary Distributor Road
Regional Parks & Recreation
Drainage/Waterways

OTHER
IP47 Subject Area

1.3.1.2 City of Kwinana Town Planning Scheme No. 2

As part of the process of lifting the "Urban Deferred" zone for the original majority northern portion of the site, a request using the provisions of Section 126 (3) of the Planning and Development Act 2005 was lodged by the City of Kwinana for the concurrent rezoning of the land to a "Development" zone under the City of Kwinana Town Planning Scheme No. 2 (TPS 2). This request was agreed by the WAPC and approved upon gazettal.

The more recent portion of land zoned "Urban" under MRS Amendment 1350/27 was not permitted to undergo concurrent "Development" zoning under the City of Kwinana Town Planning Scheme. This area was the subject of Scheme Amendment 159 and is now also "Development" zone.

The subdivision, use and development of land within the "Development" zone is to generally be in accordance with a Structure plan that has been prepared and adopted under the provisions of Clause 6.17 of TPS 2. The current TPS zonings and IP47 are shown on Figure 5.

1.3.1.3 Improvement Plan 47

One of the key changes to the planning framework since the initial MWLSP has been the progression of IP47. The plan has enabled confirmation of Urban uses outside of the IP47 area, certainty about the various land use interfaces to the subject site west of the Western Power easement and the Urban use of land to the immediate south west corner of the subject site on the eastern side of the easement.

The IP47 plan also provides a context for the resolution of the overall neighbourhood structure including retail facilities, movement network, public open space and community facilities. The Residential R30 designation currently being finalised under the IP47 Improvement Scheme is included in Figures 4 and 5 for clarity of zoning context.

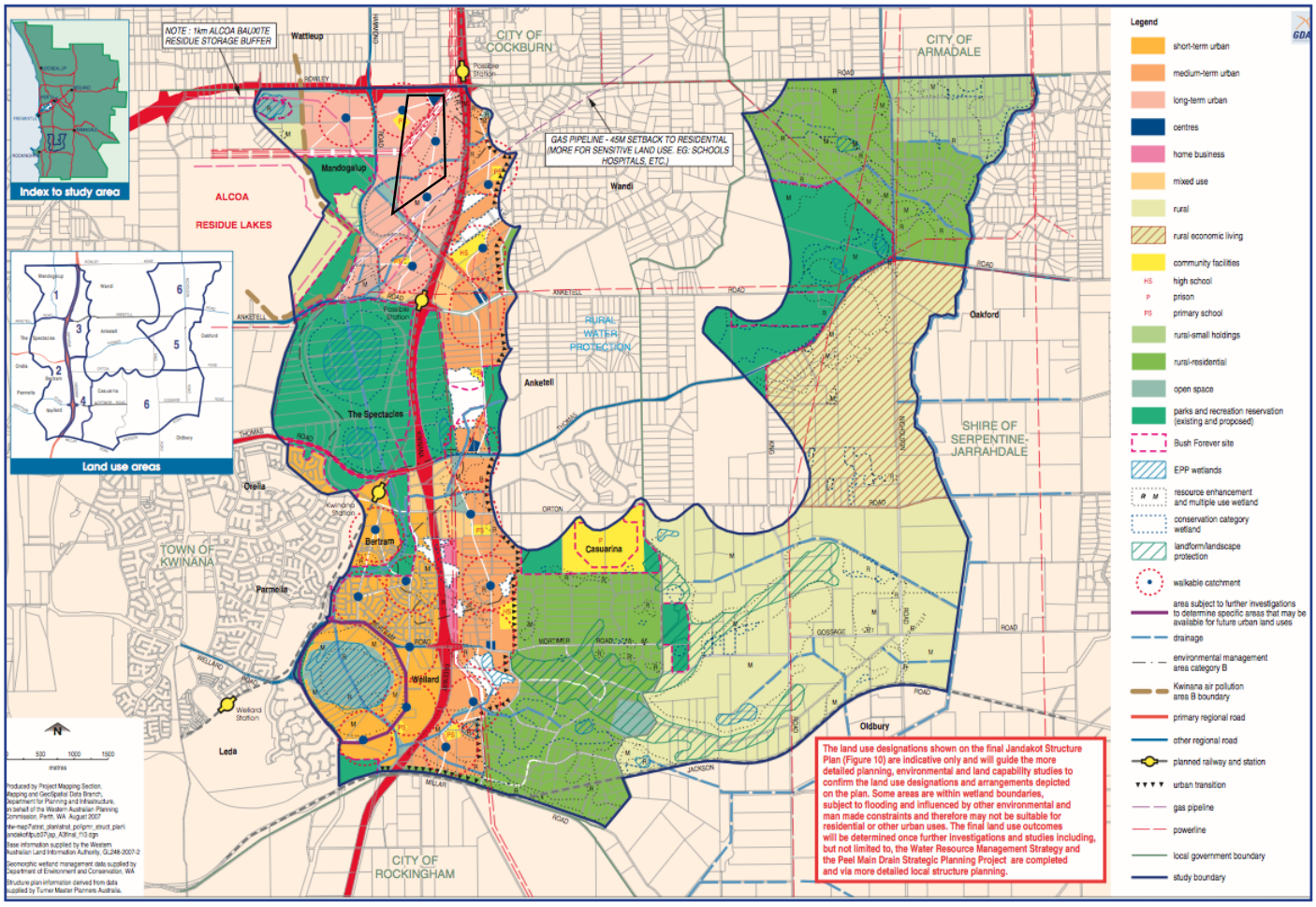
1.3.2 Regional and Sub Regional Plans

1.3.2.1 Jandakot Structure Plan

The Jandakot Structure Plan (JSP) projects a population of approximately 40,000 residents within the JSP area and outlines the general location of conservation areas, primary schools and transport links. The specific details of these aspects, such as the coordination of development and remnant vegetation protection were limited. Subsequently these formed the basis of further investigations associated with the then Town of Kwinana Draft District Structure plan, known as the Eastern Residential Intensification Concept (ERIC).

The JSP identifies the MWLSP area for urban development. The proposed MWLSP is considered to be consistent with the intent and requirements of the JSP.

Figure 6: Jandakot Structure Plan

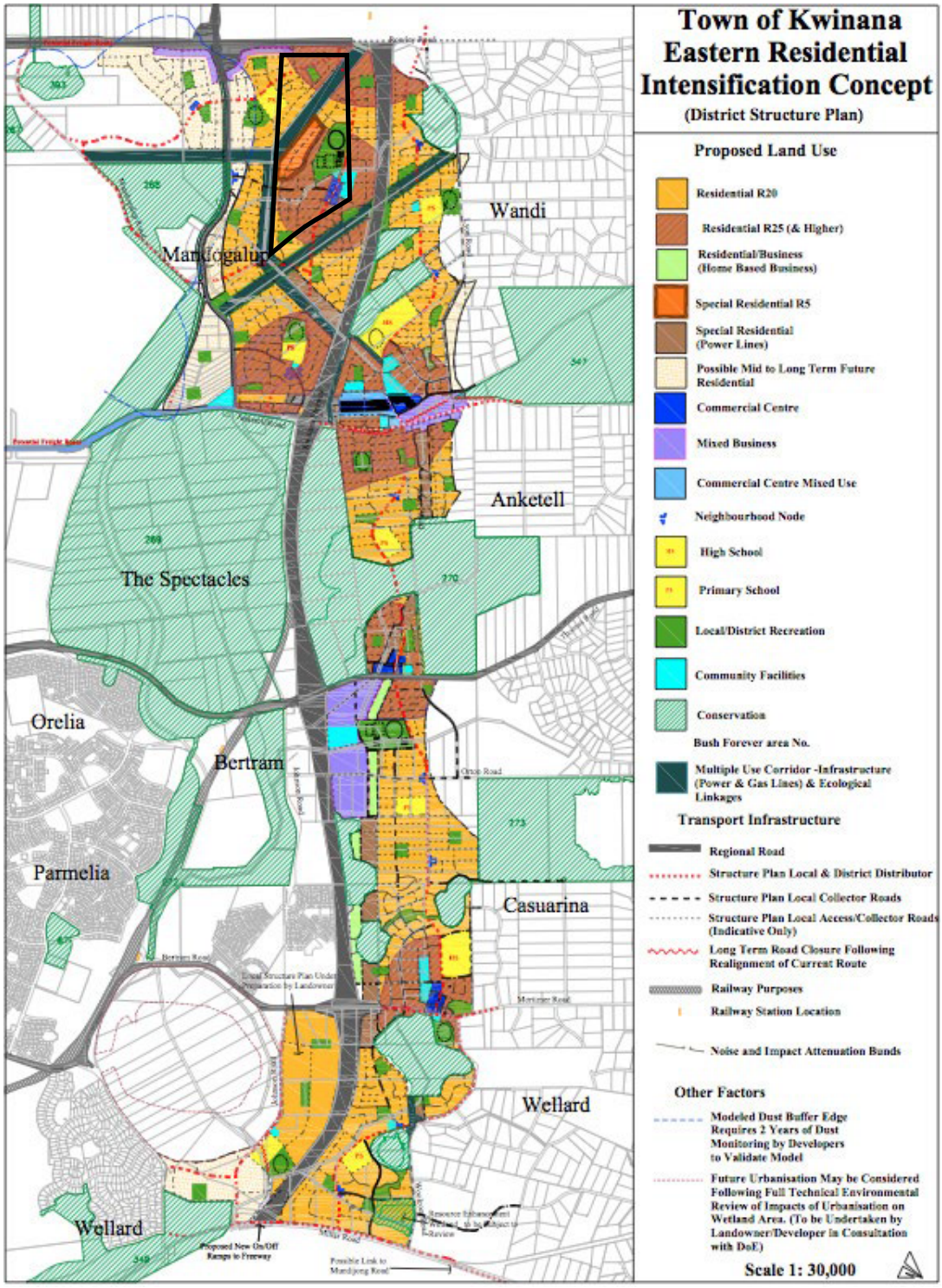


1.3.2.2 Eastern Residential Intensification Concept

The Eastern Residential Intensification Concept (ERIC) was prepared by the then Town of Kwinana in November 2005 and provides strategic direction and refinement of the future urban areas identified under the JSP (refer Figure 7). In particular, it expands upon the opportunities and constraints inherent to the land and, whilst yet to be formally approved by Council, 'defines a framework by which urban subdivision and development is able to occur in an orderly and coordinated manner'.

The MWLSP has been prepared giving due consideration to the provisions of ERIC, albeit updated to respond to the current planning framework, policies, principles and objectives. The MWLSP provides a response to more detailed site-specific analysis as required by ERIC, such as flora and fauna, water management, noise controls and traffic management, and those requirements emanating from WAPC State Planning Policies.

Figure 7: Eastern Residential Intensification Concept



1.3.3 Planning Strategies

1.3.3.1 Perth and Peel @ 3.5 million

Perth and Peel @3.5 Million provides a framework for the development of the Perth and Peel regions as the population reaches an estimated 3.5 million by 2050.

The document seeks to meet the targets identified under the earlier Directions 2031 and the State Planning Strategy 2050. The suite of documents also includes four draft 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 dwellings and employment should be located, and where important environmental assets should be protected.

The MWLSP area is situated within the South Metropolitan Peel sub-region and is identified as 'Urban' consistent with the current MRS zoning.

1.3.3.2 South Metropolitan Peel Sub-Regional Framework

The South Metropolitan Peel Sub-Regional 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. The South Metropolitan Peel sub-region is proposed to accommodate more than 1.26 million people, over 507,000 homes and approximately 430,000 jobs, with a projected additional dwelling target of 19,549 (49,499 people) within the City of Kwinana.

The MWLSP area is identified for urban development under the Framework.

An indicative subdivision design for the MWLSP identifies an approximate yield of 1160 lots (1160 dwellings), equating to a population of approximately 3,248 people (based on 2.8 people per household). The development of the MWLSP will therefore assist in achieving dwelling and population targets identified under the Framework.

The Framework also requires new urban development meet a residential density target of 15 dwellings per gross hectare. The overall density for the proposed development is anticipated to be approximately 1160 dwellings on various lot types resulting in an overall density of 11.71 dwellings per gross urban hectare (refer Table 3).

Once significant site constraints and that are unable to be developed are considered (in particular the transmission line easement and the Peel Main Drain) as well as open space areas, streets, and non-residential land; the density increases to 25.59 dwellings per site hectare. This is above the Liveable Neighbourhoods recommended minimum of 22 dwellings per site hectare and is considered appropriate for the site given its location and context.

The majority of residential lots are envisaged as more traditional R30 reflecting the fact that the majority of development is further than 400 metres from an activity centre of any kind and responding to constraints on the land including the future freight route of Rowley Road (Planning Control Area No. 112) and the transmission line easement.

This proposed density ensures the subject land is helping deliver an urban form in accordance with State Government objectives and strategic planning policy, despite the constraints associated with the subject land.

1.3.4 Liveable Neighbourhoods

Liveable Neighbourhoods (2009) was prepared by the WAPC to implement the objectives of the State Planning Strategy and deliver the strategies and actions of metropolitan spatial frameworks. Liveable Neighbourhoods is an operational policy that guides structure planning (regional, district and local), subdivision and development for new urban areas, including greenfield and large brownfield (urban infill) sites. Liveable Neighbourhoods seeks to promote the design of walkable neighbourhoods; places that offer community and a sense of place; mixed uses and active streets; accessible and sustainable parks; energy efficient design; and a variety of lot sizes and housing types.

The MWLSP has been designed in accordance with the principles and requirements of Liveable Neighbourhoods.

The indicative subdivision layout has been designed using compact streets blocks, to provide for a permeable and legible pedestrian, cycle and vehicle movement network. The public open space network provides connectivity through the site, intended to serve a variety of functions to cater for a wide demographic, with all proposed lots within approximately 200 metres of an open space area.

The MWLSP provides for a Primary School and local playing fields generally located centrally within the broader Mandogalup catchment (combined MWLSP and MELSP areas).

The indicative subdivision layout has been informed by various considerations, including but not limited to; existing site topography and landforms, achieving best possible solar orientation for future lots, servicing and water management.

In accordance with Liveable Neighbourhoods requirements for a minimum average density of 22 dwellings per residential site hectare, the MWLSP achieves approximately 25.59 dwellings per hectare of residential site hectare.

1.3.5 City of Kwinana Local Commercial and Activity Centres Strategy

The City of Kwinana Local Commercial and Activity Centres Strategy (the Strategy), adopted by Council in 2014, provides background information and input to inform the preparation of the City's new Local Planning Strategy (LPS). The document reviews and responds to the state policy setting and analyses the current configuration and future requirements for activity centres within the City based upon retail trends and population projections.

The Strategy identifies a potential local centre within Mandogalup, however, at the time of the original MWLSP this was unconfirmed subject to further, more detailed consideration. Given the uncertainty surrounding the appropriate location and viability of a centre to service the Mandogalup residents, a Retail Needs Assessment has been prepared by Taktics 4 to guide location, size and nature of commercial activity within the MWLSP and MELSP areas (Refer Appendix A).

The Taktics 4 Retail Needs Assessment report concluded that based upon the current distribution of centres (as per the Commercial and Activity Centre Strategy), the future residents of Mandogalup would need to travel almost twice as far as most urban communities to gain access to supermarkets at Harvest Lakes Neighbourhood Centre and Wandi District Centre.

Based upon a primary catchment radius of 1.5km a Neighbourhood Centre on Hammond Road could serve north and south catchments once Rowley Road / Hammond Road full access intersection is realised. The viability of this centre has been confirmed through the IP47 process and a site provided on the corner of Hammond Road and the Western Power easement.

Notwithstanding the above, a small local centre is shown within the proposed MWLSP to service the convenience needs of the more immediate Mandogalup catchment (including MELSP).

1.3.6 City of Kwinana Local Housing Study

The Draft City of Kwinana Local Housing Study , prepared in 2019, is provided as an appendix to the Draft Local Planning Strategy and facilitates the review of and amendments to TPS 2. The intent of the draft Strategy is to promote a broader range of housing types, encourage development of suitable sites, protect existing residential areas from incompatible land uses and preserve areas of remnant vegetation.

The draft Strategy identifies a housing approach that promotes medium density housing in close proximity to Public Open Space, Neighbourhood Centres and transport nodes and more traditional lot sizes for areas not within close proximity of these amenities.

The MWLSP has been prepared in accordance with the principles identified in the draft Study.

1.3.7 State Planning Policies

Development of land must have due regard to any relevant State Planning Policies which are prepared and adopted by the WAPC under statutory procedures set out in Part 3 of the Planning and Development Act 2005. The WAPC and Local Government must have due regard to the provisions of State Planning Policies when preparing or amending planning schemes and when making decisions on planning matters.

The MWLSP responds to the following relevant State Planning Policies:

State Planning Policy 2.1 – Peel Harvey Coastal Plain Catchment

- Preparation and approval of a LWMS to support the MWLSP; and
- Preparation and implementation of an Urban Water Management Plan to be required as a condition of future subdivision approvals.

State Planning Policy 2.4 – Basic Raw Materials

- There are no designated SPP 2.4 policy areas ('Key Extraction Area' or 'Priority Resource Location') located within or immediately adjacent to the MWLSP area.
- A sand extraction area is located approximately 400m to the west of the MWLSP area; and
- The location of this existing sand extraction area is not a constraint to the development of the subject land in accordance with an approved Structure plan.

State Planning Policy 2.9 - Water Resources

The purpose of this policy is to guide development of land that may impact on water resources in the State. Under the policy, water resources include water in the landscape with current or potential value to the community or environment". This incorporates features such as wetlands and waterways, surface water, groundwater, drinking water catchments and sources, stormwater and wastewater. The policy aims to ensure that the quality and quantity of water resources in the State are not adversely affected by development and land use.

The MWLSP design and LWMS ensure the quality of water collected and infiltrated through the site does not impact the landscape and environment qualities of the locality.

State Planning Policy 3 - Urban Growth and Settlement

- Consideration of lot product mix and distribution / location of density;
- Provision and distribution of amenity throughout the MWLSP;
- Consideration of access, both locally and beyond;
- Consideration of walkability and cycle opportunities; and
- Consideration of 'neighbourhood character' in street block layout, open space provision and landscape design.

State Planning Policy 3.7 – Planning in Bushfire Prone Areas

- Preparation of a Bushfire Management Plan to support the MWLSP; and
- Consideration of fire management in concept planning and allocation of public open space, as well as in the landscape master plan.

State Planning Policy 4.1 - Industrial Transition

- The south west boundary of the MWLSP area intersects with IP47 which has provided an interim resolution of landuse, including certainty of full development of residential uses over the MWLSP area; and
- The Western Power easement and Light Industrial uses further west provide an appropriate interim transition to heavy industrial uses with an opportunity to review land use west of the easement once the future of Alcoa's operations are resolved.

State Planning Policy 5.4 - Road and Rail Transport and Freight Considerations in Land Use Planning

- The preparation and endorsement of an acoustic assessment responding to the noise impacts of the Kwinana Freeway, the Perth to Mandurah Railway Line and Rowley Road (future Freight Route). The assessment includes noise mitigation requirements and the identification of lots subject to quite house design and 'deemed-to-comply' noise insulation packages.

1.3.8 Local Planning Policies

The MWLSP responds to the following City of Kwinana Local Planning Policies:

Planning for Bushfire Protection Guidelines

- Preparation of a Bushfire Management Plan to support the MWLSP; and
- Consideration of fire management in concept planning and allocation of public open space, as well as in the landscape master plan.

Public Open Space

- Provision of a minimum of 10% open space;
- Consideration for the City of Kwinana Community Infrastructure plan;
- Consideration of public open space location, size, functional distribution and useability requirements;
- Consideration for drainage requirements and restrictions with credited public open space areas;
- Consideration for requirement regarding conservation and wetland areas within public open space; and
- Provision of additional bonus public open space amenity through Western Power easement and Peel Main Drain upgrades.

Landscape Feature and Tree Retention

- Identification and retention of significant trees (in accordance with the definition under the policy) within public open space and road reserves;
- Consideration of existing site topography in preliminary earthworks, servicing and drainage considerations, information the indicative street block layout; and
- The preparation of the landscape feature and significant tree retention strategy.

Other Local Planning Policies to be considered through the detailed design and subdivision stages include:

- Design Guidelines for Medium Density Development;
- Crossovers;
- Footpaths;
- Residential Development;
- Residential Subdivision Development Guidelines;
- Residential Subdivision Road Standards;
- Retaining Wall Levels;
- Street Lighting;
- Street Naming; and
- Street Trees and Verge Treatments.

2.0 Site Conditions and Constraints

2.1 Biodiversity and Natural Area Assets

Given the previous agricultural land uses performed on the land (market gardens and grazing), portions of the site were predominantly cleared of native vegetation and degraded from an ecological perspective. Remnant vegetation on the northern and central portion of the land which varies from "Very Degraded" to "Excellent" condition in the north-west corner of the site where Banksia Woodland is present. Significant area have already been retained through the entry park and easement POS.

Cardno completed a Flora, Vegetation, Fauna and Wetland Assessment and survey for the area in 2005, with a subsequent study being undertaken by Plantecology Consulting in 2012. During the surveys, no Declared Rare, Priority or Significant flora species were located within the site pursuant to the Wildlife Conservation Act 1950 or the Environmental Protection and Biodiversity Conservation Act 1999 (EPBC). No Threatened Ecological Communities were located during the time of survey and are not thought to occur within a 5km radius of the subject site.

An assessment of the likely occurrence of each fauna species identified by the Environmental Protection and Biodiversity Conservation Act 1999 Protected Matters database has also been undertaken. Of the species, the Forest Red-Tailed Black Cockatoo and the Carneby's Black Cockatoo were likely to be found within the area, in addition to a number of migratory species. The proposed clearing of 38.7ha of native vegetation was referred under the EPBC Act and determined to be a "controlled action". Approval was granted for clearing of the native vegetation subject to the purchase of suitable off-set land.

The northern portion of the site reflects woodland vegetation of the Bassendean Complex Central and South. The vegetation is dominated by an over- storey of low banksia and sheoak, as well as an understorey of emergent eucalypts, shrubs and grasses. The central portion of the site contained a small area of low banksia woodlands. The remaining central and southern portions of the site have been cleared for agricultural purposes. These areas are now largely developed for POS, residential and Primary School use.

A site survey completed by Plantecology Consulting in 2012 also identified existing Jarrah and Malaleuca trees worthy of retention. The location of these trees was a consideration that informed the location and configuration of POS areas within the MWLSP design. The development of the parks will aim to retain the trees where possible, subject to engineering constraints.

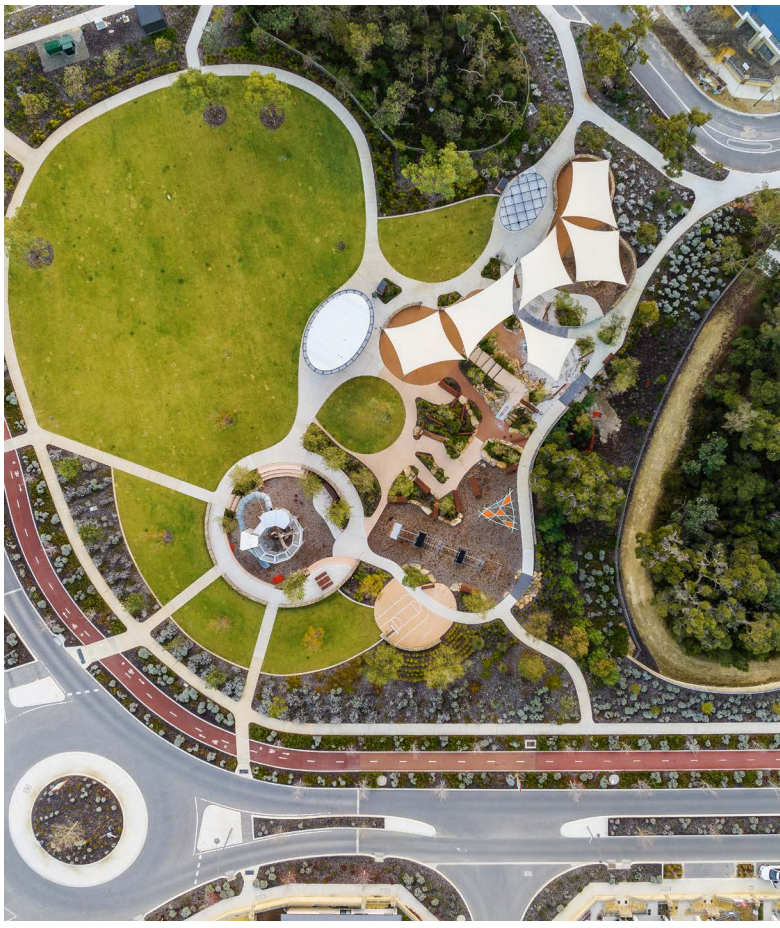
JBSG have provided a letter outlining the environmental work completed to date, in an effort to summarise the outcomes of the various environmental studies undertaken for the site over the years (refer Appendix B). The letter concludes that the on-site vegetation does not pose a constraint to development and also outlines various other environmental considerations including contamination, Acid Sulphate Soils and fauna.

2.2 Landform and Soils

Although now largely earthworked the site generally undulates from the highest point in the north-west corner on Rowley Road (approx. 42 AHD) down to the natural low point of the old Mandogalup Swamp (approx. 13 AHD). A relatively steep ridge runs through the middle of the site in a north-east/south-west alignment with the land falling in an eastern and southern direction. An additional low point also exists within the transmission line easement, which currently forms a natural, low-lying drainage point (refer Figure 8).

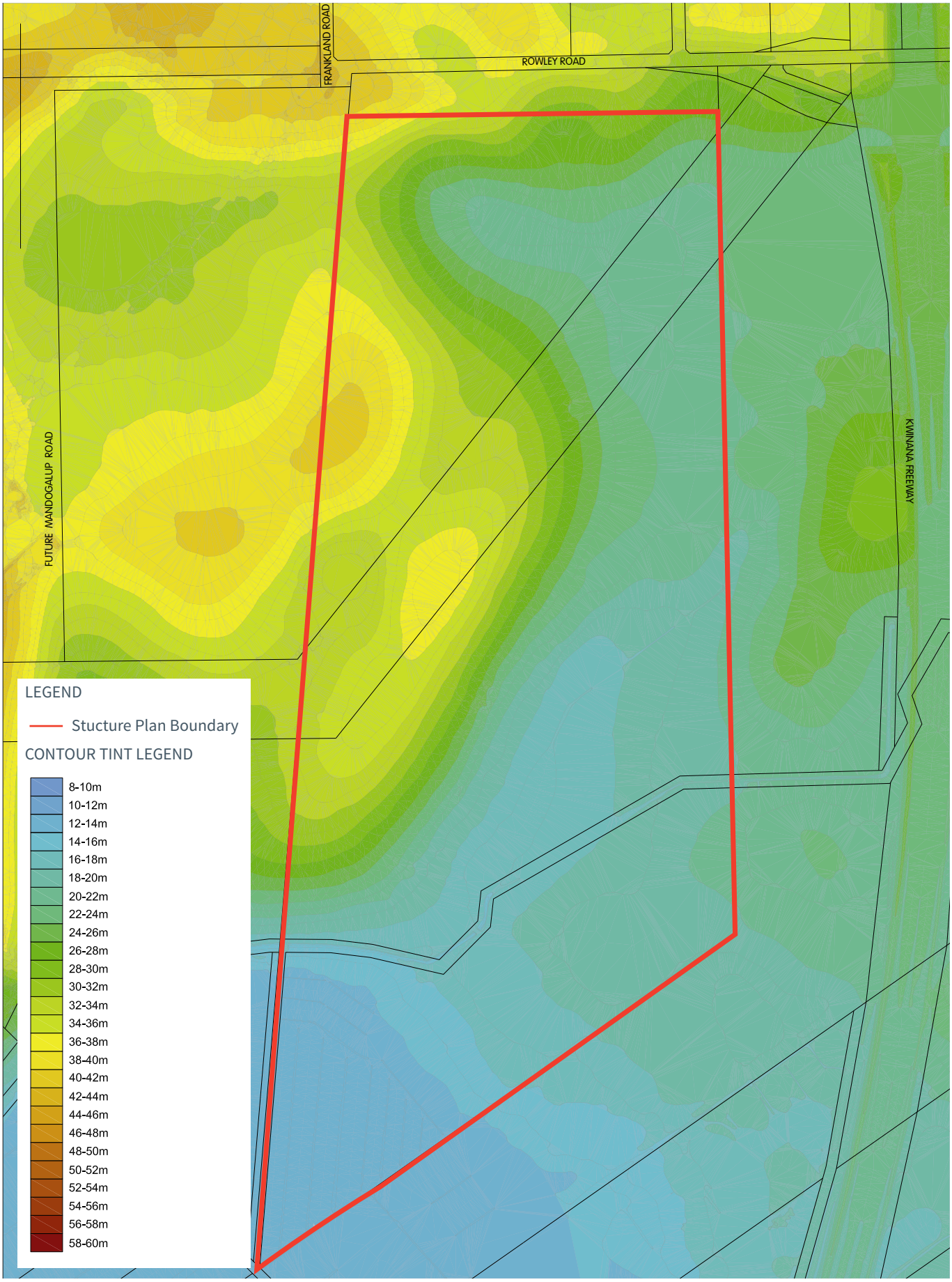
The site forms part of the Bassendean Dune system, consisting of Bassendean Sands and Bassendean Sands overlying Clayey Sand of the Guildford formation. Small portions of Peaty Clay and Sandy Silt exist on the site but are not considered a constrain to development. Further details are contained within the Engineering Servicing Report authored by Cossill and Webley (refer Appendix C).

The majority of the site is Moderate to Low Risk of Acid Sulfate Soils occurring within 3 metres from the soil surface, with a small portion of High Risk. The potential presence of Acid Sulfate Soils is not considered a constraint to development, however, it is anticipated that the presence of Acid Sulfate Soils will be managed through the preparation of an Acid Sulfate Soils Management Plan prior to subdivision commencing.



Event space and adventure playground with Copenhagen Bike Path (POS A)

Figure 8: Topography



2.3 Groundwater and Surface Water

The site is subject to the provisions of the State Planning Policy 2.1 – The Peel Harvey Coastal Plain Catchment, based on the location of the site within the catchment of the Ramsar listed wetlands of the Peel Inlet– Harvey Estuary and the importance of this regionally significant wetland chain.

The Estuary is impacted by surface drainage from the area via the Peel Main Drain and the Serpentine River. As such, acceptable regional ground water levels and quality require consideration.

The Peel Harvey Catchment Council supports urbanisation of land within the catchment based on completion of water management strategies in accordance with regional water management strategies and design criteria.

The JSP recommended extensive regional water modelling be undertaken to protect these environmental assets. The Jandakot Drainage and Water Management Plan No.3 (Peel Main Drain Catchment) (JDWMP) identified acceptable regional ground-water levels, an arterial drainage scheme and key design criteria to be addressed through further water management planning.

In accordance with the JDWMP, a District Water Management Plan (DWMS) was prepared and subsequently approved, facilitating the lifting of urban deferment in accordance with the Better Urban Water Management (2008) framework.

To facilitate the development of the MWLSP area, a Local Water Management Plan (LWMS) has been prepared in support of the Structure plan, to further refine and implement district and local drainage and groundwater quality requirements (refer Appendix D).

An existing drainage reserve, the Peel Main Drain, traverses the southern portion of the site, grading from the eastern boundary to the west and will continue to perform a role in the stormwater collection and disposal strategy.

2.4 Bushfire Management

As subdivision commences on site, the site will be largely cleared of any remnant native vegetation and therefore bushfire hazard within the site will be limited. Where existing vegetation is proposed to be retained within POS areas,

individual canopy trees will not pose a significant bushfire risk to future assets of the site. The parks will be largely grassed, with small planted areas that will not be of sufficient size or density to pose a risk.

Remnant vegetation exists within PCA No. 112. A vegetated screen has been retained directly adjacent to Rowley Road, where overstorey trees are preserved to create an entry into the site. The remainder of the area will be cleared and earthworked, providing a significant buffer, subject to the approval of the WAPC.

To the east of the site, on Lot 9019, a combination of Flooded Gum open forest and Banksia low woodland in excellent condition are proposed to be retained. The area is classified as an 'extreme' bushfire hazard and a hazard rating will be assigned through the Bushfire Management Plan (BMP) prepared for the MELSP.

An updated BMP been prepared for the MWLSP, in accordance with State Planning Policy 3.7: Planning in Bushfire Prone Areas (SPP 3.7) and Australian Standards 3959 (AS 3959). The BMP considers the bushfire hazards within and adjacent to the MWLSP area, and the associated bushfire risk, is readily manageable through standard management responses and compliance with acceptable solutions outlined in SPP 3.7 and AS 3959 (refer Appendix E).

2.5 Heritage

A search of the Department of Indigenous Affairs Aboriginal Heritage Inquiry System identified no registered sites of aboriginal heritage significance within the MWLSP area or immediate surrounds. However, the search did identify one 'Other Heritage Place', being a mythological site (Site 3427 – Mandogalup Swamp / Spectacles) that extends in the southern portion of the MWLSP area. This listing does not restrict the development.

A search of the Western Australian Register of Heritage Places identified no sites of state heritage significance within the MWLSP area.

A search of the City of Kwinana's Municipal Heritage Inventory identified no sites of local historic significance within the MWLSP area.



community cafe opposite entry park (POS A)

2.6 Planning Control Area No. 95/112 and Rowley Road

The MWLSP area is directly south of Rowley Road, which is classified as a District Distributor Integrator A Road in the Main Roads WA Functional Road Hierarchy document. Rowley Road has been identified as a primary freight route to the Kwinana Industrial Area and future container port. In the future Rowley Road, will be constructed to four lanes and will have significant upgrades to on and off ramps to the Kwinana Freeway.

To protect the freight route from inappropriate development Planning Control Area No. 95 was declared in February 2010 and was subsequently replaced by Planning Control Area No. 112 (PCA No. 112), declared in November 2015. PCA No. 112 covers a 4.53ha portion of former Lot 652, along the northern boundary with Rowley Road.

The MWLSP design does not propose development within PCA No. 112 other than to provide the necessary Neighbourhood Integrator B Road connection to the existing roundabout and a landscaped entry statement.

The Transportation Noise Assessment (Herring Storer, July 2017) identifies future lots that will require Notification on Title and Quiet House Design Package A architectural treatments as a result of the potential noise impacts from Rowley Road. The implementation of these requirements will be provided through the preparation of Local Development Plans.

2.7 Transmission Line Easement

An existing transmission line easement traverses the MWLSP area, running north-east to south-west, and then south along the western boundary. The easements contain 132 kv and 330 kv power lines. The easements are associated with the power network that connects to the Kwinana Industrial Area and the wider metropolitan grid to the south and north.

The MWLSP design takes into consideration the constraints to development associated with the easement. As a result of the Structure plan preparation process, an agreement has been reached with Western Power and the City of Kwinana for the future use of the easement. The easement has already been partially developed as restricted use local open space, catering to passive recreational activities, and vested to the local government for ongoing management.

The ongoing use of the easement as local open space complies with the Western Power guidelines for transmission line easements. It is noted that the MWLSP has not sought a public open space credit for the open space provided in the easement but the the improvements have enabled significant retention and management of Banksia Woodland.

Interface treatments between the easement and the MWLSP have been addressed in the final MWLSP design and are complimentary to and have consideration to the interface treatments proposed within the MELSP.

Lots largely back onto the easement in the southern portion due to the presence of the Optus Fibre cable which limits amendments to ground levels within the easement. Connections to the easement are provided at the Peel Main Drain and on the southern boundary where there is road and open space interface.

Figure 9: Opps & Constraints

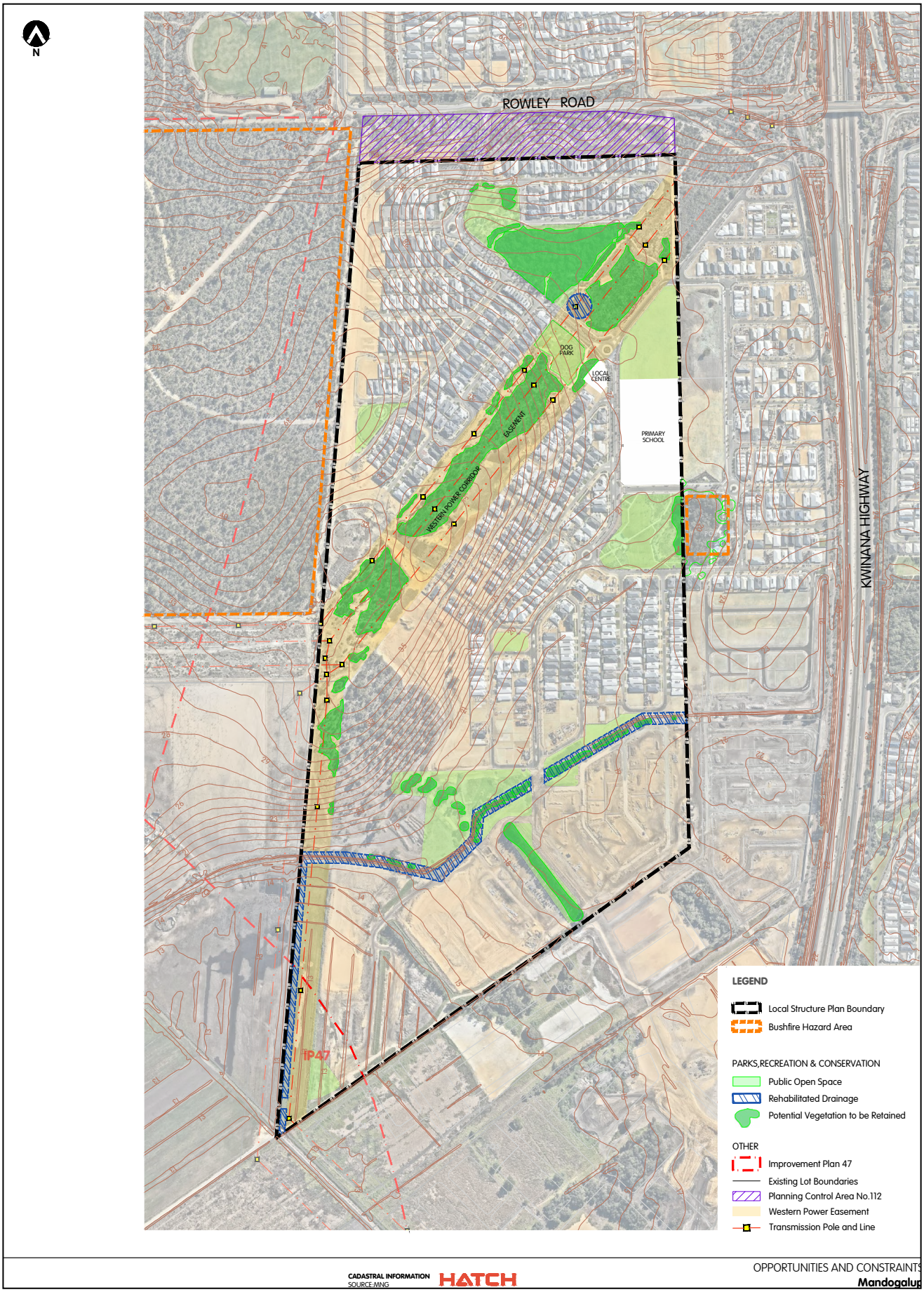
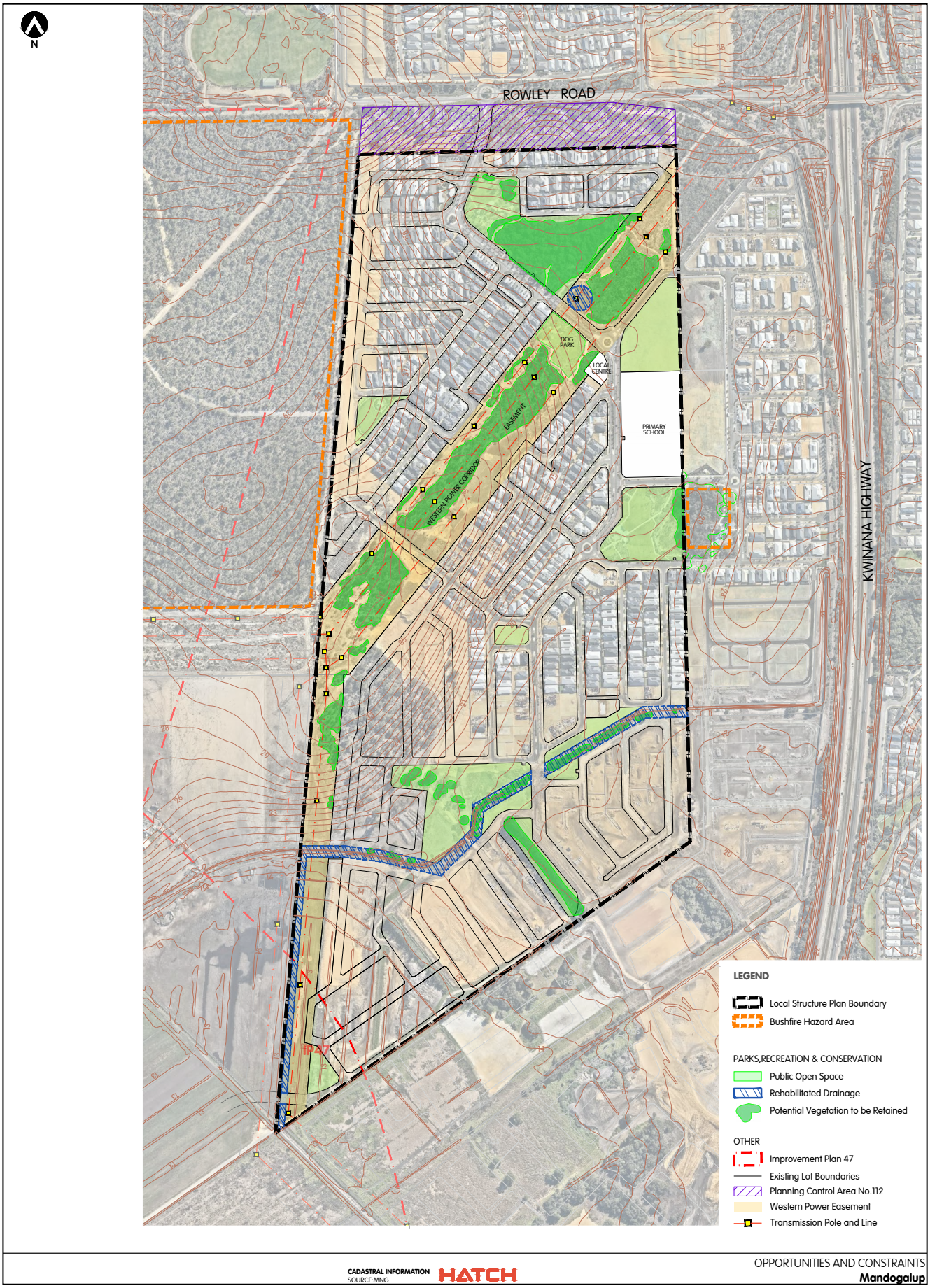


Figure 10: Concept Design Overlay



3.0 Land Use and Subdivision Requirements

3.1 Land Use

The MWLSP sets out land uses, residential densities, public open space network, public and private transport provision, environmental considerations and servicing requirements.

The MWLSP is proposed to comprise residential development with density codes ranging from R30 up to R60. The MWLSP also comprises a range of local and neighbourhood public open space areas in accordance with Liveable Neighbourhoods requirements, as well as a Local Centre, Primary School and playing fields to service the Mandogalup catchment.

The following sections describe the design response proposed under the MWLSP and address the relevant elements of Liveable Neighbourhoods (LN). Please also refer to the land use summary table provided below and Plan 1 – Mandogalup West Local Structure Plan.

Table 1: Land Use Summary

ITEM	DATA	SECTION NUMBER REFERENCED IN REPORT
Total area covered by the Structure plan	94.282	1.3.2
Estimate area of each land use proposed:		
Zones		3.0
Residential	44.852 ha	
Local Centre	0.0993 ha	
Reserves		
Public Open Space	10.079 ha	
Existing Drainage Reserve	2.0407 ha	
Public Purpose -Primary School	2.0076 ha	
Road	19.889 ha	
Transmission Line Easement	14.230 ha	
Improvement Plan 47	2.4573 ha	
Estimated lot yield:	1160	3.3
Estimated number of dwellings	1160	3.3
Estimated residential site density (dwellings/site hectare):	25.59	3.3
Estimated population (@ 2.8 people per household)	3,248	3.3
Number of high schools	0	3.7
Number of primary schools	1	3.7
Estimated commercial floor space (nett lettable area):	750m2	3.8
Estimated area and percentage of public open space given over to:		
Regional open space	Nil	
District open space	1.358 ha (playing fields)	3.2
Neighbourhood parks	3.6354 ha | 2 parks	
Local parks	5.1012 ha | 8 parks	
Estimated number and area of natural area	7.52 ha	3.2

3.2 Open Space

Under the provisions of LN, a range of site responsive urban parkland is required, which appropriately addresses district, neighbourhood and local needs of residents, comprising a mixture of unrestricted and restricted open space.

The MWLSP therefore provides a hierarchy of public open space (POS) areas across the site, considering the requirements for drainage and vegetation retention. Detailed subdivision design will provide further refinement to the MWLSP POS network, defining specific configuration, uses and treatment within each POS area. In accordance with LN, the MWLSP complies with the required POS provision of 10 per cent of the gross subdivisible (refer Table 2).

The foundation of the POS network is the retention of existing vegetation as identified by previous studies and the updated Landscape Feature and Tree Retention Management Plan prepared for the Amendment 1 area. (refer Appendix B). The work to retain remnant vegetation has resulted in a high proportion of POS area capturing endemic and exotics species providing extensive habitat and preserving cultural landscape.

The POS network is generally configured around a central avenue, which forms a green corridor flowing through and connecting the entire neighbourhood. A series of POS areas along the avenue strengthen the recreational and land value of both the avenue and major areas of open space. The shifting avenue alignment creates vistas towards and through these areas of POS amenity with the backdrop of retained trees as you move through the community.

A series of complimentary secondary links cross connect each of the parks, creating a network of walking circuits for the community. The sense of nature, emphasis on avenue tree plantings and high level of connectivity between open spaces creates a strong emphasis on walking and cycling, particularly to the centrally located Primary School.

The MWLSP POS areas have been configured and located to take into consideration results of the tree survey, engineering report and site topography, to allow the retention of significant existing mature trees. The design of the overall MWLSP POS network will ensure the majority of residents are within a 400 metre walkable catchment of a park that can cater for a variety of recreational uses. This has resulted in the proposed park sizes ranging from 3000sqm for smaller pocket parks to larger parks of approximately 2.4 hectares (refer Figure 11). This range in POS sizes will create spaces that are fit for purpose and provide for both passive and active recreation.

The City of Kwinana Public Open Space Local Planning Policy (POS Policy) outlines that each suburb area should generally provide 40% of its open space contribution as conservation areas. In the context of the MWLSP open space areas, further discussion and negotiation with the City of Kwinana have resulted in an agreement that the retained vegetation within:

- POS A, D, F, H and J;
- Western Power easement and Peel Main Drain; and
- the localised retention of trees within road reserves, which combined meet the conservation area requirement of the POS Policy.

The POS network has been updated to provide additional open space areas around the Peel Main Drain (Lot 3), which provides an improved design response, improved integration between the MWLSP area and the Peel Main Drain and brings the MWLSP in line with the design of the adjacent MELSP.

The POS network helps dictate the design of other major features of the development including the location of medium density residential lots, movement networks, water management features and links to educational facilities. The neighbourhood configuration therefore responds to the location of POS areas and draws amenity through the development with a series of vistas, vista terminations and lots with a direct outlook across green spaces. This is anticipated to be further defined through the planting of primary and secondary street trees to create a “garden setting”.

Given the importance of the POS spine in the creation of amenity and identity for the future community in Mandogalup, Plan E have prepared a Landscape Principles Plan (refer Appendix F).

POS within the additional Amendment 1 area has built on the substantial environmental restoration opportunity in and around the Peel Main Drain, preserving vegetation and integrating Water Sensitive Urban Design treatments to enhance water quality.

The consolidation of POS around the Peel Main Drain provides a major multi function Neighbouhood Park on the north side of the Peel Main Drain and connects to the consolidated POS on the south side of the drain, including the large retained windrow which is a defining element of the lands rural history.

The overall outcome for the MWLSP POS network is:

- Retention of 7.52ha of existing vegetation;
- Response to landscape and character including:
  - Banksia Woodland;
  - Wetland and Peel Main Drain restoration; and
  - Retention of Rural landscape elements.
- Diverse POS network including;
  - Multiple linear natural habitat areas;
  - Large northern, central and southern neighbourhood parks;
  - Central shared playing fields adjacent to Primary School;
  - Range of smaller pocket parks; and
  - Central linear ‘bike boulevard’ linking through entire community with key connections to primary school, POS, cafe/sales centre and potential local centre.
- Base POS over 10% requirement with and additional 3.3ha of restoration and POS amenity in easment and Peel Main Drain land.

Existing vegetation in the northern portion of the Amendment 1 area could not be retained due to the complex integration of earthworks, particularly the transition of levels for adjoining high points within the easement including fibre optic and major power transmission infrastructure. Removal of the vegetation accords with existing Commonwealth approval and $378,000 of offset payments which have enable the purchase of land for retention of 154ha of remnant vegetation.

Figure 11: POS Plan

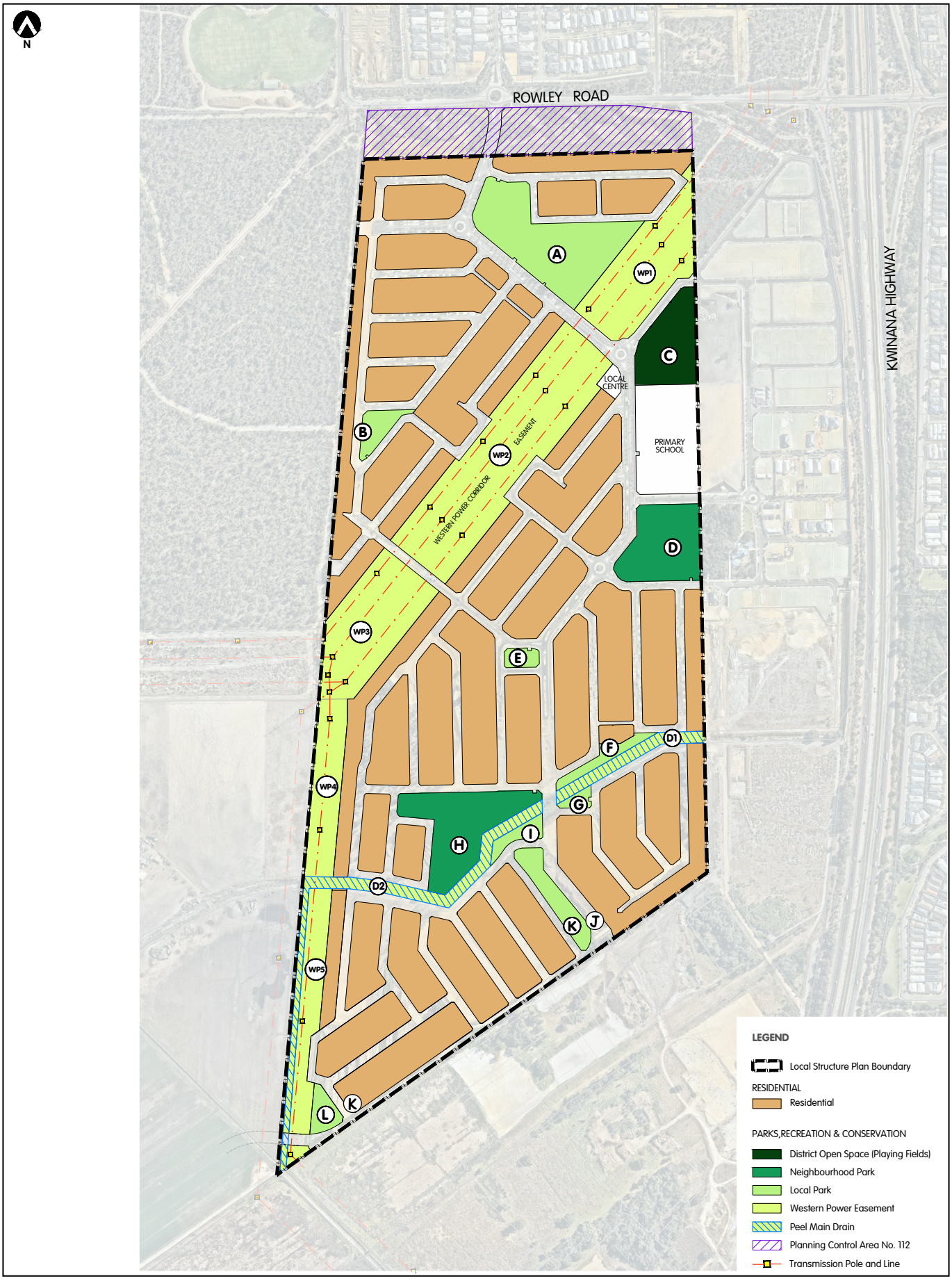


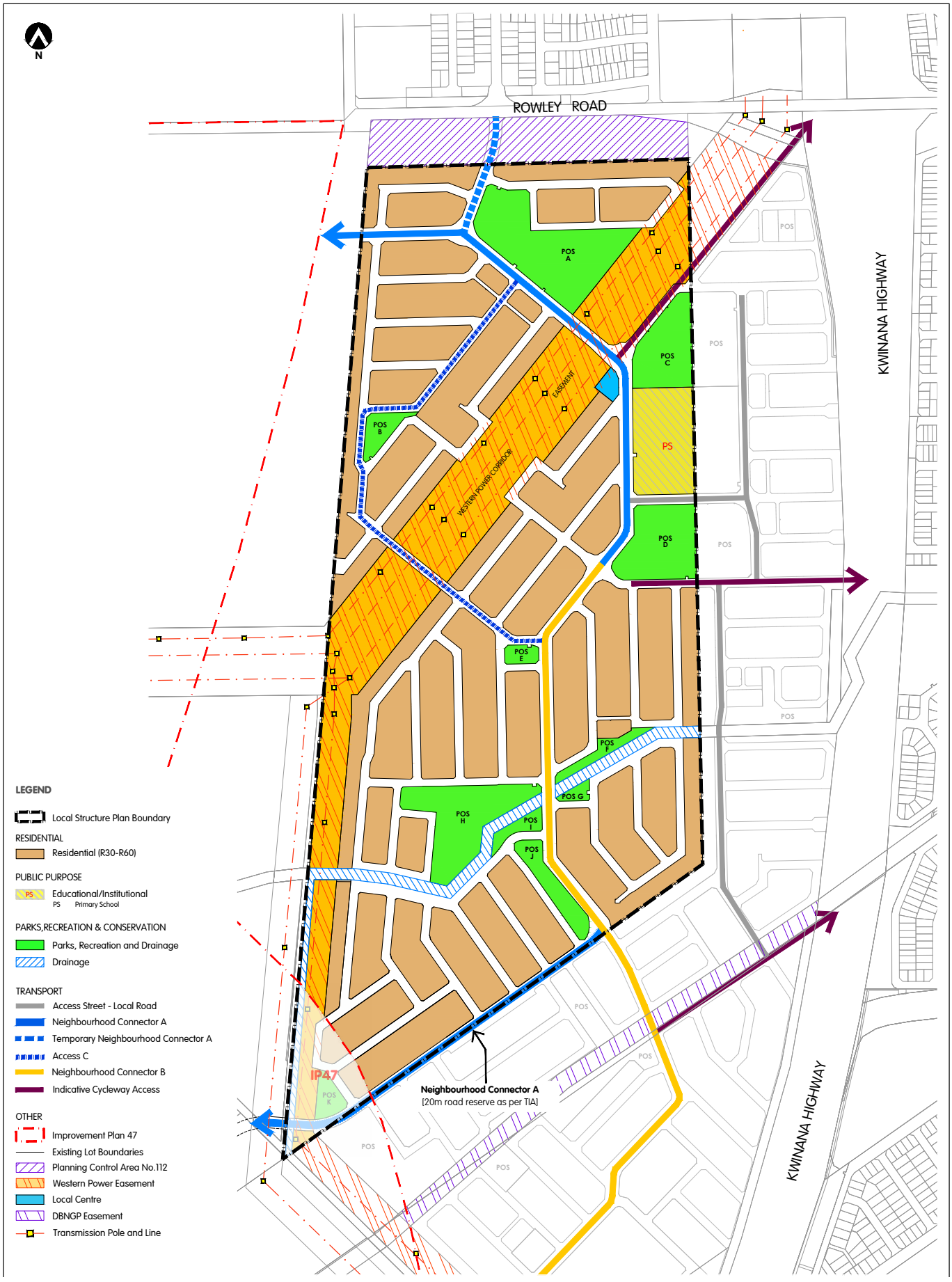
Table 2: Indicative Pos Schedule

PROPOSED PUBLIC OPEN SPACE SCHEDULE				
Site Area				94.282
Deductions				
Dedicated drainage reserve not included in POS (1:1 year event)		1.003		
Peel Main Drain		2.041		
Power Easement		14.230		
Primary School		2.000		
Restricted POS over 20%		0.620		
Total Deductions				19.893
Gross subdivisible area				74.389
Public open space @ 10 percent				7.439
May comprise:				
- minimum 80% unrestricted POS		5.951		
- maximum 20% restricted POS		1.488		
Public Open Space Contribution	**Open Space Area (gross)**	**Unrestricted**	**Restricted (1:1 - 1:5 year event)**	**Dedicated Drainage (1:1 year event)**
A	2.8970	0.9740	1.7060	0.2170
B	0.3700	0.3700		
C	1.3425	1.3425		
D	1.6270	1.5340	0.0060	0.0870
E	0.1889	0.1889		
F	0.3299	0.2934	0.0030	0.0335
G	0.1336	0.1336		
H	2.0084	1.5884	0.0600	0.3600
I	0.2588	0.1558	0.0030	0.1000
J	0.6630	0.3480	0.2600	0.0550
K	0.2600	0.0400	0.0700	0.1500
Sub-total	**10.0791**	**6.969**	**1.4878**	**1.0025**
Total*	**8.46**	**11.37%**		

*Note that the Western Power Easement (14.23 ha) is not included in the total POS contribution but vested as open space to City of Kwinana. The easement includes areas of useable open space such as a dog park, cycle and walking paths, and retained vegetation.

3.3 Residential

Figure 12: Overall Concept Plan



An indicative subdivision layout has been prepared for the MWLSP area, identifying an approximate yield of 1160 lots. Based on approximately 1160 dwellings within the MWLSP area, the site achieves an overall density of approximately 11.71 dwellings per gross urban hectare. Once significant site constraints that are unable to be developed are considered (in particular the transmission line easement and the Peel Main Drain), the overall density increases to 25.59 dwellings per site hectare. This is considered appropriate for the site considering its location and context.

The MWLSP allocates a density code range of R30-R60 across the residential zoned portions of the structure plan area. Indicative residential density codes have been allocated across the site and have been used in the preparation of the indicative subdivision layout and density calculations. The MWLSP assumes a base density code of R30, with areas of R40 and R60 concentrated around higher amenity and access areas, including (but not limited to) the future local centre, the primary school, public open space and adjacent to public transport or neighbourhood connector routes.

For reference, an indicative Lot Type Plan is provided at Figure 13. It is noted that this plan is provided for explanatory purposes only and is subject to review and detailed design at the subdivision stage.

The density code range facilitates the provision of a diversity of lot product across the site, providing for a range of dwelling types to cater for the broad cross-section of community housing needs. The preparation of Local Development Plans will also assist in facilitating the delivery of diversity in lot product, as well as seeking to achieve built form outcomes consistent with the development intent of the site. The MWLSP design also allows that the majority of residential lots will be able to achieve optimal solar orientation, particularly along an east-west alignment.

3.4 Movement Networks

The overall movement network has been designed to optimise walking and cycling environments, particularly the central cycleway spine and cross connections to the Principle Shared Path located to the west of Kwinana Freeway. This will allow uninterrupted cycleway access from the Mandogalup neighbourhood through to the Aubin Grove rail station, optimising the use of public transport and increasing commuter options to the city.

The interconnected network of streets with dual use and pedestrian paths also provide ready access to localised areas of high amenity and walking circuits connecting parks, the primary school and the future neighbourhood centre. In addition, it allows sight lines, vista points and visual connections through to retained vegetation, emphasising its importance in creating a sense of place for the community.

The proposed street network has also made extensive and significant effort to avoid view lines and associated visual impacts associated with the transmission line stands.

The hierarchy of streets within and adjacent to the MWLSP area is based on the hierarchy defined within LN. The proposed design provides for a permeable, interconnected road network that allows for the free flow of pedestrians, cyclists and motorists within the MWLSP area (refer Figure 13 and 14).

The north-south Neighbourhood Connector A road is the key entry and exit point into the new Mandogalup neighbourhood. The connector road will link the community to areas of amenity and the primary school, which have been positioned to emphasise the key north south axis. In addition, the proposed cross section for the Neighbourhood Connector A will provide for a multi-functional movement route.

As well as performing its function of channelling traffic through the area, the road will be designed with off-road cycle paths, footpaths on both sides, on-street parking, and will be planted with street trees to emphasise its avenue nature and intended position as a central meeting point. The placement of the road also emphasises the natural fall of the land, with it entering the LSP area through a natural amphitheatre at POS A, before following an existing contour to provide a flat connection through the neighbourhood to the primary school.

Rowley Road is classified as a District Distributor Integrator A road and is currently constructed as a rural standard single carriageway. It provides an east-west linkage between South Western Highway, Tonkin Highway, Kwinana Freeway and Rockingham Road and has been identified as a primary freight route to the Naval Base and Kwinana Industrial Area. In the future, it will be constructed to four lanes and divided according to Main Roads WA standards.

Rowley Road also provides the main point of access into the MWLSP area through its intersection with the proposed north-south Neighbourhood Connector A road. The intersection is proposed at an appropriate distance to ensure the full functioning of the Kwinana Freeway. Ultimately, when Mandogalup Road is extended, the Neighbourhood Connector intersection will be downgraded to a left in left out, with full access being transferred to the west.

An off-road cycleway will run along the north-south Neighbourhood Connector road, providing a safe bike link from existing infrastructure on Rowley Road, through the neighbourhood, past the primary school, and development to the south. Access Streets B and C will also be provided with Dual Use Paths to connect cyclists to the future Neighbourhood Centre, the regional bike networks and the principal shared path that follows the route of the Kwinana Freeway. Footpaths are also proposed throughout the entire neighbourhood. The key pedestrian and cyclist routes will be planted with street streets to emphasise the safe, green networks that will be developed throughout the area and promote walking and cycling.

A Transport Assessment Report has been prepared that provides a detailed analysis of existing and proposed infrastructure, traffic generation calculations and intersection treatments (refer Appendix G).

Figure 13: Road Hierarchy Plan

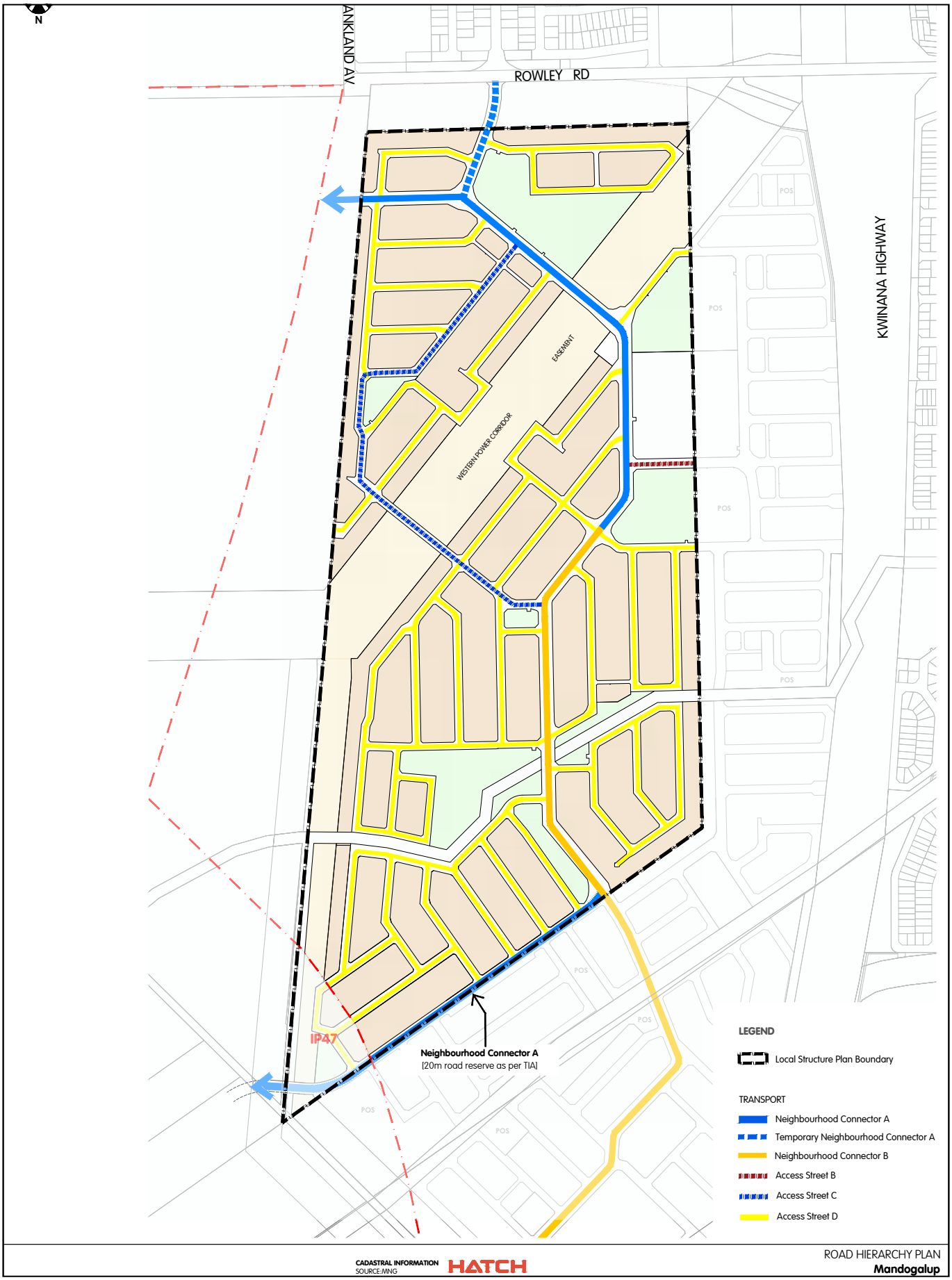
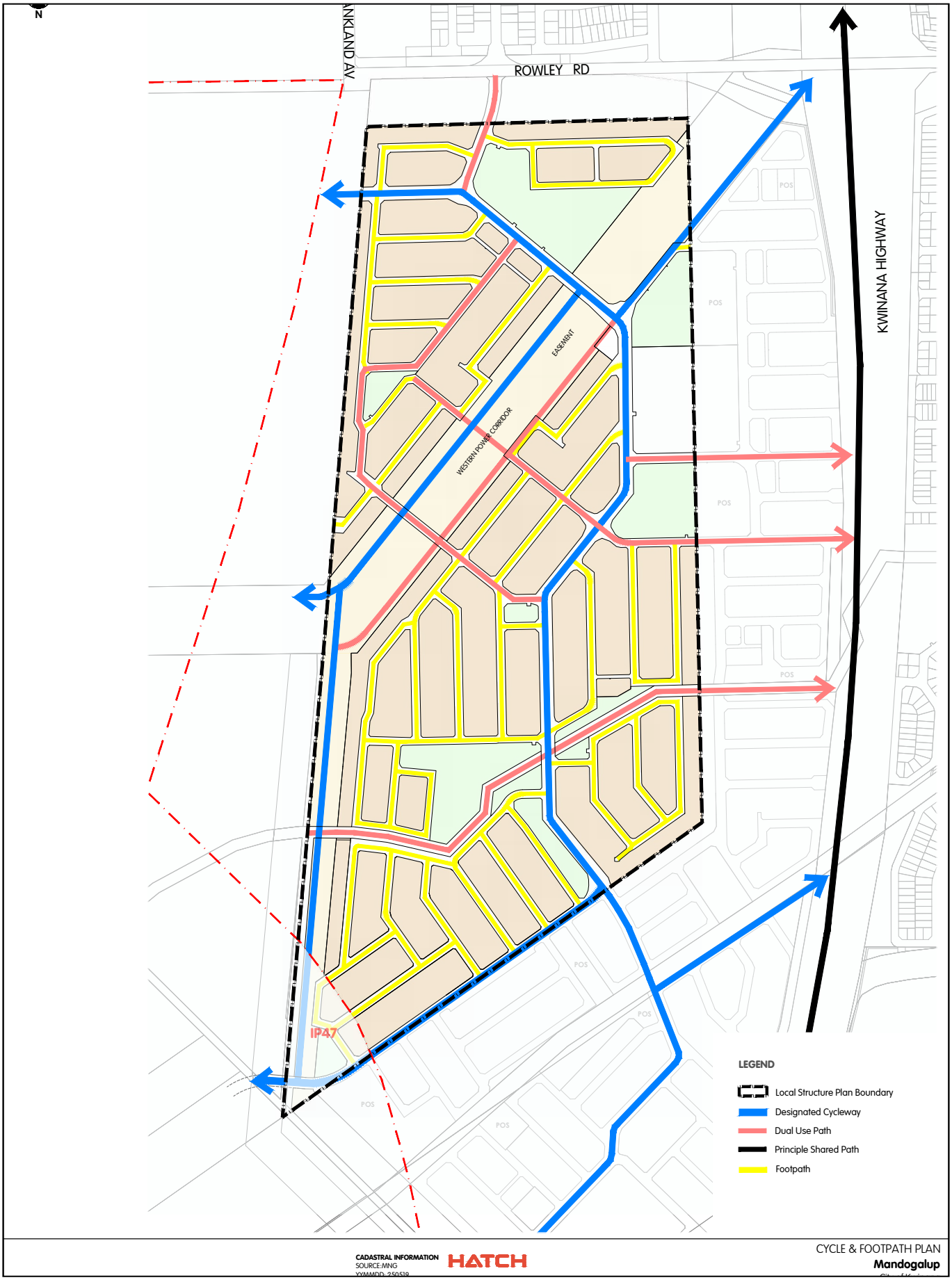


Figure 14: Cycle/Footpath Plan



3.5 Local Development Plans

A Local Development Plan is required in the following circumstances:

- Lots with an area of 260 square metres or less;
- Irregular shaped lots;
- Lots where specific vehicle access and egress control is required;
- Lots abutting public open space;
- Lots with particular site constraints;
- Lots subject of a notification on title;
- Lots abutting the Western Power transmission line easement;
- Lots abutting / adjacent to the Peel Main Drain;
- Lots with a BAL rating of 12.5 or greater; and
- Lots that require Quiet House Design for noise attenuation through deemed to comply noise target/limit package and for lots identified as subject to specialist acoustic advice.

Local Development Plans are to address, as a minimum, the following:

- Dwelling orientation;
- Type of fencing;
- Location of carports/garages and vehicular access;
- Surveillance;
- Setback variations; and
- Requirements for dwelling construction compliant with an approved Bushfire Management Plan and Noise Management Plan.

In preparing Local Development Plans, the design responses and interface treatments between the MWLSP and MELSP will need to be considered to ensure the effortless transition between the two developments, whilst noting the different design objectives of the two estates to create individual character and sense of place.

Permitted variations to the R Code standards for garages and open space have been include in Part 1, in order for the development standards applied to the existing stages of development to remain consistent.

The residential developable land within the MWLSP has been assigned an associated density code range of R30 to R60 to enable a range of lot sizes and dwelling types.

3.6 Water Management

A Local Water Management Strategy (LWMS) has been prepared by JDA for the MWLSP (refer Appendix D). The LWMS requires stormwater runoff generated from the proposed development of the site be detained and infiltrated on-site in POS areas, in accordance with the DWMS.

Groundwater recharge will be maximised through the adoption of 'Best Management Practices' that promote the dispersion and infiltration of runoff as close to source as possible. The LWMS proposes the diversion of runoff into a pit and pipe network combined with inter-allotment drainage soakwells to infiltrate runoff from building roofs and private open space areas and the disposal of road runoff into infiltration basins within POS areas.

Drainage from public roads and lanes is to be collected via conventional gullies. The drainage collection and conveyance system will be designed to cater for the runoff from storms with up to a 1 in 5 year recurrence interval. A series of interconnected detention basins will store runoff to the pre- development peak flow rates for the 5, 10 & 100 year ARI events. The dispersion of stormwater disposal throughout the site will maximise the area of recharge down through the soil profile to the shallow aquifer, thereby maximising the potential for nutrient stripping and water quality improvements.

Overflow drainage from POS A is proposed to be accommodated within the transmission line easement. The area identified in the LWMS already performs this role and is a natural low point on the site, and therefore is the practical and logical choice for post-development overflow drainage. The use of the area minimises the need for earth working and reduces the impact of drainage on the adjoining POS. Drainage in an open space area is a non-sensitive land use and will allow for the purposeful use of the land within the transmission line easement. This area will be developed to a low maintenance rural standard.

The easement will be developed as restricted use local open space, catering to passive recreational activities, and vested to the local government for ongoing management. The proposed use of the easement as local open space will comply with the Western Power guidelines for transmission line easements. It is noted that the MWLSP does not seek a public open space credit for the open space provided in the easement.

3.7 Education Facilities

The MWLSP (and in part the MELSP) provides for a shared primary school site. The catchment for the future Mandogalup Primary School is contributed to by the proponents of the MWLSP and Satterley Property Group, being the proponent of the adjacent MELSP.

Given the importance of the north-south Neighbourhood Connector road in providing a walking and cycling route along a flat and high amenity area, it was integral that the primary school site be located in close proximity to this design feature.

The primary school is proposed to be co-located with the City of Kwinana's shared use playing fields. The layout shown on the MWLSP map has been prepared in consultation with the Department of Education and City of Kwinana. The size and location of the primary school, plus the shared playing fields, have been agreed to by all stakeholders, including the proponents of the MELSP.

Given the additional residential catchments across MWLSP, MELSP, recently approved MRS Amendment in South Mandogalup and residential areas with IP47 a second Primary School site has been provide for within the southern portion of MELSP. This is consistent with liaison with the Department of Education, however, could be reviewed if additional residential is provided in the IP47 area as a result of the Alcoa closure.

3.8 Activity Centres and Employment

A Retail Needs Assessment (refer Appendix A) has been prepared by Taktics 4 in response to uncertainty surrounding the requirement for a local centre in the area. The report concludes that without a local centre, the community of Mandogalup would be underserviced for retail options and would need to travel almost twice as far as other urban communities to gain access to everyday goods and services. In short, the report indicated the need for the provision of a small supermarket based local centre of approximately 750 square metres of retail floor space.

The proposed local centre will sufficiently service the future residents of Mandogalup and will provide for day-to-day goods, services, community facilities and employment opportunities. The proposed small supermarket local centre is expected to be developed following the establishment of a sufficient catchment in the new residential neighbourhoods. In line with the recommendations of the retail assessment, the MWLSP identifies an interim local centre, centrally located to the MWLSP and MELSP catchment.

As a result of expansion of the retail catchment a larger Neighbourhood Centre has been provided on the corner of Hammond Road and the Western Power easement through the IP47 process. For higher order goods and services, it is expected that Mandogalup residents will utilise the secondary centres of Kwinana and Cockburn, which are located approximately 7km south and north of the MWLSP area, respectively. These centres, in addition to the Kwinana and Henderson Industrial areas, are expected to provide a wide variety of jobs and employment opportunities for the resident community.

3.9 Infrastructure Coordination, Servicing and Staging

The following provides a summary of the infrastructure and servicing for the MWLSP. Further information is contained within the Engineering Servicing Report prepared by Cossill and Webley (refer Appendix C).

3.9.1 Sewer

The Site forms part of the Water Corporation's Thompson's Lake waste water reticulation system and preliminary planning has been undertaken to develop strategies for providing deep sewerage to all proposed urban land within the subject area.

The Water Corporation has recently updated their sewer strategy and confirmed the Site will be serviced via construction of a new Type 90 Pump Station servicing all development west of the Freeway. This new "Thomsons Lake PS J" will include a pressure main north through the existing Western Power easement an up Barfield Road to an existing sewer discharge tower near the intersection of Jackadder Avenue.

Design of this pump station is underway in order to support development of the Structure Plan area. Standard Water Corporation headworks will apply.

3.9.2 Water Reticulation

The site is located within the current boundary of the Water Corporation's Water Supply Scheme and overall planning for the scheme has made provision for residential development of the site.

The Water Corporation has however indicated that water distribution planning for the area is under review. The current planning indicates that the site will ultimately be serviced by extension of an existing 610mm distribution main in Hammond Road that currently terminates north of the intersection with Russell Road. This extension is a Water Corporation capital project, and would be extended south as demand requires.

3.9.3 Power

Electrical consultant UDP has advised that the site and proposed development can be supplied from the existing power network located on the northern side of Rowley Road through the existing development of the Apsley Estate. All site power will be underground and fed from transformers located strategically within the site.

3.9.4 Gas

ATCO Gas can be supplied via a connection to the existing system within the Apsley Estate.

3.9.5 Telecommunications

The National Broadband Network Company (NBN Co.) can be extended within the existing Apsley Estate.

3.9.6 Staging

The staging has delivered lots adjacent to Rowley Road, given their ease of servicing and access. The proposed vegetation screen adjacent to Rowley Road within PCA No. 112 has provided an entry into the neighbourhood, with a large neighbourhood park and cafe adjacent to the north-south Neighbourhood Connector A road.

Lot development has then generally progressed in a southerly direction along the north – south Neighbourhood Connector towards the Peel Main Drain and due to high market demand in recent years only 150 lots are available for construction under existing approvals. The timely approval of the MWLSP is essential to maintain contiguous land supply.

3.10 Developer Contribution Arrangements

The MWLSP is situated within the Mandogalup cell for the purposes of Developer Contribution arrangements, and forms part of the Development Contribution Area b (DCA 8) for community infrastructure and Development Contribution Area 6 (DCA 6) for traditional infrastructure.

DCA 8 was introduced by way of Scheme Amendment 115 (Gazetted on 19 June 2012). However, the City of Kwinana has since reviewed the requirements for community infrastructure on the basis of current planning and population forecasts, in accordance with a revised draft Community Infrastructure Plan (2011-2031).

The City of Kwinana therefore advertised Amendments 145 and 100A, concurrently with the Community Infrastructure Plan (2015) between 16 October and 30 November 2015, seeking to amend DCA 8 and introduce DCA 6 to TPS 2. Amendment 100A was subsequently adopted by Council on 23 November 2016 and subsequentially approved by the Minister and Gazetted.

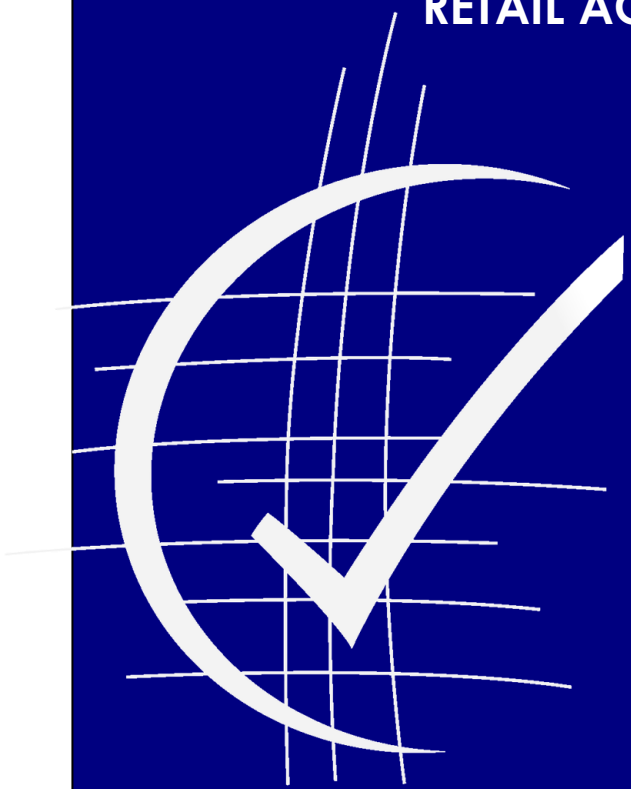
Appendix A

Retail Needs Assessment

(Taktics 4)

Taktics4
Mandogalup Local Structure Plan (East and West)

RETAIL ACTIVITY STRATEGY



Satterley & Qube
July 2017
1630-2d

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1 INTRODUCTION

This Retail Activity Strategy for Mandogalup (incorporating the East Mandogalup and West Mandogalup Local Structure Plans) is designed to guide the location and nature of commercial activity in the planned Mandogalup community. It responds specifically to policy implications and market drivers to ascertain the most commercially efficient and equitable distribution of commercial activity for future residents.

1.1 Purpose

The findings in this paper are subsequently based on the assessment of the current and future retail needs of the resident population and other consumer markets in the vicinity of the planning area. The findings will guide the future planning, development and staging of retail and associated commercial and community development.

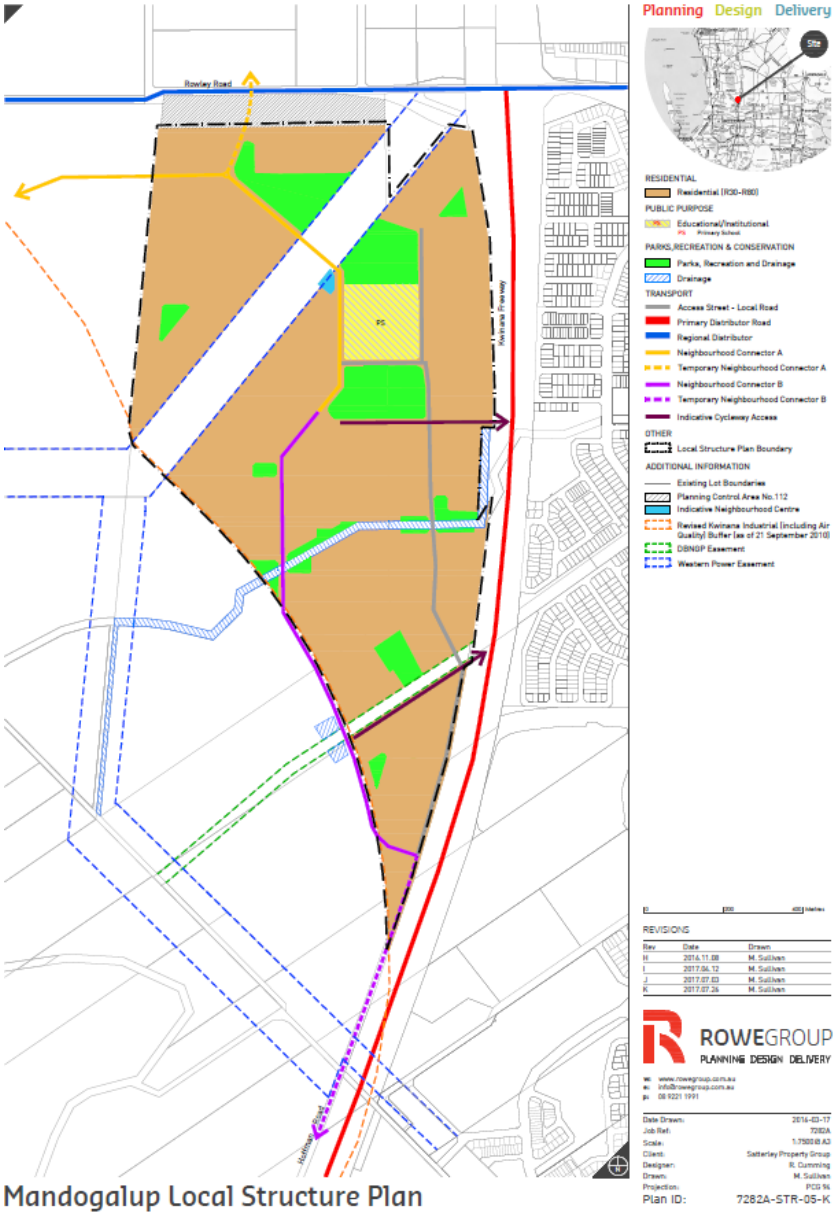
It provides advice designed to inform the layout and design of the structure plan in Mandogalup by identifying the size and nature, components and configuration, location and land area, timing and staging and commercial risks associated with the delivery of any retail activity.

1.2 Approach

The findings are based on analysis of:

- the extent of major retailer demand in the area by highlighting the existing and planned distribution of their store networks;
- the extent of the intended resident catchment planned retail activity will likely service;
- the number and nature of the resident community planned for the catchment;
- the spending capacity of the resident catchment;
- the extent and nature of spending profiles of other consumer markets;
- the correlation between spending capacity, potential market share, sales productivity to retail floor space and retail development models;
- other commercial or community opportunities associated with the development;
- any economic impacts associated with delivering retail activity in the area

MANDOGALUP LOCAL STRUCTURE PLAN



2 STRATEGY AND POLICY

The delivery of activity centres in Mandogalup will be influenced by broader planning policies and strategies prepared at the State and Local Government level.

2.1 SPP 4.2 – Activity Centres Perth and Peel

State Planning Policy 4.2 applies throughout the Perth and Peel regions to guide the preparation and review of local planning strategies, schemes and structure plans; and development control. It promotes a hierarchy of activity centres to guide and prioritise the development of activity and employment throughout the Metropolitan Region.

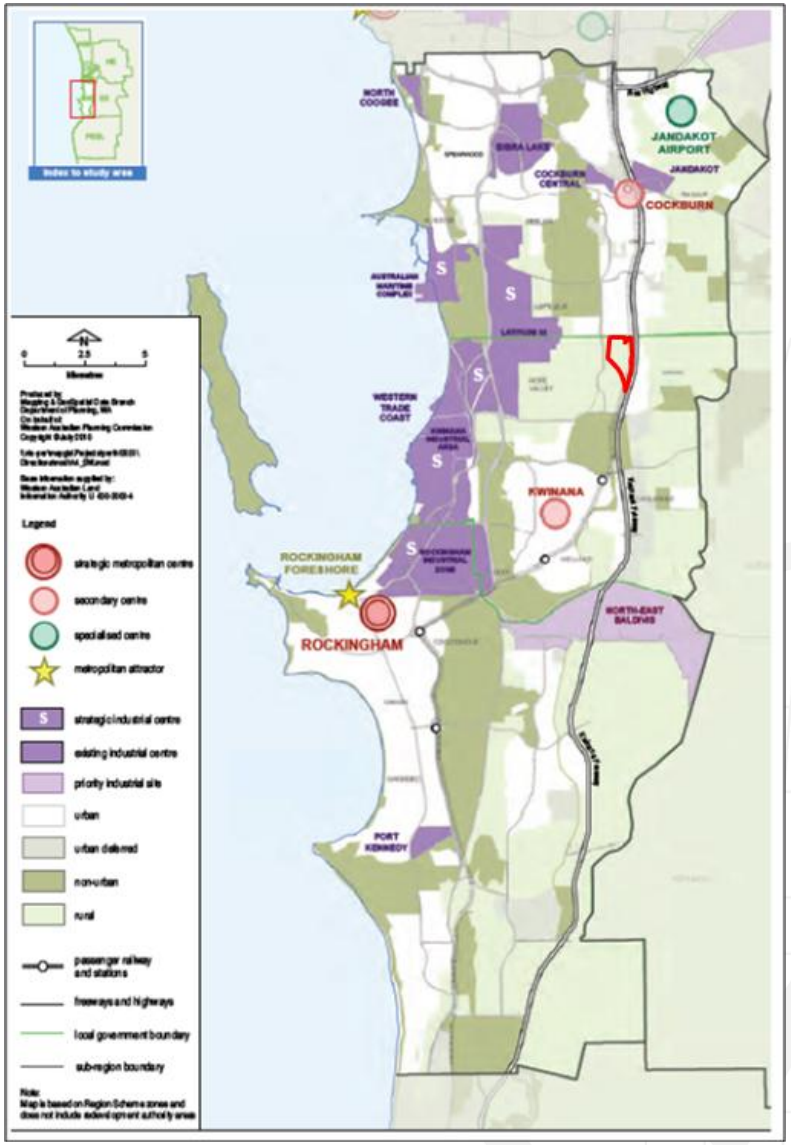
Strategic Metropolitan Centres

Mandogalup is located midway between three existing designated Strategic Metropolitan Centres at Fremantle, Rockingham and Armadale. The relatively long distance to these facilities from the planned Mandogalup community is offset to a degree by the increased choice of having access to these three centres. Each centre provides a different activity and employment focus. The relatively large distances from Mandogalup to each of these centres places a greater emphasis on the lower order centres to deliver the regional and district needs of the resident community.

Secondary Centres

Mandogalup is also located mid way between two existing designated Secondary Centres at Cockburn and Kwinana.

FIGURE 1 - COMMERCIAL ACTIVITY NETWORK AND HIERARCHY



SPP4.2 (WAPC 2010)

Cockburn Gateway

Cockburn Secondary Centre is located 6km north of Mandogalup and offers direct access for Mandogalup residents via the Kwinana Freeway. Cockburn began primarily as a shopping based centre. But it has more recently developed as a comprehensive Secondary Centre, with an increased range of non retail commercial and residential activity predominantly around the Cockburn Railway Station.

Kwinana Town Centre

Kwinana Secondary Centre is located 7.5km south of Mandogalup. Although it is closer than The Cockburn Secondary Centre, the Kwinana Secondary Centre is more difficult to access for Mandogalup residents. This is compounded by the fact that Kwinana represents travel in the opposite direction to the Perth CBD. This subsequently increases the perception of distance to centres in the opposite direction to normal travel patterns.

The future residents of Mandogalup and its immediate surrounds will have access to a full range of Secondary Centre activity at two centres within acceptable urban travel distances for these facilities. This reduces demand for Secondary Centres to be included within the Mandogalup community.

District Centres

A future District Centre is currently designated for Wandi on Anketell Road immediately east of the Kwinana Freeway interchange. This centre is located 3.5km south east from the centre of Mandogalup. Wandi will subsequently have the greatest influence over the planning of retail activity in the immediate Mandogalup area. Wandi District Centre has been allocated 20,000sqm of retail floor space and 10,000sqm of bulky goods/showroom floor space. The floor space allocation is capable of supporting two full line supermarkets and a Discount Department Store (Kmart, Target or BigW) and a wide range of complementary specialty shops.

Mandogalup residents will have direct access to Wandi District Centre via Anketell Road. The location of the Wandi District Centre would appear to remove the demand for any additional District Centre (or DDS based centres) in Mandogalup.

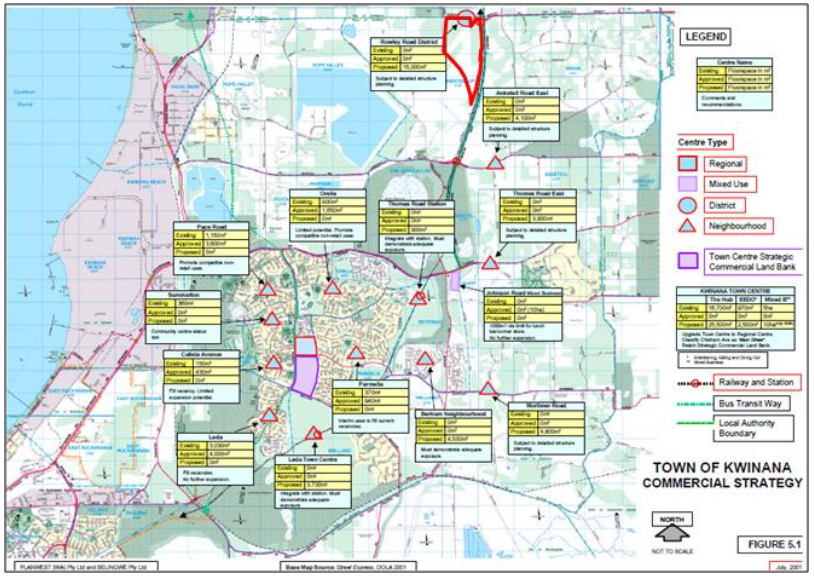
Neighbourhood and Local Centres

SPP 4.2 does not cover the distribution of neighbourhood and local centres. These centres are subsequently designated and allocated by Local Government Commercial Strategies and further refined during District Structure Planning of urban areas.

2.2 City of Kwinana

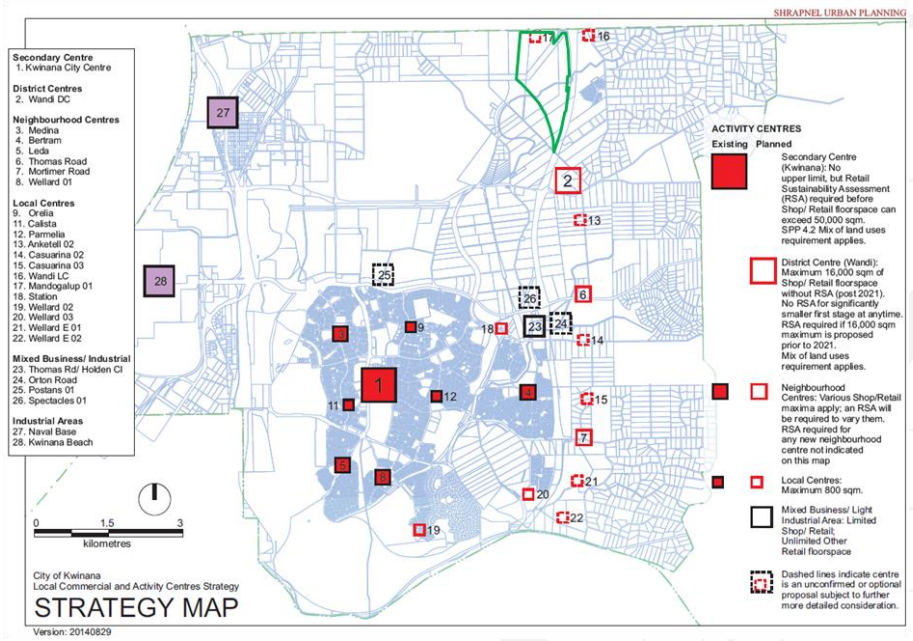
Kwinana Commercial Activity Centres Strategy (September 2003) - Superseded

The distribution and roles of commercial activity in the City of Kwinana was initially guided by the Kwinana Centre Strategy (adopted in 2003 and subsequently superseded in 2014). This plan allocated a District Centre of 15,000sqm on Rowley Road (west of Freeway) in Mandogalup. This was partly designed to also allow the centre to cater to the residents north of Rowley Road in the City of Cockburn. It was also intended to reflect Transit Oriented Design principles based on its proximity to the planned railway station immediately south of Rowley Road. A railway station is no longer planned for this area, removing any potential synergies with a District Centre on Rowley Road. The strategy also allocated a neighbourhood centre of 4,100sqm on Anketell Road (east of the Freeway). These were the only two centres currently allocated to serve the Mandogalup community in the commercial strategy.



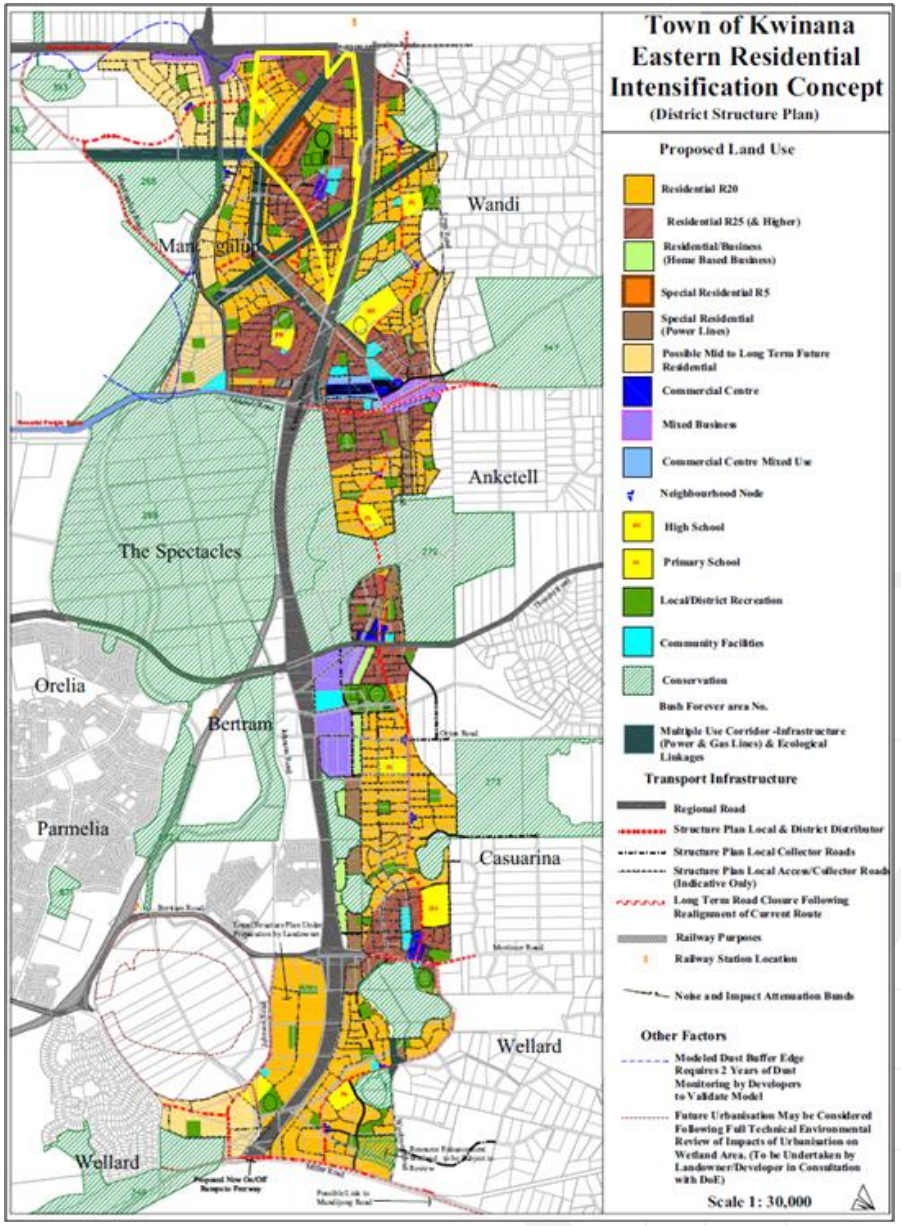
Local Commercial & Activity Centres Strategy Final (Sept 2014)

A review of the 2003 Local Commercial Strategy has resulted in the preparation of a Local Commercial Strategy (completed and adopted in September 2014). The latest draft has subsequently superseded the 2003 strategy. It has changed the distribution of retail activity in the Mandogalup vicinity. The new strategy proposes a District Centre (DC2) in Anketell Road immediately east of the Freeway replacing the initial allocation of a District Centre on Rowley Road west of the Freeway. This new DC2 District Centre is allocated 20,000sqm of retail floor space and 10,000sqm of bulky goods showroom floor space. It also reallocates a Neighbourhood Centre (17) for Mandogalup on Rowley Road. This Centre is allocated up to 1,500sqm of retail floor space.



Eastern Residential Intensification Concept District Structure Plan – (ERIC)

The Eastern Residential Intensification Concept sets out the broad location for future urban areas within the City of Kwinana. It reinforces that a significant future residential population is planned for Mandogalup. Residential dwelling and population yields for Mandogalup are primarily defined from ERIC. ERIC indicates a range of commercial nodes for the area although these are all subject to future planning and are not necessarily considered to be the preferred location or distribution of activity for the area. The District Centre initially planned on Rowley Road in the Local Commercial Strategy is reallocated to the Anketell Road District Centre site due primarily to the designation and role of Rowley Road as a freight route which was considered to reduce the accessibility of district facilities for local residents.



2.3 City of Cockburn

Mandogalup is located solely within the City of Kwinana administrative boundary. However the site abuts Rowley Road which forms the southern boundary of the City of Cockburn. The catchment for any commercial activity may therefore include communities within the City of Cockburn. The future Mandogalup community may potentially be served by centres either designated or planned to the north of Rowley Road in the City of Cockburn. Similarly the advent of a commercial centre south of Rowley Road may also be expected to serve the residents in the suburbs of Hammond Park in the City Cockburn north of Rowley Road.

<u>City of Cockburn Local Commercial Strategy (December 2006) - Superseded</u>

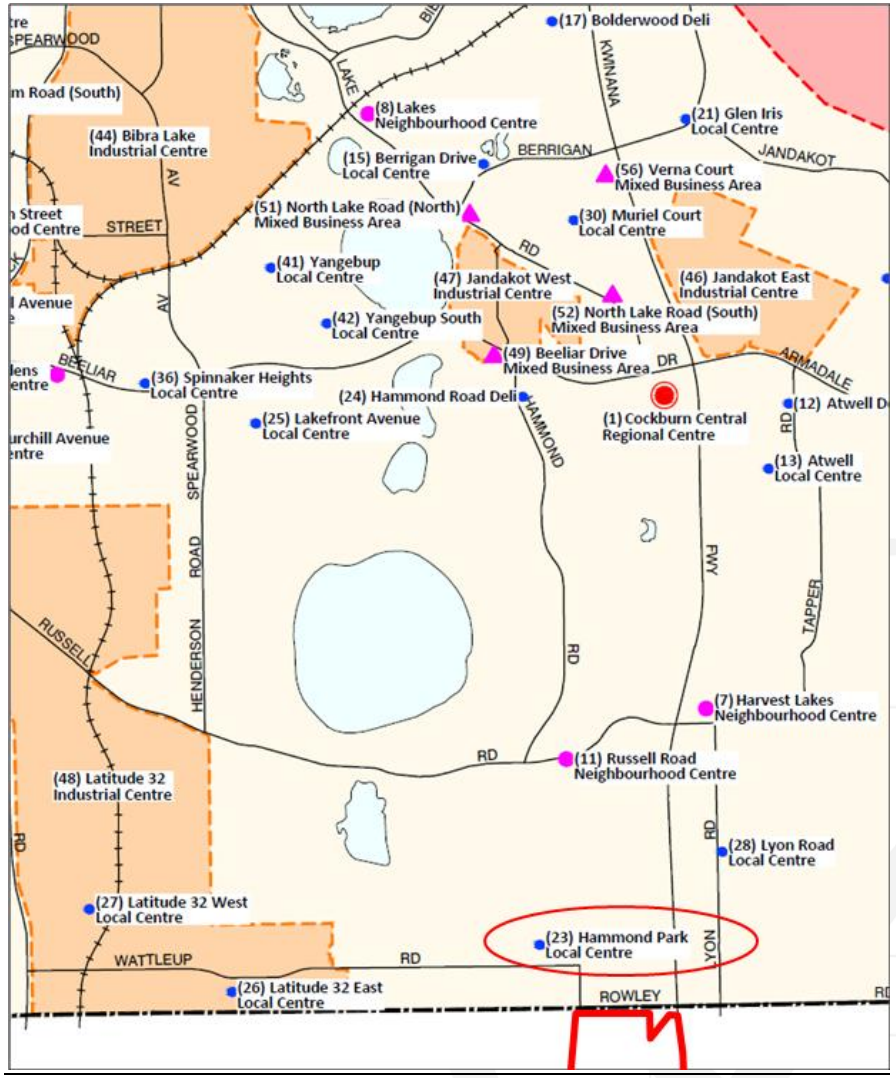
The City of Cockburn Commercial Activity Centres Strategy was finalised and adopted in December 2006. The strategy allocated centres or floor space to specific communities. A local centre was allocated to Hammond Park immediately north of Rowley Road and Mandogalup. No other commercial activity was planned in the vicinity of Hammond Park. The Hammond Park Local Centre (Centre 23) is allocated only 800sqm of retail floor space. A centre of this size is incapable of containing a major supermarket.

<u>Local Commercial and Activity Centres Strategy (December 2012)</u>

A new Local Commercial Strategy was completed for the City of Cockburn in December 2012. Whilst it represents a comprehensive review of all employment based activity in the City of Cockburn it did not make any recommended changes to the distribution and role of centres in Hammond Park and its surrounds.

The timing and subsequent reviews of Kwinana and Cockburn Commercial Strategies have appeared to create a gap in the retail market in this area through the redistribution of centres.

CITY OF COCKBURN LOCAL COMMERCIAL STRATEGY MAP



City of Cockburn

City of Cockburn - Local Structure Plans

Structure plans are continuing to be prepared for properties immediately north of Rowley Road in the City of Cockburn. Only a limited amount of centre activity is currently allocated in the Hammond Park areas that have adopted structure plans in the City of Cockburn north of Rowley Road.

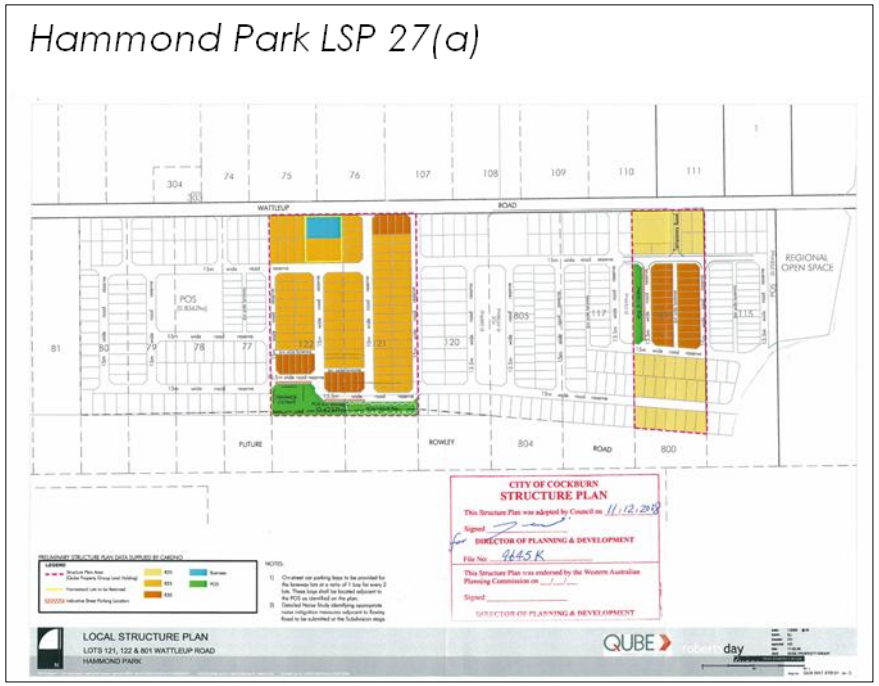
Local Structure Plans - 26(i) and 27(a) have been adopted by the City of Cockburn. They both provide for a local centre within close proximity to Rowley Road, immediately north of the Mandogalup Structure Plan Area.

Both of these local centre areas are relatively small in nature, and may be expected to generate up to 500sqm of retail floor space on each site.

Whilst this is less than the prescribed allocation for Hammond Park within the City of Cockburn Local Commercial Strategy, the adoption of these local centres locations and sizes will subsequently result in the expectation that they are to serve their immediate local communities in Hammond Park north of Rowley Road.

It therefore appears that recent structure planning for Hammond Park in the City of Cockburn, north of Rowley Road has provision for local centres to serve the Hammond Park community.





Note:
Whilst the LSP has been adopted by the City of Cockburn, it has not been approved by the WAPC due to the inclusion of a portion of the land in the Revised Kwinana Industrial (Including Air Quality) buffer as of 21st September 2010.

3 CATCHMENT ANALYSIS

This section considers the potential influences on the market demand for retail activity in the planning area, and subsequently delineates the likely extent of the resident catchment available to major tenants as the basis for determining the retail market demand in the area.

3.1 Philosophy

Retailers such as major supermarket chains and Discount Department Stores capture a significant share of overall retail sales. They therefore underpin visitor traffic for our shopping centres and generate the exposure necessary for smaller specialty shops to survive. A shopping centres commercial viability is severely reduced without having an anchor tenant to drive the foot traffic for these smaller specialty shops. If the major tenant or tenants are able to generate sufficient sales from a particular catchment then the remaining specialty shops are generally in a position to capitalise on their success. To this end analysis in this report focuses on understanding the market demand for these major tenants in order to ascertain the overall demand and sustainability for a centre.

3.2 Networks and Distribution Pattern

The distribution network for major supermarkets throughout urban Australia generally highlights that a supermarket requires a dedicated residential catchment of at least 1.5km. Smaller supermarkets require a smaller catchment. The distribution pattern for Discount Department Stores throughout urban Australia suggests these larger stores require a dedicated catchment of 3.5km.

3.3 Major Tenants

Discount Department Stores

Discount Department Stores will ultimately be expected to be developed at Cockburn Gateway and Kwinana Town Centre (Secondary Centres) and Anketell District Centre. Kwinana and Cockburn will be expected to play a role in the shopping needs of the Mandogalup community. However, Wandi District Centre will ultimately provide the main DDS and associated tenant needs for the Mandogalup residents.

Supermarkets

No major supermarket based centres have been allocated in and around Mandogalup. The nearest supermarket based centres planned around Mandogalup include:

- Harvest Lakes Neighbourhood Centre (Atwell)
- Wandi District Centre (Anketell Road)

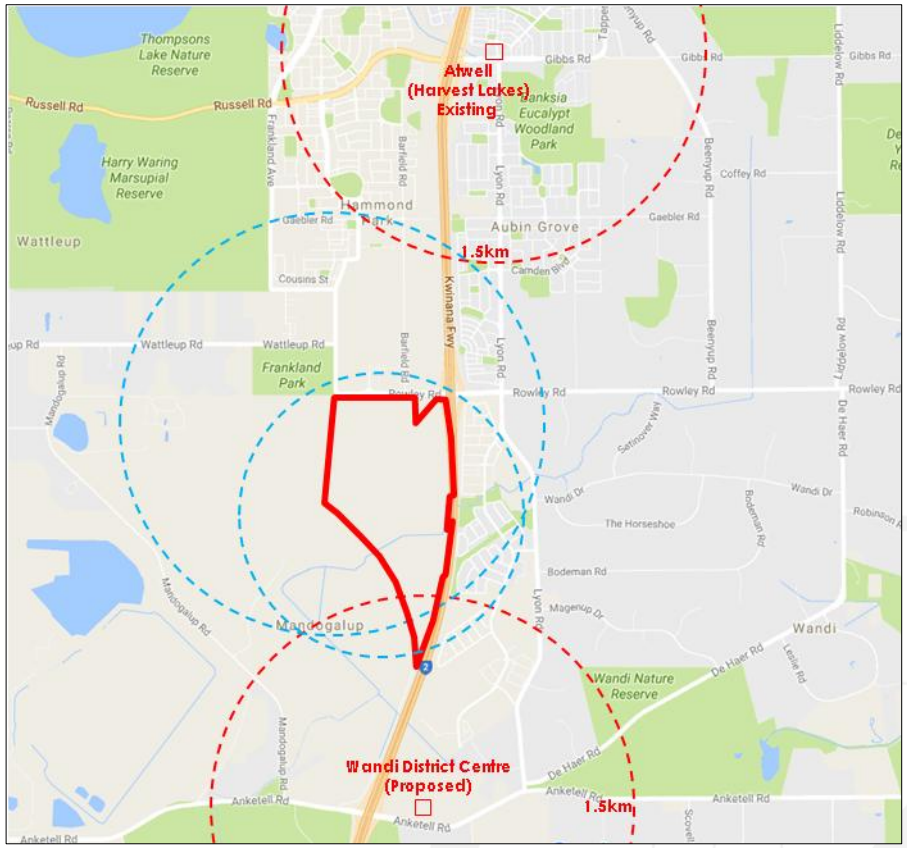
Atwell NC (Harvest Lakes) is 3km north of Rowley Road. While Anketell Road (Wandi DC) will also provide supermarket needs to the south although this centre is also over 3km south of Rowley Road.

3.4 Summary

The current future network of centres affirms the view that the Mandogalup or surrounding region may be capable of spatially sustaining a supermarket based centre if the market demand is capable of sustaining it. Provision for commercial activity within the East and West Mandogalup communities will only be required to serve the Mandogalup community and not the Hammond Park community immediately to the north of Rowley Road. Planning for commercial activity in Mandogalup therefore centres on the future residents solely within the planned Mandogalup community.

The following sections will determine the extent of the planned residential market within the Mandogalup community, and its subsequent ability to sustain a centre in Mandogalup.

SPATIAL RETAIL NETWORK AND DISTRIBUTION PATTERNS



Taktics4

4 CONSUMER MARKETS

Having delineated the intended resident catchment(s) available to major tenants, this section considers the extent and nature of the current and future resident population within the delineated catchment as a starting point for determining the capacity for retail floor space in the planning area.

4.1 Mandogalup Population

Development of the overall Mandogalup LSP confirms the opportunity for over 1,500 dwellings to be developed comprising 900 dwellings in Mandogalup West and 674 dwellings in Mandogalup east. These dwellings are expected to accommodate a population of over 4,500 residents within the catchment.

POPULATION AND DWELLINGS

Structure Plan Area	Dwelling yield	Average household size	Estimated population
Mandogalup West	900	2.9	2,610
Mandogalup East	674	2.9	1,950
Mandogalup Total	1,574	2.9	4,560

Structure Plan Analysis

It would be reasonable to expect that the development could be developed over a 10 year period. A five year and ten year population base has subsequently been used as a basis for determining the timing of future commercial activity in Mandogalup.

4.2 Resident Retail Spending Capacity

Retail spending profiles are derived from two main data sets.

1. Household Expenditure Surveys are captured by ABS every six years. The most recent survey was completed in 2009/10 with data becoming available during 2011. This data records the weekly spending behaviour of households against a range of demographic profiles.

2. Retail sales are also captured by the ABS on a monthly basis. This data is recorded against a range of retail categories and store types.

The correlation of these two data sets to a common per capita variable allows the reporting of the average annual retail spending per person for each designated store type against a range of demographic profiles. The most influential characteristic in determining the amount and store of an individual is household income and household size. The Hammond Park community has recorded an average household income of $111,000 p.a. which is 27% above Australian averages. Household sizes of 2.9 people are 12% above Australian averages. These profiles are consistent with a retail spending profile reflecting households in the fourth quintile of income generation.

Household Income	
Average Annual Household Income	$111,124
difference from Australian Average	27%
Household Size	
average persons per household	2.9
difference to Australian average	12%
Quintile spending profile to use	Fourth

Census (ABS 2011)

Average Spending Capacity

Household with an average income reflecting the fourth quintile of income earners are estimated to generate nearly $9,000 in convenience based retail spending per person per annum.

AVERAGE SPENDING CAPACITY ($/p.a.)

Store category	Average Retail Spending (per capita/p.a.)1
Total Food	$5,545
Non Food Convenience	$1,627
Cafes, restaurants and takeaway food	$1,807
All Convenience based Store Categories	**$8,979**

Household Expenditure Surveys (ABS 2009/10)
Retail CPI Index (2016)

Aggregate Retail Spending Capacity

Base on the average spending profiles the combined Mandogalup catchment is expected to produce $20M p.a. in aggregate retail spending capacity, including $12M p.a. in food/grocery spending by 2021 (after 5 years of development). By 2026, the fully developed Mandogalup resident catchment is expected to generate nearly $40M p.a. in retail spending including $24 M p.a. in food and grocery spending.

AGGREGATE SPENDING CAPACITY ($M P.A.) IN 2016 DOLLARS

Store category	2021 (year 5)	2026 (Year 10)
Food	$12	$24
Convenience based – non food	$4	$7
Cafes, restaurants and takeaway food	$4	$8
All Convenience based Store Categories	**$20**	**$39**

Household Expenditure Surveys (ABS 2009/10)
Retail CPI Index (2016)

There are limited opportunities or additional sales to be derived from other consumer markets.

5 MARKET POTENTIAL

Having determined the spending capacity of the catchment and other markets available to the centre and its tenants, this section assesses the potential market share of the available retail spending capacity that a tenant and its centre may be capable of achieving.

5.1 Market Capture

The market capture rates for a retail centre and major tenants may be assessed a number of ways, including retail gravity modelling. However major tenants simply identify the overall spending capacity and the expected market share based on proximity and accessibility of other major competing retailers. Taktics4 adopts this more transparent method to highlight the market share a centre may attract and is better able to assess the sensitivity of the market share to its overall performance and sustainability.

The potential for Wandi District Centre to be developed to at least a single supermarket based centre in the medium term, and ultimately a second supermarket suggests that a centre at Mandogalup may ultimately only be able to capture 33% of the retail spending capacity from within the Mandogalup catchment.

Contribution from Outside Catchment

The centre would also expect to capture a relatively small proportion of its sales from outside its main catchment. A small supermarket based centre may expect to generate up to a modest 2.5% of its sales from outside its primary catchment from visitors and reps and employees to the centre.

5.2 Sales Potential

Based on these market capture rates, and catchment contributions, retail activity in the planning area could expect to generate the following retail sales. By 2021, a centre in Mandogalup could expect to generate $6.5M p.a., including $4 M p.a. in supermarket sales. By 2026, the same centre could expect to generate $13M p.a. including $8m p.a. in supermarket sales.

SALES FROM CATCHMENT SPENDING ($M P.A.)

Store category	2021	2026
Food	$4.0	$8.0
Non food Convenience	$1.0	$2.5
Cafes, restaurants and takeaway	$1.5	$2.5
All Store Categories	**$6.5**	**$13.0**

Household Expenditure Surveys (ABS 2009/10)

5.3 Sustainable Floor space

The potential retail sales from the resident population for the LSP Area of Mandogalup will ultimately be capable of supporting a centre of 750 sqm of retail floor space comprising a 500sqm deli and up to 4 specialty shops which may contain a hair dresser, newsagency, fast food and or cafe. These activities will not be sustained until the full development of the catchment occurs.

SUSTAINABLE FLOOR SPACE (SQM)

Store category	shops	Floor space (sqm)
Food	1	500
Non food Convenience	2	125
Cafes, restaurants and takeaway	2	125
All Store Categories	**0**	**750**

Household Expenditure Surveys (ABS 2009/10)

6 DISTRIBUTION AND CONFIGURATION

The layout and configuration of the centre will have a significant role in its economic performance and its subsequent ability to achieve the objectives from the redevelopment. This section assesses the implications of the location, layout for the centre under the range of development scenarios.

6.1 Number of Centres

There is an opportunity for a single supermarket local centre to be located in Mandogalup. It allows for a small supermarket to be developed in a manner which complements the planned District Centre offering at Anketell Road without having an undue impact on sales or performance of this centre and its components.

6.2 Nature

The centre needs listed in this strategy are inconsistent with the City of Kwinana Local Commercial Strategy. Although the strategy does state that the centre allocation for Mandogalup should be subject to further detailed consideration.

6.3 Location

The centre should ideally be located further north to satisfy the immediate needs of the catchment toward Rowley Road. The southern residents closer to Anketell Road will ultimately be serviced more readily by the planned activity in the Wandi DC.

6.4 Site

A 750 sqm small supermarket local centre would require a land area of at least 1,500sqm (0.15Ha). The land should be relatively uniform with similar dimensions to all sides to create flexibility for design and layout of the centre. The centre may be designed to accommodate on street parking where possible.

6.5 Staging and Timing

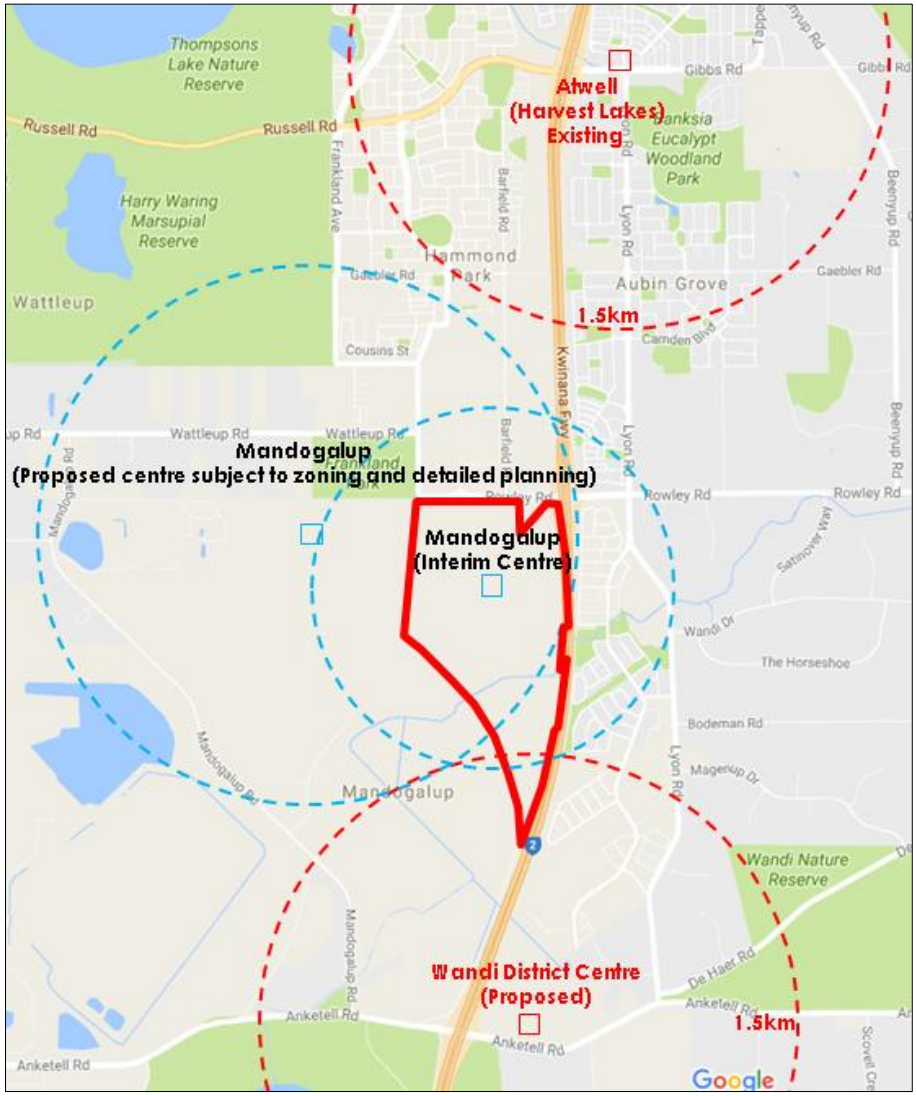
The centre will function at its best upon full development of its residential catchment. However, it may be delivered earlier to satisfy the needs of the establishing catchment and create loyalty and strong trading habits amongst local residents. The timing of the centre should have no impact on the performance or timing of other centres.

6.6 Future Planning

Any expansion of the current residential catchment within Mandogalup would increase the spending capacity and sales potential within the community. Therefore, any future planning for the expansion of the Mandogalup residential catchment should be cognisant of providing and planning for additional retail activity.

Earlier analysis (refer Taktics4 report dated April 2014) and modelling concludes that an increased catchment would support the need for an increased sized retail centre and relocation of same from its current temporary/interim location (MWLSP) to a location more accessible for Mandogalup and surrounding catchments, with that location being the Hammond Road South site within Lot 2 as identified in the following map. In doing this, the need for the interim centre (as depicted in this report) would no longer be required.

PLANNED MANDOGALUP RETAIL STRATEGY



Taktics4

Appendix B

Environmental Assessment Letter + Landscape Feature and Tree Retention Management Plan (Strategen + JBSG)

Apsley, Mandogalup: Landscape Feature and Tree Retention Management Plan Addendum

QUBE Property Pty Ltd

Report (Rev 2)

JBS&G 65648 | 155,129

1 July 2025



We acknowledge the Traditional Custodians of Country throughout Australia and their connections to land, sea and community.

We pay respect to Elders past and present and in the spirit of reconciliation, we commit to working together for our shared future.



Caring for Country The Journey of JBS&G
Artist: Patrick Caruso, Eastern Arrernte

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Appendices

Appendix A **EPBC Extension Approval (Ref: 2014/7126)**

Appendix B **Cut to Fill Plan (Cossill and Webley 2020)**

Appendix C **Level 1 Fauna Survey and Habitat Assessment: Various allotments, Mandogalup (Emerge 2011)**

Appendix D **Assessment of identified trees; Apsley Estate, Mandogalup (ArborLogic 2018a)**

Appendix E **Assessment of identified trees adjacent Peel Main Drain; Apsley Estate, Mandogalup (ArborLogic 2018b)**

Appendix F **Apsley Stage 18B – Roundabout Clearance (Arborite 2025)**

Appendix G **Arboriculture Report – Apsley Estate Subdivision (Paperbark Technologies 2025)**

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1. Introduction

1.1 Project Background

QUBE Mandogalup Development Pty Ltd (QUBE) has developed a portion of Lot 682 and Lot 52 Rowley Road, Mandogalup, Western Australia for residential purposes. QUBE are seeking to expand the area of approval for residential properties to a further portion of Lot 682 Rowley Road (the project area; Figure 1). The project area is approximately 25 ha, located approximately 33 km south of Perth in the City of Kwinana (CoK), and is bounded by the Kwinana Freeway to the east, Anketell Road to the south, Mandogalup Road to the west and Rowley Road to the north. The project area is comprised of two portions of land, separated by the Peel Main Drain reserve, and bounded to the north by a Western Power high voltage easement.

Strategen-JBS&G, now known as JBS&G, prepared a comprehensive Landscape Feature and Tree Retention Plan (LFTRMP) in 2021 to support QUBE in their original Local Structure Plan submission for Apsley Estate. Subdivision has since been approved throughout the Structure Plan area. This LFTRMP is an addendum to the original LFTRMP which covers the Apsley Estate and provides for an updated LFTRMP assessment specific to the project area, as required to support the proposed Structure Plan Amendment. This LFTRMP addendum should be read in conjunction with the original Structure Plan LFTRMP (Strategen-JBS&G 2021).

1.2 Existing Approvals

In 2014, the proposed development of the project area was referred to the Department of the Environment and Energy (DoEE) (now known as the Department of Climate Change, Energy, the Environment and Water [DCCEEW]) under the *Environment Protection and Biodiversity Conservation Act 1999* (EBPC Act) due to the potential impacts to listed threatened species and threatened ecological communities (TEC), particularly Carnaby's Cockatoo and Forest Red-tailed Black-Cockatoo potential foraging habitat and potential breeding trees.

Approval was granted by the DoEE in August 2014 (EBPC 2014/7126) to clear native vegetation, which includes approximately 38.7 ha of potential foraging habitat inclusive of potential breeding trees (>500 mm Diameter at Breast Height [DBH]) for Carnaby's Cockatoo and Forest Red-tailed Black Cockatoo. In 2018, EPBC referral (EPBC 2018/8186) was submitted to clear an additional 1.1 ha of the Banksia Woodland TEC and potential Black Cockatoo foraging habitat and three potential breeding trees outside the boundaries of EPBC 2014/7126. This proposed action was deemed not a controlled action.

In September 2023, a Request to Extend Period of Effect of Approval for EPBC 2014/7126 was submitted to DCCEEW to extend the period of time by 5 years. This has been approved and is now set to expire on 31 July 2029.

The project area will be developed in accordance with the Mandogalup West Local Structure Plan (MWLSP), which was approved by Western Australian Planning Commission (WAPC) in March 2018.

The City of Kwinana referred Town Planning Scheme 2 Amendment 159 for Lots 52 & 9002 Rowley Road, Mandogalup to the Environmental Protection Authority (EPA) for a determination on whether the proposed amendment required assessment. The EPA determined that the proposed scheme is unlikely to have a significant effect on the environment and does not warrant formal assessment under Part IV of the Environmental Protection Act.

The EPA advice and recommendations regarding the Environmental Factors of Flora and Vegetation, and Terrestrial Fauna, noted the site has 5.38 ha of potential Black Cockatoo foraging habitat and 143 potential habitat trees with none containing hollows suitable for breeding. The EPA noted that the EPBC approval (EPBC 2014/7126) included offset requirements for the Banksia Woodland TEC and Black Cockatoo foraging habitat contained within the Apsley site as part of the conditions. The preparation of a LFTRMP is supported by the EPA at the local structure plan stage and consideration should be given to retaining foraging habitat and trees

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with existing hollows where possible. The EPA concludes the environmental objectives for these factors can be met through existing planning controls.

Since the approval of the MWSLP, a Plan of Subdivision (WAPC 155567) with conditions was approved by WAPC in June 2018 to develop the site for residential purposes, including residential lots, an internal public access road network, primary school, and public open space (POS).

Following the grant of approval under WAPC 155567, subsequent subdivisional approvals have been issued over the site:

- WAPC 158763 (2019)
- WAPC 159806 (2020)

These more recent approvals have enabled the lot mix to be updated, subsequently resulting in additional significant trees being identified for retention, since the original approval of WAPC 155567.

The approved subdivision is consistent with the requirements of the MWLSP.

1.3 Report Background

Condition No. 28 of WAPC subdivision approval No. 155567 states that:

"Prior to the commencement of subdivisional works a landscape feature and tree retention management plan is to be prepared and approved to ensure the protection and management of the sites environmental assets in accordance with the approved Mandogalup West Local Structure Plan with the satisfactory arrangement being made for the implementation of the approved plan."

With relation to the above condition, WAPC provided additional advice stating that Condition 28 is:

"…not to be interpreted as requiring the protection of vegetation, landscape features and trees that can't be retained as a consequence of implementation of this subdivision approval in respect of road alignments, fill levels, drainage and the like."

The following reports have been approved for the site:

- A Landscape Feature and Tree Retention Management Plan (LFTRMP) for the full landholding was prepared by Strategen (now JBS&G) in 2018; and
- An updated LFTRMP was prepared by JBS&G in 2021.

This additional LFTRMP is required to cover an area not included by the previous LFTRMPs and is an addendum to be read in conjunction with the other LFTRMPs.

1.4 Purpose and Scope of this Document

This LFTRMP has been prepared to support the proposed Structure Plan Amendment for an area not covered by previous reports. This LFTRMP should be read in conjunction with the previously prepared documents.

To date, the following tree surveys have been undertaken within the MWLSP area:

- *Preliminary Assessment of the identified trees at Qube, Mandogalup* (ArborLogic 2016).
- *Assessment of identified Trees at Apsley Estate, Mandogalup* (ArborLogic 2018a)
- *Assessment of identified Trees adjacent to the Peel Main Drain, Apsley, Mandogalup* (ArborLogic 2018b).
- *Apsley Stage 18B – Roundabout Clearance* (Arborite 2025).
- *Arboriculture Report – Apsley Estate Subdivision* (Paperbark Technologies 2025).
- *Trees and Services Detail Plan 6027-07-SK05* (Cossill & Webley 2021).

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- *Level 1 Fauna Survey and Habitat Assessment: Various Allotments, Mandogalup* (Emerge 2011; Appendix C).

Based on the above tree surveys, this LFTRMP has been prepared to:

- Summarise and illustrate the location, species, size and structural health of significant trees within the project area
- Summarise and illustrate which significant trees and landscape features are to be retained and which significant trees are to be removed, fill or cut at the significant tree location, and the location of services and infrastructure
- If applicable, buffer distances around significant trees in accordance with AS 4970-2009 – Protection of Trees on Development Sites
- Methodology to avoid impacts to landscape features and trees which are proposed to be retained
- Management and maintenance actions.

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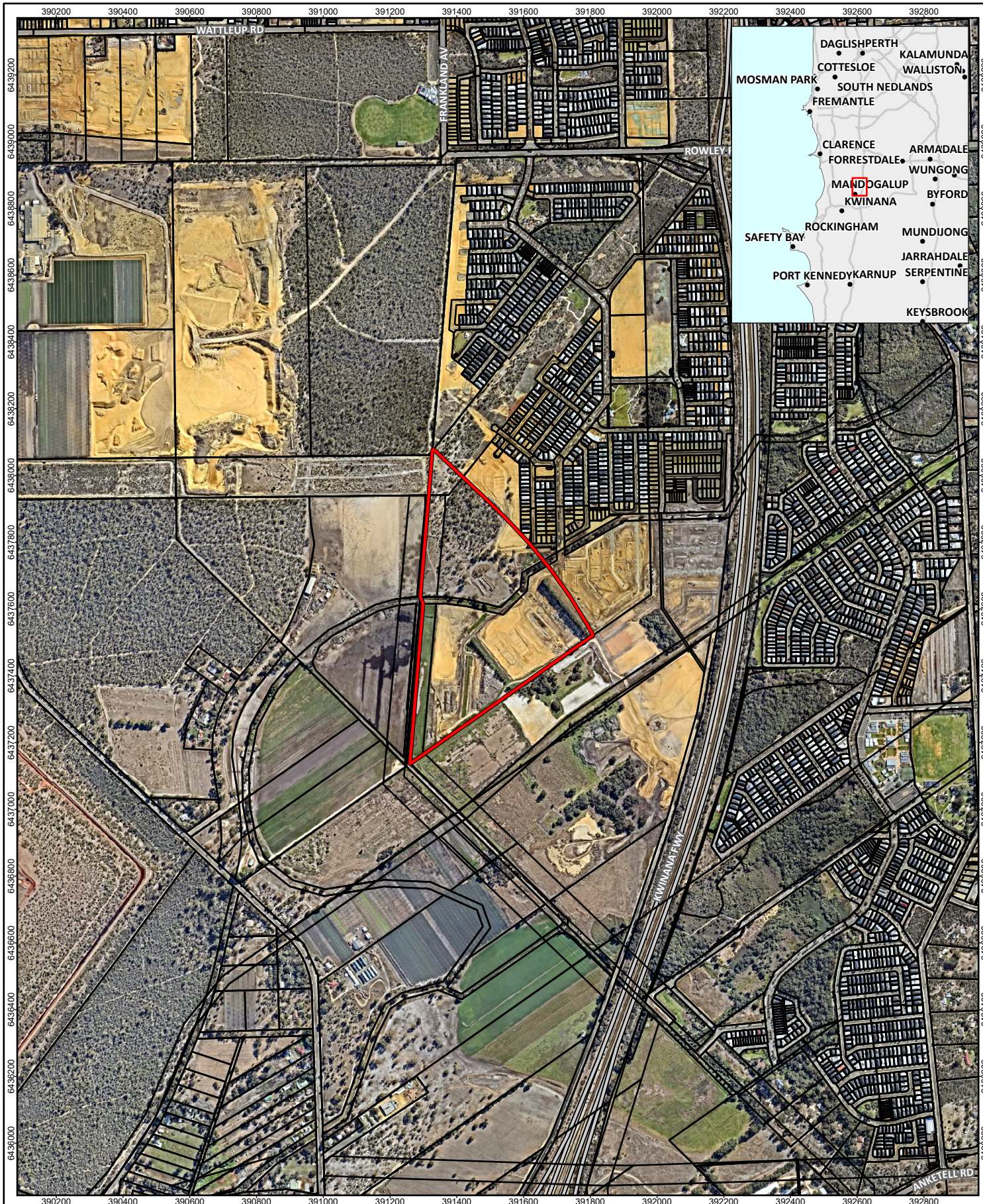

Legend

- Project area
- Cadastral boundary (LGATE-002)

Roads (LGATE-195)

- Highway
- Major road

Scale: 1:15,000 at A4 (0 100 200 metres)	**Lot 682 Rowley Road Mandogalup, WA**
Coord. Sys. GDA2020 MGA Zone 50	**PROJECT AREA**
Job Number: 65648	
Client: Qube Property Group Pty Ltd	**FIGURE 1**
Version: A / Date: 01-Jul-2025	JBS&G
Drawn By: jcrute / Checked By: MGellender	

File Name: C:\Users\jcrute\JBS&G Australia\JBS&G - DCS - Internal - Documents\Projects\Qube\65648 Mandogalup LFTRP Update and EPBC Extension Request\GIS\02_MapProjects\65648_LFTRP_R01\65648_LFTRP_R01.aprx
Image Reference: www.nearmap.com© - Imagery Date: 19. April 2025.

2. Existing Environment

2.1 Topography and Soils

The project area predevelopment, slopes from north to south, with elevations ranging from approximately 40 m Australian Height Datum (AHD) at the northern boundary to 13 mAHD at the southwest boundary.

Four soil-landscape types have been identified across the project area, as described below:

- 211Sp_S1b: Dune ridges with deep siliceous yellow brown sands or pale sands with yellow-brown subsoil and slopes up to 15%.
- 212Bs__B2: Flat to very gently undulating sandplain with well to moderately well drained deep bleached grey sands with a pale yellow B horizon or a weak iron-organic hardpan 1–2 m.
- 212Bs__B4: Broad poorly drained sandplain with deep grey siliceous sands or bleached sands, underlain at depths generally greater than 1.5 m by clay or less frequently a strong iron-organic hardpan.
- 211Va_V9: Areas of former swamps which have been artificially drained, with uniform loamy or peaty sands.

Land adjacent to the northeast of the project area has had levels significantly altered from the original levels, as approved by the DoEE, WAPC and the City of Kwinana, and is much lower than the remnant vegetation making it physically very hard to retain. To allow for the area to be retained within the approved Structure Plan, the vegetation will need to be cleared to enable the retaining wall to be built with suitable structural integrity to support the weight of the soil. CoK approved civil works to date on the Apsley estate have been planned to service projected residential lots within the project area at levels dictated by the agreed levels already in place on the adjacent subdivision approved area. The proposed levels for the project area are in Appendix B.

2.2 Hydrology

2.2.1 Groundwater

Regional groundwater contours (DWER 2020) indicate that based on predevelopment topography, the depth to groundwater south of the Western Power easement, ranges from approximately 16 to 1.5mbgl adjacent to the Peel Main Drain.

The Peel Main Drain runs east to west through the southern part of the project area and discharges into Mandogalup Swamp in the southern part of the Project area and the Spectacles Wetland south of Anketell Road (JDA 2018).

2.2.2 Surface Water and Wetlands

The Mandogalup Swamp South geomorphic wetland (dampland) (UFI 6530) is classified as a Multiple Use Wetland (MUW) (Hill et al. 1998) and is located both within the southern portion and adjacent to the east of the Project area. No permanent natural surface water features are present within the project area.

2.3 Flora and Vegetation

The vegetation within the project area will be progressively cleared to allow for cut and fill across the entire Apsley site. Two flora surveys have been undertaken of the Apsley site, a total of 83 taxa were recorded during the 2005 survey including 13 introduced (weed) species (Cardno 2005). Two vegetation communities have been previously identified across the Project area which included the following:

1. BaHh – Low Banksia woodland with emergent *Eucalyptus marginata* over heath of *Hibbertia hypericoides*, *Stirlingia latifolia* and *Xanthorrhoea preissii* on yellow to grey sands.

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2. PC - Parkland cleared, scattered native trees over paddock grasses (Emerge 2011).

The 2012 survey was a Target Priority and Threatened Flora search and did not record any priority or threatened flora (DRF) on the project area (Cardno 2005; Plantecology Consulting 2012).

A significant portion of the Project area is largely degraded due to historic and current agricultural land uses of market gardening and grazing. The pre-development vegetation condition varies from 'Completely Degraded' to 'Very good - good' condition.

2.4 Fauna and Habitat

A level 1 Terrestrial Fauna survey was undertaken by Emerge (2011) in accordance with the Environmental Protection Authority (EPA) *Guidance Statement No. 56 – Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004). A total of 54 fauna species were observed (or positively identified from scats, tracks, skeletons or calls) within the larger Apsley site during both the 2005 (Greg Harewood) and 2010/2011 Emerge surveys.

The two species of black cockatoo, namely Carnaby's Black Cockatoo and Forest Red-tailed Black Cockatoo, were identified as occurring within the project area from foraging evidence. The habitat assessment identified 206 trees with a DBH of greater than or equal to 500 mm across the Apsley Estate area, which includes the current project area, of which 17 contained large hollows (>12 cm) that appeared big enough and oriented favourably to possibly allow entry to a black cockatoo.

The project area covered by this Addendum contains 129 significant trees, of which 5 trees have been identified as having potential breeding hollows as shown in Figure 2. None of these hollows (at the time of survey) showed any evidence of current or past use by black cockatoos (Emerge 2011).

2.5 Dieback Status

A dieback (*Phytophthora cinnamomi*) survey of the project area has not been undertaken; however, the Apsley site supports an area of bushland that has been subject to a range of previous disturbances and is located within an existing industrial and residential area. Disturbance for the development of the project area is unlikely to introduce new plant diseases through management measures/protocols.

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Legend

- Project area
- Cadastral boundary (LGATE-002)
- Proposed POS
- Black Cockatoo foraging habitat
- Black Cockatoo roosting/nesting habitat
- Proposed lot layout
- Stage boundaries
- Potentially suitable hollows

Scale: 1:4,200 at A4 (0 25 50 metres)		**Lot 682 Rowley Road Mandogalup, WA**
Coord. Sys. GDA2020 MGA Zone 50		**BLACK COCKATOO ASSESSMENT**
Job Number: 65648		
Client: Qube Property Group Pty Ltd		**FIGURE 2**
Version: A	Date: 01-Jul-2025	JBS&G
Drawn By: jcrute	Checked By: MGellender	

File Name: C:\Users\jcrute\JBS&G Australia\JBS&G - DCS - Internal - Documents\Projects\Qube\65648 Mandogalup LFTRP Update and EPBC Extension Request\GIS\02_MapProjects\65648_LFTRP_R01\65648_LFTRP_R01.aprx
Image Reference: www.nearmap.com© - Imagery Date: 19. April 2025.

3. Landscape Features

3.1 Landscape Feature Criteria

Within the City of Kwinana LPP No. 1, a Landscape Feature is defined as:

"A unique or identifiable feature of the landscape including ridgelines, rocky outcrops, vegetation, creek lines and wetlands."

3.2 Identified Landscape Features

No landscape features meeting the above definition have been identified for the project area.

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4. Significant Tree Assessment

4.1 Significant Tree Criteria

The City of Kwinana LPP No. 1 defines a Significant Tree as:

"A tree with a diameter at breast height (DBH) of 0.5 metres or greater."

Under LPP No. 1, a tree may also be considered as Culturally significant if it is:

"A tree which has special significance because of its aesthetic, historic, scientific or social significance."

Significant trees have been considered across the Apsley Estate and have been provided for under Policy Objective 1(a) of LPP No.1 and by the approved subdivision with the original approved LFTRMP (Strategen-JBS&G 2021) submitted as part of this process. Since the original Strategen-JBS&G report was submitted, further studies have been conducted across the southern portion of the Apsley Estate which is this Addendum. The adjoining subdivision application and engineering plans was the opportunity for the City of Kwinana to retain the character of the area as part of Policy Objective 1(b) of LPP No.1, of which the Apsley Estate comprises part of. Decisions made to date across the Apsley Estate now dictate the levels which need to be implemented within the project area.

4.2 Identified Significant Trees

To date, the following tree surveys have been undertaken within the Apsley site:

1. *Preliminary Assessment of Identified Trees at QUBE Subdivision, Mandogalup* (ArborLogic 2016).
2. *Assessment of Identified Trees at Apsley Estate, Mandogalup* (ArborLogic 2018a).
3. *Assessment of identified Trees adjacent to the Peel Main Drain, Apsley, Mandogalup* (ArborLogic 2018b).
4. *Apsley Stage 18B – Roundabout Clearance* (Arborite 2025).
5. *Arboriculture Report – Apsley Estate Subdivision* (Paperbark Technologies 2025).
6. *Trees and Services Detail Plan 6027-07-SK05* (Cossill & Webley 2021).
7. *Level 1 Fauna Survey and Habitat Assessment: Various Allotments, Mandogalup* (Emerge 2011; Appendix C).

An engineering and planning assessment was undertaken with a key consideration in this assessment being the level of cut and fill that would be required at the location of the significant trees. A significant tree was retained where the tree met all of the following criteria, being:

a. of 'high' and 'medium' retention value located within and outside areas of POS
b. located in fill +/- 500mm from natural ground level
c. a species retained by the City of Kwinana
d. able to be designed into a location of public open space, road reserve, group housing or education.

Results of the detailed engineering assessment indicate that retention of significant trees will occur across the wider Apsley site within the following areas:

- Mokare Reserve Adventure Playground
- Road reserves
- Within the Peel Main Drain
- Within the Western Power corridor (Lot 52) vegetation retention area.

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Significant trees identified by Cossill & Webley (2021) for retention or removal in stage 7 have been reviewed by the City of Kwinana and approved as part of ongoing clearing activities. The following criteria were used in this judgment:

a. located in fill +/- 500mm from natural ground level

b. of a diameter 0.5m or greater

c. a species retained by the City of Kwinana

d. able to be designed into a location of public open space, road reserve, group housing or education.

Additionally, in consultation with the City of Kwinana Environment Services, all trees identified with a 'very low' or 'low' retention value located outside of a POS are not considered as a viable tree for retention due to the potential risk to community. Therefore, trees of 'very low' or 'low' retention value located outside Public Open Space are not proposed to be retained.

Within the project area a total of 129 trees were identified with a DBH of 0.5 m or greater fitting the definition for a significant tree, and these are shown in Figure 3. A portion of these trees were further assessed and considered for their potential to be utilised by Black Cockatoos as breeding hollows (**Table 4-1**) as discussed in Section 2.4.

Table 4-1: Trees with a diameter of 0.5 m or greater (adapted from Emerge (2011))

Map No.	Tree tag ID	Species	DBH (cm)[1]	Tree Height (m)	No. of Hollows	Potential for Breeding
Preliminary Assessment of Identified Trees at QUBE Subdivision, Mandogalup **(ArborLogic 2016)**						
1	41	Dead Unknown	>50	15-20	5+	No
2	43	Tuart (*Eucalyptus gomphocephala*)	>50	20+	0	No
3	44	Tuart (*Eucalyptus gomphocephala*)	>50	20+	5+	No
4	45	Tuart (*Eucalyptus gomphocephala*)	>50	15-20	0	No
5	46	Tuart (*Eucalyptus gomphocephala*)	>50	20+	5+	No
6	47	Tuart (*Eucalyptus gomphocephala*)	>50	20+	5+	No
7	48	Tuart (*Eucalyptus gomphocephala*)	>50	20+	0	No
8	49	Tuart (*Eucalyptus gomphocephala*)	>50	15-20	1	No
9	50	Flooded Gum (*Eucalyptus grandis*)	>50	15-20	1	No
10	51	Tuart (*Eucalyptus gomphocephala*)	>50	15-20	0	No
11	52	Flooded Gum (*Eucalyptus grandis*)	>50	10-15	0	No
12	53	Tuart (*Eucalyptus gomphocephala*)	>50	20+	0	No
13	54	Tuart (*Eucalyptus gomphocephala*)	>50	15-20	1	No
14	55	Tuart (*Eucalyptus gomphocephala*)	>50	10-15	3	No
15	56	Dead Unknown	>50	5-10	1	No
16	57	Jarrah (*Eucalyptus marginata*)	>50	15-20	0	No
17	58	Jarrah (*Eucalyptus marginata*)	>50	15-20	0	No
18	59	Dead Unknown	>50	5-10	1	No
19	60	Jarrah (*Eucalyptus marginata*)	>50	10-15	1	No
20	61	Jarrah (*Eucalyptus marginata*)	>50	10-15	0	No
21	62	Jarrah (*Eucalyptus marginata*)	>50	15-20	0	No
22	63	Jarrah (*Eucalyptus marginata*)	>50	20+	5+	No
23	64	Jarrah (*Eucalyptus marginata*)	>50	20+	5+	Yes
24	65	Dead Jarrah (*Eucalyptus marginata*)	>50	15-20	5+	No
25	66	Tuart (*Eucalyptus gomphocephala*)	>50	20+	0	No
26	67	Jarrah (*Eucalyptus marginata*)	>50	15-20	2	No
27	68	Tuart (*Eucalyptus gomphocephala*)	>50	20+	0	No
28	69	Tuart (*Eucalyptus gomphocephala*)	>50	10-15	1	No
29	70	Jarrah (*Eucalyptus marginata*)	>50	10-15	0	No
30	71	Dead Unknown	>50	15-20	5+	Yes
31	72	Jarrah (*Eucalyptus marginata*)	>50	15-20	5+	Yes

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Map No.	Tree tag ID	Species	DBH (cm)[1]	Tree Height (m)	No. of Hollows	Potential for Breeding
32	73	Jarrah (*Eucalyptus marginata*)	>50	15-20	5+	No
33	74	Jarrah (*Eucalyptus marginata*)	>50	10-15	5+	No
34	75	Jarrah (*Eucalyptus marginata*)	>50	15-20	5+	No
35	76	Jarrah (*Eucalyptus marginata*)	>50	20+	0	Yes
36	77	Jarrah (*Eucalyptus marginata*)	>50	15-20	0	No
37	78	Jarrah (*Eucalyptus marginata*)	>50	15-20	1	No
38	79	Jarrah (*Eucalyptus marginata*)	>50	10-15	2	No
39	80	Jarrah (*Eucalyptus marginata*)	>50	15-20	1	No
40	81	Jarrah (*Eucalyptus marginata*)	>50	10-15	1	No
41	82	Jarrah (*Eucalyptus marginata*)	>50	10-15	0	No
42	83	Jarrah (*Eucalyptus marginata*)	>50	10-15	5+	No
43	84	Jarrah (*Eucalyptus marginata*)	>50	15-20	0	No
44	85	Jarrah (*Eucalyptus marginata*)	>50	15-20	1	No
45	86	Jarrah (*Eucalyptus marginata*)	>50	10-15	5+	Yes
46	87	Jarrah (*Eucalyptus marginata*)	>50	10-15	5+	No
***Assessment of Identified Trees at Apsley Estate, Mandogalup* (ArborLogic 2018a)**						
47	1	River Sheoak (*Casuarina cunninghamiana*)	>50	22	Not recorded	Not recorded
48	2	River Sheoak (*Casuarina cunninghamiana*)	>50	22	Not recorded	Not recorded
49	3	River Sheoak (*Casuarina cunninghamiana*)	>50	22	Not recorded	Not recorded
50	4	River Sheoak (*Casuarina cunninghamiana*)	>50	22	Not recorded	Not recorded
51	5	River Sheoak (*Casuarina cunninghamiana*)	>50	22	Not recorded	Not recorded
52	6	River Sheoak (*Casuarina cunninghamiana*)	>50	19	Not recorded	Not recorded
53	7	River Sheoak (*Casuarina cunninghamiana*)	>50	22	Not recorded	Not recorded
54	8	River Sheoak (*Casuarina cunninghamiana*)	>50	16	Not recorded	Not recorded
55	9	River Sheoak (*Casuarina cunninghamiana*)	>50	20	Not recorded	Not recorded
56	10	River Sheoak (*Casuarina cunninghamiana*)	>50	20	Not recorded	Not recorded
57	11	River Sheoak (*Casuarina cunninghamiana*)	>50	20	Not recorded	Not recorded
58	12	River Sheoak (*Casuarina cunninghamiana*)	>50	18	Not recorded	Not recorded
59	13	River Sheoak (*Casuarina cunninghamiana*)	>50	17	Not recorded	Not recorded
60	14	River Sheoak (*Casuarina cunninghamiana*)	>50	17	Not recorded	Not recorded
61	15	River Sheoak (*Casuarina cunninghamiana*)	>50	17	Not recorded	Not recorded
62	17	River Sheoak (*Casuarina cunninghamiana*)	>50	22	Not recorded	Not recorded
63	18	River Sheoak (*Casuarina cunninghamiana*)	>50	22	Not recorded	Not recorded
64	19	River Sheoak (*Casuarina cunninghamiana*)	>50	22	Not recorded	Not recorded
65	20	River Sheoak (*Casuarina cunninghamiana*)	>50	22	Not recorded	Not recorded
66	21	River Sheoak (*Casuarina cunninghamiana*)	>50	22	Not recorded	Not recorded
67	22	River Sheoak (*Casuarina cunninghamiana*)	>50	20	Not recorded	Not recorded
68	23	River Sheoak (*Casuarina cunninghamiana*)	>50	20	Not recorded	Not recorded
69	24	River Sheoak (*Casuarina cunninghamiana*)	>50	20	Not recorded	Not recorded
70	25	River Sheoak (*Casuarina cunninghamiana*)	>50	18	Not recorded	Not recorded
71	26	River Sheoak (*Casuarina cunninghamiana*)	>50	19	Not recorded	Not recorded
72	27	River Sheoak (*Casuarina cunninghamiana*)	>50	20	Not recorded	Not recorded
73	28	River Sheoak (*Casuarina cunninghamiana*)	>50	20	Not recorded	Not recorded
74	29	River Sheoak (*Casuarina cunninghamiana*)	>50	18	Not recorded	Not recorded
75	30	River Sheoak (*Casuarina cunninghamiana*)	>50	17	Not recorded	Not recorded
76	31	River Sheoak (*Casuarina cunninghamiana*)	>50	20	Not recorded	Not recorded
77	32	River Sheoak (*Casuarina cunninghamiana*)	>50	21	Not recorded	Not recorded
78	33	River Sheoak (*Casuarina cunninghamiana*)	>50	13	Not recorded	Not recorded
79	34	Swamp Mahogany (*Eucalyptus robusta*)	>50	18	Not recorded	Not recorded
80	39	River Sheoak (*Casuarina cunninghamiana*)	>50	13	Not recorded	Not recorded
81	40	River Sheoak (*Casuarina cunninghamiana*)	>50	18	Not recorded	Not recorded
82	50	Swamp Mahogany (*Eucalyptus robusta*)	>50	16	Not recorded	Not recorded
83	58	Swamp Mahogany (*Eucalyptus robusta*)	>50	18	Not recorded	Not recorded
84	60	Swamp Mahogany (*Eucalyptus robusta*)	>50	23	Not recorded	Not recorded
85	62	Swamp Mahogany (*Eucalyptus robusta*)	>50	23	Not recorded	Not recorded
86	67	Tasmanian Blue Gum (*Eucalyptus globulus*)	>50	15	Not recorded	Not recorded
87	69	Swamp Mahogany (*Eucalyptus robusta*)	>50	3	Not recorded	Not recorded
88	72	Swamp Mahogany (*Eucalyptus robusta*)	>50	23	Not recorded	Not recorded

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Map No.	Tree tag ID	Species	DBH (cm)[1]	Tree Height (m)	No. of Hollows	Potential for Breeding
89	75	Swamp Mahogany (*Eucalyptus robusta*)	>50	23	Not recorded	Not recorded
90	77	Swamp Mahogany (*Eucalyptus robusta*)	>50	19	Not recorded	Not recorded
91	83	Swamp Mahogany (*Eucalyptus robusta*)	>50	14	Not recorded	Not recorded
92	85	Swamp Mahogany (*Eucalyptus robusta*)	>50	18	Not recorded	Not recorded
93	101	River Sheoak (*Casuarina cunninghamiana*)	>50	18	Not recorded	Not recorded
94	102	Tuart (*Eucalyptus gomphocephala*)	>50	15	Not recorded	Not recorded
95	103	Flooded Gum (*Eucalyptus rudis*)	>50	15	Not recorded	Not recorded
96	104	White Cedar (Melia azedarach)	>50	14	Not recorded	Not recorded
***Assessment of Identified Trees adjacent to the Peel Main Drain, Apsley, Mandogalup* (ArborLogic 2018b)**						
116	236	Flooded Gum (*Eucalyptus rudis*)	>50	20	Not recorded	Not recorded
117	240	Flooded Gum (*Eucalyptus rudis*)	>50	16	Not recorded	Not recorded
118	241	Freshwater Paperbark (*Melaleuca rhaphiophylla*)	>50	10	Not recorded	Not recorded
119	243	Flooded Gum (*Eucalyptus rudis*)	>50	20	Not recorded	Not recorded
120	276	Flooded Gum (*Eucalyptus rudis*)	>50	6.5	Not recorded	Not recorded
121	277	Freshwater Paperbark (*Melaleuca rhaphiophylla*)	>50	7	Not recorded	Not recorded
122	278	Flooded Gum (*Eucalyptus rudis*)	>50	17	Not recorded	Not recorded
123	288	Flooded Gum (*Eucalyptus rudis*)	>50	7	Not recorded	Not recorded
Adapted from Arborite (2025)						
124	5	Coastal Sheoak (*Casuarina equisetifolia*)	70	20-25	Not recorded	Not recorded
125	4	Coastal Sheoak (*Casuarina equisetifolia*)	80	20-25	Not recorded	Not recorded
126	3	Coastal Sheoak (*Casuarina equisetifolia*)	70	20-25	Not recorded	Not recorded
127	2	Stone Pine (*Pinus pinea*)	70	15-20	Not recorded	Not recorded
128	1	Stone Pine (*Pinus pinea*)	75	15-20	Not recorded	Not recorded
Adapted from Paperbark Technologies (2025)						
129	1	Maritime Pine (*Pinus pinaster*)	74	16	Not recorded	Not recorded
130	2	Maritime Pine (*Pinus pinaster*)	70	16	Not recorded	Not recorded
131	3	Maritime Pine (*Pinus pinaster*)	60	14	Not recorded	Not recorded
132	4	Maritime Pine (*Pinus pinaster*)	58	7	Not recorded	Not recorded
133	7	Maritime Pine (*Pinus pinaster*)	60	14	Not recorded	Not recorded
134	9	Maritime Pine (*Pinus pinaster*)	51	14.5	Not recorded	Not recorded
135	11	Maritime Pine (*Pinus pinaster*)	57	15	Not recorded	Not recorded
136	12	Maritime Pine (*Pinus pinaster*)	56	15	Not recorded	Not recorded
137	28	Swamp Mahogany (*Eucalyptus robusta*)	76.49	10.7	Not recorded	Not recorded
138	13	Flooded Gum (*Eucalyptus rudis*)	88	12	Not recorded	Not recorded
139	14	Flooded Gum (*Eucalyptus rudis*)	84.05	12	Not recorded	Not recorded
140	16	Flooded Gum (*Eucalyptus rudis*)	58	11	Not recorded	Not recorded
141	17	Flooded Gum (*Eucalyptus rudis*)	80.62	11	Not recorded	Not recorded
142	18	Flooded Gum (*Eucalyptus rudis*)	77.34	12	Not recorded	Not recorded
143	20	Flooded Gum (*Eucalyptus rudis*)	80	10	Not recorded	Not recorded
144	21	Flooded Gum (*Eucalyptus rudis*)	54.92	8	Not recorded	Not recorded
145	23	Flooded Gum (*Eucalyptus rudis*)	71.59	10	Not recorded	Not recorded
146	24	Flooded Gum (*Eucalyptus rudis*)	78.43	9	Not recorded	Not recorded
147	25	Flooded Gum (*Eucalyptus rudis*)	89.5	16	Not recorded	Not recorded
148	27	Flooded Gum (*Eucalyptus rudis*)	78.6	9	Not recorded	Not recorded

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Legend

- Project area
- Cadastral boundary (LGATE-002)
- Proposed POS
- Stage boundaries
- Proposed lot layout

Roads (LGATE-195)

- Minor road

Significant trees

- Dead Jarrah
- Dead Unknown
- Flooded Gum
- Freshwater Paperbark
- Jarrah
- River Sheoak
- Swamp Mahogany
- Tasmanian Blue Gum
- Tuart
- White Cedar
- Coastal Sheoak
- Stone Pine
- Maritime Pine
- Potential hollows

JBS&G

0 50 metres

Job Number: 65648

Client: Qube Property Group Pty Ltd

Scale 1:2,800 at A3

Drawn By: jcrute

Coord. Sys. GDA2020 MGA Zone 50

Checked By: MGellender

Version: Rev A

Date: 01-Jul-2025

Lot 682 Rowley Road Mandogalup, WA

SIGNIFICANT TREES

FIGURE: 3

Document Path: C:\Users\jcrute\JBS&G Australia\JBS&G - DCS - Internal - Documents\Projects\Qube\65648 Mandogalup LFTRP Update and EPBC Extension Request\GIS\02_MapProjects\65648_LFTRP_R01\65648_LFTRP_R01.aprx
Image Reference: www.nearmap.com© - Imagery 19. April 2025.
Layout: 65648_A3P_03_SigTrees

The initial assessment of significant trees undertaken by ArborLogic (2016) identified 141 significant trees, of which, 101 have been retained within the wider Apsley Estate including within the established Mokare Reserve Adventure Playground, the conservation area and landscaped areas. Since this initial assessment and in discussions with the City of Kwinana (July 2021), a further 10 significant trees have been marked to be retained.

Of the 129 trees in the project area only five were identified as trees with the potential to be utilised by Black Cockatoos as breeding trees (Emerge 2011), comprising of the following:

- Jarrah (*Eucalyptus marginata*)
- Dead tree of unknown species

4.3 Trees to be Retained

Two rows of trees to the south of the Peel Main Drain have been assessed to determine which are significant trees as per the City of Kwinana criteria. The eastern most row (trees 47–77 in **Table 4-1**) is comprised of mature River Sheoaks which Black Cockatoo species utilise for foraging, and these will be retained within POS Cell I.

Healthy, significant trees within the Peel Main Drain (trees 116–123, and 138–143 in **Table 4-1**) and POS Cell G1 (trees 3–15 and 93–95 in **Table 4-1**) will be retained.

4.4 Trees to be Removed

All of the 129 trees identified as fitting the criteria of significant trees by the City of Kwinana, within the project area, are located within an area which has been granted approval for clearing under EPBC 2014/7126. Of the 129, 69 are to be removed as they are part of the proposed residential subdivision area. The difference in ground levels which needs to be addressed for the project area, is the purpose for obtaining EPBC approval for the site.

As part of the EPBC approval process, the approval holder was authorised to clear no more than 38.7 ha of native vegetation and to construct approximately 950 residential lots, a primary school, Public Open Space (POS) and supporting infrastructure development on Lot 682, Mandogalup, Western Australia. The clearing of potential Black Cockatoo habitat has been offset by the following:

- Lot 102 Wannamal Road, Gingin – 154 ha
- Lot 1143 Wye Road, Nannup – 34.06 ha

Within the Peel Main Drain, the significant trees will be retained, as well as the majority of trees that are not classified as significant trees. Only those trees deemed damaged and unable to be saved will be removed. Figure 3 shows the POS cells which are proposed within the project area and the trees located within POS and the Peel Main Drain that will be retained. Trees located outside these areas will be cleared for residential development.

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5. Management and Maintenance

Table 5-1 below outlines the proposed management measures, timing and responsibilities for the protection and maintenance of retained significant trees on site. This will continue to be followed for all trees which have been identified as being retained across the entire Apsley Estate.

Table 5-1: Proposed protection and maintenance management measures for significant trees to be retained

Aspect	Management measure	Timing	Responsibility
Protection of retained trees and landscape features	In accordance with Section 4 of AS 4970-2009, establish/delineate Tree Protection Zones for each significant tree to be retained and install protective measures (if applicable) such as: • Protection fencing in accordance with AS4970-2009 • Signs • Trunk and branch protection • Ground protection.	Prior to clearing	Civil or Landscape Contractor
	Ground truth public open space and road reserves prior to clearing, with a representative from the City of Kwinana to ensure all significant trees and landscape features that are to be retained are surveyed and clearly identified.	Prior to clearing	Civil Contractor
	The City of Kwinana should be contacted in the event that a significant tree identified is removed without appropriate authorisation or damaged to a point where removal is necessary.	During site works	Civil Contractor
	Exclude the following activities within the Tree Protection Zones: • Machine excavation including trenching • Cultivation • Storage of equipment • Parking of vehicles and plant machinery • Dumping of waste • Placement filling • Physical damage of tree.	During site works and construction	Civil or Landscape Contractor
	Future civil design drawings (submitted to the City of Kwinana) to incorporate the requirements of this LFTRMP (including for retaining walls, drainage and POS, roads, services and footpaths).	During site works and construction	Engineering Consultant
	Remove tree protection measures (if installed).	Post subdivisional works, at landscaping stage	Civil or Landscape Contractor
Maintenance of retained trees	All retained trees should be pruned to remove dead branches.	Practical completion of subdivision works	Landscaping Contractor
	Tree limbs overhanging properties should be pruned as advised by the City of Kwinana in consultation with the proponent's arborist.	Practical completion of subdivision works	Landscaping Contractor
	Any retained trees in poor health may require review by an independent arborist to determine if the tree remains viable.	Practical completion of subdivision works	Landscaping Contractor
	Retained trees that are not viable will be removed (including the stump) and replaced with a tree of the same species by the proponent.	Practical completion of subdivision works	Landscaping Contractor
	Feral beehives in trees to be retained or cleared shall be removed and relocated out of the subdivision. Native bees in trees to be cleared will be relocated within the development. Native beehives in trees that are to be retained will not be removed.	Practical completion of subdivision works	Landscaping Contractor

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6. Limitations

Scope of services

This report ("the report") has been prepared by JBS&G in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and JBS&G. In some circumstances, a range of factors such as time, budget, access and/or site disturbance constraints may have limited the scope of services. This report is strictly limited to the matters stated in it and is not to be read as extending, by implication, to any other matter in connection with the matters addressed in it.

Reliance on data

In preparing the report, JBS&G has relied upon data and other information provided by the Client and other individuals and organisations, most of which are referred to in the report ("the data"). Except as otherwise expressly stated in the report, JBS&G has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report ("conclusions") are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. JBS&G has also not attempted to determine whether any material matter has been omitted from the data. JBS&G will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to JBS&G. The making of any assumption does not imply that JBS&G has made any enquiry to verify the correctness of that assumption.

The report is based on conditions encountered and information received at the time of preparation of this report or the time that site investigations were carried out. JBS&G disclaims responsibility for any changes that may have occurred after this time. This report and any legal issues arising from it are governed by and construed in accordance with the law as at the date of this report.

Environmental conclusions

Within the limitations imposed by the scope of services, the preparation of this report has been undertaken and performed in a professional manner, in accordance with generally accepted environmental consulting practices. No other warranty, whether express or implied, is made.

The advice herein relates only to this project and all results conclusions and recommendations made should be reviewed by a competent person with experience in environmental investigations, before being used for any other purpose.

JBS&G accepts no liability for use or interpretation by any person or body other than the client who commissioned the works. This report should not be reproduced without prior approval by the client, or amended in any way without prior approval by JBS&G, and should not be relied upon by other parties, who should make their own enquiries.

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7. References

Arborite (2025). *Apsley Stage 18B – Roundabout Clearance*. Report prepared for QUBE Property Group.

ArborLogic (2016). *Preliminary Assessment of Identified Trees at QUBE Subdivision, Mandogalup*. Report prepared for QUBE Property Group.

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Appendix A EPBC Extension Approval (Ref: 2014/7126)

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Australian Government
Department of Climate Change, Energy, the Environment and Water

EPBC ref: 2014/7126

Mr Mark Hector
Managing Director
QUBE Property Group
Mark@qubeproperty.com.au

Extension of the period of effect of the approval for Residential Estate Development, Lot 682 Rowley Road, Mandogalup, Western Australia (EPBC 2014/7126)

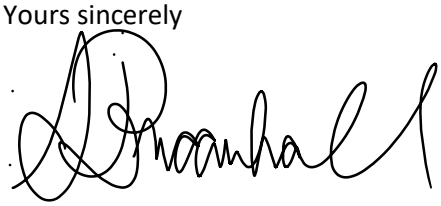
Dear Mr Hector

Thank you for your correspondence to the department dated 19 September 2023 requesting extension of the period of effect of *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) approval 2014/7126.

I have considered the request for extension in accordance with section 145D of the EPBC Act and, as a delegate of the Minister for the Environment and Water, I have decided to extend the period of effect of approval of EPBC Act approval 2014/7126 until 31 July 2029. A formal notification is attached. The notification will be published on the department's website.

Should you require any further information please contact Max Stratton by email to PostApproval@dcceew.gov.au.

Yours sincerely



Sara Broomhall
Director, Post Approvals Section (WA, NSW, ACT, Vic, Tas)
Environment Assessments (Vic, Tas) and Post Approvals Branch
18 October 2023

Attach: Extension Notice

Appendix B Cut to Fill Plan (Cossill and Webley 2020)

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No.	DATE	DRAWN	CHECKED	AMENDMENT
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Appendix C Level 1 Fauna Survey and Habitat Assessment: Various allotments, Mandogalup (Emerge 2011)

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LEVEL 1 FAUNA SURVEY AND HABITAT ASSESSMENT

VARIOUS ALLOTMENTS, MANDOGALUP

EP10-018

Prepared for Qube Mandogalup Land Development Company
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Executive Summary

The Qube Mandogalup Land Development Company Pty Ltd. (QMLDC) owns seven parcels of land within the locality of Mandogalup (see **Figure 1**). These land parcels are Lots 664, 668 and 669 Mandogalup Road, Lot 791 and 663 Norkett Road and Lots 52 and 682 Rowley Road, herein referred to as 'the site'. The site covers an area of approximately 147 ha and comprises mainly cleared land used for market gardening and associated agricultural activities (see **Figure 2**).

The site has been identified as an area for future residential development through State level strategic planning frameworks, and at a local level in the Town of Kwinana's Eastern Residential Intensification Concept (ERIC). The site is zoned 'Urban Deferred' and 'Rural' pursuant to the Metropolitan Region Scheme (MRS), although it is understood that the 'Rural' zoned portions will ultimately be rezoned to either "Urban Deferred' or 'Urban' in the near future.

QMLDC intend to develop these lots for residential purposes, and Emerge Associates (Emerge) were engaged to undertake a Level 1 fauna survey and habitat assessment across the site, with the aim of understanding any significant fauna and fauna habitat values within the site to inform future site planning and development approvals purposes. This survey provides an update to the original level 1 fauna assemblage survey undertaken by zoologist Greg Harewood in 2005.

The level 1 survey was undertaken in accordance with the Environmental Protection Authority's (EPA's) *Guidance Statement No. 56 – Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004). The survey scope also included the following targeted surveys:

- A black cockatoo habitat assessment, inclusive of locating potential habitat trees (trees with a Diameter at Breast Height (DBH) of ≥ 500 mm) and identification and delineation of any potential foraging habitat areas based on vegetation composition and any foraging evidence observed on site.
- An assessment of the presence/absence of graceful sun-moth and its habitat within the site in accordance with the Western Australian Department of Environment and Conservation's (DEC's) *Guidelines for the Graceful Sun-Moth (Synemon gratiosa) & Site Habitat Assessments* (Bishop, Williams et al. 2010) and if necessary the delineation of potentially suitable habitat.
- Determination of the likely occurrence (or otherwise) of Chuditch (*Dasyurus geoffroii*) within the site based on an assessment of suitable habitat, scats, fur or tracks.

The fauna habitat assessment identified three native plant communities and areas that were 'Parkland Cleared' (cleared land with scattered native tree species). Lot 682 Rowley Road supports two patches of intact woodland. The northern patch is in 'Excellent' to 'Very Good' condition and the southern patch in 'Good' to 'Very Good' condition. Lot 669 Mandogalup Road supports an isolated patch of *Banksia* woodland in 'Degraded' condition. These remnant patches represent the only stands of native vegetation within the site and cover an area of approximately 40.79 ha. Of this, 37.76 ha is considered sufficiently intact enough to potentially retain its structure and condition in the longer term with management, although 10.32 ha of this is fragmented, isolated and already been subject to degrading influences and would require a significantly higher degree of intervention to maintain any biodiversity values. 3.03 ha (of the total 40.79 ha) is significantly degraded to the extent that it is unlikely to remain viable in the medium to longer term, even with significant management intervention.

The culmination of this fauna assessment was the compilation of a list of fauna species that were either observed during the site visits or were noted as potentially occurring within the site based on the habitat types present. A total of 54 fauna species were observed (or positively identified from scats, tracks, skeletons or calls) within the site during both the 2005 and 2010/2011 surveys.

A total of 37 fauna species with conservation significance were identified as occurring or potentially occurring within the site. These are listed pursuant to the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), the Western Australian *Wildlife Conservation Act 1950* (WC Act) and the China-Australia, Japan-Australia and Republic of Korea-Australia Migratory Birds Agreements (CAMBA/JAMBA/ROKAMBA) or other State or local based frameworks.

Following the fauna assessment, those conservation significant species that were deemed potentially relevant for the site were:

- carnaby's black cockatoo (*Calyptorhynchus latirostris*) (Endangered EPBC Act, S1 WC Act).
- forest red-tailed black cockatoo (*Calyptorhynchus banksii naso*) (Vulnerable EPBC Act, S1 WC Act)
- graceful sun-moth (*Synemon gratiosa*) (Endangered EPBC Act, S1 WC Act)
- rainbow bee-eater (*Merops ornatus*) (S3 WC Act, JAMBA)
- fork-tailed swift (*Apus pacificus*) (S3 WC Act, JAMBA/CAMBA/ROKAMBA)
- white-bellied sea eagle (*Haliaeetus leucogaster*) (S3 WC Act, CAMBA)
- great egret (*Ardea alba*) (S3 WC Act, JAMBA/CAMBA)
- cattle egret (*Ardea Ibis*) (S3 WC Act, JAMBA/CAMBA)
- peregrine falcon (*Falco perigrinus*) (S4 WC Act).

The two species of black cockatoo were considered to be the most significant fauna species actively or potentially occurring within the site. The chuditch (*Dasyurus geoffroii*) red-tailed phascogale (*Phascogale calura*) and quokka (*Setonix brachyurus*), while identified from the Department of Sustainability, Environment, Population and Communities (DSEWPC) database, were excluded from the fauna inventory list due to lack of suitable habitat within the site and no evidence of these species utilising the site during the reconnaissance survey. The rainbow bee-eater, great egret, cattle egret, peregrine falcon, fork-tailed swift and white-bellied sea eagle are all considered to potentially use the site on occasion, usually part of a much larger home range, but it is highly unlikely they would rely on the site for their ongoing occurrence in the wider local area.

Potential habitat for the graceful sun moth was mapped as part of the targeted survey. The potential habitat areas were the intact *Banksia* woodland communities across the site, and in particular the areas in 'Excellent' to 'Very Good' condition within the northern portion of Lot 682. No *Lomandra* species were recorded within the *Eucalyptus rudis* and *Melaleuca preissiana* woodland. No graceful sun moths were observed within the site during the surveys, and one moth was observed along the boundary of Lot 682 Rowley Road, although it is considered likely that this individual originated from similar remnant vegetation to the west of the site, also in 'Excellent' condition. While based on the broadly known habitat preferences for this species, potential habitat does exist within the site, following the extensive survey effort and the survey results it can be concluded that the site does not support a population of this species.

Based on recently released carnaby's black cockatoo habitat mapping published by the Department of Planning (in collaboration with the Department of Environment and Conservation), the site is identified as supporting foraging habitat (based on its broad vegetation community type), although no nesting or roosting sites are located within the site. The closest known nesting site is located a significant distance east on the Darling Scarp, and the nearest known roost site is located about 3 km east at Wandi.

Evidence of the carnaby's black cockatoo and the forest red-tailed black cockatoo included actual sightings and foraging evidence (chewed jarrah, marri, and sheoak fruits and *Banksia* cones). The habitat assessment identified 231 trees with a DBH of greater than or equal to 500 mm, of which 17 contained large hollows (>12 cm) that appeared big enough and oriented favorably to possibly allow entry to a black cockatoo. None of these hollows showed any evidence of current or past use by black cockatoos, and there are no known records of either species nesting in this part of the Swan Coastal Plain. The known nesting sites on the Swan Coastal Plain occur in tuart trees, and are significantly distanced both north and south from the site.

All three plant communities within the site contain known black cockatoo foraging plant species. No foraging evidence was recorded within the areas of 'Degraded' *Banksia* woodland within the south of the site. Based on the percentage covers of each identified foraging species within each plant community, the two *Banksia* communities had greater cover values for the known foraging species. Therefore the areas of *Banksia* woodland are considered to provide the greatest carrying capacity for foraging black cockatoos within the site.

Therefore, arising from the findings of this fauna survey and habitat assessment, the most significant areas for actual or potential fauna habitat is the remnant vegetation within the northern portion of the site, in 'Excellent' and 'Very Good' condition (see **Figure 7**). This covers an area of approximately 24.7 ha is and also proximal to other large areas of remnant vegetation to the north, west and southwest of this area. The central eastern portion of this area has been excluded given it is more low lying and supports a different vegetation community of which the key cockatoo foraging species are less dominant.

This area provides the core known and potential foraging habitat for both conservation significant black cockatoo species. While other areas within the site do support remnant vegetation that contains black cockatoo foraging habitat and potential nesting habitat, these areas are currently more degraded and fragmented and therefore less easily retained in a single conservation area (i.e. within public open space or other reservation) given the long term presence of a power transmission easement. The remnant vegetation in the southern extents of Lot 682 (10.32 ha on the southern side of the power transmission easement) has a much lower area to perimeter ratio, and already shows signs of pressure compared to the larger more intact areas to the north.

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Appendices

Appendix A
Level 1 Fauna Survey 2005

Appendix B
Fauna Inventory

Appendix C
Graceful sun-moth survey report (Emerge Associates 2011)

Appendix D
Targetted black cockatoo survey data

Appendix E
Database searches and species descriptions

Introduction

Project background

The Qube Mandogalup Land Development Company Pty Ltd. (QMLDC) owns seven parcels of land within the locality of Mandogalup. These land parcels are:

- Lots 664, 668 and 669 Mandogalup Road.
- Lots 791 and 663 Norkett Road.
- Lots 52 and 682 Rowley Road.

The land parcels, referred to herein as 'the site', are generally located to the west of Kwinana Freeway, east of Mandogalup Road and between Rowley Road in the north and Anketell Road in the south (see **Figure 1**). Under the Metropolitan Region Scheme (MRS), Lots 52 and 682 Rowley Road are zoned 'Urban Deferred', while the remaining lots are zoned as 'Rural'. State and local level strategic planning frameworks, including the Town of Kwinana's Eastern Residential Intensification Concept (ERIC), intend for the progression of all areas identified within the site to an 'Urban' zoning and ultimately development for residential and associated community purposes.

QMLDC intend to develop these lots for residential purposes and to facilitate the progression of broad level structure planning and subsequent development approvals for the site, QMLDC appointed Emerge Associates (Emerge) to undertake a Level 1 fauna survey and habitat assessment across the site.

The site covers an area of approximately 147 hectares (ha) and comprises area of cleared land that has been used for market gardening and associated agricultural activities (see **Figure 2**). Lot 682 Rowley Road supports two patches of *Banksia* woodland, while Lot 669 Mandogalup Road supports an isolated *Banksia* woodland patch in a 'Degraded' condition (Cardno BSD 2005). These remnant patches represent the only stands of native vegetation within the site and cover an area of approximately 40.79 ha. The fauna survey investigations have primarily focused, but not been limited to, these remnant vegetation/bushland patches.

1.1 Purpose of this assessment

The purpose of this assessment was to investigate and document the fauna and fauna habitat values of the site, determine whether the site supported significant fauna or fauna habitat values, with the ultimate aim of facilitating the progression of structure planning for the site. This survey provides an update to the level 1 fauna assemblage survey undertaken by zoologist Greg Harewood across the site in 2005. The original 2005 survey report has been provided as **Appendix A**.

1.2 Assessment methodology

This assessment has been structured around the methodology provided by the Environmental Protection Authority (EPA) in their *Guidance Statement No. 56 – Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (Environmental Protection Authority 2004) to undertake a level 1 fauna assemblage survey.

The methodology for undertaking a level 1 survey as defined within *Guidance Statement No. 56* is to:

a) Undertake a desktop assessment.

b) Complete a reconnaissance field survey.

The purpose of the desktop assessment is to compile a list of fauna species that are known or likely to occur within the site based on a search of all relevant literature, data and spatially based information. In addition, information should also be gathered on the site and the habitat values of the site (usually at the locality scale).

The purpose of the reconnaissance field survey is to:

- Verify the accuracy of the background assessment.
- Further delineate and characterise the fauna and faunal assemblages present in the site.
- Identify potential impacts on fauna that may result from the development of the site.

In addition to the level 1 fauna assemblage survey as described within *Guidance Statement No. 56* (Environmental Protection Authority 2004), this survey also included the following targeted assessments:

- A black cockatoo habitat assessment, inclusive of locating potential habitat trees (trees with a Diameter at Breast Height (DBH) of ≥ 500 mm) and foraging habitat areas based on both observed foraging evidence and from the species composition of remnant vegetation.
- An assessment of the presence/absence of graceful sun-moth and its habitat within the site in accordance with the Western Australian Department of Environment and Conservation's (DEC's) *Guidelines for the Graceful Sun-Moth (Synemon gratiosa) & Site Habitat Assessments* (Bishop, Williams et al. 2010).
- Determination of the likely presence/absence of Chuditch (*Dasyurus geoffroii*) within the site based on an assessment of suitable habitat, scats, fur or tracks.

1.3 Assessment limitations

The assessment reported on here is based on a desktop assessment and a reconnaissance field survey that included opportunistic fauna observations made across two survey periods (in 2005 and 2010). No repeat seasonal sampling or trapping has been conducted. The conclusions presented are based upon field data collected over the above specified period of time and are therefore indicative of the environmental condition of the site at the time of preparing the report.

Fauna species are indicated as potentially present based on there being suitable (quality and extent) habitat within the site (or immediately adjacent). With respect to opportunistic observations, the possibility exists that certain species may not have been detected during field investigations due to:

- Seasonal inactivity during field survey.
- Species present within micro habitats not surveyed.
- Cryptic species able to avoid detection.
- Transient wide-ranging species not present during survey period.

In recognition of the above survey limitations a precautionary approach was adopted for this assessment. Any fauna species that would possibly occur within the site (or immediately adjacent) as identified through databases, publications, discussions with local experts/residents and the habitat knowledge of the author, has been assumed to potentially occur.

During the black cockatoo habitat survey, trees with hollows were recorded (i.e. habitat trees). It should be noted that identifying hollows suitable for fauna species from ground level has limitations. Generally the full characteristics of any hollow seen are not fully evident (e.g. internal dimensions). It is also difficult to locate all hollows as some are not observable from ground level.

Notwithstanding the above, the methodology adopted has involved more than one visit to the site and a scope of work that is more comprehensive than a standard level 1 fauna survey. It is suggested that the survey is more than adequate to understand the fauna and fauna habitat values of the site and be used to inform structure planning and approval process, particularly for the key species of concern.

2 Desktop Assessment

This desktop assessment provides information on potential and known fauna and fauna habitat that occurs or potentially occurs within and adjacent to the site based on a search of all relevant literature, data and spatially based information. This section has been divided into information on:

- fauna habitat and its conservation significance
- fauna species and their conservation significance.

2.1 Fauna Habitat

2.1.1 Vegetation

At a regional scale, vegetation complex mapping of the Swan Coastal Plain undertaken by Heddle, Loneragan et al. (1980), which is based on soil and geomorphology (and water availability) patterns, indicates that the remnant vegetation within the site is likely to represent the Bassendean vegetation complex. The Bassendean vegetation complex is described as:

*Woodland of Eucalyptus marginata – Allocasuarina fraseriana – Banksia spp. to low woodland of Melaleuca spp. and sedgelands on the moister sites (*Heddle, Loneragan et al. 1980).

At a local scale, plant community mapping has been undertaken across the site (including some adjoining lots) by Cardno BSD in 2005. This survey identified two plant communities present within the site, these being a *Banksia* spp. woodland community within Lot 682 Rowley Road and a *Melaleuca/Eucalyptus rudis* woodland community in lots 668 and 669. The remaining lots were not recorded as containing intact native plant communities, but instead consisted of cleared agricultural land.

The *Banksia* spp. woodland within the northern portion of Lot 682 Rowley Road was observed to be in 'Excellent' condition, while the southern portion of Lot 682 was in a 'Good' to 'Very Good' condition. The *Melaleuca/Eucalyptus rudis* woodland within lots 668 and 669 Mandogalup Road was recorded to be in a 'Degraded' condition. The vegetation condition scale used was that of Keighery (1994).

2.1.2 Biodiversity linkages

In an increasingly fragmented landscape biodiversity linkages or corridors can be very important mechanisms to help maintain viable populations of plants and animals between bush land fragments by maintaining connectivity. A biodiversity linkage can be described as a linear landscape element that connects two or more patches of natural habitat and functions to facilitate movement (Soule and Gilpin, cited in Hilty et al. 2006).

A network of proposed Regional Ecological Linkages have been identified for the Perth Metropolitan Region based on work undertaken as part of:

- Bush Forever (Vol. 2) (Government of Western Australia 2000)
- Perth Greenways Report (Alan Tingay and Associates 1998)
- System 6 Report (CALM 1983).

A Regional Ecological Linkage has been generally identified within the Mandogalup area, between Thompson Lake Reserve in the north to the Spectacles in the south. The identified linkage generally extends from Bush Forever Site No. 391 (BF 391): *Thompson Lake Nature Reserve and Adjacent Bushland,* through BF 392: *Harry Waring Marsupial Reserve, Wattleup* and Frankland Park (not a Bush Forever site but vested with the local government), into the remnant vegetation in the north-west corner of the site and further south along the western boundary of the site (in adjacent bushland) and south to BF 268 and BF 269 (see **Figure 6)**.

The key mechanism to implement and achieve these linkages is generally through local government local biodiversity strategies. The Town of Kwinana does not have a local biodiversity strategy, and it would not appear that any intentions to accommodate the linkage are evident in the plan prepared for ERIC. Notwithstanding this any remnant vegetation within the site along the northern and southern boundaries could assist with achieving local biodiversity connectively, but this would need to be addressed at a wider local level rather than just at a site level.

Remnant vegetation situated immediately to the west of the site would appear to be more continuously directly connected with Frankland Park and BF 268 and BF 269, and therefore the remnant vegetation within the site would not appear to be critical for the linkage, but rather supplement it. There also appear to be opportunities to improve the direct connectivity of the linkage outside of the site.

2.2 Fauna Species

2.2.1 Fauna Inventory

A fauna inventory of all the potential fauna (mainly vertebrate species) occurring within the site has been compiled and provides an update to the original 2005 survey list. This was achieved by undertaking searches of the DEC's Threatened Fauna and 'Naturemap' database (joint DEC, Western Australian Museum (WAM) and Birds Australia data) and the Department of Sustainability, Environment, Water, Population and Communities (DSEWPAC) 'Protected Matters Search Tool' database, published and unpublished reports and specialist books detailing fauna of the general area.

Fauna survey reports have been undertaken in nearby areas in the past, though not all are publically available and could not be referenced. The most significant of those available have been used as the primary reference material for compiling the fauna inventory. Those reports referred to included, but were not limited to:

- ENV Australia (2010). Cape Peron Fauna Assessment. Perth, unpublished report for Strategen Environmental Consultants.
- Harewood, G. (2009). Fauna Survey (Level 2) East Rockingham WWTP Site and Pipeline Corridors. Unpublished report for ERM Australia Pty Ltd.
- How R.A., Harvey M.S., Dell J. and Waldock J. (1996). Ground Fauna of Urban Bushland Remnants in Perth. Report N93/04 to the Australian Heritage Commission (Woodman Point Results).

Both the database searches and the reports refer to species that would not occur within the site due to a lack of suitable habitat (extent and/or quality) present within the site or species that would be well outside of their natural ranges. This was taken into consideration when compiling the total fauna inventory. This fauna inventory list is provided as **Appendix B**.

2.2.2 Fauna of conservation significance

Some Western Australian fauna species have been identified under state, federal and international policies, agreements and laws to be of specific conservation significance. The term 'conservation significance' has been used in this report to refer to species that are listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), the Western Australian *Wildlife Conservation Act 1950* (WC Act), the Japan-Australia Migratory Birds Agreement (JAMBA), the China-Australia Migratory Birds Agreement (CAMBA), the Republic of Korea-Australia Migratory Birds Agreement (ROKAMBA), Bush Forever Decreaser Species (which includes bird habitat specialists) and species that are considered to be of local significance. These are described further below.

2.2.2.1 Environment Protection and Biodiversity Conservation Act 1999

The EPBC Act is the Australian Government's legal framework to protect threatened fauna species of national and international importance. Threatened fauna may be listed in any one of the categories provided in **Table 1**, and as defined in Section 179 of the EPBC Act.

A search was undertaken of the DSEWPAC's database using the 'Protected Matters Search Tool' within a 6 km radius from the site. A total of six fauna species were identified from this search and are considered to be Matters of National Environmental Significance (MNES) pursuant to the EPBC Act. These species were:

- carnaby's black cockatoo (*Calyptorhynchus latirostris*) - Engangered
- graceful sun-moth (*Synemon gratiosa*) - Endangered
- red-tailed phascogale - (*Phascogale calura*) - Endangered
- chuditch (*Dasyurus geoffroii*) - Vulnerable
- forest red-tailed black cockatoo (*Calyptorhynchus banksii naso*) - Vulnerable
- quokka (*Setonix brachyurus*) - Vulnerable.

The EPBC Act also lists migratory species, and a number of migratory species were identified from the DSEWPC search, however these species have been addressed separately in **Section 2.2.2.3** below.

2.2.2.2 Western Australian Wildlife Conservation Act 1950

All fauna in Western Australia is protected under Section 14 of the *Wildlife Conservation Act 1950* (WC Act). In particular, and in order to acknowledge conservation significant fauna, the WC Act lists species that are acknowledged to be under some threat of extinction. These lists are confirmed through formal notices, which are lists of significant species subject to protection under the WC Act (i.e. the *Wildlife Conservation (Specially Protected Fauna) Notice 2010(2)*). The WC Act acknowledges the level of threat or vulnerability according to four levels of 'schedules' (see **Table 2**).

Of the species identified as part of the fauna inventory, the following are scheduled fauna under the WC Act:

- forest red-tailed black cockatoo (*Calyptorhynchus banksii naso*) S1
- carnaby's black cockatoo (*Calyptorhynchus latirostris*) - S1
- graceful sun-moth (*Synemon gratiosa*) - S1
- chuditch (*Dasyurus geoffroii*) - S1
- red-tailed phascogale (*Phascogale calura*) - S1
- quokka (*Setonix brachyurus*) - S1

- great egret (*Ardea alba*) - S3
- cattle egret (*Ardea ibis*) - S3
- white-bellied sea-eagle (*Haliaeetus leucogaster*) - S3
- peregrine falcon (*Falco peregrinus*) - S4
- fork-tailed swift (*Apus pacificus)* - S3
- rainbow bee-eater (*Merops ornatus*) - S3

*Table 1: Conservation categories of the EPBC Act and their criteria (*species which are deemed to be a "Matter of National Environmental Significance" pursuant to the EPBC Act)*

CONSERVATION CATEGORY	CRITERIA FOR INCLUSION IN CONSERVATION CATEGORY
Extinct	(a) there is no reasonable doubt that the last member of the species has died.
*Extinct in the wild	(a) it is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or (b) it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
*Critically Endangered	(a) it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
*Endangered	(a) it is not critically endangered; and (b) it is facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.
*Vulnerable	(a) it is not critically endangered or endangered; and (b) it is facing a high risk of extinction in the wild in the medium term future, as determined in accordance with the prescribed criteria.
Conservation Dependent	(a) the species is the focus of a specific conservation program the cessation of which would result in the species becoming vulnerable, endangered or critically endangered; or (b) the following subparagraphs are satisfied: (i) the species is a species of fish; (ii) the species is the focus of a plan of management that provides for management actions necessary to stop the decline of, and support the recovery of, the species so that its chances of long term survival in nature are maximised; (iii) the plan of management is in force under a law of the Commonwealth or of a State or Territory; (iv) cessation of the plan of management would adversely affect the conservation status of the specie

Table 2: Western Australian WC Act threatened fauna categories

SCHEDULE	CODE	DESCRIPTION
Schedule 1	S1	Fauna which is rare or likely to become extinct
Schedule 2	S2	Fauna which is presumed extinct
Schedule 3	S3	Birds which are subject to an agreement between the governments of Australia and Japan (JAMBA) relating to the protection of migratory birds and birds in danger of extinction
Schedule 4	S4	Fauna that is otherwise in need to special protection

2.2.2.3 Japan-Australia, China-Australia and Republic of Korea-Australia Migratory Birds Agreement

The Japan-Australia, China-Australia and Republic of Korea-Australia Migratory Bird Agreement (JAMBA/CAMBA/ROKAMBA) are bilateral agreements between the aforementioned governments for the protection of migratory bird species and their habitats.

The three agreements list terrestrial, water and shorebird species which migrate between Australia and Japan/China/Korea. Both agreements require the parties to:

- protect migratory birds from take or trade except under limited circumstances
- protect and conserve habitats
- exchange information
- build cooperative relationships.

The JAMBA agreement also includes specific provisions for cooperation on conservation of threatened birds. All migratory bird species listed in the annexes to these agreements are protected as MNES under the EPBC Act 1999. JAMBA, CAMBA and ROKAMBA species that appear on the fauna inventory list are indicated within **Appendix B**.

2.2.2.4 Bush Forever Decreaser Species

A number of bird species have been listed as significant on the Swan Coastal portion of the Perth Metropolitan Region (Government of Western Australia 2000). The bird species are often referred to as Bush Forever Decreaser species and are listed in three categories which are:

- Habitat specialists with reduced distribution on the Swan Coastal Plain.
- Wide ranging species with reduced populations on the Swan Coastal Plain.
- Extinct species in the Perth region.

The presence of Bush Forever Decreaser species should be taken into consideration when determining the fauna values. Bush Forever Decreaser species are indicated as such within the fauna inventory list within **Appendix B**.

2.2.2.5 Local conservation significance

The local (sub-regional) significance of the study area has been determined by applying site specific criteria which are:

- Fauna species and/or habitat present that is poorly represented in the general study area.
- Fauna habitat within the general study area supporting species of conservation or other significance.
- Fauna habitat in better condition that other similar locations in general subject area.

The Department of Environment and Conservation (DEC) produces a supplementary list of Priority fauna species. These species are not considered threatened under the WC Act, but due to lack of knowledge or where species are poorly represented in secure conservation reserves some concern for their long term survival exists. The five classification levels are shown in **Table 3**, and the list of species is provided in **Appendix B**.

Table 3: DEC Priority Fauna Categories

CATEGORY	CODE	DESCRIPTION
Priority 1	P1	Taxa with few, poorly known populations on threatened lands.
Priority 2	P2	Taxa with few, poorly known populations on conservation lands.
Priority 3	P3	Taxa with several, poorly known populations, some on conservation lands
Priority 4	P4	Taxa in need of monitoring (not currently threatened or in need of special protection, but could be if present circumstances change)
Priority 5	P5	Taxa in need of monitoring (not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years)

3 Reconnaissance Field Survey

3.1 Methods

3.1.1 Habitat assessment

A detailed habitat assessment was carried out by two environmental scientists from Emerge on the 10 December 2010 with the aim of confirming plant community mapping undertaken by Cardno BSD in 2005. The site was traversed on-foot and each plant community mapped within the site in 2005 was revisited. The revised vegetation community and condition mapping is shown in **Figure 3** and **Figure 4** respectively.

3.1.2 Reconnaissance survey

The reconnaissance fauna survey was undertaken on the 14 December 2010 and the 17 January 2011 by zoologist Greg Harewood and an environmental scientist from Emerge. Survey traverses were conducted on foot and in total covered approximately15 lineal kilometers. This supplemented a reconnaissance survey also undertaken by Greg Harewood in 2005.

3.1.3 Black cockatoo habitat assessment

A targeted black cockatoo habitat assessment was carried out during the site reconnaissance survey. All trees within the site were assessed for the potential to contain or develop suitable hollows for black cockatoos. For the purposes of this study a potential cockatoo hollow has been defined as:

Generally any tree which is alive or dead that contains one or more visible hollows (cavities within the trunk or branches) suitable for occupation by any of the three black cockatoo species for the purpose of nesting/breeding. Hollows that had an entrance greater than about 12cm in diameter and would allow the entry of a cockatoo (white tailed or red-tailed) into a suitably orientated and sized branch/trunk, were recorded as a "potential nest hollow".

Target tree species included tuart (*Eucalyptus gomphocephala*), marri (*Corymbia calophylla*) and jarrah (*Eucalyptus marginata*) and any other suitable tree species of a suitable size that may be present. Peppermint (*Agonis flexuosa*), *Banksia* spp., sheoak (*Casuarina* spp., *Allocasuarina* spp.) and *Melaleuca* spp., were not assessed as they typically do not develop hollows that are used by black cockatoos.

The locations of identified potential habitat trees were recorded using a handheld Global Positioning System (GPS) unit. In addition, details including the number, type and size of hollows observed and an assessment of their likelihood of representing an existing or potential black cockatoo nest hollow were noted.

Specific observations of foraging and roosting evidence were made during the survey, with the location and nature of the evidence observed (if any) recorded. The diet of black cockatoos includes the fruits, seeds, flowers, nectar and grubs from a range of plant species. Foraging habitat can therefore be regarded as any area of vegetation containing plant species that one or more of the black cockatoos normally feed upon. Roosting sites represent trees where, at night, black cockatoos aggregate in groups to rest. Roosting sites are generally within groves of large, tall trees.

3.1.4 Graceful sun-moth survey

A graceful sun-moth survey was undertaken across the site in 2011 in accordance with DEC guidelines (Bishop, Williams et al. 2010). The survey methodology consisted of two parts:

- A detailed Lomandra density survey.
- Graceful sun-moth survey using the results of the *Lomandra* density survey.

The *Lomandra* density survey was conducted between the 25 and 28 of January 2011 with the aim of mapping and quantifying potential graceful sun-moth habitat.

Graceful sun-moth surveys were undertaken between February and March 2011. Six repeat surveys were carried out on the 24 February and 3, 10, 15, 25 and 31 of March. The full graceful sun-moth report (Emerge Associates 2011) is contained within **Appendix C**.

3.1.5 Taxonomy and Nomenclature

Taxonomy and nomenclature for fauna species used in this report is generally taken from the DEC's WA Fauna Census Database which is assumed to follow Aplin and Smith (2001) for amphibians and reptiles, How et al. (2001) for mammals and Johnstone (2001) for birds.

Common names are taken from the Western Australia Museum (WAM) when specified, though where common names are not provided they have been acquired from other publications. Sources include Van Dyck & Strahan (2008), Bush et al (2010), Bush et al (2007), Wilson and Swan (2008), Bush et al (2002), Tyler et al. (2000), Christidis and Boles (1994) and Glauret (1961). Not all common names are generally accepted.

3.2 Results

3.2.1 Habitat assessment

The habitat assessment generally confirmed previous plant community mapping undertaken by Cardno BSD in 2005 for the site. A number of refinements were made to the original mapping, with the vegetation on Lot 669 Mandogalup Road in the south of the site being determined as *Banksia attenuata* woodland rather than *Melaleuca preissiana-Eucalyptus rudis* woodlands (see **Plate 1)**. A few *Eucalyptus rudis* and *Melaleuca preissiana* species were present on the fringes of this degraded *Banksia* woodland, however the main plant community was *Banksia* woodland.

In the northern *Banksia* woodland community (Lot 682 Rowley Road), an additional two plant communities have been delineated, which includes a forest of low-lying *Banksia attenuata* and *Banksia illicifolia* over a sedgeland of *Dasypogon bromeliifolius* and *Lyginia barbata* and a *Eucalyptus rudis* and *Melaleuca preissiana* woodland. The low lying forest of banksia is a transitional community between the *Banksia attenuata* woodland on the drier upper sandy slopes and the *Melaleuca preissiana* and *Eucalyptus rudis* woodland that was identified in the depression. The plant communities and their fauna habitat potential are described below and shown on **Figure 3**.

- ***Parkland cleared* (*approximately 22 ha, see Plate 2***) – Cleared farmland with scattered native trees over introduced grasses and broadleaf species. Some areas of the cleared pasture are inundated during winter and provide foraging habitat for birds of prey, waterbird species and breeding grounds for frogs. Scattered trees include tuart, jarrah and flooded gum and while limited

in number, provide foraging and breeding opportunities for fauna. Generally speaking the fauna habitat values of these areas is low.

- **Banksia low woodland** (**approximately 33 ha, Plate 3**) – Low Banksia attenuata woodlands with emergent Eucalyptus marginata over heath of Hibbertia hypericoides, Stirlingia latifolia and Xanthorrhoea preissii. The amount of leave litter varies considerably from area to area and ranges from non-existent to dense. The best quality and most expansive Banksia low woodland occurs within the northern portion of Lot 682 Rowley Road and is in 'Excellent' condition. In 2005 evidence of Quenda and a sighting of the Western brush wallaby was made here. Significant sized fallen logs are rare, however hollows are relatively common in the eucalypt species with some significant sized hollows present. The Banksia species are likely to be used as a food source for the black cockatoo species that pass through the area. The greatest density of Lomandra hermaphrodita was mapped to occur within the Banksia low woodland, which is known as potential habitat for the graceful sun-moth. Despite a thorough survey during the graceful sun moth survey, that specifically targeted this area, there were no moths observed except for at the western boundary of the site in this area
- ***Banksia low forest (approximately 5 ha, see Plate 4)*** – Low *Banksia attenuata, Banksia illicifolia* and *Banksia menziesii* forest over heath of *Dasypogon bromeliifolius, Lyginia barbata* and *Schoenus* sp. This *Banksia* community has the same fauna habitat properties as the *Banksia* low woodland community described above.
- ***Eucalyptus rudis and Melaleuca preissiana woodland (approximately 3 ha, Plate 5)*** – Woodland of *Eucalyptus rudis* over *Melaleuca preissiana* and *Banksia littoralis* over *Astartea scoparia, Juncus pallidus*, **Carpobrotus edulis, **Zantedeschia aethiopica* and **Arctotheca calendula*. This community type, while being disturbed by some invasive groundcover weeds, provides a dense cover that could provide potential habitat for some fauna species that require refuge from predators, such as Quenda (a Quenda was observed in 2011 in this community while the graceful sun-moth survey was being undertaken). No *Lomandra hermaphrodita* or any sightings of graceful sun-moth were made in this community type.

The remainder of the site retains no native vegetation and has been delineated as 'No native species' on the plant community map shown in **Figure 3**. This covers approximately 73 ha of the site and is likely to provide very limited foraging habitat for birds of prey, waterbird species and breeding grounds for frogs. In addition Lot 52 was not fully surveyed and contains approximately 12 ha that has been cleared/slashed for the power transmission easement.

The remnant patches of native vegetation outlined above represent the only stands of native vegetation within the site and cover an area of approximately 40.79 ha. Of this, 37.76 ha is considered sufficiently intact enough to potentially retain its structure and condition in the longer term with management, although 10.32 ha of this is fragmented, isolated and already subject to some degrading influences and would require a significantly higher degree of management intervention. 3.03 ha (of the total 40.79 ha) is significantly degraded to the extent that it is unlikely to remain viable in the medium to longer term, even with significant management intervention.



Plate 1: Degraded Banksia attenuata woodland on Lot 669 Mandogalup Road in the south of the site that was previously mapped as Melaleuca preissiana-Eucalyptus rudis woodland. A number of scattered Eucalyptus rudis and Melaleuca preissiana trees were observed on the fringes of the Banksia woodland.



Plate 2: Parkland Cleared areas which consisting mainly of cleared paddocks with some scattered native tree species.



Plate 3: Banksia attenuata low woodland in an 'Excellent' condition over low heath of Hibbertia hypericoides, Xanthorrhoea preissii and Stirlingia latifolia.



Plate 4: Banksia attenuata, Banksia menziesii and Banksia illicifolia low forest over sedgeland of Dasypogon bromeliifolius, Lyginia barbata and Schoenus sp. in an 'Excellent' to 'Very Good' Condition.



*Plate 5: Woodland of Eucalyptus rudis over Melaleuca preissiana and Banksia littoralis over Astartea scoparia, Juncus pallida over *Carpobrotus edulis and *Zantedeschia aethiopica in a 'Very Good' condition.*

3.2.2 Reconnaissance survey

The results of the reconnaissance fauna survey (from both the 2005 and 2010 observations) are summarised below in **Table 4** and listed in the fauna inventory (see **Appendix B)**. A total of 57 fauna species were observed (or positively identified from scats, tracks, skeletons or calls) within the site during both reconnaissance surveys.

Table 4: Summary of potential and observed fauna species as listed in Appendix B.

GROUP	TOTAL NO. POTENTIAL SPECIES	TOTAL NO. OBSERVED SPECIES
Amphibians	9	3
Reptiles	37	1
Birds	96 (six are introduced species)	48 (two are introduced species)
Mammals	22 (six are introduced species)	5 (one is an introduced species)

3.2.3 Black Cockatoo Habitat Assessment

The black cockatoo habitat assessment identified a total of 231 trees within the site with a DBH of greater than 500 mm (**Figure 4**). Ninety nine (43%) of the trees did not contain hollows of any size. One hundred and fifteen (50%) of the trees contained one or more "small" hollows (<12 cm entrance size or >12 cm entrance in a small branch/trunk) which were considered not suitable for black cockatoos to use for nesting purposes. Seventeen (7%) trees contained hollows with larger entrances (>12 cm) that appeared large enough and orientated favorably to possibly allow the entry of a black cockatoo into a suitably sized branch/trunk. None of the trees containing large hollows showed any evidence of current or past use by black cockatoos.

Thirty six (16%) of all the trees with a DBH greater than 500 mm were dead. Details on the potential breeding habitat trees can be found in **Appendix D**.

As shown in **Figure 5**, these trees occurred across all three plant communities and within 'Parkland cleared' areas.

Evidence of two black cockatoo species foraging within the site was observed, associated with Carnaby's black cockatoo and the forest red-tailed black cockatoo. Evidence was in the form of chewed jarrah, tuart and sheoak fruits and chewed *Banksia* cones. The locations of these observations are shown in **Figure 6** with details provided in **Appendix D**. No foraging evidence was observed within the 'Degraded' *Banksia* woodland within the south of the site. The areas of most concentrated black cockatoo foraging evidence coincides with the *Banksia* woodland communities.

All three plant communities within Lot 682 Rowley Road have documented black cockatoo foraging species. Based on the percentage covers of each species within each plant community, the two *Banksia* communities had greater cover values of identified foraging species.

No black cockatoo roosting trees were identified within the site during the survey period. A recent cockatoo roost survey carried out by the DEC within the defined "Swan Region" (DEC 2010), which includes the Perth metropolitan area did not locate any roosts within or in the immediate vicinity of either of the inlet corridor study areas. The closest roost site listed within the report is located about 3 km east of the site at Wandi (Roost Code: DEC11 – 63 Carnaby's roosting - DEC 2010). The closest breeding sites do not occur on the Swan Coastal Plain but in the forest along the Darling Scarp.

3.2.4 Graceful sun-moth survey

Three species of *Lomandra* were recorded in the *Lomandra* density survey, *Lomandra caespitosa, Lomandra hermaphrodita* and *Lomandra maritima*, that latter two of these species being the only known habitat species for the graceful sun-moth (Bishop, Williams et al. 2010). The two *Lomandra* species were recorded at 52 of the 104 quadrats surveyed (see **Figure 3** of **Appendix C**). *Lomandra hermaphrodita* was more prolific across the site (recorded in 51 quadrats), whilst *Lomandra maritima* was recorded in seven quadrats. Both species were recorded in low numbers (1 - 16 plants), with *Lomandra hermaphrodita* having an average number of plants per quadrat of 3.8 (± 3.2) and *Lomandra maritima* having an average cover of 0.5% (± 0.5%).

No graceful sun-moth were found within the site across all six visits, however one moth was observed on the western boundary of the site that adjoins another area of similar remnant vegetation. This moth was recorded on the western firebreak of Lot 682 Rowley Road, and was observed to fly from the fire break into bush land on the adjacent land holding (10 Rowley Road). The graceful sun-moth survey report has been attached as **Appendix C**.

3.2.5 Fauna of Conservation Significance

The fauna inventory identified 37 species of conservation significance that could potentially occur within the site (see **Appendix B**). Not all species listed in the database and literature searches have been included within the fauna inventory, due to lack of suitable habitat. Of the species identified as potentially occurring within the site, three are listed pursuant to the EPBC Act, eight are listed under the WC Act, four are JAMBA/CAMBA/ROKAMBA migratory bird species, 28 are Bush Forever Decreaser species and four are DEC Priority Fauna (note that some of these species are listed under multiple levels of the significance framework). Information on potential conservation significant species is provided in **Appendix E**.

Carnaby's black cockatoo (*Calyptorhynchus latirostris*) (Endangered, S1): Foraging evidence attributed to this species was found during the survey (chewed tuart fruits, jarrah fruits and *Banksia* cones). The three plant communities and the areas that are 'Parkland Cleared' contain black cockatoo foraging species including tuart, jarrah and *Banksia,* however the 'Degraded' *Banksia* woodland and "Parkland cleared' areas in the south of the site did not show any evidence of foraging. Larger trees (≥ 500 mm DBH) are considered by the DSEWPAC as potential breeding habitat, although this is more prevalent in areas of surrounding woodland rather than isolated paddock trees. No evidence of actual breeding in any of the larger hollows observed was found, and the species is not known to nest in this part of the Swan Coastal Plain. There are no known roosts within the site and the closest identified/known roost site is located approximately 3 km east at Wandi.

Forest red-tailed black cockatoo (*Calyptorhynchus banksii naso*) (Vulnerable, S1): Foraging evidence attributed to this species was found during the site survey (chewed jarrah and sheoak fruits). The three plant communities and the areas of 'Parkland Cleared' contain black cockatoo foraging species including jarrah and sheoak, however the 'Degraded' *Banksia* woodland and 'Parkland Cleared' areas in the south of the site did not record any evidence of foraging. Larger trees (≥ 500 mm DBH) are considered by the DSEWPC as potential breeding habitat, although no evidence of actual breeding in the larger hollows observed was found and the species is not known to nest on the Swan Coastal Plain.

Graceful sun-moth (*Synemon gratiosa*) (Endangered, S1): The *Lomandra* density survey identified potential graceful sun-moth habitat within the *Banksia* woodland communities within Lot 682 Rowley Road. No *Lomandra* species were recorded within the *Eucalyptus rudis* and *Melaleuca preissiana* woodland. No graceful sun moth were recorded within the site over the six surveys, however one graceful sun-moth was recorded along the western firebreak of Lot 682 Rowley Road. The *Banksia* woodland community present within Lot 682 would provide potential habitat for the sun-moth, however considering the intensity of the survey, it is considered that the site does not support a population of the graceful sun-moth.

Rainbow bee-eater (*Merops ornatus*) (S3, JAMBA): This species was observed during the field survey foraging in open areas adjacent to the *Banksia* woodland within the north of the site. This species may also roost overnight in the site at times. It possibly breeds in some sections of the site though population levels would not be significant as it usually breeds in pairs, rarely in small colonies.

Fork-tailed Swift (*Apus pacificus*) (S3 JAMBA/CAMBA/ROKAMBA): This species is potentially an occasional summer visitor to the site, but it is entirely aerial and largely independent of terrestrial habitat.

White-bellied Sea Eagle (*Haliaeetus leucogaster*) (S3 CAMBA): This species potentially utilises some sections of the site as part of a much larger home range.

Great Egret (*Ardea alba*) (S3 JAMBA/CAMBA): The Great Egret is likely to commonly visit the area in low numbers, particularly in winter when the pasture areas are flooded.

Cattle Egret (*Ardea Ibis*) (S3 JAMBA/CAMBA): This species is likely to infrequently visit the area in low numbers, particularly in winter when pastures are flooded.

Peregrine Falcon (*Falco perigrinus*) (S4): This species potentially utilises some sections of the site as part of a much larger home range.

Quenda (*Isoodon obesulus fusciventer*) (P5): A dead Quenda was found in bushland just west of the current site during the 2005 survey (Harewood 2005) along with numerous diggings. One Quenda was observed during the graceful sun-moth survey by an environmental scientist from Emerge near the *Eucalyptus rudis* and *Melaleuca preissiana* woodland. Quenda are likely to utilise those sections of the site with the densest groundcover.

Western brush wallaby (*Macropus irma*) (P4): A Western brush wallaby was observed within the current site boundary during the 2005 survey (Harewood 2005). Current status in the area is however difficult to determine. This species typically only occurs in low densities so its capacity to persist in small, fragmented bush remnants is limited. It has been listed as a potential species, but may be locally extinct.

Perth Lined Lerista (*Lerista lineata*) (P3): Records of this species at the Spectacles suggest it may be present within the *Banksia* woodland within the site.

Black-striped Snake (*Neelaps calonotos*) (P3): Given the presence of suitable good quality habitat, it is likely to be present within the site.

A total of 28 Bush Forever Decreaser species were identified as potentially occurring within the site (**Appendix B**). Fifteen of these species were observed during the reconnaissance survey, these were:

- broad-tailed thornbill (*Acanthiza apicalis*)
- yellow-rumped thornbill (*Acanthiza chrysorrhoa*)
- western thornbill (*Acanthiza inornata*)
- grey shrike-thrush (*Colluricincla harmonica*)
- splendid fairy-wren (*Malurus splendens*)
- golden whistler (*Pachycephala pectoralis*)
- scarlet robin (*Petroica multicolor*)
- common bronzewing (*Phaps chalcoptera*)
- weebill (*Smicrornis brevirostris*)
- brown goshawk (*Accipiter fasciatus*)
- wedge-tailed eagle (*Aquila audax*)
- whistling kite (*Haliastur sphenurus*)
- new holland honeyeater (*Phylidonyris novaehollandiae*)
- carnaby's black cockatoo (*Calyptorhynchus latirostris*)
- forest red-tailed black-cockatoo (*Calyptorhynchus banksii naso*).

The chuditch, red-tailed phascogale and quokka were all identified on the DESWPAC database search but were not included within the fauna inventory list. This was because these species are not considered to occur within the site as no evidence of this species was observed, and no suitable habitat (due to the size of the remnant and lack of dense understorey) exists within the site.

4 Discussion

As a consequence of the extensive clearing within the site (only 40.79 ha of the total 147.69 ha site area retains native vegetation) and the surrounding local area, the diversity of fauna species has been significantly reduced from pre-clearing levels. Habitat alteration/degradation as a result of clearing, altered fire regimes and predation by introduced predators is likely to have had an effect on fauna species diversity in the areas of this site that retain remnant vegetation.

Notwithstanding this, the results of the fauna assessment indicate that the site potentially hosts a range of fauna species. A total of 57 fauna species were observed (or positively identified from scats, tracks, skeletons or calls) within the site during both the 2005 and 2010/2011 surveys. .The site was also found to provide suitable habitat for a number of conservation significant species..

The desktop assessment and reconnaissance survey identified 37 species of conservation significance that use or potentially use the site. The most significant species, and those that are most relevant for the planning process, are species that are listed pursuant to the EPBC Act, WC Act and CAMBA/JAMBA/ROKAMBA agreements. These species are:

- carnaby's black cockatoo (*Calyptorhynchus latirostris*) (Endangered, S1)
- forest red-tailed black cockatoo (*Calyptorhynchus banksii naso*) (Vulnerable S1)
- graceful sun-moth (*Synemon gratiosa*) (Endangered, S1)
- rainbow bee-eater (*Merops ornatus*) (S3, JAMBA/CAMBA)
- great egret (*Ardea alba*) (S3, JAMBA/CAMBA)
- cattle egret (*Ardea Ibis*) (S3, JAMBA/CAMBA)
- peregrine falcon (*Falco perigrinus*) (S4)
- fork-tailed swift (*Apus pacificus*) (S3, JAMBA/CAMBA/ROKAMBA)
- white-bellied sea eagle (*Haliaeetus leucogaster*) (S3, CAMBA).

The chuditch (*Dasyurus geoffroii*), red-tailed phascogale (*Phascogale calura*), and quokka (*Setonix brachyurus*), while identified as part of the initial DSEWPAC database search were excluded from the fauna inventory due to lack of suitable habitat within the site and no evidence of these species utilising the site during the reconnaissance survey.

Of the species of conservation significance listed above, only the two species of black cockatoo are considered to regularly utilise the site for foraging and potential habitat. The rainbow bee-eater, great egret, cattle egret, peregrine falcon, fork-tailed swift and white-bellied sea eagle are all considered to potentially use the site on occasion, usually part of a much larger home range, but it is unlikely they rely on the site for their ongoing presence in the wider local area.

In regards to the graceful sun-moth, potential habitat was identified during the targeted survey within the *Banksia* woodland communities in 'Excellent' to 'Very Good' condition within the northern portion of Lot 682 Rowley Road. No *Lomandra* species were recorded within the *Eucalyptus rudis* and *Melaleuca preissiana* woodland. There were no graceful sun moths identified within the site during the six surveys, however one moth was observed along the western boundary of Lot 682 Rowley Road. It is therefore concluded that while potential habitat for this species exists, the site does not support a population of this species. The site was extensively surveyed over numerous visits and the identified moth was therefore likely to have originated from the bush land to the west of the site which also appears to support suitable potential habitat in 'Excellent' condition.

Evidence of the carnaby's black cockatoo and the forest red-tailed black cockatoo included sightings and foraging evidence. The habitat assessment identified 231 trees with a DBH of greater than or equal to 500 mm, of which 17 contained large hollows (>12 cm) that appeared big enough and oriented favorably to possibly allow entry to a black cockatoo, although none of these hollows showed any evidence of current or past use by black cockatoos. The closest roost site listed as part of the DEC cockatoo roost (DEC 2010) is located about 3 km east of the site at Wandi, and neither species are known to nest on this part of the Swan Coastal Plain.

All three plant communities identified within the site contain documented black cockatoo foraging species. No foraging evidence was recorded within the areas of 'Degraded' *Banksia* woodland within the south of the site. Based on the percentage covers of each species within each plant community, the two *Banksia* communities had greater cover values of identified cockatoo foraging species. Therefore the areas of *Banksia* woodland are considered to provide the greatest carrying capacity for foraging black cockatoos within the site.

Therefore, based on the results of the fauna and fauna habit assessment it is considered that the northern *Banksia* woodland communities, that are in 'Excellent' to 'Very Good' condition represent the most significant area of fauna habitat within the site and provide the core habitat area for the two species of black cockatoo within the site. This area is shown on **Figure 7**.

While this area also supports vegetation that could be considered suitable habitat for the graceful sun-moth species, a population of this species was not encountered following a comprehensive and targeted survey. While the black cockatoos are not known to breed in this area, this area also contains potential nesting trees which would be more likely to persist in the longer term compared to single paddock trees or trees in degraded woodland stands.

While other areas within the site do support remnant vegetation that contains black cockatoo foraging habitat and potential nesting habitat, these areas are currently degraded and isolated, and therefore less easily retained in a single conservation area (i.e. within public open space or other reservation) given the long term presence of the power transmission easement. The remnant vegetation in the southern extents of Lot 682 (10.32 ha on the southern side of the power transmission easement) has a much lower area to perimeter ratio, and already shows signs of pressure compared to the larger more intact areas to the north.

5 Conclusions and Recommendations

The level 1 fauna survey and habitat assessment identified a variety of fauna species and fauna habitats within the Mandogalup site

The fauna survey generated a total fauna inventory for the site, which consisted of both observed and potentially occurring species. A total of 57 of these were observed, or positively identified from scats, tracks, skeletons or calls, within the site during both the 2005 and 2010/2011 surveys.

From the total fauna inventory, 37 species were identified as having conservation significance at either National, State or Local levels. After detailed consideration of the potential habitat within the site and existing site conditions, it was concluded that the most significant fauna/fauna habitat value within the site is associated with the carnaby's black cockatoo (*Calyptorhynchus latirostris*) (Endangered EPBC Act, S1 WC Act) and the forest red-tailed black cockatoo (*Calyptorhynchus banksii naso*) (Vulnerable EPBC Act, S1 WC Act). Potential habitat for the graceful sun-moth was identified within the site, however there were no graceful sun moth recorded within the site and therefore it was concluded to be unlikely that the site supports a population of this species.

Foraging evidence for the two species of black cockatoo was identified across Lot 682 Rowley Road and given its structure and species composition all of the remnant vegetation across the site can be considered to provide some form of foraging habitat (although quite limited in some areas compared to other areas) for the two species of black cockatoo. This is approximately 40.79 ha of remnant vegetation, mostly across Lot 682.

Of this potential foraging habitat, it is recommended that the northern *Banksia* woodland communities that are in 'Excellent' to 'Very Good' condition provides the most valuable and intact potential foraging habitat for both black cockatoo species. This has been delineated on **Figure 7** and covers an area of approximately 24.7 ha. This area is considered to be relatively intact and therefore likely to retain its values in the longer term with routine and reasonable levels of ongoing management. All other areas are either significantly degraded or would require a significant management intervention to maintain foraging values in the long term.

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FIGURES

Figure 1: Location plan

Figure 2: The site and surrounding areas

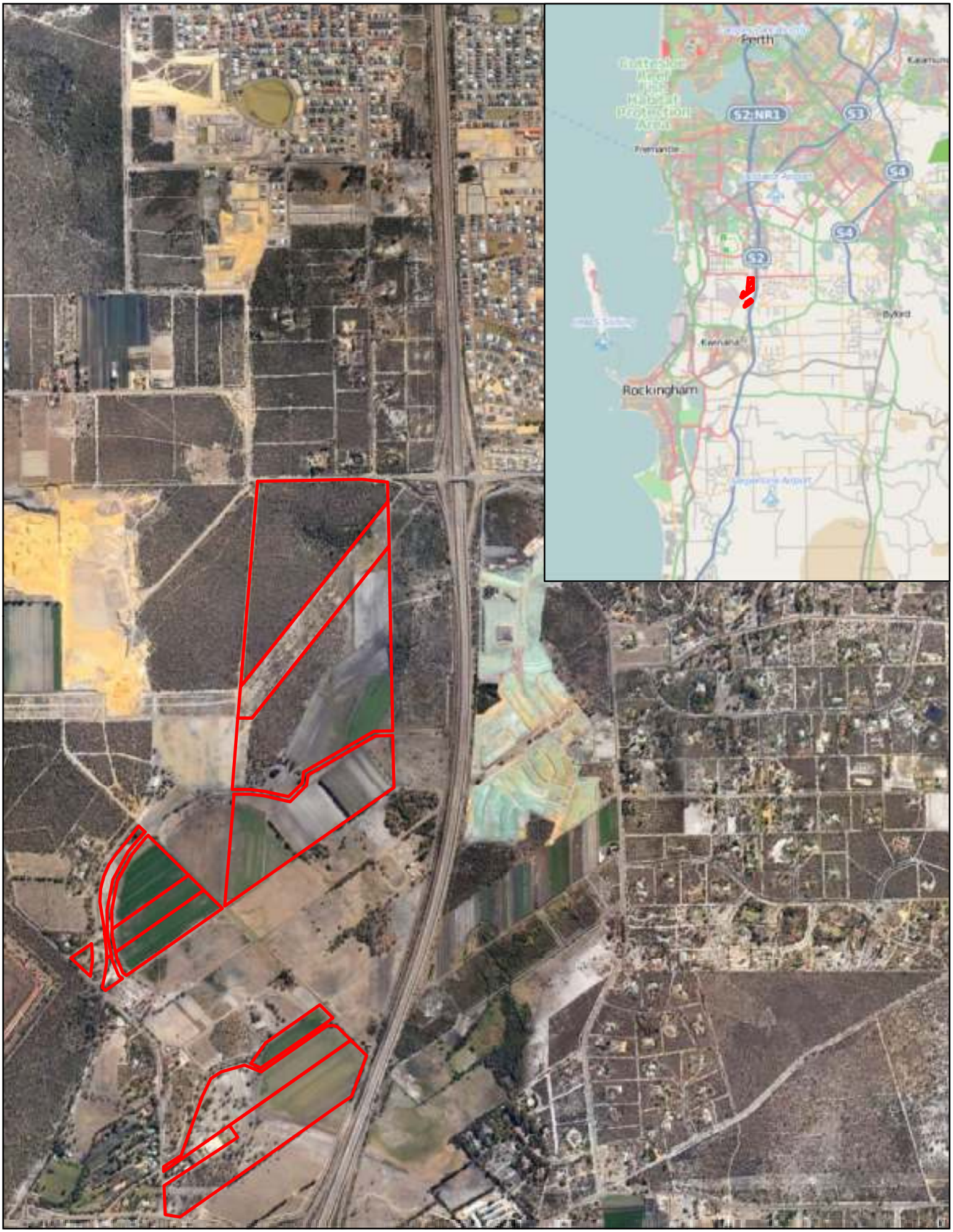
Figure 3: Plant community mapping

Figure 4: Plant community condition mapping

Figure 5: Potential black cockatoo breeding habitat trees

Figure 6: Locations of black cockatoo foraging evidence

Figure 7: Significant habitat areas



Client:
Qube Mandogalup Land Development Company

Project:
Mandogalup Level 1 Fauna Survey

Title:
Figure 1: Location Plan

Metres
0 150 300 600

Legend
Site boundary

19/09/11 :Date
1:20,000@A4 :Scale
EP10-18(01)--F13a :Plan Number
JDH :Checked
JDH :Approved

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Client:
Qube Mandogalup Land Development Company

Project:
Mandogalup Level 1 Fauna Survey

Title:
Figure 2: Site Location

Metres
0 100 200 400

Legend
Site boundary

19/09/11 :Date
1:13,000@A4 :Scale
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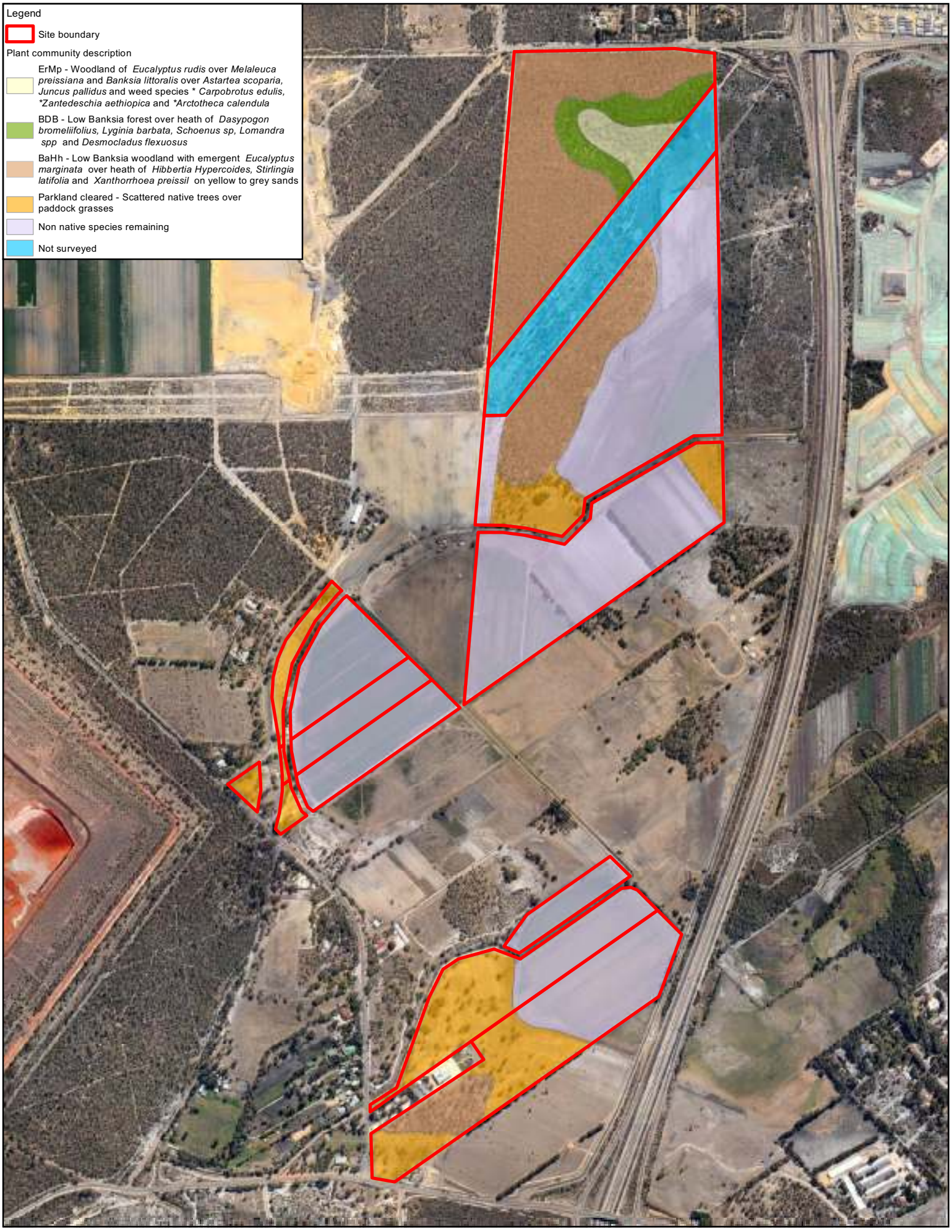

Client:
Qube Mandogalup Land Development Company

Project:
Mandogalup Level 1 Fauna Survey

Title:
Figure 3: Plant Community Mapping

Metres
0 100 200 400

19/09/11 :Date
1:13,000@A4 :Scale
EP10-18(01)--F15a_QA :Plan Number
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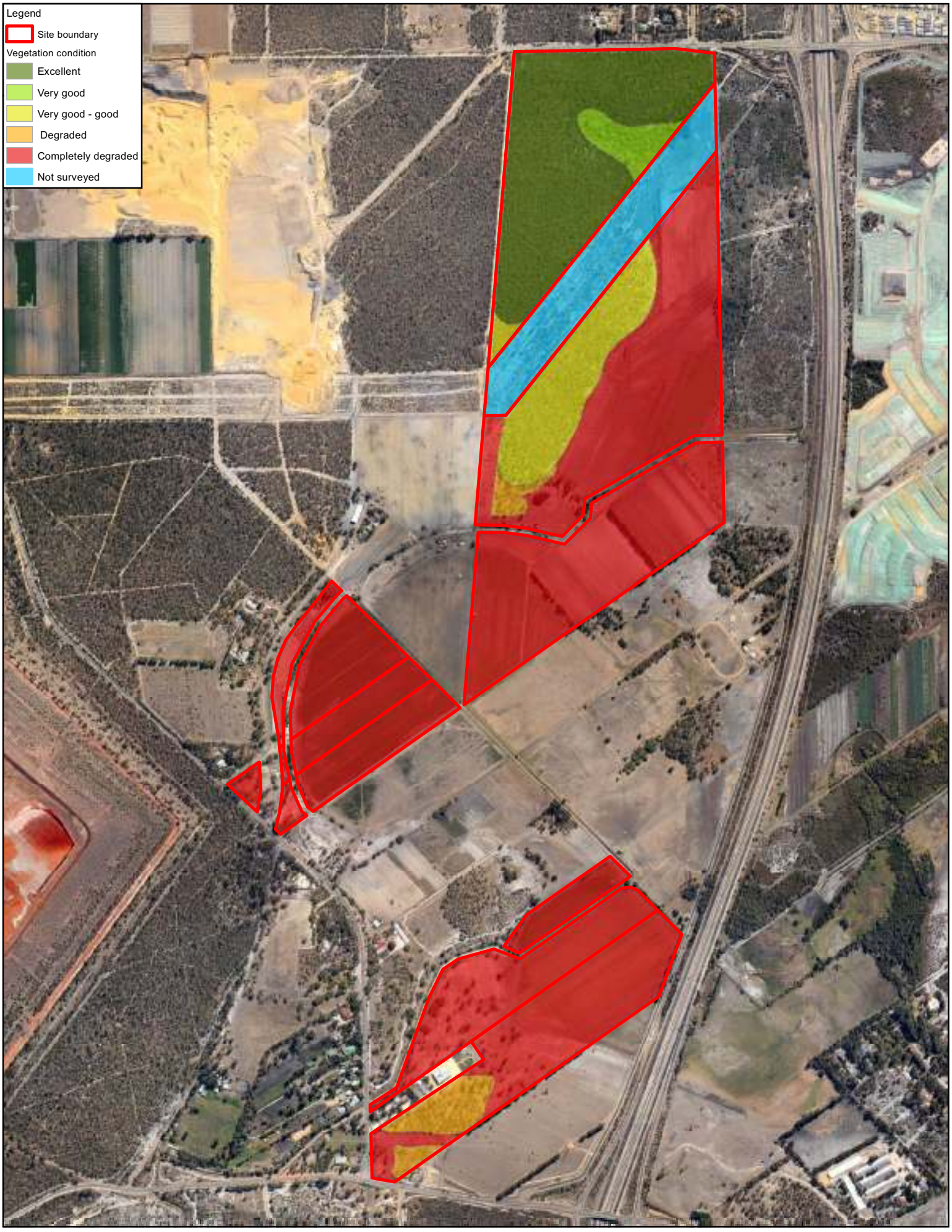

Client:
Qube Mandogalup Land Development Company

Project:
Mandogalup Level 1 Fauna Survey

Title:
Figure 4: Vegetation Condition

Metres
0 100 200 400

19/09/11 :Date
1:13,000@A4 :Scale
EP10-18(01)--F19_QA :Plan Number
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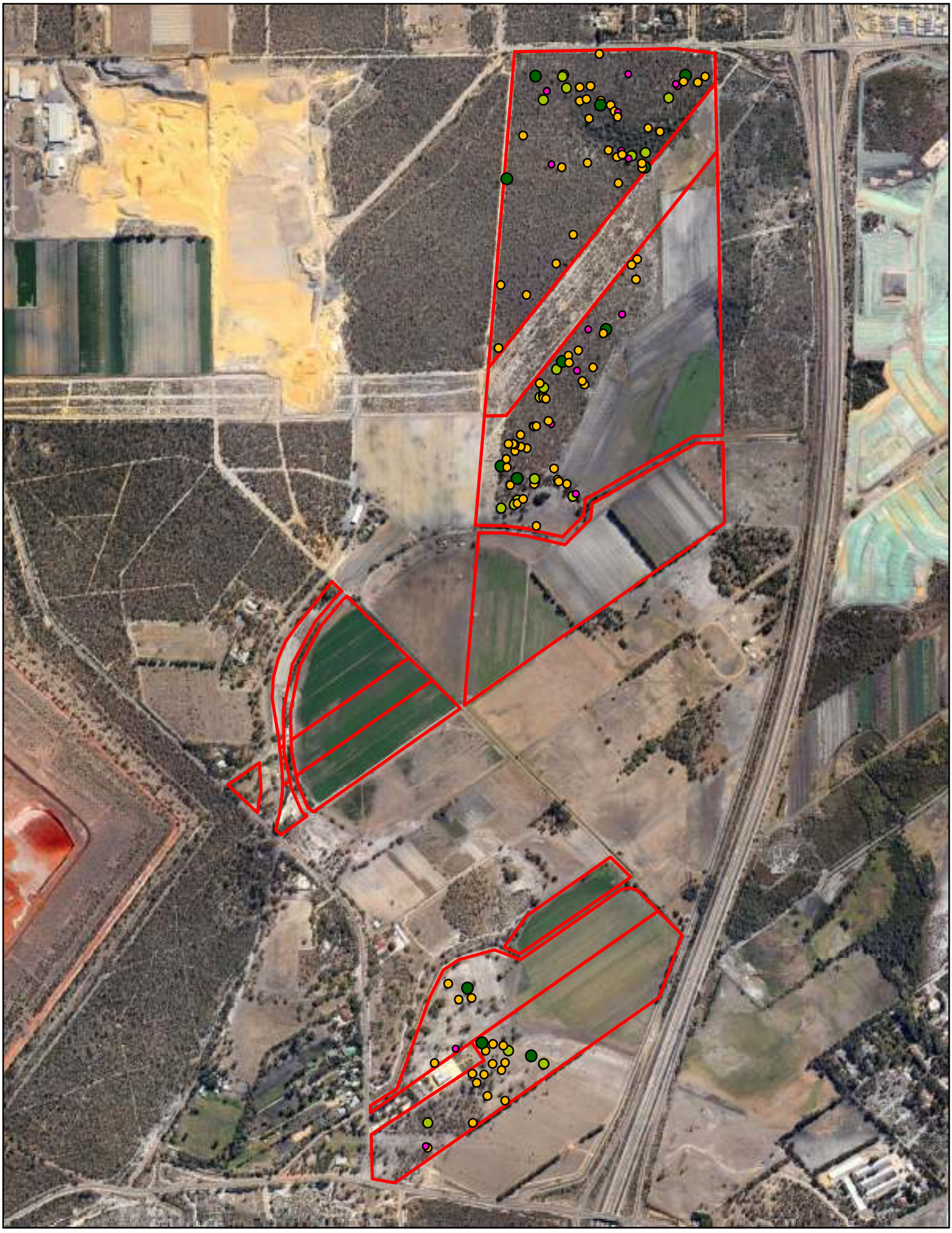

Client:
Qube Mandogalup Land Development Company

Project:
Mandogalup Level 1 Fauna Survey

Title:
Figure 5: Potential Black Cockatoo Breeding Habitat Trees

Metres
0 100 200 400

Legend
Site boundary
Mandogalup tree hollow size
<5
5-10
10-20
20+

19/09/11 :Date
1:13,000@A4 :Scale
EP10-18(01)--F17_QA :Plan Number
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Client:
Qube Mandogalup Land Development Company

Project:
Mandogalup Level 1 Fauna Survey

Title:
Figure 6: Black Cockatoo Foraging Evidence

Metres
0 100 200 400

Legend
Site boundary
Survey data evidence
Banksia Cones
Jarrah Seeds
Sheoak Seeds
Tuart Seeds

19/09/11 :Date
1:13,000@A4 :Scale
EP10-18(01)--F18 :Plan Number
JDH :Checked
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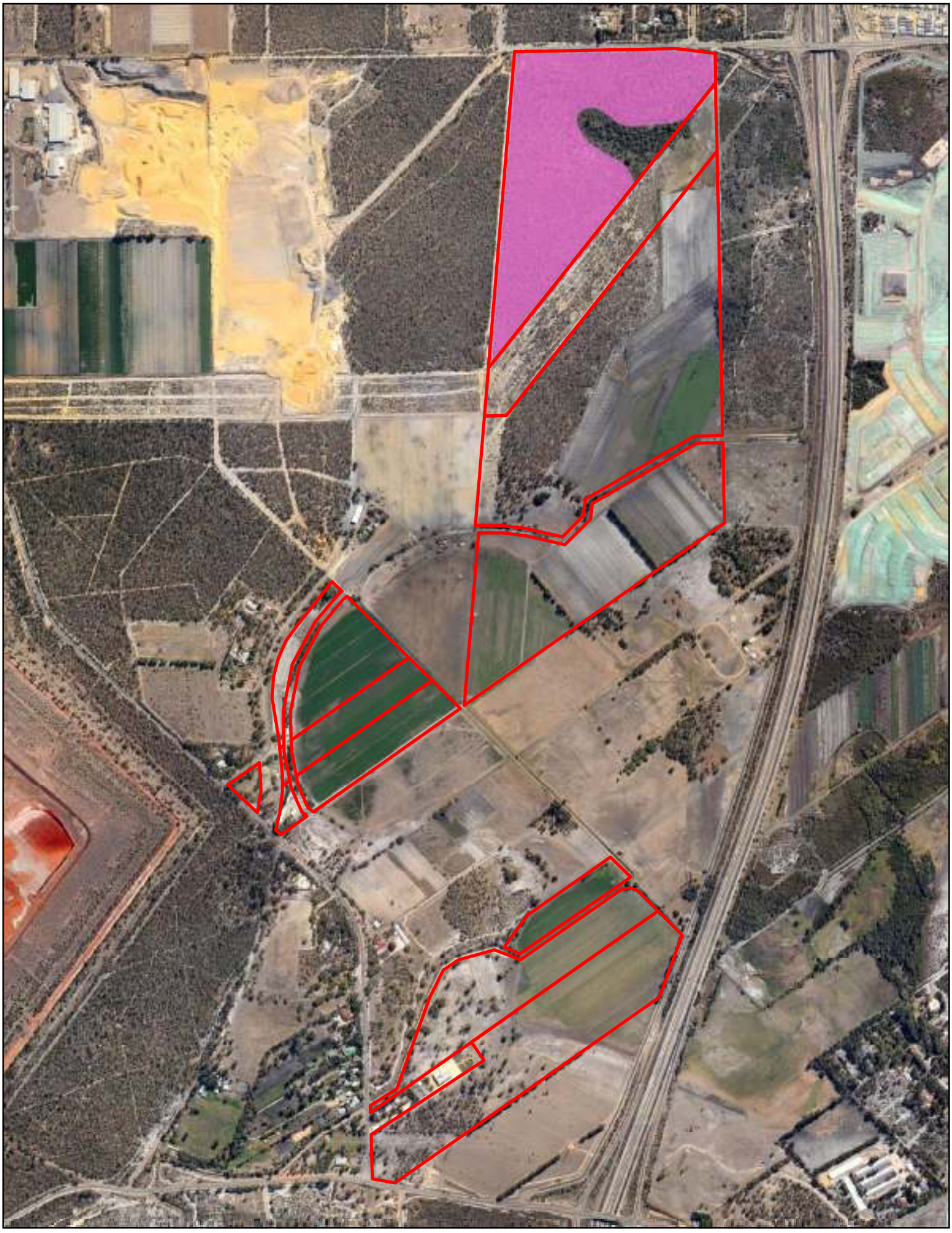

Client:
Qube Mandogalup Land Development Company

Project:
Mandogalup Level 1 Fauna Survey

Title:
Figure 7: Core Fauna Habitat Area

Metres
0 100 200 400

Legend
Site boundary
Core fauna habitat area

19/09/11 :Date
1:13,000@A4 :Scale
EP10-18(01)--F16a :Plan Number
JDH :Checked
JDH :Approved

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Integrated Science & Design

APPENDIX A

LEVEL 1 FAUNA SURVEY 2005

FAUNA ASSESSMENT

MANDOGALUP

OCTOBER 2005

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STATEMENT OF LIMITATIONS

Scope of Services

This fauna assessment report ("the report") has been prepared in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and Greg Harewood ("the Author"). In some circumstances the scope of services may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints.

Reliance on Data

In preparing the report, the Author has relied upon data, surveys, analyses, designs, plans and other information provided by the Client and other individuals and organisations, most of which are referred to in the report ("the data"). Except as otherwise stated in the report, the Author has not verified the accuracy of completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report ("conclusions") are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. The Author will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to the Author.

Environmental Conclusions

In accordance with the scope of services, the Author has relied upon the data and has conducted environmental field monitoring and/or testing in the preparation of the report. The nature and extent of monitoring and/or testing conducted is described in the report.

The conclusions are based upon field data and the environmental monitoring and/or testing carried out over a limited period of time and are therefore merely indicative of the environmental condition of the site at the time of preparing the report. Also it should be recognised that site conditions, can change with time.

Within the limitations imposed by the scope of services, the field assessment and preparation of this report have been undertaken and performed in a professional manner, in accordance with generally accepted practices and using a degree of skill and care ordinarily exercised by reputable environmental consultants under similar circumstances. No other warranty, expressed or implied, is made.



Report for Benefit of Client

The report has been prepared for the benefit of the Client and no other party. The Author assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including without limitation matters arising from any negligent act or omission of the Author or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in the report). Other parties should not rely upon the report or the accuracy or completeness of any conclusions and should make their own enquiries and obtain independent advice in relation to such matters.

Other Limitations

The Author will not be liable to update or revise the report to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.

The scope of services did not include any assessment of the title to or ownership of the properties, buildings and structures referred to in the report nor the application or interpretation of laws in the jurisdiction in which those properties, buildings and structures are located.

1. INTRODUCTION

This report has been prepared in response to an invitation from Cardno BSD Pty Ltd to carry out a Level 1 (EPA 2004) fauna assemblage survey over an area of land at Mandogalup.

The study site is centred about 27 km south of Perth in Kwinana at approximately 32° 11' 39" S and 115° 50' 52" E (Figures 1). The fauna assessment was limited to the area as indicated in Figure 2. The study area totals about 350 hectares.

The assessment was carried out with reference to guidance and position statements published by the WA Environmental Protection Authority on fauna surveys and environmental protection (EPA 2002; EPA 2004). The minimum requirements for a Level 1 fauna assemblage survey as defined in these documents are:

Background research or 'desktop' study

The purpose is to gather background information on the target area (usually at the locality scale). This involves a search of all sources for literature, data and map-based information.

Reconnaissance survey

The purposes are: i) to verify the accuracy of the background study; ii) to further delineate and characterise the fauna and faunal assemblages present in the target area; and iii) to identify potential impacts. This involves a target area visit by suitably qualified personnel to undertake selective, low intensity sampling of the fauna and faunal assemblages, and to provide habitat descriptions and habitat maps of the project area.

2. METHODOLOGY

2.1 FAUNA HABITAT ASSESSMENT

A habitat assessment was carried out specifically targeting the likely habitats of listed (under the relevant Federal and State Acts) threatened vertebrate species potentially occurring in the general area. The aim of the habitat assessment was to determine if it was likely that any of the threatened species would be utilising the area.

The initial phase of the assessment involved the review of available information on the habitats of the threatened species possibly occurring in the region. During the field survey the habitat at the site was assessed to determine its potential to be hosting any of the listed threatened species in addition to aiding



in the compilation of a potential fauna list based on available habitats and opportunistic observations.

2.2 FAUNA INVENTORY

2.2.1 Opportunistic Fauna Survey

During the course of the reconnaissance field work non-systematic opportunistic observations of fauna species were made and recorded. Secondary evidence of fauna such as tracks, diggings and scats were also noted. Some active searching was undertaken in specific areas with the aim of locating the more elusive frog and reptile species that may inhabit the site. Invertebrate fauna species were not recorded.

2.2.2 Potential Fauna

A list of all vertebrate fauna potentially occurring within the study area was compiled from searches done on the WA Museum Database, the Department of Conservation and Land Managements Threatened Fauna Database, Department of the Environment and Heritage Departments Commonwealth Environment Protection and Biodiversity Conservation Database, Birds Australia's 'birdata", published and unpublished reports and specialist books detailing fauna of the general area. Species observed during field work have also been included. The results of the habitat assessment also provided information on the potential fauna assemblage.

Taxonomy and nomenclature for fauna species used in this report generally follow Aplin and Smith (2001) for amphibians and reptiles, How *et al*. (2001) for mammals and Johnstone (2001) for birds. Some names, including common names recommended for national and international use by Christidis and Boles (1994) for birds, are also used. Common names for reptiles and amphibians come from a variety of sources and are not necessarily generally accepted. Sources include Tyler *et al.* (2000) and Glauret (1961).

2.2.3 Fauna of Conservation Significance

The conservation status of fauna species in Western Australia is assessed under the federal *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the state administered *Western Australian Wildlife Conservation Act 1950 (*WAWC Act*)*.

Under the EPBC Act threatened fauna may be listed in any one of the following categories as defined in Section 179 of the Act:

- Extinct;
- *Extinct in the wild;
- *Critically endangered;
- *Endangered;
- *Vulnerable; and
- Conservation dependent.

*Only species in those categories marked with an asterix are matters of national environmental significance under the EPBC Act.

The WAWC Act uses a set of schedules (see Table 1) in addition to utilising the categories defined by the EPBC Act.

Table 1: Western Australian Threatened Fauna Categories

Category	Code	Description
Schedule 1	S1	Fauna which is rare or likely to become extinct
Schedule 2	S2	Fauna which is presumed extinct
Schedule 3	S3	Birds which are subject to an agreement between the governments of Australia and Japan (JAMBA) relating to the protection of migratory birds and birds in danger of extinction
Schedule 4	S4	Fauna that is otherwise in need of special protection

In Western Australia, the Department of Conservation and Land Management (CALM) also produce a supplementary list of priority fauna. The species listed are not considered threatened under the WAWC Act, but due to lack of knowledge or where species are poorly represented in secure conservation reserves some concern for there long term survival exists. The five classifications levels are shown in Table 2.



Table 2: CALM Priority Fauna Categories

Category	Code	Description
Priority 1	P1	Taxa with few, poorly know populations on threatened lands.
Priority 2	P2	Taxa with few, poorly known populations on conservation lands.
Priority 3	P3	Taxa with several, poorly known populations, some on conservation lands.
Priority 4	P4	Taxa in need of monitoring (Not currently threatened or in need of special protection, but could be if present circumstances change)
Priority 5	P5	Taxa in need of monitoring (Not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years)

The EPBC Act also requires the compilation of a list of migratory species that are recognized under international treaties including the Japan Australia Migratory Bird Agreement (JAMBA), the China Australia Migratory Bird Agreement (CAMBA) and the Bonn Convention (The Convention on the conservation of Migratory Species of Wild Animals). Species listed under JAMBA are also protected under Schedule 3 of the WAWC Act.

The conservation status of all the vertebrate fauna species listed as occurring or possibly occurring in the vicinity of the study area have been assessed using the most recent lists published in accordance with the above-mentioned Acts and CALM's priority fauna list and are indicated in the fauna listings of this report.

It should be noted that there are currently discrepancies between the Western Australian and Commonwealth threatened species lists. In an attempt to address this issue CALM and the Commonwealth Department of Environment and Heritage (DEH) have initiated an "alignment of lists" project where CALM provides advice on threatened species to the DEH so specific species can be assessed under the EPBC Act and the DEH database updated. This project is still in progress and subsequent changes in the DEH database may result in variations to the listings and classifications used for the project reported on here.

2.2.4 Other Species of Significance

A number of other species not listed in official lists can also be considered of regional conservation significance. These include species that have a restricted range, those that occur in breeding colonies and those at the limit of their range.



While not classified as rare, threatened or vulnerable under any State or Commonwealth legislation, a number of bird species have been listed as of significance on the Swan Coastal portion of the Perth Metropolitan Region (Bush Forever - Government of Western Australia 1998 and 2000). The bird species are often referred to as Bush Forever Decreaser Species. The two categories used for birds within the Bush Forever documents are:

- Habitat specialists with reduced distribution on the Swan Coastal Plain (code Bh)
- Wide ranging Species with reduced population's on the Swan Coastal Plain. (code Bp)

If present the species listed should be taken into consideration when determining an areas fauan value to ensure actions are taken that will aid in their continued existence in the region. Bush forever decreaser species are indicated as such within the species list.

2.3 LOCAL CONSERVATION SIGNIFICANCE OF THE STUDY AREA

The local (sub-regional) significance of the study area has been determined by applying site specific criteria such as:

- Fauna species and/or habitat present that is poorly represented in the general study area;
- Fauna habitat within the general study area supporting species of conservation or other significance;
- Fauna habitat in better condition than other similar locations in general study area.

2.4 VALUE OF THE STUDY AREA AS A WILDLIFE CORRIDOR

Corridors of native vegetation can be very important for the dispersal of species in otherwise cleared landscapes. Any areas of remnant vegetation making up part of the linkage is therefore of great value by facilitating the movement of species that cannot utilise cleared land.

During the field survey and by examination of plans and air photos of the study area, the value of the site as a corridor allowing movement between any reserves, conservation areas or other significant areas of remnant bush was assessed.



3. LIMITATIONS OF THE STUDY

The fauna assessment has been limited to a desktop analysis aimed at providing a list of expected species and a daytime site visit primarily aimed at habitat assessment and opportunistic fauna observations. No fauna trapping or seasonal sampling has been conducted. The survey has been designed and carried out to conform with a Level 1 survey as defined in EPA Guidance statement No. 56 (EPA 2004).

In recognition of survey limitations a precautionary approach has been adopted for this assessment. Any species that would potentially occur within the study area as identified through ecological databases, publications and the habitat knowledge of the Author has been assumed to potentially occur in the study area.

4. SURVEY EFFORT

The reconnaissance survey of the study site was carried out on the 7th September 2005 between 9:00am and 5:00pm. Survey traverses were conducted on foot and in total covered about 16km.

5. RESULTS

5.1 FAUNA HABITAT ASSESSMENT

The project area is situated on the extreme western margin of the central part of the Swan Coastal Plain. The Swan Coastal Plain Bioregion (SWA) was classified as part of the Interim Biogeographical Regionalisation for Australia and is in broad terms described as a:

"Low lying coastal plain mainly covered with Woodlands. It is dominated by Banksia or Tuart on sandy soils, *Allocasuarina obesa* on outwash plains, and paperbark in swampy areas. In the east, the plain rises to duricrusted Mesozoic sediments dominated by Jarrah Woodland. Warm Mediterranean. Three phases of marine sand dune development provide relief. The outwash plains, once dominated by *A. obesa* – Marri Woodlands and Melaleuca shrublands, are extensive only in the south." (Thackway and Cresswell, 1996; IBRA, 2000).

The site lies over the eastern margin of the Spearwood Dunes System which consists of dune ridges/slopes and flat to gently undulating sandplains made up of deep silicious yellow brown sand. In the central and north eastern areas of the study site extensive areas of former swamps that have been artificially drained are present and consist of uniform loamy and peaty sands. The balance of the area is a broad poorly drained sandplain composed of deep grey silicious sands (part of the Bassendean Dune System).



Over two thirds of the study site has been cleared of native vegetation. Mapping by Heddle *et al* (1980) shows that prior to disturbance the higher areas would have consisted primarily of a Woodland of *Eucalyptus marginata* and Banksia sp. with low woodlands of *Melaleuca* sp. and sedgelands in moister sites (Bassendean Complex - Central and South). The lower lying areas would have consisted of sedgelands with fringing woodlands of *E. rudis* and *Melaleuca* sp. (Herdsman Complex). A small area in the south west section of the study site would have been predominately an open forest of *E. gomphocephala – E. Marginata*, *Corymbia calophylla* and/or a woodland of *E marginata* and *Banksia* sp. (Karrakatta Complex - Central and South).

5.1.1 Habitats within the Mandogalup Study Area

The extent of the broadly defined fauna habitats within the study area are shown in Figure 3 with a description of each given below. More detail on the composition of each bush remnant can be found within the flora report.

1. **Cleared with Scattered Trees:** Cleared farmland with a mixture of introduced pasture grasses, clovers, weeds and degraded sedgelands. Some areas of the cleared pasture are inundated during winter and provide foraging habitat for birds of prey, waterbird species and breeding grounds for frogs. This area also contains scattered trees of various species (*Eucalyptus* sp, *Melaleuca* sp. and exotics). While scattered and limited in number, the remaining trees provide roosting, foraging and breeding opportunities for fauna.

2. **Artificial Drains –** A number of artificial drains traverse the study area. They do not have any significant fringing vegetation. The drains provide refuge and foraging opportunities for a variety of fauna species and breeding sites for frogs.

3. **Banksia Woodland:** Low woodlands of *Banksia attenuata* make up the majority of the remnant vegetation at Mandogalup and are typically confined to the drier upper sandy slopes and ridges. Associated tree species vary with emergent *Eucalyptus marginata* being present in the northern areas, while in the south west corner *E. gomphocephala* (Tuart) is dominant. The amount of grown cover, understorey and leaf litter varies considerably from area to area and ranges from non-existent to dense. The best quality and most expansive areas exist in the north west corner of the study area. Evidence of Quenda's (*Isoodon obesulus fusciventer*) and a sighting of the Western Brush Wallaby (*Macropus irma*) were found here. Significant sized fallen logs are very rare. Hollows are relatively common within the Eucalypts with some significant sized hollows being present. The *Banksia* species are likely to be utilised as a food source for White-tailed Balck Cockatoos that pass through the area.



4. **Flooded Gum Woodland :** Flooded gums (*E.rudis*) are typically found in the lower lying areas, forming a fringe around areas subject to inundation. Melaleuca species replace the Flooded Gum in areas subject to more lengthy periods of inundation (these are shown as Melaleuca & Flooded Gum Woodland in Figure 2). As with other areas of the study site the amount of grown cover, understorey and leaf litter varies considerably from area to area and ranges from non-existent to dense. These areas have been subject to considerable historical disturbance with the most common ground cover observed being introduced species (various grass species and Arum Lily's). Despite its weed status the dense ground cover provides potential habitat for some fauna species that require refuge from predators such as Quenda's. Hollows within the Flooded Gums were not common

5. **Melaleuca Woodland:** Several small areas of paperbark woodland occur within the study area (in some cases grouped with Flooded Gum in Figure 2). The vegetation provides important roosting and refuge habitat for waterbirds, owls, raptors and in breeding grounds for frogs. The extent of inundated areas with the paperbark was limited to the two areas of Melaleuca and Flooded Gum along the eastern boundary of the study area. Other areas were dry at the time of the survey. In the more dense occurrences of Paperbark it could be classified as a Closed Woodland/Forest.

6. **Melaleuca Shrubland**: A generally dense Melaleuca shrubland is present in the north east of the study site. The composition changes to the south with shrub density reducing and Banksia species becoming more prevalent.

5.2 FAUNA INVENTORY

5.2.1 Opportunistic Fauna Surveys

The results of the opportunistic fauna survey are summarised in Table 4 and listed in Appendix A. A total of 45 fauna species were observed (or positively identified from scats, tracks, skeletons or calls) within the study area during the reconnaissance survey. Nine bush forever decreaser bird species were observed.

5.2.2 Potential Fauna

Table 4 summarises the numbers of potential species based on vertebrate class. A complete list of terrestrial vertebrate fauna possibly inhabiting or frequently the study area is held in Appendix A.

Details on specially protected and priority species expected and/or listed as potentially occurring in the general area are given in the section 5.2.3.

Not all species listed as potentially occurring within the study area (based on searches of the EPBC Act's Threatened Fauna and Migratory species lists,



CALM's Threatened Fauna Database and various publications) are shown in the expected listing in Appendix A. Some species have been excluded from this list based largely on the lack of suitable habitat within the study area.

Table 4: Summary of Potential Fauna Species (As listed in Appendix A)

Group	Total number of potential species	Number of specially protected species	Number of priority /migratory species	Number of species observed
Amphibians	9	0	0	3
Reptiles	31	0	2	1
Birds	108[C]	3	5	37[A]
Mammals	21[C]	0	3	4[A]

Note: some species fall into more than one category of protection, A= includes one introduced species B= includes two introduced species, C= includes five introduced species

5.2.3 Fauna of Conservation Significance

A search of EPBC Act's Threatened Fauna list, CALM's Threatened Fauna Database and Priority List and scientific publications identified 13 specially protected, priority or migratory fauna species as potentially occurring in the general study area. A brief account of these species with details on their distribution and habitat preference are given below.

Perth Lined Lerista *Lerisita lineata*

Status and Distribution: Listed as Priority 3 by CALM. Found in the lower west coast from Perth to Mandurah. It has also been found at Busselton, Rottnest Island and Garden Island (Storr *et al*, 1999) and at the Spectacles, just south of the study site (Government of Western Australia 2000b).

Habitat: This small species of skink inhabits white sands (Storr *et al*, 1999) under areas of shrubs and heath where it inhabits loose soil and leaf litter at the base of shrubs.(Nevill 2005).

Likely presence in study area: Records of this species at Spectacles suggest it may be present within Banksia woodland at Mandogalup.

Black-striped Snake *Neelaps calonotos*



Status and Distribution: Listed as Priority 3 by CALM. Found in the lower west coast from Lancelin to Mandurah. It is locally abundant but is under threat due to land clearing (Storr *et al*, 1999).

Habitat: This species of snake favours sandy soils supporting heath and banksia/eucalypt woodland (Nevill 2005).

Likely presence in study area: Given the presence of suitable good quality habitat it is likely to be present in the study area.

Great Egret *Ardea alba*

Status and Distribution: This species of egret is listed as migratory under the *EPBC Act (1999)* and under international agreements to which Australia is a signatory. The Great Egret is common and very widespread in any suitable permanent or temporary habitat (Morcombe, 2003).

Habitat: Wetlands, flooded pasture, dams, estuarine mudflats, mangroves and reefs (Morcombe, 2003).

Likely presence in study area: Likely to commonly visit the area in low numbers, particularly in winter when areas of pasture are flooded.

Cattle Egret *Ardea ibis*

Status and Distribution: This species of egret is listed as migratory under the *EPBC Act 1999* and under international agreements to which Australia is a signatory. The Cattle Egret is common in the north sections of its range but is an irregular visitor to the better watered parts of the state (Johnstone and Storr 1998). The population is expanding (Morcombe, 2003).

Habitat: Moist pastures with tall grasses, shallow open wetlands and margins, mudflats (Morcombe, 2003).

Likely presence in study area: Potentially an infrequent visitor to the general area. This species was not recorded in the project area during the most recent Birds Australia Atlas survey (Barrett, 2003) and there are also no W.A. Museum records in the region.

White-bellied Sea Eagle *Haliaeetus leucogaster*

Status and Distribution: This species is listed as migratory under the *EPBC Act (1999)* and under international agreements to which Australia is a signatory. White-bellied sea eagles are common in coastal and near coastal areas of Australia and are also found in New Guinea, Indonesia, China, southeast Asia and India.

Habitat: They nest and forage mainly near the coast but will also live near large rivers and lakes inland, often moving on a seasonal basis. White-bellied Sea-Eagles build a large stick nest, which is used for many seasons in succession.

Likely presence in study area: The species may occasionally fly over the study site but is unlikely to specifically target the area for foraging or nesting.

Peregrine Falcon *Falco perigrinus*

Status and Distribution: This species is listed as Schedule 3 under the *WAWC Act 1950*. Individuals of this species are uncommon/rare but wide ranging across Australia. Moderately common at higher levels of the Stirling Range, uncommon in hilly, north west Kimberley, Hamersley and Darling Ranges; rare or scarce elsewhere (Johnstone and Storr 1998).

Habitat: Diverse from rainforest to arid shrublands, from coastal heath to alpine (Morcombe, 2003). Mainly about cliffs along coasts, rivers and ranges and about wooded watercourses and lakes (Johnstone and Storr 1998). The species utilises the ledges, cliff faces and large hollows/broken spouts of trees for nesting. It will also occasionally use the abandoned nests of other birds of prey.

Likely presence in study area: The species potentially utilises some sections of the study area as part of a much larger home range. No evidence of this species nesting within the study area was found.

Carnaby's Black- Cockatoo *Calyptorhynchus latirostris*

Status and Distribution: Carnaby's Black Cockatoo is listed as Scheduled 1 under the *WAWC Act (1950)* and as Endangered under the *EPBC Act (1999)*. Confined to the south-west of Western Australia, north to the lower Murchison River and east to Nabawa, Wilroy, Waddi Forest, Nugadong, Manmanning, Durokoppin, Noongar (Moorine Rock), Lake Cronin, Ravensthorpe Range, head of Oldfield River, 20 km ESE of Condingup and Cape Arid; also casual on Rottnest Island (Johnstone and Storr 1998).

Habitat: Forests, woodlands, heathlands, farms; feeds on banksia, hakeas, dryandras and Marri. Breeding occurs in winter/spring mainly in eastern forest and wheatbelt where they can find mature hollow bearing trees to nest in (Morcombe, 2003).

Likely presence in study area: This species is likely to visit the area during non breeding season as suitable foraging and roosting habitat exists. Unlikely to breed in the area.

Baudin's Black- Cockatoo *Calyptorhynchus baudinii*

Status and Distribution: Listed as Scheduled 1 under the *WC Act (1950)* and as Endangered under the *EPBC Act (1999)*. Confined to the south-west of Western Australia, north to Gidgegannup, east to Mt Helena, Wandering, Quindanning, Kojonup, Frankland and King River and west to the eastern strip of the Swan Coastal Plain including West Midland, Byford, Nth Dandalup, Yarloop, Wokalup and Bunbury. (Johnstone and Storr 1998).

Habitat: Mainly eucalypt forests where it feeds primarily on the Marri seeds, (Morcombe, 2003), banksia, hakeas and *Erodium* sp. Also strips bark from trees in search of beetle larvae (Johnstone and Storr 1998).

Likely presence in study area: This species is likely to visit the area during non breeding season as suitable foraging and roosting habitat exists. Unlikely to breed in the area.

Fork-tailed Swift *Apus pacificus*

Status and Distribution: The Fork-tailed Swift is listed as migratory under the *EPBC Act 1999* and under international agreements to which Australia is a signatory. It is a summer migrant (Oct-Apr) to Australia (Morcombe, 2003).

Habitat: Low to very high airspace over varied habitat from rainforest to semi desert (Morcombe, 2003).

Likely presence in study area: It is potentially to be an occasional summer visitor to the study area but is entirely aerial and largely independent of terrestrial habitats.

Rainbow Bee-eater *Merops ornatus*

Status and Distribution: This species is listed as migratory under the *EPBC Act (1999)* and under international agreements to which Australia is a signatory. The Rainbow Bee-eater is a common summer migrant to southern Australia but in the north they are resident (Morcombe, 2003).

Habitat: Open Country, of woodlands, open forest, semi arid scrub, grasslands, clearings in heavier forest, farmlands (Morcombe, 2003). Breeds underground in areas of suitable soft soil firm enough to support tunnel building.

Likely presence in study area: A potential visitor to the general area. Potentially breeds in general area.



Southern Brush-tailed Phascogale *Phascogale tapoatafa tapoatafa*

Status and Distribution: Listed as Priority 4 by CALM. Present range is believed to have been reduced to approximately 50 per cent of its former range. Now known from Perth and south to Albany, west of Albany Highway. Occurs at low densities in the northern Jarrah forest. Highest densities occur in the Perup/Kingston area, Collie River valley, and near Margaret River and Busselton (CALM information pamphlet). Records are less common from wetter forests.

Habitat: This subspecies has been observed in dry sclerophyll forests and open woodlands that contain hollow-bearing trees but a sparse ground cover. A nocturnal carnivore relying on tree hollows as nest sites. The home range for a female Brush-tailed Phascogale is estimated at between 20 and 70 ha, whilst that for males is given as twice that of females. In addition, they tend to utilise a large number (approximately 20) of different nest sites throughout their range (Soderquist, 1995).

Likely presence in study area: Potentially present as suitable hollows exist in Eucalypts founds across the study site though there appears to be no recent records from adjacent bushland areas that have been subject to more detailed surveys (i.e. Spectacles, Thomsons Lake NR)

Quenda *Isoodon obesulus fusciventer*

Status and Distribution: Listed as Priority 5 by CALM. Widely distributed in the south west from near Cervantes north of Perth to east of Esperance, patchy distribution through the Jarrah and Karri forest and on the Swan Coastal Plain, and inland as far as Hyden. Has been translocated to Julimar State Forest, Hills Forest Mundaring, Tutanning Nature Reserve, Boyagin Nature Reserve, Dongolocking Nature Reserve, Leschenault Conservation Park, and Karakamia and Paruna Sanctuaries (CALM information pamphlet) and most recently Nambung National Park (CALM pers. coms.)

Habitat: Dense scrubby, often swampy, vegetation with dense cover up to one metre high, often feeds in adjacent forest and woodland that is burnt on a regular basis and in areas of pasture and cropland lying close to dense cover. Populations inhabiting Jarrah and Wandoo forests are usually associated with watercourses. Quendas will thrive in more open habitat subject to exotic predator control (CALM information pamphlet).

Likely presence in study area: A dead male Quenda was found in the far north west corner of the study site. Diggings of this species were found to be relatively common throughout the vegetated north west corner of the study site. May also be present in the other smaller pockets of remnant vegetation in the study area.



Brush Wallaby *Macropus irma*

Status and Distribution: Listed as Priority 4 by CALM. The Western Brush Wallaby is distributed across the south-west of Western Australia from north of Kalbarri to Cape Arid. Known populations exist in adjacent bushland areas (Government of Western Australia 2000b).

Habitat: The species optimum habitat is open forest or woodland, particularly favouring open, seasonally wet flats with low grasses and open scrubby thickets. It is also found in some areas of mallee and heathland, and is uncommon in karri forest (CALM information pamphlet).

Likely presence in study area: A single individual was sighted by K. DelFante (Botanist) during the course of field work. This species is likely to be present in small numbers, moving between adjacent bushland areas.

5.2.4 Other Species of Significance

Thirty three species of birds potentially frequent or occur in the study area that are noted as Bush Forever Decreaser Species in the Perth metropoltan region (nine species were sighted during surveys see Appendix A). Decreaser species are a significant issue in biodiversity conservation in the Perth section of the Coastal Plain as there have been marked reductions in range and population levels of many sedentary bird species as a consequence of disturbance and land clearing (Dell & Hyder-Griffiths, 2002). It can be expected that with increasing pressures on land use, populations and the ranges of some fauan species will further decline unless preventative measures are implemented.

5.3 LOCAL CONSERVATION SIGNIFICANCE OF THE STUDY AREA

The majority of the study site is cleared and as a consequence the diversity of fauna species present prior to disturbance has been reduced. Habitat degradation as a result of partial clearing, altered fire regimes and predation by introduced predators is also likely to have had an effect on species diversity in other areas of the study site, in particular the smaller bush remnants. A number of existing nature reserves and bush forever sites are present within close proximity to the study site and it can be expected that the habitats and fauna species present in the study site are well represented in these areas.

Despite the considerable disturbance of the majority of the area the results of the fauna assessment indicate that the study site potentially hosts a range of fauna species, some of which are of special conservation significance. The site was also found to provide suitable habitat for a number of bird species that have reduced populations and distributions in more developed areas of the Perth section of the Swan Coastal Plain. Because of these factors the remnant bushland, in particular the more extensive areas of banksia woodland in the north of the study site must be considered of local significance.



5.4 VALUE OF THE STUDY AREA AS A WILDLIFE CORRIDOR

Linkage with adjacent bushland areas is a natural attribute of high priority in the assessment of any sites significance. Within the Beeliar Regional Park Draft Management Plan (CALM 2000) and Bush Forever Volume 1 document (Figure 6 - Government of Western Australia 2000a) the Mandogalup area was specifically identified as part of a Greenway corridor between the Thompsons Lake Nature Reserve and the Spectacles.

The identified linkage extends from the Spectacles in the south, along the western boundary of the study site (in adjacent bushland), into the remnant bushland in the north west corner of the study area and into Frankland Park.

Within the Beeliar Regional Park Draft Management Plan it is stated that it is important to maintain and improve Greenway corridors and other links between and within Beeliar Regional Park to adjoin areas of ecological significance. This is necessary to help maintain the diversity and vigour of the Park's ecological systems and to help integrate the Park within the broader urban and industrial landscapes.

Where possible, greenway concepts should be incorporated into future planning proposals as part of the development of best practice planning and design solutions (Government of Western Australia 2000a).

6. FAUNAL VALUES

The Mandogalup study site contains a variety of fauna habitats and a number of fauna species of conservation significance were identified as utilising or potentially utilising the site. Sections of the site form part of an identified Greenway corridor.

Any proposed development of the site may require the clearing of remnant vegetation and consequently the loss or degradation of potential fauna habitat. The impact on specific fauna species will vary depending on population densities and the quantity and quality of potential foraging and breeding sites, both within the area of impact and adjacent areas. Development of the site also has the potential to restrict the movement of some fauna species as the area forms part of an identified ecological linkage and wildlife corridor.

Future planning proposals for the Mandogalup site should aim to retain as much of the existing remnant vegetation as possible with particular emphasis on maintaining and enhancing linkages between areas of remnant vegetation both within the site and adjoining areas.



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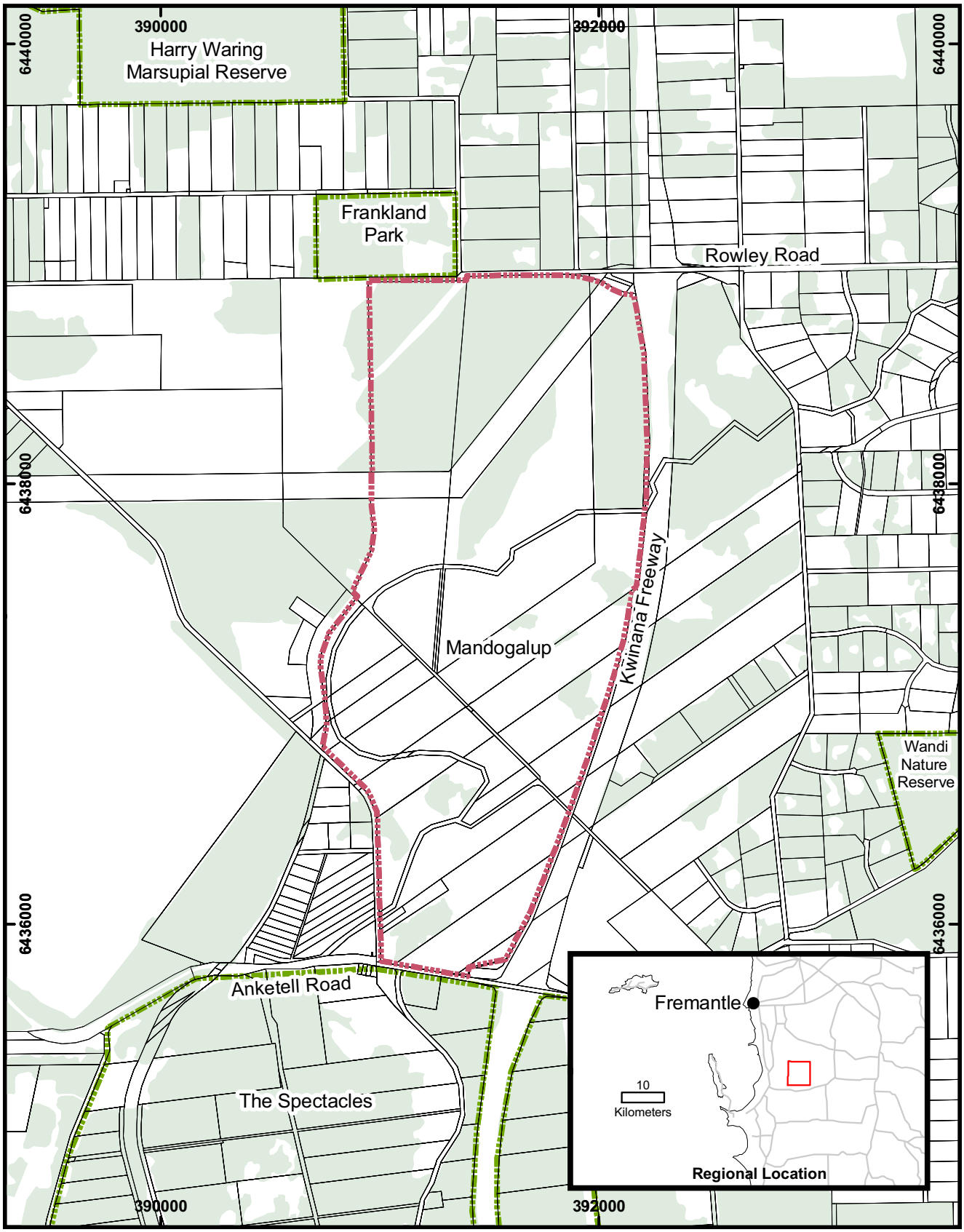
FIGURES

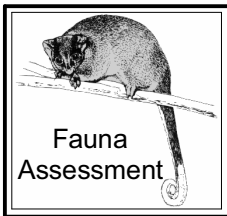


Legend

- Mandogalup Study Site
- Cadastral Boundaries
- Reserve Boundaries
- Remnant Native Vegegtation

0 500 1,000
Meters

MGA Zone 50



Fauna Assessment

DRAWN: G Harewood

DATE : Oct 2005

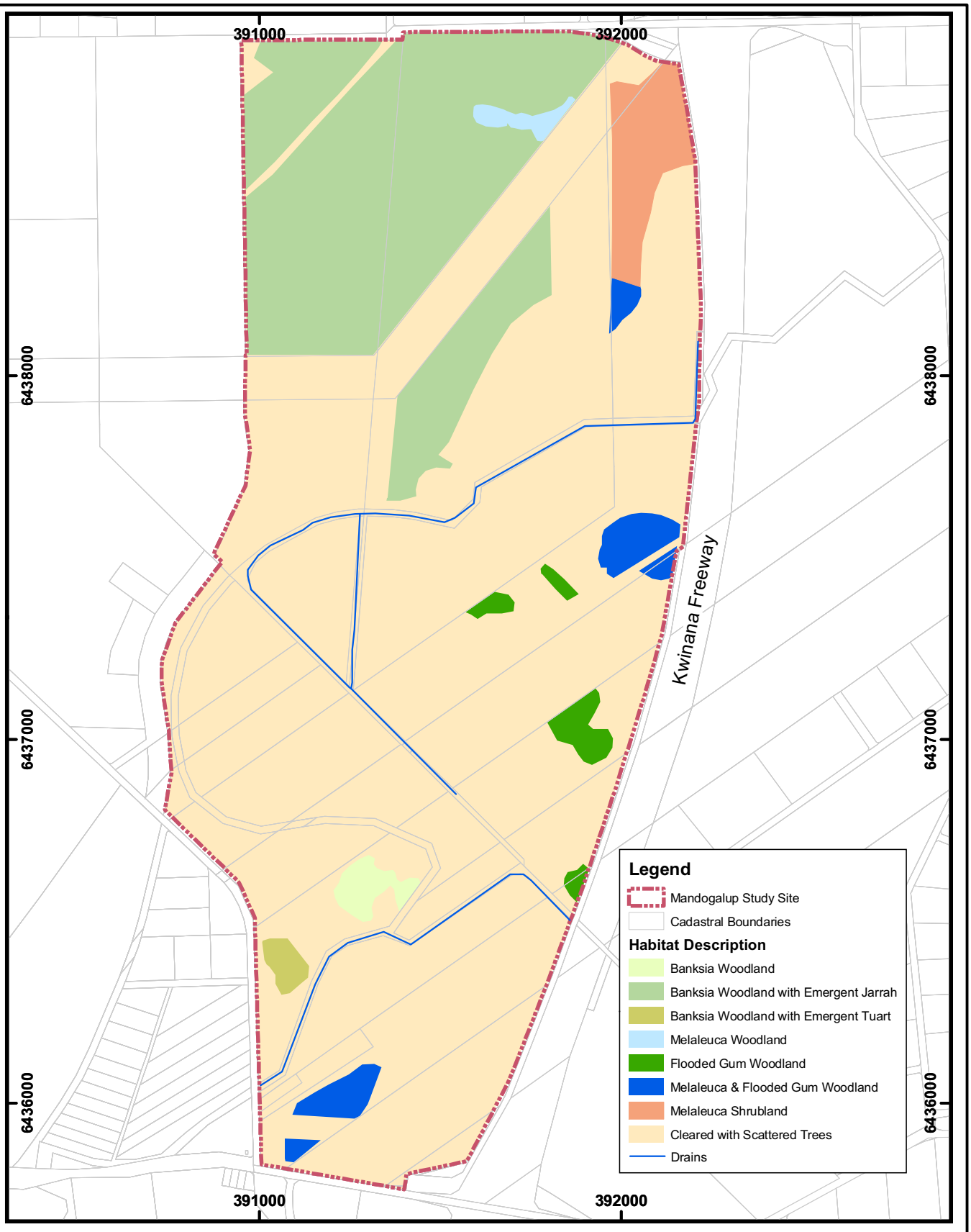
SCALE: 1: 25 000

REF :

Mandogalup
Fuana Assessment

Site Location

Figure: 1



0 500 1,000
Meters

MGA Zone 50

Fauna Assessment

Mandogalup
Fuana Assessment

Fauna Habitats

DRAWN: G Harewood

DATE : Oct 2005

SCALE: 1: 15 000

REF :

Figure: 2

APPENIDIX A

POTENTIAL FAUNA SPECIES LIST

Fauna Potentially in Study Area

Mandogalup

Compiled by Greg Harewood - September 2005

Class **Family** *Species*	Common Name	Conservation Status	Sighted Sept 05
Amphibians			
Myobatrachidae Ground or Burrowing Frogs			
Crinia georgiana	Quacking Frog		+
Crinia glauerti	Glauert`s Froglet		+
Crinia insignifera	Squelching Froglet		+
Heleioporus eyrei	Moaning Frog		
Limnodynastes dorsalis	Banjo Frog		
Myobatrachus gouldii	Turtle Frog		
Pseudophryne guentheri	Güenther`s Toadlet		
Hylidae Tree Frogs			
Litoria adelaidensis	Slender Tree Frog		
Litoria moorei	Motorbike Frog		
Reptiles			
Gekkonidae Geckoes			
Phyllodactylus marmoratus	Marbled Gecko		
Pygopodidae Legless Lizards			
Aprasia repens	Sandplain Worm Lizard		
Delma fraseri	Fraser's Scale-footed Lizard		
Delma grayii	Gray's Legless Lizard		
Lialis burtonis	Common Snake Lizard		
Pygopus lepidopodus	Common Scaleyfoot		

* =Introduced, WAWC Act Status - S1 to S4, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, CALM Priority Status - P1 to P5, Int. Agmts - CA = CAMBA, JA = JAMBA, Bush Forever Decreaser Species - Bh = habitat specialists, Bp = wide ranging species, Be = extinct in Perth Coastal Plain Region.

Class **Family** *Species*	Common Name	Conservation Status	Sighted Sept 05
Scincidae Skinks			
Acritoscincus trilineatum	Swamp Skink		
Cryptoblepharus plagiocephalus	Fence Skink		
Ctenotus australis	Western Limestone Ctenotus		
Ctenotus fallens	West Coast Ctenotus		
Ctenotus impar	South-western Odd-striped Ctenotus		
Ctenotus labillardieri	Red-legged Skink		
Egernia kingii	King's Skink		
Egernia luctuosa	Mourning Skink		
Egernia napoleonis	Salmon-bellied Skink		
Hemiergis quadrilineata	Two-toed Earless Skink		
Lerista elegans	West Coast Four-toed Lerista		
Lerista lineata	Perth Lined Lerista	P3	
Lerista praepedita	Worm Lerista		
Menetia greyii	Dwarf Skink		
Morethia lineoocellata	Western Pale-faced Morethia		
Morethia obscura	Dusky Morethia		
Tiliqua rugosa	Bobtail		+
Typhlopidae Blind Snakes			
Ramphotyphlops australis	Southern Blind Snake		
Elapidae Elapid Snakes			
Elapognathus coronatus	Crowned Snake		
Neelaps calonotos	Black-striped Snake	P3	
Notechis scutatus	Tiger Snake		
Parasuta gouldii	Gould`s Snake		
Parasuta nigriceps	Black-backed Snake		
Pseudonaja affinis	Dugite		
Simoselaps bertholdi	Jan`s Banded Snake		

Birds

Phasianidae Quails, Pheasants			
Coturnix pectoralis	Stubble Quail		+

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Class **Family** *Species*	Common Name	Conservation Status	Sighted Sept 05
Anatidae Geese, Swans, Ducks			
Anas gracilis	Grey Teal		
Anas platyrhynchos	Mallard		
Anas rhynchotis	Australasian Shoveler	Bh	
Anas superciliosa	Pacific Black Duck		+
Aythya australis	Hardhead	Bh	
Biziura lobata	Musk Duck	Bh	
Chenonetta jubata	Australian Wood Duck		+
Cygnus atratus	Black Swan		
Malacorhynchus membranaceus	Pink-eared Duck	Bh	
Oxyura australis	Blue-billed Duck	Bh	
Tadorna tadornoides	Australian Shelduck		+
Anhingidae Darters			
Anhinga melanogaster	Darter		+
Phalacrocoracidae Cormorants			
Phalacrocorax melanoleucos	Little Pied Cormorant		
Phalacrocorax sulcirostris	Little Black Cormorant		
Ardeidae Herons, Egrets, Bitterns			
Ardea alba	Great Egret	Migratory CA JA	
Ardea ibis	Cattle Egret	Migratory CA JA	
Egretta garzetta	Little Egret		
Egretta novaehollandiae	White-faced Heron		
Nycticorax caledonicus	Rufous Night Heron	Bp	
Threskiornithidae Ibises, Spoonbills			
Platalea flavipes	Yellow-billed Spoonbill		
Platalea regia	Royal Spoonbill		
Threskiornis molucca	Australian White Ibis		+
Threskiornis spinicollis	Straw-necked Ibis		

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Class **Family** *Species*	Common Name	Conservation Status	Sighted Sept 05
Accipitridae Kites, Goshawks, Eagles, Harriers			
Accipiter cirrocephalus	Collared Sparrowhawk	Bp	
Accipiter fasciatus	Brown Goshawk	Bp	
Aquila audax	Wedge-tailed Eagle	Bp	
Aquila morphnoides	Little Eagle	Bp	
Circus approximans	Swamp Harrier		
Circus assimilis	Spotted Harrier		
Elanus caeruleus	Black-shouldered Kite		+
Haliaeetus leucogaster	White-bellied Sea-Eagle	Migratory CA	
Haliastur sphenurus	Whistling Kite	Bp	
Hamirostra isura	Square-tailed Kite	Bp	
Falconidae Falcons			
Falco berigora	Brown Falcon	Bp	
Falco cenchroides	Australian Kestrel		+
Falco longipennis	Australian Hobby		
Falco peregrinus	Peregrine Falcon	S4 Bp	
Turnicidae Button-quails			
Turnix varia	Painted Button-quail	Bp	
Columbidae Pigeons, Doves			
*Columba livia**	Domestic Pigeon		
Ocyphaps lophotes	Crested Pigeon		+
Phaps chalcoptera	Common Bronzewing	Bh	+
*Streptopelia chinensis**	Spotted Turtle Dove		
*Streptopelia senegalensis**	Laughing Turtle-Dove		+
Cacatuidae Cockatoos, Corellas			
Cacatua sanguinea	Little Corella		
*Cacatua tenuirostris**	Eastern Long-billed Corella		
Calyptorhynchus baudinii	Baudin`s Cockatoo	S1 EN Bp	
Calyptorhynchus latirostris	Carnaby`s Cockatoo	S1 EN Bp	
Eolophus roseicapilla	Galah		+

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Class **Family** *Species*	Common Name	Conservation Status	Sighted Sept 05
Psittacidae Parrots			
Neophema elegans	Elegant Parrot		+
Platycercus spurius	Red-capped Parrot		+
Platycercus zonarius	Twenty-eight Parrot		+
Polytelis anthopeplus	Regent Parrot		+
Trichoglossus haematodus	Rainbow Lorikeet		
Cuculidae Parasitic Cuckoos			
Cacomantis flabelliformis	Fan-tailed Cuckoo		
Chrysococcyx basalis	Horsfield`s Bronze Cuckoo		
Chrysococcyx lucidus	Shining Bronze Cuckoo		
Cuculus pallidus	Pallid Cuckoo		
Strigidae Hawk Owls			
Ninox novaeseelandiae	Boobook Owl		
Tytonidae Barn Owls			
Tyto alba	Barn Owl		
Podargidae Frogmouths			
Podargus strigoides	Tawny Frogmouth		
Apodidae Swifts, Swiftlets			
Apus pacificus	Fork-tailed Swift	Migratory CA JA	
Halcyonidae Tree Kingfishers			
*Dacelo novaeguineae**	Laughing Kookaburra		+
Todiramphus sanctus	Sacred Kingfisher		
Meropidae Bee-eaters			
Merops ornatus	Rainbow Bee-eater	Migratory JA	
Maluridae Fairy Wrens, GrassWrens			
Malurus splendens	Splendid Fairy-wren	Bh	+

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Class **Family** *Species*	Common Name	Conservation Status	Sighted Sept 05
Pardalotidae Pardalotes, Bristlebirds, Scrubwrens, Gerygones, Thornbills			
Acanthiza apicalis	Broad-tailed Thornbill	Bh	+
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	Bh	+
Acanthiza inornata	Western Thornbill	Bh	+
Gerygone fusca	Western Gerygone		+
Pardalotus punctatus	Spotted Pardalote		
Pardalotus striatus	Striated Pardalote		+
Sericornis frontalis	White-browed Scrubwren	Bh	
Smicrornis brevirostris	Weebill	Bh	+
Meliphagidae Honeyeaters, Chats			
Acanthorhynchus superciliosus	Western Spinebill		+
Anthochaera carunculata	Red Wattlebird		+
Anthochaera lunulata	Western Little Wattlebird	Bp	
Epthianura albifrons	White-fronted Chat		
Lichenostomus virescens	Singing Honeyeater		+
Lichmera indistincta	Brown Honeyeater		
Melithreptus lunatus	White-naped Honeyeater	Bp	
Phylidonyris melanops	Tawny-crowned Honeyeater	Bp	
Phylidonyris nigra	White-cheeked Honeyeater	Bp	
Phylidonyris novaehollandiae	New Holland Honeyeater	Bp	+
Petroicidae Australian Robins			
Petroica cucullata	Hooded Robin	Bh	
Petroica goodenovii	Red-capped Robin		
Petroica multicolor	Scarlet Robin	Bh	+
Neosittidae Sitellas			
Daphoenositta chrysoptera	Varied Sittella	Bh	
Pachycephalidae Crested Shrike-tit, Crested Bellbird, Shrike Thrushes, Whistlers			
Colluricincla harmonica	Grey Shrike-thrush	Bh	
Pachycephala pectoralis	Golden Whistler	Bh	+
Pachycephala rufiventris	Rufous Whistler		

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Class **Family** *Species*	Common Name	Conservation Status	Sighted Sept 05
Dicruridae Monarchs, Magpie Lark, Flycatchers, Fantails, Drongo			
Grallina cyanoleuca	Magpie-lark		+
Rhipidura fuliginosa	Grey Fantail		+
Rhipidura leucophrys	Willie Wagtail		+
Campephagidae Cuckoo-shrikes, Trillers			
Coracina novaehollandiae	Black-faced Cuckoo-shrike		
Lalage sueurii	White-winged Triller		
Artamidae Woodswallows, Butcherbirds, Currawongs			
Artamus cinereus	Black-faced Woodswallow	Bp	
Artamus cyanopterus	Dusky Woodswallow	Bp	
Cracticus tibicen	Australian Magpie		+
Cracticus torquatus	Grey Butcherbird		+
Corvidae Ravens, Crows			
Corvus coronoides	Australian Raven		+
Motacillidae Old World Pipits, Wagtails			
Anthus novaeseelandiae	Australian Pipit		
Dicaeidae Flowerpeckers			
Dicaeum hirundinaceum	Mistletoebird		
Hirundinidae Swallows, Martins			
Cheramoeca leucosternus	White-backed Swallow		
Hirundo neoxena	Welcome Swallow		
Hirundo nigricans	Tree Martin		
Sylviidae Old World Warblers			
Cincloramphus cruralis	Brown Songlark		
Zosteropidae White-eyes			
Zosterops lateralis	Grey-breasted White-eye		+

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Class **Family** *Species*	Common Name	Conservation Status	Sighted Sept 05
Mammals			
Dasyuridae Carnivorous Marsupials			
Phascogale tapoatafa tapoatafa	Southern Brush-tailed Phascogale	P3	
Peramelidae Bandicoots			
Isoodon obesulus fusciventer	Southern Brown Bandicoot	P5	+
Phalangeridae Brushtail Possums, Cuscuses			
Trichosurus vulpecula	Common Brushtail Possum		
Burramyidae Pygmy Possums			
Cercartetus concinnus	Western Pygmy-possum		
Tarsipedidae Honey Possum			
Tarsipes rostratus	Honey Possum		
Macropodidae Kangaroos, Wallabies			
Macropus fuliginosus	Western Grey Kangaroo		+
Macropus irma	Western Brush Wallaby	P4	+
Molossidae Freetail Bats			
Mormopterus planiceps	Western Freetail Bat		
Tadarida australis	White-striped Freetail-bat		
Vespertilionidae Ordinary Bats			
Chalinolobus gouldii	Gould`s Wattled Bat		
Chalinolobus morio	Chocolate Wattled Bat		
Nyctophilus geoffroyi	Lesser Long-eared Bat		
Nyctophilus gouldi	Gould`s Long-eared Bat		
Nyctophilus timoriensis major	Greater Long-eared Bat		
Vespadelus regulus	Southern Forest Bat		
Muridae Rats, Mice			
*Mus musculus**	House Mouse		
Rattus fuscipes	Western Bush Rat		
*Rattus rattus**	Black Rat		

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Class **Family** *Species*	Common Name	Conservation Status	Sighted Sept 05
Canidae Dogs, Foxes			
*Vulpes vulpes**	Red Fox		
Felidae Cats			
*Felis catus**	Cat		
Leporidae Rabbits, Hares			
*Oryctolagus cuniculus**	Rabbit		+

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APPENDIX B

FAUNA INVENTORY

Fauna Observed or Potentially in Region of Study Area

Mandogalup, W.A.

Approximate centroid = 32.195226°S 115.848675°E

Emerge Associates (2011) - this report and Harewood, G (2005) Fauna Survey (Level 1) Mandogalup. Unpublished report for Cardno BSD,
Harewood, G. (2009) Fauna Survey (Level 2) East Rockingham WWTP Site Pipeline Corridors. Unpublished report for ERM.
ENV Australia (2010). Cape Peron Fauna Assessment. Unpublished report for Strategen.
How R.A., Harvey M.S., Dell J. and Waldock J. (1996) Ground Fauna of Urban Bushland Remnants in Perth. Report N93/04 to the Australian Heritage Commission (Woodman Point Results).
DEC (2011). NatureMap Database search. “By Circle” 115° 50' 47" E, 33° 11' 49" S – Mandogalup Area (plus 6km buffer). 9th April 2011.

Compiled by Greg Harewood - April 2011
Recorded (Sighted/Heard/Signs/Captured) = X

Class **Family** *Species*	Common Name	Conservation Status	Emerge '11 Harewood '05 Mandogalup	Harewood '09 ERWWTP	ENV '10 Point Peron	How et al '96 Woodman Pt	DEC '11 NatureMap
Amphibia							
Myobatrachidae Ground or Burrowing Frogs							
Crinia georgiana	Quacking Frog	LC	X				
Crinia glauerti	Clicking Frog	LC	X		X		X
Crinia insignifera	Squelching Froglet	LC	X				
Heleioporus eyrei	Moaning Frog	LC			X		X
Limnodynastes dorsalis	Western Banjo Frog	LC			X	X	X
Myobatrachus gouldii	Turtle Frog	LC					X
Pseudophryne guentheri	Crawling Toadlet	LC					

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Class **Family** *Species*	Common Name	Conservation Status	Emerge '11 Harewood '05 Mandogalup	Harewood '09 ERWWTP	ENV '10 Point Peron	How et al '96 Woodman Pt	DEC '11 NatureMap
Hylidae Tree or Water-Holding Frogs							
Litoria adelaidensis	Slender Tree Frog	LC			X		X
Litoria moorei	Motorbike Frog	LC			X		
Reptilia							
Diplodactylidae Geckoes							
Strophurus spinigerus	Soft Spiny-tailed Gecko			X	X		
Gekkonidae Geckoes							
Christinus marmoratus	Marbled Gecko			X	X		X
Pygopodidae Legless Lizards							
Aprasia repens	Sandplain Worm Lizard				X	X	
Delma fraseri	Fraser's Legless Lizard			X			X
Delma grayii	Side-barred Delma				X		
Lialis burtonis	Burton's Legless Lizard			X	X	X	
Pygopus lepidopodus	Common Scaly Foot						X

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Class **Family** *Species*	Common Name	Conservation Status	Emerge '11 Harewood '05 Mandogalup	Harewood '09 ERWWTP	ENV '10 Point Peron	How et al '96 Woodman Pt	DEC '11 NatureMap
Agamidae Dragon Lizards							
Ctenophorus adelaidensis	Western Heath Dragon			X	X		X
Pogona minor	Western Bearded Dragon			X	X		X
Varanidae Monitor's or Goanna's							
Varanus gouldii	Gould's Sand Monitor						
Varanus tristis	Racehorse Monitor			X		X	

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Class **Family** *Species*	Common Name	Conservation Status	Emerge '11 Harewood '05 Mandogalup	Harewood '09 ERWWTP	ENV '10 Point Peron	How et al '96 Woodman Pt	DEC '11 NatureMap
Scincidae Skinks							
Acritoscincus trilineatum	Southwestern Cool Skink				X		
Cryptoblepharus buchananii	Fence Skink			X	X	X	
Ctenotus australis	Western Ctenotus			X			X
Ctenotus fallens	West Coast Ctenotus			X	X	X	
Ctenotus impar	Odd-striped Ctenotus						
Egernia kingii	King's Skink						
Egernia napoleonis	Salmon-bellied Skink						X
Hemiergis quadrilineata	Two-toed Mulch Skink			X	X	X	X
Lerista elegans	West Coast Four-toed Lerista			X	X		X
Lerista lineata	Perth Lined Lerista	P3			X	X	X
Lerista praepedita	Western Worm Lizard						
Menetia greyii	Dwarf Skink			X	X	X	X
Morethia lineoocellata	West Coast Pale-flecked Morethia			X	X		X
Morethia obscura	Shrubland Pale-flecked Morethia			X			

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Class **Family** *Species*	Common Name	Conservation Status	Emerge '11 Harewood '05 Mandogalup	Harewood '09 ERWWTP	ENV '10 Point Peron	How et al '96 Woodman Pt	DEC '11 NatureMap
Tiliqua occipitalis	Western Bluetongue			X			
Tiliqua rugosa	Bobtail		X	X	X	X	X
Typhlopidae Blind Snakes							
Ramphotyphlops australis	Southern Blind Snake				X		X
Elapidae Elapid Snakes							
Brachyurophis semifasciata	Southern Half-girdled Snake						X
Demansia psammophis reticulata	Yellow-faced Whipsnake						X
Elapognathus coronatus	Crowned Snake						
Neelaps calonotos	Black-striped Snake	P3					X
Notechis scutatus	Tiger Snake						X
Parasuta gouldii	Gould's Hooded Snake						X
Parasuta nigriceps	Black-backed Snake						
Pseudonaja affinis	Dugite			X	X		X
Simoselaps bertholdi	Jan's Banded Snake						X

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Class **Family** *Species*	Common Name	Conservation Status	Emerge '11 Harewood '05 Mandogalup	Harewood '09 ERWWTP	ENV '10 Point Peron	How et al '96 Woodman Pt	DEC '11 NatureMap
Aves							
Phasianidae Quails, Pheasants							
Coturnix pectoralis	Stubble Quail	LC	X				X
Anatidae Geese, Swans, Ducks							
Anas gracilis	Grey Teal	LC			X		X
Anas superciliosa	Pacific Black Duck	LC	X		X		X
Chenonetta jubata	Australian Wood Duck	LC	X				X
Tadorna tadornoides	Australian Shelduck	LC	X				X
Ardeidae Herons, Egrets, Bitterns							
Ardea alba	Great Egret	S3 Mi CA JA			X		
Ardea ibis	Cattle Egret	S3 Mig CA JA					
Ardea novaehollandiae	White-faced Heron	LC			X		
Ardea pacifica	White-necked Heron	LC					X

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Threskiornithidae Iibises, Spoonbills							
Threskiornis molucca	Australian White Ibis	LC	X		X		X
Threskiornis spinicollis	Straw-necked Ibis	LC	X				X
Accipitridae Kites, Goshawks, Eagles, Harriers							
Accipiter cirrocephalus	Collared Sparrowhawk	Bp LC		X			X
Accipiter fasciatus	Brown Goshawk	Bp LC	X	X		X	X
Aquila audax	Wedge-tailed Eagle	Bp LC	X				X
Aquila morphnoides	Little Eagle	Bp LC		X		X	
Circus approximans	Swamp Harrier	LC			X		X
Circus assimilis	Spotted Harrier	LC					
Elanus caeruleus	Black-shouldered Kite	LC	X	X	X		
Haliaeetus leucogaster	White-bellied Sea-Eagle	S3 Mig CA LC					X
Haliastur sphenurus	Whistling Kite	Bp LC	X	X	X		X
Hamirostra isura	Square-tailed Kite	Bp LC					

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Falconidae Falcons							
Falco berigora	Brown Falcon	Bp LC					X
Falco cenchroides	Australian Kestrel	LC	X	X	X		X
Falco longipennis	Australian Hobby	LC	X	X	X		X
Falco peregrinus	Peregrine Falcon	S4 Bp LC		X			X
Turnicidae Button-quails							
Turnix varia	Painted Button-quail	Bp LC					X
Charadriidae Lapwings, Plovers, Dotterels							
Vanellus tricolor	Banded Lapwing	LC					X

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Class **Family** *Species*	Common Name	Conservation Status	Emerge '11 Harewood '05 Mandogalup	Harewood '09 ERWWTP	ENV '10 Point Peron	How et al '96 Woodman Pt	DEC '11 NatureMap
Columbidae Pigeons, Doves							
Columba livia	Domestic Pigeon	Introduced			X		X
Ocyphaps lophotes	Crested Pigeon	LC	X				X
Phaps chalcoptera	Common Bronzewing	Bh LC	X	X		X	X
Streptopelia chinensis	Spotted Turtle-Dove	Introduced					X
Streptopelia senegalensis	Laughing Turtle-Dove	Introduced	X	X	X		X

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Psittacidae Parrots							
Cacatua roseicapilla	Galah	LC	X	X	X	X	
Cacatua sanguinea	Little Corella	LC	X				X
Cacatua tenuirostris	Eastern Long-billed Corella	Introduced			X		
Calyptorhynchus banksii naso	Forest Red-tailed Black-Cockatoo	S1 VU VU Be LC	X				X
Calyptorhynchus latirostris	Carnaby's Black Cockatoo	S1 EN Bp EN A2bcd+3bcd	X	X			X
Glossopsitta porphyrocephala	Purple-crowned Lorikeet	LC					
Neophema elegans	Elegant Parrot	LC	X				X
Platycercus icterotis icterotis	Western Rosella (western ssp)	Bp LC			X		X
Platycercus spurius	Red-capped Parrot	LC	X	X		X	
Platycercus zonarius	Australian Ringneck Parrot	LC	X	X	X	X	X
Polytelis anthopeplus	Regent Parrot	LC	X				X
Trichoglossus haematodus	Rainbow Lorikeet	Introduced					X

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Cuculidae Parasitic Cuckoos							
Cacomantis flabelliformis	Fan-tailed Cuckoo	LC				X	X
Chrysococcyx basalis	Horsfield's Bronze Cuckoo	LC		X		X	
Chrysococcyx lucidus	Shining Bronze Cuckoo	LC				X	
Cuculus pallidus	Pallid Cuckoo	LC					X
Strigidae Hawk Owls							
Ninox novaeseelandiae	Boobook Owl	LC					X
Tytonidae Barn Owls							
Tyto alba	Barn Owl	LC		X			X
Podargidae Frogmouths							
Podargus strigoides	Tawny Frogmouth	LC					X
Caprimulgidae Nightjars							
Eurostopodus argus	Spotted Nightjar	LC					

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Aegothelidae Owlet-nightjars							
Aegotheles cristatus	Australian Owlet-nightjar	LC					
Apodidae Swifts, Swiftlets							
Apus pacificus	Fork-tailed Swift	S3 Mig CA JA RK LC					
Halcyonidae Tree Kingfishers							
Dacelo novaeguineae	Laughing Kookaburra	Introduced	X	X	X	X	X
Todiramphus sanctus	Sacred Kingfisher	LC				X	X
Meropidae Bee-eaters							
Merops ornatus	Rainbow Bee-eater	S3 Mig JA LC	X	X	X	X	X
Maluridae Fairy Wrens, GrassWrens							
Malurus splendens	Splendid Fairy-wren	Bh LC	X	X	X	X	X

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Acanthizidae Thornbills, Geryones, Fieldwrens & Whitefaces							
Acanthiza apicalis	Broad-tailed Thornbill	Bh LC	X	X	X	X	X
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	Bh LC	X			X	X
Acanthiza inornata	Western Thornbill	Bh LC	X	X	X		X
Gerygone fusca	Western Gerygone	LC	X	X	X	X	X
Sericornis frontalis	White-browed Scrubwren	Bh LC		X	X	X	X
Smicrornis brevirostris	Weebill	Bh LC	X	X	X	X	X
Pardalotidae Pardalotes							
Pardalotus punctatus	Spotted Pardalote	LC					X
Pardalotus striatus	Striated Pardalote	LC	X	X	X	X	X

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Meliphagidae Honeyeaters, Chats							
Acanthorhynchus superciliosus	Western Spinebill	LC	X				X
Anthochaera carunculata	Red Wattlebird	LC	X	X	X	X	X
Anthochaera lunulata	Western Little Wattlebird	Bp LC					X
Lichenostomus virescens	Singing Honeyeater	LC	X	X	X	X	X
Lichmera indistincta	Brown Honeyeater	LC		X	X	X	X
Phylidonyris nigra	White-cheeked Honeyeater	Bp LC			X		
Phylidonyris novaehollandiae	New Holland Honeyeater	Bp LC	X	X	X		X
Petroicidae Australian Robins							
Petroica goodenovii	Red-capped Robin	LC					X
Petroica multicolor	Scarlet Robin	Bh LC	X	X			
Neosittidae Sitellas							
Daphoenositta chrysoptera	Varied Sittella	Bh LC		X			X

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Class **Family** *Species*	Common Name	Conservation Status	Emerge '11 Harewood '05 Mandogalup	Harewood '09 ERWWTP	ENV '10 Point Peron	How et al '96 Woodman Pt	DEC '11 NatureMap
Pachycephalidae Crested Shrike-tit, Crested Bellbird, Shrike Thrushes, Whistlers							
Colluricincla harmonica	Grey Shrike-thrush	Bh LC	X	X		X	X
Pachycephala pectoralis	Golden Whistler	Bh LC	X			X	X
Pachycephala rufiventris	Rufous Whistler	LC		X	X	X	X
Dicruridae Monarchs, Magpie Lark, Flycatchers, Fantails, Drongo							
Grallina cyanoleuca	Magpie-lark	LC	X	X	X	X	X
Rhipidura fuliginosa	Grey Fantail	LC	X	X	X	X	
Rhipidura leucophrys	Willie Wagtail	LC	X	X	X	X	X
Campephagidae Cuckoo-shrikes, Trillers							
Coracina novaehollandiae	Black-faced Cuckoo-shrike	LC		X		X	X
Lalage tricolor	White-winged Triller	LC					
Artamidae Woodswallows, Butcherbirds, Currawongs							
Artamus cinereus	Black-faced Woodswallow	Bp LC			X		X
Artamus cyanopterus	Dusky Woodswallow	Bp LC					X

WC Act Status - S1 to S4, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, DEC Priority Status - P1 to P5, Int. Agmts - CA = CAMBA, JA = JAMBA, RK = ROKAMBA, Bush Forever Decreaser Species - Bh = habitat specialists, Bp = wide ranging species, Be = extinct in Perth Coastal Plain Region. IUCN Red List Category Definitions LC = Least Concern - see Appendix A and www.iucnredlist.org/info/categories_criteria2001#categories for others.

Class **Family** *Species*	Common Name	Conservation Status	Emerge '11 Harewood '05 Mandogalup	Harewood '09 ERWWTP	ENV '10 Point Peron	How et al '96 Woodman Pt	DEC '11 NatureMap
Cracticidae Currawongs, Magpies & Butcherbirds							
Cracticus tibicen	Australian Magpie	LC	X	X	X	X	X
Cracticus torquatus	Grey Butcherbird	LC	X	X	X	X	X
Corvidae Ravens, Crows							
Corvus coronoides	Australian Raven	LC	X	X	X	X	X
Motacillidae Old World Pipits, Wagtails							
Anthus australis	Australian Pipit	LC		X			
Dicaeidae Flowerpeckers							
Dicaeum hirundinaceum	Mistletoebird	LC					
Hirundinidae Swallows, Martins							
Hirundo neoxena	Welcome Swallow	LC		X	X	X	X
Hirundo nigricans	Tree Martin	LC		X		X	

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Class **Family** *Species*	Common Name	Conservation Status	Emerge '11 Harewood '05 Mandogalup	Harewood '09 ERWWTP	ENV '10 Point Peron	How et al '96 Woodman Pt	DEC '11 NatureMap
Sylviidae Old World Warblers							
Cincloramphus cruralis	Brown Songlark	LC					
Cincloramphus mathewsi	Rufous Songlark	LC					
Zosteropidae White-eyes							
Zosterops lateralis	Grey-breasted White-eye	LC	X	X	X	X	X
Mammalia							
Tachyglossidae Echidnas							
Tachyglossus aculeatus	Echidna	LR/LC					
Peramelidae Bandicoots							
Isoodon obesulus fusciventer	Southern Brown Bandicoot	P5 LC	X	X		X	X
Phalangeridae Brushtail Possums, Cuscuses							
Trichosurus vulpecula vulpecula	Common Brushtail Possum	LR/LC					
Burramyidae Pygmy Possums							
Cercartetus concinnus	Western Pygmy-possum	LR/LC					

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Class **Family** *Species*	Common Name	Conservation Status	Emerge '11 Harewood '05 Mandogalup	Harewood '09 ERWWTP	ENV '10 Point Peron	How et al '96 Woodman Pt	DEC '11 NatureMap
Tarsipedidae Honey Possum							
Tarsipes rostratus	Honey Possum, Noolbenger	LR/LC					X
Macropodidae Kangaroos, Wallabies							
Macropus fuliginosus	Western Grey Kangaroo	LR/LC	X	X			
Macropus irma	Western Brush Wallaby	P4 LR/NT	X				X
Molossidae Freetail Bats							
Mormopterus planiceps	Southern Freetail-bat	LR/LC		X			
Tadarida australis	White-striped Freetail-bat	LR/LC			X		

WC Act Status - S1 to S4, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, DEC Priority Status - P1 to P5, Int. Agmts - CA = CAMBA, JA = JAMBA, RK = ROKAMBA, Bush Forever Decreaser Species - Bh = habitat specialists, Bp = wide ranging species, Be = extinct in Perth Coastal Plain Region. IUCN Red List Category Definitions LC = Least Concern - see Appendix A and www.iucnredlist.org/info/categories_criteria2001#categories for others.

Class **Family** *Species*	Common Name	Conservation Status	Emerge '11 Harewood '05 Mandogalup	Harewood '09 ERWWTP	ENV '10 Point Peron	How et al '96 Woodman Pt	DEC '11 NatureMap
Vespertilionidae Ordinary Bats							
Chalinolobus gouldii	Gould's Wattled Bat	LR/LC		X	X		
Chalinolobus morio	Chocolate Wattled Bat	LR/LC					
Nyctophilus geoffroyi	Lesser Long-eared Bat	LR/LC					
Nyctophilus gouldi	Gould's Long-eared Bat	LR/LC					
Nyctophilus timoriensis	Greater Long-eared Bat	LR/LC		X			
Vespadelus regulus	Southern Forest Bat	LR/LC		X			
Muridae Rats, Mice							
Mus musculus	House Mouse	Introduced		X	X	X	X
Rattus fuscipes	Western Bush Rat	LR/LC			X		X
Rattus rattus	Black Rat	Introduced		X		X	X
Canidae Dogs, Foxes							
Canis lupus familiaris	Dog	Introduced		X			
Vulpes vulpes	Red Fox	Introduced		X	X	X	

WC Act Status - S1 to S4, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, DEC Priority Status - P1 to P5, Int. Agmts - CA = CAMBA, JA = JAMBA, RK = ROKAMBA, Bush Forever Decreaser Species - Bh = habitat specialists, Bp = wide ranging species, Be = extinct in Perth Coastal Plain Region. IUCN Red List Category Definitions LC = Least Concern - see Appendix A and www.iucnredlist.org/info/categories_criteria2001#categories for others.

Class **Family** *Species*	Common Name	Conservation Status	Emerge '11 Harewood '05 Mandogalup	Harewood '09 ERWWTP	ENV '10 Point Peron	How et al '96 Woodman Pt	DEC '11 NatureMap
Felidae Cats							
Felis catus	Cat	Introduced		X		X	X
Leporidae Rabbits, Hares							
Oryctolagus cuniculus	Rabbit	Introduced	X	X	X	X	

WC Act Status - S1 to S4, EPBC Act Status - EN = Endangered, VU = Vulnerable, EX = Extinct, DEC Priority Status - P1 to P5, Int. Agmts - CA = CAMBA, JA = JAMBA, RK = ROKAMBA, Bush Forever Decreaser Species - Bh = habitat specialists, Bp = wide ranging species, Be = extinct in Perth Coastal Plain Region. IUCN Red List Category Definitions LC = Least Concern - see Appendix A and www.iucnredlist.org/info/categories_criteria2001#categories for others.

APPENDIX C

GRACEFUL SUN-MOTH SURVEY REPORT

GRACEFUL SUN-MOTH SURVEY

VARIOUS ALLOTMENTS, MANDOGALUP

Project Number EP10-018

Prepared for Qube Mandogalup Land Development Company Pty Ltd.
September 2011

Document Control

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Executive Summary

Emerge Associates (Emerge) was commissioned by Qube Mandogalup Land Development Company Pty Ltd. (QMLDC) to undertake a graceful sun-moth (*Synemon gratiosa*) survey across seven parcels of land (Lots 664, 668 and 669 Mandogalup Road, Lot 791 and 663 Norkett Road and Lots 52 and 682 Rowley Road) within the locality of Mandogalup (herein referred to as 'the site', see **Figure 1** and **Figure 2**).

The site is proposed for future residential development, and currently comprises land that has been used for market gardening and other agricultural activities with areas to the north (Lot 682 Rowley Road) supporting areas of reasonably intact remnant bush land. There is also a patch of degraded bush land in the southern most portion of the site (Lot 669 Mandogalup Road). The graceful sun-moth survey was undertaken only in the remaining bush land areas, which comprise a total area of approximately 39 ha across the site.

The graceful sun-moth is listed as 'Endangered' pursuant to the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and declared as 'fauna that is rare or is likely to become extinct' under the Western Australian *Wildlife Conservation Act 1950* (WC Act). Therefore its presence (or otherwise) on the site is relevant to state environmental and development approvals processes as well as assessing the need for a referral pursuant to the EPBC Act.

The scope of this work was to undertake a graceful sun-moth survey in accordance with the Western Australian Department of Environment and Conservation's (DEC's) *Guidelines for the Graceful Sun-Moth (Synemon gratiosa) & Site Habitat Assessments* (Bishop *et al.* 2010). Emerge have specifically undertaken this work in accordance with these guidelines so that the presence (or otherwise) of this species is rigorously and technically surveyed and documented.

The graceful sun-moth survey (as outlined within the DEC guidelines) consists of two parts:

- A detailed *Lomandra* density survey, which should ideally be conducted prior to the graceful sun-moth survey to help determine an appropriate moth survey transect route.
- A graceful sun-moth survey using the results of the *Lomandra* density survey.

A *Lomandra* density survey was completed to determine the likely distribution of the graceful sun-moth across the site. A total of 104, two metre by two metre quadrats were sampled for *Lomandra* spp. densities.

Lomandra hermaphrodita and *Lomandra maritima* were recorded at 52 of the 104 quadrats surveyed. *Lomandra hermaphrodita* was more prolific across the site, being recorded in 51 quadrats, whilst *Lomandra maritima* was recorded in seven quadrats. Both species were recorded in low numbers (one - 16 plants), with *Lomandra hermaphrodita* having an average number of plants per quadrat of 3.8 (± 3.2) and *Lomandra maritima* having an average cover of 0.5% (± 0.5%).

The vegetation condition predominately associated with *Lomandra* occurrences was "Excellent" however both *Lomandra* species were also recorded in "Very Good", "Good" and "Degraded" vegetation conditions.

The graceful sun-moth surveys were undertaken in February and March 2011. Six repeat surveys of the site were carried out (due to the presence of *Banksia* woodland habitat in accordance with the DEC guidelines) on 24th February and 3rd, 10th, 15th, 25th and 31st March 2011, between 10am and 3pm and were at least 4 days apart. Windy (wind speeds of greater than 18km/h) periods were avoided.

Three transects totaling approximately 6 km in length (0.75, 3.7 and 1.6 km) were traversed across the site. Transect paths were chosen primarily within areas of remnant vegetation, and concentrated in areas of high *Lomandra* density and graceful sun-moth known preferred habitats (such as firebreaks, hills and ridgelines).

One graceful sun-moth was recorded on the boundary of the site during one of the six surveys, resulting on one positive identification for the entire survey. This moth was recorded on the boundary (within the western firebreak) of Lot 682 Rowley Road, and was observed to fly into neighbouring bush land (10 Rowley Road), which would also appear to be suitable graceful sun-moth habitat. Since there were no graceful sun-moth encountered within the site it is unlikely that the site could be would be considered to support a population of graceful sun-moth. Given this, it is recommended that the development of the site does not have the potential to pose a significant impact to the graceful sun-moth.

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1 Introduction

1.1 Project Background

Emerge Associates (Emerge) was commissioned by Qube Mandogalup Land Development Company Pty Ltd. (QMLDC) to undertake a graceful sun-moth (*Synemon gratiosa*) survey across seven parcels of land (Lots 664, 668 and 669 Mandogalup Road, Lot 791 and 663 Norkett Road and Lots 52 and 682 Rowley Road) within the locality of Mandogalup (herein referred to as 'the site'). The site is located approximately 46.5 kilometers south-west of the Perth Central Business District (CBD), Western Australia, and is shown in **Figure 1**.

The site is situated within the local government area of the Town of Kwinana, and is bounded by the Kwinana Freeway to the east, Mandogalup Road to the west, Rowley Road to the north and Anketell Road to the south (see **Figure 2**).

The site is proposed for future residential development, and currently comprises land that has been used for market gardening and other agricultural activities and the areas to the north (Lot 682 Rowley Road) supports areas of intact remnant bush land. There is also a patch of degraded bush land in the southern most portion of the site (Lot 669 Mandogalup Road). The graceful sun-moth survey was targeted in these remaining bush land areas, which comprise a total area of approximately 39 ha across the site.

1.2 Scope of Work

The scope of this work was to undertake a graceful sun-moth survey in accordance with the Western Australian Department of Environment and Conservation's (DEC's) *Guidelines for the Graceful Sun-Moth (Synemon gratiosa) & Site Habitat Assessments* (Bishop *et al.* 2010). Emerge have specifically undertaken this work in accordance with these guidelines so that the presence (or otherwise) of this species is rigorously and technically surveyed and documented.

The graceful sun-moth survey (as outlined within the DEC guidelines) consists of two parts:

- A detailed *Lomandra* density survey, which should ideally be conducted prior to the graceful sun-moth survey to help determine an appropriate transect route.
- A graceful sun-moth survey using the results of the *Lomandra* density survey.

This report documents the outcomes of both the *Lomandra* density survey and the graceful sun-moth survey within a single document. The report details *Lomandra* spp. density, graceful sun-moth presence/absence determined from the survey and provides advice with regards to the likely level of impact significance developing the site could have on the graceful sun-moth.

2 Background

2.0 Climate

The area is characterised by a dry Mediterranean climate with hot dry summers and cool wet winters. Long term climatic averages indicate the site is located in an area of moderate to high rainfall, receiving 762 mm on average (data for Medina Research Centre, the nearest current reporting station (Bureau of Meteorology 2011) with the majority of rainfall received between June and August. The region receives rainfall on an average of 90 days annually.

Mean maximum temperatures range from 18.2°C in July to 31.4°C in February. Mean minimum temperatures range from 8.3°C in August to 17.4°C in February.

2.1 Vegetation

The site lies within the Swan Coastal Plain Interim Biogeographic Regionalisation for Australia (IBRA) region (Thackway and Cresswell 1995). The Swan Coastal Plain IBRA region is broadly compatible with the Swan Coastal Plain (Drummond Botanical Subdistrict) Phytogeographical Subregion as described by Beard (1990). This region is characterised by *Banksia* low woodland on leached sands with *Melaleuca* swamps where ill-drained, woodland of tuart (*Eucalyptus gomphocephala*), jarrah (*Eucalyptus marginata*) and marri (*Corymbia calophylla*) on less leached soils.

Heddle *et al.* (1980) mapped vegetation complexes of the Swan Coastal Plain based on soil and geomorphology (and water availability) patterns. The distribution of these vegetation complexes are largely related to the main geomorphic entities (the dune systems and Pinjarra Plain) but is also influenced by the north-south latitudinal changes. The site occurs mainly within the Bassendean vegetation complex. The Bassendean vegetation complex is described as Woodland of *Eucalyptus marginata – Allocasuarina fraseriana – Banksia* spp. to low woodland of *Melaleuca* spp. and sedgelands on the moister sites (Heddle *et al.* 1980).

At a local scale, a flora and vegetation survey was conducted within the site by Cardno BSD in 2005 (Cardno BSD 2005) with a follow-up survey by Emerge in 2011 as part of a fauna habitat assessment (Emerge Associates 2011). These surveys determined that remnant vegetation within the site was largely 'Degraded' but there were areas of vegetation in "Very Good" and "Excellent" condition. The southernmost portion of remnant vegetation (Lot 669) has been grazed and was determined to be in "Degraded" condition.

> ***Banksia* low woodland** – Low *Banksia attenuata* woodlands with emergent *Eucalyptus marginata* over heath of *Hibbertia hypericoides*, *Stirlingia latifolia* and *Xanthorrhoea preissii* (Lots 669 and 682).
>
> ***Banksia* low forest** – Low *Banksia attenuata*, *Banksia ilicifolia* and *Banksia menziesii* forest over heath of *Dasypogon bromeliifolius*, *Lyginia barbata* and *Schoenus* sp. (Lot 682).
>
> ***Eucalyptus rudis* and *Melaleuca preissiana* woodland** – Woodland of *Eucalyptus rudis* over *Melaleuca preissiana* and *Banksia littoralis* over *Astartea scoparia*, *Juncus pallidus*, **Carpobrotus edulis*, **Zantedeschia aethiopica* and **Arctotheca calendula* (Lot 682).

Remnant plant communities within the site are described below and shown on **Figure 3.** Vegetation condition for the site is shown on **Figure 4**.

2.2 Graceful Sun-Moth

2.2.1 Distribution

At present there is limited knowledge relating to the population distribution of the graceful sun-moth. Prior to 2009, the species was thought to be confined to a small number of *Banksia* woodland bush reserves in the northern suburbs of Perth, of which none were in formal conservation reserves (Bishop *et al.* 2010). Targeted survey work undertaken between February and April of 2010, led by the DEC and supported by industry, has resulted in an extended known range of the graceful sun-moth, with the number of known populations increasing from 10 to 49 (Bishop *et al.* 2010). This new range extends from Jurien Bay in the north to Binningup in the south (Bishop *et al.* 2010).

The graceful sun-moth is currently only known from two vegetation types;

- *Banksia* woodland/woolly bush on deep sands, in the northern suburbs of Perth on the Swan Coastal Plain. In this vegetation type the graceful sun-moth breeds on *Lomandra hermaphrodita* (Bishop *et al.* 2010).
- Open coastal areas of herbland, heathland and shrubland on Quindalup soils. In this vegetation type the graceful sun-moth breeds on *Lomandra maritima* (Bishop *et al.* 2010).

After the 2010 survey effort it is clear that the graceful sun-moth is more numerous or dense in the coastal dune habitat, and that the coastal dunes appear to be the preferred and core habitat of this species (Bishop *et al.* 2010).

2.2.2 Taxonomy and Appearance

The graceful sun-moth is one of approximately 30 sun-moth species (family Castniidae) found in Western Australia. The moth is characterised by black-brown forewings with light grey markings and bright orange hind wings with some darker grey bands; see **Plate 1**. The extent of this orange colouration is quite variable and often dulls as the moth ages (DEC 2011). Their wingspan ranges between 25-30 mm and the female is generally slightly larger than the male (**Plate 1a**). Graceful sun-moth are generally inconspicuous when settled (**Plate 1b)**, displaying only the dark forewings, however the orange hind wings are clearly visible when flying making this species easily recognizable during surveys.

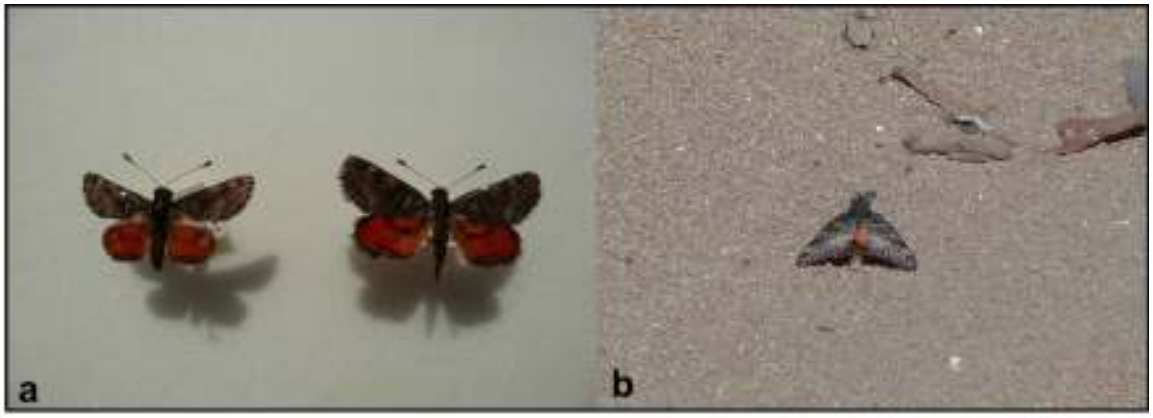

Plate 1: The graceful sun-moth; a) preserved male (left) and female (right) specimens[1]; b) as seen in the field.
[1]Photograph courtesy of Greg Harewood

2.2.3 Life cycle

At present the exact life cycle of the graceful sun-moth is not well known and is assumed to be between 1-3 years (Bishop *et al.* 2010; DEC 2011). Their eggs are laid at the base of plants of either *Lomandra maritima* or *Lomandra hermaphrodita*, the known food source for the larvae of the graceful sun-moth. The larvae then either live entirely within or alongside the underground part of the host plant until adulthood, feeding on the underground culms, roots or rhizomes. It is thought that larvae take between one or two years to reach maturity, however this is still largely unknown. Males of the species first appear as moths in late February, followed by the females in early March. Throughout March and early April mating occurs after which the females lay their eggs. By early April all adult moths have died off, after a brief two to ten day lifespan.

The flight time during which the moths are detectable seems to vary somewhat between years; this is likely due to climatic conditions. Bishop *et al.* (2010) also notes that flight behaviour can also vary with latitude and proximity to the coast.

2.2.4 Behaviour

The graceful sun-moth is distinctively diurnal (active during the day), preferring sunny conditions and are usually most active in the hottest part of the day (between 10am to 3pm). They are thought to be more mobile when there is little to no wind and typically do not fly more than a few metres above the ground.

Male graceful sun-moth are very territorial and prefer open areas such as tracks, firebreaks, hilltops and ridges, with territories approximately 20 square metres in extent (Bishop *et al.* 2010) . Females are not as active as males and prefer less open areas. Male graceful sun-moth are sedentary, but the extent to which females disperse is unknown. It is believed that females disperse less than 1 km from their colony of birth and are unlikely to cross unsuitable habitat (DSEWPC 2009).

2.2.5 Conservation status

The graceful sun-moth is listed as ‘Endangered’ pursuant to the Commonwealth EPBC Act and is also declared as ‘fauna that is rare or is likely to become extinct’ under the Western Australian WC Act. The DEC is currently undertaking a conservation project to better understand the graceful sun-moth on the

Swan Coastal Plain, including the 2010 survey program mentioned above and including the current 2011 survey effort, to which this survey will contribute.

2.3 Lomandra

Lomandra hermaphrodita and *Lomandra maritima* are currently the only known food source for graceful sun-moth larvae (Bishop *et al.* 2010).

2.3.1 Distribution

Both *Lomandra maritima* and *Lomandra hermaphrodita* are endemic to Western Australia. *Lomandra maritima* is known to occur between Carnarvon and Bunbury and grows only in coastal regions within sandy soils, being particularly common on the foredune (Western Australian Herbarium 2011). *Lomandra hermaphrodita* is known to occur from Geraldton to Albany and has a more widespread distribution, growing on sandy soils on the coastal plain and lateritic soils throughout the Darling Range of Western Australia.

2.3.2 Taxonomy and Morphology

Lomandra hermaphrodita and *Lomandra maritima* are two closely related and morphologically similar species of the *Lomandra* “mat-rushes” within the family Asparagaceae. *Lomandra* species are broadly described as grass-like perennial herbs, with an Australia wide distribution. Species within the genus comes in a variety of forms, but predominantly have long strap-like leaves. Generally *Lomandra* species are dioecious, with male and female flowers occurring on different plants. *Lomandra maritima* grows in clumps to 0.3 metres wide and 0.2 metres high, flowering from August to November (Western Australian Herbarium 2011). *Lomandra hermaphrodita* grows in clumps to 0.2 metres wide and 0.2 metres high and flowers from April to June (Western Australian Herbarium 2011). Both species are shown in **Plate 2**.



Plate 2: Lomandra hermaphrodita[1] *(top) and maritima*[2] *(below).*
[1] Image courtesy of Bishop *et al.* (2010)
[2] Image courtesy of FloraBase (Western Australian Herbarium 2011)

3 Methodology

3.0 Lomandra survey

A *Lomandra* density survey was completed to help determine the likely distribution of the graceful sun-moth across the site. The survey was conducted by two environmental scientists from Emerge on the 25th and 28th of January 2011, in accordance with DEC guidelines (Bishop *et al.* 2010).

A total of 104, two metre by two metre quadrats were sampled for *Lomandra* spp. density, with the number of quadrats determined according to the area (in ha) of the site and the corresponding minimum number values provided in **Table 1** (Bishop *et al.* 2010).

*Table 1: Number of Lomandra quadrats required per site area (*Bishop *et al.* 2010*)*

SITE AREA (HA)	MINIMUM NUMBER OF QUADRATS
10	30
20	50
50	100
100	150
200	240
300	320

Quadrats were positioned based on a 50 metre grid system, with quadrats located along these gridlines, and particularly concentrated along ridgelines and within plant communities known to contain *Lomandra* spp. The location of all quadrats was recorded in the field with a hand-held Global Positioning System (GPS).

Data was collected at each quadrat using the standardised forms provided by Bishop *et al.* (Bishop *et al.* 2010) with the following being collected:

- Site Details (site name, quadrat number, observers, quadrat location, date).
- Environmental Data (slope, aspect, bare-ground, soil type and colour, position in landscape).
- Biological Data (vegetation structure and condition, *Lomandra* spp. and density).

The vegetation condition was rated according to Keighery (1994), a vegetation condition scale commonly used in the Perth Metropolitan region. The categories are shown below in **Table 2**.

Table 2: Vegetation condition scale (Keighery 1994)

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

3.1 Graceful Sun-Moth Survey

The graceful sun-moth surveys were undertaken by three environmental scientists from Emerge in February and March 2011. Six repeat surveys of the site were carried out (due to the *Banksia* woodland habitat) on 24th February and 3rd, 10th, 15th, 25th and 31st March 2011, between 10am and 3pm and were at least 4 days apart. Windy (wind speed of greater than 18 km/h) periods were avoided. Climatic conditions on these days are shown in **Table 3.**

Three transects totaling approximately 6 km in length (0.75, 3.7 and 1.6 km) were traversed across the site. Transect paths were chosen primarily within areas of remnant vegetation, and concentrated in areas of high *Lomandra* density and graceful sun-moth known preferred habitats (such as firebreaks, hills and ridgelines). **Figure 6** shows the transect routes. A minimum transect route length of 4.9 km was calculated using the following formula from the DEC guidelines (Bishop *et al.* 2010):

$$\text{Transect length in km} = 0.7\left(\sqrt{\text{site area (ha)}}\right)$$

Transects were walked by teams of two, with at least one member of each team having undertaken the DEC graceful sun-moth survey training. Any graceful sun-moth/s observed over the area five metres either side of the transect, and five metres ahead were recorded on the standardised data sheets provided by Bishop *et al.* (2010) with a hand-held GPS providing an accurate record of the location. Any graceful sun-moth observed outside of this corridor, or detected at the site during other activities, were recorded as an 'incidental' observation.

The "standard details" for transects were recorded as outlined in Appendix 1 of the Survey Guidelines document (Bishop *et al.* 2010) and are presented in **Appendix A**.

Table 3: Climatic conditions on graceful sun-moths survey days.

DATE	MAXIMUM TEMPERATURE (°C)	MINIMUM TEMPERATURE (°C)	WIND SPEED RANGE (KM/HR)
24th February 2011	36.8	23.8	0 - 5
3rd March 2011	35.7	19.9	5 - 10
10th March 2011	32.0	15.5	0 - 5
15th March 2011	36.3	22.8	5 - 15
25th March 2011	35.2	20.4	0 - 5
31st March 2011	32.5	18.6	0 - 5

Note: Temperature observations from Medina Research Centre (Bureau of Meteorology 2011). Wind observations measured using an anemometer on site.

4 Results

4.0 Lomandra

4.0.1 *Lomandra* density

Three species of *Lomandra* were recorded during the density survey, *Lomandra caespitosa, Lomandra hermaphrodita* and *Lomandra maritima*. Only the latter two of these species are known habitat species for the graceful sun-moth (Bishop *et al.* 2010).

These two *Lomandra* species were recorded at 52 of the 104 quadrats surveyed, as shown in **Figure 5**. *Lomandra hermaphrodita* was more prolific across the site, being recorded in 51 quadrats, whilst *Lomandra maritima* was recorded in seven quadrats. Both species were recorded in low numbers (1 - 16 plants), with *Lomandra hermaphrodita* having an average number of plants per quadrat of 3.8 (± 3.2) and *Lomandra maritima* having an average cover of 0.5% (± 0.5%).

During the survey, light grey sand overlying yellow sand was observed to be the soil type most closely associated with occurrences of the two *Lomandra* species. The vegetation condition predominately associated with *Lomandra hermaphrodita occurrences* was "Excellent" however both *Lomandra* species were also recorded in "Very Good", "Good" and "Degraded" vegetation conditions. The raw data collected as a part of the *Lomandra* density survey is presented in **Appendix B**.

4.1 Graceful Sun-Moth

4.1.1 Number of moths observed

One graceful sun-moth was observed within the site from all six survey visits. This moth was recorded on the boundary (western firebreak) of Lot 682 Rowley Road, and was observed to fly into neighbouring bushland (10 Rowley Road), which also appeared to be similar vegetation conditions as within Lot 682. **Table 4** summarises the results of the six surveys carried out over the site. The transect routes and the single graceful sun-moth observation is shown in **Figure 6.** Additional details on each survey and the specimens observed are provided in **Appendix C**.

Table 4: Summary of graceful sun-moth survey results

SURVEY NUMBER	SURVEY DATE	NUMBER OF GRACEFUL SUN-MOTH OBSERVED	
		LOT 682	LOT 669
1	24/02/2011	0	0
2	03/03/2011	1	0
3	10/03/2011	0	0
4	15/03/2011	0	0
5	25/03/2011	0	0
6	31/03/2011	0	0
Total		1	0

5 Discussion

In 1997, the graceful sun-moth was listed as threatened fauna under the WC Act. It was then assessed and found to meet IUCN (International Union for Conservation of Nature) 'Endangered' criteria, based on the extent of its occurrence, area of known habitat and the fragmentation of habitat area. The graceful sun-moth was also listed as 'Endangered' under the EPBC Act in 2009 (Bishop *et al.* 2010). As the graceful sun-moth is a comparatively recent addition to Australia's threatened fauna at both Federal and State levels, there is still limited knowledge with regards to its occurrence, lifecycle and behavior and therefore its initial listing as threatened fauna was based on sparse information available at the time.

The purpose of the recent broad scale survey effort (March 2010 and 2011) undertaken by the DEC and assisted by industry was to gain a better understanding of the distribution of graceful sun-moth and the likely habitat of this species. The 2010 studies found the species to range well beyond its previously known distribution (*Banksia* woodland of the Swan region) into the coastal parts of the northern south- west of Western Australia and the southern Midwest regions where *Lomandra maritima* is found. It appears that this coastal habitat is the preferred habitat of the species and that the relative contribution of the *Banksia* woodland habitat to the total population and area of occupied habitat is small (Bishop *et al.* 2010).

The number of known graceful sun-moth populations was less than ten in 2009 and none of these populations were in secure conservation reserves. This number increased significantly to 49 populations after one survey season in 2010. Of the 49 sites recorded, 26 of these sites are under some form of conservation reserve (such as Bush Forever); however 17 of these sites have development proposals over them. Many of the sites proposed for development occur within coastal dune populations in the Alkimos-Yanchep and Lake Clifton-Yalgorup areas, and contain some of the largest populations of graceful sun-moth.

As part of this survey, no graceful sun-moth were recorded within the site and one moth was recorded on the boundary of Lot 682 Rowley Road, within *Banksia* woodland habitat. Within the wider local area, several other locations were surveyed as part of the 2010 survey effort, which include:

- Jandakot Regional Park (9 km to the north) - three moths
- Samson (14 km to the north-west) – one moth
- Anketell Road (2 km to the east) – two moths
- Roe Highway extension, Cockburn (10 km to the north) – six moths

The graceful sun-moth observations in the above areas are also contained within *Banksia* woodland habitats in which the graceful sun-moth subsists mainly on *Lomandra hermaphrodita*. As mentioned above, in comparison to the *Lomandra maritima* coastal dune habitat, the *Banksia* woodland habitat has generally been found to support smaller populations of the moth, as illustrated by the numbers recorded from the surveyed land parcels listed above. As a result of these small population sizes, the number of surveys required to adequately survey for graceful sun-moth in *Banksia* woodland was increased in 2010 from four to six (Bishop et al. 2010).

The results of the 2011 surveys are forthcoming, thus it is difficult to draw conclusions with regards to the observations made during this graceful sun-moth survey in comparison to broader population trends. The results so far suggest that the species is much more widespread than previously known, and the newly identified populations within the coastal dune habitat reduce the amount of fragmentation compared to the understanding prior to 2009.

The DEC will be considering the outcomes of the 2011 survey effort and other research findings and will review the conservation status of the graceful sun-moth. The DEC currently have the view that if it is demonstrated that other areas of occupied coastal dune habitat exist, it is probable that the graceful sun-moth would not meet the criteria for 'Endangered'. Any proposed changes to the status will be presented to, and reviewed by the Western Australian Threatened Species Scientific Committee for approval by the Minister for Environment. Any approved changes to the conservation status will then be referred to the Commonwealth Threatened Species Scientific Committee for a review of the listing under the EPBC Act (Bishop *et al.* 2010).

As part of their conservation advice, the DEC is of the view that impact on some populations of the graceful sun-moth will not cause extinction of the species. However, until such a time as the conservation status of the species is assessed and 'Significant Impact Guidelines' are prepared by the DEC, they advise that the "primary objective for decision makers should be *in situ* retention and protection of as much known habitat as possible, in the best condition and arrangement as possible" (DEC 2011).

Since there were no graceful sun-moth observed within the site, and one moth observed on the site's boundary following six separate surveys within the site, it is unlikely that the site supports a population of graceful sun-moth.

6 Conclusions and recommendations

The 2011 survey for the graceful sun-moth across Lots 664, 668 and 669 Mandogalup Road, Lot 791 and 663 Norkett Road and Lots 52 and 682 Rowley Road, Mandogalup, recorded one sun-moth at the boundary of Lot 682 Rowley Road. Suitable habitat for the sun-moth was recorded across the site with *Banksia* woodland being the dominant plant community observed and *Lomandra hermaphrodita* being recorded at an average density of 3.8 (± 3.2) plants per 2 m x 2 m quadrat sampled.

Information gathered by the DEC over the last two graceful sun-moth survey seasons indicate that the species is much more widespread than previously known, and newly identified populations within the coastal dune habitat reduce the amount of fragmentation compared to the general state of understanding prior to 2009. The DEC currently have the view that if it is demonstrated that other areas of occupied coastal dune habitat exist, it is probable that the graceful sun-moth would not meet the criteria for 'Endangered', and this will be reviewed considering the outcomes of the 2011 survey effort and other research findings. However, until such a time as the conservation status of the species is assessed and 'Significant Impact Guidelines' are prepared by DEC, the DEC advises that the "primary objective for decision makers should be *in situ* retention and protection of as much known habitat as possible, in the best condition and arrangement as possible" (DEC 2011).

It is unlikely that the one moth found at the boundary of the site would be considered to represent a population of graceful sun-moth within the site, considering the current research findings and the recent DEC conservation advice provided.

Therefore based on the findings of this survey, the recent survey effort by the DEC and their conservation advice, it is not considered that the development of the site has the potential to pose a significant impact to the graceful sun-moth.

7 References

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FIGURES

Figure 1 Location plan

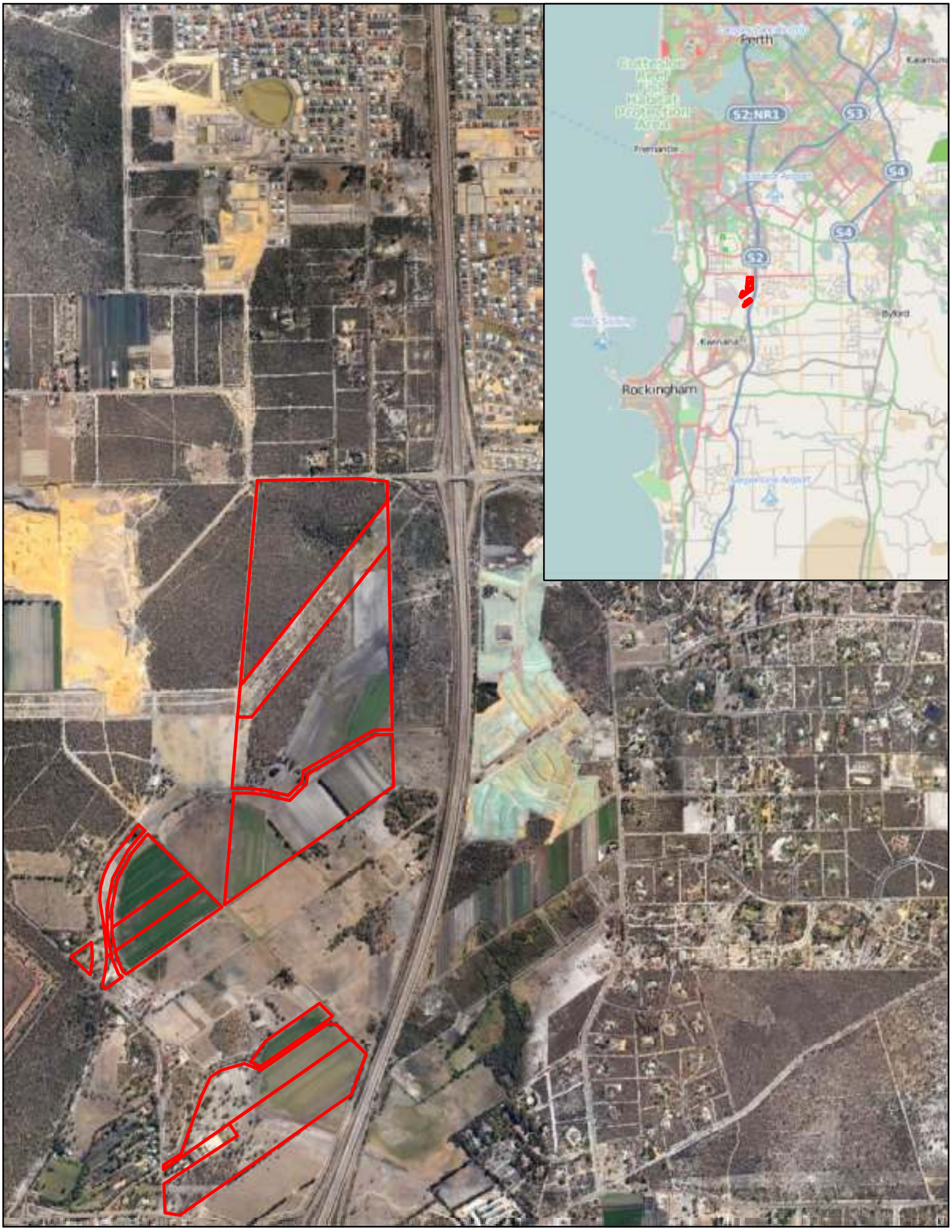
Figure 2 Site plan

Figure 3 Vegetation community mapping

Figure 4 Vegetation condition mapping

Figure 5 *Lomandra* density and plant communities

Figure 6 Graceful sun-moth transect locations



Client:
Qube Mandogalup Land Development Company

Project:
Mandogalup Graceful Sun-Moth Survey

Title:
Figure 1: Location Plan

Metres
0 150 300 600

Legend
Site boundary

19/09/11 :Date
1:20,000@A4 :Scale
EP10-18(03)--F07a :Plan Number
JDH :Checked
JDH :Approved

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Client:
Qube Mandogalup Land Development Company

Project:
Mandogalup Graceful Sun-Moth Survey

Title:
Figure 2: Site Location

Metres
0 100 200 400

Legend
Site boundary

19/09/11 :Date
1:13,000@A4 :Scale
EP10-18(03)--F08a :Plan Number
JDH :Checked
JDH :Approved

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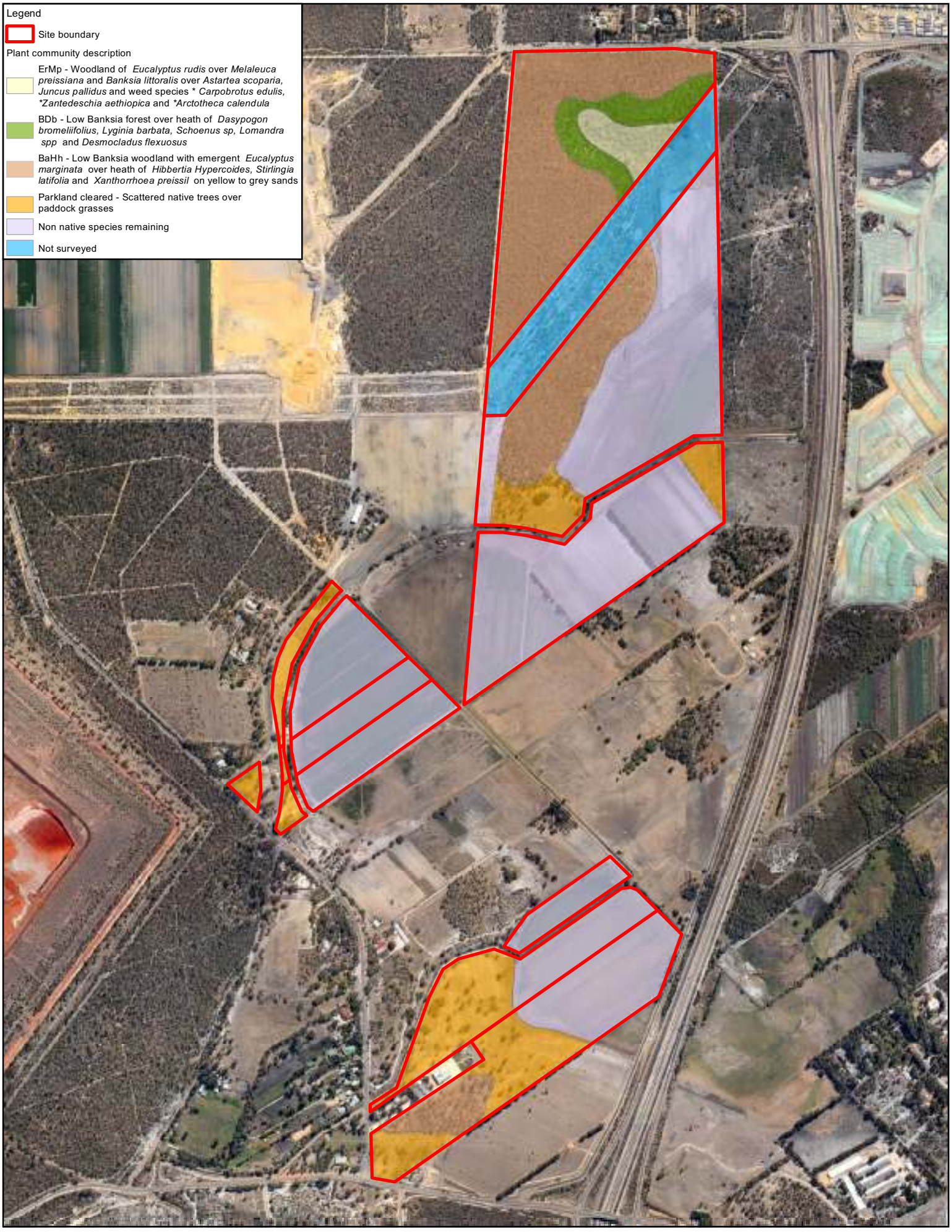

Client:
Qube Mandogalup Land Development Company

Project:
Mandogalup Graceful Sun-Moth Survey

Title:
Figure 3: Plant Community Mapping

Metres
0 100 200 400

19/09/11 :Date
1:13,000@A4 :Scale
EP10-18(03)--F11b :Plan Number
JDH :Checked
JDH :Approved

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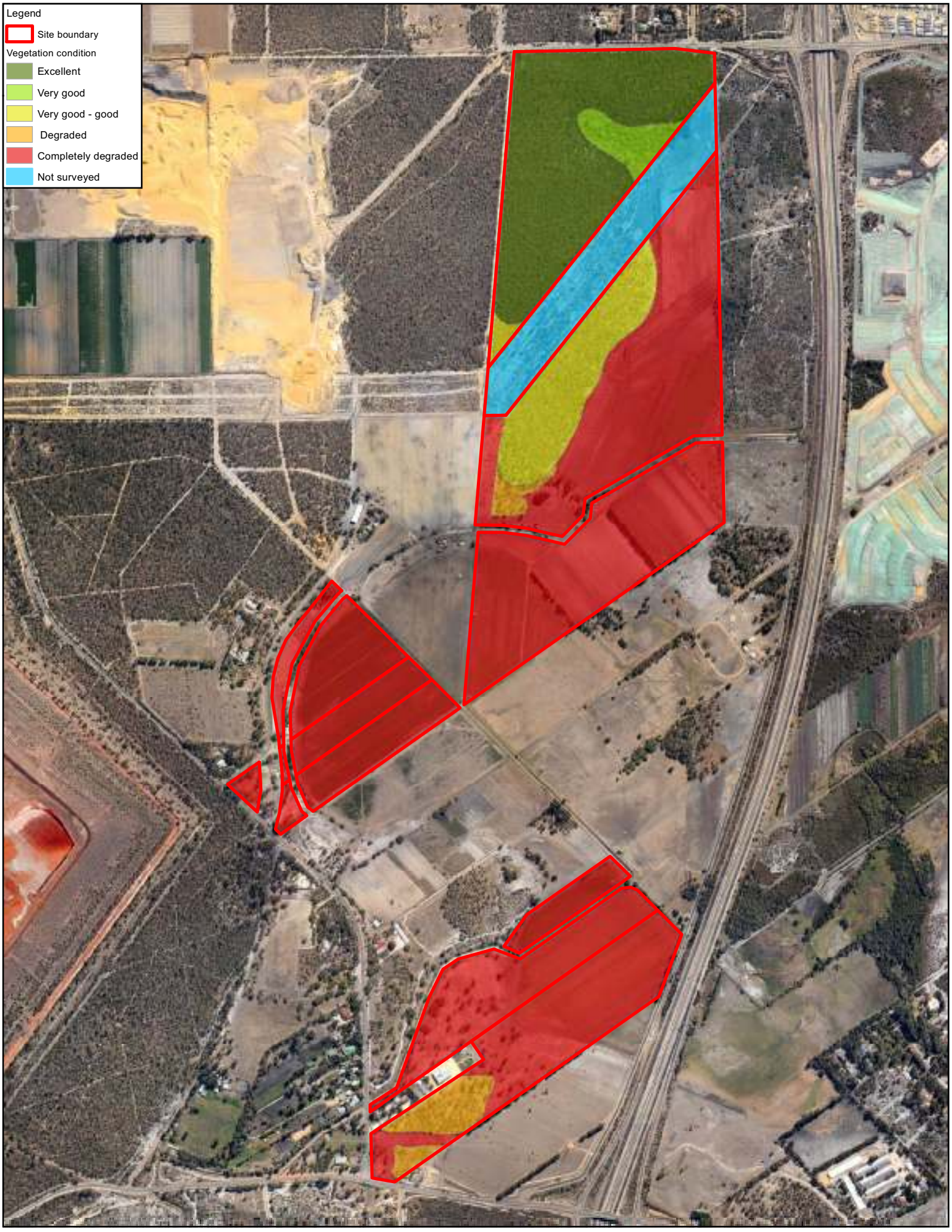

Client:
Qube Mandogalup Land Development Company

Project:
Mandogalup Graceful Sun-Moth Survey

Title:
Figure 4: Vegetation Condition

Metres
0 100 200 400

19/09/11 :Date
1:13,000@A4 :Scale
EP10-18(03)--F12b :Plan Number
JDH :Checked
JDH :Approved

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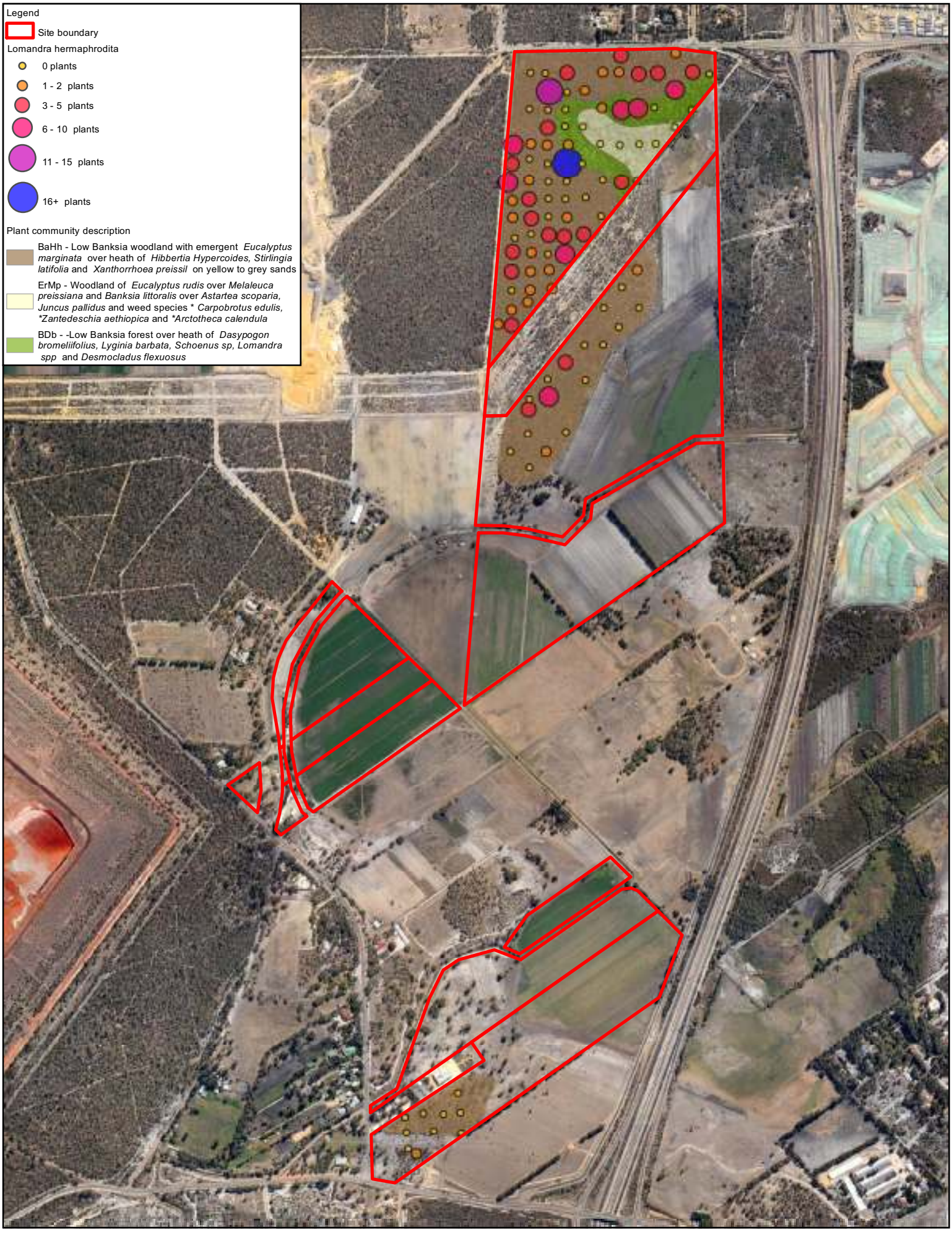

Client:
Qube Mandogalup Land Development Company

Project:
Mandogalup Graceful Sun-Moth Survey

Title:
Figure 5: Lomandra Density and Plant Communities

Metres
0 100 200 400

19/09/11 :Date
1:13,000@A4 :Scale
EP10-18(03)--F09b :Plan Number
JDH :Checked
JDH :Approved

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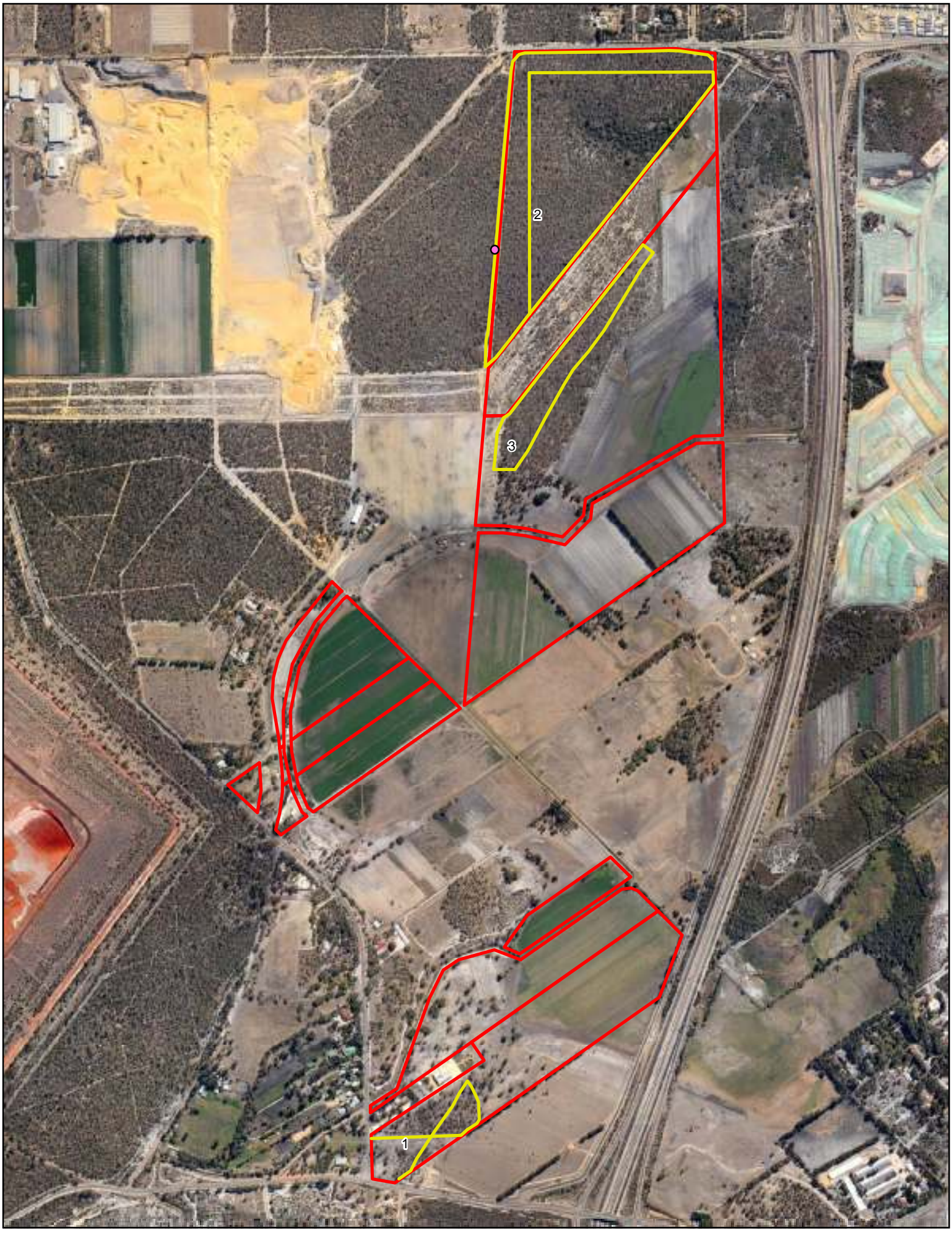

Client:
Qube Mandogalup Land Development Company

Project:
Mandogalup Graceful Sun-Moth Survey

Title:
Figure 6: Graceful Sun-Moths and Locations

Metres
0 100 200 400

Legend
Site boundary
Graceful sun-moth location
Transect path
2 Transect number

19/09/11 :Date
1:13,000@A4 :Scale
EP10-18(03)--F10b :Plan Number
JDH :Checked
JDH :Approved

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APPENDIX A

STANDARD DETAILS FOR TRANSECTS

Graceful sun-moth data sheet – one sheet per transect

Site name:	
Date:	Start time:
Observers:	End time:
Transect #:	Wind speed (km/hr):
Temperature C°:	Wind direction:

Comments

GSM specimen #	% Cloud	Comments (track / vegetation)	Easting	Northing	Time	Temp C°	Wind Speed

APPENDIX B

LOMANDRA DENSITY SURVEY – RAW DATA

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: E	Surface soil: light grey
Initials: GT	% Bare ground: 50%	Sub-surface soil: Yellow
Quadrat number: 2BW	Slope: Very gently inclined	% exposed rock: N/A
Transect number: 2B	Position in landscape: MS	Time since fire: > 5
Easting: 391439	Northing: 6437796	Veg condition: D - CD

Vegetation description/Comments
Open woodland - *Allocasuarina fraseriana, Eucalyptus marginata, Banksia menziesii* over scattered *Xanthorrhoea preissii* over **Ehrharta calycina*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: E-SE	Surface soil: Light grey
Initials: GT	% Bare ground: 50%	Sub-surface soil: Yellow
Quadrat number: 2AV	Slope: Very gently inclined	% exposed rock: N/A
Transect number: 2A	Position in landscape: US	Time since fire: >5
Easting: 391386	Northing: 6437840	Veg condition: D

Vegetation description/Comments
Low open woodland - *Banksia menziesii, Banksia attenuata* and emergent *Eucalyptus marginata* over *Xanthorrhoea preissii, Hibbertia hypericoides, Acanthocarpus preissii, Stirlingia latifolia* and **Ehrharta calycina*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: E-SE	Surface soil: light grey
Initials: GT	% Bare ground: 50%	Sub-surface soil: Yellow
Quadrat number: 2CV	Slope: Gently inclined	% exposed rock: N/A
Transect number: 2C	Position in landscape: LS	Time since fire: > 5
Easting: 391485	Northing: 6437840	Veg condition: D-G

Vegetation description/Comments
Low open forest - *Banksia attenuata, Banksia menziesii, Allocasuarina fraseriana and Eucalyptus marginata* over *Hibbertia hypericoides, Stirlingia laterfolia and Xanthorrhoea preissii*

Species	Cover/Count	Comments
L. hermaphrodita	2	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: SE	Surface soil: Light grey
Initials: GT	% Bare ground: 35%	Sub-surface soil: Yellow
Quadrat number: 2BU	Slope: Very gently inclined	% exposed rock: N/A
Transect number: 2B	Position in landscape: US	Time since fire: >5
Easting: 391435	Northing: 6437890	Veg condition: D-G

Vegetation description/Comments
Low open forest - *Banksia attenuata, Banksia menziesii, Allocasuarina fraseriana and Eucalyptus marginata* over *Hibbertia hypericoides, Stirlingia laterfolia and Xanthorrhoea preissii*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: E	Surface soil: light grey
Initials: GT	% Bare ground: 10%	Sub-surface soil: Yellow
Quadrat number: 2CS	Slope: Very gently inclined	% exposed rock: N/A
Transect number: 2C	Position in landscape:	Time since fire: > 5
Easting: 391493	Northing: 6437993	Veg condition: G

Vegetation description/Comments Woodland - *Banksia attenuata, Banksia menziesii* and *Eucalyptus marginata* over *Xanthorrhoea* preissii, *Acanthocarpus preissii* and *Hibbertia hypericoides*

Species	Cover/Count	Comments
L. hermaphrodita	8	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: N/A	Surface soil: Grey sand
Initials: GT	% Bare ground: 70	Sub-surface soil: Yellow sand
Quadrat number: 2BS	Slope: N/A	% exposed rock: N/A
Transect number: 2B	Position in landscape: Crest	Time since fire: >5
Easting: 391439	Northing: 6437985	Veg condition: D-G

Vegetation description/Comments Woodland - *Banksia attenuata, Banksia menziesii, Allocasuarina fraseriana* and *Eucalyptus marginata* over *Hibbertia hypericoides, Mesomelaena pseudostygia* and *Xanthorrhoea preissii*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: N/A	Surface soil: light grey
Initials: GT	% Bare ground: 15%	Sub-surface soil: Yellow
Quadrat number: 2CR	Slope: N/A	% exposed rock: N/A
Transect number: 2C	Position in landscape: Crest	Time since fire: > 5
Easting: 391490	Northing: 6438040	Veg condition: G

Vegetation description/Comments Low woodland - *Banksia attenuata, Banksia menziesii, Allocasuarina fraseriana* and*Eucalyptus marginata* over *Xanthorrhoea preissii, Hibbertia hypericoides* and *Mesomelaena pseudostygia*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Site Name:	Job No.

Date: 28/01/2011	Aspect:	Surface soil:
Initials:	% Bare ground:	Sub-surface soil:
Quadrat number:	Slope:	% exposed rock:
Transect number:	Position in landscape:	Time since fire:
Easting:	Northing:	Veg condition:

Vegetation description/Comments

Species	Cover/Count	Comments
L. hermaphrodita		
L.maritima		

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 25/01/2011	Aspect: W	Surface soil: grey sand
Initials: GT	% Bare ground: 40%	Sub-surface soil: grey sand
Quadrat number:1AC	Slope: Very gently inclined	% exposed rock: N/A
Transect number: 1A	Position in landscape: LS	Time since fire: > 5
Easting: 391098	Northing: 6435949	Veg condition: CD

Vegetation description/Comments
Low woodland - *Allocasuarina fraseriana, Banksia attenuata, Kunzea glabrescens* over *Xanthorrhoea preissii* and *Acacia pulchella*

Species	Cover/Count	Comments
L. hermaphrodita	0	Grazed
L.maritima	0	Grazed

Site Name: Mandogalup	Job No. EP10-018-003

Date: 25/01/2011	Aspect: w	Surface soil: grey sand
Initials: GT	% Bare ground: 20%	Sub-surface soil: grey sand
Quadrat number: 1BD	Slope: Very gently inclined	% exposed rock: N/A
Transect number: 1B	Position in landscape:	Time since fire: >5
Easting: 391144	Northing: 6436003	Veg condition: D

Vegetation description/Comments
Low woodland - *Banksia menziesii, Kunzea glabrescens, Allocasuarina fraseriana* over *Hibbertia hypericoides* and *Xanthorrhoea preissii* over weeds

Species	Cover/Count	Comments
L. hermaphrodita	0	L. caespitosa (1 plant)
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 25/01/2011	Aspect: W	Surface soil: grey sand
Initials: GT	% Bare ground: 10-15%	Sub-surface soil: grey sand
Quadrat number: 1CD	Slope: Very gently inclined	% exposed rock: N/A
Transect number: 1C	Position in landscape: MS	Time since fire: > 5
Easting: 391200	Northing: 6436000	Veg condition: D

Vegetation description/Comments Low woodland - *Banksia menziesii, Banksia attenuata* and *Allocasuarina fraseriana* over *Xanthorrhoea preissii, Hibbertia hypericoides* and *Acacia pulchella*

Species	Cover/Count	Comments
L. hermaphrodita	0	L. caespitosa (2 plants) and heavily grazed
L. maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 25/01/2011	Aspect: W	Surface soil: grey sand
Initials: GT	% Bare ground: 60%	Sub-surface soil: grey sand
Quadrat number: 1DD	Slope: Very gently inclined	% exposed rock: N/A
Transect number: 1D	Position in landscape: MS	Time since fire: >5
Easting: 391248	Northing: 6436005	Veg condition: D

Vegetation description/Comments Low woodland - *Banksia menziesii, Banksia attenuata* and *Allocasuarina fraseriana* over *Xanthorrhoea preissii, Hibbertia hypericoides* and *Acacia pulchella*

Species	Cover/Count	Comments
L. hermaphrodita	0	L. caespitosa
L. maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 25/01/2011	Aspect: W	Surface soil: yellow-grey sand
Initials: GT	% Bare ground: 30%	Sub-surface soil: as above
Quadrat number: 1DE	Slope: N/A	% exposed rock: N/A
Transect number: 1D	Position in landscape: MS	Time since fire: > 5
Easting: 391241	Northing: 6436059	Veg condition: D

Vegetation description/Comments
Low woodland - *Banksia menziesii, Banksia attenuata* and *Allocasuarina fraseriana* over *Xanthorrhoea preissii, Hibbertia hypericoides* and *Acacia pulchella*

Species	Cover/Count	Comments
L. hermaphrodita	0	*L. caespitosa*
L. maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 25/01/2011	Aspect: W	Surface soil: grey sand
Initials: GT	% Bare ground: 5%	Sub-surface soil: grey sand
Quadrat number: 1DC	Slope: N/A	% exposed rock: N/A
Transect number: 1D	Position in landscape: MS	Time since fire: >5
Easting: 391250	Northing: 6435948	Veg condition: D

Vegetation description/Comments
Low woodland - *Banksia menziesii, Banksia attenuata* and *Allocasuarina fraseriana* over *Xanthorrhoea preissii, Hibbertia hypericoides* and *Acacia pulchella*

Species	Cover/Count	Comments
L. hermaphrodita	0	*L. caespitosa present*
L. maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 25/01/2011	Aspect: W	Surface soil:grey sand
Initials: GT	% Bare ground: 60%	Sub-surface soil: grey sand
Quadrat number: Opp	Slope: Very gently inclined	% exposed rock: N/A
Transect number:	Position in landscape: LS	Time since fire: > 5
Easting: 391174	Northing: 6435953	Veg condition: D

Vegetation description/Comments
Scattered *Eucalyptus rudis* over Low woodland - *Banksia attenuata, Allocasuarina fraseriana, Kunzea glabrescens* over *Acacia pulchella* over weeds

Species	Cover/Count	Comments
L. hermaphrodita	0	*L. caespitosa*
L.maritima	0	

Site Name:	Job No.

Date:	Aspect:	Surface soil:
Initials:	% Bare ground:	Sub-surface soil:
Quadrat number:	Slope:	% exposed rock:
Transect number:	Position in landscape:	Time since fire:
Easting:	Northing:	Veg condition:

Vegetation description/Comments

Species	Cover/Count	Comments
L. hermaphrodita		
L.maritima		

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 25/01/2011	Aspect: W	Surface soil: dark grey sand
Initials: GT	% Bare ground: 2%	Sub-surface soil: grey sand
Quadrat number: 1AB	Slope: Very gently inclined	% exposed rock: N/A
Transect number: 1A	Position in landscape: LS	Time since fire: > 5
Easting: 391102	Northing: 6435904	Veg condition: CD

Vegetation description/Comments Low woodland - *Eucalyptus rudis, Kunzea glabrescens, Banksia menziesii* over *Xanthorrhoea preissii* over weeds

Species	Cover/Count	Comments
L. hermaphrodita	0	Understorey completely degraded, weeds.
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 25/01/2011	Aspect: W	Surface soil: grey sand
Initials: GT	% Bare ground: 40%	Sub-surface soil: grey sand
Quadrat number: Opp	Slope: Very gently inclined	% exposed rock: N/A
Transect number:	Position in landscape: LS	Time since fire: >5
Easting: 391126	Northing: 6435891	Veg condition: D

Vegetation description/Comments Low woodland - *Banksia attenuata, Banksia menziesii, Banksia illicifolia* and K*unzea glabrescens* over *Xanthorrhoea preissii* over weeds

Species	Cover/Count	Comments
L. hermaphrodita	2	Grazed to ground (Leaf litter including twigs approximately 10%)
L.maritima		

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 25/01/2011	Aspect: W/NW	Surface soil: grey sand
Initials: GT	% Bare ground: 50%	Sub-surface soil: grey sand
Quadrat number: 1AD	Slope: Very gently inclined	% exposed rock: N/A
Transect number: 1A	Position in landscape: LS	Time since fire: > 5
Easting: 391094	Northing: 6435992	Veg condition: CD

Vegetation description/Comments Scattered *Eucalyptus rudis* over *Kunzea glabrescens* over weeds

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Site Name:	Job No.

Date:	Aspect:	Surface soil:
Initials:	% Bare ground:	Sub-surface soil:
Quadrat number:	Slope:	% exposed rock:
Transect number:	Position in landscape:	Time since fire:
Easting:	Northing:	Veg condition:

Vegetation description/Comments

Species	Cover/Count	Comments
L. hermaphrodita		
L.maritima		

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 25/01/2011	Aspect: NE	Surface soil: brown-grey sand
Initials: GT	% Bare ground: N/A	Sub-surface soil: grey sand
Quadrat number: 2AE	Slope: Gently inclined	% exposed rock: N/A
Transect number: 2A	Position in landscape: US	Time since fire: > 5
Easting: 391395	Northing: 6438691	Veg condition: E

Vegetation description/Comments Low woodland - *Banksia menziesii, Banksia attenuata* and *Allocasuarina fraseriana* with emergent *Eucalyptus marginata* over *Xanthorrhoea preissii and Hibbertia hypericoides*

Species	Cover/Count	Comments
L. hermaphrodita	10	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 25/01/2011	Aspect: NE	Surface soil: yellow-grey sand
Initials: GT	% Bare ground: 20%	Sub-surface soil: yellow-grey
Quadrat number: 2AF	Slope: Very gently inclined	% exposed rock: N/A
Transect number: 2A	Position in landscape: US	Time since fire: >5
Easting: 391391	Northing: 6438638	Veg condition: E

Vegetation description/Comments Low woodland - *Banksia menziesii, Banksia attenuata* and *Allocasuarina fraseriana* with emergent *Eucalyptus marginata* over *Xanthorrhoea preissii and Hibbertia hypericoides*

Species	Cover/Count	Comments
L. hermaphrodita	3	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 25/01/2011	Aspect: NE	Surface soil: grey sand
Initials: GT	% Bare ground: 60%	Sub-surface soil: yellow sand
Quadrat number: 2AG	Slope: Very gently inclined	% exposed rock: N/A
Transect number: 2A	Position in landscape: Crest	Time since fire: > 5
Easting: 391380	Northing: 6438587	Veg condition: E

Vegetation description/Comments
Low woodland - *Banksia menziesii, Banksia attenuata* and *Allocasuarina fraseriana* with emergent *Eucalyptus marginata* over *Xanthorrhoea preissii and Hibbertia hypericoides*

Species	Cover/Count	Comments
L. hermaphrodita	10	Approximately 2%
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 25/01/2011	Aspect: NW	Surface soil: light grey sand
Initials: GT	% Bare ground: 20%	Sub-surface soil: yellow sand
Quadrat number: 2AH	Slope: Very gently inclined	% exposed rock: N/A
Transect number: 2A	Position in landscape: Crest	Time since fire: >5
Easting: 391392	Northing: 6438536	Veg condition: E

Vegetation description/Comments
Low woodland - *Banksia attenuata, Banksia menziesii* and *Allocasuarina fraseriana* over *Hibbertia hypericoide* s, *Mesomelaena pseudostygia* and *Xanthorrhoea preissii*

Species	Cover/Count	Comments
L. hermaphrodita	2	Less than 1%
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 25/01/2011	Aspect: N	Surface soil: light brown-grey
Initials: GT	% Bare ground: 20%	Sub-surface soil: yellow
Quadrat number: 2AI	Slope: Very gently inclined	% exposed rock: N/A
Transect number: 2A	Position in landscape: Crest	Time since fire: >5
Easting: 391393	Northing: 6438490	Veg condition: E

Vegetation description/Comments
Low woodland/forest - *Banksia attenuata, Banksia menziesii* and *Allocasuarina fraseriana* over *Xanthorrhoea preissii, Mesomelaena pseudostygia, Hibbertia hypericoides* and *Stirlingia laterifolia*

Species	Cover/Count	Comments
L. hermaphrodita	1	Approximately 1%
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 25/01/2011	Aspect: NW	Surface soil: light grey
Initials: GT	% Bare ground: N/A	Sub-surface soil: yellow
Quadrat number: 2AJ	Slope: Very gently inclined	% exposed rock: N/A
Transect number: 2A	Position in landscape: Crest	Time since fire: >5
Easting: 391398	Northing: 6438433	Veg condition: E

Vegetation description/Comments
Low woodland/forest - *Banksia attentuata, Banksia menzeissi* and *Allocasuarina fraseriana* over *Xanthorrhoea preissii, Mesomelaena pseudostygia, Hibbertia hypericoides* and *Stirlingia laterifolia*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 25/01/2011	Aspect: N/A	Surface soil: light grey
Initials: GT	% Bare ground: 40%	Sub-surface soil: yellow
Quadrat number: 2AK	Slope: N/A	% exposed rock: N/A
Transect number: 2A	Position in landscape: Crest	Time since fire: >5
Easting: 391393	Northing: 6438395	Veg condition: E

Vegetation description/Comments
Low woodland/forest - *Banksia attenuata, Banksia menziesii* and *Allocasuarina fraseriana* over *Xanthorrhoea preissii, Mesomelaena pseudostygia, Hibbertia hypericoides* and *Stirlingia laterifolia*

Species	Cover/Count	Comments
L. hermaphrodita	4	Approximately 1%
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 25/01/2011	Aspect: SE	Surface soil: light grey
Initials: GT	% Bare ground: 10%	Sub-surface soil: yellow
Quadrat number: 2AL	Slope: Gently inclined	% exposed rock: N/A
Transect number: 2A	Position in landscape: US	Time since fire: >5
Easting: 391389	Northing: 6438338	Veg condition: E

Vegetation description/Comments
Low woodland - *Banksia menziesii, Banksia attenuata* and *Allocasuarina fraseriana* with emergent *Eucalyptus marginata* over *Hibbertia hypericoides, Mesomelaena pseudostygia, Xanthorrhoea preissii* and *Stirlingia laterifolia*

Species	Cover/Count	Comments
L. hermaphrodita	5	Approximately 1%
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 25/01/2011	Aspect: SE	Surface soil: light grey sand
Initials: GT	% Bare ground: 40%	Sub-surface soil: yellow sand
Quadrat number: 2AM	Slope: Gently inclined	% exposed rock: N/A
Transect number: 2A	Position in landscape: MS	Time since fire: >5
Easting: 391389	Northing: 6438286	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia attenuata, Banksia menziesii* and *Allocasuarina fraseriana* over *Xanthorrhoea preissii, Stirlingia laterifolia* and *Hibbertia hypericoides*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 25/01/2011	Aspect: SW	Surface soil: light grey sand
Initials: GT	% Bare ground: 5%	Sub-surface soil: yellow sand
Quadrat number: 2AN	Slope: Gently inclined	% exposed rock: N/A
Transect number: 2A	Position in landscape: LS	Time since fire: >5
Easting: 391390	Northing: 6438233	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia menziesii, Banksia attenuata, Allocasuarina fraseriana* and *Xylomelum occidentale* over *Stirlingia laterifolia* and *Patersonia occidentalis*

Species	Cover/Count	Comments
L. hermaphrodita	2	Approximately 1%
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 25/01/2011	Aspect: N/A	Surface soil: grey sand
Initials: GT	% Bare ground: 30%	Sub-surface soil: yellow sand
Quadrat number: 2AO	Slope: N/A	% exposed rock: N/A
Transect number: 2A	Position in landscape: LS	Time since fire: >5
Easting: 391390	Northing: 6438191	Veg condition: VG

Vegetation description/Comments Open forest - *Eucalyptus marginata* and *Xylomelum occidentale* over *Allocasuarina fraseriana, Banksia attenuata* over *Hibbertia hypericoides, Xanthorrhoea preissii* and *Mesomelaena pseudostygia.*

Species	Cover/Count	Comments
L. hermaphrodita	3	Approximately 1%
L.maritima	1%	Collected specimen

Site Name: Mandogalup	Job No. EP10-018-003

Date: 25/02/2011	Aspect: SE	Surface soil: light grey
Initials: GT	% Bare ground: 20%	Sub-surface soil: yellow sand
Quadrat number: 2O	Slope: N/A	% exposed rock: N/A
Transect number: 2	Position in landscape: MS-LS	Time since fire: >5
Easting: 391352	Northing: 6438193	Veg condition: VG

Vegetation description/Comments Low open forest 0 *Banksia attenuata, Xylomelum occidentale* and *Allocasuarina fraseriana* over *Hibbertia hypericoides, Mesomelaena pseudostygia, Xanthorrhoea preissii* and **Ehrharta calycina*

Species	Cover/Count	Comments
L. hermaphrodita	1	Approximately 1%
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 25/01/2011	Aspect: SW	Surface soil: light grey sand
Initials: GT	% Bare ground: 50%	Sub-surface soil: yellow sand
Quadrat number: 2BN	Slope: Very gently inclined	% exposed rock: N/A
Transect number: 2B	Position in landscape: LS	Time since fire: >5
Easting: 391435	Northing: 6438254	Veg condition: VG

Vegetation description/Comments
Low open forest with emergent *Eucalyptus marginata* over *Xanthorrhoea preissii* over *Hibbertia hypericoides* and *Mesomelaena pseudostygia*

Species	Cover/Count	Comments
L. hermaphrodita	2	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 25/01/2011	Aspect: SE	Surface soil: light grey sand
Initials: GT	% Bare ground: N/A	Sub-surface soil: yellow sand
Quadrat number: 2BM	Slope: Very gently inclined	% exposed rock: N/A
Transect number: 2B	Position in landscape: MS	Time since fire: >5
Easting: 391441	Northing: 6438288	Veg condition: E

Vegetation description/Comments
Low open forest with emergent *Eucalyptus marginata* over *Xanthorrhoea preissii* over *Hibbertia hypericoides* and *Mesomelaena pseudostygia*

Species	Cover/Count	Comments
L. hermaphrodita	2	> 1%
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 25/01/2011	Aspect: SE	Surface soil: white-light grey
Initials: GT	% Bare ground: 60%	Sub-surface soil: yellow
Quadrat number: 2BL	Slope: Gently inclined	% exposed rock: N/A
Transect number: 2B	Position in landscape: MS	Time since fire: >5
Easting: 391442	Northing: 6438338	Veg condition: E

Vegetation description/Comments
Low open woodland - *Banksia attenuata, Banksia menziesii* and *Allocasuarina fraseriana* over *Hibbertia hypericoides and Xanthorrhoea preissii*

Species	Cover/Count	Comments
L. hermaphrodita	2	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 25/01/2011	Aspect: SE	Surface soil: light grey
Initials: GT	% Bare ground: 10%	Sub-surface soil: yellow
Quadrat number: 2BK	Slope: Gently inclined	% exposed rock: N/A
Transect number: 2B	Position in landscape: US	Time since fire: >5
Easting: 391445	Northing: 6438393	Veg condition: E

Vegetation description/Comments
Low open woodland - *Banksia attenuata, Banksia menziesii* and *Allocasuarina fraseriana* over *Hibbertia hypericoides and Xanthorrhoea preissii*

Species	Cover/Count	Comments
L. hermaphrodita	2	
L.maritima	< 1%	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 25/01/2011	Aspect: E-NE	Surface soil: light grey
Initials: GT	% Bare ground: 15%	Sub-surface soil: yellow
Quadrat number: 2BJ	Slope: Very gently inclined	% exposed rock: N/A
Transect number: 2B	Position in landscape:	Time since fire: >5
Easting: 391443	Northing: 6438444	Veg condition: E

Vegetation description/Comments
Low open woodland - *Banksia attenuata, Banksia menziesii* and *Allocasuarina fraseriana* over *Hibbertia hypericoides and Xanthorrhoea preissii*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 25/01/2011	Aspect: E	Surface soil: light grey
Initials: GT	% Bare ground: 10%	Sub-surface soil: yellow
Quadrat number: 2BI	Slope: very gently inclined	% exposed rock: N/A
Transect number: 2B	Position in landscape: US	Time since fire: >5
Easting: 391445	Northing: 6438487	Veg condition: E

Vegetation description/Comments
Low open woodland - *Banksia attenuata, Banksia menziesii* and *Allocasuarina fraseriana* over *Hibbertia hypericoides and Xanthorrhoea preissii*

Species	Cover/Count	Comments
L. hermaphrodita	5	
L.maritima	1%	Sample collected

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 25/01/2011	Aspect: E	Surface soil: light grey
Initials: GT	% Bare ground: 30%	Sub-surface soil: yellow
Quadrat number: 2BH	Slope: Very gently inclined	% exposed rock: N/A
Transect number: 2B	Position in landscape:	Time since fire: >5
Easting: 391438	Northing: 6438540	Veg condition: E

Vegetation description/Comments
Low open woodland - *Banksia attenuata, Banksia menziesii* and *Allocasuarina fraseriana* over *Hibbertia hypericoides and Xanthorrhoea preissii*

Species	Cover/Count	Comments
L. hermaphrodita	4	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 25/01/2011	Aspect: NE	Surface soil: light grey
Initials: GT	% Bare ground: 10%	Sub-surface soil: yellow
Quadrat number: 2BG	Slope: Gently inclined	% exposed rock: N/A
Transect number: 2B	Position in landscape: US	Time since fire: >5
Easting: 391438	Northing: 6438593	Veg condition: E

Vegetation description/Comments
Low open woodland - *Banksia attenuata, Banksia menziesii* and *Allocasuarina fraseriana* over *Hibbertia hypericoides and Xanthorrhoea preissii*

Species	Cover/Count	Comments
L. hermaphrodita	2	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 25/01/2011	Aspect: E	Surface soil: light grey
Initials: GT	% Bare ground: 10%	Sub-surface soil: yellow
Quadrat number: 2BF	Slope: Very gently inclined	% exposed rock: N/A
Transect number: 2B	Position in landscape: US	Time since fire: >5
Easting: 391439	Northing: 6438653	Veg condition: E

Vegetation description/Comments
Low open woodland - *Banksia attenuata, Banksia menziesii* and *Allocasuarina fraseriana* over *Hibbertia hypericoides and Xanthorrhoea preissii*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	1%	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 25/01/2011	Aspect: NE	Surface soil: light grey
Initials: GT	% Bare ground: 40%	Sub-surface soil: yellow
Quadrat number: 2BE	Slope: Gently inclined	% exposed rock: N/A
Transect number: 2B	Position in landscape: US	Time since fire: >5
Easting: 391443	Northing: 6438695	Veg condition: E

Vegetation description/Comments
Low open woodland - *Banksia attenuata, Banksia menziesii* and *Allocasuarina fraseriana* over *Hibbertia hypericoides and Xanthorrhoea preissii*

Species	Cover/Count	Comments
L. hermaphrodita	1	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: S	Surface soil: white/grey sand
Initials: GT	% Bare ground: 10%	Sub-surface soil: yellow sand
Quadrat number: 2BC	Slope: Gently inclined	% exposed rock: N/A
Transect number: 2B	Position in landscape: MS	Time since fire: >5
Easting: 391439	Northing: 6438790	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia menziesii, Banksia attenuata, Allocasuarina fraseriana* with emergent *Eucalyptus marginata* over *Xanthorrhoea preissii, Hibbertia hypericoides* and *Leucopogon sp* .

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: S-SE	Surface soil: white/grey sand
Initials: GT	% Bare ground: 10%	Sub-surface soil: yellow sand
Quadrat number: 2CA	Slope: Very gently inclined	% exposed rock: N/A
Transect number: 2C	Position in landscape: US	Time since fire: >5
Easting: 391483	Northing: 6438892	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia menziesii, Banksia attenuata, Allocasuarina fraseriana* with emergent *Eucalyptus marginata* over *Xanthorrhoea preissii, Hibbertia hypericoides* and *Leucopogon sp* .

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: S	Surface soil: grey sand
Initials: GT	% Bare ground: 25%	Sub-surface soil: yellow sand
Quadrat number: 2CB	Slope: Gently inclined	% exposed rock: N/A
Transect number: 2C	Position in landscape: US	Time since fire:>5
Easting: 391495	Northing: 6438840	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia menziesii, Banksia attenuata* and *Allocasuarina fraseriana* with emergent *Eucalyptus marginata* over *Hibbertia hypericoides, Xanthorrhoea preissii* and *Stirlingia laterifolia*

Species	Cover/Count	Comments
L. hermaphrodita	12	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: SE	Surface soil: grey sand
Initials: GT	% Bare ground: 40%	Sub-surface soil: yellow sand
Quadrat number: 2CC	Slope: Gently inclined	% exposed rock: N/A
Transect number: 2C	Position in landscape: MS	Time since fire: >5
Easting: 391491	Northing: 6438788	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia menziesii, Banksia attenuata* and *Allocasuarina fraseriana* with emergent *Eucalyptus marginata* over *Hibbertia hypericoides, Xanthorrhoea preissii* and *Stirlingia laterifolia*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: E	Surface soil: white/grey sand
Initials: GT	% Bare ground: 70%	Sub-surface soil: yellow sand
Quadrat number: 2CD	Slope: Gently inclined	% exposed rock: N/A
Transect number: 2C	Position in landscape: MS	Time since fire: >5
Easting: 391490	Northing: 6438739	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia menziesii, Banksia attenuata* and *Allocasuarina fraseriana* with emergent *Eucalyptus marginata* over *Hibbertia hypericoides, Xanthorrhoea preissii, Stirlingia laterifolia* and *Scholtzia involucrata*

Species	Cover/Count	Comments
L. hermaphrodita	3	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: E	Surface soil: grey sand
Initials: GT	% Bare ground: 40%	Sub-surface soil: yellow sand
Quadrat number: 2CE	Slope: Gently inclined	% exposed rock: N/A
Transect number: 2C	Position in landscape: MS	Time since fire: >5
Easting: 391489	Northing: 6438691	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia menziesii, Banksia attenuata* and *Allocasuarina fraseriana* with emergent *Eucalyptus marginata* over *Hibbertia hypericoides, Xanthorrhoea preissii, Stirlingia laterifolia* and *Scholtzia involucrata*

Species	Cover/Count	Comments
L. hermaphrodita	2	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: NE	Surface soil: grey sand
Initials: GT	% Bare ground: 0%	Sub-surface soil: yellow sand
Quadrat number: 2CF	Slope: Gently inclined	% exposed rock: N/A
Transect number: 2C	Position in landscape: MS	Time since fire: >5
Easting: 391490	Northing: 6438639	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia menziesii, Banksia attenuata* and *Allocasuarina fraseriana* with emergent *Eucalyptus marginata* over *Hibbertia hypericoides, Xanthorrhoea preissii, Stirlingia laterifolia* and *Scholtzia involucrata*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: NE	Surface soil: white/grey sand
Initials: GT	% Bare ground: 40%	Sub-surface soil: yellow sand
Quadrat number: 2CG	Slope: Gently inclined	% exposed rock: N/A
Transect number: 2C	Position in landscape: US	Time since fire: >5
Easting: 391492	Northing: 6438589	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia menziesii, Banksia attenuata* and *Allocasuarina fraseriana* over *Xanthorrhoea preissii, Hibbertia hypericoides, Mesomelaena pseudostygia* and *Stirlingia laterifolia*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: N-NE	Surface soil: grey sand
Initials: GT	% Bare ground: 40%	Sub-surface soil: yellow sand
Quadrat number: 2CH	Slope: Very gently inclined	% exposed rock: N/A
Transect number: 2C	Position in landscape:	Time since fire: >5
Easting: 391492	Northing: 6438542	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia attenuata, Banksia menziesii, Allocasuarina fraseriana* over *Allocasuarina humilis, Xanthorrhoea preissii* and *Mesomelaena pseudostygia*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: NE	Surface soil: white/grey sand
Initials: GT	% Bare ground: 20%	Sub-surface soil: yellow sand
Quadrat number: 2CI	Slope: Gently inclined	% exposed rock: N/A
Transect number: 2C	Position in landscape:	Time since fire: >5
Easting: 391491	Northing: 6438492	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia attenuata, Banksia menziesii* and *Allocasuarina fraseriana* over *Hibbertia hypericoides, Mesomelaena pseudostygia* and *Xanthorrhoea preissii*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: N-NE	Surface soil: grey sand
Initials: GT	% Bare ground: 40%	Sub-surface soil: yellow sand
Quadrat number: 2CJ	Slope: Very gently inclined	% exposed rock: N/A
Transect number: 2C	Position in landscape: US	Time since fire: >5
Easting: 391493	Northing: 6438442	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia attenuata, Banksia menziesii* and *Allocasuarina fraseriana* over *Hibbertia hypericoides, Mesomelaena pseudostygia* and *Xanthorrhoea preissii*

Species	Cover/Count	Comments
L. hermaphrodita	3	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: NE	Surface soil: grey sand
Initials: GT	% Bare ground: 10%	Sub-surface soil: yellow sand
Quadrat number: 2CK	Slope: Gently inclined	% exposed rock: N/A
Transect number: 2C	Position in landscape: MS	Time since fire: >5
Easting: 391491	Northing: 6438389	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia attenuata, Banksia menziesii* and *Allocasuarina fraseriana* over *Hibbertia hypericoides, Mesomelaena pseudostygia* and *Xanthorrhoea preissii*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: N/A	Surface soil: grey sand
Initials: GT	% Bare ground: 5%	Sub-surface soil: yellow sand
Quadrat number: 2CL	Slope: N/A	% exposed rock: N/A
Transect number: 2C	Position in landscape: Flat	Time since fire: >5
Easting: 391494	Northing: 6438342	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia attenuata, Banksia menziesii* and *Allocasuarina fraseriana* with emergent *Eucalyptus marginata* over *Hibbertia hypericoides, Mesomelaena pseudostygia, Dasypogon bromeliifolius* and *Xanthorrhoea preissii*

Species	Cover/Count	Comments
L. hermaphrodita	1	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: N/A	Surface soil: grey sand
Initials: GT	% Bare ground: 30%	Sub-surface soil: yellow sand
Quadrat number: 2CM	Slope: N/A	% exposed rock: N/A
Transect number: 2C	Position in landscape: Flat	Time since fire: >5
Easting: 391502	Northing: 6438291	Veg condition: G

Vegetation description/Comments
Adjacent to firebreak. Low open forest - *Banksia attenuata and Banksia menziesii* over *Hibbertia hypericoides, Scholtzia involucrata* and M*esomelaena pseudostygia*

Species	Cover/Count	Comments
L. hermaphrodita	1	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: N/A	Surface soil: grey/brown sand
Initials: GT	% Bare ground: 30%	Sub-surface soil: yellow sand
Quadrat number: 2EJ	Slope: N/A	% exposed rock: N/A
Transect number: 2E	Position in landscape: Flat	Time since fire: >5
Easting: 391590	Northing: 6438444	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia attenuata, Banksia menziesii and Allocasuarina fraseriana* with emergent *Eucalyptus marginata* over *Hibbertia hypericoides, Xanthorrhoea preissii* and *Lyginia barbata*

Species	Cover/Count	Comments
L. hermaphrodita	3	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: N-NE	Surface soil: light grey sand
Initials: GT	% Bare ground: 10%	Sub-surface soil: yellow sand
Quadrat number: 2EH	Slope: N/A	% exposed rock: N/A
Transect number: 2E	Position in landscape: N/A	Time since fire: >5
Easting: 391595	Northing: 6438545	Veg condition: E

Vegetation description/Comments
Fox den present.
Low open forest - *Banksia attenuata, Banksia menziesii and Allocasuarina fraseriana* with emergent *Eucalyptus marginata* over *Hibbertia hypericoides, Xanthorrhoea preissii* and *Lyginia barbata*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: NE	Surface soil: grey sand
Initials: GT	% Bare ground: 25%	Sub-surface soil:
Quadrat number: 2EF	Slope: Very gently inclined	% exposed rock: N/A
Transect number: 2E	Position in landscape: LS	Time since fire: >5
Easting: 391585	Northing: 6438639	Veg condition: VG

Vegetation description/Comments Low open forest - *Banksia attenuata, Banksia illicifolia, Banksia menziesii* and *Nuytsia floribunda* over *Dasypogon bromeliifolius*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: N/A	Surface soil: grey sand
Initials: GT	% Bare ground: 0%	Sub-surface soil:
Quadrat number: 2ED	Slope: N/A	% exposed rock: N/A
Transect number: 2E	Position in landscape: Dep.	Time since fire: >5
Easting: 391588	Northing: 6438742	Veg condition: E-VG

Vegetation description/Comments Open forest - *Banksia illicifolia* and M*elaleuca preissiana* over *Astartea scoparia* and *Xanthorrhoea preissii* over D*asypogon bromeliifolius*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: S-E	Surface soil: grey sand
Initials: GT	% Bare ground: 15%	Sub-surface soil: yellow sand
Quadrat number: 2EB	Slope: Gently inclined	% exposed rock: N/A
Transect number: 2E	Position in landscape: MS	Time since fire: >5
Easting: 391593	Northing: 6438843	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia attenuata and Banksia menziesii* with emergent *Eucalyptus marginata* over *Hibbertia hypericoides, Xanthorrhoea preissii* and *Macrozamia riedlei*

Species	Cover/Count	Comments
L. hermaphrodita	2	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: S	Surface soil: light grey sand
Initials: GT	% Bare ground: 35%	Sub-surface soil: yellow sand
Quadrat number: 2GAA	Slope: Very gently inclined	% exposed rock: N/A
Transect number: 2G	Position in landscape: US	Time since fire: >5
Easting: 391693	Northing: 6438940	Veg condition: E

Vegetation description/Comments
Low open woodland/forest - *Banksia attenuata and Banksia menziesii* with emergent *Eucalyptus marginata* over *Hibbertia hypericoides, Xanthorrhoea preissii* and *Macrozamia riedlei*

Species	Cover/Count	Comments
L. hermaphrodita	4	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: S	Surface soil: light grey sand
Initials: GT	% Bare ground: 15%	Sub-surface soil: yellow sand
Quadrat number: 2GA	Slope: very gently inclined	% exposed rock: N/A
Transect number: 2G	Position in landscape: US	Time since fire: N/A
Easting: 391688	Northing: 6438895	Veg condition: E

Vegetation description/Comments
Low open woodland - *Banksia attenuata and Banksia menziesii* over *Hibbertia hypericoides, Xanthorrhoea preissii* and *Macrozamia riedlei*

Species	Cover/Count	Comments
L. hermaphrodita	1	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: S-SE	Surface soil: grey sand
Initials: GT	% Bare ground: 80%	Sub-surface soil:
Quadrat number: 2GC	Slope: Gently inclined	% exposed rock: N/A
Transect number: 2G	Position in landscape: LS	Time since fire: >5
Easting: 391695	Northing: 6438788	Veg condition: E-VG

Vegetation description/Comments
Low open woodland - *Banksia attenuata and Banksia menziesii* over *Hibbertia hypericoides, Xanthorrhoea preissii* and *Macrozamia riedlei*

Species	Cover/Count	Comments
L. hermaphrodita	9	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: N/A	Surface soil: grey sand
Initials: GT	% Bare ground: 50%	Sub-surface soil:
Quadrat number: 2GE	Slope: N/A	% exposed rock: N/A
Transect number: 2G	Position in landscape: Dep.	Time since fire: >5
Easting: 391690	Northing: 6438691	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia illicifolia, Banksia attenuata, Banksia menziesii, Melaleuca preissiana* and *Allocasuarina fraseriana* over *Astartea scoparia, Adenanthos cygnorum* and *Dasypogon bromeliifolius*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: N	Surface soil: light grey sand
Initials: GT	% Bare ground: 5%	Sub-surface soil: yellow sand
Quadrat number: 2GG	Slope: very gently inclined	% exposed rock: N/A
Transect number: 2G	Position in landscape: LS	Time since fire: >5
Easting: 391695	Northing: 6438588	Veg condition: VG

Vegetation description/Comments
Low open forest - B*anksia illicifolia, Banksia menziesii* and *Banksia attenuata* with emergent *Eucalyptus marginata* over dense *Dasypogon bromeliifolius* and sedges.

Species	Cover/Count	Comments
L. hermaphrodita	3	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: N	Surface soil: brown organics
Initials: GT	% Bare ground: 0%	Sub-surface soil: grey sand
Quadrat number: 2IE	Slope: N/A	% exposed rock: N/A
Transect number: 2I	Position in landscape: Dep.	Time since fire: >5
Easting: 391790	Northing: 6438695	Veg condition: VG

Vegetation description/Comments
Open tall forest - *Melaleuca preissiana* and *Eucalyptus marginata* over *Kunzea glabrescens, Astartea scoparia* and *Xanthorrhoea preissii* over D*asypogon bromeliifolius*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: S-SW	Surface soil: light grey sand
Initials: GT	% Bare ground: 50%	Sub-surface soil: yellow sand
Quadrat number: 2IC	Slope: gently inclined	% exposed rock: N/A
Transect number: 2I	Position in landscape: LS	Time since fire: >5
Easting: 391785	Northing: 6438795	Veg condition: VG-E

Vegetation description/Comments
Low open forest - *Banksia illicifolia, Banksia menziesii and Banksia attenuata* over *Xanthorrhoea preissii, Stirlingia laterifolia and Dasypogon bromeliifolius*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: S-SE	Surface soil: light grey sand
Initials: GT	% Bare ground: 50%	Sub-surface soil: yellow sand
Quadrat number: 2IA	Slope: very gently inclined	% exposed rock: N/A
Transect number: 2I	Position in landscape: MS	Time since fire: >5
Easting: 391795	Northing: 6438891	Veg condition: E

Vegetation description/Comments
Low open woodland - B*anksia attenuata, Banksia menziesii and Banksia illicifolia* with emergent *Eucalyptus marginata*

Species	Cover/Count	Comments
L. hermaphrodita	5	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: S-SW	Surface soil: light grey sand
Initials: GT	% Bare ground: 0%	Sub-surface soil: yellow sand
Quadrat number: 2LA	Slope: very gently inclined	% exposed rock: N/A
Transect number: 2L	Position in landscape: MS	Time since fire: >5
Easting: 391938	Northing: 6438889	Veg condition: VG

Vegetation description/Comments
Low open forest - *Banksia attenuata, Banksia menziesii, Eucalyptus marginata* and *Allocasuarina fraseriana* over *Xanthorrhoea preissii, Hibbertia hypericoides* and *Kunzea glabrescens*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: E	Surface soil: light grey sand
Initials: GT	% Bare ground: 0%	Sub-surface soil: yellow sand
Quadrat number: 2DU	Slope: gently inclined	% exposed rock: N/A
Transect number: 2D	Position in landscape: MS	Time since fire: >5
Easting: 391540	Northing: 6437895	Veg condition: G

Vegetation description/Comments
Low open forest - *Banksia attenuata, Banksia menziesii, Eucalyptus marginata* and *Allocasuarina fraseriana.*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: E	Surface soil: light grey/brown
Initials: GT	% Bare ground: 40%	Sub-surface soil: yellow sand
Quadrat number: 2CT	Slope: very gently inclined	% exposed rock: N/A
Transect number: 2C	Position in landscape: US	Time since fire: >5
Easting: 391437	Northing: 6437958	Veg condition: G

Vegetation description/Comments
Low open forest - *Banksia attenuata, Banksia menziesii, Eucalyptus marginata* and *Allocasuarina fraseriana.*

Species	Cover/Count	Comments
L. hermaphrodita	4	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: E	Surface soil: light grey sand
Initials: KK	% Bare ground: 80%	Sub-surface soil: yellow sand
Quadrat number: 2DQ	Slope: gently inclined	% exposed rock: N/A
Transect number: 2D	Position in landscape: US	Time since fire: >5
Easting: 391539	Northing: 6438086	Veg condition: G-P

Vegetation description/Comments
Low open forest - *Eucalyptus marginata, Banksia attenuata, Allocasuarina fraseriana* over *Xanthorrhoea preissii, Hibbertia hypericoides* over weeds

Species	Cover/Count	Comments
L. hermaphrodita	4	Approximately 1%
L.maritima		

Site Name: Mandogalup	Job No. EP10-018-003

Date:	Aspect:	Surface soil:
Initials:	% Bare ground:	Sub-surface soil:
Quadrat number:	Slope:	% exposed rock:
Transect number:	Position in landscape:	Time since fire:
Easting:	Northing:	Veg condition:

Vegetation description/Comments

Species	Cover/Count	Comments
L. hermaphrodita		
L.maritima		

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: E	Surface soil: light grey sand
Initials: KK	% Bare ground: 70%	Sub-surface soil: yellow sand
Quadrat number: 2HL	Slope: very gently inclined	% exposed rock: N/A
Transect number: 2H	Position in landscape: MS	Time since fire: >5
Easting: 391738	Northing: 6438342	Veg condition: G

Vegetation description/Comments
Low woodland - *Eucalyptus marginata, Allocasuarina fraseriana, Banksia attenuata, Banksia illicifolia and Banksia menziesii* over *Hibbertia hypericoides, Xanthorrhoea preissii and Stirlingia laterifolia*

Species	Cover/Count	Comments
L. hermaphrodita	1	< 1%
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: E	Surface soil: light grey sand
Initials: KK	% Bare ground: 30%	Sub-surface soil: grey sand
Quadrat number: 2HN	Slope: very gently inclined	% exposed rock: N/A
Transect number: 2H	Position in landscape: MS	Time since fire: >5
Easting: 391743	Northing: 6438238	Veg condition: P

Vegetation description/Comments
Low woodland - *Eucalyptus marginata, Banksia attenuata, Banksia illicifolia, Banksia menziesii* over *Xanthorrhoea preissii, Carpobrotus modestus* and weeds

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: NE	Surface soil: light grey sand
Initials: KK	% Bare ground: 80%	Sub-surface soil: yellow sand
Quadrat number: 2GO	Slope: gently inclined	% exposed rock: N/A
Transect number: 2G	Position in landscape: MS	Time since fire: >5
Easting: 391688	Northing: 6438185	Veg condition: P

Vegetation description/Comments
Low woodland - *Eucalyptus marginata, Banksia attenuata, Banksia menziesii, Banksia illicifolia* over *Hibbertia hypericoides, Xanthorrhoea preissii* and weeds.

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: E	Surface soil: light grey sand
Initials: KK	% Bare ground: 70%	Sub-surface soil: grey sand
Quadrat number: 2GM	Slope: gently inclined	% exposed rock: N/A
Transect number: 2G	Position in landscape: US	Time since fire: >5
Easting: 391695	Northing: 6438295	Veg condition: P

Vegetation description/Comments
Low woodland - *Eucalyptus marginata, Banksia attenuata, Banksia menziesii, Banksia illicifolia* over *Hibbertia hypericoides, Xanthorrhoea preissii* and weeds.

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: E	Surface soil: light grey sand
Initials: KK	% Bare ground: 20%	Sub-surface soil: yellow sand
Quadrat number: 2FN	Slope: gently inclined	% exposed rock: N/A
Transect number: 2F	Position in landscape: US	Time since fire: >5
Easting: 391646	Northing: 6438238	Veg condition: G

Vegetation description/Comments
Low woodland - *Eucalyptus marginata, Banksia attenuata, Banksia menziesii, Banksia illicifolia* over *Hibbertia hypericoides, Xanthorrhoea preissii* and weeds.

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: E	Surface soil: light grey sand
Initials: KK	% Bare ground: 10%	Sub-surface soil: yellow sand
Quadrat number: 2FP	Slope: gently inclined	% exposed rock: N/A
Transect number: 2F	Position in landscape: MS	Time since fire: >5
Easting: 391644	Northing: 6438137	Veg condition: G

Vegetation description/Comments
Low open forest - *Banksia attenuata, Banksia menziesii, Allocasuarina fraseriana* with emergent *Eucalyptus marginata* over *Xanthorrhoea preissii, Hibbertia hypericoides and Stirlingia laterifolia*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: SE	Surface soil: light grey sand
Initials: KK	% Bare ground: 40%	Sub-surface soil: yellow sand
Quadrat number: 2EP	Slope: gently inclined	% exposed rock: N/A
Transect number: 2E	Position in landscape: US	Time since fire: >5
Easting: 391592	Northing: 6438136	Veg condition: G

Vegetation description/Comments
Low woodland - B*anksia attenuata, Banksia menziesii, Allocasuarina fraseriana* with emergent *Eucalyptus marginata* over *Xanthorrhoea preissii, Hibbertia hypericoides* and weeds

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: E	Surface soil: light grey sand
Initials: KK	% Bare ground: 0%	Sub-surface soil: yellow sand
Quadrat number: 2ER	Slope: gently inclined	% exposed rock: N/A
Transect number: 2E	Position in landscape: MS	Time since fire: >5
Easting: 391594	Northing: 6438038	Veg condition: G

Vegetation description/Comments
Low open forest - *Eucalyptus marginata, Banksia attenuata, Banksia menziesii, Allocasuarina fraseriana* over *Macrozamia riedlei, Xanthorrhoea preissii, Hibbertia hypericoides, Acacia pulchella* and weeds.

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: SE	Surface soil: light grey sand
Initials: KK	% Bare ground: 20%	Sub-surface soil: yellow sand
Quadrat number: 2BA	Slope: gently inclined	% exposed rock: N/A
Transect number: 2B	Position in landscape: US	Time since fire: >5
Easting: 391442	Northing: 6438893	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia attenuata, Banksia menziesii, Allocasuarina fraseriana* with emergent *Eucalyptus marginata* over *Xanthorrhoea preissii, Hibbertia hypericoides and Stirlingia laterifolia*

Species	Cover/Count	Comments
L. hermaphrodita	0	L. sericea present
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: SE	Surface soil: light grey sand
Initials: KK	% Bare ground: 40%	Sub-surface soil: yellow sand
Quadrat number: 2DA	Slope: gently inclined	% exposed rock: N/A
Transect number: 2D	Position in landscape: US	Time since fire: >5
Easting: 391543	Northing: 6438893	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia attenuata, Banksia menziesii, Allocasuarina fraseriana* with emergent *Eucalyptus marginata* over *Xanthorrhoea preissii, Hibbertia hypericoides and Stirlingia laterifolia*

Species	Cover/Count	Comments
L. hermaphrodita	4	
L.maritima	1%	1 plant, diggings around base

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: E-SE	Surface soil: light grey sand
Initials: KK	% Bare ground: 40%	Sub-surface soil: yellow sand
Quadrat number: 2DB	Slope: gently inclined	% exposed rock: N/A
Transect number: 2D	Position in landscape: US	Time since fire: >5
Easting: 391543	Northing: 6438838	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia attenuata, Banksia menziesii, Allocasuarina fraseriana* with emergent *Eucalyptus marginata* over *Xanthorrhoea preissii, Hibbertia hypericoides and Stirlingia laterifolia*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	1	2 plants

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: SE	Surface soil: light grey sand
Initials: KK	% Bare ground: 70%	Sub-surface soil: yellow sand
Quadrat number: 2DC	Slope: very gently inclined	% exposed rock: N/A
Transect number: 2D	Position in landscape: MS	Time since fire: >5
Easting: 391539	Northing: 6438789	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia attenuata, Banksia menziesii, Allocasuarina fraseriana* with emergent *Eucalyptus marginata* over *Xanthorrhoea preissii, Hibbertia hypericoides and Stirlingia laterifolia*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: E	Surface soil: light grey sand
Initials: KK	% Bare ground: 30%	Sub-surface soil: dark grey
Quadrat number: 2DD	Slope: very gently inclined	% exposed rock: N/A
Transect number: 2D	Position in landscape: MS	Time since fire: >5
Easting: 391538	Northing: 6438743	Veg condition: E

Vegetation description/Comments Low open forest - *Banksia attenuata, Banksia menziesii* over *Xanthorrhoea preissii* and *Hibbertia hypericoides*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: NE	Surface soil: light grey sand
Initials: KK	% Bare ground: 50%	Sub-surface soil: dark grey
Quadrat number: 2DE	Slope: very gently inclined	% exposed rock: N/A
Transect number: 2D	Position in landscape: MS	Time since fire: >5
Easting: 391547	Northing: 6438692	Veg condition: E

Vegetation description/Comments Low open forest - *Banksia illicifolia, Banksia attenuata, Banksia menziesii* over *Xanthorrhoea preissii* , *Dasypogon bromeliifolius and Hibbertia hypericoides*

Species	Cover/Count	Comments
L. hermaphrodita	2	>1%
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: NW	Surface soil: light grey sand
Initials: KK	% Bare ground: 60%	Sub-surface soil:
Quadrat number: 2DF	Slope: MS	% exposed rock: N/A
Transect number: 2D	Position in landscape: MS	Time since fire: >5
Easting: 391545	Northing: 6438641	Veg condition: E

Vegetation description/Comments
Low woodland - *Banksia attenuata, Banksia menziesii, Allocasuarina fraseriana* over *Stirlingia laterifolia, Hibbertia hypericoides* and *Xanthorrhoea preissii*

Species	Cover/Count	Comments
L. hermaphrodita	16	5% coverage
L.maritima		

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: NE	Surface soil: light grey sand
Initials: KK	% Bare ground: 45%	Sub-surface soil: yellow sand
Quadrat number: 2DG	Slope: gently inclined	% exposed rock: N/A
Transect number: 2D	Position in landscape: US	Time since fire: >5
Easting: 391542	Northing: 6438589	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia attenuata, Banksia menziesii, Allocasuarina fraseriana, Banksia illicifolia* with emergent *Eucalyptus marginata* over *Xanthorrhoea preissii, Hibbertia hypericoides* and *Stirlingia laterifolia*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: NE	Surface soil: light grey sand
Initials: KK	% Bare ground: 10%	Sub-surface soil: yellow sand
Quadrat number: 2DH	Slope: gently inclined	% exposed rock: N/A
Transect number: 2D	Position in landscape: US	Time since fire: >5
Easting: 391539	Northing: 6438540	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia attenuata, Banksia menziesii, Allocasuarina fraseriana, Banksia illicifolia* with emergent *Eucalyptus marginata* over *Xanthorrhoea preissii, Hibbertia hypericoides* and *Stirlingia laterifolia*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: NE	Surface soil: light grey sand
Initials: KK	% Bare ground: 30%	Sub-surface soil: yellow sand
Quadrat number: 2DI	Slope: gently inclined	% exposed rock: N/A
Transect number: 2D	Position in landscape: US	Time since fire: >5
Easting: 391544	Northing: 6438490	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia attenuata, Banksia menziesii, Allocasuarina fraseriana, Banksia illicifolia* with emergent *Eucalyptus marginata* over *Xanthorrhoea preissii, Hibbertia hypericoides* and *Stirlingia laterifolia*

Species	Cover/Count	Comments
L. hermaphrodita	1	<1%
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: SE	Surface soil: light grey sand
Initials: KK	% Bare ground: 30%	Sub-surface soil: yellow sand
Quadrat number: 2DJ	Slope: very gently inclined	% exposed rock: N/A
Transect number: 2D	Position in landscape: US	Time since fire: >5
Easting: 391536	Northing: 6438437	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia attenuata, Banksia menziesii, Allocasuarina fraseriana, Banksia illicifolia* with emergent *Eucalyptus marginata* over *Xanthorrhoea preissii, Hibbertia hypericoides* and *Stirlingia laterifolia*

Species	Cover/Count	Comments
L. hermaphrodita	4	1%
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: N/A	Surface soil: light grey sand
Initials: KK	% Bare ground: 20%	Sub-surface soil: yellow sand
Quadrat number: 2DK	Slope: N/A	% exposed rock: N/A
Transect number: 2D	Position in landscape: US	Time since fire: >5
Easting: 391538	Northing: 6438388	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia attenuata, Banksia menziesii, Allocasuarina fraseriana, Banksia illicifolia* with emergent *Eucalyptus marginata* over *Xanthorrhoea preissii, Hibbertia hypericoides* and *Stirlingia laterifolia*

Species	Cover/Count	Comments
L. hermaphrodita	10	2%
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: E-NE	Surface soil: yellow/light grey
Initials: KK	% Bare ground: 40%	Sub-surface soil: yellow
Quadrat number: 2FI	Slope: very gently inclined	% exposed rock: N/A
Transect number: 2F	Position in landscape: US	Time since fire: >5
Easting: 391638	Northing: 6438493	Veg condition: E

Vegetation description/Comments
Low woodland - *Banksia menziesii, Banksia attenuata, Allocasuarina fraseriana* with emergent *Eucalyptus marginata* over *Xanthorrhoea preissii, Hibbertia hypericoides and Stirlingia laterifolia*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: N-NW	Surface soil: light grey sand
Initials: KK	% Bare ground: 60%	Sub-surface soil: yellow sand
Quadrat number: 2FG	Slope: very gently inclined	% exposed rock: N/A
Transect number: 2F	Position in landscape: US	Time since fire: >5
Easting: 391642	Northing: 6438593	Veg condition: E

Vegetation description/Comments
Low open forest - B*anksia menziesii, Banksia attenuata, Allocasuarina fraseriana* with emergent *Eucalyptus marginata* over *Xanthorrhoea preissii, Hibbertia hypericoides* and *Stirlingia laterifolia*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: NE	Surface soil: grey sand
Initials: KK	% Bare ground: 0%	Sub-surface soil: grey sand
Quadrat number: 2FE	Slope: very gently inclined	% exposed rock: N/A
Transect number: 2F	Position in landscape: LS	Time since fire: >5
Easting: 391636	Northing: 6438695	Veg condition: E

Vegetation description/Comments
Open forest - *Melaleuca preissiana, Allocasuarina fraseriana* and *Eucalyptus marginata* over *Kunzea glabrescens, Xanthorrhoea preissii* and *Dasypogon bromeliifolius*
Appears to be an area of transition between vegetation communities

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: SW	Surface soil: light grey
Initials: KK	% Bare ground: 40%	Sub-surface soil:
Quadrat number: 2FC	Slope: gently inclined	% exposed rock: N/A
Transect number: 2F	Position in landscape: MS	Time since fire: >5
Easting: 391640	Northing: 6438794	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia menziesii, Banksia attenuata, Eucalyptus marginata, Banksia illicifolia* over *Xanthorrhoea preissii, Dasypogon bromeliifolius, Stirlingia laterifolia, Macrozamia riedlei* and *Hibbertia hypericoides*

Species	Cover/Count	Comments
L. hermaphrodita	2	< 1%
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: E	Surface soil: light grey
Initials: KK	% Bare ground: 30%	Sub-surface soil: yellow sand
Quadrat number: 2FA	Slope: gently inclined	% exposed rock: N/A
Transect number: 2F	Position in landscape: US	Time since fire: >5
Easting: 391642	Northing: 6438895	Veg condition: E

Vegetation description/Comments
Low open forest - *Allocasuarina fraseriana, Banksia attenuata and Banksia menziesii* over *Hibbertia hypericoides, Xanthorrhoea preissii* and *Stirlingia laterifolia*

Species	Cover/Count	Comments
L. hermaphrodita	2	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: SW	Surface soil: light grey
Initials: KK	% Bare ground: 10%	Sub-surface soil:
Quadrat number: 2HA	Slope: very gently inclined	% exposed rock: N/A
Transect number: 2H	Position in landscape: MS	Time since fire: >5
Easting: 391743	Northing: 6438889	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia attenuata, Banksia illicifolia, Banksia menziesii* and *Allocasuarina fraseriana* with emergent *Eucalyptus marginata* over *Xanthorrhoea preissii, Hibbertia hypericoides and Stirlingia laterifolia*

Species	Cover/Count	Comments
L. hermaphrodita	4	1%
L.maritima	0.01%	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: S	Surface soil: light grey sand
Initials: KK	% Bare ground: 40%	Sub-surface soil: yellow sand
Quadrat number: 2HC	Slope: gently inclined	% exposed rock: N/A
Transect number: 2H	Position in landscape: MS	Time since fire: >5
Easting: 391740	Northing: 6438792	Veg condition: E

Vegetation description/Comments
Low open forest - *Banksia attenuata, Banksia illicifolia, Banksia menziesii* and *Allocasuarina fraseriana* with emergent *Eucalyptus marginata* over *Xanthorrhoea preissii, Hibbertia hypericoides and Stirlingia laterifolia*

Species	Cover/Count	Comments
L. hermaphrodita	6	Digging around base observed
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: N/A	Surface soil: grey sand
Initials: KK	% Bare ground: N/A	Sub-surface soil: grey sand
Quadrat number: 2HE	Slope: N/A	% exposed rock: N/A
Transect number: 2H	Position in landscape: MS	Time since fire: >5
Easting: 391744	Northing: 6438693	Veg condition: E

Vegetation description/Comments
Open forest - *Banksia illicifolia, Banksia attenuata, Kunzea glabrescens* over *Dasypogon bromeliifolius* with emergent *Eucalyptus marginata*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: SE	Surface soil: grey sand
Initials: KK	% Bare ground: 30%	Sub-surface soil: grey sand
Quadrat number: 2HG	Slope: very gently inclined	% exposed rock: N/A
Transect number: 2H	Position in landscape: US	Time since fire: >5
Easting: 391738	Northing: 6438591	Veg condition: G

Vegetation description/Comments
Low open forest - *Banksia illicifolia, Banksia attenuata, Eucalyptus marginata, Allocasuarina fraseriana* and *Banksia menziesii* over *Xanthorrhoea preissii, Carpobrotus modesta* and weeds

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: N/A	Surface soil: grey sand
Initials: KK	% Bare ground: 0%	Sub-surface soil: grey sand
Quadrat number: 2JD	Slope: flat	% exposed rock: N/A
Transect number: 2J	Position in landscape: Dep.	Time since fire: >5
Easting: 391843	Northing: 6438741	Veg condition: VG

Vegetation description/Comments
Low open forest - *Melaleuca preissii, Eucalyptus marginata* over *Kunzea glabrescens* and *Dasypogon bromeliifolius*

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: SE	Surface soil: light grey sand
Initials: KK	% Bare ground: 60%	Sub-surface soil: yellow sand
Quadrat number: 2JB	Slope: gently inclined	% exposed rock: N/A
Transect number: 2J	Position in landscape: US	Time since fire: >5
Easting: 391844	Northing: 6438844	Veg condition: VG

Vegetation description/Comments
Low woodland - *Banksia attenuata, Banksia menziesii, Allocasuarina fraseriana* and *Eucalyptus marginata* over *Macrozamia riedlei, Xanthorrhoea preissii, Hibbertia hypericoides and Stirlingia laterifolia*

Species	Cover/Count	Comments
L. hermaphrodita	6	1% coverage
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: SE	Surface soil: light grey sand
Initials: KK	% Bare ground: 20%	Sub-surface soil: yellow sand
Quadrat number: 2J2	Slope: gently inclined	% exposed rock: N/A
Transect number: 2J	Position in landscape: US	Time since fire: >5
Easting: 391845	Northing: 6438946	Veg condition: VG

Vegetation description/Comments
Low woodland - *Banksia attenuata, Banksia menziesii, Allocasuarina fraseriana* and *Eucalyptus marginata* over *Macrozamia riedlei, Xanthorrhoea preissii, Hibbertia hypericoides and Stirlingia laterifolia*

Species	Cover/Count	Comments
L. hermaphrodita	1	<1% coverage
L.maritima		

Lomandra Density Survey Data Sheet

Site Name: Mandogalup	Job No. EP10-0018-003

Date: 28/01/2011	Aspect: NE-E	Surface soil: light grey sand
Initials: KK	% Bare ground: 40%	Sub-surface soil: yellow sand
Quadrat number: 2KA	Slope: gently inclined	% exposed rock: N/A
Transect number: 2K	Position in landscape: MS	Time since fire: >5
Easting: 391892	Northing: 6438895	Veg condition: VG

Vegetation description/Comments
Low woodland - *Eucalyptus marginata, Banksia menziesii, Banksia attenuata* and *Allocasuarina fraseriana* over *Xanthorrhoea preissii, Hibbertia hypericoides and Stirlingia laterifolia*

Species	Cover/Count	Comments
L. hermaphrodita	3	1% coverage
L.maritima	0	

Site Name: Mandogalup	Job No. EP10-018-003

Date: 28/01/2011	Aspect: SW	Surface soil: grey sand
Initials: KK	% Bare ground: N/A	Sub-surface soil: grey sand
Quadrat number: 2KC	Slope: very gently inclined	% exposed rock: N/A
Transect number: 2K	Position in landscape: LS	Time since fire: >5
Easting: 391889	Northing: 6438788	Veg condition: G

Vegetation description/Comments
Low open forest - *Banksia illicifolia, Banksia attenuata, Allocasuarina fraseriana* over *Kunzea glabrescens, Xanthorrhoea preissii, Dasypogon bromeliifolius* and weeds

Species	Cover/Count	Comments
L. hermaphrodita	0	
L.maritima	0	

APPENDIX C

GRACEFUL SUN-MOTH SURVEY – RAW DATA

Graceful sun-moth data sheet

Site name: Mandogalup			
Date:	24/02/2011	Start time:	10:15
Observers:	KK & GT	End time:	10:50
Transect #:	1	Wind speed (km/hr):	
Temperature:	34	Wind direction:	NE

Comments
Degraded to completely degraded Banksia woodland. Heavily grazed understorey. Wind gusty.
No GSM sighted.

GSM specimen #	% Cloud	Comments (track/vegetated)	Easting	Northing	Time	Temp (C°)	Wind speed

Site name: Mandogalup			
Date:	24/02/2011	Start time:	11:00
Observers:	KK & GT	End time:	12:00
Transect #:	2	Wind speed (km/hr	occasional gusts
Temperature:	34	Wind direction:	NE

Comments
Walked firebreak around vegetation. Cloud starting to come over although still sunny.
No GSM sighted.

GSM specimen #	% Cloud	Comments (track/vegetated)	Easting	Northing	Time	Temp (C°)	Wind speed

Graceful sun-moth data sheet

Site name: Mandogalup			
Date:	24/02/2011	Start time:	12:25
Observers:	KK & GT	End time:	13:05
Transect #:	3	Wind speed (km/l	occasional gusts
Temperature:	35	Wind direction:	NW

Comments
Through vegetation, other smaller moths present, heavy cloud cover started to come over but sunny patches. No GSM sighted.

GSM specimen #	% Cloud	Comments (track/vegetated)	Easting	Northing	Time	Temp (C°)	Wind speed

Site name: Mandogalup			
Date:	24/02/2011	Start time:	1:15 PM
Observers:	KK & GT	End time:	1:48 PM
Transect #:	4	Wind speed (km/l	occasional gusts
Temperature:	35	Wind direction:	NE

Comments
Through predominately degraded vegetation (Banksia woodland). Heavy cloud cover beginning to come over but sunny patches
No GSM sighted.

GSM specimen #	% Cloud	Comments (track/vegetated)	Easting	Northing	Time	Temp (C°)	Wind speed

Graceful sun-moth data sheet

Site name: Mandogalup			
Date:	3/03/2011	Start time:	10:03
Observers:	GT &SP	End time:	10:19
Transect #:	1	Wind speed (km/hr	5
Temperature:	27	Wind direction:	SE

Comments
No GSM sighted.

GSM specimen #	% Cloud	Comments (track/vegetated)	Easting	Northing	Time	Temp (C°)	Wind speed

Site name: Mandogalup			
Date:	3/03/2011	Start time:	10:30
Observers:	GT &SP	End time:	11:52
Transect #:	2	Wind speed (km/hr	5-7
Temperature:	28	Wind direction:	SE

Comments

GSM specimen #	% Cloud	Comments (track/vegetated)	Easting	Northing	Time	Temp (C°)	Wind speed
1	0	track - WP 560	391359	6438394	10:51	33	5

Site name: Mandogalup			
Date:	3/03/2011	Start time:	12:05
Observers:	GT &SP	End time:	12:26
Transect #:	3	Wind speed (km/hr	8-10
Temperature:	34	Wind direction:	SE

Comments
No GSM sighted.

GSM specimen #	% Cloud	Comments (track/vegetated)	Easting	Northing	Time	Temp (C°)	Wind speed

Graceful sun-moth data sheet

Site name: Mandogalup			
Date:	10/03/2011	Start time:	10:05
Observers:	GT &SP	End time:	10:19
Transect #:	1	Wind speed (km/h	0
Temperature:	28	Wind direction:	-

Comments
No GSM sighted.

GSM specimen #	% Cloud	Comments (track/vegetated)	Easting	Northing	Time	Temp (C°)	Wind speed

Site name: Mandogalup			
Date:	10/03/2011	Start time:	10:31
Observers:	GT &SP	End time:	11:33
Transect #:	2	Wind speed (km/h	0-5
Temperature:	30-34	Wind direction:	-

Comments
No GSM sighted.

GSM specimen #	% Cloud	Comments (track/vegetated)	Easting	Northing	Time	Temp (C°)	Wind speed

Site name: Mandogalup			
Date:	10/03/2011	Start time:	12:06
Observers:	GT &SP	End time:	12:23
Transect #:	3	Wind speed (km/h	0-5
Temperature:	34	Wind direction:	-

Comments
No GSM sighted.

GSM specimen #	% Cloud	Comments (track/vegetated)	Easting	Northing	Time	Temp (C°)	Wind speed

Graceful sun-moth data sheet

Site name: Mandogalup			
Date:	15/03/2011	Start time:	10:22
Observers:	GT &SP	End time:	10:37
Transect #:	1	Wind speed (km/hr	5 with gusts up to 15
Temperature:	30	Wind direction:	E-SE

Comments
No GSM sighted.

GSM specimen #	% Cloud	Comments (track/vegetated)	Easting	Northing	Time	Temp (C°)	Wind speed

Site name: Mandogalup			
Date:	15/03/2011	Start time:	10:48
Observers:	GT &SP	End time:	11:50
Transect #:	2	Wind speed (km/hr	5 with gusts up to 15
Temperature:	33	Wind direction:	E-SE

Comments
No GSM sighted.
Low Open Banksia Woodland.

GSM specimen #	% Cloud	Comments (track/vegetated)	Easting	Northing	Time	Temp (C°)	Wind speed

Site name: Mandogalup			
Date:	15/03/2011	Start time:	12:04
Observers:	GT &SP	End time:	12:23
Transect #:	3	Wind speed (km/hr	5-10, gust s up to 15
Temperature:	34	Wind direction:	SW

Comments
No GSM sighted.

GSM specimen #	% Cloud	Comments (track/vegetated)	Easting	Northing	Time	Temp (C°)	Wind speed

Graceful sun-moth data sheet

Site name: Mandogalup			
Date:	25/03/2011	Start time:	11:35
Observers:	GT &SP	End time:	11:51
Transect #:	1	Wind speed (km/hr	0-5
Temperature	30	Wind direction:	-

Comments
No GSM sighted.

GSM specimen #	% Cloud	Comments (track/vegetated)	Easting	Northing	Time	Temp (C°)	Wind speed

Site name: Mandogalup			
Date:	25/03/2011	Start time:	9:45
Observers:	GT &SP	End time:	10:45
Transect #:	2	Wind speed (km/hr	0-2
Temperature	27	Wind direction:	-

Comments
No GSM sighted.
Low Open Banksia Woodland.

GSM specimen #	% Cloud	Comments (track/vegetated)	Easting	Northing	Time	Temp (C°)	Wind speed

Site name: Mandogalup			
Date:	25/03/2011	Start time:	10:50
Observers:	GT &SP	End time:	11:09
Transect #:	3	Wind speed (km/hr	0-5
Temperature	27	Wind direction:	-

Comments
No GSM sighted.

GSM specimen #	% Cloud	Comments (track/vegetated)	Easting	Northing	Time	Temp (C°)	Wind speed

Graceful sun-moth data sheet

Site name: Mandogalup			
Date:	31/03/2011	Start time:	9:58
Observers:	GT &SP	End time:	10:11
Transect #:	1	Wind speed (km/hr	5
Temperature:	27	Wind direction:	s-sw

Comments
No GSM sighted.

GSM specimen #	% Cloud	Comments (track/vegetated)	Easting	Northing	Time	Temp (C°)	Wind speed

Site name: Mandogalup			
Date:	31/03/2011	Start time:	10:20
Observers:	GT &SP	End time:	11:24
Transect #:	2	Wind speed (km/hr	5
Temperature:	27	Wind direction:	S-SW

Comments
No GSM sighted. No cloud

GSM specimen #	% Cloud	Comments (track/vegetated)	Easting	Northing	Time	Temp (C°)	Wind speed

Site name: Mandogalup			
Date:	31/03/2011	Start time:	11:30
Observers:	GT &SP	End time:	11:57
Transect #:	3	Wind speed (km/hr	5
Temperature:	29	Wind direction:	S-SW

Comments
No GSM sighted. No cloud.

GSM specimen #	% Cloud	Comments (track/vegetated)	Easting	Northing	Time	Temp (C°)	Wind speed

APPENDIX D

TARGETTED BLACK COCKATOO SURVEY DATA

Black Cockatoo Foraging Evidence
Datum - GDA94

Waypoint Number	Zone	mE	mN	Evidence Age	Evidence Type 1	Likely Species	Comments
wpt008	50H	391716	6438653	Recent	Jarrah Seeds	Carnaby's/FRTBC	
wpt013	50H	391716	6438670	Recent	Sheoak Seeds	FRTBC	
wpt014	50H	391734	6438628	Old	Banksia Cones	Carnaby's	
wpt015	50H	391749	6438603	Recent	Banksia Cones	Carnaby's	
wpt019	50H	391704	6438342	Recent	Jarrah Seeds	Carnaby's/FRTBC	
wpt022	50H	391744	6438285	Recent	Sheoak Seeds	FRTBC	
wpt023	50H	391741	6438270	Recent	Banksia Cones	Carnaby's	
wpt025	50H	391723	6438240	Recent	Banksia Cones	Carnaby's	
wpt031	50H	391637	6438124	Old	Banksia Cones	Carnaby's	
wpt034	50H	391612	6438050	Recent	Sheoak Seeds	FRTBC	
wpt038	50H	391575	6438045	Recent	Jarrah Seeds	Carnaby's/FRTBC	
wpt047	50H	391502	6437916	Recent	Jarrah Seeds	Carnaby's/FRTBC	
wpt077	50H	391425	6437675	Recent	Tuart Seeds	Carnaby's	
wpt081	50H	391370	6437719	Recent	Sheoak Seeds	FRTBC	
wpt086	50H	391393	6437834	Old	Banksia Cones	Carnaby's	
wpt092	50H	391395	6437861	Recent	Jarrah Seeds	Carnaby's/FRTBC	
wpt094	50H	391391	6437876	Recent	Jarrah Seeds	Carnaby's/FRTBC	
wpt101	50H	391471	6437989	Recent	Jarrah Seeds	Carnaby's/FRTBC	
wpt107	50H	391469	6438029	Recent	Jarrah Seeds	Carnaby's/FRTBC	
wpt111	50H	391549	6438106	Recent	Jarrah Seeds	Carnaby's/FRTBC	
wpt115	50H	391627	6438223	Recent	Sheoak Seeds	FRTBC	
wpt117	50H	391873	6438884	Recent	Banksia Cones	Carnaby's	
wpt144	50H	391709	6438729	Old	Banksia Cones	Carnaby's	
wpt150	50H	391781	6438789	Old	Banksia Cones	Carnaby's	
wpt168	50H	391408	6438782	Old	Jarrah Seeds	Carnaby's/FRTBC	
wpt171	50H	391491	6438637	Old	Jarrah Seeds	Carnaby's/FRTBC	
wpt180	50H	391573	6438782	Recent	Banksia Cones	Carnaby's	
wpt181	50H	391438	6438686	Recent	Sheoak Seeds	FRTBC	

Waypoint Number	Zone	mE	mN	Evidence Age	Evidence Type 1	Likely Species	Comments
wpt184	50H	391397	6438465	Recent	Jarrah Seeds	Carnaby's/FRTBC	
wpt185	50H	391361	6438302	Recent	Jarrah Seeds	Carnaby's/FRTBC	
wpt186	50H	391360	6438249	Old	Jarrah Seeds	Carnaby's/FRTBC	

APPENDIX E

DATABASE SEARCHES AND SPECIES DESCRIPTIONS

NatureMap - Mandogalup - Invertebrates

Created By Greg Harewood on 09/04/2011

Kingdom Animalia
Species Group Invertebrates
Method 'By Circle'
Centre 115°50' 47" E,32°11' 49" S
Buffer 6km

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
1.		*Coccinella repanda*			
2.		*Cryptolaemus montrouzieri*			
3.		*Henosepilachna 26-punctata*			
4.		*Mesodina cyanophracta*			
5.		*Metriorrhynchus sp.*			
6.		*Perthida glyphopa*			
7.		*Phoracantha semipunctata*			
8.		*Phyllococerus purpurascens*			
9.	33992	*Synemon gratiosa (Graceful Sunmoth)*		T	

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.

NatureMap - Mandogalup - Frogs

Created By Greg Harewood on 09/04/2011

Kingdom Animalia
Species Group Amphibians
Method 'By Circle'
Centre 115°50' 47" E,32°11' 49" S
Buffer 6km

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
1.	25399	*Crinia glauerti (Clicking Frog)*			
2.	25410	*Heleioporus eyrei (Moaning Frog)*			
3.	25415	*Limnodynastes dorsalis (Western Banjo Frog)*			
4.	25378	*Litoria adelaidensis (Slender Tree Frog)*			
5.	25420	*Myobatrachus gouldii (Turtle Frog)*			

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.

NatureMap - Mandogalup - Reptiles

Created By Greg Harewood on 09/04/2011

Kingdom Animalia
Species Group Reptiles
Method 'By Circle'
Centre 115°50' 47" E,32°11' 49" S
Buffer 6km

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
1.	25245	*Brachyurophis semifasciata*			
2.	24980	*Christinus marmoratus (Marbled Gecko)*			
3.	30893	*Cryptoblepharus buchananii*			
4.	30899	*Ctenophorus adelaidensis (Southern Heath Dragons)*			
5.	25027	*Ctenotus australis*			
6.	25766	*Delma fraseri*			
7.	25296	*Demansia psammophis subsp. reticulata*			
8.	25100	*Egernia napoleonis*			
9.	25119	*Hemiergis quadrilineata*			
10.	25133	*Lerista elegans*			
11.	25147	*Lerista lineata*		P3	
12.	25184	*Menetia greyii*			
13.	25191	*Morethia lineoocellata*			
14.	25248	*Neelaps bimaculatus (Black-naped Snake)*			
15.	25249	*Neelaps calonotos (Black-striped Snake)*		P3	
16.	25252	*Notechis scutatus (Tiger Snake)*			
17.	25253	*Parasuta gouldii*			
18.	25007	*Pletholax gracilis subsp. gracilis*			
19.	24907	*Pogona minor subsp. minor*			
20.	25511	*Pseudonaja affinis (Dugite)*			
21.	25259	*Pseudonaja affinis subsp. affinis (Dugite)*			
22.	25008	*Pygopus lepidopodus (Common Scaly Foot)*			
23.	25271	*Ramphotyphlops australis*			
24.	25266	*Simoselaps bertholdi (Jan's Banded Snake)*			
25.	25519	*Tiliqua rugosa*			
26.	25207	*Tiliqua rugosa subsp. rugosa*			

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.

NatureMap - Mandogalup - Birds

Created By Greg Harewood on 09/04/2011

Kingdom Animalia
Species Group Birds
Method 'By Circle'
Centre 115°50' 47" E,32°11' 49" S
Buffer 6km

	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.	25755	*Acrocephalus australis (Australian Reed Warbler)*			
8.	24310	*Anas castanea (Chestnut Teal)*			
9.	24312	*Anas gracilis (Grey Teal)*			
10.	24315	*Anas rhynchotis (Australasian Shoveler)*			
11.	24316	*Anas superciliosa (Pacific Black Duck)*			
12.	-1591	*Anhinga novaehollandiae*			
13.	-1701	*Anser anser*			
14.	-1693	*Anser sp.*			
15.	24561	*Anthochaera carunculata (Red Wattlebird)*			
16.	24562	*Anthochaera lunulata (Western Little Wattlebird)*			
17.	-1612	*Anthus novaeseelandiae*			
18.	24285	*Aquila audax (Wedge-tailed Eagle)*			
19.	-1578	*Ardea modesta*			
20.	24341	*Ardea pacifica (White-necked Heron)*			
21.	25566	*Artamus cinereus (Black-faced Woodswallow)*			
22.	24353	*Artamus cyanopterus (Dusky Woodswallow)*			
23.	24318	*Aythya australis (Hardhead)*			
24.	-1633	*Barnardius zonarius*			
25.	24319	*Biziura lobata (Musk Duck)*			
26.	25716	*Cacatua sanguinea (Little Corella)*			
27.	25598	*Cacomantis flabelliformis (Fan-tailed Cuckoo)*			
28.	-1590	*Cacomantis pallidus*			
29.	24779	*Calidris acuminata (Sharp-tailed Sandpiper)*			
30.	24784	*Calidris ferruginea (Curlew Sandpiper)*			
31.	24788	*Calidris ruficollis (Red-necked Stint)*			
32.	24789	*Calidris subminuta (Long-toed Stint)*			
33.	24731	*Calyptorhynchus banksii subsp. naso (Forest Red-tailed Black-Cockatoo)*		T	
34.	24734	*Calyptorhynchus latirostris (Carnaby's Cockatoo)*		T	
35.	-1700	*Calyptorhynchus sp.*			
36.	-1624	*Chalcites basalis*			
37.	-1581	*Chalcites lucidus*			
38.	24377	*Charadrius ruficapillus (Red-capped Plover)*			
39.	24321	*Chenonetta jubata (Australian Wood Duck (Wood Duck))*			
40.	-1579	*Chlidonias hybrida*			
41.	-1648	*Chlidonias leucopterus*			
42.	-1637	*Chroicocephalus novaehollandiae*			
43.	24288	*Circus approximans (Swamp Harrier)*			
44.	24774	*Cladorhynchus leucocephalus (Banded Stilt)*			
45.	25675	*Colluricincla harmonica (Grey Shrike-thrush)*			
46.	24399	*Columba livia (Domestic Pigeon)*	Y		
47.	25568	*Coracina novaehollandiae (Black-faced Cuckoo-shrike)*			
48.	25592	*Corvus coronoides (Australian Raven)*			
49.	24671	*Coturnix pectoralis (Stubble Quail)*			
50.	25701	*Coturnix ypsilophora (Brown Quail)*			
51.	25595	*Cracticus tibicen (Australian Magpie)*			
52.	25596	*Cracticus torquatus (Grey Butcherbird)*			
53.	24322	*Cygnus atratus (Black Swan)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
54.	30901	*Dacelo novaeguineae (Laughing Kookaburra)*	Y		
55.	25673	*Daphoenositta chrysoptera (Varied Sittella)*			
56.	-1623	*Egretta garzetta*			
57.	-1577	*Egretta novaehollandiae*			
58.	-1600	*Elanus axillaris*			
59.	-1573	*Elseyornis melanops*			
60.	-1569	*Eolophus roseicapillus*			
61.	24567	*Epthianura albifrons (White-fronted Chat)*			
62.	24379	*Erythrogonys cinctus (Red-kneed Dotterel)*			
63.	25621	*Falco berigora (Brown Falcon)*			
64.	25622	*Falco cenchroides (Australian Kestrel)*			
65.	25623	*Falco longipennis (Australian Hobby)*			
66.	25624	*Falco peregrinus (Peregrine Falcon)*		S	
67.	25727	*Fulica atra (Eurasian Coot)*			
68.	25729	*Gallinula tenebrosa (Dusky Moorhen)*			
69.	25730	*Gallirallus philippensis (Buff-banded Rail)*			
70.	25530	*Gerygone fusca (Western Gerygone)*			
71.	24443	*Grallina cyanoleuca (Magpie-lark)*			
72.	24293	*Haliaeetus leucogaster (White-bellied Sea-Eagle)*			
73.	24295	*Haliastur sphenurus (Whistling Kite)*			
74.	-1601	*Hieraaetus morphnoides*			
75.	25734	*Himantopus himantopus (Black-winged Stilt)*			
76.	24491	*Hirundo neoxena (Welcome Swallow)*			
77.	-1632	*Ixobrychus dubius*			
78.	-1641	*Lalage sueurii*			
79.	24581	*Lichenostomus virescens (Singing Honeyeater)*			
80.	25661	*Lichmera indistincta (Brown Honeyeater)*			
81.	25741	*Limosa limosa (Black-tailed Godwit)*			
82.	-1616	*Lophoictinia isura*			
83.	24326	*Malacorhynchus membranaceus (Pink-eared Duck)*			
84.	25654	*Malurus splendens (Splendid Fairy-wren)*			
85.	25758	*Megalurus gramineus (Little Grassbird)*			
86.	-1570	*Melanodryas cucullata*			
87.	-1649	*Melithreptus lunatus*			
88.	24598	*Merops ornatus (Rainbow Bee-eater)*			
89.	-1636	*Microcarbo melanoleucos*			
90.	24738	*Neophema elegans (Elegant Parrot)*			
91.	25748	*Ninox novaeseelandiae (Boobook Owl)*			
92.	25564	*Nycticorax caledonicus (Rufous Night Heron)*			
93.	24407	*Ocyphaps lophotes (Crested Pigeon)*			
94.	24328	*Oxyura australis (Blue-billed Duck)*			
95.	25679	*Pachycephala pectoralis (Golden Whistler)*			
96.	25680	*Pachycephala rufiventris (Rufous Whistler)*			
97.	25681	*Pardalotus punctatus (Spotted Pardalote)*			
98.	25682	*Pardalotus striatus (Striated Pardalote)*			
99.	24648	*Pelecanus conspicillatus (Australian Pelican)*			
100.	-1640	*Petrochelidon nigricans*			
101.	-1650	*Petroica boodang*			
102.	24659	*Petroica goodenovii (Red-capped Robin)*			
103.	25697	*Phalacrocorax carbo (Great Cormorant)*			
104.	24667	*Phalacrocorax sulcirostris (Little Black Cormorant)*			
105.	25699	*Phalacrocorax varius (Pied Cormorant)*			
106.	24409	*Phaps chalcoptera (Common Bronzewing)*			
107.	-1643	*Phylidonyris niger*			
108.	24596	*Phylidonyris novaehollandiae (New Holland Honeyeater)*			
109.	24841	*Platalea flavipes (Yellow-billed Spoonbill)*			
110.	25720	*Platycercus icterotis (Western Rosella)*			
111.	24843	*Plegadis falcinellus (Glossy Ibis)*			
112.	25703	*Podargus strigoides (Tawny Frogmouth)*			
113.	25704	*Podiceps cristatus (Great Crested Grebe)*			
114.	24681	*Poliocephalus poliocephalus (Hoary-headed Grebe)*			
115.	25722	*Polytelis anthopeplus (Regent Parrot)*			
116.	25731	*Porphyrio porphyrio (Purple Swamphen)*			
117.	24769	*Porzana fluminea (Australian Spotted Crake)*			
118.	25732	*Porzana pusilla (Baillon's Crake)*			
119.	24771	*Porzana tabuensis (Spotless Crake)*			
120.	-1580	*Purpureicephalus spurius*			
121.	24776	*Recurvirostra novaehollandiae (Red-necked Avocet)*			
122.	-1654	*Rhipidura albiscapa*			
123.	25614	*Rhipidura leucophrys (Willie Wagtail)*			

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
124.	25534	*Sericornis frontalis (White-browed Scrubwren)*			
125.	30948	*Smicrornis brevirostris (Weebill)*			
126.	24329	*Stictonetta naevosa (Freckled Duck)*			
127.	25597	*Strepera versicolor (Grey Currawong)*			
128.	25589	*Streptopelia chinensis (Spotted Turtle-Dove)*	Y		
129.	25590	*Streptopelia senegalensis (Laughing Turtle-Dove)*	Y		
130.	25705	*Tachybaptus novaehollandiae (Australasian Grebe (Black-throated Grebe))*			
131.	24331	*Tadorna tadornoides (Australian Shelduck (Mountain Duck))*			
132.	-1621	*Thinornis rubricollis*			
133.	24844	*Threskiornis molucca (Australian White Ibis)*			
134.	24845	*Threskiornis spinicollis (Straw-necked Ibis)*			
135.	25549	*Todiramphus sanctus (Sacred Kingfisher)*			
136.	-1617	*Tribonyx ventralis*			
137.	25723	*Trichoglossus haematodus (Rainbow Lorikeet)*			
138.	24808	*Tringa nebularia (Common Greenshank)*			
139.	25761	*Turnix varia (Painted Button-quail)*			
140.	-1626	*Tyto javanica*			
141.	24386	*Vanellus tricolor (Banded Lapwing)*			
142.	25765	*Zosterops lateralis (Grey-breasted White-eye (Silvereye))*			

Conservation Codes
T - Rare or likely to become extinct
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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.

NatureMap - Mandogalup - Mammals

Created By Greg Harewood on 09/04/2011

Kingdom Animalia
Species Group Mammals
Method 'By Circle'
Centre 115°50' 47" E,32°11' 49" S
Buffer 6km

	Name ID	Species Name	Naturalised	Conservation Code	[1]Endemic To Query Area
1.	24189	*Falsistrellus mackenziei (Western False Pipistrelle)*		P4	
2.	24041	*Felis catus (Cat)*	Y		
3.	24215	*Hydromys chrysogaster (Water-rat)*		P4	
4.	25478	*Isoodon obesulus*			
5.	24153	*Isoodon obesulus subsp. fusciventer (Southern Brown Bandicoot, Quenda)*		P5	
6.	24131	*Macropus eugenii subsp. derbianus (Tammar)*		P5	
7.	24133	*Macropus irma (Western Brush Wallaby)*		P4	
8.	24223	*Mus musculus (House Mouse)*	Y		
9.	24146	*Myrmecobius fasciatus (Numbat, Walpurti)*		T	
10.	24099	*Phascogale tapoatafa subsp. tapoatafa (Southern Brush-tailed Phascogale, Wambenger)*			
11.	24243	*Rattus fuscipes (Western Bush Rat)*			
12.	24245	*Rattus rattus (Black Rat)*	Y		
13.	24167	*Tarsipes rostratus (Honey Possum, Noolbenger)*			

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.

EPBC Act Protected Matters Report: Coordinates

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.

You may wish to print this report for reference before moving to other pages or websites.

Information about the EPBC Act including significance guidelines, forms and application process details can be found at http://www.environment.gov.au/epbc/assessmentsapprovals/index.html

Report created: 09/04/11 09:27:30



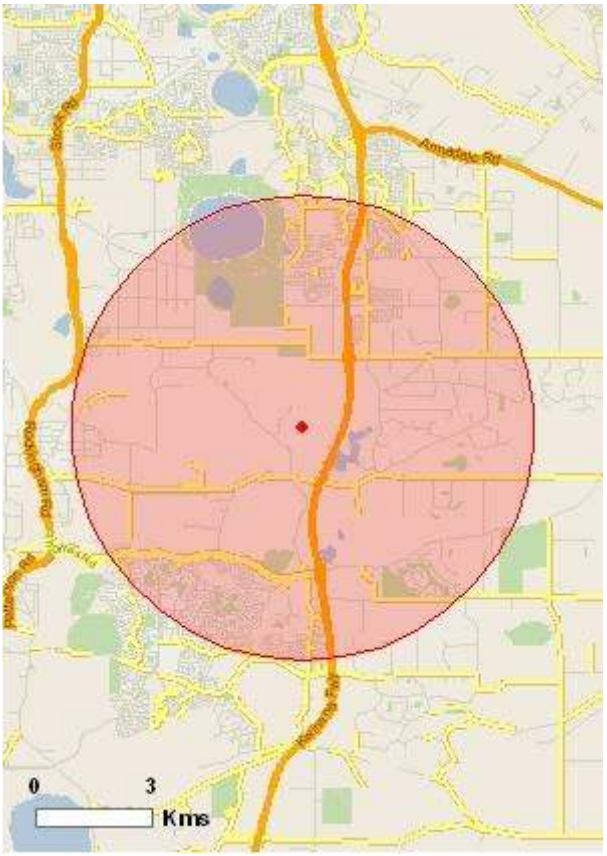
Summary

Details

Matters of NES
Other matters protected by the EPBC Act
Extra Information

Caveat

Acknowledgements



This map may contain data which are ©Commonwealth of Australia (Geoscience Australia), ©PSMA 2010

Coordinates
Buffer: 6Km

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 - see http://www.environment.gov.au/epbc/assessmentsapprovals/guidelines/index.html.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Significance (Ramsar Wetlands):	2
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Threatened Ecological Communitites:	None
Threatened Species:	13
Migratory Species:	15

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 and the heritage values of a place on the Register of the National Estate. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage/index.html

Please note that the current dataset on Commonwealth land is not complete. Further information on Commonwealth land would need to be obtained from relevant sources including Commonwealth agencies, local agencies, and land tenure maps.

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. Information on EPBC Act permit requirements and application forms can be found at http://www.environment.gov.au/epbc/permits/index.html.

Commonwealth Lands:	1
Commonwealth Heritage Places:	None
Listed Marine Species:	21

Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves:	None

Report Summary for Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

Place on the RNE:	6
State and Territory Reserves:	6
Regional Forest Agreements:	None
Invasive Species:	16
Nationally Important Wetlands:	3

Details

Matters of National Environmental Significance

Wetlands of International Significance (RAMSAR Sites)		**[Resource Information]**
Name	Proximity	
Forrestdale & thomsons lakes	Within Ramsar site	
Peel-yalgorup system	Upstream from Ramsar site	

Threatened Species		**[Resource Information]**
Name	Status	Type of Presence
BIRDS		
Calyptorhynchus banksii naso Forest Red-tailed Black-Cockatoo [67034]	Vulnerable	Species or species habitat may occur within area
Calyptorhynchus latirostris Carnaby's Black-Cockatoo, Short-billed Black-Cockatoo [59523]	Endangered	Species or species habitat likely to occur within area
INSECTS		
Synemon gratiosa Graceful Sun Moth [66757]	Endangered	Species or species habitat may occur within area
MAMMALS		
Dasyurus geoffroii Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat likely to occur within area
Phascogale calura Red-tailed Phascogale [316]	Endangered	Species or species habitat may occur within area
Setonix brachyurus Quokka [229]	Vulnerable	Species or species habitat may 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	Endangered	Species or species habitat likely to occur within area

Spider-orchid [7309]		
Centrolepis caespitosa [6393]	Endangered	Species or species habitat likely to occur within area
Darwinia foetida Muchea Bell [83190]	Critically Endangered	Species or species habitat likely to occur within area
Diuris micrantha Dwarf Bee-orchid [55082]	Vulnerable	Species or species habitat likely to occur within area
Drakaea elastica Glossy-leaved Hammer-orchid, Praying Virgin [16753]	Endangered	Species or species habitat likely to occur within area
Lepidosperma rostratum Beaked Lepidosperma [14152]	Endangered	Species or species habitat likely to occur within area

Migratory Species [Resource Information]

Name	Status	Type of Presence
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat may occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Migratory Terrestrial Species		
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Migratory Wetlands Species		
Ardea alba Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]		Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]		Species or species habitat known to occur within area
Calidris ruficollis Red-necked Stint [860]		Species or species habitat known 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]	Species or species habitat known to occur within area
Tringa glareola Wood Sandpiper [829]	Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]	Species or species habitat known to occur within area

Other Matters Protected by the EPBC Act

Commonwealth Lands [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.

Commonwealth Land -

Listed Marine Species [Resource Information]

Name	Status	Type of Presence
Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat may occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Calidris acuminata Sharp-tailed Sandpiper [874]		Species or species habitat known to occur within area
Calidris canutus Red Knot, Knot [855]		Species or species habitat known to occur within area
Calidris ferruginea Curlew Sandpiper [856]		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]		Species or species habitat known to occur within area
Calidris subminuta Long-toed Stint [861]		Species or species habitat known to occur within area
Charadrius dubius Little Ringed Plover [896]		Species or species habitat known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Species or species habitat known to occur within area

Haliaeetus leucogaster White-bellied Sea-Eagle [943]	Species or species habitat likely to occur within area
Himantopus himantopus Black-winged Stilt [870]	Species or species habitat known 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]	Species or species habitat known to occur within area
Merops ornatus Rainbow Bee-eater [670]	Species or species habitat may occur within area
Philomachus pugnax Ruff (Reeve) [850]	Species or species habitat known to occur within area
Recurvirostra novaehollandiae Red-necked Avocet [871]	Species or species habitat known to occur within area
Thinornis rubricollis Hooded Plover [59510]	Species or species habitat known to occur within area
Tringa glareola Wood Sandpiper [829]	Species or species habitat known to occur within area
Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]	Species or species habitat known to occur within area

Extra Information

Places on the RNE [Resource Information]

Note that not all Indigenous sites may be listed.

Name	Status
Natural	
Gibbs Road Wetland System WA	Indicative Place
Modong Nature Reserve WA	Indicative Place
Beeliar Regional Park and Adjacent Areas WA	Interim List
Reserve 7756 (March 1978 Boundary) WA	Registered
Thomson Lake Reserve WA	Registered
Wandi Nature Reserve WA	Registered

State and Territory Reserves [Resource Information]

Wandi, WA
Thomsons Lake, WA
Modong, WA
Unnamed WA48291, WA
Unnamed WA49561, WA
Harry Waring Marsupial Reserve, 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
Mammals		
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat may occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Brachiaria mutica Para Grass [5879]		Species or species habitat may occur within area
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat may occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
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 may occur within area
Lycium ferocissimum African Boxthorn, Boxthorn [19235]		Species or species habitat may occur within area
Olea europaea Olive, Common Olive [9160]		Species or species habitat may 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 may occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtiji Willows except Weeping		Species or species habitat may occur within area

Willow, Pussy Willow and
Sterile Pussy Willow [68497]
Salvinia molesta
Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665] Species or species habitat may occur within area

Nationally Important Wetlands **[Resource Information]**

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 Heritage and Register of National Estate properties, Wetlands of International 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.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under 'type of presence'. For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

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

115.84623 -32.19715

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:

-Department of Environment, Climate Change and Water, New South Wales
-Department of Sustainability and Environment, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment and Natural Resources, South Australia
-Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts
-Environmental and Resource Management, Queensland
-Department of Environment and Conservation, Western Australia
-Department of the Environment, Climate Change, Energy and Water
-Birds Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-SA 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, Atherton and Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
-State Forests of NSW
-Other groups and individuals

Environment Australia 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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Graceful Sun Moth *Synemon gratiosa*

Status and Distribution: Listed as Scheduled 1 under the *WC Act (1950)* and as Endangered under the *EPBC Act (1999)*. It is also ranked as 'Endangered' under IUCN (2001) criteria.

The GSM was, up until recently thought to be confined to a small number of bush reserves in the northern suburbs of Perth. Targeted survey work between February and April 2010 by a number of consultants and the DEC have now extended the known range of the species north to Leeman and south as far as Binningup (Bishop *et al* 2010b).

Previous to this the ten known extant subpopulations of GSM were all located in Perth's northern metropolitan area. Two of these subpopulations are distinct fragments within Warwick Conservation Reserve, and another seven sub-populations occur in *Banksia* woodland in very small areas in Koondoola Bushland, Errina Road Bushland, Marangaroo Bushland, Landsdale Road Bushland, Gumblossom Reserve, Shenton Bushland and Whiteman Park (DEWHA 2009). All of these sites (except Shenton Bushland), are within 4 km of each other. Two other sub-populations occur in coastal heath/shrubland vegetation at Sorrento (DEC 2008) and Ocean Reef (SMEC 2009).

Areas at which the species has recently found are located mainly in coastal locations near Leeman, Jurien Bay, Lancelin, Guilderton, Wilbinga, Rockingham, Yalgorup National Park and Binningup (Bishop *et al* 2010b).

Survey work carried out in 2010 has expanded the previously document area of occupancy of the GSM from 18km^2 to 43 km^2 and the extent of occurrence from 230km^2 to 2015km^2. The area of occupancy is potentially a conservative estimate at this stage and if habitat anticipated to be occupied by GSM is included, the area of occupancy may be as high as 119 km^2 (Bishop *et al* 2010b). Additional surveys planned for 2011 north and south of the known range may also expand the species range

Habitat: The graceful sun-moth is currently only known from two general vegetation types:

- Banksia woodland/woolly bush on deep sands, in the northern suburbs of Perth on the Swan Coastal Plain. In these sites the GSM breeds on *Lomandra hermaphrodita*, which often occurs in low numbers.

- Open areas of herbland, heathland and shrubland on Quindalup soils (sand and limestone) close to the coast where it breeds on *Lomandra*

maritima, which is often present in reasonable numbers and may even be a dominant understorey herb. Sites on limestone may have both *Lomandra* species present.

Prior to 2009, the graceful sun-moth had only been recorded in Banksia woodland containing the monocotyledon *Lomandra hermaphrodita* (Asparagaceae). In early 2009 new populations of the graceful sun-moth were located in coastal heathland associated with *Lomandra maritima*, a species closely related to the original host plant *L. hermaphrodita*. *Lomandra maritima* is abundant in coastal vegetation between Binningup and Shark Bay, so the discovery of this new host plant meant it was possible that additional habitat and populations of graceful sun-moth may be found (Bishop *et al* 2010b).

The presence of *Lomandra* species therefore provides a good indication of prospective habitat, however, sufficient numbers and densities of these plants are thought to be necessary to sustain a viable breeding colony of Graceful Sun-Moths (DEWHA 2009).

Natural fragmentation of habitat results from the graceful sun-moth's narrow habitat preference for coastal heathland on secondary coastal sand dunes, where variations in soil and vegetation types produce a mosaic of occupied and unoccupied habitat at small spatial scales. Superimposed upon this natural pattern there has been a substantial loss of habitat through past clearing of native vegetation, exacerbating fragmentation that can restrict sub-populations to small, isolated, relictual habitat remnants (Bishop *et al* 2010b)

Male moths first appear in late February and females in early March. Mating occurs during March and females lay eggs during March and early April, then all adult moths die off. The larvae (caterpillars) take 11 months to fully develop and then emerge as adult moths the following year (Willers, 2009; DEWHA, 2009 cited from WA CALM 2005). The larvae are thought to feed exclusively on *Lomandra* sp. To date the species has been recorded in association with *Lomandra hermaphrodita* and *Lomandra maritima* (DEWHA 2009, SMEC 2009). Hence, the presence of *Lomandra* species provides a good indication of prospective habitat, however, sufficient numbers and densities of these plants are thought to be necessary to sustain a viable breeding colony of Graceful Sun-Moths (DEWHA 2009). The larvae of other species of sun moths, apart from feeding on *Lomandra* spp have also been reported to utilise *Lepidosperma* spp. (Common 1990; Nielsen et al. 1996).

Adult Graceful Sun-Moths emerge during hot weather in bright sunshine. Graceful Sun-Moth males are sedentary, but the extent to which females

disperse is unknown. It is believed that females disperse less than 1 km from their colony of birth and are unlikely to cross unsuitable habitat (DEWHA 2009). Despite being able to fly, most species of butterflies and day-flying moths will not disperse across unsuitable habitat, and do not disperse far during their lifetime (DEWHA 2009). Due to the limited dispersal ability of the Graceful Sun Moth, recolonisation at locally extinct sites is unlikely (TSSC 2008).

Likely presence in study area: Surveys carried by Emerge Associates in March 2011 confirmed the presence of this species within the study area.

Potential impact of development: Potential loss of habitat.

Perth Lined Lerista *Lerista lineata*

Status and Distribution: Listed as Priority 3 by the DEC. Found in the lower west coast from Perth to Leschenault Peninsula. It has also been found at Rottnest Island and Garden Island (Storr *et al* 1999). Recent records from Rockingham (ENV Australia 2010a), and Bibra Lake (Greg Harewood pers. obs.). Also known from the Spectacles reserve (Government of Western Australia 2000b).

Habitat: This small species of skink inhabits white sands (Storr *et al*, 1999) under areas of shrubs and heath where it inhabits loose soil and leaf litter at the base of shrubs (Nevill 2005).

Likely presence in study area: Records of this species at Spectacles and other nearby areas suggest it may be present within the Banksia woodland areas at Mandogalup.

Potential impact of development: Potential loss of habitat.

Jewelled Ctenotus *Ctenotus gemmula*

Status and Distribution: Listed as Priority 3 by DEC. In the west at Cataby and from Wanneroo south to Medina. In the southern interior and along the south coast from Rocky Gully inland to Lake Magenta and east to Toolina Cove (Storr *et al*, 1999). Rarely seen in the Perth Region (Bush *et al* 2010).

Habitat: Prefers pale sandplains supporting either *Banksia* or mallee with heath. Seeks shelter beneath leaf litter, in abandoned stick-ant nest and burrows at the base of trees and shrubs (Bush *et* al 2002).

Likely presence in study area: Status in area difficult to determine, however the lack of recent records in the general area despite several detailed surveys

(Rockingham, East Rockingham, Bibra Lake, Jandakot) suggests that it no longer persists in the southern Perth suburbs. Not listed as a potential species..

Potential impact of development: No impact anticipated as this species is considered unlikely to be present.

Southern Carpet Python *Morelia spilota impricata*

Status and Distribution: The south western population is classified as Priority 4 by the DEC and is also listed in Schedule 4 under the *WC Act*. This subspecies has wide distribution within the south west but is uncommon. Occurs north to Geraldton and Yalgoo and east to Pinjin, Kalgoorlie, Fraser Range and Eyre (Storr *et al*, 2002). Found throughout the Perth region including Garden Island though only persisting in large, undisturbed bushland areas (Bush *et al* 2010)

Habitat: This species has been recorded from semi-arid coastal and inland habitats, Banksia woodland, Eucalypt woodlands, and grasslands. Most often found utilising hollow logs in addition the burrows of other animals for shelter. Often arboreal and will also use tree hollows for refuge.

Likely presence in study area: Status in area difficult to determine. Typically only occurs in low densities and the generally degraded and fragmented nature of bushland in the general area may make it difficult for a population of this species to persist. The lack of recent records in the general area despite several detailed surveys (Rockingham, East Rockingham, Bibra Lake, Jandakot) also suggests that it no longer persists in the general area. Not listed as a potential species.

Potential impact of development: No impact anticipated as this species is not likely to utilise the area.

Black-striped Snake *Neelaps calonotos*

Status and Distribution: Listed as Priority 3 by DEC. Found in the lower west coast from Lancelin to Mandurah. It is locally abundant but is under threat due to land clearing (Storr *et al*, 1999).

Habitat: This species of snake favours sandy soils supporting heath and banksia/eucalypt woodland (Nevill 2005).

Likely presence in study area: Status in area difficult to determine. Listed as a potential species despite a lack of recent records from the general area. Habitat appears suitable.

Potential impact of development: Potential impact of development: Potential loss of habitat.

Great Egret *Ardea alba*

Status and Distribution: This species of egret is listed as Schedule 3 under the *WC Act* and as migratory under the *EPBC Act* and under international agreements to which Australia is a signatory. The Great Egret is common and very widespread in any suitable permanent or temporary habitat (Morcombe, 2003).

Species or species habitat listed as likely to occur in general area within EPBC database search.

Habitat: Wetlands, flooded pasture, dams, estuarine mudflats, mangroves and reefs (Morcombe 2003).

Likely presence in study area: Potentially utilised flooded paddock areas and drains in small numbers during wetter months of the year. This species would not breed on site.

Potential impact of development: Modification/loss of some degraded habitat, but impact will not be significant.

Cattle Egret *Ardea ibis*

Status and Distribution: This species of egret is listed as Schedule 3 under the *WC Act* and as migratory under the *EPBC Act* and under international agreements to which Australia is a signatory. The Cattle Egret is common in the north sections of its range but is an irregular visitor to the better watered parts of the state (Johnstone and Storr 1998). The population is expanding (Morcombe 2003).

Species or species habitat listed as likely to occur in general area within EPBC database search.

Habitat: Moist pastures with tall grasses, shallow open wetlands and margins, mudflats (Morcombe 2003).

Likely presence in study area: Potentially utilised paddock areas and drains in small numbers particularly if cattle present. This species would not breed on site.

Potential impact of development: Modification/loss of some degraded habitat, but impact will not be significant.

Australasian Bittern *Botaurus poiciloptilus*

Status and Distribution: Classified as Schedule 1 under the *WC Act* and as Endangered under the *EPBC Act (1999*. The species is uncommon to rare (Morcombe, 2003), but locally common in wetter parts of south west (Johnstone and Storr 1998). Occurs north to Moora and east to Mt Arid (Johnstone and Storr 1998).

Habitat: Freshwater wetlands, occasionally estuarine; prefers heavy vegetation (Morcombe 2003) such as beds of tall dense *Typha*, *Baumea* and sedges in freshwater swamps (Johnstone and Storr 1998).

Likely presence in study area: There is no suitable habitat for this species in the study area. Not listed as a potential species.

Potential impact of development: No impact anticipated as this species is not likely to utilise the area.

Black Bittern *Ixobrychus flavicollis*

Status and Distribution: Listed as Priority 3 by DEC. Occurs north to Yanchep and Northam and east to Albany (Johnstone and Storr 1998).

Habitat: Freshwater pools, swamps and lagoons, well screened with trees. Shelters in dense waterside vegetation (Johnstone and Storr 1998).

Likely presence in study area: There is no suitable habitat for this species in the study area. Not listed as a potential species.

Potential impact of development: No impact anticipated as this species is not likely to utilise the area.

Little Bittern *Ixobrychus minutus*

Status and Distribution: Listed as Priority 4 by DEC. Occurs north to Moora and east to Two Peoples Bay; accidental or on migration further north and east and on Rottnest Island and central district (Condingup district) (Johnstone and Storr 1998).

Habitat: In south dense beds of Freshwater pools, swamps and lagoons, well screened with trees. Shelters in dense beds of *Typha*, *Baumea* and tall rushes in freshwater swamps around lakes and along rivers (Johnstone and Storr 1998).

Likely presence in study area: There is no suitable habitat for this species in the study area. Not listed as a potential species.

Potential impact of development: No impact anticipated as this species is not likely to utilise the area.

White-bellied Sea Eagle *Haliaeetus leucogaster*

Status and Distribution: This species is listed as Schedule 3 under the *WC Act* and as migratory under the *EPBC Act* and under international agreements to which Australia is a signatory. White-bellied sea eagles are moderately common to common on Kimberley and Pilbara islands, coasts and estuaries, on Bernier, Dorre and Dirk Hartog Is., in Houtman Abrolhos and in the Archipelago of the Recherche; rare to uncommon elsewhere (Johnstone and Storr 1998). Also found in New Guinea, Indonesia, China, southeast Asia and India. Scarce near major coastal cities (Morcombe 2003).

Species or species habitat listed as likely to occur in general area within EPBC database search.

Habitat: This species nest and forages usually near the coast over islands, reefs, headlands, beaches, bays, estuaries, mangroves, but will also live near seasonally flooded inland swamps, lagoons and floodplains, often far inland on large pools of major rivers. Established pairs usually sedentary, immatures dispersive (Morcombe 2003). White-bellied Sea-Eagles build a large stick nest, which is used for many seasons in succession.

Likely presence in study area: May fly over the site occasionally due to proximity to ocean and lakes. Known to nest in coastal forest (recent record from Baldivis). No existing nest sites observed during the field survey.

Potential impact of development: No significant impact on this species anticipated and under normal circumstance it would not utilise the study area for any purpose.

Osprey *Pandion haliaetus*

Status and Distribution: This species is listed as migratory under the *EPBC Act* and under international agreements to which Australia is a signatory. Moderately common to very common in sheltered seas around the north and west coast islands south to 31°S; uncommon to common on mainland coasts, estuaries and large rivers north of tropic, rare to uncommon elsewhere (Johnstone and Storr 1998).

Habitat: Coasts, estuaries, bays, inlets, islands, and surrounding waters, coral atolls, reefs, lagoons, rock cliffs and stacks. Ascends larger rivers (Pizzey & Knight 2007). Construct nests on prominent headland, large trees, communication towers (Simpson and Day 2010).

Likely presence in study area: May fly over the site very occasionally due to proximity to ocean and lakes. Actual study area represents unsuitable habitat. Not listed as a potential species.

Potential impact of development: No impact on this species is anticipated.

Peregrine Falcon *Falco peregrinus*

Status and Distribution: This species is listed as Schedule 4 under the *WC Act*. Individuals of this species are uncommon/rare but wide ranging across Australia. Moderately common at higher levels of the Stirling Range, uncommon in hilly, north west Kimberley, Hamersley and Darling Ranges; rare or scarce elsewhere (Johnstone and Storr 1998).

Habitat: Diverse from rainforest to arid shrublands, from coastal heath to alpine (Morcombe 2003). Mainly about cliffs along coasts, rivers and ranges and about wooded watercourses and lakes (Johnstone and Storr 1998). The species utilises the ledges, cliff faces and large hollows/broken spouts of trees for nesting. It will also occasionally use the abandoned nests of other birds of prey.

Likely presence in study area: This species potentially utilises some sections of the study area as part of a much larger home range. No existing nest sites observed.

Potential impact of development: No significant impact anticipated.

Bush Stone Curlew *Burhinus grallarius*

Status and Distribution: Listed as Priority 4 by DEC. Occurs over much of the western half of the state (and Kimberley) but rare to uncommon in the south of its range due to fox predation (Johnstone and Storr 1998).

Habitat: Lightly wooded country (including partly cleared forests) near daytime shelter e.g. thickets or long grass (Johnstone and Storr 1998).

Likely presence in study area: Records in the DEC database represent historical records. This species is rarely if ever recorded in Perth and viable natural populations would not exist in the area. Can be considered to be regionally extinct. Not listed as a potential species.

Potential impact of any development: No impact on this species will occur.

Migratory Shorebirds

A number of migratory shorebirds are listed as potentially occurring in the general area. Specific species are not discussed.

Status and Distribution: Migratory seabirds are listed under the *EPBC Act 1999* and under international agreements to which Australia is a signatory. All species are either widespread summer migrants to Australia or residents. State and Federal conservation status varies between species.

Habitat: Varies between species but includes beaches and permanent/temporary wetlands varying from billabongs, swamps, lakes, floodplains, sewerage farms, saltwork ponds, estuaries, lagoons, mudflats sandbars, pastures, airfields, sports fields and lawns.

Likely presence in study area: Some nearby lakes maybe used by some of the listed migratory species but the paddock areas and drains within and adjacent to the study area represents very marginal habitat for all migratory shorebirds and the site cannot be regarded as having any significant value to any species. None listed as a potential species.

Potential impact of development: No significant impact on migratory shorebirds will occur as the result of development within the study area.

Hooded Plover *Charadrius rubricollis*

Status and Distribution: Listed as Priority 4 by DEC. In WA coastally west from Israelite Bay north to Jurien Bay and inland salt lakes more than 100km from the coast. In eastern Australia confined to suitable habitat from Jervis Bay (NSW) through Bass Strait and Tasmanian and west to Great Australian Bight in South Australia.

Habitat: Broad sandy ocean beaches and bays, coastal and inland salt lakes (Pizzey & Knight 2006).

Likely presence in study area: No suitable habitat. Not listed as a potential species.

Potential impact of development: No impact on this species is anticipated to occur as the result of the proposal proceeding.

Forest Red-tailed Black Cockatoo *Calyptorhynchus banksii naso*

Status and Distribution: Listed as Scheduled 1 under the *WC Act* and as Vulnerable under the *EPBC Act*. Found in the humid and subhumid south west, mainly hilly interior, north to Gingin and east to Mt Helena, Christmas Tree Well, North Bannister, Mt Saddleback, Rock Gully and the upper King River (Johnstone and Storr 1998).

Habitat: Eucalypt forests, feeds on Marri, Jarrah, Blackbutt, Karri, Sheoak and Snottygobble. The Forest Red-tailed Black Cockatoo nests in the large hollows of Marri, Jarrah and Karri (Johnstone and Kirkby 1999). In Marri, the nest hollows of the Forest Red-tailed Black Cockatoo range from 8-14m above ground, the entrance is 12 – 41cm in diameter and the depth is one to five metres (Johnstone and Storr 1998).

There are few records of breeding in the Forest Red-tailed Black Cockatoo (Johnstone and Storr 1998) but up until recently the main period of breeding was thought to commence in winter/spring with eggs being laid in October and November (Johnstone 1997; Johnstone and Storr 1998). Recent data however indicates that breeding in all months of the year occurs with peaks in spring and autumn–winter (Ron Johnstone pers comms). Incubation period 29 – 31 days. Young fledge at 8 to 9 weeks (Simpson and Day 2004).

J	F	M	A	M	J	J	A	S	O	N	D

Period in which breeding is most likely to commence
Period in which fledging/weening could extend through

Likely presence in study area: Foraging evidence attributed to this species was found during the site survey (chewed Jarrah and Sheoak fruits). Remnant vegetation containing Jarrah and Sheoak within the study area presents potential foraging habitat for this species. Larger trees (>50cm DBH) are considered by the SEWPaC as potential breeding habitat. No evidence of actual breeding in the larger hollows observed was found. This species may also roost on site on occasions.

Potential impact of development: Loss of foraging, breeding and roosting opportunities.

Baudin's Black- Cockatoo *Calyptorhynchus baudinii*

Status and Distribution: Listed as Scheduled 1 under the *WC Act* and as Vulnerable under the *EPBC Act*. Confined to the south-west of Western Australia, north to Gidgegannup, east to Mt Helena, Wandering, Quindanning,

Kojonup, Frankland and King River and west to the eastern strip of the Swan Coastal Plain including West Midland, Byford, Nth Dandalup, Yarloop, Wokalup and Bunbury (Johnstone and Storr 1998). On the southern Swan Coastal Plain this cockatoo is in some areas resident but mainly a migrant moving from the deep south-west to the central and northern Darling Range. Between March and September most flocks move north and are concentrated in the northern parts of the Darling Range. During this period birds forage well out onto the southern Swan Coastal Plain to areas such as Harvey, Myalup, Bunbury, Capel, Dunsborough and Meelup. While generally more common in the Darling Range this species can also be common on parts of the southern Swan Coastal Plain especially in mid-August – September when flocks begin to return to their breeding quarters (Johnstone 2008).

Habitat: Mainly eucalypt forests where it feeds primarily on the Marri seeds, (Morcombe, 2003), Banksia, Hakeas and *Erodium* sp. Also strips bark from trees in search of beetle larvae (Johnstone and Storr 1998). This species of cockatoo nests in large tree hollows, 30–40 cm in diameter and more than 30 cm deep (Saunders 1974).

Baudin's Black-Cockatoo breeds in late winter and spring, from August to November or December (Gould 1972; Johnstone 1997; Saunders 1974; Saunders *et al*. 1985). Eggs laid in October (Johnstone and Storr 1998). Based on observations at currently known nest sites breeding mainly occurs within the October-December period (Ron Johnstone pers comms). Incubation is 28 – 30 days. Young fledge at 8 to 9 weeks (Simpson and Day 2004).

J	F	M	A	M	J	J	A	S	O	N	D

Period in which breeding is most likely to commence
Period in which fledging could extend through

Likely presence in study area: The study area is outside of this species normal range and it is unlikely to frequent the area except on very rare occasions. Not listed as a potential species.

Potential impact of development: No impact on this species will occur as a consequence of the pipeline installation.

Carnaby's Black- Cockatoo *Calyptorhynchus latirostris*

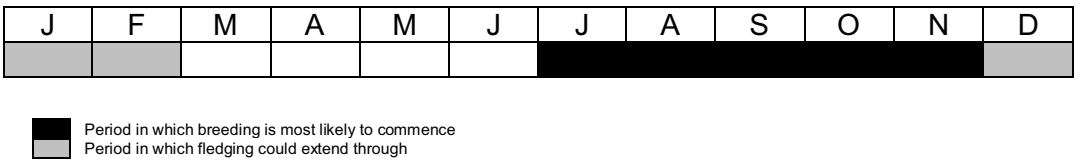
Status and Distribution: Carnaby's Black Cockatoo is listed as Scheduled 1 under the *WC Act* and as Endangered under the *EPBC Act*. Confined to the

south-west of Western Australia, north to the lower Murchison River and east to Nabawa, Wilroy, Waddi Forest, Nugadong, Manmanning, Durokoppin, Noongar (Moorine Rock), Lake Cronin, Ravensthorpe Range, head of Oldfield River, 20 km ESE of Condingup and Cape Arid; also casual on Rottnest Island (Johnstone and Storr 1998).

Habitat: Forests, woodlands, heathlands, farms; feeds on Banksia, Hakeas and Marri. Carnaby's Cockatoo has specific nesting site requirements. Nests are mostly in smoothed-barked eucalypts with the nest hollows ranging from 2.5 to 12m above the ground, an entrance from 23-30cm diameter and a depth of 0.1-2.5m (Johnstone and Storr, 1998).

Breeding occurs in winter/spring mainly in eastern forest and wheatbelt where they can find mature hollow bearing trees to nest in (Morcombe, 2003). Judging from records in the Storr-Johnstone Bird Data Bank, this species is currently expanding its breeding range westward and south into the Jarrah – Marri forest of the Darling Scarp and into the Tuart forests of the Swan Coastal Plain including the region between Mandurah and Bunbury. Carnaby's Black Cockatoo has been known to breed close to the town of Mandurah, as well as at Dawesville, Lake Clifton and Baldivis (pers. comm., Ron Johnstone, WA Museum) and there are small resident populations on the southern Swan Coastal Plain near Mandurah, Lake Clifton and near Bunbury. At each of these sites the birds forage in remnant vegetation and adjacent pine plantations (Johnstone 2008).

Carnaby's Black-Cockatoo lays eggs from July or August to October or November, with most clutches being laid in August and September (Saunders 1986). Birds in inland regions may begin laying up to three weeks earlier than those in coastal areas (Saunders 1977). The female incubates the eggs over a period of 28-29 days. The young depart the nest 10–12 weeks after hatching (Saunders 1977; Smith & Saunders 1986).



Likely presence in study area: Foraging evidence attributed to this species was found during the site survey (chewed Tuart fruits, Jarrah fruits and Banksia cones). Remnant vegetation containing Tuart, Jarrah and Banksia within the study area presents potential foraging habitat for this species. Larger trees

(>50cm DBH) are considered by the SEWPaC as potential breeding habitat. No evidence of actual breeding in the larger hollows observed was found. This species may also roost on site on occasions.

Potential impact of development: Loss of foraging, breeding and roosting opportunities.

Barking Owl *Ninox connivens connivens*

Status and Distribution: Listed as Priority 2 by DEC. Found north to Perth (formerly) and east to Northam, Katanning and nearly to Bremer Bay. Declining in south west (Johnstone and Storr 1998).

Habitat: Dense vegetation, especially forest and thickets of waterside vegetation such as melaleucas (Johnstone and Storr 1998). Roosts in tree hollows.

Likely presence in study area: Status on the site and in the general area difficult to determine. Rarely recorded in the Perth area. Not listed as a potential species.

Potential impact of development: No impact on this species will occur as the site is unlikely to represent significant habitat for this species.

Masked Owl *Tyto novaehollandae novaehollandae*

Status and Distribution: Listed as Priority 3 by DEC. Found north to Yanchep and east to Yealering, Gnowangerup and Albany, casual further north. Locally common in south west but generally uncommon (Johnstone and Storr 1998).

Habitat: Roosts and nests in heavy forest, hunts over open woodlands and farmlands (Morcombe, 2003). Probably breeding in forested deep south west with some autumn–winter wanderings northwards (Johnstone and Storr 1998).

Likely presence in study area: Single DEC record from Henderson and unpublished record from Leda suggests this species is a rare, infrequent visitor to the general area, though it can be difficult to observe and is easily overlooked. Not listed as a potential species.

Potential impact of development: No significant impact on this species is considered likely as it is would only infrequently utilise the general area and would not be specifically attracted to the site.

Fork-tailed Swift *Apus pacificus*

Status and Distribution: The Fork-tailed Swift is listed as Schedule 3 under the *WC Act* an as migratory under the *EPBC Act* and under international agreements to which Australia is a signatory. This species breeds in Siberia and the Himalayas and migrates to Australia in October, returning to the breeding grounds by May or June (Morcombe 2003).

Habitat: Low to very high airspace over varied habitat from rainforest to semi desert (Morcombe 2003).

Likely presence in study area: It is potentially an occasional summer visitor to the study area but is entirely aerial and largely independent of terrestrial habitats.

Potential impact of development: No impact on this species is anticipated.

Rainbow Bee-eater *Merops ornatus*

Status and Distribution: This species is listed as Schedule 3 under the *WC Act* and as migratory under the *EPBC Act* and under international agreements to which Australia is a signatory. The Rainbow Bee-eater is a common summer migrant to southern Australia but in the north they are resident (Morcombe 2003).

Habitat: Open Country, of woodlands, open forest, semi arid scrub, grasslands, clearings in heavier forest, farmlands (Morcombe 2003). Breeds underground in areas of suitable soft soil firm enough to support tunnel building.

Likely presence in study area: Common seasonal visitor to south west. Observed during the field survey foraging in open areas adjacent to Banksia woodland. May also roost overnight in the study area at times. Possibly breeds in some sections of the study area though population levels would not be significant as it usually breeds in pairs, rarely in small colonies (Johnstone and Storr 1998).

Potential impact of development: Despite the potential for breeding no significant impact on this species is anticipated as individuals' present onsite at any one time are unlikely to represent a substantial proportion of the population.

Chuditch *Dasyurus geoffroii*

Status and Distribution: Listed as Scheduled 1 under the *WC Act* and as Vulnerable under the *EPBC Act.* Formerly occurred over nearly 70 per cent of Australia. The Chuditch now has a patchy distribution throughout the Jarrah forest and mixed Karri/Marri/Jarrah forest of southwest Western Australia. Also occurs in very low numbers in the Midwest, Wheatbelt and South Coast Regions

with records from Moora to the north, Yellowdine to the east and south to Hopetoun.

Habitat: Chuditch are known to have occupied a wide range of habitats from woodlands, dry sclerophyll (leafy) forests, riparian vegetation, beaches and deserts. Riparian vegetation appears to support higher densities of Chuditch, possibly because food supply is better or more reliable and better cover is offered by dense vegetation. Chuditch appear to utilise native vegetation along road sides in the wheatbelt (CALM 1994). The estimated home range of a male Chuditch is over 15 km^2 whilst that for females is 3-4 km^2 (Sorena and Soderquist 1995).

Likely presence in study area: Generally considered to be extinct on the Perth section of the Swan Coastal Plain. Occasional records (e.g. Wandi, Pagononi Swamp) are most likely transient individuals from Darling Range forests. Not listed as a potential species

Potential impact of development: No impact on this species is anticipated as it is unlikely to be present.

Red-tailed Phascogale *Phascogale calura*

Status and Distribution: Listed as Scheduled 1 under the Wildlife Conservation Act, 1950 (*WC* Act) and as Endangered under the Environment Protection and Biodiversity Act, 1999 (*EPBC* Act). This species was recorded across much of arid and semi-arid Australia, from western NSW, to central Australia (Tennant Creek), Great Sandy Desert, southwest Western Australia, and parts of southern South Australia. Populations are currently known from several isolated nature reserves in the south-west of Western Australia, from the wheatbelt to the south coast, such as Tutanning, Boyagin, Dryandra, Dongolocking, and Parkeyerring, as well as remnant vegetation on private property. Red-tailed Phascogales have also been recorded on the south coast near Ravensthorpe (DEC information pamphlet).

Habitat: The Red-tailed Phascogale inhabits Wandoo (*Eucalyptus wandoo*) and Sheoak (*Allocasuarina huegeliana*) woodland associations, with populations being most dense in the latter vegetation type. They show a preference for long unburnt habitat with a continuous canopy and tree hollows. (DEC information pamphlet).

Wandoo trees provide excellent nesting sites in the form of hollow logs and limbs, which they line with grass and feathers. Nest sites occur in highly flammable

areas, and may often be in dead sheoaks, skirts of live (or stumps of dead) grass trees (*Xanthorrhoea* spp.) (DEC information pamphlet).

Young are born from mid June to mid August (Kitchener 1981). Weening is completed after about 90 days (Van Dyk and Strahan 2008). Young are independent at about 4 months (Menkhorst and Knight 2001).

J	F	M	A	M	J	J	A	S	O	N	D

Period in which breeding is most likely to commence
Period in which fledging/weening could extend to

Likely presence in study area: The study site is well outside of the currently documented range of this species and the habitat present is unsuitable for this species to persist. Extremely unlikely to be present and may in fact may never have occurred in the area historically (i.e. *EPBC Act* database listing is erroneous).

Potential impact of development: No impact on this species is anticipated.

Southern Brush-tailed Phascogale *Phascogale tapoatafa ssp*

Status and Distribution: Listed as Scheduled 1 under the *WC Act*. Present distribution is believed to have been reduced to approximately 50 per cent of its former range. Now known from Perth and south to Albany, west of Albany Highway. Occurs at low densities in the northern Jarrah forest. Highest densities occur in the Perup/Kingston area, Collie River valley, and near Margaret River and Busselton (DEC information pamphlet). Records are less common from wetter forests.

Habitat: This subspecies has been observed in dry sclerophyll forests and open woodlands that contain hollow-bearing trees but a sparse ground cover. A nocturnal carnivore relying on tree hollows as nest sites. The home range for a female Brush-tailed Phascogale is estimated at between 20 and 70 ha, whilst that for males is given as twice that of females. In addition, they tend to utilise a large number (approximately 20) of different nest sites throughout their range (Soderquist, 1995).

Likely presence in study area: The lack of recent records in the general area despite several detailed surveys (Rockingham, East Rockingham, Bibra Lake, Jandakot) suggests that it no longer persists in the general area. Not listed as a potential species. .

Potential impact of development: No impact on this species is anticipated.

Quenda *Isoodon obesulus fusciventer*

Status and Distribution: Listed as Priority 5 by DEC. Widely distributed in the south west from near Cervantes north of Perth to east of Esperance, patchy distribution through the Jarrah and Karri forest and on the Swan Coastal Plain, and inland as far as Hyden. Has been translocated to Julimar State Forest, Hills Forest Mundaring, Tutanning Nature Reserve, Boyagin Nature Reserve, Dongolocking Nature Reserve, Leschenault Conservation Park, and Karakamia and Paruna Sanctuaries (DEC information pamphlet) and Nambung National Park (DEC pers. coms.)

Habitat: Dense scrubby, often swampy, vegetation with dense cover up to one metre high, often feeds in adjacent forest and woodland that is burnt on a regular basis and in areas of pasture and cropland lying close to dense cover. Populations inhabiting Jarrah and Wandoo forests are usually associated with watercourses. Quendas can thrive in more open habitat subject to exotic predator control (DEC information pamphlet).

Likely presence in study area: A dead Quenda was found in bushland just west of the current study area during the 2005 survey (Harewood 2005) along with numerous digging. While no direct evidence of this species was observed in the more recent assessment it is likely to utilise those sections of the study area with the densest groundcover.

Potential impact of development: Potential for the loss of some habitat.

Western Brush Wallaby *Macropus irma*

Status and Distribution: Listed as Priority 4 by DEC. The Western Brush Wallaby is distributed across the south-west of Western Australia from north of Kalbarri to Cape Arid (DEC information pamphlet).

Habitat: The species optimum habitat is open forest or woodland, particularly favouring open, seasonally wet flats with low grasses and open scrubby thickets. It is also found in some areas of mallee and heathland, and is uncommon in karri forest (DEC information pamphlet).

Likely presence in study area: A Western Brush Wallaby was observed within the current study area boundary during the 2005 survey (Harewood 2005). Current status in the area is however difficult to determine. Typically only occurs

in low densities so its capacity to persist in small, fragmented bush remnants is limited. Listed as a potential species by maybe locally extinct.

Potential impact of development: Loss of potential habitat.

Quokka *Setonix brachyurus*

Status and Distribution: Listed as Scheduled 1 under the *WC Act* and as Vulnerable under the *EPBC Act*. Rare and restricted in south west W.A. from south of Perth to Two Peoples Bay. The distribution of the Quokka includes Rottnest and Bald Islands, and at least 25 known sites on the mainland, including Two Peoples Bay Nature Reserve, Torndirrup National Park, Mt Manypeaks National Park, Walpole-Nornalup National Park, and various swamp areas through the south-west forests from Jarrahdale to Walpole.

Species or species habitat listed as likely to occur in general area within EPBC database search.

Habitat: Mainland populations of this species are currently restricted to densely vegetated coastal heaths, swamps, riverine habitats including tea-tree thickets on sandy soils along creek systems where they are less vulnerable to predation. The species is nocturnal

Likely presence in study area: Locally extinct. Not listed as a potential species

Potential impact of development: No impact on this species will occur as it does not persist in the area.

Western False Pipistrelle *Falsistrellus mackenziei*

Status and Distribution: Listed as Priority 4 by DEC. Listed as vulnerable by the ICUN. Confined to south west W.A. south of Perth and east to the wheat belt. Most records from Karri forests but also recorded in wetter stands of jarrah and tuart and woodlands on the Swan Coastal Plain (Menkhorst and Knight 2001). Range appears to be contracting southwards, presumably due to drying climate. Not recorded north of Collie in recent times (Bob Bullen pers. comm.)

Habitat: This species of bat occurs in high forest and coastal woodlands. It roosts in small colonies in tree hollows and forages at canopy level and in the cathedral-like spaces between trees.

Likely presence in study area: Rarely recorded in this area in recent times. Not listed as a potential species.

Potential impact of development: No impact on this species is anticipated.

Water Rat *Hydromys chrysogaster*

Status and Distribution: Listed as Priority 4 by DEC. The water rat is widely distributed around Australia and its offshore islands, New Guinea and some adjacent islands. It occurs in fresh brackish water habitats in the south-west of Western Australia, but occurs in marine environments along the Pilbara coastline and offshore islands. Previous survey work in the south west suggested this species was relatively common and widespread though difficult to capture (Christensen *et al* 1985, How *et al* 1987).

Habitat: The water rat occupies habitat in the vicinity of 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).

Likely presence in study area: No suitable habitat.

Potential impact of development: No impact on this species is anticipated.

Appendix D Assessment of identified trees; Apsley Estate, Mandogalup (ArborLogic 2018a)

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August 31, 2018

Plan E
414 Rokeby Road
Subiaco WA 6008

Attention: **Jo Olive**

RE: **Assessment of identified trees; Apsley Estate, Mandogalup**

Dear Jo,

Further to your request, the following is a summary of my assessment of the identified trees at the Apsley Estate development, Mandogalup.

Should you have any queries regarding the findings of this report, or if I can be of any further assistance in the management of the identified trees, please do not hesitate to contact me.

Yours sincerely



JASON ROYAL

Dip. Arboriculture (UK)
Tech. Arbor A

Assessment of identified Trees at Apsley Estate, Mandogalup

Prepared For

Plan E

Prepared By

ARBOR logic

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Company Information & Disclaimer

1. Particulars to the Assessment

1.1 Terms Used

The following terms have been used in this report:

'Site'	meaning the area that was included in this particular assessment
'Tree'	meaning any individual tree identified on Site to be included in the assessment
'AS 4970'	meaning Australian Standards guideline 4970 (2009); Protection of trees on development sites
'AS 4373'	meaning Australian Standards guideline 4373 (2007); Pruning of amenity trees
'TPZ'	meaning Tree Protection Zone; the area where the majority of the given Tree's root mass is considered likely to be found, and the area that is recommended to be protected during any development or landscape activity

1.2 Limitations and Particulars of this Assessment

The information and opinions provided in this document are based on the findings from the visual observations of the Trees on the Site during the inspection undertaken August 24, 2018.

All observations of all of the Trees were undertaken from ground level.

No exploratory excavations were undertaken as part of this particular assessment to verify the actual root spread of any given Tree. As such the allocation of TPZ for each Tree has at this stage been based on AS 4970 guidelines, with some amendments being made for the physical size and canopy dimensions of the Tree, its condition, the known root zone morphology of its given species in the sort of soil profile considered to be typical to this area of Western Australia.

The Trees were noted to not have been tagged to enable identification. As such each Tree to be included in the assessment was identified as best as practicably possible based on the plan of the Site provided.

2. Scope of Works

The purpose of the inspection was to:

2.1. Undertake an inspection of the Trees in the two identified avenues shown on the plan provided below.



2.2. Provide basic cursory information on each of the identified Trees in terms of their species, approximate height, main stem diameter, canopy spread, estimated age, health and structural condition and any comments deemed pertinent to the tree.

2.3. Provide an opinion on the suitability of retention of each of the identified trees on the site in the context of a development process.

2.4. Provide any broad-brush purposeful and practical recommendations for any design and construction implications that may apply for any trees identified as being suitable for retention within the proposed development so to ensure their preservation if undertaken remains successful.

2.5. Provide details of any canopy management works that may be required as part of any development that occurs.

3. Methodology of the Assessment

All of the identified Trees were visually inspected from ground level in accordance with visual tree assessment ("VTA") methods and principles.

The VTA method is based on the sciences of tree biology, physiology, tree structure, and tree bio-mechanics. It is a method widely used by arborists worldwide to identify visible signs on trees that indicate any health or potential structural issues that in turn could increase the risks associated with the given tree.

The overall health of each Tree was adjudged from an inspection of its leaf, overall percentage of leaf mass present in the canopy of the Tree, and the presence (or absence) of any pest or disease factor that could have an effect on the overall health of the Tree.

The structural integrity of each Tree was determined from a visual inspection of its main stem, primary (and secondary) branch unions to determine the presence of any areas considered to be a structural 'defect' or 'imperfection' such as unions with included bark, swelling, or noticeable splitting at them.

Symptoms of decay, growth patterns and defects are identified and assessed as to their potential to cause whole tree, part tree or branch failure, and where considered necessary further investigation by way of the use of sounding techniques was utilised to determine the presence and general extent of any areas of cavity or associated decay within a tree's main stem structure.

With regards to any future development the known natural species traits of the given tree and its suitability for use in an urban area and if the identified specimen is of a species that can be subject to the sudden branch failure phenomenon or is known to be potentially problematic in terms of self-sowing (weed) issues, was also considered as part of the assessment process.

The Tree's species and its ability to cope with disturbances to its root zone that typically occur as part of a development process, as well as its ability to cope with the new parameters that are commonly created by an urban development (i.e. decreased soil oxygen due to compaction, increased un-seasonal watering from irrigation, increased pollution, increased radiated heat/light from urban infrastructure (roads, walls, buildings etc.) are all also taken into consideration.

The known root zone morphology of the species was taken into consideration when allocating the recommended TPZ for each of the identified trees. Note: Whilst some reference and acknowledgment is given to the guidelines set down in AS 4970, the TPZ for each Tree has been based on the known typical root zone morphology for specimens of their species, the condition of the given Tree, and the known tolerance to root zone disturbance of the given species.

4. Summary of Key Findings of the Assessment

4.1 Avenue 1





4.1.1 General Observations and Findings

A total of 32 Trees were identified in this avenue.

All of the Trees were identified as River Sheoak (*Casuarina cunninghamiana*).

All but one of the Trees looks to be mature, possibly in the order of 30-40 years old and look to have been purposely planted as a windbreak to the adjacent areas. One Tree was noted to be younger, not on the same alignment as the others and looks to be a self-sown specimen from a nearby Tree.

All of the Trees showed to be in good health at this time and there was no visible indications of any pest or disease pathogen that could have an adverse impact to their health at the time of inspection.

They all look to have (what is considered to be) good i.e. typical structural form for specimens of their given species although their development has been influenced to some extent by their proximity to each other. Branch failures were noted to have occurred in most of the Trees; all look to have been as a result of force loading (i.e. storm damage); considered to be typical for trees planted as a windbreak formation.

4. Summary of Key Findings of the Assessment

All of the mature Trees were noted to have been planted at an even 7 metre spacing between each other.

Overall a good avenue of mature specimens of this species, and any risks associated with the Trees look to be remaining within the realms and scope of management at this time, and are considered likely to remain so for the foreseeable future as this species is generally considered to be a relatively low risk species in terms of their propensity for branch failure.

Given the correct care and management these Trees could be anticipated to have (at least) another 15-40 years of 'safe-useful-life-expectancy' remaining.

4.1.2 Retention comments

Retention of these Trees in the context of a development is considered acceptable and would be encouraged.

Given their alignment and form they would be more suited to a (wide) median strip or area of POS where any potential issues from canopy overhang, and the volume of needle (leaf) litter they will produce can be better managed and mitigated by way of good design and landscape below.

Removal of a select few Trees to enable a footpath, or side road or similar to go between the Trees would be acceptable.

However, given their form, retention of as many of the Trees as a single avenue as possible would be recommended as opposed to removal of too many adjacent Trees and retaining individual specimens as thinning of a windbreak of this nature could increase the potential for branch failures to occur in the other remaining Trees.

Although their nominal TPZ does vary to some extent, I would suggest allowing a minimum area of **6 metre radius of any Tree's main stem as their TPZ**; the area where the majority of roots from the Trees will likely be found. Note: Whilst roots from the Trees may well extend well beyond this TPZ area, removal of any root mass outside of this radius is considered unlikely to have a major impact to the future health or in-ground stability of the Trees.

Any development works required within the 'modified' TPZ is strongly recommended to include a degree of further arboricultural input to review the extent of works required and advise on any remedial measures that may be required.

Their canopy could be raised to around 3-5 metres above ground level if desired and would not necessarily detract from the overall aesthetics of the avenue. If undertaken the removal of any larger deadwood and remains of any broken branches would also be recommended to occur at the same time.

4.1.3 The following pages provide further comments on each of the Trees identified in this avenue.

Note: Trees have been numbered sequentially starting from the western end of the avenue.

Tree No.	Species	Approx. Height (metres)	DBH (cm)	Canopy Spread (metres diameter)		Health	Structure	Image	comments	Canopy Works	Specific Development Considerations	Nominal TPZ (metres radius)
				N-S	E-W							
1	River Sheoak (*Casuarina cunninghamiana*)	22	116	13-14	13-14	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy. Main stem furcates into three. Union looks to be ok	Broken branch , larger deadwood, ok to raise canopy (if Better to retain as a row desired)		13.92
2	River Sheoak (*Casuarina cunninghamiana*)	22	67	13-14	5--6	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy	Broken branch , larger deadwood, ok to raise canopy (if Better to retain as a row desired)		8.04
3	River Sheoak (*Casuarina cunninghamiana*)	22	88	13-14	6--7	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy	Broken branch , larger deadwood, ok to raise canopy (if Better to retain as a row desired)		10.56
4	River Sheoak (*Casuarina cunninghamiana*)	22	66, 65	13-14	7--8	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy. Main stem bi-furcates. Union looks to be Ok at this stage	Broken branch , larger deadwood, ok to raise canopy (if Better to retain as a row desired)		7.92
5	River Sheoak (*Casuarina cunninghamiana*)	22	65, 59	13-14	7--8	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy. Main stem bi-furcates. Union looks to be Ok at this stage	Broken branch , larger deadwood, ok to raise canopy (if Better to retain as a row desired)		7.8
6	River Sheoak (*Casuarina cunninghamiana*)	19	56, 51, 32	13-14	7--8	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy. Main stem furcates into three. Union looks to be ok	Broken branch , larger deadwood, ok to raise canopy (if Better to retain as a row desired)		6.72
7	River Sheoak (*Casuarina cunninghamiana*)	22	80, 45	13-14	5--6	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Union looks to be ok. Broken branch in canopy. Co-dominant leader	Broken branch , larger deadwood, ok to raise canopy (if Better to retain as a row desired)		9.6

Tree No.	Species	Approx. Height (metres)	DBH (cm)	Canopy Spread (metres diameter)		Health	Structure	Image	comments	Canopy Works	Specific Development Considerations	Nominal TPZ (metres radius)
				N-S	E-W							
8	River Sheoak (*Casuarina cunninghamiana*)	16	76	13-14	5--6	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy	Broken branch , larger deadwood, ok to raise canopy (if desired)	Better to retain as a row	9.12
9	River Sheoak (*Casuarina cunninghamiana*)	20	95	13-14	5--6	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy. Evidence of (various sized) branch failures (storm damage). Co-dominant leader. Union looks to be ok	Broken branch , larger deadwood, ok to raise canopy (if desired)	Better to retain as a row	11.4
10	River Sheoak (*Casuarina cunninghamiana*)	20	56, 51, 32	13-14	5--6	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy. Evidence of (various sized) branch failures (storm damage). Union looks to be ok. Main stem furcates into three	Broken branch , larger deadwood, ok to raise canopy (if desired)	Better to retain as a row	6.72
11	River Sheoak (*Casuarina cunninghamiana*)	20	80, 39	13-14	6--7	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy. Union looks to be ok. Co-dominant leader	Broken branch , larger deadwood, ok to raise canopy (if desired)	Better to retain as a row	9.6
12	River Sheoak (*Casuarina cunninghamiana*)	18	76	13-14	5--6	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy. Main stem bi-furcates. Union looks to be Ok at this stage	Broken branch , larger deadwood, ok to raise canopy (if desired)	Better to retain as a row	9.12
13	River Sheoak (*Casuarina cunninghamiana*)	17	75	13-14	5--6	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy. Main stem bi-furcates. Union looks to be Ok at this stage	Broken branch , larger deadwood, ok to raise canopy (if desired)	Better to retain as a row	9
14	River Sheoak (*Casuarina cunninghamiana*)	17	63	13-14	5--6	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy. Main stem bi-furcates. Union looks to be Ok at this stage	Broken branch , larger deadwood, ok to raise canopy (if desired)	Better to retain as a row	7.56

Tree No.	Species	Approx. Height (metres)	DBH (cm)	Canopy Spread (metres diameter)		Health	Structure	Image	comments	Canopy Works	Specific Development Considerations	Nominal TPZ (metres radius)
				N-S	E-W							
15	River Sheoak (*Casuarina cunninghamiana*)	17	56, 40	13-14	6--7	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy. Co-dominant leader. Union looks to be ok	Broken branch , larger deadwood, ok to raise canopy (if desired)	Better to retain as a row	6.72
16	River Sheoak (*Casuarina cunninghamiana*)	7	25	4--5	3--4	Excellent	Acceptable		Reasonably good specimen. No issues or concerns visible at this time. Canopy is one sided south. Canopy is one-sided due to proximity of the adjacent tree. Co-dominant leader. Looks to be self-sown	Broken branch , larger deadwood, ok to raise canopy (if desired)	WOULDN'T BE MISSED IF REMOVED. Low canopy wouldn't be able to be raised much without impact to the Tree. Canopy is one sided south. Not in the same aligned as the other larger Trees	3
17	River Sheoak (*Casuarina cunninghamiana*)	22	113	13-14	6--7	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy. Co-dominant leader. Union looks to be ok	Broken branch , larger deadwood, ok to raise canopy (if desired)	Better to retain as a row	13.56
18	River Sheoak (*Casuarina cunninghamiana*)	22	101	13-14	6--7	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy. Co-dominant leader. Union looks to be ok	Broken branch , larger deadwood, ok to raise canopy (if desired)	Better to retain as a row	12.12
19	River Sheoak (*Casuarina cunninghamiana*)	22	104	13-14	5--6	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy. Co-dominant leader. Union looks to be ok	Broken branch , larger deadwood, ok to raise canopy (if desired)	Better to retain as a row	12.48
20	River Sheoak (*Casuarina cunninghamiana*)	22	72	13-14	6--7	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy	Broken branch , larger deadwood, ok to raise canopy (if desired)	Better to retain as a row	8.64
21	River Sheoak (*Casuarina cunninghamiana*)	22	73, 62, 47	13-14	7--8	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy. Main stem furcates into three. Union looks to be ok	Broken branch , larger deadwood, ok to raise canopy (if desired)	Better to retain as a row	8.76

Tree No.	Species	Approx. Height (metres)	DBH (cm)	Canopy Spread (metres diameter)		Health	Structure	Image	comments	Canopy Works	Specific Development Considerations	Nominal TPZ (metres radius)
				N-S	E-W							
22	River Sheoak (*Casuarina cunninghamiana*)	20	86	11--12	5--6	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy. Evidence of (various sized) branch failures (storm damage)	Broken branch , larger deadwood, ok to raise canopy (if Better to retain as a row desired)		10.32
23	River Sheoak (*Casuarina cunninghamiana*)	20	90	12--13	5--6	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy. Evidence of (various sized) branch failures (storm damage)	Broken branch , larger deadwood, ok to raise canopy (if Better to retain as a row desired)		10.8
24	River Sheoak (*Casuarina cunninghamiana*)	20	82	13-14	6--7	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy. Evidence of (various sized) branch failures (storm damage)	Broken branch , larger deadwood, ok to raise canopy (if Better to retain as a row desired)		9.84
25	River Sheoak (*Casuarina cunninghamiana*)	18	66, 47	13-14	6--7	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy. Evidence of (various sized) branch failures (storm damage). Multi-stemmed from near ground level. Union looks to be ok	Broken branch , larger deadwood, ok to raise canopy (if Better to retain as a row desired)		7.92
26	River Sheoak (*Casuarina cunninghamiana*)	19	79	13-14	5--6	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy	Broken branch , larger deadwood, ok to raise canopy (if Better to retain as a row desired)		9.48
27	River Sheoak (*Casuarina cunninghamiana*)	20	102	13-14	6--7	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy	Broken branch , larger deadwood, ok to raise canopy (if Better to retain as a row desired)		12.24
28	River Sheoak (*Casuarina cunninghamiana*)	20	75	13-14	5--6	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy. Main stem bi-furcates. Union looks to be Ok at this stage	Broken branch , larger deadwood, ok to raise canopy (if Better to retain as a row desired)		9

Tree No.	Species	Approx. Height (metres)	DBH (cm)	Canopy Spread (metres diameter)		Health	Structure	Image	comments	Canopy Works	Specific Development Considerations	Nominal TPZ (metres radius)
				N-S	E-W							
29	River Sheoak (*Casuarina cunninghamiana*)	18	103	13-14	7--8	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy. Main stem bi-furcates. Union looks to be Ok at this stage. Evidence of (various sized) branch failures (storm damage)	Broken branch , larger deadwood, ok to raise canopy (if desired)	Better to retain as a row	12.36
30	River Sheoak (*Casuarina cunninghamiana*)	17	73	13-14	6--7	Good	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy. Evidence of (various sized) branch failures (storm damage). Reasonably good specimen. Few dead tips/ some deadwood but otherwise ok	Broken branch , larger deadwood, ok to raise canopy (if desired)	Better to retain as a row	8.76
31	River Sheoak (*Casuarina cunninghamiana*)	20	82	13-14	6--7	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy. Evidence of (various sized) branch failures (storm damage)	Broken branch , larger deadwood, ok to raise canopy (if desired)	Better to retain as a row	9.84
32	River Sheoak (*Casuarina cunninghamiana*)	21	65	13-14	7--8	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok. Broken branch in canopy. Evidence of (various sized) branch failures (storm damage)	Broken branch , larger deadwood, ok to raise canopy (if desired)	Even 7m spacings between Trees	7.8

4. Summary of Key Findings of the Assessment

4.2 Avenue 2




4.2.1 General Observations and Findings

A total of 53 Trees were identified in this avenue.

Three different species of tree were identified. The majority (37x) were identified as River Sheoak (*Casuarina cunninghamiana*). 15 are Swamp Mahogany (*Eucalyptus robusta*), and there is one Tasmanian Blue Gum (*Eucalyptus globulus*).

The Swamp Mahogany and Tasmanian Blue Gum look to be more mature and are estimated to be of a similar age; possibly in the order of 30-40 years old.

The River Sheoak look to be younger trees; possibly planted as an in-fill windbreak for any previously existing trees that may have been present within the avenue, or to increase the properties and effectiveness of the windbreak to the adjacent fields.

Five dead Trees were noted in this avenue; mostly towards the eastern end of the avenue. All of the other Trees showed to be in good health at this time and there was no visible indications of any pest or disease pathogen that could have an adverse impact to their health at the time of inspection.

The majority look to have (what is considered to be) good i.e. typical structural form for specimens of their given species although their development has been influenced to some extent by their proximity to each other particularly some of the River Sheoak which (due to their close proximity to each other) have developed on a slight lean or have one-sided canopy as a result. Branch failures were noted to have occurred in some of the larger Swamp Mahogany. All look to have been as a result of force loading (i.e. storm damage); considered to be typical for trees planted as a windbreak formation.

Spacings between Trees was noted to vary. Most were noted to be at an even 2 metre 'centres' particularly towards the western end. Towards the eastern end of the avenue spacing between Trees was noted to increase; possibly more so due to other previously existing trees having died and been removed/fallen over rather than by design.

Overall a reasonably good avenue of trees (although Avenue 1 does look to have better quality trees). Any risks associated with the majority of them look to be remaining within the realms and scope of management at this time.

4. Summary of Key Findings of the Assessment

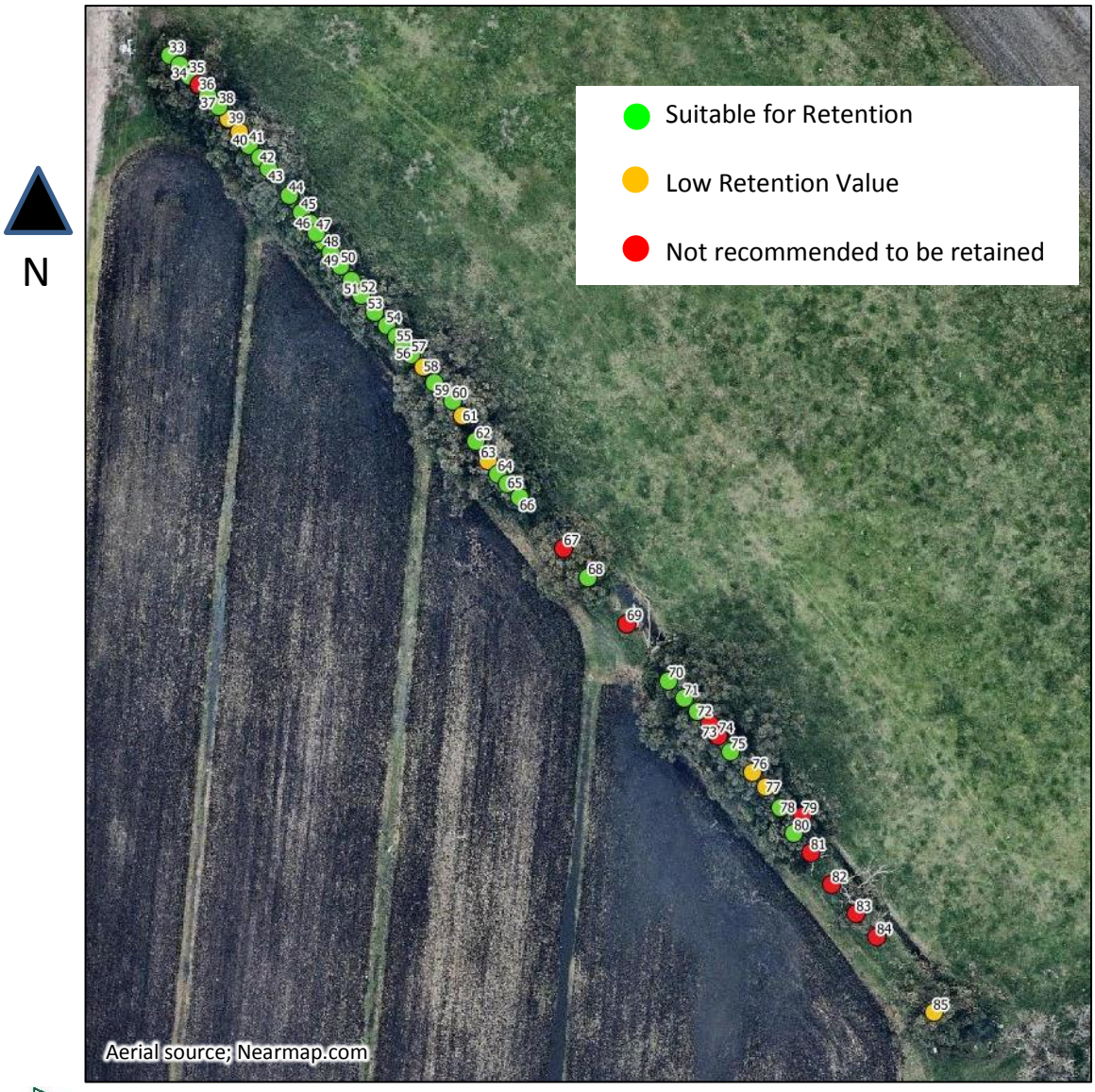
4.2.2 Retention comments

Similar to Avenue 1, given their alignment and form they would be more suited to a (wide) median strip or area of POS where any potential issues from canopy overhang, and the volume of needle (leaf) litter they will produce can be better managed and mitigated by way of good design and landscape below.

There are a few Trees within the avenue that will need to be removed (i.e. the dead trees). However removal of these Trees and removal of a number of the very small Trees from this avenue would not necessarily detract from its overall aesthetic amenity. In some areas every other Tree could possibly be removed if desired which would allow the remaining Trees to mature further unimpeded.

Removal of a select few Trees to enable a footpath, or side road or similar to go between the Trees would also be acceptable. However, retention of as many of the Trees as a single avenue as possible would be recommended as opposed to removal of too many adjacent Trees and retaining individual specimens as thinning of a windbreak of this nature could increase the potential for branch failures to occur in the other remaining Trees.

The Trees towards the eastern end of the avenue look also to have a lower retention value compared to those at the western end of the avenue and this has been expressed in a colour code on an aerial of the avenue below.



4. Summary of Key Findings of the Assessment

Although their nominal TPZ does vary to some extent, I would suggest allowing a minimum area of **6 metre radius of any Tree's main stem as their TPZ for the larger Swamp Mahogany, 3 metres for the smaller River Sheoak**. Note: Whilst roots from some of the larger Trees in this avenue may well extend well beyond this TPZ area, removal of any root mass outside of this radius is considered unlikely to have a major impact to the future health or in-ground stability of the Trees.

Any development works required within this 'modified' TPZ is strongly recommended to include a degree of further arboricultural input to review the extent of works required and advise on any remedial measures that may be required.

The canopy of most of these Trees could be raised to around 3-4 metres above ground level if desired for the smaller trees, slightly higher for the larger ones and would not necessarily detract from the overall aesthetics of the avenue. However some of the very small Trees in this avenue would **not** be able to be raised without impact to their aesthetics or future health.

If undertaken the removal of any larger deadwood and remains of any broken branches would also be recommended to occur at the same time.

4.2.3 The following pages provide further comments on each of the Trees identified in this avenue.

Note: Trees have been numbered sequentially starting from the western end of the avenue.

Tree No.	Species	Approx. Height (metres)	DBH (cm)	Canopy Spread (metres diameter)		Health	Structure	Image	comments	Canopy Works	Specific Development Considerations	Nominal TPZ (metres radius)
				N-S	E-W							
33	River Sheoak (*Casuarina cunninghamiana*)	13	58	9--10	5--6	Excellent	Good		Good specimen. No issues or concerns visible at this time. Canopy is one sided west. Canopy is one-sided due to proximity of the adjacent tree. Effectively forms the one canopy with the adjacent Tree	Should be ok to raise canopy if desired	Canopy is relatively one-sided west. Better to retain as a row. Looks to have originally been 2m spacing's between trees	6.96
34	Swamp Mahogany (*Eucalyptus robusta*)	18	64	9--10	7--8	Excellent	Good		Good specimen. No issues or concerns visible at this time. Effectively forms the one canopy with the adjacent Tree. Canopy is one sided north	Should be ok to raise canopy if desired	Better to retain as a row	7.68
35	River Sheoak (*Casuarina cunninghamiana*)	13	45	9--10	3--4	Excellent	Good		Good specimen. No issues or concerns visible at this time. Effectively forms the one canopy with the adjacent Tree	Should be ok to raise canopy if desired	Better to retain as a row	5.4
36	River Sheoak (*Casuarina cunninghamiana*)	13	25	1--2	1--2	Dead	Hazardous		Dead tree. Looks to have partially snapped at ground level	Remove to ground level	Better to retain as a row	3
37	River Sheoak (*Casuarina cunninghamiana*)	13	45	9--10	4--5	Excellent	Good		Good specimen. No issues or concerns visible at this time	Should be ok to raise canopy if desired	Better to retain as a row	5.4
38	River Sheoak (*Casuarina cunninghamiana*)	11	33	4--5	3--4	Excellent	Good		Good specimen. No issues or concerns visible at this time	Should be ok to raise canopy if desired	4m gap between 37/38	3.96
39	River Sheoak (*Casuarina cunninghamiana*)	13	50	6--7	3--4	Excellent	Undesirable		Ok specimen. No issues or concerns visible at this time. Main stem bi-furcates. Included bark & swelling at the union. Union looks to be ok at this time but looks likely to cause issues longer term	Should be ok to raise canopy if desired	Structure looks likely to cause issues longer term	6

Tree No.	Species	Approx. Height (metres)	DBH (cm)	Canopy Spread (metres diameter)		Health	Structure	Image	comments	Canopy Works	Specific Development Considerations	Nominal TPZ (metres radius)
				N-S	E-W							
40	Swamp Mahogany (*Eucalyptus robusta*)	18	65	10--11	11--12	Excellent	Undesirable		Ok specimen. No issues or concerns visible at this time. Canopy is one sided north. Grown on an angle. Looks to be ok at this time but may cause issues longer term	Should be ok to raise canopy if desired. Remove any larger deadwood	Structure looks likely to cause issues longer term	7.8
41	River Sheoak (*Casuarina cunninghamiana*)	8	34	3--4	2--3	Excellent	Good		Good specimen. No issues or concerns visible at this time	Wouldn't be able to be raised much without impacting the tree	Small tree so may question retention of the adjacent larger trees were removed	4.08
42	River Sheoak (*Casuarina cunninghamiana*)	16	41	6--7	2--3	Excellent	Good		Good specimen. No issues or concerns visible at this time	Should be ok to raise canopy if desired	Better to retain as a row	4.92
43	River Sheoak (*Casuarina cunninghamiana*)	15	35	6--7	3--4	Excellent	Good		Good specimen. No issues or concerns visible at this time	Should be ok to raise canopy if desired	Better to retain as a row. 6m gap between 43/44	4.2
44	River Sheoak (*Casuarina cunninghamiana*)	15	40	7--8	4--5	Excellent	Good		Good specimen. No issues or concerns visible at this time	Should be ok to raise canopy if desired	Better to retain as a row. 6m gap between 43/44. 4m gap between 44/45	4.8
45	River Sheoak (*Casuarina cunninghamiana*)	13	24	4--5	1--2	Excellent	Good		Ok specimen. No issues or concerns visible at this time. Smaller tree and possibly wouldn't be missed if removed	Should be ok to raise canopy if desired	4m gap between 44/45. Smaller tree and possibly wouldn't be missed if removed	2.88
46	River Sheoak (*Casuarina cunninghamiana*)	14	35	6--7	3--4	Excellent	Good		Good specimen. No issues or concerns visible at this time. Broken branch in canopy. Co-dominant leader	Should be ok to raise canopy if desired	Better to retain as a row	4.2

Tree No.	Species	Approx. Height (metres)	DBH (cm)	Canopy Spread (metres diameter)		Health	Structure	Image	comments	Canopy Works	Specific Development Considerations	Nominal TPZ (metres radius)
				N-S	E-W							
47	River Sheoak (*Casuarina cunninghamiana*)	15	31	6--7	3--4	Excellent	Good		Good specimen. No issues or concerns visible at this time. Small diameter (<10cm) broken branch hanging in the canopy	Should be ok to raise canopy if desired	Better to retain as a row	3.72
48	River Sheoak (*Casuarina cunninghamiana*)	15	35	8--9	3--4	Excellent	Good		Good specimen. No issues or concerns visible at this time	Should be ok to raise canopy if desired	Better to retain as a row	4.2
49	River Sheoak (*Casuarina cunninghamiana*)	11	34	6--7	3--4	Excellent	Good		Good specimen. No issues or concerns visible at this time	Should be ok to raise canopy if desired	Better to retain as a row	4.08
50	Swamp Mahogany (*Eucalyptus robusta*)	16	65	11--12	7--8	Excellent	Good		Good specimen. No issues or concerns visible at this time	Should be ok to raise canopy if desired. Remove any larger deadwood	Better to retain as a row	7.8
51	River Sheoak (*Casuarina cunninghamiana*)	10	30	4--5	2--3	Excellent	Good		Reasonably good specimen. No issues or concerns visible at this time	Should be ok to raise canopy if desired	Smaller tree and possibly wouldn't be missed if removed	3.6
52	River Sheoak (*Casuarina cunninghamiana*)	9	21	2--3	2--3	Excellent	Good		Reasonably good specimen. No issues or concerns visible at this time	Should be ok to raise canopy if desired	Smaller tree and possibly wouldn't be missed if removed	2.52
53	River Sheoak (*Casuarina cunninghamiana*)	11	30	6--7	2--3	Excellent	Good		Reasonably good specimen. No issues or concerns visible at this time	Should be ok to raise canopy if desired	Better to retain as a row	3.6

Tree No.	Species	Approx. Height (metres)	DBH (cm)	Canopy Spread (metres diameter)		Health	Structure	Image	comments	Canopy Works	Specific Development Considerations	Nominal TPZ (metres radius)
				N-S	E-W							
54	River Sheoak (*Casuarina cunninghamiana*)	11	30	4--5	2--3	Excellent	Good		Reasonably good specimen. No issues or concerns visible at this time. Main stem bi-furcates. Union looks to be Ok at this stage	Should be ok to raise canopy if desired	Better to retain as a row	3.6
55	River Sheoak (*Casuarina cunninghamiana*)	8	18	3--4	1--2	Excellent	Good		Ok specimen. No issues or concerns visible at this time	Should be ok to raise canopy if desired	Smaller tree and possibly wouldn't be missed if removed	2.16
56	River Sheoak (*Casuarina cunninghamiana*)	8	25	2--3	1--2	Excellent	Good		Reasonably good specimen. No issues or concerns visible at this time. Canopy is one sided west. Canopy is one-sided due to proximity of the adjacent tree	Should be ok to raise canopy if desired	Better to retain as a row	3
57	River Sheoak (*Casuarina cunninghamiana*)	8	24	2--3	2--3	Excellent	Good		Reasonably good specimen. No issues or concerns visible at this time. Canopy is one sided west. Canopy is one-sided due to proximity of the adjacent tree	Should be ok to raise canopy if desired	Possibly wouldn't be missed if removed	2.88
58	Swamp Mahogany (*Eucalyptus robusta*)	18	83	14-15	10--11	Excellent	Undesirable		Canopy is one sided west. Canopy is one-sided due to proximity of the adjacent tree. Evidence of (various sized) branch failures (storm damage). Looks likely to have high probability for branch failures. Top of main leader has snapped (storm damage). Low canopy northern side	Deadwood, Broken branch, Raise canopy, Reduce weight loading	Canopy is relatively one-sided NW. Structure looks likely to cause issues longer term. Low canopy wouldn't be able to be raised much without impact to the Tree. Better suited to low target areas i.e. POS	9.96
59	River Sheoak (*Casuarina cunninghamiana*)	8	26	2--3	2--3	Excellent	Good		Reasonably good specimen. No issues or concerns visible at this time. Canopy is one sided west. Canopy is one-sided due to proximity of the adjacent tree	Wouldn't be able to be raised much without impacting the tree	Smaller tree and possibly wouldn't be missed if removed	3.12
60	Swamp Mahogany (*Eucalyptus robusta*)	23	75	14-15	8--9	Excellent	Good		Evidence of (various sized) branch failures (storm damage). Large mature tree. Some larger deadwood but otherwise ok	Should be ok to raise canopy if desired. Remove any larger deadwood		0.06

Tree No.	Species	Approx. Height (metres)	DBH (cm)	Canopy Spread (metres diameter)		Health	Structure	Image	comments	Canopy Works	Specific Development Considerations	Nominal TPZ (metres radius)
				N-S	E-W							
61	River Sheoak (*Casuarina cunninghamiana*)	3	11	1--2	1--2	Fair	Good		Ok tree but looks to be struggling to establish	Wouldn't be able to be raised much without impacting the tree	Smaller tree and possibly wouldn't be missed if removed	1.32
62	Swamp Mahogany (*Eucalyptus robusta*)	23	84	14-15	9--10	Excellent	Good		Evidence of (various sized) branch failures (storm damage). Large mature tree. Some larger deadwood but otherwise ok	Broken branch, Deadwood		10.08
63	River Sheoak (*Casuarina cunninghamiana*)	10	22	3--4	2--3	Good	Good		Ok tree. Canopy slightly sparse. Remaining leaf still good condition. Canopy is one-sided due to proximity of the adjacent tree	Should be ok to raise canopy if desired	Would question retention if the adjacent tree was removed. Smaller tree and possibly wouldn't be missed if removed	2.64
64	River Sheoak (*Casuarina cunninghamiana*)	10	27	4--5	1--2	Good	Good		Ok tree. Canopy slightly sparse. Remaining leaf still good condition. Canopy is one-sided due to proximity of the adjacent tree	Should be ok to raise canopy if desired	Would question retention if the adjacent tree was removed. Smaller tree and possibly wouldn't be missed if removed	3.24
65	River Sheoak (*Casuarina cunninghamiana*)	15	36	5--6	3--4	Excellent	Good		Good specimen. No issues or concerns visible at this time. Effectively forms the one canopy with the adjacent Tree	Should be ok to raise canopy if desired	Better to retain as a row	4.32
66	River Sheoak (*Casuarina cunninghamiana*)	15	49	7--8	6--7	Excellent	Good		Good specimen. No issues or concerns visible at this time. Effectively forms the one canopy with the adjacent Tree	Should be ok to raise canopy if desired	Gap to next tree	5.88
67	Tasmanian Blue Gum (*Eucalyptus globulus*)	15	105	10--11	9--10	Excellent	Questionable		Small diameter (<10cm) broken branch hanging in the canopy. Area of decay. Possibly impacting structural integrity. Large mature specimen	Suggest remove to ground level	Structure looks likely to cause issues longer term. 15m gap between 66/67	12.6

Tree No.	Species	Approx. Height (metres)	DBH (cm)	Canopy Spread (metres diameter)		Health	Structure	Image	comments	Canopy Works	Specific Development Considerations	Nominal TPZ (metres radius)
				N-S	E-W							
68	River Sheoak (*Casuarina cunninghamiana*)	16	40	5--6	4--5	Excellent	Acceptable		Reasonably good specimen. No issues or concerns visible at this time. Canopy is one sided east. Effectively forms the one canopy with the adjacent Tree. Grown on an angle but looks to be ok at this time	Should be ok to raise canopy if desired	Would question retention if the adjacent tree was removed	4.8
69	Swamp Mahogany (*Eucalyptus robusta*)	3	54	0	0	Dead	Questionable		Dead tree	Remove to ground level	Dead tree	6.48
70	River Sheoak (*Casuarina cunninghamiana*)	10	36	6--7	5--6	Excellent	Good		Good specimen. No issues or concerns visible at this time	Wouldn't be able to be raised much without impacting the tree	18m gap between 68/70	4.32
71	River Sheoak (*Casuarina cunninghamiana*)	9	27	3--4	3--4	Excellent	Good		Good specimen. No issues or concerns visible at this time	Wouldn't be able to be raised much without impacting the tree	Looks to now be 3m spacing's between trees	3.24
72	Swamp Mahogany (*Eucalyptus robusta*)	23	115	15-16	17-18	Excellent	Acceptable		Evidence of (various sized) branch failures (storm damage). Large mature specimen. Some large (>10cm diameter) deadwood in canopy. Leaning slightly north. May warrant further investigation into root plate stability	Should be ok to raise canopy if desired. Remove any larger deadwood	Better suited to low target areas i.e. POS	13.8
73	River Sheoak (*Casuarina cunninghamiana*)	3	7.5	1--2	1--2	Fair	Good		Canopy is relatively sparse and looks to be struggling to establish properly	Wouldn't be able to be raised much without impacting the tree	Would question retention if the adjacent tree was removed. Smaller tree and possibly wouldn't be missed if removed	0.9
74	River Sheoak (*Casuarina cunninghamiana*)	4	13, 10, 10	3--4	3--4	Fair	Good		Multi-stemmed from near ground level. Looks to be struggling to establish properly	Wouldn't be able to be raised much without impacting the tree	Would question retention if the adjacent tree was removed. Smaller tree and possibly wouldn't be missed if removed	1.56

Tree No.	Species	Approx. Height (metres)	DBH (cm)	Canopy Spread (metres diameter)		Health	Structure	Image	comments	Canopy Works	Specific Development Considerations	Nominal TPZ (metres radius)
				N-S	E-W							
75	Swamp Mahogany (*Eucalyptus robusta*)	23	82	12--13	9--10	Excellent	Good		Large mature tree. Some larger deadwood but otherwise ok	Should be ok to raise canopy if desired. Remove any larger deadwood		9.84
76	River Sheoak (*Casuarina cunninghamiana*)	8	33	6--7	3--4	Excellent	Good		Ok specimen. No issues or concerns visible at this time. Suppressed to some degree by the adjacent trees	Wouldn't be able to be raised much without impacting the tree	6m gap between 75/76. Possibly wouldn't be missed if removed	3.96
77	Swamp Mahogany (*Eucalyptus robusta*)	19	75	12--13	9--10	Excellent	Acceptable		Large mature specimen. Some large (>10cm diameter) deadwood in canopy . Top of main leader is dead. Canopy is relatively one sided. Area of decay. Not of a major concern at this time	Should be ok to raise canopy if desired. Remove any larger deadwood	Canopy is relatively one-sided north. Structure looks likely to cause issues longer term	9
78	River Sheoak (*Casuarina cunninghamiana*)	8	26	3--4	2--3	Excellent	Good		Reasonably good specimen. No issues or concerns visible at this time. Slightly suppressed by the adjacent tree but developing ok	Wouldn't be able to be raised much without impacting the tree	Small tree so may question retention of the adjacent larger trees were removed	3.12
79	River Sheoak (*Casuarina cunninghamiana*)	5	18	3--4	2--3	Excellent	Undesirable		Ok specimen. No issues or concerns visible at this time. Canopy is one sided north. Looks to be self-sown	Suggest remove to ground level	Canopy is one sided north. Low canopy wouldn't be able to be raised much without impact to the Tree. Not on same alignment as the other Trees	2.16
80	River Sheoak (*Casuarina cunninghamiana*)	13	33	6--7	6--7	Excellent	Good		Good specimen. No issues or concerns visible at this time	Should be ok to raise canopy if desired	Approximately 30m between 80/85	3.96
81	Swamp Mahogany (*Eucalyptus robusta*)	15	40	4--5	2--3	Dead	Poor		Dead tree	Remove to ground level	Dead tree	4.8

Tree No.	Species	Approx. Height (metres)	DBH (cm)	Canopy Spread (metres diameter)		Health	Structure	Image	comments	Canopy Works	Specific Development Considerations	Nominal TPZ (metres radius)
				N-S	E-W							
82	Swamp Mahogany (*Eucalyptus robusta*)	13	35	4--5	2--3	Dead	Poor		Dead tree	Remove to ground level	Dead tree	4.2
83	Swamp Mahogany (*Eucalyptus robusta*)	14	60	6--7	5--6	Poor	Questionable		"Section of its canopy is dead. remainder slightly sparse". Area of decay. Possibly impacting structural integrity	Remove to ground level	Dead tree	7.2
84	Swamp Mahogany (Eucalyptus robusta)	11	45	3--4	3--4	Dead	Poor		Dead tree	Remove to ground level	Dead tree	5.4
85	Swamp Mahogany (Eucalyptus robusta)	18	72	12--13	13-14	Good	Acceptable		Reasonably good specimen. No issues or concerns visible at this time. Canopy slightly sparse. Remaining leaf still good condition. Minor amount of moderate (5-10cm diameter) deadwood. Evidence of (various sized) branch failures (storm damage)	Should be ok to raise canopy if desired. Remove any larger deadwood, broken branches etc.	Structure looks likely to cause issues longer term. Approximately 30m between 85/80	8.64

4.3 Additional Trees

A number of additional Trees were also inspected as part of this assessment; identified on an aerial image below.



4.3.1 '101'





Species; River Sheoak (*Casuarina cunninghamiana*), Swamp Sheoak (*Casuarina obesa*)
Height; 18 metres
DBH; range 30-60cm
Canopy Spread 18-20 metres North-South
18-20 metres East -West

Comments; Group of 11 trees in close proximity that effectively form the one canopy. Looks to be two different species; River Sheoak (*Casuarina cunninghamiana*), Swamp Sheoak (*Casuarina obesa*). One dead tree amongst the group. Otherwise they all show good health at this time and have (what is considered to be) typical structural form for specimens of their given species. Canopy of some is however one sided due to power line clearance pruning (western side). Evidence of a few branch failures (storm damage). Otherwise no issues at this time

4.3 Additional Trees

Opinion; Better to retain as a group. Removal of the dead tree from the group would not necessarily detract from the overall aesthetic amenity of the group.

Suggest to allow a 5 metre radius of any Tree's main stem as its nominal TPZ at this time.

Any development works required within this 'modified' TPZ is strongly recommended to include a degree of further arboricultural input to review the extent of works required and advise on any remedial measures that may be required.

4.3.2 '102'



Species; Tuart (*Eucalyptus gomphocephala*)
Height; 15 metres
DBH; 80cm
Canopy Spread 9-10 metres North-South
9-10 metres East -West

Comments; Large mature tree. Apical sections of its canopy are dead/declining and its canopy condition suggests possibly limited life remaining. Area of decay also noted; possibly impacting structural integrity. Broken branch in canopy.

Opinion; Despite its size/age this Tree is considered to have a low retention value in the context of retention and inclusion into an urban development.

If it was to be retained, then it would be suited to a low (or even no) Target area of public open space only.

Suggest treating a 10 metre radius if its main stem as its nominal TPZ at this time if it is to be retained.

4.3 Additional Trees

4.3.3 '103'



Species; Flooded Gum (*Eucalyptus rudis*)
Height; 15 metres
DBH; 62, 61cm
Canopy Spread 9-10 metres North-South
9-10 metres East -West

Comments; Large mature tree. Multi-stemmed from near ground level. One stem dead. The top part of the other is also dead, although there is some live leaf mass remaining in its mid canopy region. Area of decay. Possibly impacting structural integrity. Evidence of (various sized) branch failures (storm damage).

Opinion; Removal of the dead section would result in a one sided canopy.

As a result this Tree is considered to have a low retention value in the context of retention and inclusion into an urban development.

If it was to be retained, then it would be suited to a low (or even no) Target area of public open space only.

Suggest treating a 10 metre radius if its main stem as its nominal TPZ at this time if it is to be retained.

4.3 Additional Trees

4.3.4 '104'



Species; Tuart (*Eucalyptus gomphocephala*)
Height; 15 metres
DBH; 72cm
Canopy Spread 8-9 metres North-South
9-10 metres East -West

Comments; Large mature tree. Apical parts (tips) of its canopy are dead/declining. Still has some leaf mass remaining and looks to be recovering to some degree but all leaf mass is epicormic stress regrowth at this time. Ok (typical) structural form. Area of decay. Not of a major concern at this time. Evidence of (various sized) branch failures (storm damage).

Opinion; Despite its size/age this Tree is considered to have a fairly low retention value in the context of retention and inclusion into an urban development.

If it was to be retained, then it would be suited to a low (or even no) Target area of public open space only.

Suggest treating a 10 metre radius if its main stem as its nominal TPZ at this time if it is to be retained.

4.3 Additional Trees

4.3.5 '105'



Species; Tuart (*Eucalyptus gomphocephala*)

Height; 27 metres
DBH; 129cm
Canopy Spread 16-17 metres North-South
20-22 metres East -West

Comments; Large mature tree. Some larger deadwood throughout its canopy but otherwise ok. Canopy slightly sparse. Remaining leaf still good condition. Evidence of (various sized) branch failures (storm damage). Bark damage at branch unions (typical of birds); looks to be ok at this time but may cause issues longer term. Some suggestions of bark canker as well, but looks to be having minimal impact at this time.

Opinion; Considered to have a reasonably high retention value. However it would be better suited to low target areas such as POS due to it's physical size and issues physically larger trees can often present in urbanised areas.

Any impact to its root zone could severely impact its future health and potential life span.

Recommend treating a minimum 15 metre radius of its main stem as its nominal TPZ at this time.

Any works required in that area are strongly recommended to include a degree of further arboricultural input to ensure impact to the Tree will remain minimal and that any future potential management issues can be mitigated as much as practicably possible by way of good design.

4.3 Additional Trees

4.3.6 '105a'



Species; Tuart (*Eucalyptus gomphocephala*)
Height; 20 metres
DBH; 129m
Canopy Spread 15-16 metres North-South
15-16 metres East -West

Comments; Large mature tree. Canopy is all one sided north due to the proximity of the adjacent larger Tree. Top parts of its canopy is dead. Still has some leaf mass remaining though in the lower canopy area. Top of main leader has snapped at some stage in the past (storm damage) and there is evidence of numerous previous branch failures (large >200mm diameter) having occurred. Termites seen in lower main stem and an area of decay. Not of a major concern at this time but may cause issues longer term.

Opinion; Despite its size/age this Tree is considered to have a fairly low retention value in the context of retention and inclusion into an urban development.

Its canopy is all one sided north and its structure looks likely to cause issues longer term.

If it was to be retained, then it would be suited to a low (or even no) Target area of public open space only.

4.3 Additional Trees

4.3.7 '106'



Species; White Cedar (*Melia azedarach*)
Height; 14 metres
DBH; range 35-90cm
Canopy Spread 24-26 metres North-South
28-30 metres East -West

Comments; Large group of 12 or so trees in close proximity that effectively form the one canopy.

Most show good health and structural form.

One tree in the middle has previously collapsed and subsequently re-gavenuen a number of sucker stems. Some deadwood in some trees but otherwise ok and no issues at this time.

Opinion; Better to retain as a group. Removal of the collapsed tree from the group would not necessarily detract from the overall aesthetic amenity of the group.

Suggest to allow a 5 metre radius of each Tree's main stem as its nominal TPZ at this time.

Trees are on a south-east facing slope so final levels may need to be considered.

5. Further Considerations; Development Design and Construction

5.1 The nominal TPZ and canopy spread of each Tree is recommended to be overlaid onto all development plans used during the design process.

Where encroachments into a designated TPZ are found to be required, further discussion with an experienced independent arboricultural consultant will be required if the Tree is desired to be retained as part of the development.

This is not to say that some encroachment and development activity would not be permitted to be undertaken within a TPZ area as part of a development process.

However any encroachment required/proposed will require further input and discussion with the arboricultural consultant as part of any detailed design process to determine what the potential impact on the given Tree will be, and what design modifications or measures may need to be implemented to mitigate any potential negative impact on the given Tree.

If considered necessary, some exploratory excavation works may also be required to verify actual root spread and determine what impact could occur.

5.2 During the development design process further arboricultural input will likely be required to discuss:

a. Current existing ground levels and proposed resulting levels of the various areas of the Site. Note: As previously mentioned, retaining and maintaining current existing ground levels within the designated TPZ of any tree is of paramount importance to the success of tree retention.

b. Delineation of any underground services pipework including drainage, sewerage, water, gas, electricity, telecommunications and the like; specifically should they pass through any designated TPZ.

c. Location of any drainage required to be installed in the POS near to the Trees or within their TPZ areas.

d. Any site remediation requirements within TPZ areas as part of the Site clearing process.

e. Final landscape treatments and installation of any irrigation through TPZ areas.

5.3 Once designs have been finalised, tree protection method statements are recommended to be drafted to be included into any tender specification so that protection of the Trees to AS 4970 guidelines will occur during the construction stages of the development.

Company Information

Company Name:	ARBOR logic
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Disclaimer

This Report has been provided in good faith and based upon the material information provided by the Client to Arbor logic, and/or based on the visual inspection of the tree(s) at the time this advice was prepared.

The contents of this Report should be read in full, and at no time shall any part of the Report be referred to unless taken in full context with the remainder of the document.

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- The provision of misleading or incorrect information by the Client or any other party to Arbor logic upon which this advice was prepared.
- This advice being used by the Client or any other party in circumstances or situations other than the specific subject of this advice.
- Failure by the Client to follow this advice.
- The action(s) or inaction(s) of the Client or any other party that gives rise to the loss of, or damage to, the tree(s) that are the subject of this advice.

It is also important to take into consideration that all trees are living organisms and as such there are many variables that can affect their health and structural properties that remain beyond the scope of reasonable management practices or the advice provided in this Report based on the visual inspection of the tree(s).

As such a degree of risk will still remain with any given tree(s) despite the adoption of any best management practices or recommendations made in this Report.

Appendix E Assessment of identified trees adjacent Peel Main Drain; Apsley Estate, Mandogalup (ArborLogic 2018b)

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November 13, 2018

Plan E
414 Rokeby Road
Subiaco WA 6008

Attention: **Jo Olive**

RE: **Assessment of identified trees adjacent Peel Main Drain, Apsley Mandogalup**

Dear Jo,

Further to your request, the following is a summary of my assessment of the identified trees adjacent to the Peel Main Drain, Apsley, Mandogalup.

Should you have any queries regarding the findings of this report, or if I can be of any further assistance in the management of the identified trees, please do not hesitate to contact me.

Yours sincerely



JASON ROYAL

Dip. Arboriculture (UK)
Tech. Arbor A

Assessment of identified Trees adjacent to the Peel Main Drain, Apsley, Mandogalup

Prepared For

Plan E

Prepared By

ARBOR logic

Contents

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Attachments to the Report;

Company Information & Disclaimer

1. Particulars to the Assessment

1.1 Terms Used

The following terms have been used in this report:

'Site'	meaning the area that was included in this particular assessment
'Tree'	meaning any individual tree identified on Site to be included in the assessment
'AS 4970'	meaning Australian Standards guideline 4970 (2009); Protection of trees on development sites
'AS 4373'	meaning Australian Standards guideline 4373 (2007); Pruning of amenity trees
'TPZ'	meaning Tree Protection Zone; the area where the majority of the given Tree's root mass is considered likely to be found, and the area that is recommended to be protected during any development or landscape activity

1.2 Limitations and Particulars of this Assessment

The information and opinions provided in this document are based on the findings from the visual observations of the Trees on the Site during the inspection undertaken November 9, 2018.

All observations of all of the Trees were undertaken from ground level.

No exploratory excavations were undertaken as part of this particular assessment to verify the actual root spread of any given Tree. As such the allocation of TPZ for each Tree has at this stage been based on AS 4970 guidelines, with some amendments being made for the physical size and canopy dimensions of the Tree, its condition, the known root zone morphology of its given species in the sort of soil profile considered to be typical to this area of Western Australia.

The Trees on Site were noted to <u>not</u> have been tagged to enable identification.

As such each Tree to be included in the assessment was identified as best as practicably possible based on the plan of the Site provided.

2. Scope of Works

The purpose of the inspection was to:

- Undertake an inspection of the trees in the identified area shown on the plan provided.
- Provide basic cursory information on each of the identified trees in terms of their species, approximate height, main stem diameter, canopy spread, estimated age, health and structural condition and any comments deemed pertinent to the tree.
- Provide an opinion on the suitability of retention of each of the identified trees on the site in the context of a development process.
- Provide any broad-brush purposeful and practical recommendations for any design and construction implications that may apply for any trees identified as being suitable for retention within the proposed development so to ensure their preservation if undertaken remains successful.
- Provide details of any canopy management works that may be required as part of any development that occurs.

3. Methodology of the Assessment

All of the identified Trees were visually inspected from ground level in accordance with visual tree assessment ("VTA") methods and principles.

The VTA method is based on the sciences of tree biology, physiology, tree structure, and tree bio-mechanics. It is a method widely used by arborists worldwide to identify visible signs on trees that indicate any health or potential structural issues that in turn could increase the risks associated with the given tree.

The overall health of each Tree was adjudged from an inspection of its leaf, overall percentage of leaf mass present in the canopy of the Tree, and the presence (or absence) of any pest or disease factor that could have an effect on the overall health of the Tree.

The structural integrity of each Tree was determined from a visual inspection of its main stem, primary (and secondary) branch unions to determine the presence of any areas considered to be a structural 'defect' or 'imperfection' such as unions with included bark, swelling, or noticeable splitting at them.

Symptoms of decay, growth patterns and defects are identified and assessed as to their potential to cause whole tree, part tree or branch failure, and where considered necessary further investigation by way of the use of sounding techniques was utilised to determine the presence and general extent of any areas of cavity or associated decay within a tree's main stem structure.

With regards to any future development the known natural species traits of the given tree and its suitability for use in an urban area and if the identified specimen is of a species that can be subject to the sudden branch failure phenomenon or is known to be potentially problematic in terms of self-sowing (weed) issues, was also considered as part of the assessment process.

The Tree's species and its ability to cope with disturbances to its root zone that typically occur as part of a development process, as well as its ability to cope with the new parameters that are commonly created by an urban development (i.e. decreased soil oxygen due to compaction, increased un-seasonal watering from irrigation, increased pollution, increased radiated heat/light from urban infrastructure (roads, walls, buildings etc.) are all also taken into consideration.

The known root zone morphology of the species was taken into consideration when allocating the recommended TPZ for each of the identified trees. Note: Whilst some reference and acknowledgment is given to the guidelines set down in AS 4970, the TPZ for each Tree has been based on the known typical root zone morphology for specimens of their species, the condition of the given Tree, and the known tolerance to root zone disturbance of the given species.

4. Summary of Key Findings of the Assessment

4.1 No of Trees

74 Trees were identified and included in the assessment. 6 of the Trees identified and included in this assessment were noted to not be shown on the Plan provided.

4.2 Species Present

The majority of the Trees were noted to be local west Australian native tree species, including Flooded Gum (*Eucalyptus rudis*), Freshwater Paperbark (*Melaleuca rhaphiophylla*) Stout Paperbark (*Melaleuca preissiana*) and Coastal Moort (*Eucalyptus utilis*).

One other introduced species was also identified; Edible Fig (*Ficus carica*).

Flooded Gum are the most common species present on the Site with 58 Trees, followed by Freshwater Paperbark with 13 of the Trees.

4.3 Age Class

The majority of the Trees look to be mature specimens; possibly in the order of 30-40 years old for most with some of the larger Flooded Gum and Paperbark being more in the order of 60-80 years old.

All of the Trees look to be self-sown specimens rather than planted.

4.4 Health Condition

Many of the Flooded Gum looked to be in an average health condition at this time. There is evidence to suggest major damage has been caused by Leaf Blister Saw-Fly (*Phylacteophaga froggatti*) although many also show signs of health issues typically associated with environmental factors such as poor seasonal rainfalls. Some of the larger older Trees on the Site also showed signs of damage from past bushfire activity.

Some of the affected Trees look likely to recover canopy leaf over the remainder of the spring and summer period. However equally a number may either be slow to recover, or have limited recovery. There is also the chance of repeated infestations of Leaf Blister Saw-Fly occurring again which could have an adverse impact to their health as could any works that result in the loss of root mass.

4.5 Structural Condition

The majority of the Trees showed to have what is considered to be fairly typical structural form for specimens of their given species.

Branch failures were noted to have occurred on a small number of the Trees, but looks to have occurred as a result of force loading i.e. storm damage as opposed to any genetic predisposition for branch failure.

Four of the Trees were noted to have fallen (up-rooted) at some stage in the past; but kept growing. A small number of other Trees showed some evidence to suggest that they may have partially failed/fallen or are in the process of losing their in-ground stability.

For the most part any issues noted with the structure of most of the Trees looks to be remaining within the realms and scope of management at this time.

4. Summary of Key Findings of the Assessment

4.6 Images of the Trees


Tree #100 (Northern End)


Trees #125, #126


Trees #133 - #153


Trees #178, #179


Trees #198 - #204


Trees #223 - #235


Trees #228 - #236


Trees #247 - #297 (Southern End)

4. Summary of Key Findings of the Assessment

4.7 Retention Suitability

Retention of a large proportion of the Trees on this Site in the context of a development is considered acceptable and would be encouraged.

However some of them would only be suited to low (or even no) target areas of public open space where the risks and future management requirements for the Trees can be more effectively managed. Should targets be introduced into the fall zone of some of these Trees, then retention may become questionable.

The following classification was used during this assessment for retention value.

High Retention Value; Generally a good/very good specimen that shows good health, structural and aesthetic form. Trees with High retention value are generally strongly recommended to be retained as part of a development process.

13 of the Trees on this Site were considered to have a High retention value.

Medium Retention Value; Reasonably good specimen of its species and worth retaining as part of development. These trees may have reduced health/vigour, or structural imperfections that (whilst within the realms and scope of management) may have higher management and maintenance requirements.

36 of the Trees were considered to have a Medium retention value.

Low Retention Value; Ok specimen. This typically includes trees that indicate a declining health or have structural imperfections that are assessed to be starting to affect the structural integrity of the tree. Low retention value trees may have high environmental benefits, but their structure may limit their potential for retention other than in areas of POS where the risks associated with the Tree can then be better managed by way of good design.

19 Trees were considered to have a Low retention value.

Very Low Retention Value; These are generally poor quality trees that are typically suggested to be removed from a risk management perspective. Typically includes dead trees and trees with poor structural form that look to have a high probability for failure. Such trees may have high environmental benefit, but retention even within an area of open space would be highly questioned from a risk management responsibility UNLESS design of the area around them was able to prevent potential targets from entering into their fall zone.

6 Trees were considered to have a Low retention value.

This retention value has been colour-coded and overlaid onto an aerial of the Site overleaf for reference.

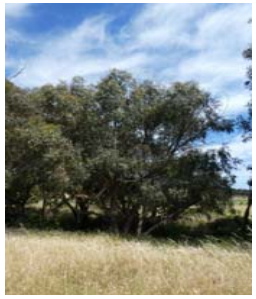
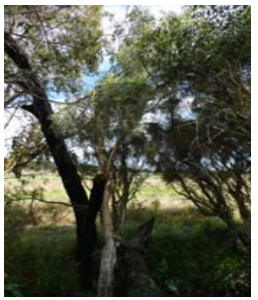
4.8 The following pages provide further comments on each of the individual Trees identified in this avenue.

Note: Trees have been numbered as per the plan provided starting from the northern end of the avenue.



Aerial source; Nearmap.com

Tree No.	Species	Approx. Height (metres)	Approx. DBH (cm)	Approx. Canopy Spread (metres diameter)		Health	Structure	Age Class	SULE	Image	Comments	Retention Value	Nominal TPZ (metres radius)	Development Considerations
				N-S	E-W									
100	Freshwater Paperbark (*Melaleuca rhaphiophylla*)	5	44, 24	6--7	6--7	Good	Good	Mature	Long term (>40 yrs)		Two trees in close proximity that effectively form the one canopy. No issues or concerns visible at this time	Medium	5.3	Low canopy wouldn't be able to be raised without impact to the Tree
125	Freshwater Paperbark (*Melaleuca rhaphiophylla*)	7	36, 34	6--7	6--7	Poor	Questionable	Mature	Short-term (5-15 yrs)		Multi-stemmed from near ground level. Large cavity in base of main stem and one stem has collapsed. Tips of its canopy are dead	Low	4.3	Low canopy wouldn't be able to be raised without impact to the Tree. Structure looks likely to cause issues longer term
126	Flooded Gum (*Eucalyptus rudis*)	8.5	36, 36	8--9	7--8	Excellent	Good	Early-mature	Long term (>40 yrs)		Good specimen. No issues or concerns visible at this time. Co-dominant leader but union ok. Leaf Blister Saw-Fly damage noted	HIGH	4.3	Low spreading canopy
133	Flooded Gum (*Eucalyptus rudis*)	13	25 (x6)	7--8	6--7	Excellent	Acceptable	Semi-mature	Long term (>40 yrs)		Reasonably good specimen. No issues or concerns visible at this time. Multi-stemmed from ground level, and looks to be regrowth off/around an old stump/original tree. Leaf Blister Saw-Fly damage noted.	Medium	3.0	

Tree No.	Species	Approx. Height (metres)	Approx. DBH (cm)	Approx. Canopy Spread (metres diameter)		Health	Structure	Age Class	SULE	Image	Comments	Retention Value	Nominal TPZ (metres radius)	Development Considerations
				N-S	E-W									
134	Flooded Gum (*Eucalyptus rudis*)	7.5	40, 38	6--7	7--8	Excellent	Acceptable	Early-mature	Long term (>40 yrs)		Reasonably good specimen. No issues or concerns visible at this time. Multi-stemmed from ground level. Leaf Blister Saw-Fly damage noted.	Medium	4.8	
135	Freshwater Paperbark (*Melaleuca rhaphiophylla*)	5	35,	3--4	3--4	Good	Acceptable	Early-mature	Long term (>40 yrs)		Multi-stemmed from ground level. Ok specimen. No issues or concerns visible at this time. Canopy slightly sparse. Remaining leaf still good condition. Canopy is one sided north	Medium	4.2	Low canopy wouldn't be able to be raised without impact to the Tree
143	Freshwater Paperbark (*Melaleuca rhaphiophylla*)	6	25 (multiple)	5--6	4--5	Good	Acceptable	Early-mature	Long term (>40 yrs)		Ok tree. Multi-stemmed from ground level and one sided west. Canopy slightly sparse. Remaining leaf still good condition and no real issues visible at this time	Medium	3.0	Low canopy wouldn't be able to be raised without impact to the Tree. Canopy is one sided west
144	Freshwater Paperbark (*Melaleuca rhaphiophylla*)	5	25,	2--3	2--3	Good	Acceptable	Semi-mature	Long term (>40 yrs)		Reasonably good specimen. Canopy slightly sparse. Remaining leaf still good condition and no real issues visible at this time	Medium	3.0	Low canopy wouldn't be able to be raised without impact to the Tree

Tree No.	Species	Approx. Height (metres)	Approx. DBH (cm)	Approx. Canopy Spread (metres diameter)		Health	Structure	Age Class	SULE	Image	Comments	Retention Value	Nominal TPZ (metres radius)	Development Considerations
				N-S	E-W									
136	Flooded Gum (*Eucalyptus rudis*)	7.5	34,	2--3	2--3	Excellent	Acceptable	Semi-mature	Long term (>40 yrs)		Reasonably good specimen. No issues or concerns visible at this time. Canopy is one sided east	Medium	4.1	Canopy is one sided east
137	Flooded Gum (*Eucalyptus rudis*)	7.5	18, 26	2--3	2--3	Excellent	Acceptable	Semi-mature	Long term (>40 yrs)		Ok specimen. No issues or concerns visible at this time. Co-dominant leader. Union looks to be ok at this time but looks likely to cause issues longer term. Canopy is one sided east.	Medium	2.2	Canopy is one sided east.
145	Flooded Gum (*Eucalyptus rudis*)	9	44, 38	6--7	6--7	Excellent	Acceptable	Early-mature	Long term (>40 yrs)		Reasonably good specimen. No issues or concerns visible at this time. Canopy is one sided west. Multi-stemmed from ground level	HIGH	5.3	Canopy is one sided west.
146	Flooded Gum (*Eucalyptus rudis*)	7.5	18, 12	1--2	2--3	Excellent	Acceptable	Semi-mature	Long term (>40 yrs)		Reasonably good specimen. No issues or concerns visible at this time. Multi-stemmed from ground level possibly more than one tree. Canopy is one sided west.	Medium	2.2	Canopy is one sided west.

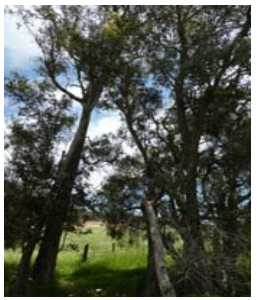
Tree No.	Species	Approx. Height (metres)	Approx. DBH (cm)	Approx. Canopy Spread (metres diameter)		Health	Structure	Age Class	SULE	Image	Comments	Retention Value	Nominal TPZ (metres radius)	Development Considerations
				N-S	E-W									
147	Flooded Gum (*Eucalyptus rudis*)	14	61, 54	8--9	9--10	Excellent	Acceptable	Mature	Long term (>40 yrs)		Large old mature tree. Multi-stemmed from ground level. Section of canopy is dead. Remainder still good at this time. Area of decay but not of a major concern at this time. Some larger deadwood and broken branch in canopy (from adjacent Tree) but otherwise ok.	HIGH	7.3	
148	Flooded Gum (*Eucalyptus rudis*)	8.5	18,	2--3	4--5	Excellent	Acceptable	Semi-mature	Long term (>40 yrs)		Ok specimen. No issues or concerns visible at this time. Leaf Blister Saw-Fly damage noted. Canopy is one sided west and low spreading	Medium	2.2	Canopy is one sided west.
149	Flooded Gum (*Eucalyptus rudis*)	8.5	32,	2--3	4--5	Excellent	Acceptable	Semi-mature	Long term (>40 yrs)		Reasonably good specimen. No issues or concerns visible at this time. Canopy is one sided west. Leaf Blister Saw-Fly damage noted	Medium	3.8	Canopy is one sided west.
141	Flooded Gum (*Eucalyptus rudis*)	16	70,	6--7	7--8	Good	Acceptable	Mature	Long term (>40 yrs)		Large mature specimen. Some large (>10cm diameter) deadwood and a broken branch in canopy. Area of decay noted but not of a major concern at this time. Leaf Blister Saw-Fly damage noted	HIGH	8.4	

Tree No.	Species	Approx. Height (metres)	Approx. DBH (cm)	Approx. Canopy Spread (metres diameter)		Health	Structure	Age Class	SULE	Image	Comments	Retention Value	Nominal TPZ (metres radius)	Development Considerations
				N-S	E-W									
142	Flooded Gum (*Eucalyptus rudis*)	11	63,	6--7	9--10	Excellent	Acceptable	Early-mature	Long term (>40 yrs)		Reasonably good specimen. Section of canopy is dead but the remainder still good at this time. Area of decay. Not of a major concern at this time. Some large (>10cm diameter) deadwood in canopy. Leaf Blister Saw-Fly damage noted.	HIGH	7.6	
153	Flooded Gum (*Eucalyptus rudis*)	14	101, 48	10--11	11--12	Excellent	Acceptable	Mature	Long term (>40 yrs)		Large mature specimen. Old tree. Co-dominant leader. Area of decay. Not of a major concern at this time. Some large (>10cm diameter) deadwood in canopy.	HIGH	12.1	Structure may cause issues longer term
173	Flooded Gum (*Eucalyptus rudis*)	11	48, 48, 48, 46	10--11	11--12	Good	Undesirable	Mature	Medium term (15-40 yrs)		Large mature specimen. Old tree. Looks to have died and regrown at some stage in the past. Area of decay and cavity noted but not of a major concern at this time. Main stem furcates into four; union ok. Broken branch in canopy. Leaf Blister Saw-Fly damage noted. Some large (>10cm diameter) deadwood in canopy .	Medium	5.8	Structure may cause issues longer term
174	Stout Paperbark (*Melaleuca preissiana*)	4.5	24, 23	2--3	2--3	Good	Acceptable	Early-mature	Long term (>40 yrs)		Ok specimen. No issues or concerns visible at this time. Canopy is one sided south due to the proximity of the adjacent tree. Multi-stemmed from ground level	Medium	2.9	Canopy is one sided south. Question retention if the adjacent tree was removed

Tree No.	Species	Approx. Height (metres)	Approx. DBH (cm)	Approx. Canopy Spread (metres diameter)		Health	Structure	Age Class	SULE	Image	Comments	Retention Value	Nominal TPZ (metres radius)	Development Considerations
				N-S	E-W									
178	Flooded Gum (*Eucalyptus rudis*)	4.5	12 (multiple)	4--5	4--5	Excellent	Acceptable	Juvenile	Long term (>40 yrs)		Ok specimen. No issues or concerns visible at this time. Multi-stemmed from ground level and looks to be regrowth off/around an old stump/original tree	Medium	1.4	Low canopy spread
179	Flooded Gum (*Eucalyptus rudis*)	17	82,	9--10	13-14	Fair	Good	Mature	Medium term (15-40 yrs)		Large mature specimen. Canopy is fairly sparse. Remaining leaf still good condition. Some large (>10cm diameter) deadwood and a broken branch in canopy. Evidence of previous branch failure (100-200mm diameter)	Medium	9.8	
195	Flooded Gum (*Eucalyptus rudis*)	4	12 (multiple)	2--3	2--3	Fair	Acceptable	Juvenile	Long term (>40 yrs)		Ok tree. Looks to be regrowth off/around an old stump/original tree. Canopy is slightly sparse & suggests decline. Leaf Blister Saw-Fly damage noted.	Low	1.4	
196	Flooded Gum (*Eucalyptus rudis*)	4	18, 12, 10	2--3	2--3	Fair	Acceptable	Juvenile	Long term (>40 yrs)		Ok tree. Canopy is slightly sparse & suggests decline. Leaf Blister Saw-Fly damage noted.	Low	2.2	Low canopy spread

Tree No.	Species	Approx. Height (metres)	Approx. DBH (cm)	Approx. Canopy Spread (metres diameter)		Health	Structure	Age Class	SULE	Image	Comments	Retention Value	Nominal TPZ (metres radius)	Development Considerations
				N-S	E-W									
197	Flooded Gum (*Eucalyptus rudis*)	16	52,	4--5	5--6	Fair	Acceptable	Mature	Medium term (15-40 yrs)		Large mature specimen. Section of canopy is dead, remainder still good at this time	Medium	6.2	
1	Flooded Gum (*Eucalyptus rudis*)	6	60,	13-14	3--4	Good	Acceptable	Mature	Medium term (15-40 yrs)		Large mature specimen. Looks to have fallen over but kept growing. **Doesn't look to be on the Plan provided**	Medium	7.2	Low canopy wouldn't be able to be raised without impact to the Tree. Fallen over but ok for POS. **Not shown on the Plan provided**
2	Edible Fig (*Ficus carica*)	6	60,	10--11	7--8	Excellent	Good	Early-mature	Long term (>40 yrs)		Good specimen. No issues or concerns visible at this time. Multi-stemmed from ground level **possibly more than one tree**. Widespread low canopy form. **Doesn't look to be on the Plan provided**	Medium	7.2	Low canopy wouldn't be able to be raised without impact to the Tree. **Not shown on the Plan provided**
3	Flooded Gum (*Eucalyptus rudis*)	6	25,	2--3	3--4	Excellent	Good	Semi-mature	Long term (>40 yrs)		Reasonably good specimen. No issues or concerns visible at this time. Canopy is one sided north. **Doesn't look to be on the Plan provided**	Medium	3.0	Canopy is one sided north. **Not shown on the Plan provided**

Tree No.	Species	Approx. Height (metres)	Approx. DBH (cm)	Approx. Canopy Spread (metres diameter)		Health	Structure	Age Class	SULE	Image	Comments	Retention Value	Nominal TPZ (metres radius)	Development Considerations
				N-S	E-W									
4	Flooded Gum (*Eucalyptus rudis*)	6	25,	2--3	3--4	Near Dead	Good	Semi-mature	Limited (<5 yrs)		Mostly dead tree. Multi-stemmed from ground level. **Doesn't look to be on the Plan provided**	Very Low	3.0	**Not shown on the Plan provided**
198	Flooded Gum (*Eucalyptus rudis*)	17	63,	6--7	10--11	Poor	Acceptable	Mature	Short-term (5-15 yrs)		Large mature tree. Canopy is one sided north due to proximity of the adjacent tree and effectively forms the one canopy with it. Canopy is relatively sparse and limited leaf remaining	Very Low	7.6	
199	Flooded Gum (*Eucalyptus rudis*)	17	63,	4--5	4--5	Near Dead	Acceptable	Mature	Limited (<5 yrs)		Near dead/mostly dead tree. Canopy is one sided south due to proximity of the adjacent tree and effectively forms the one canopy with it.	Very Low	7.6	
203	Flooded Gum (*Eucalyptus rudis*)	14	61,	4--5	7--8	Fair	Acceptable	Mature	Short-term (5-15 yrs)		Canopy is one-sided east/north due to proximity of the adjacent tree and effectively forms the one canopy with it. Area of decay and cavity noted but not of a major concern at this time. Evidence of previous branch failure (large >200mm diameter)	Low	7.3	

Tree No.	Species	Approx. Height (metres)	Approx. DBH (cm)	Approx. Canopy Spread (metres diameter)		Health	Structure	Age Class	SULE	Image	Comments	Retention Value	Nominal TPZ (metres radius)	Development Considerations
				N-S	E-W									
204	Flooded Gum (*Eucalyptus rudis*)	15	72,	8--9	7--8	Fair	Acceptable	Mature	Medium term (15-40 yrs)		Large mature specimen. Some large (>10cm diameter) deadwood in canopy . Top of main leader has snapped (storm damage). Canopy is slightly sparse but remaining leaf still good condition.	Medium	8.6	
5	Flooded Gum (*Eucalyptus rudis*)	15	45,	3--4	4--5	Fair	Acceptable	Mature	Medium term (15-40 yrs)		Fallen tree but still alive. Fell east of the drain. **Not shown on Plan provided but ok for POS**	Low	5.4	Canopy wouldn't be able to be raised/reduced without impact to the Tree. Fallen over. **Not shown on Plan provided**
205	Freshwater Paperbark (*Melaleuca rhaphiophylla*)	8.5	68, 52, 35, 34	6--7	4--5	Excellent	Acceptable	Mature	Long term (>40 yrs)		Large mature tree. No issues or concerns visible at this time. Good specimen. Multi-stemmed from ground level	HIGH	8.2	Low canopy wouldn't be able to be raised without impact to the Tree
206	Flooded Gum (*Eucalyptus rudis*)	14	54,	4--5	4--5	Good	Acceptable	Mature	Long term (>40 yrs)		Good specimen. Large mature tree. No issues or concerns visible at this time. Canopy is one sided west due to proximity of the adjacent tree	Medium	6.5	Canopy is one sided west

Tree No.	Species	Approx. Height (metres)	Approx. DBH (cm)	Approx. Canopy Spread (metres diameter) N-S	E-W	Health	Structure	Age Class	SULE	Image	Comments	Retention Value	Nominal TPZ (metres radius)	Development Considerations
207	Flooded Gum (*Eucalyptus rudis*)	14	54,	4--5	6--7	Good	Acceptable	Mature	Long term (>40 yrs)		Reasonably good specimen. Canopy slightly sparse. Remaining leaf still good condition. Canopy is one sided east due to proximity of the adjacent tree. Leaf Blister Saw-Fly damage noted	Medium	6.5	Canopy is one sided east.
208	Flooded Gum (*Eucalyptus rudis*)	5	31,	2--3	2--3	Dead	HAZARDOUS	Early-mature	n/a. Dead tree		Dead tree. Main stem has snapped	Very Low	3.7	
209	Flooded Gum (*Eucalyptus rudis*)	18	71,	9--10	8--9	Good	Good	Mature	Long term (>40 yrs)		Large mature specimen. Canopy slightly sparse. Remaining leaf still good condition. Leaf Blister Saw-Fly damage noted. Minor amount of moderate (5-10cm diameter) deadwood	HIGH	8.5	
210	Flooded Gum (*Eucalyptus rudis*)	10	34,	4--5	4--5	Fair	Good	Early-mature	Long term (>40 yrs)		Ok tree. Effectively forms the one canopy with the adjacent Tree. Canopy slightly sparse. Remaining leaf still good condition. Leaf Blister Saw-Fly damage noted. Minor amount of moderate (5-10cm diameter) deadwood.	Medium	4.1	

Tree No.	Species	Approx. Height (metres)	Approx. DBH (cm)	Approx. Canopy Spread (metres diameter)		Health	Structure	Age Class	SULE	Image	Comments	Retention Value	Nominal TPZ (metres radius)	Development Considerations
				N-S	E-W									
214	Flooded Gum (*Eucalyptus rudis*)	16	40, 38	4--5	3--4	Fair	Good	Early-mature	Long term (>40 yrs)		Reasonably good specimen. Few dead tips/ some deadwood but otherwise ok. Leaf Blister Saw-Fly damage noted. Main stem bi-furcates. Union looks to be Ok at this stage	Medium	4.8	
215	Flooded Gum (*Eucalyptus rudis*)	16	46, 36, 35	4--5	4--5	Poor	Good	Early-mature	Short-term (5-15 yrs)		Canopy is sparse, indicates decline, and suggests possibly limited life remaining. Multi-stemmed from ground level. Leaf Blister Saw-Fly damage noted	Low	5.5	
216	Flooded Gum (*Eucalyptus rudis*)	16	46, 44	4--5	4--5	Poor	Good	Early-mature	Short-term (5-15 yrs)		Canopy is very sparse, indicates decline, and suggests possibly limited life remaining. Multi-stemmed from ground level. Leaf Blister Saw-Fly damage noted	Low	5.5	
217	Freshwater Paperbark (*Melaleuca rhaphiophylla*)	12	46, 42	4--5	4--5	Fair	Good	Mature	Long term (>40 yrs)		Multi-stemmed from ground level possibly more than one tree. Section of canopy is dead, remainder still good at this time. Canopy is one sided south.	Medium	5.5	Low canopy wouldn't be able to be raised without impact to the Tree. Canopy is one sided south.

Tree No.	Species	Approx. Height (metres)	Approx. DBH (cm)	Approx. Canopy Spread (metres diameter) N-S	E-W	Health	Structure	Age Class	SULE	Image	Comments	Retention Value	Nominal TPZ (metres radius)	Development Considerations
218	Flooded Gum (*Eucalyptus rudis*)	17	50,	6--7	6--7	Fair	Good	Mature	Long term (>40 yrs)		Large mature specimen. Canopy is fairly sparse. Remaining leaf still good condition. Leaf Blister Saw-Fly damage noted	Medium	6.0	Low canopy wouldn't be able to be raised without impact to the Tree
222	Flooded Gum (*Eucalyptus rudis*)	8	38,	3--4	3--4	Fair	Good	Mature	Medium term (15-40 yrs)		Ok tree. Section of its canopy is dead. remainder slightly sparse	Medium	4.6	Low canopy wouldn't be able to be raised without impact to the Tree
223	Flooded Gum (*Eucalyptus rudis*)	20	58,	6--7	5--6	Fair	Good	Mature	Medium term (15-40 yrs)		Large mature specimen. Apical sections of its canopy are dead/declining. Leaf Blister Saw-Fly damage noted	Medium	7.0	
224	Freshwater Paperbark (*Melaleuca rhaphiophylla*)	7	46, 44	6--7	5--6	Fair	Acceptable	Mature	Medium term (15-40 yrs)		Ok tree. Canopy is fairly sparse. Remaining leaf still good condition. Canopy is relatively one sided. Multi-stemmed from near ground level	Medium	5.5	Low canopy wouldn't be able to be raised without impact to the Tree

Tree No.	Species	Approx. Height (metres)	Approx. DBH (cm)	Approx. Canopy Spread (metres diameter)		Health	Structure	Age Class	SULE	Image	Comments	Retention Value	Nominal TPZ (metres radius)	Development Considerations
				N-S	E-W									
225	Flooded Gum (*Eucalyptus rudis*)	6	28,	3--4	3--4	Fair	Acceptable	Early-mature	Medium term (15-40 yrs)		Ok tree. Apical sections of its canopy are dead/declining. Canopy is one sided east. Leaf Blister Saw-Fly damage noted	Medium	3.4	Low canopy wouldn't be able to be raised without impact to the Tree
226	Flooded Gum (*Eucalyptus rudis*)	4	15 (multiple)	3--4	3--4	Fair	Acceptable	Semi-mature	Long term (>40 yrs)		Ok tree. Canopy is relatively one sided. Looks to be regrowth off/around an old stump/original tree	Medium	1.8	Low canopy wouldn't be able to be raised without impact to the Tree
227	Flooded Gum (*Eucalyptus rudis*)	18	52, 48, 35, 24	7--8	7--8	Poor	Acceptable	Mature	Short-term (5-15 yrs)		Apical sections of its canopy are dead/declining and canopy condition suggests possibly limited life remaining. Multi-stemmed from ground level	Medium	6.2	
228	Flooded Gum (*Eucalyptus rudis*)	17	49, 48, 46, 46, 45	9--10	8--9	Poor	Acceptable	Mature	Short-term (5-15 yrs)		Apical sections of its canopy are dead/declining. Canopy condition suggests possibly limited life remaining. Multi-stemmed from ground level.	Low	5.9	

Tree No.	Species	Approx. Height (metres)	Approx. DBH (cm)	Approx. Canopy Spread (metres diameter)		Health	Structure	Age Class	SULE	Image	Comments	Retention Value	Nominal TPZ (metres radius)	Development Considerations
				N-S	E-W									
232	Flooded Gum (*Eucalyptus rudis*)	16	44, 44, 43	9--10	8--9	Poor	Acceptable	Mature	Short-term (5-15 yrs)		Large sections of its canopy are dead/declining. Canopy condition suggests possibly limited life remaining. Multi-stemmed from ground level.	Low	5.3	
233	Flooded Gum (*Eucalyptus rudis*)	14	46, 42	5--6	6--7	Fair	Acceptable	Mature	Medium term (15-40 yrs)		Ok tree. Canopy is one sided north. Leaf Blister Saw-Fly damage noted. Multi-stemmed from ground level possibly more than one tree. One section is dead, the other ok	Medium	5.5	Question retention if the adjacent tree is removed
234	Flooded Gum (*Eucalyptus rudis*)	4	22,	3--4	4--5	Fair	Acceptable	Semi-mature	Medium term (15-40 yrs)		Ok tree. Leaf Blister Saw-Fly damage noted. Canopy is one sided east	Low	2.6	Low canopy wouldn't be able to be raised without impact to the Tree. Question retention if the adjacent tree is removed. Canopy is one sided east
235	Flooded Gum (*Eucalyptus rudis*)	6.5	30,	3--4	3--4	Fair	Acceptable	Semi-mature	Medium term (15-40 yrs)		Ok tree. Leaf Blister Saw-Fly damage noted. Canopy is one sided east	Medium	3.6	Low canopy wouldn't be able to be raised without impact to the Tree. Question retention if the adjacent tree is removed. Canopy is one sided east

Tree No.	Species	Approx. Height (metres)	Approx. DBH (cm)	Approx. Canopy Spread (metres diameter) N-S	E-W	Health	Structure	Age Class	SULE	Image	Comments	Retention Value	Nominal TPZ (metres radius)	Development Considerations
236	Flooded Gum (*Eucalyptus rudis*)	20	61, 60, 60	10--11	9--10	Fair	Acceptable	Mature	Medium term (15-40 yrs)		Large mature specimen. Multi-stemmed from near ground level. Section of canopy is dead. Leaf Blister Saw-Fly damage noted. Canopy slightly sparse. Remaining leaf still good condition. Also a Freshwater Paperbark forms part of its canopy	HIGH	7.3	Low canopy wouldn't be able to be raised without impact to the Tree
240	Flooded Gum (*Eucalyptus rudis*)	16	61, 46, 37, 35	12--13	9--10	Good	Acceptable	Mature	Long term (>40 yrs)		Large mature. Canopy slightly sparse. Remaining leaf still good condition. specimen. Broken branch in canopy. Multi-stemmed from ground level possibly more than one tree. Leaf blister sawfly damage	HIGH	7.3	
242	Flooded Gum (*Eucalyptus rudis*)	10	30,	3--4	3--4	Fair	Good	Semi-mature	Long term (>40 yrs)		Ok tree. Multi-stemmed from ground level. Apical sections of its canopy are dead/declining but mid/lower canopy ok	Low	3.6	Low canopy wouldn't be able to be raised without impact to the Tree
243	Flooded Gum (*Eucalyptus rudis*)	20	70,	8--9	8--9	Fair	Questionable	Mature	Medium term (15-40 yrs)		Leaning tree; May have been multi-stemmed but northern side looks to have previously failed. Canopy is one sided south as a result. Apical sections of its canopy are dead/declining. Canopy is fairly sparse	Low	8.4	**Retention subject to what Targets would be introduced into its Fall Zone due to questionable structural form**

Tree No.	Species	Approx. Height (metres)	Approx. DBH (cm)	Approx. Canopy Spread (metres diameter)		Health	Structure	Age Class	SULE	Image	Comments	Retention Value	Nominal TPZ (metres radius)	Development Considerations
				N-S	E-W									
244	Flooded Gum (*Eucalyptus rudis*)	7.5	25 (multiple)	6--7	6--7	Fair	Acceptable	Semi-mature	Medium term (15-40 yrs)		Multi-stemmed from ground level; Looks to be regrowth off/around an old stump/original tree. Apical sections of its canopy are dead; looks to have died off some time ago and is now regrowing. Leaf Blister Saw-Fly damage noted.	Low	3.0	
245	Flooded Gum (*Eucalyptus rudis*)	4.5	20,	2--3	2--3	Fair	Acceptable	Semi-mature	Medium term (15-40 yrs)		Leaf Blister Saw-Fly damage noted. Canopy is one sided south. Ok tree. Canopy is one-sided due to proximity of the adjacent tree	Low	2.4	Low canopy wouldn't be able to be raised without impact to the Tree
275	Flooded Gum (*Eucalyptus rudis*)	4.5	25,	5--6	5--6	Fair	Acceptable	Semi-mature	Medium term (15-40 yrs)		Ok tree. Apical sections of its canopy are dead/declining. Canopy is fairly sparse. Remaining leaf still good condition. Leaf Blister Saw-Fly damage noted	Low	3.0	Low canopy wouldn't be able to be raised without impact to the Tree
276	Flooded Gum (*Eucalyptus rudis*)	6.5	60,	4--5	5--6	Fair	Acceptable	Early-mature	Medium term (15-40 yrs)		Ok tree. Canopy is one-sided south due to proximity of the adjacent tree. Grown on a lean and out of the drainage ditch itself	Low	7.2	Low canopy wouldn't be able to be raised without impact to the Tree. Growing in the drainage ditch itself

Tree No.	Species	Approx. Height (metres)	Approx. DBH (cm)	Approx. Canopy Spread (metres diameter)		Health	Structure	Age Class	SULE	Image	Comments	Retention Value	Nominal TPZ (metres radius)	Development Considerations
				N-S	E-W									
241	Freshwater Paperbark (*Melaleuca rhaphiophylla*)	10	61, 58, 47, 38	12--13	9--10	Excellent	Acceptable	Mature	Long term (>40 yrs)		Large mature specimen. Multi-stemmed from ground level; Southern stem may have partially failed. Broken branch in canopy.	HIGH	7.3	Low canopy wouldn't be able to be raised without impact to the Tree
278	Flooded Gum (*Eucalyptus rudis*)	17	64,	7--8	7--8	Fair	Good	Mature	Medium term (15-40 yrs)		Large mature specimen. Canopy is fairly sparse. Remaining leaf still good condition. Leaf Blister Saw-Fly damage noted. Some larger deadwood but otherwise ok	Medium	7.7	Low canopy wouldn't be able to be raised without impact to the Tree, but the stem over ditch could be removed if desired
277	Freshwater Paperbark (*Melaleuca rhaphiophylla*)	7	95,	8--9	7--8	Good	Good	Mature	Long term (>40 yrs)		Old large mature specimen. High aesthetic and amenity value. Good specimen. Growing on edge of the drainage ditch	HIGH	11.4	Low canopy wouldn't be able to be raised without impact to the Tree. Growing in the drainage ditch itself
286	Freshwater Paperbark (*Melaleuca rhaphiophylla*)	6.5	35, 35, 30, 25	5--6	10--11	Excellent	Acceptable	Early-mature	Long term (>40 yrs)		Reasonably good specimen. No issues or concerns visible at this time. Multi-stemmed from ground level. Widespread canopy form. One low stem extends over drainage ditch	HIGH	4.2	Low canopy wouldn't be able to be raised without impact to the Tree although stem over the ditch could be removed if desired without major impact

Tree No.	Species	Approx. Height (metres)	Approx. DBH (cm)	Approx. Canopy Spread (metres diameter)		Health	Structure	Age Class	SULE	Image	Comments	Retention Value	Nominal TPZ (metres radius)	Development Considerations
				N-S	E-W									
287	Freshwater Paperbark (*Melaleuca rhaphiophylla*)	3	48,	4--5	4--5	Excellent	Questionable	Early-mature	Medium term (15-40 yrs)		Looks to have fallen over drainage ditch bet kept growing	Low	5.8	Low canopy wouldn't be able to be raised without impact to the Tree. Has fallen over the ditch
6	Coastal Moort (*Eucalyptus utilis*)	8	30,	3--4	3--4	Excellent	Acceptable	Early-mature	Medium term (15-40 yrs)		Ok tree. Effectively forms the one canopy with the adjacent Tree (#287). Evidence of previous branch failure (100-200mm diameter). Area of decay. Possibly impacting structural integrity. Removal of the adjacent tree #287 may impact this trees root zone	Low	3.6	Removal of the adjacent tree could impact this trees root zone. **Not shown on Plan provided but directly next to #287**
288	Flooded Gum (*Eucalyptus rudis*)	7	50,	4--5	8--9	Dead	Poor	Early-mature	n/a. Dead tree		Dead tree	Very Low	6.0	
289	Flooded Gum (*Eucalyptus rudis*)	12	37, 28	5--6	6--7	Fair	Good	Early-mature	Long term (>40 yrs)		Reasonably good specimen. Section of canopy is dead, remainder still good at this time. Grown on a lean but not considered an issue at this time	Medium	4.4	

Tree No.	Species	Approx. Height (metres)	Approx. DBH (cm)	Approx. Canopy Spread (metres diameter)		Health	Structure	Age Class	SULE	Image	Comments	Retention Value	Nominal TPZ (metres radius)	Development Considerations
				N-S	E-W									
290	Flooded Gum (*Eucalyptus rudis*)	14	56,	4--5	4--5	Good	Undesirable	Mature	Medium term (15-40 yrs)		Looks to have fallen over eastwards and over the ditch but kept growing. Section of its canopy is dead but overall ok for a POS	Low	6.7	Looks to have fallen over eastwards and over the ditch
297	Freshwater Paperbark (*Melaleuca rhaphiophylla*)	3.5	30,	3--4	3--4	Poor	Good	Early-mature	Limited (<5 yrs)		Ok tree although apical sections of its canopy are dead/declining and its canopy condition suggests possibly limited life remaining	Very Low	3.6	

5. Further Considerations; Development Design and Construction

5.1 Development Design Considerations

It remains difficult to provide specific recommendations for the protection of each Tree on this Site at this time and much of their protection requirements will be somewhat dependent on the design of any development proposed and what changes are proposed to occur to their surrounds.

The retention of the existing current ground level and soil profile within a Tree's designated TPZ is however generally of paramount and key importance in the success of the retention of any Tree.

Whilst the root zone spread of each Tree will vary, at this time it is suggested to consider an area of 8-10 metres radius of each Tree's main stem as the area where much of their root mass will be found.

Any works required in this zone could have the potential to impact the Trees; particularly any changes to the existing drainage channel, changes to the natural drainage pattern of the area around the Trees.

This is not to say that some encroachment and development activity would not be permitted to be undertaken within a TPZ area as part of a development process.

However any encroachment required/proposed will require further input and discussion with the arboricultural consultant as part of any detailed design process to determine what the potential impact on the given Tree will be, and what design modifications or measures may need to be implemented to mitigate any potential negative impact on the given Tree.

As an initial recommendation:

- Efforts are recommended to be spent on the retention of the Trees considered to have a high retention value.
- The areas where the Very Low and Low retention value Trees are located are suggested to be used as areas where greater amounts of disturbance and excavation can occur; even if it means the existing lower retention value Trees are needed to be removed in the process.
- The nominal TPZ and canopy spread of each Tree is recommended to be overlaid onto all development plans used during the design process.

  Where encroachments into a designated TPZ are found to be required, further discussion with an experienced independent arboricultural consultant will be required if the Tree is desired to be retained as part of the development.
- Design is also strongly recommended to take into consideration the low canopy nature of some of them as raising the canopy of those Trees may not be viable without major impact to the future health or aesthetics of the Tree to a point where its retention becomes questionable; particularly some of the Paperbark specimens.

During the development design process further arboricultural input will likely be required to discuss:

- Extent of works required along the main drain channel itself.
- Current existing ground levels and proposed resulting levels of the various areas of the Site.
- Any site remediation requirements within TPZ areas as part of the Site clearing process.
- Final landscape treatments and installation of any irrigation through TPZ areas.

5. Further Considerations; Development Design and Construction

5.2 Physical Protection of Trees during Development

Once designs have been finalised, tree protection method statements are recommended to be drafted to be included into any tender specification so that protection of the Trees to AS 4970 guidelines will occur during the construction stages of the development.

It will be of critical importance that the appropriate protection measures are set up and maintained from the outset; i.e. before any Site clearing/demolition works commence.

Implementing tree protection measures after damage has occurred from works is often of little to no value other than affording some protection from further damages occurring.

However effective protection of the Trees on this Site must begin with good design and specifications so that the physical protection of the Trees during the construction stages of the development will remain viable and achievable.

Including arboricultural input during all stages of the development is seen as an integral part of the successful protection of trees on a development Site.

5.3 Canopy Works

Canopy works are likely to be required on a number of the Trees as part of the development process.

The extent of canopy works on each Tree is however very much dependent on the eventual landscape around the Tree and what potential targets (people, structures etc.) may eventually be within the given Tree's projected fall zone.

At this stage canopy works are likely to be restricted to the removal of any larger diameter deadwood (i.e. any dead branches 50mm or greater in diameter) and/or the raising of canopy's where necessary to provide clearances for any future footpaths, structures and/or the drainage channel itself.

However, it should be noted that some of the Trees on this Site will not tolerate much in the way of canopy raising without it impacting their future health, potential life span or aesthetics; particularly the *Melaleuca* specimens, and some of the smaller one-sided Flooded Gum.

All canopy works are recommended to be undertaken by suitably qualified and experienced tree surgeons, who possess a minimum qualification of AQF certificate 3 arboriculture, or recognised equivalent qualification.

All canopy pruning works must also comply with Australian Standards 4373; Pruning of Amenity Trees.

Company Information

Company Name:	ARBOR logic
A.C.N.:	107 194 061
A.B.N.:	66 566 369 687

Insurance Details:

General Liability;	QBE	$20 million
Professional Indemnity;	Vero	$10 million
Personal Protection;	Zurich, Asteron	

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Arboricultural Association Technician Member
TE140

Arboriculture Australia
Member No. 1254

MEMBER International Society of Arboriculture ISA
J. Royal; 172723

QTRA Registered User
Lisc. No. 1743

Disclaimer

This Report has been provided in good faith and based upon the material information provided by the Client to Arbor logic, and/or based on the visual inspection of the tree(s) at the time this advice was prepared.

The contents of this Report should be read in full, and at no time shall any part of the Report be referred to unless taken in full context with the remainder of the document.

The contents of this Report may not be reissued to another party or published in part or full without Arbor logic's written permission.

Arbor logic does not accept liability arising out of loss or damage that results from: -

- Material information not being provided by the Client to Arbor logic at the time this advice was prepared.
- The provision of misleading or incorrect information by the Client or any other party to Arbor logic upon which this advice was prepared.
- This advice being used by the Client or any other party in circumstances or situations other than the specific subject of this advice.
- Failure by the Client to follow this advice.
- The action(s) or inaction(s) of the Client or any other party that gives rise to the loss of, or damage to, the tree(s) that are the subject of this advice.

It is also important to take into consideration that all trees are living organisms and as such there are many variables that can affect their health and structural properties that remain beyond the scope of reasonable management practices or the advice provided in this Report based on the visual inspection of the tree(s).

As such a degree of risk will still remain with any given tree(s) despite the adoption of any best management practices or recommendations made in this Report.

Appendix F Apsley Stage 18B – Roundabout Clearance (Arborite 2025)

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ARBORITE
TREE MANAGEMENT SOLUTIONS

David Cuddihy
Graduate Certificate Arboriculture
arboritetms@gmail.com
#0456 152 142

Mike O'Donoghue
Construction Manager
Wormall Civil

27th May 2025
RE: Apsley Stage 18B – Roundabout clearance

Dear Mike,
This letterhead is to document my site visit on the 2nd May 2025 to inspect five trees scheduled for removal due to the construction of a roundabout.

Tree survey

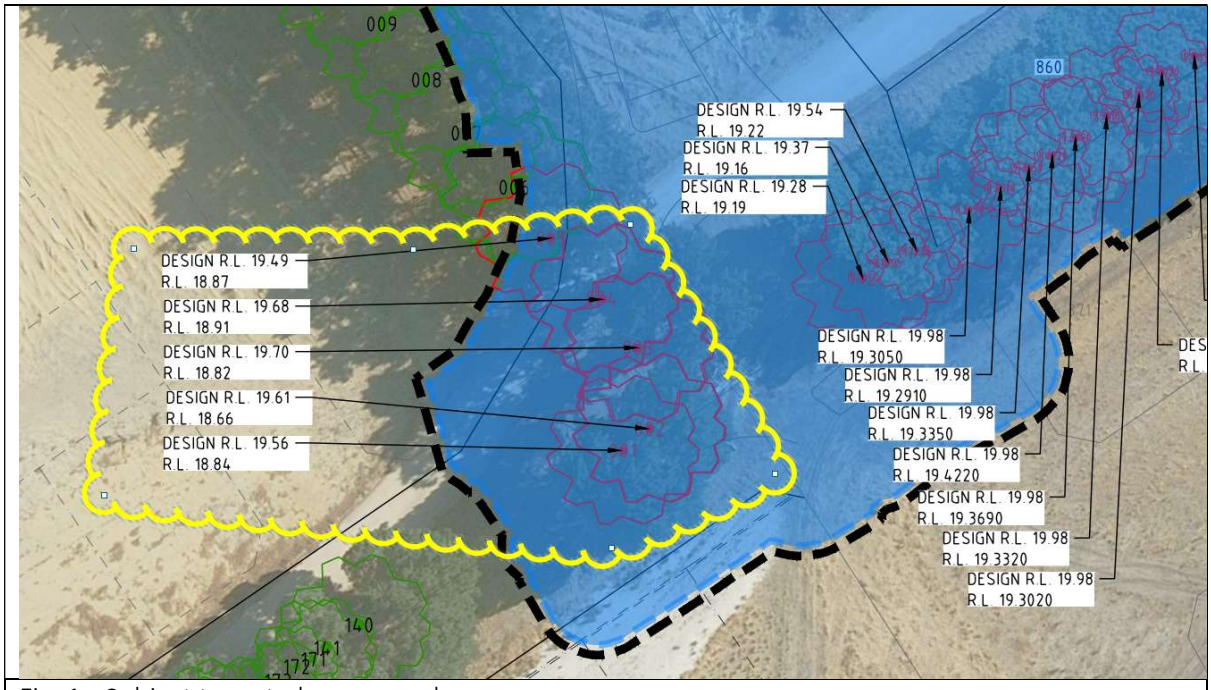

Fig. 1 - Subject trees to be removed

ARBORITE
TREE MANAGEMENT SOLUTIONS

David Cuddihy
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#0456 152 142

Tree 1



Fig. 1 - Tree 1 *Pinus pinea*

Scientific name:	*Pinus pinea*
Common name:	Stone Pine
Height:	15-20m
Width:	10-15m
DBH:	0.75m
Age class:	Mature
Health:	8
Structure:	7
ULE:	15-40 years
Tree cover:	Some
Significance:	Some
Suitability:	Just
Form:	Good

Comments:

- Historic of failures
- Major deadwood

Tree 2



Fig. 2 - Tree 2 *Pinus pinea*

Scientific name:	*Pinus pinea*
Common name:	Stone Pine
Height:	15-20m
Width:	10-15m
DBH:	0.7m
Age class:	Semi-mature
Health:	8
Structure:	7
ULE:	15-40 years
Tree cover:	Some
Significance:	Some
Suitability:	Just
Form:	Good

Comments:

- Historic of failures
- Major deadwood

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Tree 3



Fig. 3 - Tree 3 *Casuarina equisetifolia*

Scientific name: *Casuarina equisetifolia*
Common name: Coastal she-oak
Height: 20-25m
Width: 10-15m
DBH: 0.7m
Age class: Semi-mature
Health: 8
Structure: 7
ULE: 15-40 years
Tree cover: Some
Significance: Some
Suitability: Just
Form: Average
Comments:

- Historic of failures

Tree 4

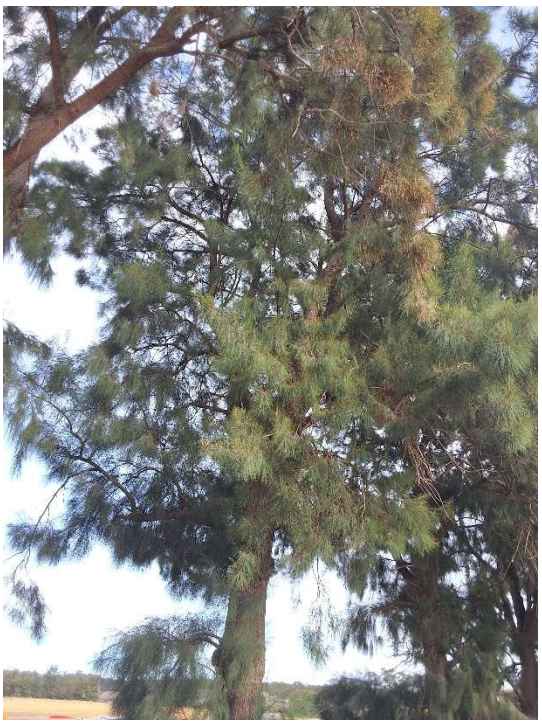

Fig. 4 - Tree 4 *Casuarina equisetifolia*

Scientific name: *Casuarina equisetifolia*
Common name: Coastal she-oak
Height: 20-25m
Width: 10-15m
DBH: 0.8m
Age class: Mature
Health: 8
Structure: 7
ULE: 15-40 years
Tree cover: Some
Significance: Some
Suitability: Just
Form: Good
Comments:

- Historic of failures

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Tree 5



Fig. 5 - Tree 5 *Casuarina equisetifolia*

Scientific name:	*Casuarina equisetifolia*
Common name:	Coastal she-oak
Height:	20-25m
Width:	10-15m
DBH:	0.7m
Age class:	Semi-mature
Health:	8
Structure:	7
ULE:	15-40 years
Tree cover:	Some
Significance:	Some
Suitability:	Just
Form:	Average

Comments:

- Historic of failures

Guillaume Esposito
Arborite Tree Management Solutions
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Appendix G Arboriculture Report – Apsley Estate Subdivision (Paperbark Technologies 2025)

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Arboricultural Report – Apsley Estate Subdivision

18th of June 2025
Total Tree Count: 29

Brief

This consultant has been commissioned by Wormall Civil to carry out an inspection of 29 remnant trees within Apsley Estate Subdivision, Mandogalup to submit a report on the trees health and structural condition and recommend any remedial works that are required.

The objective of the audit was to undertake an inspection of each tree, carry out an examination of each tree as delineated upon the map attached; to assess each trees health & structure and itemise remedial tree surgery works in relation to surrounding targets.

The survey scope requires:

- The identification of tree species.
- Measurement of the height & canopy spread of the trees.
- Measurement of trunk diameters.
- Tree age.
- Current health and structural condition of the trees.
- Problems identified and itemised.
- Retention Value (Low, Medium, High).
- ULE (Useful Life Expectancy).
- Tree Protection Zone Radius (TPZ).
- Structural Root Zone Radius (SRZ).
- Works priority rating.
- Recommended remedial pruning or other works that may be required.

All trees are digitally mapped and tagged, and this consultant confirms that the site inspection was carried out on the 18th of June 2025 with a total of 29 trees audited.

Scope of works

Apsley Estate is undergoing construction works to develop the area into a housing estate. The trees inspected are to be retained and protected while the construction works are being completed.
This consultant was not provided with project plans or information on works surrounding these trees, therefore it is recommended to have these trees reinspected prior to the confirmed design plans for the roadway and house lots so that construction works are not likely to damage the trees and that they remain in a healthy condition.

Trees 1 – 12 are a row of *Pinus pinaster* (Maritime Pine) which may have been planted as a windbreak in previous years. It would be recommended to retain these trees in a POS or an area where they will not have major root encroachment.
Trees 13-27 were located adjacent a creek with tree 13 located on the southern side and 14-27 located on the northern side. Tree 13 is not tagged due to limited access.

Tree 29 is a domestic Fig tree (*Ficus carica*) in poor structural condition and not worthy of retaining in a development site.

The TPZ and SRZ radius details for each tree provided in the report are based upon AS 4970-2009 *Protection of trees on development sites* and provide a guide to assist with the care and protection of trees to be retained.

A list of remedial works and maps displaying the TPZ and SRZ accompany this report.

Summary/Remedial works

29 trees are recommended for remedial works which consist predominantly of:

- Entire tree removal.
- The removal of deadwood greater than 30mm in diameter held in the canopy.
- Canopy lift pruning.
- The removal of hanging branches held in the canopy.
- Removal of epicormic growth.

Priority rating

This consultant has categorised the pruning works as moderate due to the site still being under construction. This work will need to be completed prior to the completion of the construction works and it is recommended to have these trees reinspected once works are completed to ensure they retain their health and structural condition.

The trees that require remedial works have been prioritised into the following category:

- **Low** – 0 trees with defects or problems requiring works within the next 12 months.
- **Moderate** – 29 trees with defects or problems requiring works within the next 6 months.
- **High** – 0 trees with defects or problems requiring works within the next 3 months.
- **Urgent** – 0 trees requiring works as soon as possible.

Pruning of trees is to be limited to required works indicated within this report and approved by the project manager. No additional pruning is recommended to be undertaken without further arborist consultation and all approved pruning is to be carried out by a qualified Arborist in accordance with AS4373 – 2007 *Pruning of Amenity Trees*.

The proposed works are to be located outside the TPZ of all trees. Where works are proposed inside the TPZ of the trees, an Arborist Spotter would be required on site to oversee tree roots which may be found. If roots are located, then the Arborist can assess the roots for pruning. Roots are to be cleanly cut using a hand saw or secateurs. Roots above 30mm diameter are not to be cut without authorisation from a qualified Arborist.

Excavation in proximity of trees to be retained is to be carried out by small, tracked machinery fitted with a flat bladed bucket with an Arborist Spotter wherever practicable. The initial use of smaller machinery adjacent trees to be retained is likely to limit root damage by allowing roots to be exposed and cleanly cut prior to larger machinery working the area, thereby preventing splitting and tearing of roots that may extend back to the base of the tree.

The removal of live canopy and major limbs may significantly damage the trees. Therefore, work methods and equipment must be suitable to the scale of works and operating space to ensure accidental canopy and structural damage are prevented.

It is also recommended that all trees are protected by temporary fencing to delineate tree protection areas consistent with AS4970-2009 (refer to below ‘Appendix - Tree Protection Fencing’) and that it is installed prior to works commencing. It is to be an area of tree and root protection with no digging and no storage of equipment or tools. No filling, trenching or other earthworks shall be carried out unless there is written arborist approval. Soil is not to be lowered or raised within this zone and no washing of tools or cement/paint or chemicals is to be deposited in this zone.
Where temporary fencing cannot be achieved due to the restricted amount of practicable space within the site during the development works, it is recommended to provide at least trunk/branch and ground protection to avoid mechanical injuries from small and large machinery.

Supplementary watering of the retained trees is required to minimise stress on the trees associated with site disruption and root loss. It is generally recommended to water once per week with a minimum of 600 liters per tree, however this may vary. Water is to be applied in a manner that minimises runoff and it is recommended that the initial watering incorporates a wetting agent to assist water infiltration.

Storage of tools and equipment and the storage of materials are recommended to be located within an open area, preferably not within 6m of trees to be retained. The parking of vehicles shall be located within open areas a minimum of 6.0m from the base of all adjacent trees.

The future management, maintenance and condition of the trees have a considerable bearing on their location, with safety to property and persons the main priority. Therefore, each tree retained is recommended to be re-inspected annually to ensure that the trees remain healthy and in a structurally sound condition with a level of risk that is acceptable.



Zana Sheary & Darcie Hill - Arboricultural Consultants
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www.paperbarktechnologies.com.au

Limitation of liability

Trees can be managed, but they cannot be controlled. To live or work near a tree involves a degree of risk.

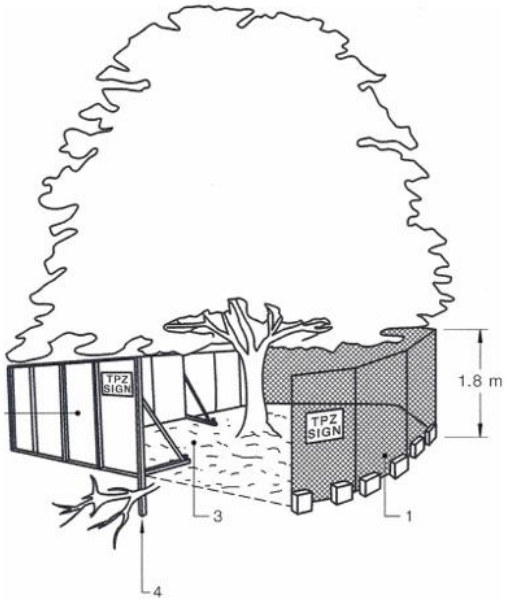
This report only covers identifiable defects present at the time of inspection. Paperbark Technologies accepts no responsibility and cannot be held liable for any structural defect or unforeseen event/situation or adverse weather conditions that may occur after the time of inspection. Paperbark Technologies cannot guarantee that the tree/s contained within this report will be structurally sound under all circumstances, and is not able to detect every condition that may possibly lead to the structural failure of a tree. Paperbark Technologies cannot guarantee that the recommendations made will categorically result in the tree being made safe.

Unless specifically mentioned this report will only be concerned with above ground inspections, as such all observations have been visually assessed from ground level. Trees are living organisms and as such cannot be classified as safe under any circumstances. Trees fail in ways that the arboriculture industry does not fully understand.

The recommendations are made on the basis of what can be reasonably identified at the time of inspection therefore Paperbark Technologies accepts no liability for any recommendations made. All care has been taken to obtain information from reliable sources, however Paperbark Technologies can neither guarantee nor be responsible for the accuracy of information provided by others. In the event that reinspection of the tree/s is recommended it is the client's responsibility to make arrangements with Paperbark Technologies.

Appendix - Tree Protection Fencing

(AS4970- 2009 *Protection of trees on development sites*)



LEGEND:
1 Chain wire mesh panels with shade cloth (if required) attached, held in place with concrete feet.
2 Alternative plywood or wooden paling fence panels. This fencing material also prevents building materials or soil entering the TPZ.
3 Mulch installation across surface of TPZ (at the discretion of the project arborist). No excavation, construction activity, grade changes, surface treatment or storage of materials of any kind is permitted within the TPZ.
4 Bracing is permissible within the TPZ. Installation of supports should avoid damaging roots.

Maps of trees at Apsley Estate Subdivision:




Overall Map of Trees at Apsley Estate Subdivision - SRZ
Common Name
Domestic Fig
Flooded Gum (15)
Maritime Pine (12)
Swamp Mahogany
N
20 m


Overall Map of Trees at Apsley Estate Subdivision - TPZ
Common Name
Domestic Fig
Flooded Gum (15)
Maritime Pine (12)
Swamp Mahogany
N
20 m


Map 1 of Trees at Apsley Estate Subdivision - SRZ
Common Name
Domestic Fig
Flooded Gum (15)
Maritime Pine (12)
Swamp Mahogany
1
2
3
4
5
6
7
8
9
10
11
12
28
29
N
10 m


Map 1 of Trees at Apsley Estate Subdivision - TPZ
Common Name
Domestic Fig
Flooded Gum (15)
Maritime Pine (12)
Swamp Mahogany
1
2
3
4
5
6
7
8
9
10
11
12
28
29
N
10 m


Map 2 of Trees at Apsley Estate Subdivision - SRZ
Common Name
Domestic Fig
Flooded Gum (15)
Maritime Pine (12)
Swamp Mahogany
27
26
25
22
23
24
21
19
20
17
18
16
15
14
13
N
10 m


Map 2 of Trees at Apsley Estate Subdivision - TPZ
Common Name
Domestic Fig
Flooded Gum (15)
Maritime Pine (12)
Swamp Mahogany
27
26
25
22
23
24
21
19
20
17
18
16
15
14
13
N
10 m

Maritime Pine Tree ID #1

Tree Details

Latin Name:	Pinus pinaster
Latitude:	-32.193880825513
Longitude:	115.85175964335
Tree Height (Estimated) [m]:	16
Canopy Spread [m]:	12
DBH [cm]:	74
Health:	Good
Structure:	Fair
Problems:	Deadwood major >50, Deadwood minor <50
Notes:	
Priority:	Moderate
Tree Work:	Canopy lift, Remove major deadwood
Observation Comments:	
Tree Protection Zone (TPZ) [m]:	8.88
Structural Root Zone (SRZ) [m]:	2.98
Useful Life Expectancy:	20-40 years
Retention Value:	Very high
Risk of Harm Number:	Not applicable

Photos | Street View | Map View



image.jpg
18/06/2025

Maritime Pine Tree ID #2

Tree Details

Latin Name:	Pinus pinaster
Latitude:	-32.193894809027
Longitude:	115.85173162167
Tree Height (Estimated) [m]:	16
Canopy Spread [m]:	10
DBH [cm]:	70
Health:	Good
Structure:	Fair
Problems:	Hanging branch, Deadwood minor <50, Deadwood major >50
Notes:	
Priority:	Moderate
Tree Work:	Remove hanger, Remove major deadwood
Observation Comments:	
Tree Protection Zone (TPZ) [m]:	8.4
Structural Root Zone (SRZ) [m]:	2.92
Useful Life Expectancy:	20-40 years
Retention Value:	Very high
Risk of Harm Number:	Not applicable

Photos | Street View | Map View



image.jpg
18/06/2025

Maritime Pine Tree ID #3

Tree Details

Latin Name:	Pinus pinaster
Latitude:	-32.19392034449
Longitude:	115.85170077626
Tree Height (Estimated) [m]:	14
Canopy Spread [m]:	8
DBH [cm]:	60
Health:	Good
Structure:	Fair
Problems:	Deadwood major >50, Suppressed canopy, Leaning, Deadwood minor <50
Notes:	
Priority:	Moderate
Tree Work:	Remove major deadwood, Remove hanger
Observation Comments:	
Tree Protection Zone (TPZ) [m]:	7.2
Structural Root Zone (SRZ) [m]:	2.73
Useful Life Expectancy:	20-40 years
Retention Value:	Very high
Risk of Harm Number:	Not applicable

Photos Street View Map View



image.jpg
18/06/2025

Maritime Pine Tree ID #4

Tree Details

Latin Name:	Pinus pinaster
Latitude:	-32.193942475219
Longitude:	115.85166926031
Tree Height (Estimated) [m]:	7
Canopy Spread [m]:	6.5
DBH [cm]:	58
Health:	Good
Structure:	Fair
Problems:	Deadwood minor <50, Deadwood major >50
Notes:	
Priority:	Moderate
Tree Work:	Remove major deadwood
Observation Comments:	
Tree Protection Zone (TPZ) [m]:	6.96
Structural Root Zone (SRZ) [m]:	2.71
Useful Life Expectancy:	20-40 years
Retention Value:	Very high
Risk of Harm Number:	Not applicable

Photos | Street View | Map View



image.jpg
18/06/2025

Maritime Pine Tree ID #5

Tree Details

Latin Name:	Pinus pinaster
Latitude:	-32.193961201215
Longitude:	115.85163774435
Tree Height (Estimated) [m]:	15
Canopy Spread [m]:	7
DBH [cm]:	47
Health:	Good
Structure:	Fair
Problems:	Bark wound, Deadwood major >50, Deadwood minor <50
Notes:	
Priority:	Moderate
Tree Work:	Remove major deadwood
Observation Comments:	
Tree Protection Zone (TPZ) [m]:	5.64
Structural Root Zone (SRZ) [m]:	2.51
Useful Life Expectancy:	20-40 years
Retention Value:	Very high
Risk of Harm Number:	Not applicable

Photos | Street View | Map View



image.jpg
18/06/2025

Maritime Pine Tree ID #6

Tree Details

Latin Name:	Pinus pinaster
Latitude:	-32.1939787923
Longitude:	115.85161628668
Tree Height (Estimated) [m]:	13.5
Canopy Spread [m]:	7
DBH [cm]:	46
Health:	Fair
Structure:	Fair
Problems:	Deadwood major >50, Deadwood minor <50, Bark wound
Notes:	
Priority:	Moderate
Tree Work:	Remove major deadwood
Observation Comments:	
Tree Protection Zone (TPZ) [m]:	5.52
Structural Root Zone (SRZ) [m]:	2.47
Useful Life Expectancy:	20-40 years
Retention Value:	Very high
Risk of Harm Number:	Not applicable

Photos | Street View | Map View



image.jpg
18/06/2025

Maritime Pine Tree ID #7

Tree Details

Latin Name:	Pinus pinaster
Latitude:	-32.193995248473
Longitude:	115.85158879404
Tree Height (Estimated) [m]:	14
Canopy Spread [m]:	11
DBH [cm]:	60
Health:	Good
Structure:	Fair
Problems:	Leaning, Deadwood minor <50, Deadwood major >50
Notes:	
Priority:	Moderate
Tree Work:	Remove major deadwood
Observation Comments:	
Tree Protection Zone (TPZ) [m]:	7.2
Structural Root Zone (SRZ) [m]:	2.74
Useful Life Expectancy:	20-40 years
Retention Value:	Very high
Risk of Harm Number:	Not applicable

Photos | Street View | Map View



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Maritime Pine Tree ID #8

Tree Details

Latin Name:	Pinus pinaster
Latitude:	-32.19401283955
Longitude:	115.85155861919
Tree Height (Estimated) [m]:	14.5
Canopy Spread [m]:	7
DBH [cm]:	49
Health:	Good
Structure:	Fair
Problems:	Deadwood minor <50, Deadwood major >50
Notes:	
Priority:	Moderate
Tree Work:	Remove major deadwood
Observation Comments:	
Tree Protection Zone (TPZ) [m]:	5.88
Structural Root Zone (SRZ) [m]:	2.55
Useful Life Expectancy:	20-40 years
Retention Value:	Very high
Risk of Harm Number:	Not applicable

Photos Street View Map View



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Maritime Pine Tree ID #9

Tree Details

Latin Name:	Pinus pinaster
Latitude:	-32.194028728263
Longitude:	115.85153380875
Tree Height (Estimated) [m]:	14.5
Canopy Spread [m]:	7
DBH [cm]:	51
Health:	Good
Structure:	Fair
Problems:	Deadwood major >50, Deadwood minor <50
Notes:	
Priority:	Moderate
Tree Work:	Remove major deadwood
Observation Comments:	
Tree Protection Zone (TPZ) [m]:	6.12
Structural Root Zone (SRZ) [m]:	2.57
Useful Life Expectancy:	20-40 years
Retention Value:	Very high
Risk of Harm Number:	Not applicable

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Maritime Pine Tree ID #10

Tree Details

Latin Name:	Pinus pinaster
Latitude:	-32.194049156604
Longitude:	115.85150832777
Tree Height (Estimated) [m]:	8
Canopy Spread [m]:	4
DBH [cm]:	47
Health:	Good
Structure:	Poor
Problems:	Deadwood minor <50, Deadwood major >50, Suppressed canopy, Previous limb failure
Notes:	
Priority:	Moderate
Tree Work:	Remove Tree
Observation Comments:	
Tree Protection Zone (TPZ) [m]:	5.64
Structural Root Zone (SRZ) [m]:	2.47
Useful Life Expectancy:	1-5 years
Retention Value:	Low
Risk of Harm Number:	Not applicable

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Maritime Pine Tree ID #11

Tree Details

Latin Name:	Pinus pinaster
Latitude:	-32.194062775495
Longitude:	115.85147949402
Tree Height (Estimated) [m]:	15
Canopy Spread [m]:	11
DBH [cm]:	57
Health:	Good
Structure:	Fair
Problems:	Deadwood major >50, Deadwood minor <50, Codominant Stem, Hanging branch
Notes:	
Priority:	Moderate
Tree Work:	Remove hanger, Remove major deadwood
Observation Comments:	
Tree Protection Zone (TPZ) [m]:	6.84
Structural Root Zone (SRZ) [m]:	2.71
Useful Life Expectancy:	20-40 years
Retention Value:	Very high
Risk of Harm Number:	Not applicable

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Maritime Pine Tree ID #12

Tree Details

Latin Name:	Pinus pinaster
Latitude:	-32.194080934013
Longitude:	115.85145468359
Tree Height (Estimated) [m]:	15
Canopy Spread [m]:	6
DBH [cm]:	56
Health:	Good
Structure:	Fair
Problems:	Deadwood major >50, Deadwood minor <50
Notes:	
Priority:	Moderate
Tree Work:	Remove major deadwood
Observation Comments:	
Tree Protection Zone (TPZ) [m]:	6.72
Structural Root Zone (SRZ) [m]:	2.71
Useful Life Expectancy:	20-40 years
Retention Value:	Very high
Risk of Harm Number:	Not applicable

Photos | Street View | Map View



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Flooded Gum Tree ID #13

Tree Details

Latin Name:	Eucalyptus rudis
Latitude:	-32.192861688047
Longitude:	115.84878193847
Tree Height (Estimated) [m]:	12
Canopy Spread [m]:	10
DBH [cm]:	88
Health:	Fair
Structure:	Fair
Problems:	Epicormic growth, Deadwood major >50, Deadwood minor <50, Multi Crown leaders
Notes:	Remove basal epicormic growth
Priority:	Moderate
Tree Work:	Remove major deadwood, Remove epicormic growth
Observation Comments:	
Tree Protection Zone (TPZ) [m]:	10.56
Structural Root Zone (SRZ) [m]:	3.01
Useful Life Expectancy:	20-40 years
Retention Value:	High
Risk of Harm Number:	Not applicable

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Flooded Gum Tree ID #14

Tree Details

Latin Name:	Eucalyptus rudis
Latitude:	-32.192789892578
Longitude:	115.84876567041
Tree Height (Estimated) [m]:	12
Canopy Spread [m]:	10
DBH [cm]:	84.05
Health:	Poor
Structure:	Poor
Problems:	Leaning, Epicormic growth, Deadwood minor <50, Deadwood major >50, Secondary stem
Notes:	Remove basal epicormic growth and dead lower limb. Consider removal if this tree is close to high targets
Priority:	Moderate
Tree Work:	Other (Describe Below), Remove epicormic growth, Remove major deadwood
Observation Comments:	
Tree Protection Zone (TPZ) [m]:	10.09
Structural Root Zone (SRZ) [m]:	3.21
Useful Life Expectancy:	6-10 years
Retention Value:	Medium
Risk of Harm Number:	Not applicable

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Flooded Gum Tree ID #15

Tree Details

Latin Name:	Eucalyptus rudis
Latitude:	-32.1927846856
Longitude:	115.84866807383
Tree Height (Estimated) [m]:	12
Canopy Spread [m]:	9
DBH [cm]:	44.72
Health:	Dead
Structure:	Fair
Problems:	Deadwood major >50
Notes:	
Priority:	Moderate
Tree Work:	Remove Tree
Observation Comments:	
Tree Protection Zone (TPZ) [m]:	5.37
Structural Root Zone (SRZ) [m]:	2.57
Useful Life Expectancy:	0 years
Retention Value:	Low
Risk of Harm Number:	Not applicable

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Flooded Gum Tree ID #16

Tree Details

Latin Name:	Eucalyptus rudis
Latitude:	-32.192768860553
Longitude:	115.84859478308
Tree Height (Estimated) [m]:	11
Canopy Spread [m]:	9
DBH [cm]:	58
Health:	Good
Structure:	Fair
Problems:	Decayed pruning stub, Previous limb failure, Epicormic growth, Deadwood major >50
Notes:	
Priority:	Moderate
Tree Work:	Remove major deadwood, Canopy lift
Observation Comments:	
Tree Protection Zone (TPZ) [m]:	6.96
Structural Root Zone (SRZ) [m]:	2.71
Useful Life Expectancy:	20-40 years
Retention Value:	Very high
Risk of Harm Number:	Not applicable

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Flooded Gum Tree ID #17

Tree Details

Latin Name:	Eucalyptus rudis
Latitude:	-32.192735334794
Longitude:	115.8485562772
Tree Height (Estimated) [m]:	11
Canopy Spread [m]:	9
DBH [cm]:	80.62
Health:	Fair
Structure:	Poor
Problems:	Broken branch, Deadwood major >50, Epicormic growth, Trunk Decay, Previous limb failure
Notes:	Remove low dead limbs
Priority:	Moderate
Tree Work:	Canopy lift, Other (Describe Below), Remove major deadwood
Observation Comments:	
Tree Protection Zone (TPZ) [m]:	9.67
Structural Root Zone (SRZ) [m]:	3.27
Useful Life Expectancy:	6-10 years
Retention Value:	Low
Risk of Harm Number:	Not applicable

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Flooded Gum Tree ID #18

Tree Details

Latin Name:	Eucalyptus rudis
Latitude:	-32.192768813487
Longitude:	115.84852608503
Tree Height (Estimated) [m]:	12
Canopy Spread [m]:	9
DBH [cm]:	77.34
Health:	Good
Structure:	Fair
Problems:	Previous limb failure, Codominant Stem, Deadwood major >50, Epicormic growth
Notes:	
Priority:	Moderate
Tree Work:	Remove major deadwood
Observation Comments:	
Tree Protection Zone (TPZ) [m]:	9.28
Structural Root Zone (SRZ) [m]:	3.15
Useful Life Expectancy:	11-20 years
Retention Value:	Medium
Risk of Harm Number:	Not applicable

Photos | Street View | Map View



image.jpg
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Flooded Gum Tree ID #19

Tree Details

Latin Name:	Eucalyptus rudis
Latitude:	-32.192576126472
Longitude:	115.84849527145
Tree Height (Estimated) [m]:	16
Canopy Spread [m]:	11
DBH [cm]:	76
Health:	Good
Structure:	Fair
Problems:	Deadwood major >50, Epicormic growth, Previous limb failure, Secondary stem, Broken branch
Notes:	
Priority:	Moderate
Tree Work:	Remove major deadwood
Observation Comments:	
Tree Protection Zone (TPZ) [m]:	9.12
Structural Root Zone (SRZ) [m]:	3.01
Useful Life Expectancy:	20-40 years
Retention Value:	Very high
Risk of Harm Number:	Not applicable

Photos | Street View | Map View



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Flooded Gum Tree ID #20

Tree Details

Latin Name:	Eucalyptus rudis
Latitude:	-32.192721593348
Longitude:	115.84841973194
Tree Height (Estimated) [m]:	10
Canopy Spread [m]:	7
DBH [cm]:	80
Health:	Dead
Structure:	Fair
Problems:	Deadwood major >50
Notes:	
Priority:	Moderate
Tree Work:	Remove Tree
Observation Comments:	
Tree Protection Zone (TPZ) [m]:	9.6
Structural Root Zone (SRZ) [m]:	3.04
Useful Life Expectancy:	0 years
Retention Value:	Low
Risk of Harm Number:	Not applicable

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Flooded Gum Tree ID #21

Tree Details

Latin Name:	Eucalyptus rudis
Latitude:	-32.192608600759
Longitude:	115.84829249723
Tree Height (Estimated) [m]:	8
Canopy Spread [m]:	9
DBH [cm]:	54.92
Health:	Good
Structure:	Fair
Problems:	Deadwood major >50, Leaning, Epicormic growth, Basal decay, Secondary stem
Notes:	
Priority:	Moderate
Tree Work:	Remove major deadwood, Canopy lift
Observation Comments:	
Tree Protection Zone (TPZ) [m]:	6.59
Structural Root Zone (SRZ) [m]:	2.9
Useful Life Expectancy:	20-40 years
Retention Value:	High
Risk of Harm Number:	Not applicable

Photos | Street View | Map View



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Flooded Gum Tree ID #22

Tree Details

Latin Name:	Eucalyptus rudis
Latitude:	-32.192578570008
Longitude:	115.84810799729
Tree Height (Estimated) [m]:	9
Canopy Spread [m]:	9
DBH [cm]:	37.22
Health:	Good
Structure:	Fair
Problems:	Epicormic growth, Deadwood major >50, Fungi, Trunk Decay, Leaning
Notes:	
Priority:	Moderate
Tree Work:	Remove major deadwood, Canopy lift
Observation Comments:	
Tree Protection Zone (TPZ) [m]:	4.47
Structural Root Zone (SRZ) [m]:	2.37
Useful Life Expectancy:	20-40 years
Retention Value:	High
Risk of Harm Number:	Not applicable

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Flooded Gum Tree ID #23

Tree Details

Latin Name:	Eucalyptus rudis
Latitude:	-32.192603537816
Longitude:	115.84807320547
Tree Height (Estimated) [m]:	10
Canopy Spread [m]:	8
DBH [cm]:	71.59
Health:	Good
Structure:	Fair
Problems:	Leaning, Deadwood major >50, Epicormic growth, Trunk Decay
Notes:	
Priority:	Moderate
Tree Work:	Canopy lift, Remove major deadwood
Observation Comments:	
Tree Protection Zone (TPZ) [m]:	8.59
Structural Root Zone (SRZ) [m]:	3.12
Useful Life Expectancy:	20-40 years
Retention Value:	High
Risk of Harm Number:	Not applicable

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Flooded Gum Tree ID #24

Tree Details

Latin Name:	Eucalyptus rudis
Latitude:	-32.19262458957
Longitude:	115.84801412172
Tree Height (Estimated) [m]:	9
Canopy Spread [m]:	9
DBH [cm]:	78.43
Health:	Good
Structure:	Fair
Problems:	Deadwood major >50, Epicormic growth, Trunk Decay, Multi Crown leaders
Notes:	
Priority:	Moderate
Tree Work:	Canopy lift, Remove major deadwood
Observation Comments:	
Tree Protection Zone (TPZ) [m]:	9.41
Structural Root Zone (SRZ) [m]:	3.31
Useful Life Expectancy:	20-40 years
Retention Value:	Medium
Risk of Harm Number:	Not applicable

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Flooded Gum Tree ID #25

Tree Details

Latin Name:	Eucalyptus rudis
Latitude:	-32.192578483801
Longitude:	115.84772345561
Tree Height (Estimated) [m]:	16
Canopy Spread [m]:	11
DBH [cm]:	89.5
Health:	Good
Structure:	Fair
Problems:	Epicormic growth, Trunk Decay, Multi Crown leaders, Deadwood major >50
Notes:	
Priority:	Moderate
Tree Work:	Canopy lift, Remove major deadwood
Observation Comments:	
Tree Protection Zone (TPZ) [m]:	10.74
Structural Root Zone (SRZ) [m]:	3.3
Useful Life Expectancy:	20-40 years
Retention Value:	High
Risk of Harm Number:	Not applicable

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Flooded Gum Tree ID #26

Tree Details

Latin Name:	Eucalyptus rudis
Latitude:	-32.192500343135
Longitude:	115.84775955497
Tree Height (Estimated) [m]:	7
Canopy Spread [m]:	3
DBH [cm]:	25
Health:	Dead
Structure:	Fair
Problems:	Deadwood major >50
Notes:	
Priority:	Moderate
Tree Work:	Remove Tree
Observation Comments:	
Tree Protection Zone (TPZ) [m]:	3
Structural Root Zone (SRZ) [m]:	1.91
Useful Life Expectancy:	0 years
Retention Value:	Low
Risk of Harm Number:	Not applicable

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Flooded Gum Tree ID #27

Tree Details

Latin Name:	Eucalyptus rudis
Latitude:	-32.192506444857
Longitude:	115.8476108429
Tree Height (Estimated) [m]:	9
Canopy Spread [m]:	6
DBH [cm]:	78.6
Health:	Good
Structure:	Poor
Problems:	Basal bifurcation, Deadwood major >50, Epicormic growth
Notes:	
Priority:	Moderate
Tree Work:	Canopy lift, Remove major deadwood
Observation Comments:	Failure within canopy
Tree Protection Zone (TPZ) [m]:	9.43
Structural Root Zone (SRZ) [m]:	3.01
Useful Life Expectancy:	11-20 years
Retention Value:	High
Risk of Harm Number:	Not applicable

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Swamp Mahogany Tree ID #28

Tree Details

Latin Name:	Eucalyptus robusta
Latitude:	-32.194173616425
Longitude:	115.85132306548
Tree Height (Estimated) [m]:	10.7
Canopy Spread [m]:	9.5
DBH [cm]:	76.49
Health:	Fair
Structure:	Poor
Problems:	Vehicle damage, Broken branch, Deadwood major >50, Deadwood minor <50, Epicormic growth, Basal bifurcation, Previous limb failure, Poorly pruned, Bark wound
Notes:	
Priority:	Low
Tree Work:	Cleanly prune jagged branch stubs, Remove major deadwood, Remove minor deadwood
Observation Comments:	The tree has had multiple branch failures and displays several large wounds
Tree Protection Zone (TPZ) [m]:	9.18
Structural Root Zone (SRZ) [m]:	2.93
Useful Life Expectancy:	20-40 years
Retention Value:	Medium
Risk of Harm Number:	

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Domestic Fig Tree ID #29

Tree Details

Latin Name:	Ficus carica
Latitude:	-32.194248865672
Longitude:	115.85120817126
Tree Height (Estimated) [m]:	5
Canopy Spread [m]:	8.5
DBH [cm]:	24.49
Health:	Fair
Structure:	Poor
Problems:	Deadwood minor <50, Broken branch, Basal bifurcation
Notes:	
Priority:	None
Tree Work:	Remove tree
Observation Comments:	Not worthy of retaining
Tree Protection Zone (TPZ) [m]:	2.94
Structural Root Zone (SRZ) [m]:	3.01
Useful Life Expectancy:	6-10 years
Retention Value:	Low
Risk of Harm Number:	

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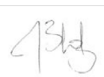
		Name	Name	Signature	Date
A	Michelle Gellender	James Blitz	James Blitz		20 October 2023
B	Michelle Gellender	James Blitz	James Blitz		10 April 2024
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STRATEGEN
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Deon White
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Level 1, 130 Royal Street
EAST PERTH WA 6004

Reference: QPG13247.01

Dear Deon,

ENVIRONMENTAL INFORMATION TO SUPPORT LOCAL STRUCTURE PLAN FOR MANDOGALUP

Strategen is pleased to offer the following advice with respect to the management of key environmental issues relating to Lot 682 Rowley Road, Mandogalup ('the Site'), including:

- acid sulphate soils (ASS)
- contaminated sites
- flora
- fauna
- fire management.

Strategen understands that QUBE Property Group (the proponent) is proposing to develop the site for residential purposes, with sand mining to occur prior to development and has prepared a Local Structure Plan (LSP) to support this.

Acid sulphate soils

Approximately half of Lot 682, predominantly in the south, is mapped by Department of Regulation (DER) as having a 'high to moderate risk' of ASS within 3 m of the surface. This area covers approximately half the property. The remainder is mapped by DER has having a 'moderate to low risk' of ASS within 3 m of the surface. As a consequence, there is a risk that dewatering and excavation on the site may result in ASS being exposed to air, potentially causing acidification.

As the DER ASS risk mapping was created at a scale of 1:50 000, it is not recommended to be applied at a lot scale and site-specific verification is recommended (DEC 2013). In order to better understand the distribution of soils presenting a risk of ASS, QUBE is proposing to undertake a staged investigation, consistent with DEC (2013). The stages will be as follows:

- Stage 1 - Desktop interpretation to better define areas requiring ASS risk management reinforced by a site walkover, preparation of sampling and analysis program and endorsement of approach by DER.
- Stage 2 - Intrusive sampling regime to corroborate findings of desktop analysis and inform the targeted management of ASS to be detailed in a management plan. This work is anticipated to be undertaken at the subdivision stage on a stage by stage basis.

ASS issues are not considered a significant issue and should not affect the LSP process. ASS investigations and management are usually required as a condition of subdivision, once the location and extent of dewatering for service installation is known. The ASS investigation is consequently proposed to commence after the LSP is submitted. Any ASS investigations and management plans will be approved by DER prior to the commencement of any works likely to result in the exposure of ASS to air.

Contaminated sites

The southern portion of Lot 682 has historically been utilised for market gardening. As a consequence, Strategen is preparing a Preliminary Site Investigation (PSI) to investigate the potential for contamination to be present on the site. At the time of writing, freedom of Information (FOI) requests have been sent out to relevant authorities and review of historical aerial photographs has taken place, noting past land uses and surrounding land uses over a period of 50 years. A site walkover has been undertaken and the PSI is being prepared to identify which parts of Lot 682 will require further investigation.

Development of former market garden sites for residential purposes in Perth is common practice and should not affect the LSP. The matter is usually addressed by requiring appropriate assessment and, if required, rehabilitation, prior to titles being issued following subdivision. Strategen is proposing to follow this approach.

Flora

Two flora surveys have been undertaken of the Site and did not identify any species of DRF or priority flora (Cardno 2005; Plantecology Consulting 2012). A total of 83 taxa were recorded during the 2005 survey including 13 introduced (weed) species (Cardno 2005). The 2012 survey was a Target Priority and Threatened Flora search and did not record any priority or threatened flora on site.

Four vegetation communities have been identified across the Proposal Area:

1. BDb – Low Banksia forest over heath of *Dasypogon bromeliifolius*, *Lyginia barbata* and *Schoenus* sp., *Lomandra* spp., and *Desmocladus flexuosus*.
2. BaHh – Low Banksia woodland with emergent *Eucalyptus marginata* over heath of *Hibbertia hypericoides*, *Stirlingia latifolia* and *Xanthorrhoea preissii* on yellow to grey sands.
3. ErMP – Woodland of *Eucalyptus rudis* over *Melaleuca preissiana* and *Banksia littoralis* over *Astartea scoparia*, *Juncus pallidus* and weed species *Carpobrotus edulis, Zantedeschia aethiopica* and *Arctotheca calendula.*
4. PC - Parkland cleared, scattered native trees over paddock grasses (Plantecology Consulting 2012).

Much of the vegetation on the Site is degraded due to historic and current agricultural land uses of market gardening and grazing (Plantecology Consulting 2012).. The vegetation varies from “Very Degraded to ‘Excellent’ condition (Plantecology Consulting 2012).. The vegetation recorded within the Proposal Area was consistent with that found commonly on the Swan Coastal Plan. The dominant remnant vegetation type is Open Banksia Woodlands with scattered Melaleucas and Jarrahs. No threatened or priority ecological communities (TECs & PECs) exist within the Proposal Area (Cardno 2005), although one TEC and four PECs are located within 5 km (Plantecology Consulting 2012).. None of these ecological communities are listed under the EPBC Act (Plantecology Consulting 2012).

An assessment of the likelihood of occurrence of each of the flora species identified by the EPBC Act Protected Matters database was undertaken. No flora species listed under the EPBC Act are likely to occur based on the vegetation types within the Proposal Area and the results of the two flora surveys.

As there have not been any TECs, PECs and Priority Species recorded, the presence of threatened or priority species and communities is not anticipated to constrain the development of the Site.

Fauna

A total of 164 species of fauna were identified as having the potential to occur within the Site as a result of desktop assessments (Emerge 2011). Reconnaissance surveys from 2005 and 2010 observed (or positively identified from scats, tracks, skeletons or calls) a total of 57 fauna species within the Site (Emerge 2011). This total included three amphibians, one reptile, 48 birds (two of which were introduced species) and five mammals (one of which was an introduced species).

An assessment of the likelihood of occurrence of each of the fauna species identified by the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) Protected Matters database was undertaken. Of these species, two are likely to occur including *Calyptorhynchus banksii naso* (Forest Red-tailed Black-Cockatoo) and *Calyptorhynchus latirostris* (Carnaby's Black-Cockatoo) (Emerge 2011). A number of migratory species listed under the EPBC Act were also likely to occur (Emerge 2011). The development of the Site has been referred to the Federal Department of the Environment for assessment under the EBPC Act. Approval is anticipated shortly.

Fire management

A Fire Management Plan (FMP) is currently being prepared for the site.

The key bush fire risk areas are those where proposed lots directly adjoin bushland on adjacent lots to the north, east and a portion of the western boundary. Unless this vegetation is proposed to be cleared prior to development, these lots will require separation to the bushland and/or suitable construction standards based on the likely Bushfire Attack Level. A similar approach is anticipated to be required for lots adjacent to public open space that consists of retained vegetation.

The FMP will be completed prior to the first application for subdivision being lodged.

I hope that this answers your queries with respect to the Site. Should you have any further questions, please do not hesitate to contact the undersigned.

Yours sincerely



Darren Walsh
CHIEF EXECUTIVE OFFICER

3 June 2014

References

Cardno 2005 *Flora, Vegetation, Fauna and Wetland Assessment Mandogalup*, report prepared for Mandogalup Land Development Company P/L, December 2005.

Department of Environment and Conservation (DEC) 2013 *Identification and investigation of acid sulfate soils and acidic landscapes*, DEC Perth.

Emerge 2011 *Level 1 Fauna Survey and Habitat Assessment, Various Allotments Mandogalup,* unpublished report to Qube Mandogalup, September 2011.

Plantecology Consulting 2012, *Targeted Priority and Threatened Flora Search –Mandogalup, unpublished report to Strategen*, December 2012.

Appendix C

Engineering Servicing Report

(Cossill & Webley)

Cossill & Webley
CONSULTING ENGINEERS



APSLEY
Structure Plan
ENGINEERING REPORT
May 2024

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1. INTRODUCTION

This report has been prepared by Cossill & Webley Pty Ltd (CW) and summarises the results of an assessment of the engineering aspects of the proposed urban development over the urban zoned land bound by the yellow boundary in Figure 1 below.

This area is the extension of the existing Mandogalup Structure Plan bound in green below.

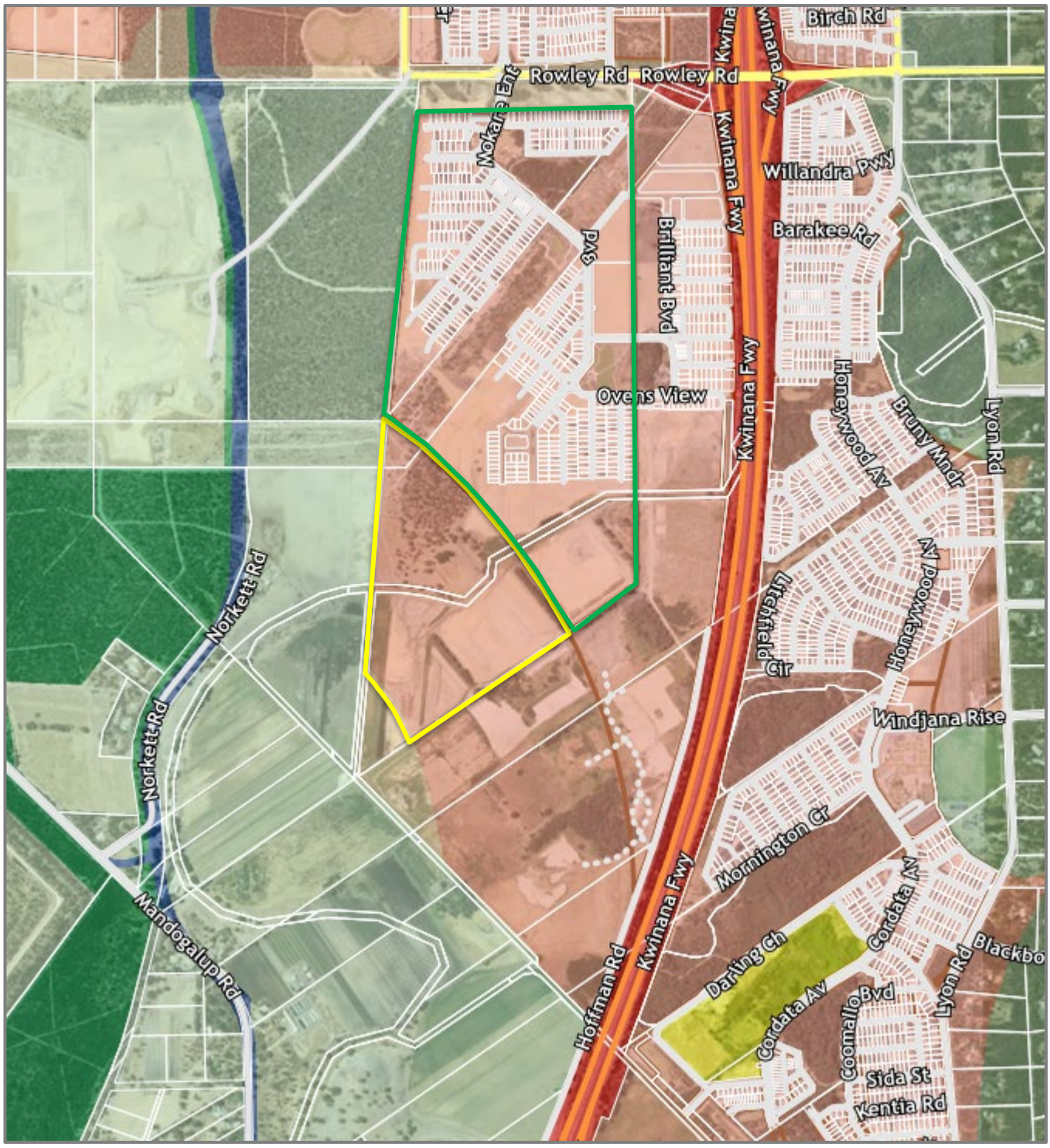


Figure 1 - Locality Plan (MNG Access, 2024)

The Site will ultimately be accessed via Rowley Road to the North, Hammond Road to the west and Anketell Road to the south.

The location of the site will require a coordinated approach to development with neighbouring properties, in particular lots to the south, for the connection of sewer services. The nature of service constraints to the property are outlined in respective sections below.

2. SITE DESCRIPTION

The Site is approximately 24.55 ha in area and is located within the City of Kwinana. Historically, where development over the land has occurred, it has consisted of a mixture of rural and agricultural uses.

A large proportion of the Site south of the Peel Main Drain has been earthworked under a Development Approval previously, with a number of larger tree windrows remaining. There is an existing patch of native vegetation north of the Peel Main Drain as presented below in Figure 2. There is a Western Power easement at the northern end of the Site, which has been selectively cleared previously, and some regrowth is present within this corridor.



Figure 2 – Aerial Photography (MNG Access, 2024)

3. GEOLOGY AND LANDFORM

The Geological Survey of Western Australia Perth Metropolitan Region soils maps for Fremantle (part 2033I & 2033IV) indicates that the majority of the Site is generally characterised by Bassendean Sand and Sandy Silt (Refer Figure 3 below). These soil types are well suited to urbanisation.

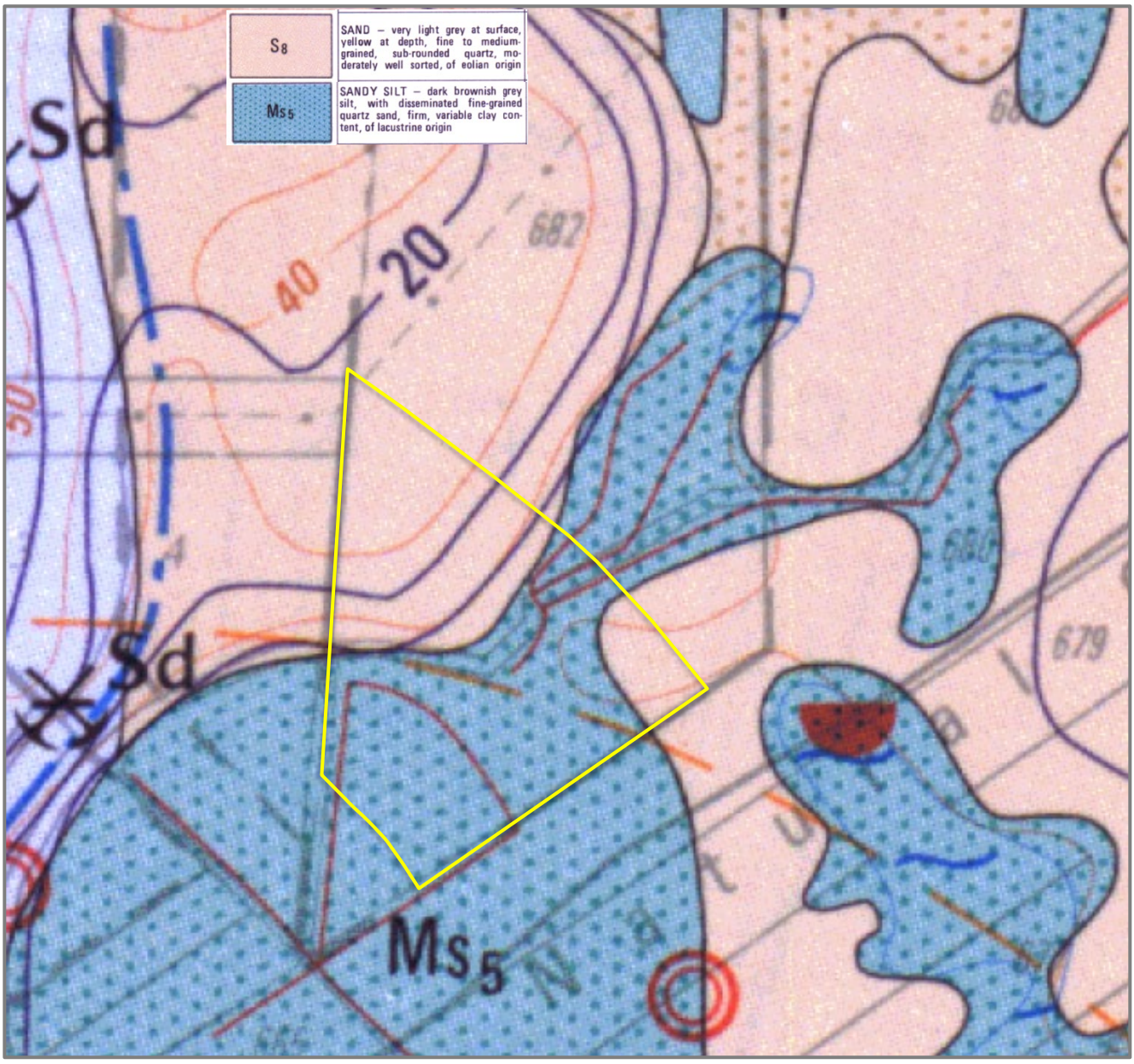


Figure 3 - Geotechnical Information (Geological Survey of WA)

A more detailed geotechnical investigation was completed by Galt Geotechnics which generally concurred with the soils maps. The report provided preliminary site classifications, site preparation requirements, management of topsoil and advice on the disposal of stormwater runoff which was used as the basis for the earthworking this area. The report confirmed the suitability of the area for urban development, and advised a Site Classification of Class A and Class M (Australian Standard AS2870 – Residential Slabs and Footings code) would be applicable following the appropriate clearing and earthworking of the area. Figure 4 below summarises the pre-earthworks site conditions.

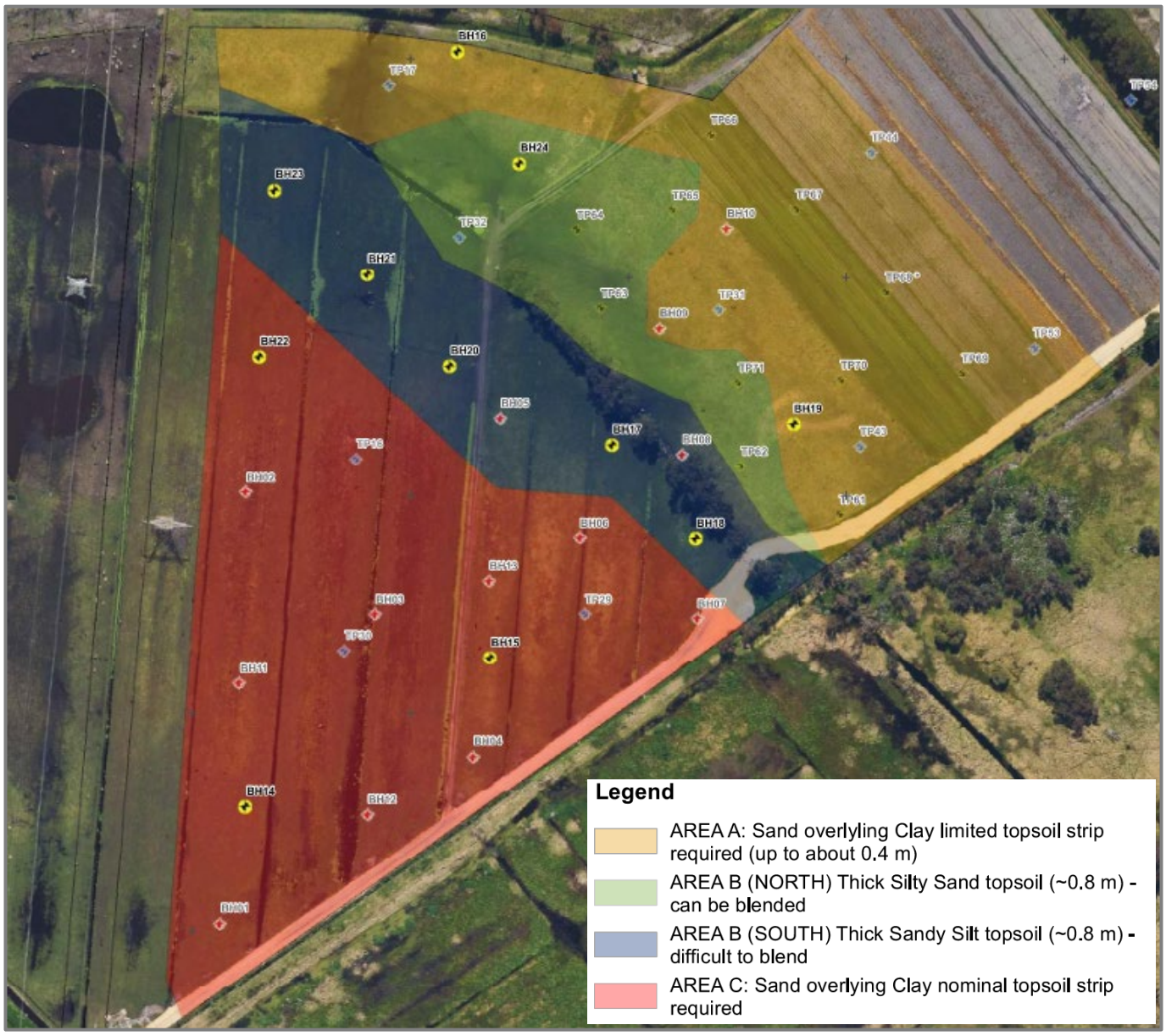


Figure 4: Galt Geotechnics Detailed Site Investigation South of the Peel Main Drain (Galt Geotechnics, 2022)

3.1 Existing Topography

Based on aerial contour information obtained from surveyors MNG, the Site is steeply graded in the northern area from a level of RL35m AHD to a low lying area in the south at RL13m AHD as per Figure 5 below.

As outlined above, substantial earthworks have occurred south of the Peel Main Drain, with finished earthworks levels ranging from RL16mAHD to RL18mAHD.

Earthworks have also been completed north of the Peel Main Drain up to boundary of the Site. Earthworks levels at the northern extent of the area are at least 4m below existing natural surface levels. Natural surface levels were reduced to ensure maximum road, sewer and drainage grades were not exceeded. Given the now existing levels of the area north of the SP are set, earthworking of the high point of the SP area depicted below is a necessary engineering requirement to meet maximum road, sewer and drainage requirements as well as City of Kwinana maximum retaining wall heights.

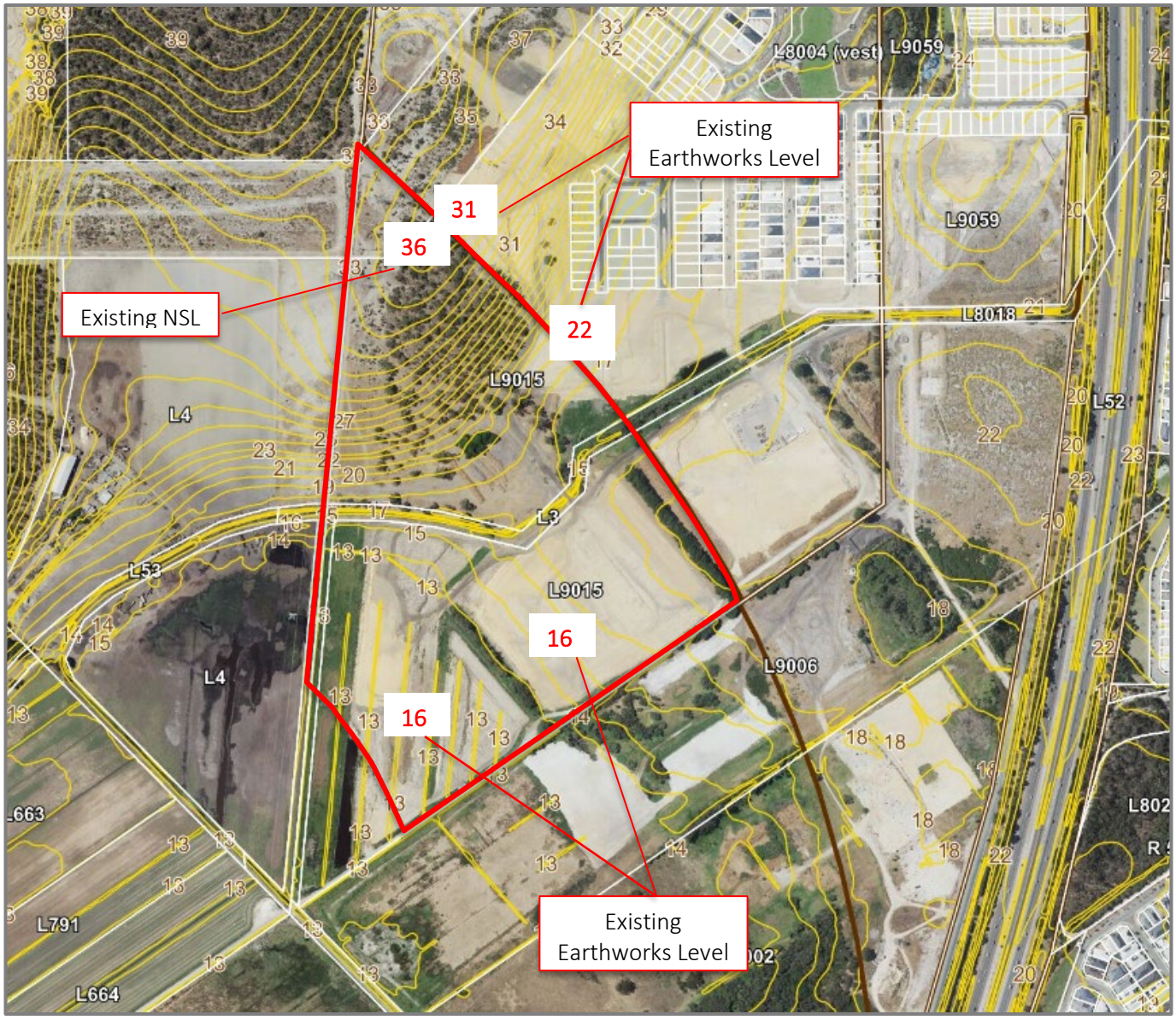


Figure 5 – Existing Topography (MNG Access, 2024)

3.2 Groundwater

The Annual Average Maximum Groundwater Levels (AAMGL) vary from approximately RL 12.5m AHD in the south-west to 18m AHD at the northern extent of the Site as presented in Figure 6 below. Ensuring there is adequate separation to the prevailing ground water levels and consideration of the drainage design will be factors in the determination of the finished earthworks levels in lower areas of the Site. It is likely that imported fill will be required in the south to provide clearance to groundwater in accordance with the district drainage strategies, and to ensure the Site can be serviced adequately with sewerage and drainage. Further discussion regarding the prevailing groundwater conditions is included in the Water Management Report prepared by JDA Consultant Hydrologists, which also accompanies this Structure Plan.

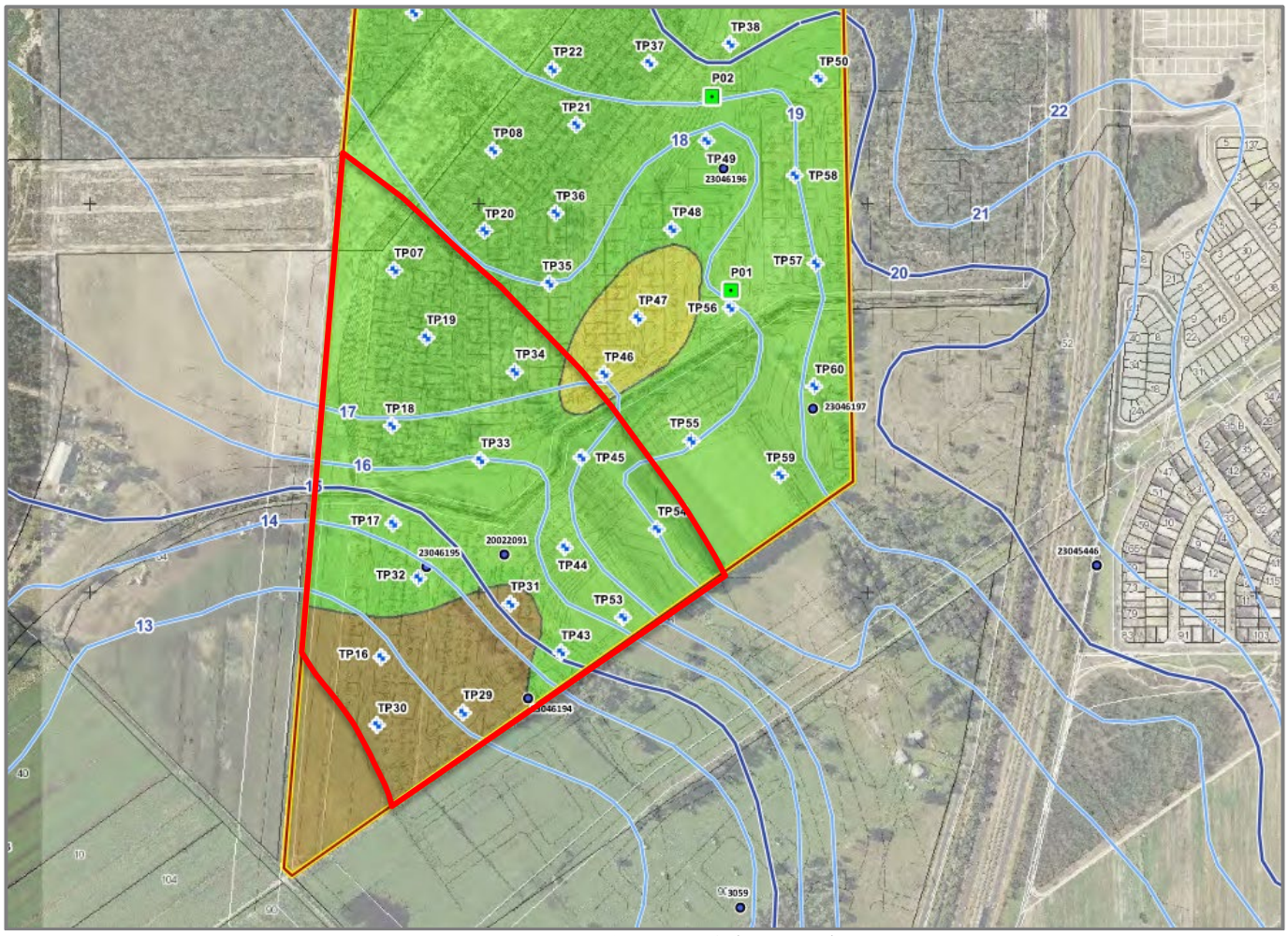


Figure 6 – Groundwater Levels (JDA, 2024)

4. EARTHWORKS CONSIDERATIONS

Siteworks will generally comprise the clearing of existing vegetation, earthworks and cut to fill earthworks to provide adequate separation to groundwater in the southern portion of the site.

As the Site has generally good separation to groundwater in the northern area, it is intended to utilise this as a source of cut to fill the lower lying area to the south. Figure 7 below depicts areas of cut (red) and fill (green).

The dark areas of red in Figure 7 in the northern part of the Site indicate depth of cut in the order of 5 metres. These levels are a function of integrating with the adjacent Mandogalup West Structure Plan levels, meeting maximum road grade and services requirements, and keeping retaining walls maximum heights to within the City of Kwinana's standards. Retention of vegetation in this area would result in significant battering or retaining walls sitting well above the adjacent proposed development levels.



Figure 7: Preliminary Cut and Fill Areas (CW, 2023)

As stated above in Section 3.1, substantial earthworks have been completed to date north of the Peel Main Drain.

The image below shows the extent of earthworks and the existing earthworked level (red), with the adjacent natural surface levels (green).

Retention of vegetation in the area below would require substantial walling (in excess of 5 metres) to the completed lots, and would make access and amenity very difficult.



The extent of siteworks will be dictated by the density and nature of development. Increased densities and decreasing lot sizes has led to the current model of providing fully earthworked level lots which are terraced with retaining walls. This approach provides a number of positive outcomes:

- House building site work costs are reduced,
- Retaining wall layouts are rationalised and designs are consistent with Local Authority specifications,
- It enables lots to be terraced up natural slopes to maintain elevation and views.

However, retention of existing vegetation and topography within the lot areas is limited, particularly where the natural surface is very steep, such in the northern area of the proposed development where road and service grades inhibit the ability to retain vegetation within lots and roads. Existing vegetation within public open spaces and along the Peel Main Drain will be retained wherever possible to provide useable space for the community.

The Site will be designed in accordance with the following objectives:

- Provide adequate separation to groundwater with consideration of expected post-development groundwater rise;
- Provide minimum levels required for drainage and sewer serviceability;
- Provide appropriate siteworks to achieve a Class A site classification;
- Allow roads and earthwork levels to be graded to best follow the existing topography and reflect the natural landscape where possible;
- Maintain suitable interface levels at the periphery of the Site.

5. DRAINAGE AND GROUNDWATER MANAGEMENT

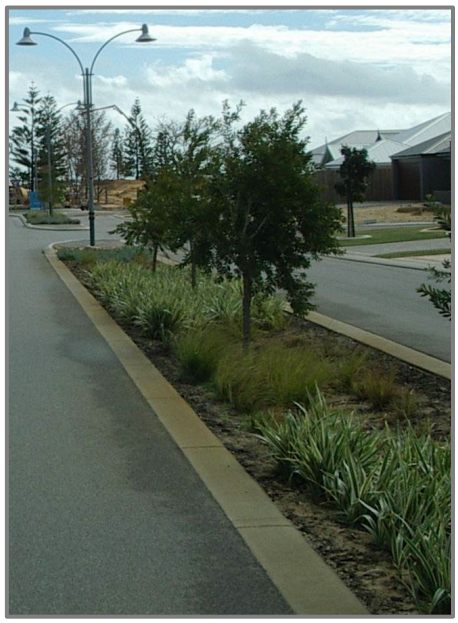
The landform through the area is generally steep with good separation from the groundwater table in the northern portion of the Site. In the southern area, the land grades become flatter and the groundwater table is much closer to the surface. The Peel Main Drain traverses the Site and grades from the eastern boundary to the west.

A District Water Management Strategy (DWMS) has been prepared by JDA Consultant Hydrologists as part of the rezoning of the land from rural to urban deferred. The DWMS notes that drainage catchment areas within the site fall into the catchment of the Peel Main Drain, as determined in the Jandakot District Water Management Plan (DWMP). The DWMS requires stormwater runoff generated from the proposed development of Lot 9000 to be detained and infiltrated on site in POS areas, with compensated flows from larger events to be directed to the Peel Main Drain.

A Local Water Management Strategy has been prepared as part of this Structure Plan which outlines the requirements for drainage storage, separation to groundwater, subsoil control requirements and drainage design.

5.1 Stormwater Management

Groundwater recharge will be maximised through the adoption of 'Best Management Practices' that promote the dispersion and infiltration of runoff as close to source as possible. The LWMS proposes the strategic use of flush kerbing, inter-allotment drainage soakwells to infiltrate runoff from building roofs and private open space areas and the disposal of road runoff into infiltration basins within POS areas.



5.2 Water Quality Management

Recharge water quality will be improved through the adoption of 'Best Management Practices' which promote the disposal of runoff via water pollution control facilities (including vegetated swales and basins, detention storages and gross pollutant traps) and the implementation of non-structural source controls (including urban design, street sweeping, community education, low fertiliser landscaping regimes, etc).

5.3 Stormwater Collection and Disposal

Lot 9000 Rowley Road, Mandogalup has varied ground conditions; some areas have free draining soils with adequate separation to ground water, and other areas where sandy silts are nearer the surface, and infiltration of water may be more difficult.

Drainage from public roads and lanes would be collected via conventional gullies or open swales depending on the nature of the adjacent land uses and the extent of traffic and pedestrian activity.

The drainage collection and conveyance system will be designed to cater for the runoff from storms up to a 20% AEP.

The LWMS outlines a series of off-line bio-retention and storage basins be located in POS areas adjacent to the Peel Main Drain. These basins will be sized to detain runoff to the pre-development peak flow rates for the 20%, 10% & 1% AEP events. In all cases roads and POS would be designed to cater for the surface overflow for more severe storms with building pad levels set at least 300 millimetres above the 1% AEP flood level in roadways and 500 millimetres above the 1% AEP flood level for storage detention basins.

The dispersion of stormwater disposal throughout the site will maximise the area of recharge down through the soil profile to the shallow aquifer, thereby maximising the potential for nutrient stripping and water quality improvements.

5.4 Groundwater Control

Where groundwater is near the existing natural surface (south of the Peel Main Drain), subsoil drainage will be installed to control levels to pre-development conditions, with imported fill being brought in to provide sufficient separation to the phreatic surface.

Subsoil drainage will also be installed where necessary below public open space areas to ensure they can dry out appropriately following storm events.

Subsoil drainage will discharge to the Peel Main Drain to control groundwater rise across the proposed development.

6. WATER RETICULATION

The Site is located within the current boundary of the Water Corporation's Water Supply Scheme and overall planning for the scheme has made provision for residential development over the subject land.

Current Water Corporation planning indicates the Site will ultimately be serviced by extension of a DN500 distribution main as presented in Figure 8 below. This extension is a Water Corporation capital project and would be extended south as demand requires.

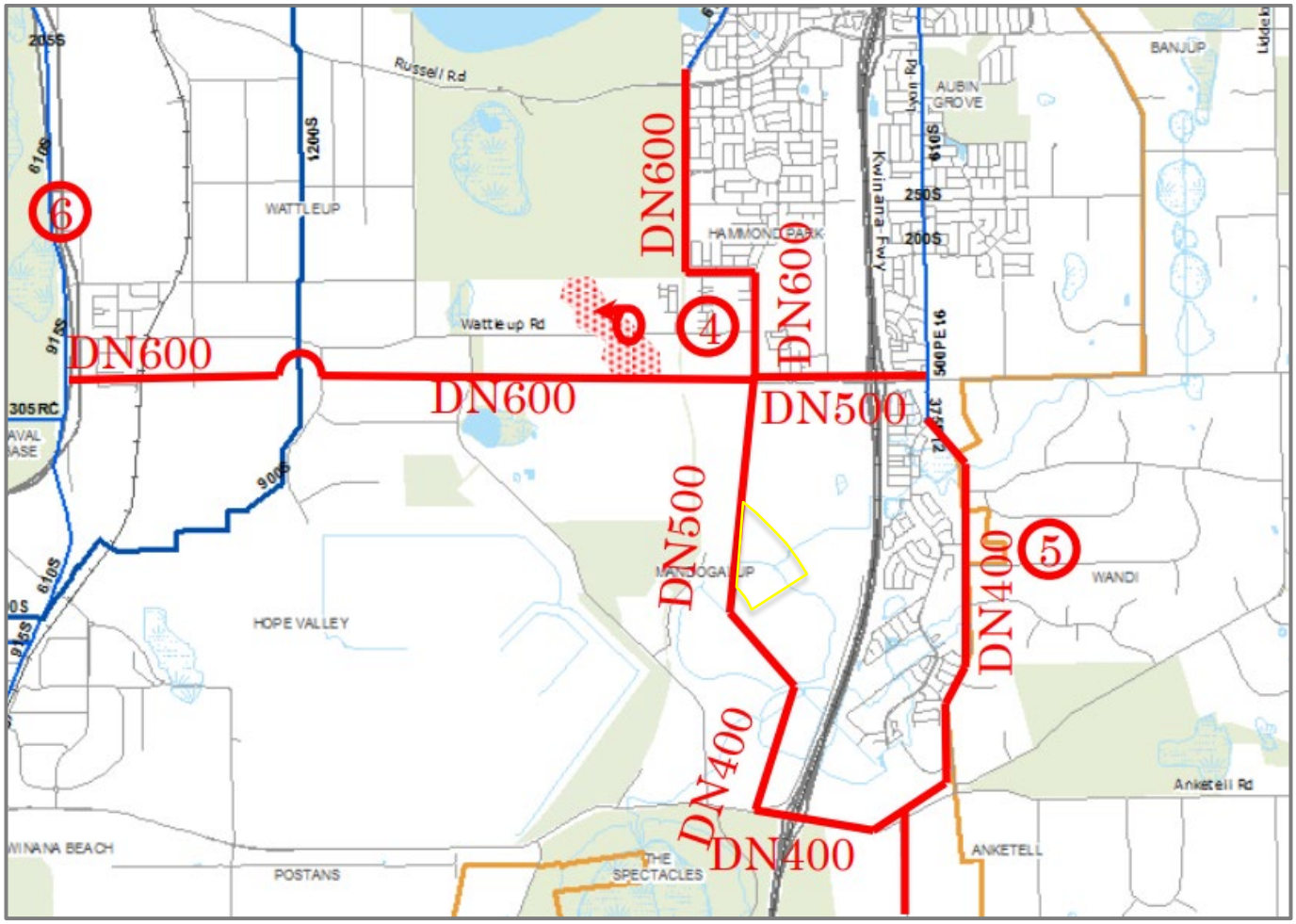


Figure 8: Distribution Water Supply Planning (Water Corporation, 2022)

7. SEWERAGE RETICULATION

The Site forms part of the Water Corporation's Thompson's Lake waste water reticulation system and preliminary planning has been undertaken to develop strategies for providing deep sewerage to all proposed urban land within the subject area.

The Water Corporation has recently updated their sewer strategy and confirmed the Site will be serviced via construction of a new Type 90 Pump Station servicing all development west of the Freeway as presented below in Figure 9. This new "Thomsons Lake PS J" will include a pressure main north through the existing Western Power easement an up Barfield Road to an existing sewer discharge tower near the intersection of Jackadder Avenue.

Design of this pump station is underway in order to support development of the Structure Plan area.

Standard Water Corporation headworks will apply.

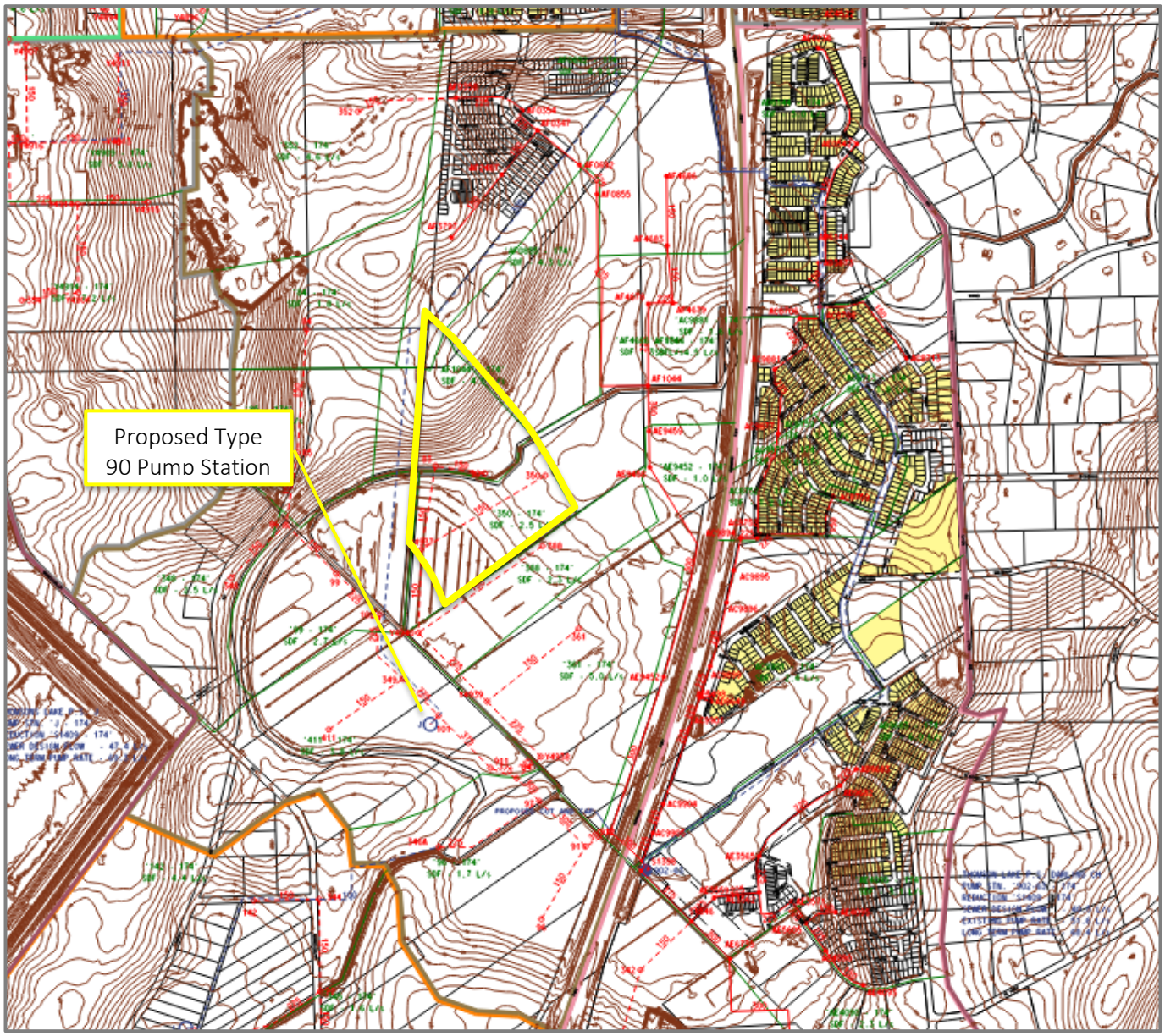


Figure 9: Sewer Strategy (Water Corporation, 2024)

8. POWER

Western Power has confirmed there is existing capacity in the surrounding network to service development of the Site.

There are a number of overhead power lines that traverse the Site as presented in Figure 10 below. These lines are protected via an easement in favour of Western Power, and preclude building development within the easement.

Some parts of the Western Power easement may be used for battering, drainage storage, road crossing, parking and public open space, consistent with the existing easement north of the Site within the Apsley development.

All power to the proposed development will be underground and fed from transformers located strategically within the Site.

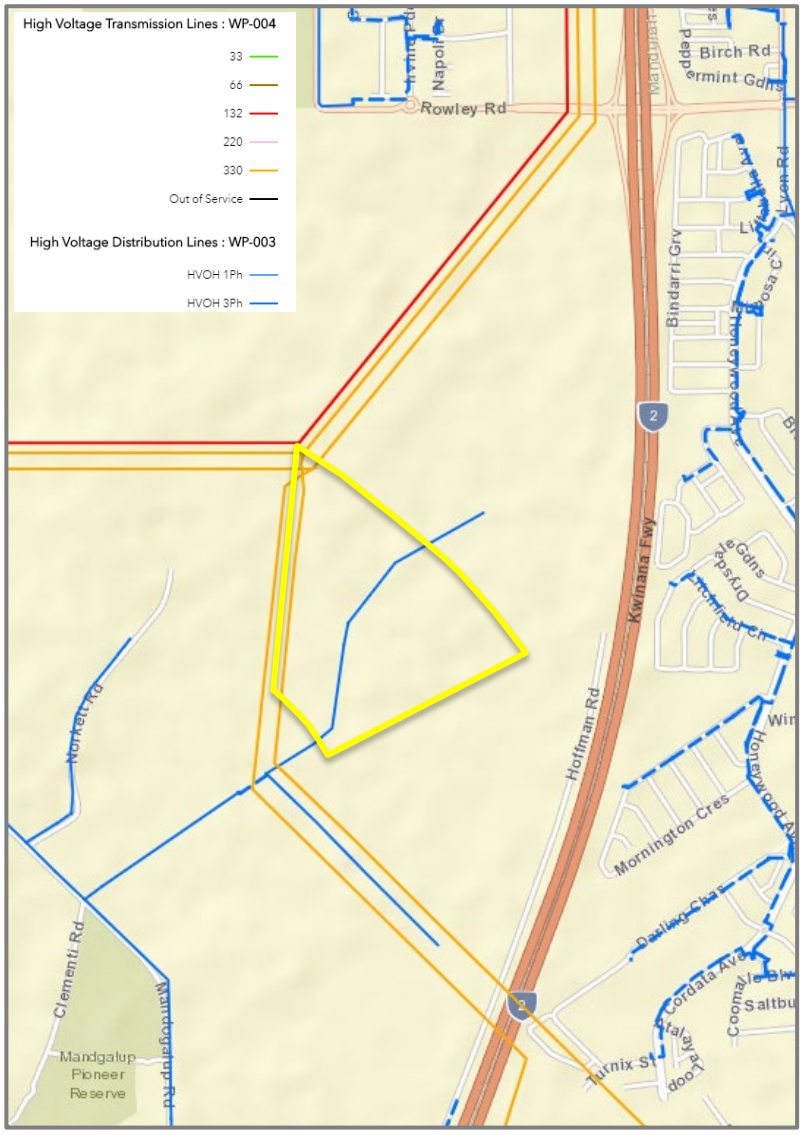


Figure 10 – Existing HV Infrastructure and Network Capacity (Western Power, 2024)

9. GAS SUPPLY

ATCO Gas has advised the Site can be supplied with reticulated gas via an extension of their existing network within the existing Apsley development. No off-site infrastructure upgrades are required.

10. TELECOMMUNICATIONS

It is proposed to extend the existing NBN network from the Apsley development to service the Site with telecommunications. No off-site infrastructure upgrades are required.

11. ROADWORKS & FOOTPATHS

Transcore has prepared a Transport Impact Assessment to accompany the Structure Plan, which outlines the proposed internal road hierarchy and distribution of traffic from the development to the surrounding external road network.

Development of this subject area will be an extension of the existing Apsley development to the north and east, and all internal roads will be constructed in accordance with the City of Kwinana and Liveable Neighbourhoods requirements to match the existing network. Roadworks will generally consist of kerbed and asphalted pavements. Minimum recommended carriageway widths will be determined in accordance with Liveable Neighbourhoods and the City of Kwinana requirements.

Main access to the Site will ultimately be via Rowley Road to the north, proposed Hammond Road to the west and ultimately Anketell Road to the south.

In all cases the road cross-sections will be designed to cater for utility services, street trees and parking embayments on standard verge alignments.

12. CONCLUSION

Lot 9000 Rowley Road, Mandogalup has planned strategies for water supply, sewerage and other public utility services. All services are available or can be extended to service the proposed urban area readily.

Cossill & Webley
CONSULTING ENGINEERS



MANDOGALUP WEST
Local Structure Plan
ENGINEERING REPORT
May 2017

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1. INTRODUCTION

The following report has been prepared by Cossill & Webley Pty Ltd (CW) and summarises the results of a preliminary assessment of the engineering aspects of the proposed urban development over Lots 52 & 682 Rowley Road, Mandogalup (referred to herein as The Site).

The Site is identified by the red boundary presented below in Figure 1.

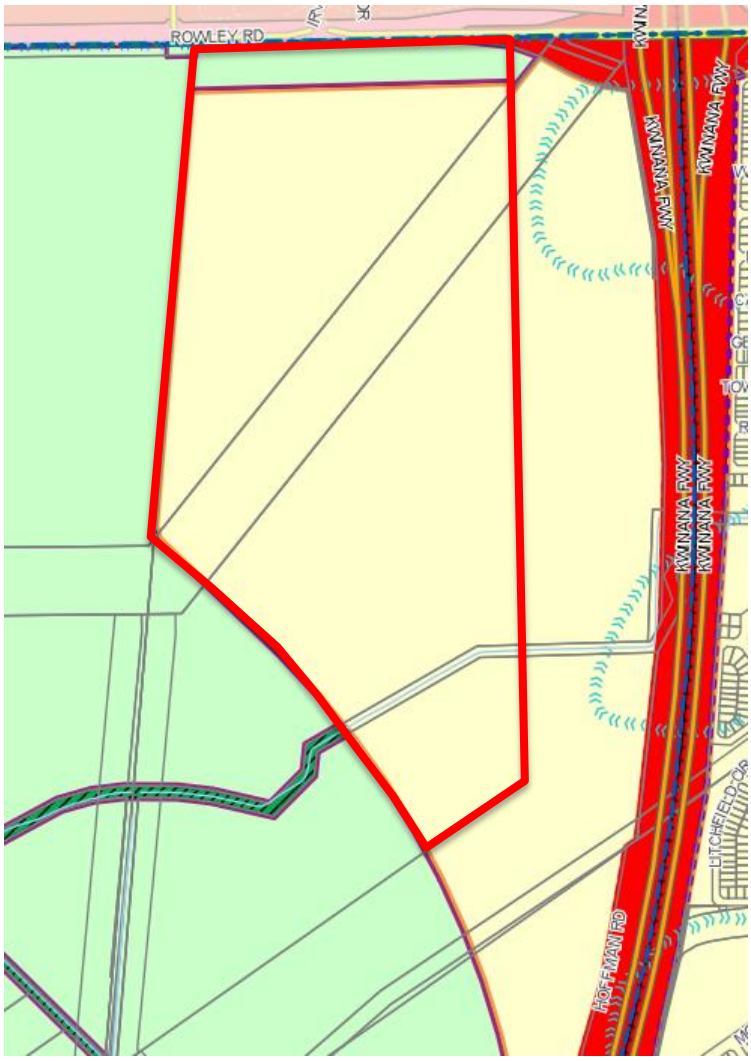


Figure 1 - Site Plan (Intramaps 2017)

The Site is bound by the existing Rowley Road to the north, and undeveloped lots to the west, south and east respectively.

The location of the site will require a coordinated approach to development with neighbouring properties, in particular lots to the south, for the connection of sewer services. The nature of service constraints to the property are outlined in respective sections below.

The north eastern portion of the landholding, outside of the Revised Kwinana Industrial (including Air Quality) Buffer as of 21 September 2010, is zoned "Development" under the City of Kwinana Town Planning Scheme No 2 , and any proposed development within the Site will be controlled through the Scheme and an approved Local Structure Plan. The south-western-most portion of the site falls within the Revised Kwinana Industrial (including Air Quality) Buffer as of 21 September 2010, and is zoned as Urban Deferred under the Metropolitan Region Scheme.

2. SITE DESCRIPTION

The site is approximately 100 ha in area and is located within the City of Kwinana. Historically, where development over the land has occurred, it has consisted of a mixture of rural and agricultural uses. This development is generally located in the south-eastern portions of the Site. Due to the nature of the historical use of the landholdings, the Site has been well cleared in these areas, and little to no remnant vegetation remains. There is a Western Power easement that traverses the Site which has been selectively cleared previously, and some regrowth is present within this corridor. The land immediately north-west of this easement and land abutting the easement to the south-west remains un-cleared, and is characterised by denser vegetation, including trees of medium height and low shrub. A recent aerial photography of the site is presented in Figure 2 below.

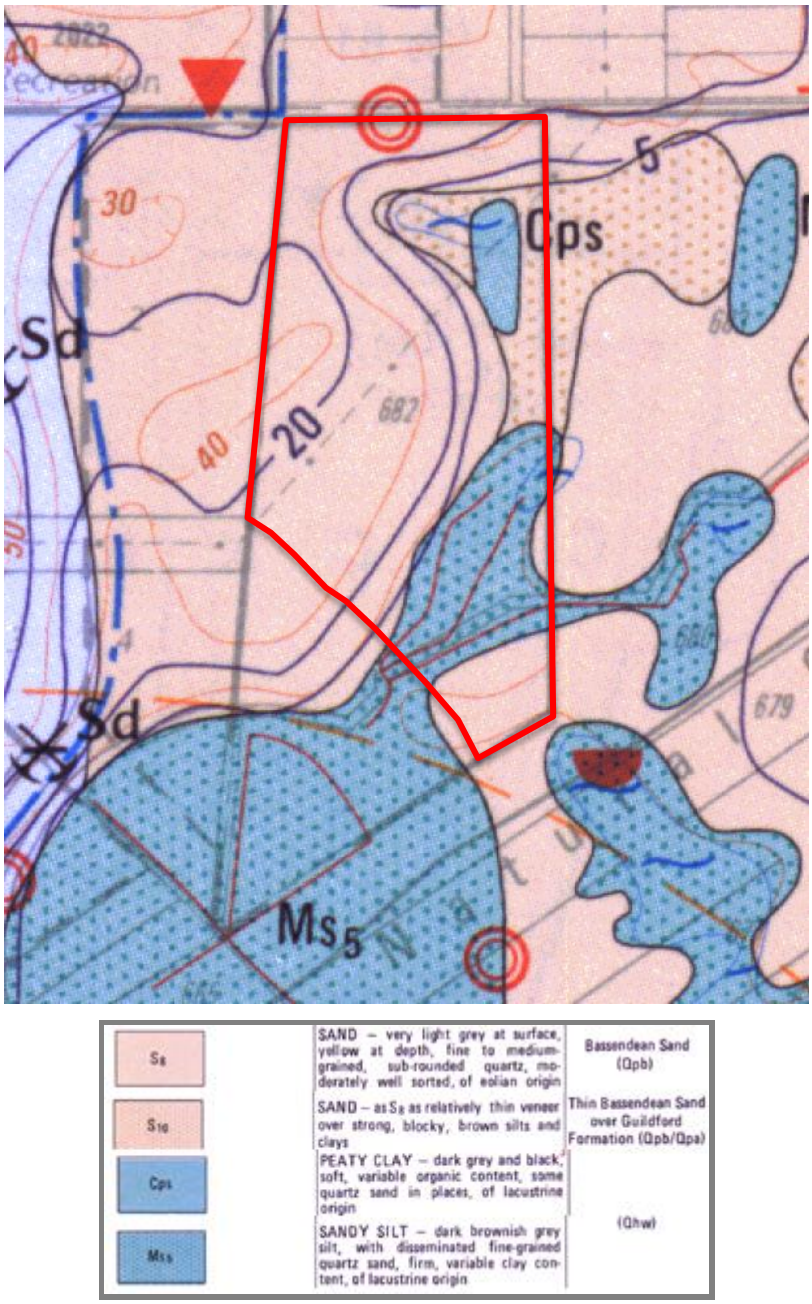


Figure 2 – Aerial Photography (Spookfish 2017)

3. GEOLOGY AND LANDFORM

The Geological Survey of Western Australia Perth Metropolitan Region soils maps for Fremantle (part 2033I & 2033IV) indicates that the majority of the Site is generally characterised by Bassendean Sand and Bassendean Sand overlying Clayey Sand of the Guildford formation (Refer Figure 3 below). These soil types are generally suitable for urbanisation.

Figure 3 below presents the geology across the Site.



S_g	SAND – very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted, of eolian origin	Bassendean Sand (Qpb)
S_{1g}	SAND – as S_g as relatively thin veneer over strong, blocky, brown silts and clays	Thin Bassendean Sand over Guildford Formation (Qpb/Qpa)
Cps	PEATY CLAY – dark grey and black, soft, variable organic content, some quartz sand in places, of lacustrine origin	(Qhw)
M_{s5}	SANDY SILT – dark brownish grey silt, with disseminated fine-grained quartz sand, firm, variable clay content, of lacustrine origin	

Figure 3 - Geotechnical Information (Geological Survey of WA)

A portion of the north east section of the Site is indicated as Peaty Clay formed from swamp deposits. Southern portions of the Site include Sandy Silt formed from Swamp Deposits.

A preliminary site-specific geotechnical investigation has been undertaken across the Site by Galt Geotechnics, and has been included as in Appendix A. The report generally concurs with the soils maps, and outlines preliminary site classifications, and site preparation requirements for urbanisation. The geotechnical report confirms the Site is suitable for urban development and provides advice on the disposal of stormwater runoff and construction requirements. The geotechnical report confirms that the majority of the site will be Class A under the Australian Standard AS2870 – Residential Slabs and Footings code.

Based on aerial contour information obtained from McMullen Nolan Group (MNG), the Site is steeply graded, with levels generally ranging from approximately RL42.0m AHD at the north-western boundary to approximately RL 13.0m AHD at the south-western boundary. There is also a localised natural low point located within the Western Power easement in the north-eastern portion of the Site.

3.1 Groundwater

The Annual Average Maximum Groundwater Levels (AAMGL) vary from approximately RL 12.5m AHD in the south-west to 20.5m AHD in the north-east according to contours provided by the JDA Consultant Hydrologists. Ensuring there is adequate separation to the prevailing ground water levels and consideration of the drainage design will be factors in the determination of the finished earthworks levels in lower areas of the Site. It is likely that imported fill will be required in southern portion of the Site to provide clearance to groundwater in accordance with the district drainage strategies, and to ensure that the Site can be serviced adequately with sewerage and drainage. Further discussion regarding the prevailing groundwater conditions is included in the Local Water Management Strategy prepared by JDA Consultant Hydrologists, which also accompanies this Local Structure Plan.

3.2 Acid Sulphate Soils

A desk top review of the Department of Environment and Conservation's ASS Risk Map for the South Metropolitan Region for potential for acid sulphate soils (ASS) indicates the majority of the Site is classed as having a moderate to low risk ASS potential, however the southern portion of the site and a pocket in the north-east of the site where Sandy Silts and Peaty Clays are present have a high to moderate risk of ASS potential. as presented below in Figure 4.

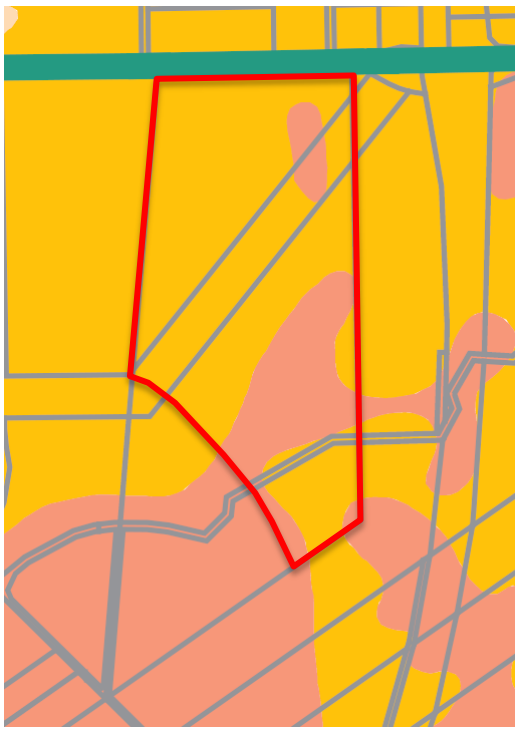


Figure 4 - Acid Sulphate Soils Risk Mapping (DEC)

Based on our experience with similar sites in the area, monitoring and treatment of groundwater effluent during the construction of underground services will be required along with treatment of soils excavated below the groundwater table. The preparation and approval of an Acid Sulphate Soils Management Plan (ASSMP) will be required before development can commence. This process can take from 6 to 9 months, and will be completed as part of the Subdivision Approval process when service depths are known.

3.3 Environmental

A review of the Department of Water's website for information pertaining to Wetlands indicates that there are no Conservation Category Wetlands within or immediately adjacent to the boundaries of the site (excerpt from Department of Water Mapping. This is presented below in Figure 5. Areas within the Site are classified as Multiple Use Wetlands, which does not preclude urban development.

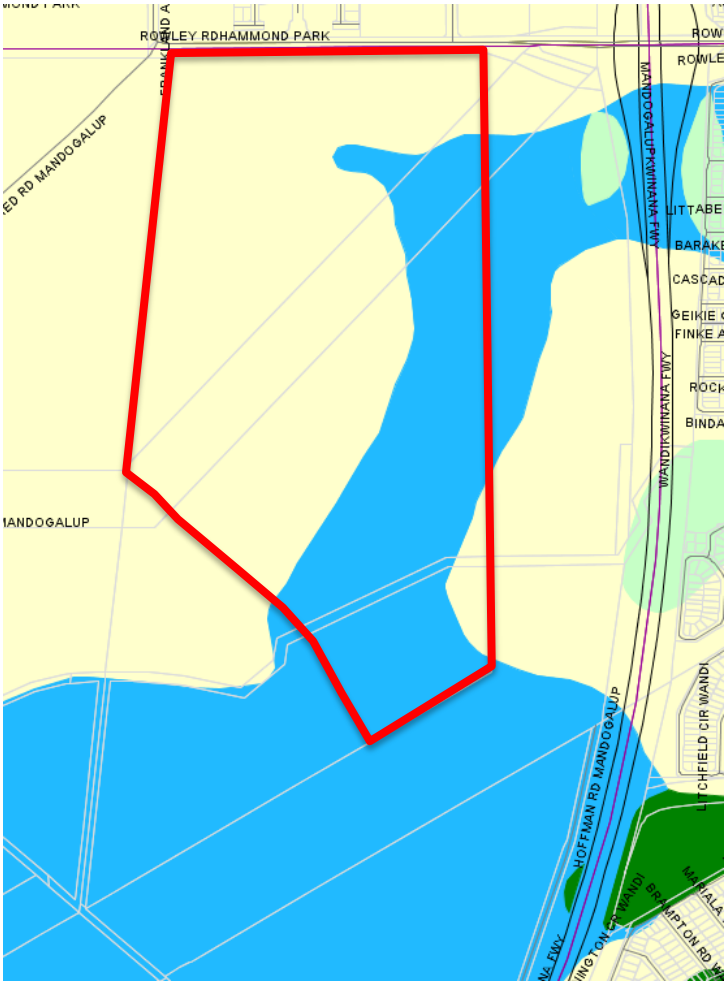


Figure 5 - Wetland Mapping (DoW 2017)

There are no Bush Forever sites located within or on the immediate boundary of the Site.

4. DRAINAGE, EARTHWORKS AND GROUNDWATER MANAGEMENT

The landform through the area is generally steep with good separation from the groundwater table in the northern and north-western portions of the Site. South of the Western Power easement, the land grades become flatter and the groundwater table is much closer to the surface. The Peel Main Drain traverses the southern portion of the Site and grades from the eastern boundary to the west.

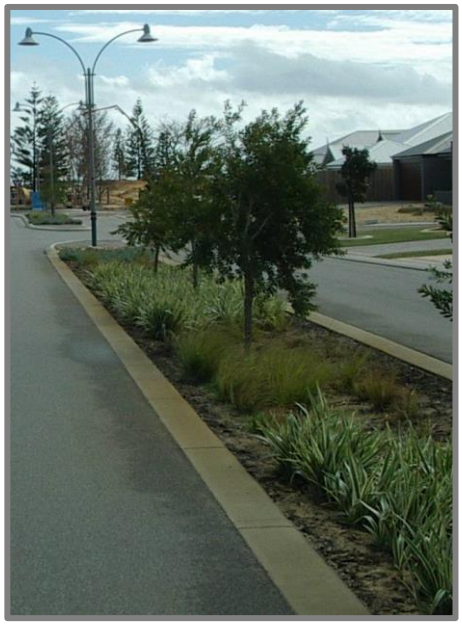
A District Water Management Strategy (DWMS) has been prepared by JDA Consultant Hydrologists as part of the rezoning of the land from rural to urban deferred, and the site falls within the area covered by the DWMS. The DWMS notes that drainage catchment areas within the site fall into the catchment of the Peel Main Drain, as determined in the Jandakot District Water Management Plan (DWMP). The DWMS requires stormwater runoff generated from the proposed development of Lot 682 to be detained and infiltrated on site in POS areas, with compensated flows from larger events to be directed to the Peel Main Drain.

A Local Water Management Strategy (LWMS) for the Structure Plan has been prepared by JDA. The LWMS requires stormwater runoff generated from the proposed development of the Site to be detained and infiltrated on site in POS areas in line with the principles outlined in the DWMS.

A condition of subdivision for the Site will be the preparation and approval of an Urban Water Management Plan (UWMP) prior to the commencement of development.

4.1 Stormwater Management

Groundwater recharge will be maximised through the adoption of 'Best Management Practices' that promote the dispersion and infiltration of runoff as close to source as possible. The LWMS proposes the strategic use of flush kerbing, inter-allotment drainage soakwells to infiltrate runoff from building roofs and private open space areas and the disposal of road runoff into infiltration basins within POS areas.



4.2 Water Quality Management

Recharge water quality will be improved through the adoption of 'Best Management Practices' which promote the disposal of runoff via water pollution control facilities (including vegetated swales and basins, detention storages and gross pollutant traps) and the implementation of non-structural source controls (including urban design, street sweeping, community education, low fertiliser landscaping regimes, etc).

Reference should be made to the LWMS prepared by JDA which supports the Local Structure Plan.

4.3 Stormwater Collection and Disposal

Lot 682 Rowley Road, Mandogalup has varied ground conditions; some areas have free draining soils with adequate separation to ground water, and other areas where peaty clays and sandy silts are nearer the surface, and infiltration of water may be more difficult.

Drainage from public roads and lanes would be collected via conventional gullies or open swales depending on the nature of the adjacent land uses and the extent of traffic and pedestrian activity.

The drainage collection and conveyance system will be designed to cater for the runoff from storms with up to a 1 in 5 year recurrence interval.

A series of interconnected detention basins would be designed to store runoff to the pre-development peak flow rates for the 5, 10 & 100 year ARI events in accordance with the LWMS. In all cases roads and POS would be designed to cater for the surface overflow for more severe storms with building pad levels set at least 300 millimetres above the 1 in 100 year flood level in roadways and 500 millimetres above the 1:100 year flood level for storage detention basins.

The dispersion of stormwater disposal throughout the site will maximise the area of recharge down through the soil profile to the shallow aquifer, thereby maximising the potential for nutrient stripping and water quality improvements. This is proposed to be achieved by locating the detention basins across the Site at strategically located POS areas. It is also proposed that where detention basins are located adjacent natural low points (such as the Western Power easement), that the pre-development flow regime be maintained to these areas. This would be achieved by treatment of the collected stormwater within the basins and bioretention areas within dedicated POS, and allowing flows for larger events (maintained at pre-development levels) to enter the natural low point within the easement.

In areas where infiltration is not possible, the attenuation of runoff in detention basins will minimise flooding in the receiving water bodies downstream. The basins will also assist nutrient removal in conjunction with other measures such as suitable vegetation planting and the use of modified soils with high phosphorous retention capacity.

The Peel Main Drain which traverses the site will also play a role in stormwater collection and disposal. The LWMS proposes that pre-development flow rates from the site continue to be discharged to the drain after detention and treatment in adjacent POS areas.

5. WATER RETICULATION

Based on discussions with the Water Corporation, the Site is located within the current boundary of the Water Corporation's Water Supply Scheme and overall planning for the scheme has made provision for residential development over the subject land.

Current Water Corporation planning indicates that the Site will ultimately be serviced by extension of an existing 610mm distribution main in Hammond Road that currently terminates north of the intersection with Russell Road. This extension is a Water Corporation capital project, and would be extended south as demand requires.

6. SEWERAGE RETICULATION

The Site forms part of the Water Corporation's Thompson's Lake waste water reticulation system and preliminary planning has been undertaken to develop strategies for providing deep sewerage to all proposed urban land within the subject area. This strategy focuses on the development of a number of discreet catchment areas which are served by pump stations.

The Site is proposed to be serviced by connection to a future DN300 reticulation sewer through the Site, discharging to a future Type 180 Waste Water Pumping Station (WWPS) 98-174B located off-site south of the proposed development.

7. POWER

We have liaised with our electrical consultant UPD regarding the existing power infrastructure in the area, and likely servicing of the land in accordance with Western Power requirements.

UPD has advised that the development can be supplied from the existing HV cable located on the northern side of Rowley Road, as illustrated in below in Figure 6.



Figure 6 - HV Infrastructure and Network Capacity (Western Power 2017)

There is an existing HV line located in the southern portion of the site that will have to be removed when development occurs.

The existing 132kV and 330kV overhead transmission lines shown within the subject area in Figure 6 are located within an existing easement, and will remain in their current location when development occurs. The LWMS proposes that a portion of the easement area in the north eastern area of the site be utilised for drainage purposes. The area nominated within the easement is a natural low area, and the LWMS proposes that the area continue to receive treated pre-development stormwater flows in larger events.

All power to the proposed development will be underground and fed from transformers located strategically within the Site.

8. GAS SUPPLY

ATCO Gas have advised that the project area can be supplied with reticulated gas by connecting into the existing 110 PE High Pressure main which has been extended south of Rowley Road from the development to the North.

9. TELECOMMUNICATIONS

As per the New Developments Policy announced by the Minister for Communications & the Digital Economy on 9 December 2010, new developments with 100 premises or more will be prioritised by NBN Co to have optic fibre infrastructure installed.

NBN Co has advised that the subject area is immediately adjacent to NBN Co's fibre footprint, with services available immediately north of Rowley Road.

Under the current scheme, the developer is required to enter into an agreement with NBN Co to provide design and pit and pipe infrastructure which is handed over free of charge to NBN upon completion. NBN Co will cover the cost of fibre deployment and any off-site extensions required to service the development within 1000m of the Site.

10. ROADWORKS & FOOTPATHS

The Site will be accessed via Rowley Road to the north of the development.

Rowley Road is classified as a District Distributor A Road. This road is currently constructed as a single carriageway rural style road and will ultimately be upgraded to a 4 lane divided dual carriageway. Allowance for the ultimate road reserve width required for this upgrade has been made under the Western Australian Planning Commission's (WAPC) Planning Control Area (PCA) No 112. Rowley Road will form the main access into and out of the development.

The Transport Assessment prepared by Transcore for the Local Structure Plan indicates that the roundabout recently constructed on Rowley Road can adequately provide interim access to the proposed development to the south. An internal road is proposed to connect to the existing Rowley Road roundabout which would provide a link to connect the main East-West Neighbourhood Connector A road within the Local Structure Plan. The Transport Assessment indicates that when the future Hammond Road extension occurs between Rowley Road and Anketell Road to the west of the development the interim access to Rowley Road from the development will be downgraded to left-in/left-out only.

All internal roadworks will be designed and constructed in accordance with the requirements and standards of the COK. Roadworks will generally consist of kerbed and asphalted pavements. Minimum recommended carriageway widths will be determined in accordance with Liveable Neighbourhoods and the COK requirements. The main north-south connector road shown on the Structure Plan has been designated as a Neighbourhood Connector A based on projected traffic volumes. In all cases the road cross-sections will be designed to cater for utility services, street trees and parking embayments on standard verge alignments.

As documented in the Jandakot Drainage and Water Management Plan (DWMP) residential streets will be designed to be serviceable up to the 5-year ARI flood event with major arterial roads trafficable in the 100-year ARI event.

11. CONCLUSION

Lot 682 Rowley Road, Mandogalup has planned strategies for water supply, sewerage and other public utility services are available or can be extended to service the proposed urban area readily. Co-ordination and co-operation with adjoining landowners will be required to extend these services to the Site, and to provide access from Rowley Road.

APPENDICES

APPENDIX A - Preliminary Geotechnical Report

Report on

PRELIMINARY GEOTECHNICAL STUDY
PROPOSED RESIDENTIAL SUBDIVISION
LOT 682 ROWLEY ROAD
MANDOGALUP

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APPENDIX G: UNDERSTANDING YOUR GEOTECHNICAL ENGINEERING REPORT

1. INTRODUCTION

This report presents the outcomes of the preliminary geotechnical study for the proposed residential subdivision at Lot 682 Rowley Road, Mandogalup ("the site"). The location of the site relative to the surrounding area is shown on Figure 1, Site and Location Plan.

The investigation was requested by Brad Marshall of Cossill & Webley and authorised by Nathan James of Qube Property Group in an email dated 2 April 2014.

2. SITE DESCRIPTION AND PROPOSED DEVELOPMENT

Based on the supplied information, the site is roughly trapezoidal in plan and covers approximately 85.3 ha. It is bounded by Rowley Road to the north and bushland and cultivated land on the other sides. The Kwinana Freeway is about 200 m east of the site.

From the provided contour plans, the surface elevation ranges from about RL 13 m AHD at the southern boundary, rising to about RL 30 m AHD towards the northern part. There are low hills over the western and northwest part with elevations of up to RL 40 m AHD.

Historical aerial photographs indicate that the southern part of the site was under cultivation prior to 1953. By about 2000, the southern 1/3 of the site was under cultivation, with little change up to the present time. A Western Power easement crosses the site diagonally, from the middle of the western boundary to the northeast corner. There is dense bushland on either side of this easement. The "Peel Main Drain" crosses the southern part of the site.

We understand that the lot is to be sub-divided into residential lots with associated roads and public open space (POS). A primary school is planned (possibly in the southern or eastern parts of the site).

According to the provided preliminary earthworks strategy (July 2011), bulk earthworks will comprise fill up to about 4 m over the lower-lying area (southern and eastern parts of the site) and cut of up to about 7 m over the western parts of the site.

3. PROJECT OBJECTIVES

The specified objectives of this preliminary study were to:

- assess subsurface soil and groundwater conditions across the site, in particular:
  - the thickness of topsoil across the site;
  - assess the depth and extents of peaty clay within the north-eastern portion of the site;
  - assess the depth and extents of sandy silt within the southern portion of the site;
  - assess the extent of previously disturbed areas and identification of any loose sand zones or uncontrolled fill
- provide preliminary site classification(s) in accordance with AS 2870-2011 "Residential Slabs and Footings" and advise on measures required to improve the site classification and/or remediate zones of uncontrolled fill, loose/soft soils etc. (if necessary);
- provide recommendations and geotechnical design parameters for earth retaining structures;
- advise on safe temporary and permanent batter slopes for in-situ soils;
- recommend appropriate site preparation procedures including compaction criteria, including
  - suitability of soils for re-use as fill;

- comment on the suitability of the use of topsoil in blending with clean sand, including a recommended blending ratio and proposed construction technique for achieving a blended material suitable for use as structural fill;
- comment and make recommendations regarding the suitability of blending sandy silt for use in general fill areas, including blending ratio and techniques;
- comment on excavatability;
- comment on the suitability of soils where subsoil drainage may be required (e.g. southern portion of the site)

- assess the permeability of the soils at the site for potential on-site disposal of stormwater by infiltration; and
- provide a preliminary subgrade California bearing ratio (CBR) value for pavement thickness design by others.

4. FIELDWORK

Fieldwork was carried out on 9 to 11 April 2014 and comprised:

- excavation of 60 test pits (TP01 to TP60) (approximately one test pit per 1.5 ha), extending to depths of between 1.5 m and 2.5 m;
- testing with a dynamic cone penetrometer (DCP) adjacent to each test pit, extending to a depth of 1.0 m in each instance;
- drilling of hand auger boreholes at 5 locations (P01 to P05), extending to depths of between 1.0 m and 1.5 m; and
- infiltration tests using the 'inverse auger hole' technique in the hand augered boreholes, at a depth of between 0.41 m to 0.57 m below ground.

General

A geotechnical engineer from Galt located the test positions, observed the test pitting, drilled the hand auger boreholes, logged the materials encountered in the test pits and boreholes, collected samples for inspection and possible laboratory testing, and performed the infiltration testing and penetrometer testing.

The test locations are shown on Figure 1, Site and Location Plan and details are summarised in Table A1, Summary of Tests at the end of text. Photographs of the site are presented in Appendix A, Site Photographs.

Test Pits

Test pits were excavated using a Komatsu 97R 9 tonne tractor mounted backhoe fitted with a 600 mm wide toothed bucket. The excavator was supplied and operated by Erskine Backhoe Low Loader Hire.

Test pit reports are presented in Appendix B, Test Pit Reports, along with the method of soil description and cementation classification, and a list of explanatory notes and abbreviations used on the reports. Photographs of the test pit excavation are included with the test pit reports.

Boreholes

Borehole reports are included in Appendix C, Summary Hand Auger Borehole Reports, along with the method of soil description used on the reports.

Dynamic Cone Penetrometer Testing

DCP tests were carried out adjacent to each test pit. Results of the DCP testing are presented in Appendix D, Dynamic Cone Penetrometer Test Results. The tests were conducted in accordance with test method AS 1289 6.3.2.

Permeability Testing

The permeability testing was undertaken using the inverse auger hole method described by Cocks[1]. The results of the permeability testing are presented in Appendix E, Permeability Test Results, and the results are summarised in Table 1: Summary of Permeability Test Results.

Table 1: Summary of Permeability Test Results

Test No.	Soil Description	Test Depth (m)	Minimum Unsaturated Permeability, k (m/day)		
			Test 1	Test 2	Test 3
P01	SAND	0.55	10.2	8.6	4.7
P02	SAND	0.54	8.5	4.2	3.9
P03	SAND	0.51	8.0	6.7	6.4
P04	Peaty SAND	0.41	0.6	0.3	0.2
P05	SAND	0.57	29.8	32.8	25.9

Note: The minimum unsaturated permeabilities shown are typically recorded towards the end of the test, with pressure head varying between about 0.16 m and 0.39 m.

5. LABORATORY TESTING

Laboratory testing on soil samples was undertaken by Mining & Civil Geotest in their NATA accredited laboratory and comprised determination of:

- particle size distribution on 4 samples;
- Atterberg limits and linear shrinkage on 4 samples;
- dry density-moisture content relationship using Modified compactive effort on 2 samples; and
- soaked California bearing ratio (CBR) on 2 remoulded samples.

Laboratory test results along with the test methods followed are included in Appendix F, Laboratory Test Results and are summarised in Table 2, Summary of Laboratory Test Results.

Table 2: Summary of Laboratory Test Results

Test Pit	Depth (m)	% Gravel	% Sand	% Fines	LL (%)	PI (%)	LS (%)	MMDD (t/m^3)	OMC (%)	CBR @ 95%
TP16	0.5 – 0.7	0	25	75	100	24	7.0	-	-	-
TP16	1.5 – 1.7	0	17	83	82	56	13.5	-	-	-
TP41	0.2 – 0.5	0	98	2	NO	NP	0.0	1.73	14.5	11
TP46	0.6 – 0.9	0	73	27	50	30	10.5	1.965	8.5	5

LL: Liquid Limit PI: Plasticity Index LS: Linear Shrinkage
MC: Moisture Content MMDD: Maximum Dry Density (using modified compaction energy)
OMC: Optimum Moisture Content NO: Not Obtainable NP: Non-Plastic
CBR @ 95%: California bearing ratio (soaked) of samples remoulded to a dry density ratio of 95% MMDD, 4.5 kg surcharge

[1] Cocks, G (2007), "Disposal of Stormwater Runoff by Soakage in Perth Western Australia", Journal and News of the Australian Geomechanics Society, Volume 42 No. 3, pp 101-114

6. SITE CONDITIONS

6.1 Geology

The Fremantle sheet of the 1:50,000 scale Environmental Geology series map indicates that the area is underlain by:

- Bassendean Sand over the northwestern part, described as "*very light grey at surface, yellow at depth, fine to medium-grained, moderately sorted, subangular to subrounded, minor heavy minerals, of eolian origin*";
- Lacustrine Deposits over the lower-lying southern and eastern parts of the site, described as "*Sandy Silt – dark brownish grey silt, with disseminated fine-grained quartz sand, firm, variable clay content; and*
- Peaty lacustrine deposits over the north-east part, described as "*Peaty Clay - dark grey and black, soft, variable organic content, some quartz sand in places".*

The findings of our investigation are generally in accordance with the geological mapping. However, the lacustrine deposits found towards the southern end of the site are clayey rather than silty.

6.2 Sub-surface Conditions

Geotechnically, the site can be very broadly separated into two areas. The typical soil profiles for the two areas generally comprise:

Majority of the Site

- SAND (SP), fine to coarse grained, sub-angular to sub-rounded, generally grey becoming pale yellow/white with depth, trace non-plastic fines in top 100 to 200 mm, trace rootlets/roots (up to 90 mm in diameter) in top 2.0 m, generally dry, generally very loose to medium dense, present from the surface extending to the maximum depth of investigation 2.5 m.

Southwest Corner of the Site (TP16, TP29, TP30, TP31)

- Silty SAND/SAND (SM/SP), fine to coarse grained, sub-angular to sub-rounded, grey, trace non-plastic fines in top 100 to 200 mm, generally 5-20% non-plastic fines, locally trace non-plastic fines , dry to moist, generally loose to dense, locally very dense, present from the surface extending to depths of between 0.3 m to 0.6 m; overlying
- CLAY (CI), low to medium plasticity, pale grey becoming brown, trace rootlets, with some fine grained sand, generally firm to stiff, locally hard, dry to moist, extending to the maximum depth of investigation of 2.5 m.

Notes:

1. The test pit reports should be referred to for more detail on the subsurface conditions at each test location.
2. Peaty sand was encountered within one of the hand auger boreholes (P04). This was located within the Western Power easement.
3. Clayey sand was encountered below the sand within one test pit (TP13) towards the north of the site at a depth of 1.8 m.
4. Clayey sand was encountered above the sand at two locations (TP46 and TP47) towards the middle of the site.
5. Some localised areas with increased non-plastic fines (~5-20%) in the top 0.5 m are present within the market garden areas of the site.
6. Locally iron-cemented sandy soil (often termed "coffee rock") was encountered within two of the test pits (TP31 and TP 43) towards the south of the site.
7. Those test pits that did not reach target depth were terminated due to either refusal on the iron-cemented sand ("coffee rock") or due to collapse of the test pit walls.

6.3 Groundwater

According to the Department of Water database, the maximum historical groundwater elevation varies from RL 13 m AHD over the southern part to about RL 22 m AHD towards the northern part of the site. This is between 1 m and 8 m below the current surface elevation. These elevations are similar to those indicated in the Jim Davies and Associates (JDA) Mandogalup District Water Management Strategy (report reference J4931f dated 27 September 2011) provided to us.

Figure 2 shows the historical groundwater elevations across the site.

Groundwater was encountered within 7 of the test pits (TP13, TP43, TP46, TP47, TP48, TP49 and TP56) and 1 hand auger borehole (P04) at depths of between 1.0 m and 1.8 m. These locations were generally in lower lying areas of the site. In one case (TP13), this water was likely perched water on top of a clayey layer.

7. GEOTECHNICAL ASSESSMENT

7.1 Preliminary Site Classification

The preliminary site classification is based on AS 2870-2011 "Residential Slabs and Footings" which defines the site classes as such in Table 3.

Table 3: Summary of Site Classifications (AS 2870-2011)

Class	Description	Characteristic Surface Movement (y_s)
A	Most sand and rock site with little or no ground movement from moisture change	Not Defined (typically <5 mm)
S	Slightly reactive clay sites with only slight ground movement from moisture changes	0 – 20 mm
M	Moderately reactive clay sites, which may experience moderate ground movements from moisture change	20 – 40 mm
H1	Highly reactive sites, which may experience high ground movements from moisture change	40 – 60 mm
H2	Highly reactive sites, which may experience very high ground movements from moisture change	60 – 75 mm
E	Extremely reactive sites, which may experience extreme ground movements from moisture change	>75 mm
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise	Not Defined

We consider that the preliminary site classifications shown in Figure 2, Site Classifications, are appropriate for the site, provided site preparation measures outlined in Section 7.2 are followed. Site classifications considered appropriate are:

- "Class A" for the majority of the site;
- "Class S" for a localised area within the market garden areas; and
- "Class M" for the low-lying clayey areas towards the southwest of the site.

Note: In its current state, most of the site would be classified as Class P due to the presence of very loose and loose sand to depths of over 1 m. In addition, we note that the historical groundwater elevation over the southern part of the site is close to ground surface.

Improvement of the entire site to "Class A" is possible with importation and placement of sand fill to produce a total thickness of about 1.8 m (in-situ sand and inert fill) overlying clayey material (except peaty areas discussed below).

We consider that a preliminary site classification of "Class P" is appropriate for part of the Western Power easement due to the presence of Peaty SAND. Excavation and removal of the Peaty SAND material will improve this area to a "Class A" or "Class S" (depending on the thickness of the underlying sand layer).

7.2 Site Preparation

The site preparation measures outlined below are aimed at improvement of the site in preparation for construction of the structures including on-ground slabs, shallow footings, retaining walls and pavements.

- Demolish and remove all infrastructure associated with farming activities.
- Strip vegetation from the site including grubbing out of tree roots.
- Strip and stockpile topsoil from the site for potential re-use in non-structural applications or for possible blending with clean sand (generally only a thin layer of topsoil was noted at the time of our investigation over a majority of the site). Topsoil strip is only necessary to remove roots. We recommend a 100 mm topsoil strip or as otherwise necessary to remove all roots from the soil. Topsoil may be retained for screening and re-use as structural fill (refer to Section 7.7).
- Compact ground surface to achieve the level of compaction specified in Section 7.5 to a minimum depth of 0.9 m below surface. **Note:** Where there is more than 1 m of bulk fill to be placed over the in-situ sand, the depth of compaction can be reduced to 0.45 m.
- Where fill is required to raise site surface levels, approved fill must be used (refer to Section 7.6), placed and compacted in layers of no greater than 300 mm loose thickness.

Note: Where soakwells are to be used for stormwater disposal, surface levels must be raised to at least 1.2 m above the historical maximum groundwater elevation.

The above are only preliminary site preparation procedures based on limited geotechnical information. The final site procedures are also likely to depend to a large extent on the actual development. Additional geotechnical and groundwater studies will enable a better appreciation of the nature and extent of the clayey and peaty soils present across the site. This information will enable more definitive site procedures to be provided.

7.3 Retaining Structures

Retaining structures must be designed in accordance with AS 4678-2002 "Earth-Retaining Structures". We recommend that all retaining walls at the site be backfilled with free-draining fill, e.g. sand (either site-derived or imported free draining sand fill with less than 5% fines).

For the design of retaining structures, the following parameters are considered appropriate for *in situ* medium dense sand and compacted sand backfill:

- angle of internal friction, $\phi = 36°$;
- coefficient of active earth pressure $K_a = 0.26$;
- coefficient of passive earth pressure $K_p = 3.85$;
- at rest coefficient of earth pressure $K_0 = 0.41$;
- bulk density: 18 kN/m^3; and

Compaction plant can augment the lateral earth pressure acting on retaining walls. Hand operated compaction equipment is recommended within 2 m of any retaining walls to minimise compaction pressures.

It is important to note that some ground movement is to be expected behind any soil retaining system, including gravity retaining walls.

7.4 Excavations

Based on the soil profile encountered, we expect that excavations on site will be readily achievable using conventional earthmoving equipment (i.e. with a 10 tonne or larger excavator).

Excavations in sand are prone to instability particularly below the water table. Above the water table, we recommend batter angles no steeper than 1V:2H for temporary slopes and 1V:3H for permanent slopes where no external restraint is provided to the slope. Even at these slope angles, rilling and erosion of the slope may occur. Where steeper slopes are required, temporary or permanent slope retention must be employed.

Below groundwater, either temporary dewatering or shoring will be required. We can advise further on this if required.

Temporary slopes up to 1V:1.5H can be considered where:

- No surcharge (machinery, stockpiles, etc) is present at the crest of the slope.
- The maximum slope height is 2 m.
- The slope is thoroughly dewatered to at least 1 m below the toe of the slope.

A geotechnical engineer must be consulted where there is any doubt regarding the stability or safety of unsupported excavations.

7.5 Compaction

Approved granular fill must be compacted using suitable compaction equipment to achieve a dry density ratio of at least 95% of maximum modified dry density (MMDD) as determined in accordance with AS 1289 5.2.1.

If sand is used as fill, a Perth sand penetrometer (PSP) may be used for compaction control. We consider a minimum blow count of 8 blows per 0.3 m penetration to correspond to 95% MMDD. If difficulty arises in achieving the specified PSP blow counts, then a calibration must be established between PSP blow count and the *in situ* density. This will allow confirmation of the blow count required to achieve the required density ratio.

Over-excavation and replacement of loose materials must be carried out where the minimum density cannot be achieved.

Fill must be placed in horizontal layers of not greater than 0.3 m loose thickness. Each layer must be compacted by suitable compaction equipment, and carefully controlled to ensure even compaction over the full area and depth of each layer.

TESTING

After compaction, verify that the required level of compaction has been achieved by testing within any fill and to a minimum depth of 0.9 m below foundations.

- on each lift of fill at the rate of 1 test per 500 m^3;
- at each spread footing location (unless footings are in clayey soil);
- at 7.5 m centres below on-ground slabs;
- at 15 m centres along retaining wall footings (where present);
- at 15 m centres in backfill behind retaining walls; and

- at 10 m centres on pavement subgrades (on the road centreline or on a grid below car parks/hardstanding).

7.6 Approved Fill

Imported granular fill must comply with the material requirements as stated in AS 3798-2007, "Guidelines on Earthworks for Commercial and Residential Developments". Sand fill must comprise clean sand that is free of organic matter and have a fines content of less than 5%.

The *in situ* sand present at the site is geotechnically suitable for re-use as inert structural fill. Any organic-rich sand or sand containing significant proportions of fines (material less than 0.075 mm in size) must not be used as structural fill. Topsoil may be re-used as structural fill when appropriately screened and blended as discussed in Section 7.7.

Where doubt exists, a geotechnical engineer must be engaged to inspect and approve the use of potential fill materials.

7.7 Re-use of Topsoil

Stripped topsoil may be re-used as structural fill providing the following steps are taken:

- Topsoil material is screened to remove all deleterious material (i.e. grass, roots, construction rubbish etc.). The use of a 50 mm or finer screen should ensure that a majority of the root matter is removed. After the material has been screened, samples should be taken for fines and organic testing of the material;
- Any topsoil or stockpile material with an organic content greater than 5% or fines content greater than 10% must be set aside for re-use in non-structural applications;
- Screened material should be blended at a nominal ratio of 1:2 or greater (topsoil : clean fill). The ratio of topsoil to clean fill depends on the organic content of the blended material (must be less than 2%) and permeability requirements. Trial pads should be formed with materials of different blend ratio to assess the permeability prior to employing topsoil blending on a large scale;
- Quality control testing (fines content and organic content testing) of the blended material should be undertaken to ensure its suitability for re-use as structural fill.

It is noted that localised topsoil in the lower-lying market garden areas of the site (encountered in TP16, TP17, TP29 to TP30, TP43, TP46 and TP47) was visually assessed to have organic contents greater than 5% or fines content greater than 12% and is not considered suitable for topsoil blending. This material should be stockpiled for use in non-structural applications or removed from the site. It is identifiable by its brown colour in contrast to generally grey topsoil in other parts of the site.

7.8 Stormwater Disposal and Site Drainage

We consider that the natural sandy soils at the site will be suitable for on-site disposal of stormwater by the use of soak wells or soakage basins. This is applicable only where the ground surface is at least 1.2 m above the maximum groundwater level. A preliminary permeability of no greater than 4 m/day can be used for design of soakage systems.

The permeability of any stormwater disposal system may be expected to decrease over time due to compaction of sands during site preparation and clogging of the pore spaces by fines deposited during the life of the stormwater disposal system.

In-situ permeability tests must be done on the completed bulk fill to confirm the design permeability.

Where possible, soak wells should not be placed within 3 m of footings (subject to local council regulations). Discharge from soakwells has been known to cause densification of loose sandy soils, leading to settlements of

footings and slabs. Where soakwells are placed closer to footings, they must be carefully wrapped with geotextile to prevent migration of sand and fines into the soakwell.

Subsoil Drainage

We understand that significant fill is to be placed during bulk earthworks (up to about 4 m over the lower-lying areas southern and eastern parts of the site). We do not consider that subsoil drainage will be required, provided at least 1.2 m of clean draining sand fill is present overlying the clayey material and above the maximum historic groundwater table.

Additionally, we do not consider the north east portion of the Western Power easement to be a suitable location for site drainage due to the presence of shallow peaty sand unless this material is removed.

7.9 Pavement Design

Where adequate site preparation measures have been completed (i.e. pavement subgrades comprise compacted *in situ* sand or sand backfill), pavement thickness design may be undertaken assuming a subgrade California bearing ratio, CBR=10%.

We do not consider the clayey material present on-site to be suitable for use as pavement subgrades, unless it can be kept dry, as we would expect a CBR value of 3% to 5% when the material becomes saturated.

8. CLOSURE

We draw your attention to Appendix G of this report, Understanding Your Geotechnical Engineering Report. The information provided within is intended to inform you as to what your realistic expectations of this report should be. Guidance is also provided on how to minimise risks associated with groundworks for this project. This information is provided not to reduce the level of responsibility accepted by Galt, but to ensure that all parties who rely on this report are aware of the responsibilities each assumes in so doing.

GALT GEOTECHNICS PTY LTD





Rick Piovesan CPEng

Geotechnical Engineer

James Harris

Geotechnical Engineer

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Tables

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ABN: 73 292 586 155

Table A1: Summary of Tests

Test Names	Test Depth (m)	Depth to Groundwater (m)	Reason for Termination	Stratigraphy
TP01	2.5	GNE[1]	Target Depth	SAND
TP02	2.5	GNE	Target Depth	SAND
TP03	2.5	GNE	Target Depth	SAND
TP04	2.5	GNE	Target Depth	SAND
TP05	2	GNE	Collapse	SAND
TP06	2	GNE	Collapse	SAND
TP07	2.5	GNE	Target Depth	SAND
TP08	2	GNE	Collapse	SAND
TP09	2.5	GNE	Target Depth	SAND
TP10	2	GNE	Collapse	SAND
TP11	2.5	GNE	Target Depth	SAND
TP12	2.5	GNE	Target Depth	SAND
TP13	2.5	1.8	Target Depth	SAND overlying Clayey SAND
TP14	1.8	GNE	Collapse	SAND
TP15	2	GNE	Collapse	SAND
TP16	2.5	GNE	Target Depth	Silty SAND overlying CLAY
TP17	2.5	GNE	Target Depth	Silty SAND/SAND overlying CLAY
TP18	2	GNE	Collapse	SAND
TP19	2	GNE	Collapse	SAND
TP20	2.5	GNE	Target Depth	SAND
TP21	2	GNE	Collapse	SAND
TP22	2.5	GNE	Target Depth	SAND
TP23	2.5	GNE	Target Depth	SAND
TP24	2.5	GNE	Target Depth	SAND
TP25	2	GNE	Collapse	SAND
TP26	2.5	GNE	Target Depth	SAND
TP27	2.5	GNE	Target Depth	SAND
TP28	2.5	GNE	Target Depth	SAND
TP29	2.5	GNE	Target Depth	Silty SAND overlying CLAY
TP30	2.5	GNE	Target Depth	SAND
TP31	2.2	GNE	Refusal	Silty SAND overlying CLAY overlying Cemented SAND
TP32	2.2	GNE	Collapse	Silty SAND overlying SAND
TP33	2	GNE	Collapse	SAND
TP34	2.1	GNE	Collapse	SAND
TP35	2.2	GNE	Collapse	SAND
TP36	2	GNE	Collapse	SAND

Test Names	Test Depth (m)	Depth to Groundwater (m)	Reason for Termination	Stratigraphy
TP37	2.1	GNE	Collapse	SAND
TP38	2	GNE	Collapse	SAND
TP39	1.9	GNE	Collapse	SAND
TP40	2.5	GNE	Target Depth	SAND
TP41	2	GNE	Collapse	SAND
TP42	2.5	GNE	Target Depth	SAND
TP43	2.2	1.5	Refusal	Silty SAND overlying SAND overlying Cemented SAND
TP44	2.5	GNE	Target Depth	SAND
TP45	2.5	GNE	Target Depth	FILL: Gravelly SAND overlying SAND
TP46	2.5	2.3	Target Depth	Clayey SAND overlying SAND
TP47	2.5	1.5	Target Depth	Clayey SAND overlying SAND
TP48	2.5	1.2	Target Depth	SAND
TP49	2.5	1.0	Target Depth	SAND
TP50	2.5	GNE	Target Depth	SAND
TP51	2.5	GNE	Target Depth	SAND
TP52	2.5	GNE	Target Depth	SAND
TP53	2.3	GNE	Collapse	SAND
TP54	2.5	GNE	Target Depth	SAND
TP55	1.9	GNE	Collapse	SAND
TP56	2.5	1.8	Target Depth	SAND
TP57	2.5	GNE	Target Depth	SAND
TP58	2.3	GNE	Collapse	SAND
TP59	2.5	GNE	Target Depth	SAND
TP60	2.5	GNE	Target Depth	SAND
P01	1	GNE	Target Depth	SAND
P02	1	GNE	Target Depth	SAND
P03	1	GNE	Target Depth	SAND
P04	1.5	1.05	Target Depth	Peaty SAND
P05	1	GNE	Target Depth	SAND

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Figures

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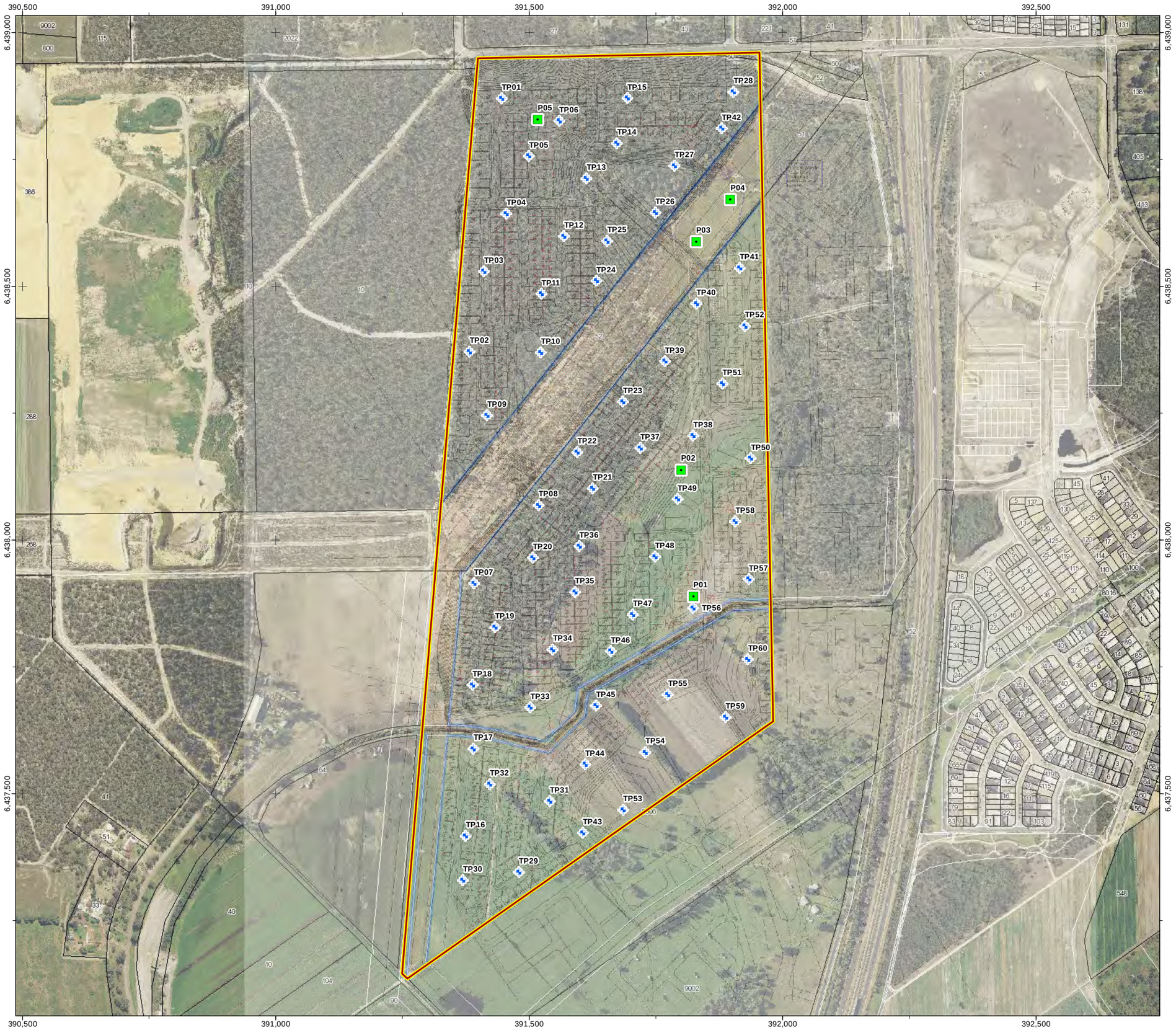




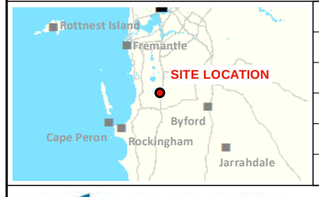
Legend

- Site Boundary
- EASEMENT
- Permeability Test
- Test Pit

N

0 120 240 360 480 600

Meters



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DATE DRAWN	29/04/2014	
CHECKED	RP	
DATE CHECKED	29/04/2014	
PROJECTION	GDA 1994 MGA Zone 50	

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CLIENT	**QUBE PROPERTY GROUP**
PROJECT	PROPOSED RESIDENTIAL SUBDIVISION
LOCATION	LOT 682 ROWLEY ROAD MANDOGALUP
TITLE	SITE & LOCATION PLAN

Job No	Fig No	Rev
J1401062	FIGURE 1	**A**

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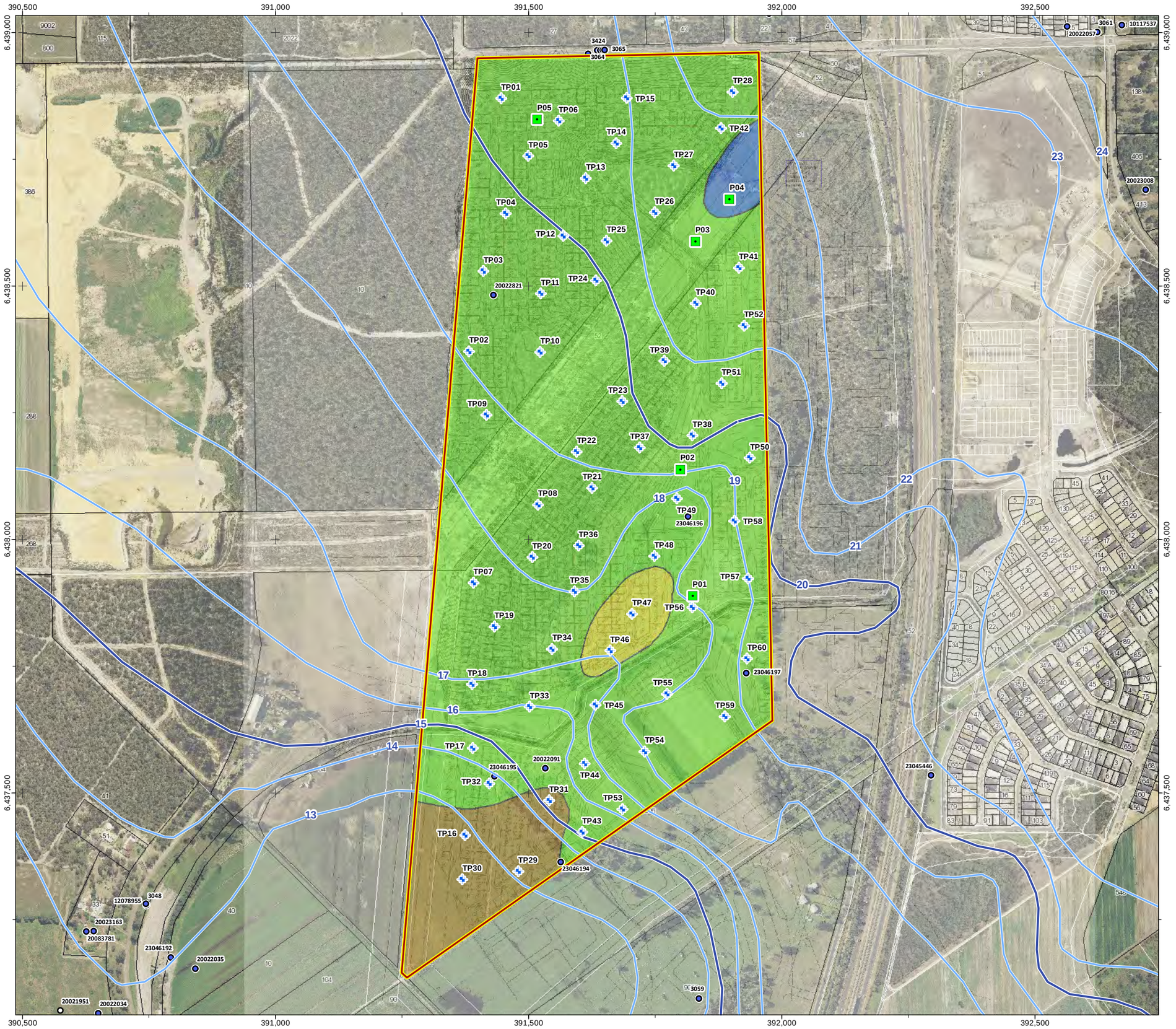

Legend

Site Boundary

SITE CLASSIFICATION

- CLASS 'A' *
- CLASS 'M'
- CLASS 'P'
- CLASS'S'

* subject to compaction of thick loose in-situ sand layer

- Permeability Test
- Test Pit

Historical maximum groundwater elevations (mAHD) (Perth Groundwater Atlas (1997))

- 5
- 1

WINSITES

- Ground, Borehole or Well
- Other

N

0 120 240 360 480 600

Meters

SCALE	1:7,500	(A3)
DRAWN	DAC	
DATE DRAWN	5/05/2014	
CHECKED	RP	
DATE CHECKED	29/04/2014	
PROJECTION	GDA 1994 MGA Zone 50	

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CLIENT	**QUBE PROPERTY GROUP**
PROJECT	PROPOSED RESIDENTIAL SUBDIVISION
LOCATION	LOT 682 ROWLEY ROAD MANDOGALUP
TITLE	SITE CLASSIFICATION
Job No	J1401062
Fig No	FIGURE 2
Rev	A

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Appendix A: Site Photographs

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Photograph 1: Dense vegetation present towards the north of the site



Photograph 2: Test pit excavation at TP45 location



Photograph 3: Looking northwest across market garden area of site from TP59



Photograph 4: Looking north from TP40

Appendix B: Test Pit Reports

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EXPLANATORY NOTES TO BE READ WITH BOREHOLE AND TEST PIT REPORTS

METHOD OF DRILLING OR EXCAVATION

AC	Air Core	E	Excavator	PQ3	PQ3 Core Barrel
AD/T	Auger Drilling with TC-Bit	EH	Excavator with Hammer	PT	Push Tube
AD/V	Auger Drilling with V-Bit	HA	Hand Auger	R	Ripper
AT	Air Track	HMLC	HMLC Core Barrel	RR	Rock Roller
B	Bulldozer Blade	HQ3	HQ3 Core Barrel	SON	Sonic Rig
BH	Backhoe Bucket	N	Natural Exposure	SPT	Driven SPT
CT	Cable Tool	NMLC	NMLC Core Barrel	WB	Washbore
DT	Diatube	PP	Push Probe	X	Existing Excavation

SUPPORT

T	Timbering

PENETRATION EFFORT (RELATIVE TO THE EQUIPMENT USED)

VE	Very Easy	E	Easy	F	Firm
H	Hard	VH	Very Hard		

WATER

►	Water Inflow	▼	Water Level
◄	Water Loss (complete)		
◁	Water Loss (partial)		

SAMPLING AND TESTING

B	Bulk Disturbed Sample	P	Piston Sample
BLK	Block Sample	PBT	Plate Bearing Test
C	Core Sample	U	Undisturbed Push-in Sample
CBR	CBR Mould Sample		U50: 50 mm diameter
D	Small Disturbed Sample	SPT	Standard Penetration Test
ES	Environmental Soil Sample		Example: 3, 4, 5 N=9
EW	Environmental Water Sample		3,4,5: Blows per 150 mm
G	Gas Sample		N=9: Blows per 300 mm after
HP	Hand Penetrometer		150 mm seating interval
LB	Large Bulk Disturbed Sample	VS	Vane Shear; P = Peak
M	Mazier Type Sample		R = Remoulded (kPa)
MC	Moisture Content Sample	W	Water Sample

ROCK CORE RECOVERY

TCR = Total Core Recovery (%) $= \frac{CRL}{TCL} \times 100$

SCR = Solid Core Recovery (%) $= \frac{CCR}{TCL} \times 100$

RQD = Rock Quality Designation (%) $= \frac{ALC>100}{TCL} \times 100$

TCL	Length of Core Run
CRL	Recovered Length of Core
CCR	Total Length of Cylindrical Pieces of Core Recovered
ALC>100	Total Length of Axial Lengths of Core Greater than 100 mm Long

METHOD OF SOIL DESCRIPTION
BOREHOLE AND TEST PIT REPORTS

GRAPHIC LOG & UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) SYMBOLS

Graphic	USCS	Soil Name
		FILL (various types)
		COBBLES
		BOULDERS
	GP	GRAVEL (poorly graded)
	GW	GRAVEL (well graded)
	GC	Clayey GRAVEL
	SP	SAND (poorly graded)
	SW	SAND (well graded)
	SC	Clayey SAND

Graphic	USCS	Soil Name
	SM	Silty SAND
	ML	SILT (low liquid limit)
	MH	SILT (high liquid limit)
	CL	CLAY (low plasticity)
	CI	CLAY (medium plasticity)
	CH	CLAY (high plasticity)
	OL	Organic SILT (low liquid limit)
	OH	Organic SILT (high liquid limit)
	Pt	PEAT

RESISTANCE TO EXCAVATION

Symbol	Term	Description
VE	Very easy	All resistances are relative to the selected method of excavation
E	Easy	
F	Firm	
H	Hard	
VH	Very hard	

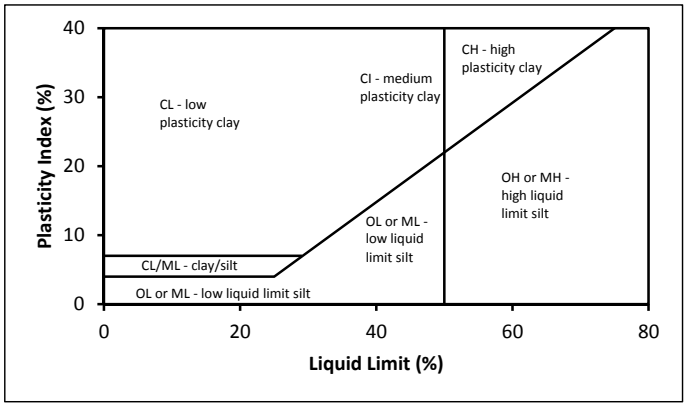
SOIL CLASSIFICATION AND INFERRED STRATIGRAPHY

Soil descriptions are based on AS1726-1993, Appendix A. Material properties are assessed in the field by visual/tactile methods in combination with field testing techniques (where used).

PARTICLE SIZE

Soil Name		Particle Size (mm)
BOULDERS		>200
COBBLES		63 to 200
GRAVEL	Coarse	20 to 63
	Medium	6 to 20
	Fine	2 to 6
SAND	Coarse	0.6 to 2.0
	Medium	0.2 to 0.6
	Fine	0.075 to 0.2
FINES	SILT	0.002 to 0.075
	CLAY	<0.002

PLASTICITY PROPERTIES



MOISTURE CONDITION

AS1726-1993

Symbol	Term	Description
D	Dry	Sands and gravels are free flowing. Clays and silts may be brittle or friable and powdery.
M	Moist	Soils are darker than in the dry condition and may feel cool. Sands and gravels tend to cohere.
W	Wet	Soils exude free water. Sands and gravels tend to cohere.

CONSISTENCY AND DENSITY

AS1726-1993 and HB160-2006

Symbol	Term	Undrained Shear Strength (kPa)	SPT "N"	DCP blows per 100 mm
VS	Very Soft	0 to 12	0 to 2	<1
S	Soft	12 to 25	2 to 4	<1
F	Firm	25 to 50	4 to 8	1 to 2
St	Stiff	50 to 100	8 to 15	3 to 4
VSt	Very Stiff	100 to 200	15 to 30	5 to 10
H	Hard	>200	>30	>10

Symbol	Term	Density Index (%)	SPT "N"	DCP blows per 100 mm	PSP Blows per 300 mm
VL	Very Loose	<15	0 to 4	<1	0 to 2
L	Loose	15 to 35	4 to 10	1 to 2	2 to 6
MD	Medium Dense	35 to 65	10 to 30	2 to 3	6 to 8
D	Dense	65 to 85	30 to 50	4 to 8	8 to 15
VD	Very Dense	>85	>50	>8	>15

Note: PSP correlations only valid to 450 mm depth

Consistency and density may also be inferred from excavation performance and material behaviour.

TEST PIT: TP01

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391446 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438871 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey becoming yellow with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 90 mm in diameter) in top 1.5 m	D	L	
			0.5									MD	
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GG_EXCAVATION J1401062.GPJ <<DrawingFile>> 05/05/2014 16:02 8.30.003 Datgal DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

TEST PIT: TP02

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391382 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438371 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming yellow with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 20 mm in diameter) in top 1.5 m	D	VL - L	
			0.5									MD	
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP03

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391411 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438530 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming pale yellow with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 20 mm in diameter) in top 2.0 m	D	L	
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GG_EXCAVATION J1401062.GPJ <<DrawingFile>> 05/05/2014 16:02 8.30.003 Datgal DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

TEST PIT: TP04

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391455 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438643 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming pale yellow with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 60 mm in diameter) in top 1.8 m	D	VL	
			0.5									L	
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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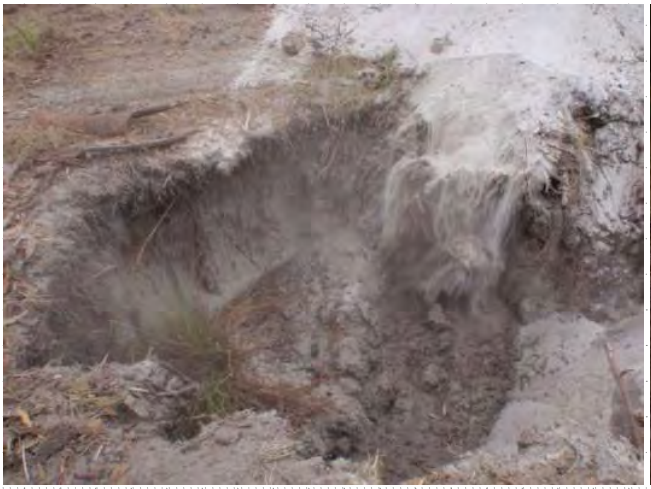
TEST PIT: TP05

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391499 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438757 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines in top 200 mm, trace rootlets/roots (up to 50 mm in diameter) in top 0.5 m	D	L MD	
			2.0							Hole Terminated at 2.00 m Collapse Groundwater Not Encountered			

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP06

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391559 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438826 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 80 mm in diameter) in top 2.0 m	D	VL L	
			2.0							Hole Terminated at 2.00 m Collapse Groundwater Not Encountered			

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP07

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391391 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6437915 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming pale yellow with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 20 mm in diameter) in top 2.0 m	D	L	
			0.5									L - MD	
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP08

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391518 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438069 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming pale yellow with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 100 mm in diameter) in top 1.0 m	D	L L - MD	
			2.0							Hole Terminated at 2.00 m Collapse Groundwater Not Encountered			

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP09

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391417 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438246 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming pale yellow with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 30 mm in diameter) in top 1.5 m	D	VL	
			0.5									L	
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP10

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391523 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438370 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 50 mm in diameter) in top 1.0 m	D	L	
			0.5										
			1.0									MD	
			1.5										
			2.0							Hole Terminated at 2.00 m Collapse Groundwater Not Encountered			
			2.5										
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP11

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Job Number:	J1401062	**Easting:**	391525 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438485 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming pale yellow with depth, trace non-plastic fines, trace rootlets/roots (up to 50 mm in diameter) in top 1.8 m	D	VL	
			0.5									L	
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP12

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391569 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438599 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming pale yellow with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 30 mm in diameter) in top 1.8 m	D	VL L MD	
			0.5										
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP13

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391613 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438713 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description						
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E	▼	0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace non-plastic fines in top 200 mm, trace rootlets/roots (up to 30 mm in diameter)	D	VL - L	
			0.5									MD	
			1.0							As above, becoming brown			Slight sulfidic odour
			1.5								M - W		
			2.0						SC	Clayey SAND: fine to coarse grained, 15-25% low to medium plasticity clay fines, pale brown			
			2.5							Hole Terminated at 2.50 m Target depth Groundwater encountered at 1.8m			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP14

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391673 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438782 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 40 mm in diameter) in top 1.2 m	D	VL	
			0.5									L	
			1.0										
			1.5										
			2.0							Hole Terminated at 1.80 m Collapse Groundwater Not Encountered			
			2.5										
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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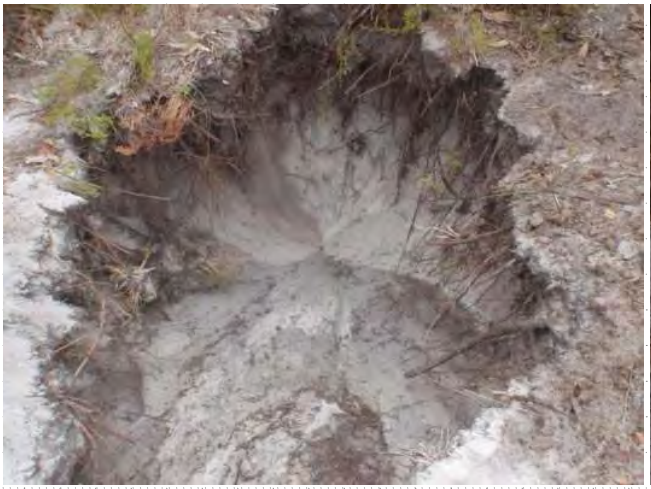
TEST PIT: TP15

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391694 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438871 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 40 mm in diameter) in top 1.8 m	D	VL	
			0.5									L	
			1.0										
			1.5										
			2.0							Hole Terminated at 2.00 m Collapse Groundwater Not Encountered			
			2.5										
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP16

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391375 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437417 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description						
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SM	Silty SAND: fine to coarse grained, brown, 15% silt fines, trace rootlets	M	L	
	F		0.5		B(TP16-01)					CLAY: medium to high plasticity, with some sand (15-25%), trace rootlets, pale grey	D	St	
			1.0										
	E		1.5		B(TP16-01)				CI	As above, becoming brown	M	F	
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP17

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391390 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437588 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, grey, with some non-plastic fines, trace rootlets	D	D	
			0.5						SM	Silty SAND: fine to coarse grained, 15-20% silt fines, brown trace rootlets	D	D - VD	
			1.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, white/grey	M		
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP18

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391388 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6437714 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming pale yellow with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 40 mm in diameter) in top 1.0 m	D	L	
			0.5										
			1.0										
			1.5										
			2.0							Hole Terminated at 2.00 m Collapse Groundwater Not Encountered			
			2.5										
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP19

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391433 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6437828 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming pale yellow with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 50 mm in diameter) in top 0.5 m	D	L	
			2.0							Hole Terminated at 2.00 m Collapse Groundwater Not Encountered			

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP20

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391507 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6437965 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width: 0.7 m	**Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey-brown, trace rootlets to 0.2 m	D	L	
			0.5							Becoming yellow			
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP21

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391626 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438102 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 50 mm in diameter) in top 1.0 m	D	VL L MD	
			0.5										
			1.0										
			1.5										
			2.0							Hole Terminated at 2.00 m Collapse Groundwater Not Encountered			
			2.5										
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP22

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391595 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438173 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming pale yellow with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 60 mm in diameter) in top 1.5 m	D	L	
			0.5									L - MD	
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP23

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391685 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438273 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming pale yellow with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 20 mm in diameter) in top 2.0 m	D	L	
			0.5									MD	
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP24

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391633 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438511 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming pale yellow with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 30 mm in diameter) in top 1.8 m	D	VL L MD	
			0.5										
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP25

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391654 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438590 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming pale yellow with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 60 mm in diameter) in top 1.8 m	D	L	
			0.5										
			1.0										
			1.5										
			2.0							Hole Terminated at 2.00 m Collapse Groundwater Not Encountered			
			2.5										
			3.0										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP26

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391749 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438645 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white, with some organic fines in top 300 mm, with some roots/rootlets (up to 80 mm in diameter) in top 800 mm	D	L	
			0.5							Trace rootlets down to 1.8 m			
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP27

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Job Number:	J1401062	**Easting:**	391787 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438738 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace fines with some rootlets/roots (up to 40 mm in diameter) in top 1.0 m	D	VL	
			0.5									L	
			1.0							White			
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP28

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391903 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438883 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace fines, trace rootlets/roots (up to 25 mm in diameter)	D	VL	
			0.5							Becoming yellow		L	
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP29

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391480 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437345 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SM	Silty SAND: fine to coarse grained, 15% silt fines, brown, trace rootlets		D	
			0.5							CLAY: medium to high plasticity, grey/pale grey, with some sand (15-25%), trace rootlets	D		
			1.0										
										As above, grey			
			1.5						CL			F - St	
											M		
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP30

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391369 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437329 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SM	Silty SAND: fine to coarse grained, 15% silt fines, brown, trace rootlets	M	L - MD	
			0.5							CLAY: medium to high plasticity, pale grey, with some sand (15-25%), trace rootlets	M - D		
			1.0							As above, becoming brown			
			1.5						CI			F	
			2.0								M		
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP31

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Job Number:	J1401062	**Easting:**	391541 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437485 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SM	Silty SAND: fine to coarse grained, 20-30% silt fines, trace roots in top 300 mm, brown	D	VD	
			0.5		B(TP31-01)				CI	CLAY: medium to high plasticity, pale grey, with some sand (15-25%), trace rootlets		H	
			1.0										
			1.5						SP	CEMENTED SAND: fine to coarse grained, brown/black, very weakly to moderately cemented			
			2.0										
			2.5							Hole Terminated at 2.20 m Refusal on "Coffee Rock" Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP32

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Job Number:	J1401062	**Easting:**	391422 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437519 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SM	Silty SAND: fine to coarse grained, 15-20% silt fines, dark grey, trace rootlets	D	MD - D	
			0.5							SAND: fine to coarse grained, sub-angular to sub-rounded, white			
			1.0										
			1.5						SP	Becoming brown			
			2.0										
			2.5							Hole Terminated at 2.20 m Collapse Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP33

Job Number:	J1401062	**Easting:**	391502 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437670 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines/rootlets in top 200 mm	D	L	
			0.5										
			1.0										
			1.5										
			2.0							Hole Terminated at 2.00 m Collapse Groundwater Not Encountered			
			2.5										
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP34

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Job Number:	J1401062	**Easting:**	391546 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437784 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines in top 300 mm, trace rootlets in top 300 mm	D	VL	
			0.5									L	
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.10 m Collapse Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP35

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Job Number:	J1401062	**Easting:**	391591 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437897 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines in top 300 mm	D	VL L - MD	
			2.0							Hole Terminated at 2.00 m Collapse Groundwater Not Encountered			

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP36

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391599 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6437988 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 60 mm in diameter) in top 1.0 m	D	L	
			2.0							Hole Terminated at 2.00 m Collapse Groundwater Not Encountered			

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP37

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391719 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438181 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines in top 200 mm, trace rootlets/roots (up to 30 mm in diameter) in top 1.5 m	D	L MD	
			0.5										
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.10 m Collapse Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP38

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391824 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438205 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, dark grey, trace rootlets in top 0.1 m	D	VL	White pipe in pit (not in use)
			0.5							Becoming white Roots are 30 mm in diameter at 0.5 m		MD	
			1.0										
			1.5										
			2.0							Hole Terminated at 2.00 m Slow progress due to collapse Groundwater Not Encountered			
			2.5										
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP39

Job Number:	J1401062	**Easting:**	391768 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438352 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 20 mm in diameter) in top 0.5 m	D	VL L	
			2.0							Hole Terminated at 1.90 m Collapse Groundwater Not Encountered			

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP40

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391830 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438466 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines in top 200 mm, trace roots in top 400 mm (occasionally down to 1.5 m)	D	L	
			0.5									MD	
			1.0										
			1.5							Becoming grey			
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP41

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391916 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438536 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0							SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines in top 200 mm, trace rootlets in top 100 mm	D	MD	
					B(TP41-01)								
			0.5										
			1.0						SP				
			1.5							Becoming grey	M		
			2.0							Hole Terminated at 2.00 m Collapse Groundwater Not Encountered			
			2.5										
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP42

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391880 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438812 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace roots/rootlets (up to 40 mm in diameter), trace fines	D	VL	
			0.5									L	
			1.0							White			
			1.5										
			2.0								M		
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP43

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391606 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437423 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description						
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0		B(TP43-01)				SM	Silty SAND: fine to coarse grained, brown, 15-20% silt, trace rootlets			
			0.5						SP	SAND: fine to coarse grained, grey becoming white, trace non-plastic fines in top 200 mm	D		
			1.0								M		
			1.5								W		Slight sulfidic odour
	H		2.0						SP	CEMENTED SAND: fine to coarse grained, brown/black, weakly to moderately cemented			
			2.5							Hole Terminated at 2.30 m Refusal on "Coffee Rock" Groundwater encountered at 1.5m			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP44

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391611 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437558 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines/rootlets in top 500 mm	D	VL	
			0.5									L	
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP45

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391632 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437673 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description						
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	FILL: Gravelly SAND, fine to coarse grained, fine to medium grained limestone gravel, pale yellow	D	MD	
			0.5						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines in top 200 mm, trace rootlets in top 500 mm			
			1.0										
			1.5										
			2.0								M		
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP46

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391661 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6437781 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0							Clayey SAND: fine to coarse grained, 20-30% medium to high plasticity clay fines, desiccated, grey	D	St - VSt	
			0.5		B(TP46-01)				SC	Becoming moist, dark grey, soft	M	S	
			1.0										
			1.5							SAND: fine to coarse grained, sub-angular to sub-rounded, grey-brown, slight odour			
		▼	2.0						SP		M - W		Groundwater is seeping through test pit walls
			2.5							Hole Terminated at 2.50 m Target depth Groundwater encountered at 2.3m			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP47

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Job Number:	J1401062	**Easting:**	391704 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6437853 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width: 0.7 m	**Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SC	Clayey SAND: fine to coarse grained, grey, 20-30% medium to high plasticity fines, trace rootlets	St - VSt	D	
			0.5							Becoming dark grey, moisture increase	S	M	
			1.0										
			1.5						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, brown			Slow seepage through test pit wall
			2.0									W	
			2.5							Hole Terminated at 2.50 m Target depth Groundwater encountered at 1.5m			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP48

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Job Number:	J1401062	**Easting:**	391749 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6437967 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description						
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E	▼	0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, dark grey becoming white, trace non-plastic fines, trace rootlets, slight sulfidic odour	MD	D	
										No fines			
			0.5								L		
										No rootlets		M	
			1.0							Becoming pale brown			Slow seepage through test pit wall
			1.5										
			2.0									W	
			2.5							Hole Terminated at 2.50 m Target depth Groundwater encountered at 1.2m			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP49

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Job Number:	J1401062	**Easting:**	391793 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438081 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E	▼	0.0		B(TP49-01)				SP	SAND: fine to coarse grained, sub-angular to sub-rounded, dark grey, with some organic fines (5-6%), trace rootlets		D	
			0.5							SAND: fine to coarse grained, sub-angular to sub-rounded, grey	MD	M	
			1.0							Becoming pale brown			Slow seepage through test pit wall
			1.5						SP			M-W	
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater encountered at 1m			
			3.0										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP50

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391937 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438161 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey to white, trace non-plastic fines, trace rootlets No fines or rootlets	L	D	
			0.5										
			1.0							Becoming pale brown		M	
			1.5										
			2.0									W	
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GG_EXCAVATION J1401062.GPJ <<DrawingFile>> 05/05/2014 16:04 8.30.003 Datgal DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

TEST PIT: TP51

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391882 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438308 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description						
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, dark grey	L	D		
										No rootlets	MD			
			0.5											
			1.0							Becoming white mottled grey				
			1.5									M		
			2.0							Becoming grey				
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered				
			3.0											

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP52

Job Number:	J1401062	**Easting:**	391926 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438422 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white, trace non plastic fines, trace rootlets No fines or rootlets	L		
			0.5								MD	D	
			1.0										
			1.5										
			2.0									M	
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GG_EXCAVATION J1401062.GPJ <<DrawingFile>> 05/05/2014 16:04 8.30.003 Datgal DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

TEST PIT: TP53

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391685 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437468 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white, trace non plastic fines, trace rootlets	L	D	
			0.5							No rootlets	MD - D		
			1.0								MD		
			1.5										
			2.0										
			2.5							Hole Terminated at 2.30 m Collapse Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP54

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391730 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6437581 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white, trace non-plastic fines, trace rootlets/roots up to 40 mm in diameter	L	D	
										No fines	MD		
			0.5										
			1.0										
			1.5										
			2.0							No rootlets/roots			
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP55

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391774 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6437695 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white, trace non-plastic fines, trace rootlets	VL - L	D	
			0.5							No fines or rootlets	L - MD		
			1.0										
			1.5										
			2.0							Hole Terminated at 1.90 m Collapse Groundwater Not Encountered			
			2.5										
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP56

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391823 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6437866 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description						
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace non plastic fines, trace rootlets	L	D	
			0.5								MD		
			1.0							Becoming white		M	Slight sulfidic odour
		▼	1.5										Water seeping through test pit wall
			2.0							Becoming pale brown		W	
			2.5							Hole Terminated at 2.50 m Target depth Groundwater encountered at 1.8m			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GG_EXCAVATION J1401062.GPJ <<DrawingFile>> 05/05/2014 16:04 8.30.003 Datgal DGD_CPT_Photo_Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

TEST PIT: TP57

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391933 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6437923 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white, trace non-plastic fines, trace rootlets	L	D	
			0.5							No fines or rootlets			
			1.0							Becoming pale grey/brown			
			1.5									M	
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP58

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391907 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438036 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white, trace non-plastic fines, trace rootlets	L	D	
			0.5							No fines or rootlets	MD		
			1.0							Becoming pale grey/brown		M	
			1.5										
			2.0										
			2.5							Hole Terminated at 2.30 m Collapse Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GG_EXCAVATION J1401062.GPJ <<DrawingFile>> 05/05/2014 16:04 8.30.003 Datgal DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

TEST PIT: TP59

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391888 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437651 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white, trace non-plastic fines, trace rootlets	L	D	
			0.5							No fines or rootlets	L - MD		
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GG_EXCAVATION J1401062.GPJ <<DrawingFile>> 05/05/2014 16:04 8.30.003 Datgal DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

TEST PIT: TP60

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391932 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437765 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey-white, trace non-plastic fines, trace rootlets, roots up to 30 mm diameter			
			0.5							No rootlets	L		
			1.0									D	
			1.5										
			2.0									M	
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GG_EXCAVATION J1401062.GPJ <<DrawingFile>> 05/05/2014 16:05 8.30.003 Datgal DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

Appendix C: Summary Hand Auger Borehole Reports

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6014

ABN: 73 292 586 155

SUMMARY BOREHOLE REPORTS

Job Number:	J1401062	**Date Performed:**	9 & 10 April 2014
Client:	Qube Property Group	**Drilled By:**	AW/MW
Project::	Proposed Residential Subdivision	**Logged By:**	AW/MW
Location:	Lot 682 Rowley Road, Mandogalup		

Hand Auger Borehole P01

Test Depth (m)	Stratigraphy
0.0 – 1.0	SAND (SP), fine to coarse grained, sub-angular to sub-rounded, dark grey becoming white, dry
End of borehole at 1.0 m Target depth Groundwater not encountered	

Hand Auger Borehole P02

Test Depth (m)	Stratigraphy
0.0 – 1.0	SAND (SP), fine to coarse grained, sub-angular to sub-rounded, dark grey becoming grey mottled white, dry
End of borehole at 1.0 m Target depth Groundwater not encountered	

Hand Auger Borehole P03

Test Depth (m)	Stratigraphy
0.0 – 1.0	SAND (SP), fine to coarse grained, sub-angular to sub-rounded, grey becoming pale grey, trace non-plastic fines, dry
End of borehole at 1.0 m Target depth Groundwater not encountered	

Hand Auger Borehole P04

Test Depth (m)	Stratigraphy
0.0 – 1.3	Peaty SAND (SP), fine to medium grained, sub-angular to sub-rounded, dark brown/black, 15-20% organic fines, fibrous, sand content increasing with depth
1.3 – 1.5	SAND (SP), fine to coarse grained, sub-angular to sub-rounded, grey becoming pale grey, trace non-plastic fines, dry
End of borehole at 1.5 m Target depth Groundwater at 1.05 m	

Hand Auger Borehole P05

Test Depth (m)	Stratigraphy
0.0 – 1.0	SAND (SP), fine to coarse grained, sub-angular to sub-rounded, grey becoming pale grey, trace non-plastic fines, dry
End of borehole at 1.0 m Target depth Groundwater not encountered	

Appendix D: Dynamic Cone Penetrometer Test Results

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6014
ABN: 73 292 586 155

DYNAMIC CONE PENETROMETER FIELD TEST DATA
(AS12896.3.2)

Client:	Qube Property Group	**Job No:**	J1401062
Project:	Proposed Residential Subdivision	**Date:**	9, 10 & 11 April 2014
Location:	Lot 682 Rowley Road, Mandogalup	**Engineer:**	JH

Test No:	1	2	3	4	5	6
Location:	TP01	TP02	TP03	TP04	TP05	TP06
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**					
0-100	-	-	-	-	-	-
100-200	1	1	1	0	1	0
200-300	1	0	1	1	1	0
300-400	2	1	1	0	1	1
400-500	2	1	1	1	1	0
500-600	2	1	2	1	2	1
600-700	2	1	2	2	2	1
700-800	3	2	1	1	2	2
800-900	3	2	2	2	2	1
900-1000	3	3	2	2	3	1

Test No:	7	8	9	10	11	12
Location:	TP07	TP08	TP09	TP10	TP11	TP12
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**					
0-100	-	-	-	-	-	-
100-200	1	1	0	0	0	0
200-300	1	1	1	1	0	1
300-400	2	1	1	1	1	1
400-500	2	1	1	1	0	1
500-600	2	2	1	1	1	1
600-700	2	1	2	1	1	2
700-800	2	2	2	1	2	2
800-900	2	2	2	2	1	2
900-1000	2	2	2	3	2	3

Test No:	13	14	15	16	17	18
Location:	TP13	TP14	TP15	TP16	TP17	TP18
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**					
0-100	-	-	-	-	-	-
100-200	1	0	0	2	3	1
200-300	0	1	1	2	3	1
300-400	1	1	1	4	9	1
400-500	0	1	1	4	12	1
500-600	1	1	1	3	6	1
600-700	1	2	1	4	4	1
700-800	2	1	1	4	6	1
800-900	3	2	2	3	6	2
900-1000	4	2	2	3	4	2

Dynamic Cone Penetrometer tests done in accordance with AS 1289.6.3.2
HB: Hammer bounce (refusal)
HW: Penetration due to hammer weight only
R: Refusal

DYNAMIC CONE PENETROMETER FIELD TEST DATA
(AS12896.3.2)

Client:	Qube Property Group	**Job No:**	J1401062
Project:	Proposed Residential Subdivision	**Date:**	9, 10 & 11 April 2014
Location:	Lot 682 Rowley Road, Mandogalup	**Engineer:**	JH

Test No:	19	20	21	22	23	24
Location:	TP19	TP20	TP21	TP22	TP23	TP24
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**					
0-100	-	-	-	-	-	-
100-200	1	1	1	1	1	0
200-300	1	1	0	1	1	1
300-400	1	1	1	1	1	1
400-500	1	2	1	1	2	2
500-600	1	1	1	1	1	2
600-700	1	2	1	2	2	2
700-800	1	1	1	2	1	3
800-900	1	2	2	2	2	2
900-1000	2	1	2	2	3	3

Test No:	25	26	27	28	29	30
Location:	TP25	TP26	TP27	TP28	TP29	TP30
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**					
0-100	-	-	-	-	-	-
100-200	1	1	0	0	5	2
200-300	1	1	0	1	4	2
300-400	1	1	1	1	4	2
400-500	1	1	1	1	4	2
500-600	2	1	1	1	2	2
600-700	1	1	1	1	2	2
700-800	2	2	1	2	4	1
800-900	1	1	2	2	3	2
900-1000	2	2	2	2	3	2

Test No:	31	32	33	34	35	36
Location:	TP31	TP32	TP33	TP34	TP35	TP36
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**					
0-100	-	-	-	-	-	-
100-200	3	2	1	0	0	1
200-300	3	3	1	0	0	1
300-400	10	3	2	2	2	1
400-500	9	3	2	2	2	1
500-600	15R	3	2	3	3	1
600-700		4	2	3	2	1
700-800		4	2	2	3	1
800-900		5	2	1	2	2
900-1000		4	2	1	3	1

Dynamic Cone Penetrometer tests done in accordance with AS 1289.6.3.2
HB: Hammer bounce (refusal)
HW: Penetration due to hammer weight only
R: Refusal

DYNAMIC CONE PENETROMETER FIELD TEST DATA
(AS12896.3.2)

Client:	Qube Property Group	**Job No:**	J1401062
Project:	Proposed Residential Subdivision	**Date:**	9, 10 & 11 April 2014
Location:	Lot 682 Rowley Road, Mandogalup	**Engineer:**	JH

Test No:	37	38	39	40	41	42
Location:	TP37	TP38	TP39	TP40	TP41	TP42
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**					
0-100	-	-	-	-	-	-
100-200	1	0	0	1	2	1
200-300	1	1	1	2	2	1
300-400	1	2	1	2	2	0
400-500	2	3	1	2	2	1
500-600	1	3	1	3	2	1
600-700	2	2	1	3	3	1
700-800	2	3	2	4	3	2
800-900	2	2	2	3	3	1
900-1000	2	2	2	3	4	2

Test No:	43	44	45	46	47	48
Location:	TP43	TP44	TP45	TP46	TP47	TP48
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**					
0-100	-	-	-	-	-	-
100-200	2	0	3	6	5	4
200-300	4	1	4	5	6	3
300-400	3	2	3	5	6	3
400-500	3	3	3	3	4	2
500-600	3	2	4	4	4	2
600-700	2	2	3	4	4	1
700-800	2	1	3	6	5	2
800-900	2	2	3	4	3	1
900-1000	3	2	3	2	2	2

.

Test No:	49	50	51	52	53	54
Location:	TP49	TP50	TP51	TP52	TP53	TP54
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**					
0-100	-	-	-	-	-	-
100-200	2	2	1	2	1	1
200-300	2	2	2	2	2	1
300-400	2	2	2	3	3	2
400-500	2	2	2	3	5	4
500-600	3	2	3	3	5	4
600-700	2	1	4	2	4	4
700-800	2	2	3	2	3	4
800-900	2	1	3	2	3	4
900-1000	2	2	4	3	2	3

Dynamic Cone Penetrometer tests done in accordance with AS 1289.6.3.2
HB: Hammer bounce (refusal)
HW: Penetration due to hammer weight only
R: Refusal

DYNAMIC CONE PENETROMETER FIELD TEST DATA
(AS12896.3.2)

Client:	Qube Property Group	**Job No:**	J1401062
Project:	Proposed Residential Subdivision	**Date:**	9, 10 & 11 April 2014
Location:	Lot 682 Rowley Road, Mandogalup	**Engineer:**	JH

Test No:	55	56	57	58	59	60
Location:	TP55	TP56	TP57	TP58	TP59	TP60
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**					
0-100	-	-	-	-	-	-
100-200	0	2	2	1	1	1
200-300	1	2	2	1	1	1
300-400	2	2	2	1	2	1
400-500	2	2	2	2	2	2
500-600	3	1	1	3	3	1
600-700	3	1	2	3	3	1
700-800	2	1	2	3	2	1
800-900	3	2	1	3	2	1
900-1000	2	3	2	3	2	1

Test No:						
Location:						
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**					
0-100						
100-200						
200-300						
300-400						
400-500						
500-600						
600-700						
700-800						
800-900						
900-1000						

Test No:						
Location:						
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**					
0-100						
100-200						
200-300						
300-400						
400-500						
500-600						
600-700						
700-800						
800-900						
900-1000						

Dynamic Cone Penetrometer tests done in accordance with AS 1289.6.3.2
HB: Hammer bounce (refusal)
HW: Penetration due to hammer weight only
R: Refusal

Appendix E: Permeability Test Results

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6014

ABN: 73 292 586 155

Permeability Calculation - Inverse Auger Hole Method

Galt Geotechnics

Job No:	J1401062
Client:	QUBE
Site:	Lot 682 Rowley Road
Location:	Mandogalup
Calc by:	JH 11-Apr-14
BH Name:	P01
Test Depth:	0.55 m

Spreadsheet author:	ORW	17-Oct-09

$$K = 1.15r\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114

Spreadsheet Legend

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	Calculated field
	Comment field
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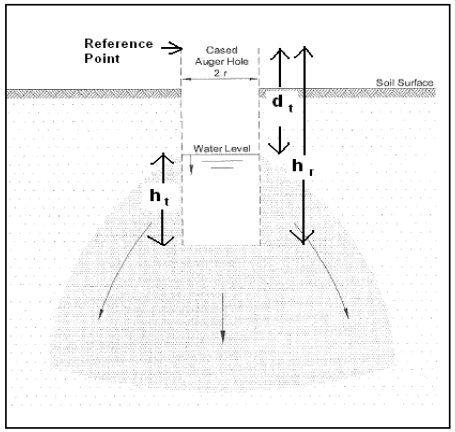
Parameter	Description	Value	Units
K	Permeability		m/s
r	radius of test hole	0.045	m
t	time since start of measurement		s
h_r	reference point height above base	0.61	m
d_t	depth from reference point to water at time t		m
h_t	Water column height at time t		m
h_0	h_t at t=0		m



Test 1

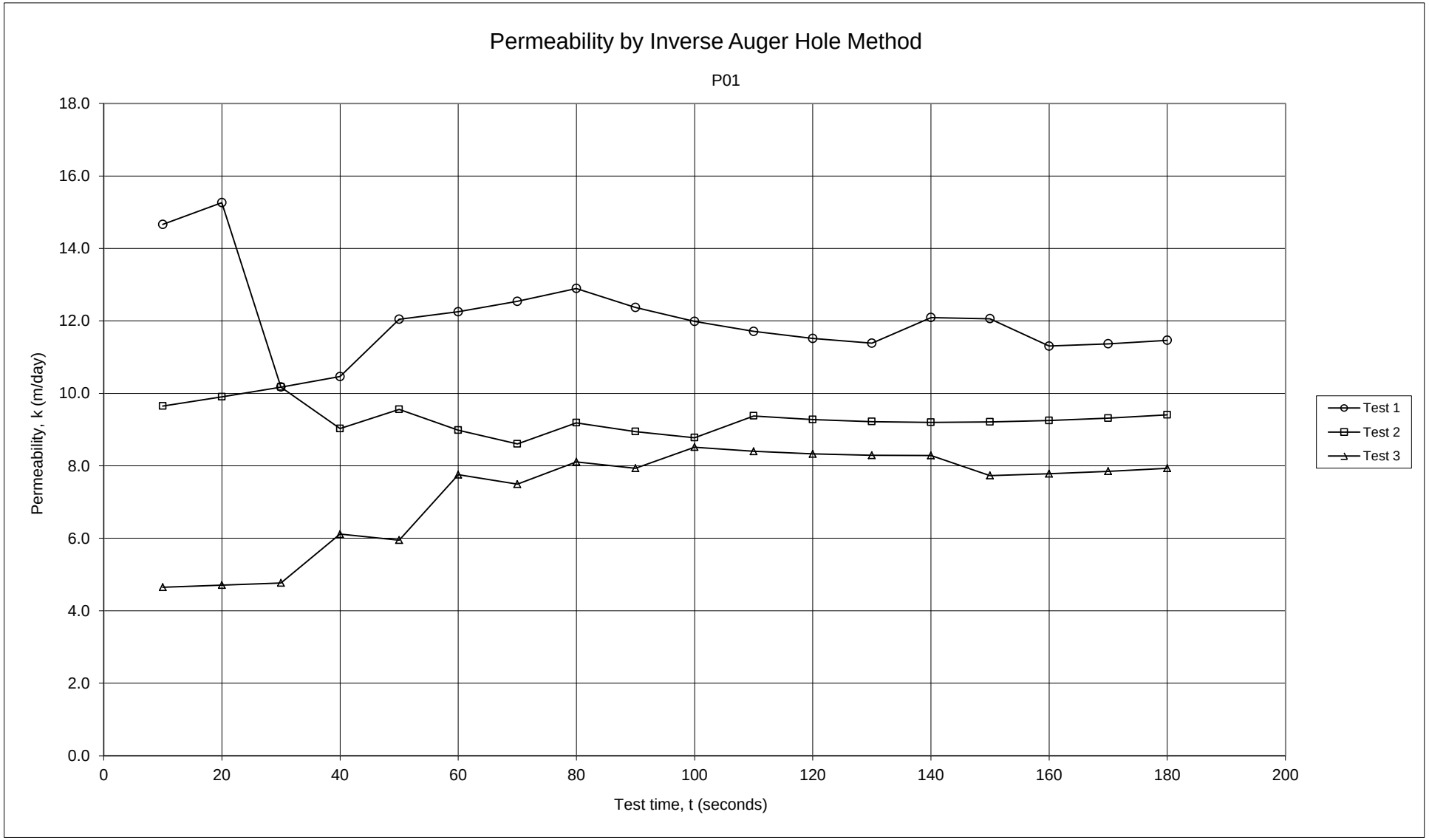
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.22	0.39		
10	0.25	0.36	1.7E-04	14.7
20	0.28	0.33	1.8E-04	15.3
30	0.28	0.33	1.2E-04	10.2
40	0.3	0.31	1.2E-04	10.5
50	0.33	0.28	1.4E-04	12.0
60	0.35	0.26	1.4E-04	12.3
70	0.37	0.24	1.5E-04	12.5
80	0.39	0.22	1.5E-04	12.9
90	0.4	0.21	1.4E-04	12.4
100	0.41	0.2	1.4E-04	12.0
110	0.42	0.19	1.4E-04	11.7
120	0.43	0.18	1.3E-04	11.5
130	0.44	0.17	1.3E-04	11.4
140	0.46	0.15	1.4E-04	12.1
150	0.47	0.14	1.4E-04	12.1
160	0.47	0.14	1.3E-04	11.3
170	0.48	0.13	1.3E-04	11.4
180	0.49	0.12	1.3E-04	11.5
		AVERAGE	1.4E-04	12.1

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.22	0.39		
10	0.24	0.37	1.1E-04	9.7
20	0.26	0.35	1.1E-04	9.9
30	0.28	0.33	1.2E-04	10.2
40	0.29	0.32	1.0E-04	9.0
50	0.31	0.3	1.1E-04	9.6
60	0.32	0.29	1.0E-04	9.0
70	0.33	0.28	1.0E-04	8.6
80	0.35	0.26	1.1E-04	9.2
90	0.36	0.25	1.0E-04	8.9
100	0.37	0.24	1.0E-04	8.8
110	0.39	0.22	1.1E-04	9.4
120	0.4	0.21	1.1E-04	9.3
130	0.41	0.2	1.1E-04	9.2
140	0.42	0.19	1.1E-04	9.2
150	0.43	0.18	1.1E-04	9.2
160	0.44	0.17	1.1E-04	9.2
170	0.45	0.16	1.1E-04	9.3
180	0.46	0.15	1.1E-04	9.4
		AVERAGE	1.1E-04	9.3

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.21	0.4		
10	0.22	0.39	5.4E-05	4.7
20	0.23	0.38	5.4E-05	4.7
30	0.24	0.37	5.5E-05	4.8
40	0.26	0.35	7.1E-05	6.1
50	0.27	0.34	6.9E-05	5.9
60	0.3	0.31	9.0E-05	7.8
70	0.31	0.3	8.7E-05	7.5
80	0.33	0.28	9.4E-05	8.1
90	0.34	0.27	9.2E-05	7.9
100	0.36	0.25	9.9E-05	8.5
110	0.37	0.24	9.7E-05	8.4
120	0.38	0.23	9.6E-05	8.3
130	0.39	0.22	9.6E-05	8.3
140	0.4	0.21	9.6E-05	8.3
150	0.4	0.21	8.9E-05	7.7
160	0.41	0.2	9.0E-05	7.8
170	0.42	0.19	9.1E-05	7.9
180	0.43	0.18	9.2E-05	7.9
		AVERAGE	8.4E-05	7.3


Permeability by Inverse Auger Hole Method
P01
Permeability, k (m/day)
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
20
40
60
80
100
120
140
160
180
200
Test time, t (seconds)
Test 1
Test 2
Test 3

Permeability Calculation - Inverse Auger Hole Method

Galt Geotechnics

Job No:	J1401062
Client:	QUBE
Site:	Lot 682 Rowley Road
Location:	Mandogalup
Calc by:	JH 11-Apr-14
BH Name:	P02
Test Depth:	0.54 m

Spreadsheet author:	ORW	17-Oct-09

$$K = 1.15r\,\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114

Spreadsheet Legend

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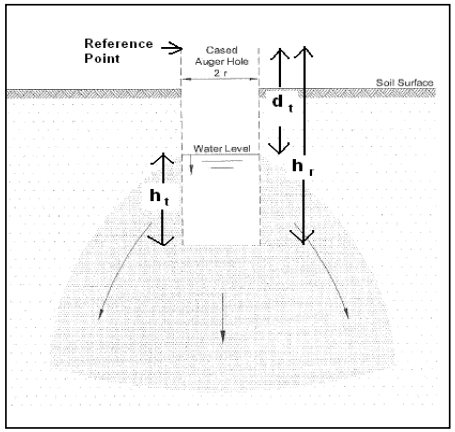
	Calculated field
	Comment field
	Field not used
	Fixed field

Parameter	Description	Value	Units
K	Permeability		m/s
r	radius of test hole	0.045	m
t	time since start of measurement		s
h_r	reference point height above base	0.61	m
d_t	depth from reference point to water at time t		m
h_t	Water column height at time t		m
h_0	h_t at t=0		m



Test 1

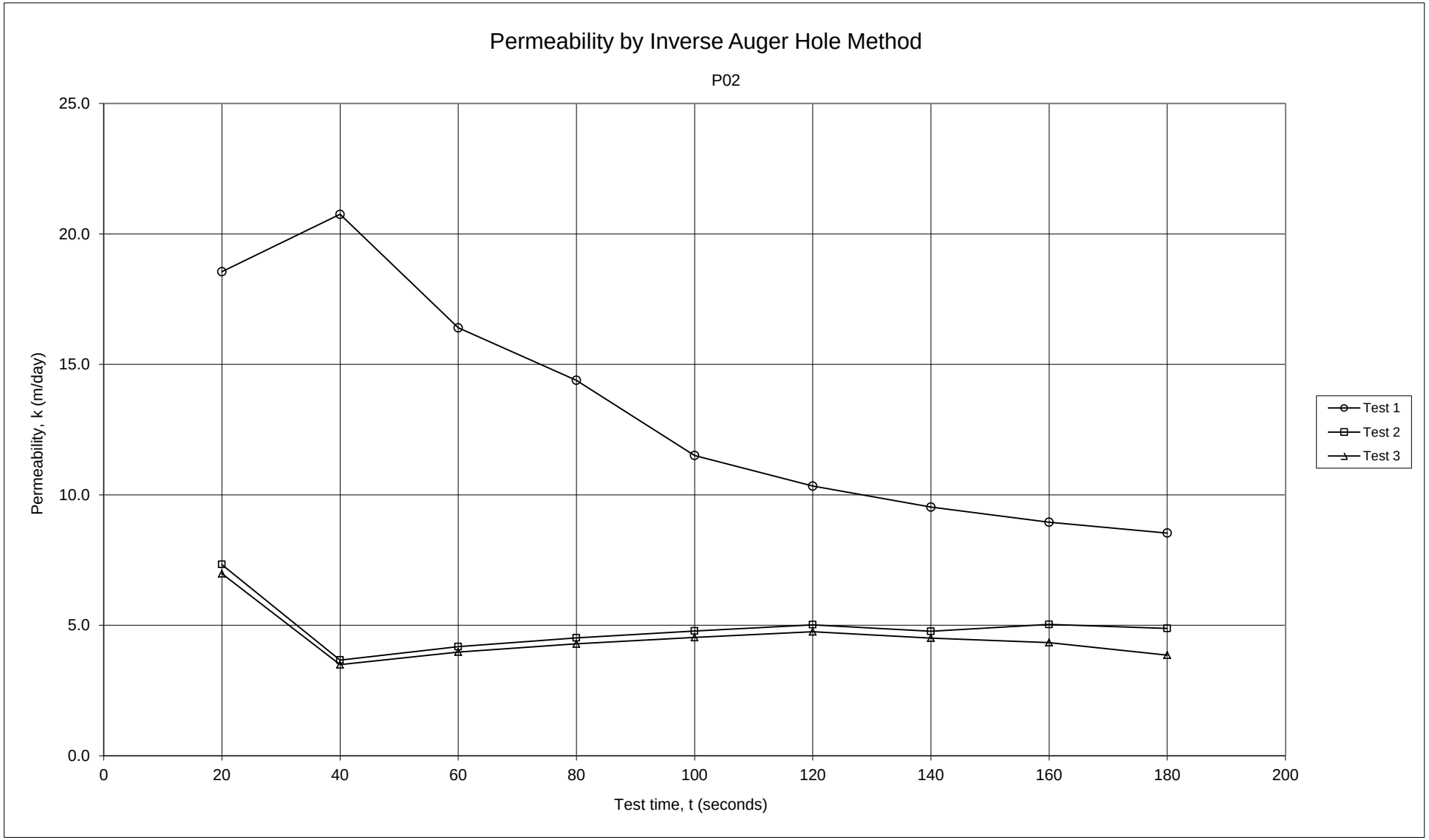
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.23	0.38		
20	0.3	0.31	2.1E-04	18.5
40	0.37	0.24	2.4E-04	20.8
60	0.39	0.22	1.9E-04	16.4
80	0.41	0.2	1.7E-04	14.4
100	0.41	0.2	1.3E-04	11.5
120	0.42	0.19	1.2E-04	10.3
140	0.43	0.18	1.1E-04	9.5
160	0.44	0.17	1.0E-04	9.0
180	0.45	0.16	9.9E-05	8.5
		AVERAGE	1.5E-04	13.2

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.22	0.39		
20	0.25	0.36	8.5E-05	7.3
40	0.25	0.36	4.2E-05	3.7
60	0.27	0.34	4.8E-05	4.2
80	0.29	0.32	5.2E-05	4.5
100	0.31	0.3	5.5E-05	4.8
120	0.33	0.28	5.8E-05	5.0
140	0.34	0.27	5.5E-05	4.8
160	0.36	0.25	5.8E-05	5.0
180	0.37	0.24	5.6E-05	4.9
		AVERAGE	5.7E-05	4.9

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.2	0.41		
20	0.23	0.38	8.1E-05	7.0
40	0.23	0.38	4.0E-05	3.5
60	0.25	0.36	4.6E-05	4.0
80	0.27	0.34	5.0E-05	4.3
100	0.29	0.32	5.2E-05	4.5
120	0.31	0.3	5.5E-05	4.7
140	0.32	0.29	5.2E-05	4.5
160	0.33	0.28	5.0E-05	4.3
180	0.33	0.28	4.5E-05	3.9
		AVERAGE	5.2E-05	4.5


Permeability by Inverse Auger Hole Method
P02
Permeability, k (m/day)
25.0
20.0
15.0
10.0
5.0
0.0
0
20
40
60
80
100
120
140
160
180
200
Test time, t (seconds)
Test 1
Test 2
Test 3

Permeability Calculation - Inverse Auger Hole Method

Galt Geotechnics

Job No:	J1401062
Client:	QUBE
Site:	Lot 682 Rowley Road
Location:	Mandogalup
Calc by:	JH 11-Apr-14
BH Name:	P03
Test Depth:	0.51 m

Spreadsheet author:	ORW	17-Oct-09

$$K = 1.15r\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114

Spreadsheet Legend

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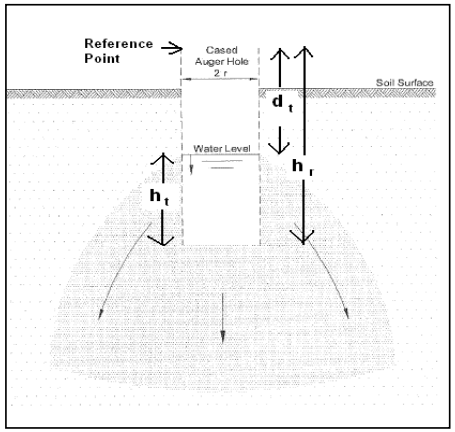
	Comment field
	Field not used
	Fixed field

Parameter	Description	Value	Units
K	Permeability		m/s
r	radius of test hole	0.045	m
t	time since start of measurement		s
h_r	reference point height above base	0.61	m
d_t	depth from reference point to water at time t		m
h_t	Water column height at time t		m
h_0	h_t at t=0		m



Test 1

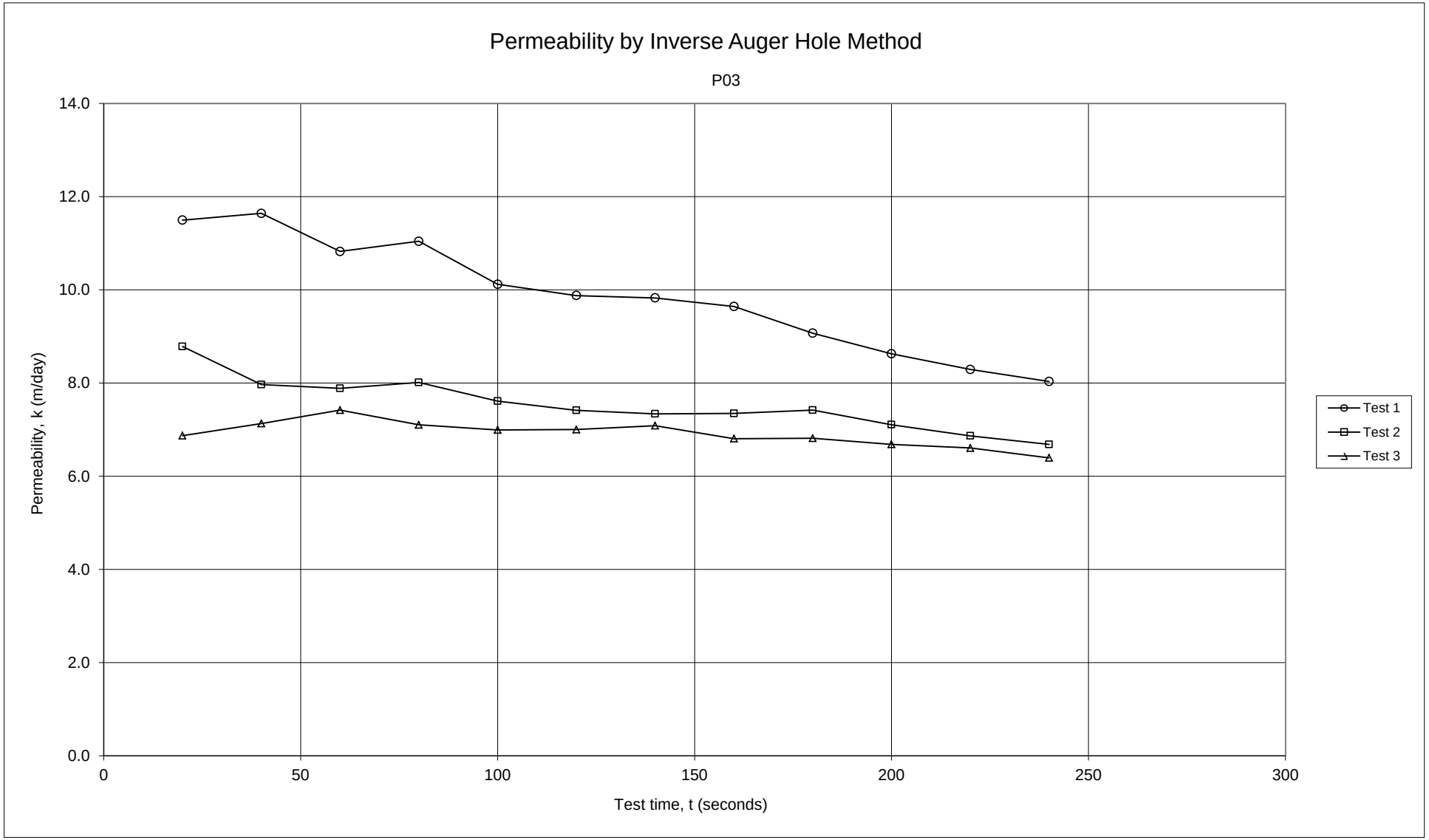
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.14	0.47		
20	0.195	0.415	1.3E-04	11.5
40	0.245	0.365	1.3E-04	11.6
60	0.28	0.33	1.3E-04	10.8
80	0.32	0.29	1.3E-04	11.0
100	0.34	0.27	1.2E-04	10.1
120	0.365	0.245	1.1E-04	9.9
140	0.39	0.22	1.1E-04	9.8
160	0.41	0.2	1.1E-04	9.6
180	0.42	0.19	1.0E-04	9.1
200	0.43	0.18	1.0E-04	8.6
220	0.44	0.17	9.6E-05	8.3
240	0.45	0.16	9.3E-05	8.0
		AVERAGE	1.1E-04	9.9

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.17	0.44		
20	0.21	0.4	1.0E-04	8.8
40	0.24	0.37	9.2E-05	8.0
60	0.27	0.34	9.1E-05	7.9
80	0.3	0.31	9.3E-05	8.0
100	0.32	0.29	8.8E-05	7.6
120	0.34	0.27	8.6E-05	7.4
140	0.36	0.25	8.5E-05	7.3
160	0.38	0.23	8.5E-05	7.3
180	0.4	0.21	8.6E-05	7.4
200	0.41	0.2	8.2E-05	7.1
220	0.42	0.19	7.9E-05	6.9
240	0.43	0.18	7.7E-05	6.7
		AVERAGE	8.7E-05	7.5

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.12	0.49		
20	0.155	0.455	7.9E-05	6.9
40	0.19	0.42	8.3E-05	7.1
60	0.225	0.385	8.6E-05	7.4
80	0.25	0.36	8.2E-05	7.1
100	0.275	0.335	8.1E-05	7.0
120	0.3	0.31	8.1E-05	7.0
140	0.325	0.285	8.2E-05	7.1
160	0.34	0.27	7.9E-05	6.8
180	0.36	0.25	7.9E-05	6.8
200	0.375	0.235	7.7E-05	6.7
220	0.39	0.22	7.6E-05	6.6
240	0.4	0.21	7.4E-05	6.4
		AVERAGE	8.0E-05	6.9



O:\Jobs\2014\J1401062 - C&W SI Mandogalup\08 Analysis\J1401062 Permeability Inverse Auger Hole Method

Permeability Calculation - Inverse Auger Hole Method

Galt Geotechnics

Job No:	J1401062
Client:	QUBE
Site:	Lot 682 Rowley Road
Location:	Mandogalup
Calc by:	JH 11-Apr-14
BH Name:	P04
Test Depth:	0.41 m

Spreadsheet author:	ORW	17-Oct-09

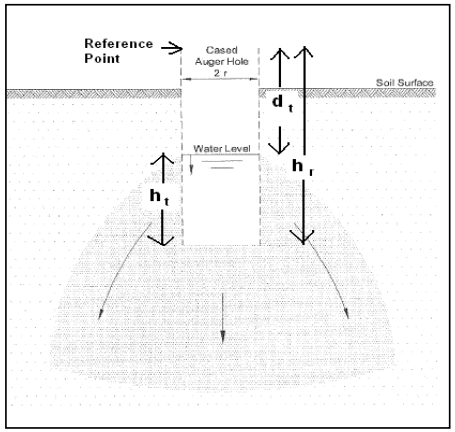
$$K = 1.15r\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114

Spreadsheet Legend

	Required input
	Calculated field
	Comment field
	Field not used
	Fixed field

Parameter	Description	Value	Units
K	Permeability		m/s
r	radius of test hole	0.045	m
t	time since start of measurement		s
h_r	reference point height above base	0.61	m
d_t	depth from reference point to water at time t		m
h_t	Water column height at time t		m
h_0	h_t at t=0		m



Test 1

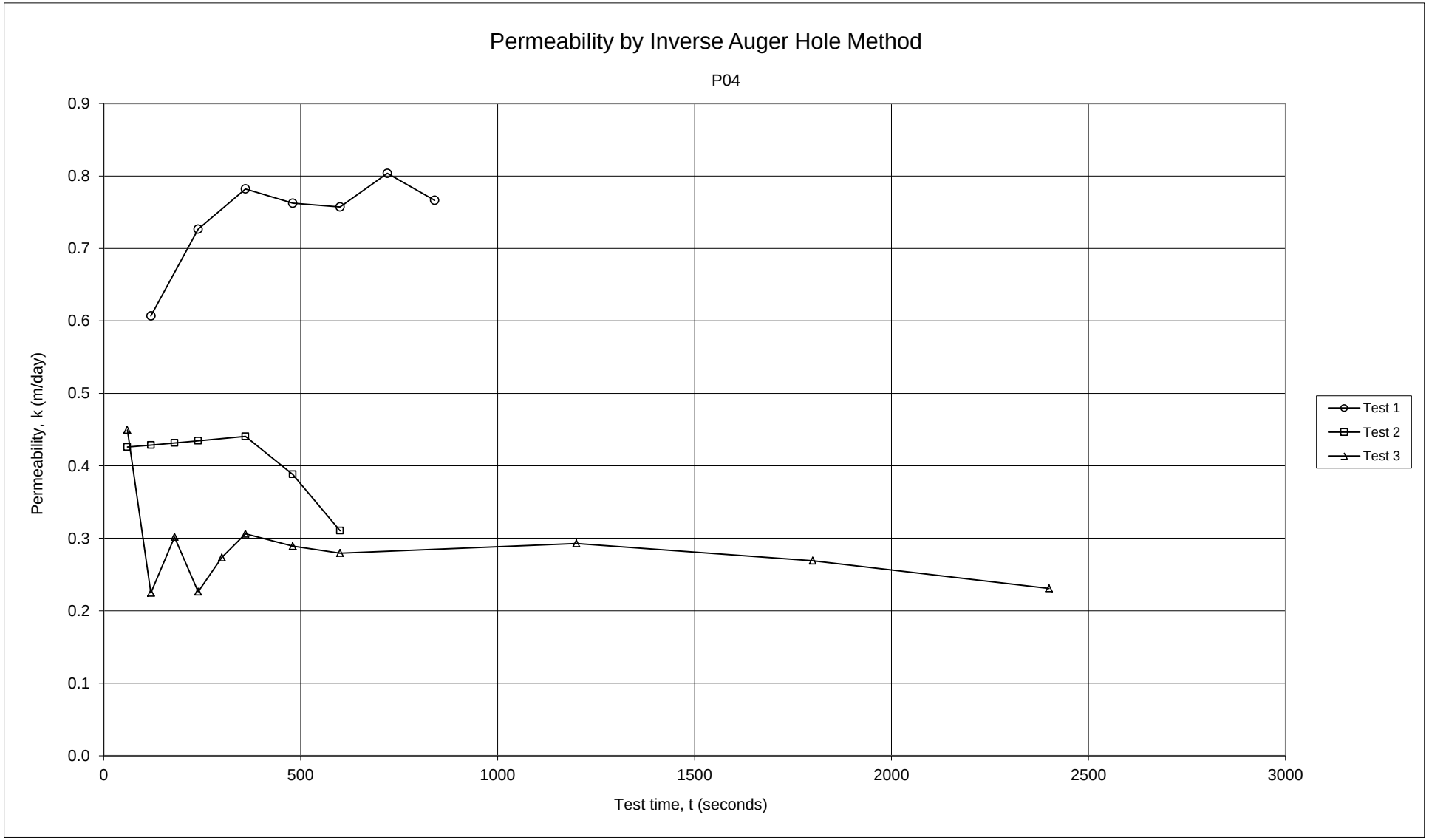
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.225	0.385		
120	0.24	0.37	7.0E-06	0.6
240	0.26	0.35	8.4E-06	0.7
360	0.28	0.33	9.1E-06	0.8
480	0.295	0.315	8.8E-06	0.8
600	0.31	0.3	8.8E-06	0.8
720	0.33	0.28	9.3E-06	0.8
840	0.34	0.27	8.9E-06	0.8
		AVERAGE	8.6E-06	0.7

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.25	0.36		
60	0.255	0.355	4.9E-06	0.4
120	0.26	0.35	5.0E-06	0.4
180	0.265	0.345	5.0E-06	0.4
240	0.27	0.34	5.0E-06	0.4
360	0.28	0.33	5.1E-06	0.4
480	0.285	0.325	4.5E-06	0.4
600	0.285	0.325	3.6E-06	0.3
		AVERAGE	4.7E-06	0.4

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.27	0.34		
60	0.275	0.335	5.2E-06	0.4
120	0.275	0.335	2.6E-06	0.2
180	0.28	0.33	3.5E-06	0.3
240	0.28	0.33	2.6E-06	0.2
300	0.285	0.325	3.2E-06	0.3
360	0.29	0.32	3.5E-06	0.3
480	0.295	0.315	3.3E-06	0.3
600	0.3	0.31	3.2E-06	0.3
1200	0.33	0.28	3.4E-06	0.3
1800	0.35	0.26	3.1E-06	0.3
2400	0.36	0.25	2.7E-06	0.2
		AVERAGE	3.3E-06	0.3


Permeability by Inverse Auger Hole Method
P04
Permeability, k (m/day)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
500
1000
1500
2000
2500
3000
Test time, t (seconds)
Test 1
Test 2
Test 3

Permeability Calculation - Inverse Auger Hole Method

Galt Geotechnics

Job No:	J1401062
Client:	QUBE
Site:	Lot 682 Rowley Road
Location:	Mandogalup
Calc by:	JH 11-Apr-14
BH Name:	P05
Test Depth:	0.57 m

Spreadsheet author:	ORW	17-Oct-09

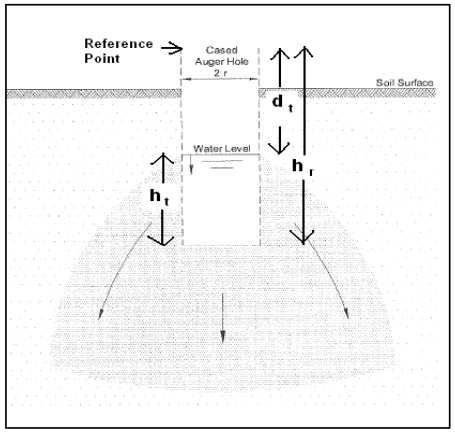
$$K = 1.15r\,\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114

Spreadsheet Legend

	Required input
	Calculated field
	Comment field
	Field not used
	Fixed field

Parameter	Description	Value	Units
K	Permeability		m/s
r	radius of test hole	0.045	m
t	time since start of measurement		s
h_r	reference point height above base	0.61	m
d_t	depth from reference point to water at time t		m
h_t	Water column height at time t		m
h_0	h_t at t=0		m



Test 1

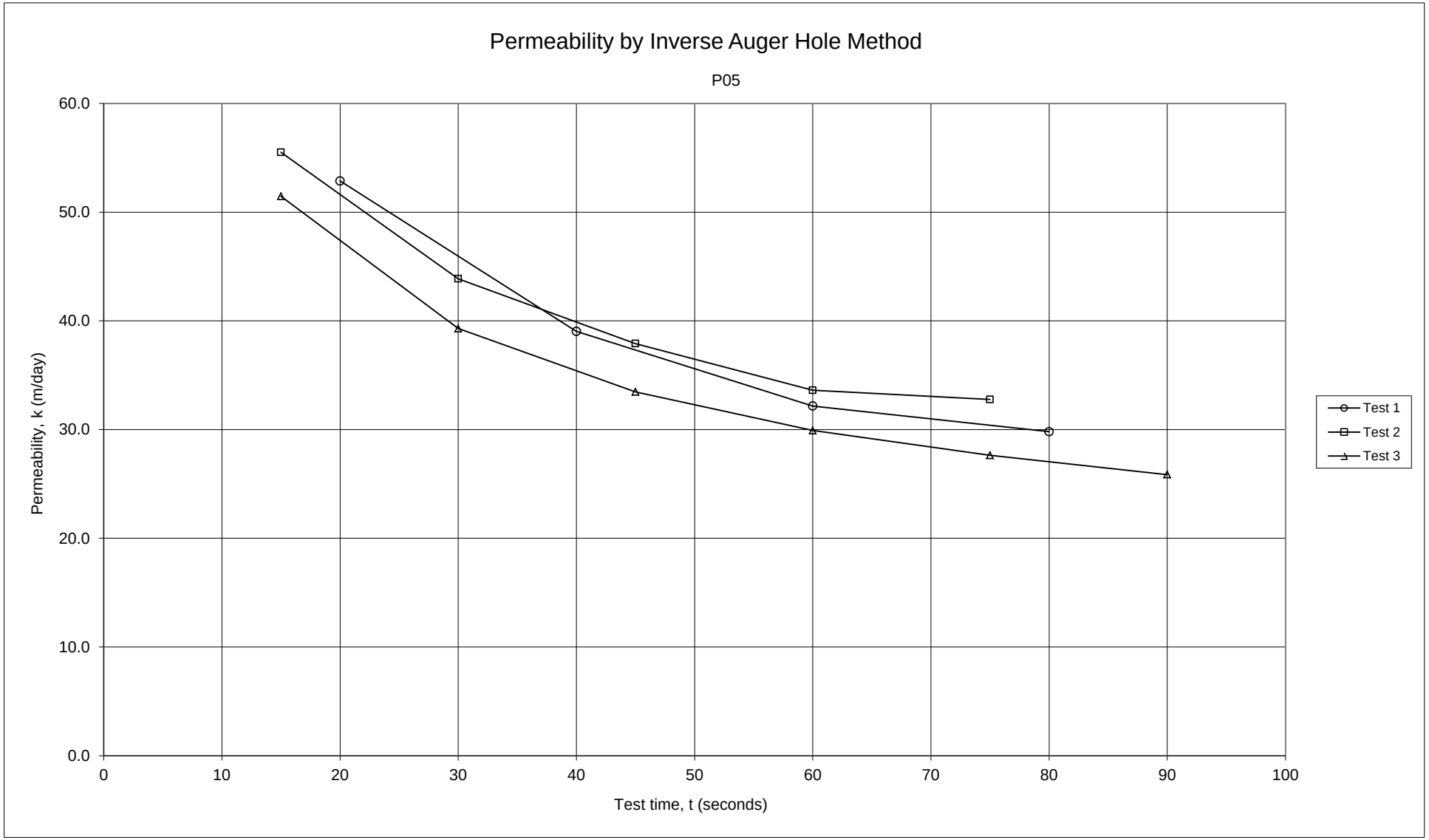
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.18	0.43		
20	0.37	0.24	6.1E-04	52.9
40	0.43	0.18	4.5E-04	39.0
60	0.465	0.145	3.7E-04	32.2
80	0.5	0.11	3.5E-04	29.8
		AVERAGE	4.5E-04	38.5

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.145	0.465		
15	0.315	0.295	6.4E-04	55.5
30	0.385	0.225	5.1E-04	43.9
45	0.43	0.18	4.4E-04	37.9
60	0.46	0.15	3.9E-04	33.6
75	0.495	0.115	3.8E-04	32.8
		AVERAGE	4.7E-04	40.7

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.16	0.45		
15	0.315	0.295	6.0E-04	51.5
30	0.375	0.235	4.5E-04	39.3
45	0.415	0.195	3.9E-04	33.5
60	0.445	0.165	3.5E-04	29.9
75	0.47	0.14	3.2E-04	27.6
90	0.49	0.12	3.0E-04	25.9
		AVERAGE	4.0E-04	34.6


Permeability by Inverse Auger Hole Method
P05
Permeability, k (m/day)
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
10
20
30
40
50
60
70
80
90
100
Test time, t (seconds)
Test 1
Test 2
Test 3

Appendix F: Laboratory Test Results

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Particle Size Distribution & Plasticity Index tests

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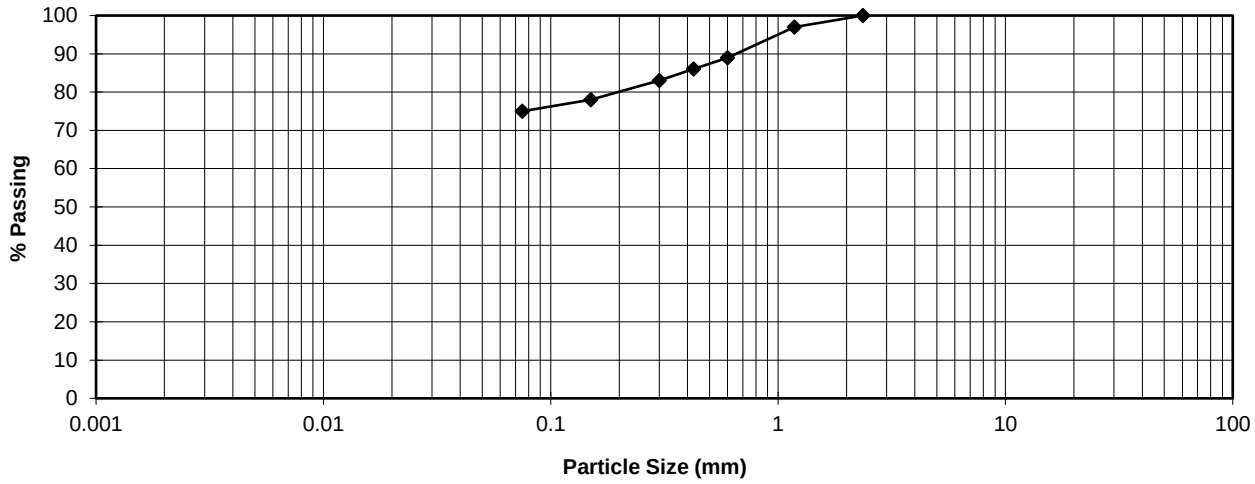
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: matt@mcgeotest.com.au

Job No:	60083
Report No:	60083-P14/1005
Sample No:	P14/1005
Issue Date:	23 April 2014

Client: Galt Geotechnics (J1401062)
Project: Proposed Residential Subdivision
Location: Lot 682 Rowley Road, Mandopalup

Sample ID: TP16
Sample Depth: 0.5-0.7



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	97
0.600	89
0.425	86
0.300	83
0.150	78
0.075	75

Plasticity index tests
AS 1289

Liquid limit 3.1.1	100	%
Plastic limit 3.2.1	76	%
Plasticity index 3.3.1	24	%
Linear shrinkage 3.4.1	7.0	%

Cracked ☐
Curled ☐

Client Address: 2/39 Flynn Street, Wembley WA

Sampling Procedure: Tested as received

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Matthew van Herk
AS PSDPI May 2009

Particle Size Distribution & Plasticity Index tests

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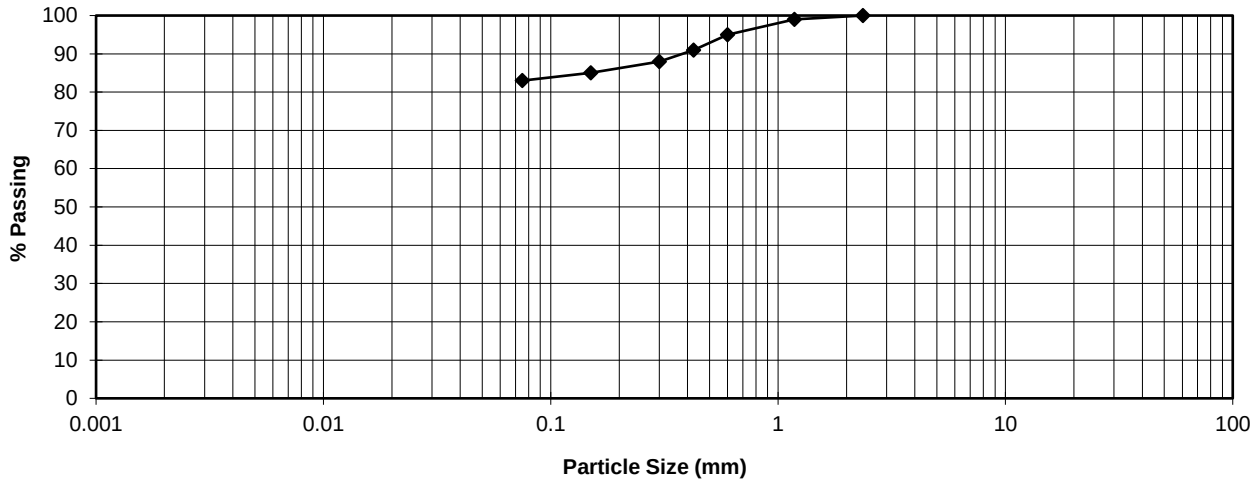
Job No:	60083
Report No:	60083-P14/1004
Sample No:	P14/1004
Issue Date:	23 April 2014

Client: Galt Geotechnics (J1401062)
Project: Proposed Residential Subdivision
Location: Lot 682 Rowley Road, Mandopalup

Sample ID: TP16
Sample Depth: 1.5-1.7



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	99
0.600	95
0.425	91
0.300	88
0.150	85
0.075	83

Plasticity index tests
AS 1289

Liquid limit 3.1.1	82	%
Plastic limit 3.2.1	26	%
Plasticity index 3.3.1	56	%
Linear shrinkage 3.4.1	13.5	%

Cracked ☐
Curled ☑

Client Address: 2/39 Flynn Street, Wembley WA

Sampling Procedure: Tested as received

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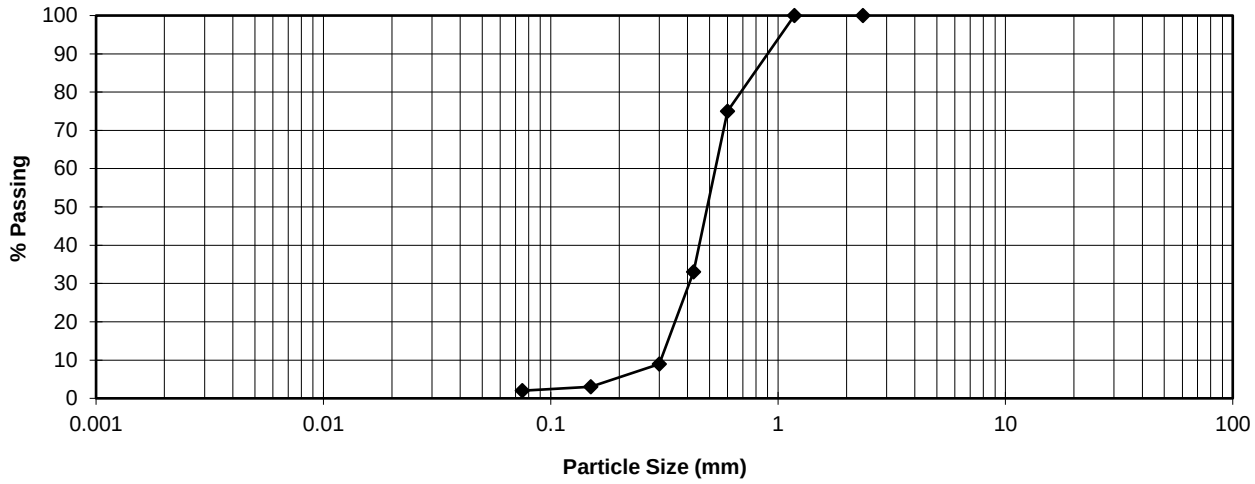
Email: matt@mcgeotest.com.au

Job No:	60083
Report No:	60083-P14/1006
Sample No:	P14/1006
Issue Date:	23 April 2014

Client: Galt Geotechnics (J1401062)
Project: Proposed Residential Subdivision
Location: Lot 682 Rowley Road, Mandopalup

Sample ID: TP41
Sample Depth: 0.2-0.5



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	100
0.600	75
0.425	33
0.300	9
0.150	3
0.075	2

Plasticity index tests
AS 1289

Liquid limit 3.1.1	SIC	%
Plastic limit 3.2.1	NP	%
Plasticity index 3.3.1	NP	%
Linear shrinkage 3.4.1	0.0	%

Cracked ☐
Curled ☐

Client Address: 2/39 Flynn Street, Wembley WA

Sampling Procedure: Tested as received

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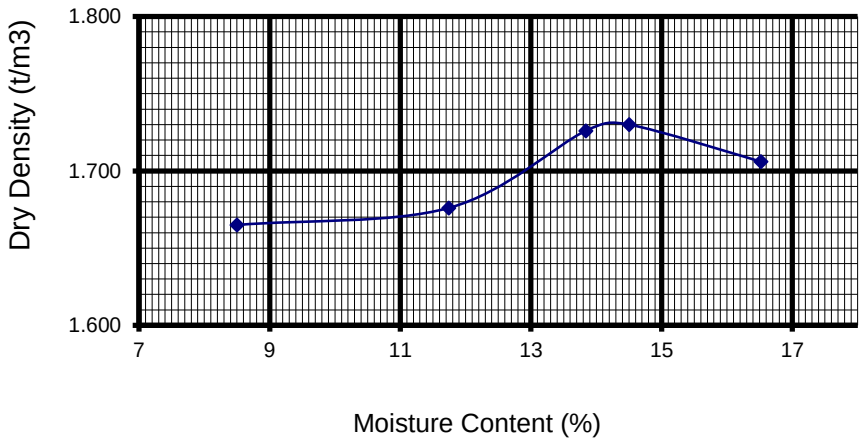
Email matt@mcgeotest.com.au

Maximum Dry Density (AS 1289.5.2.1) & California Bearing Ratio (AS 1289.6.1.1) Test Report

Certificate No:	60083-P14/1006	**Project:**	Proposed Residential Subdivision
Sample No:	P14/1006	**Client:**	Galt Geotechnics (J1401062)
Location:	Lot 682 Rowley Road, Mandopalup	**Date of Issue:**	23 April 2014
	TP41 0.2-0.5	**Job No:**	60083

Maximum Dry Density t/m^3:	1.730	**Conditions at Test**	
Optimum Moisture Content %:	14.5	Soaking Period (Days)	4
Desired Conditions:	95/100	Surcharge (kg)	4.5
Compactive Effort		Entire Moisture Content %	16.8
Mass of hammer kg	4.9	Entire Moisture Ratio %	116.0
Number of layers	5	Top 30mm Moisture Content %	16.2
Number of blows/layer	20	Top 30mm Moisture Ratio %	111.5
Conditions after Compaction		Swell %	0.0
Dry Density t/m^3	1.644	C.B.R. at 5.0 mm Penetration %	11
Moisture Content %	13.9	**Conditions after Soaking**	
Density Ratio %	95.0	Dry Density t/m^3	1.644
Moisture Ratio %	96.0	Moisture Content %	17.3
Soaked / Unsoaked	Soaked	Dry Density Ratio %	95.0
		Moisture Ratio %	119.0

Comments:



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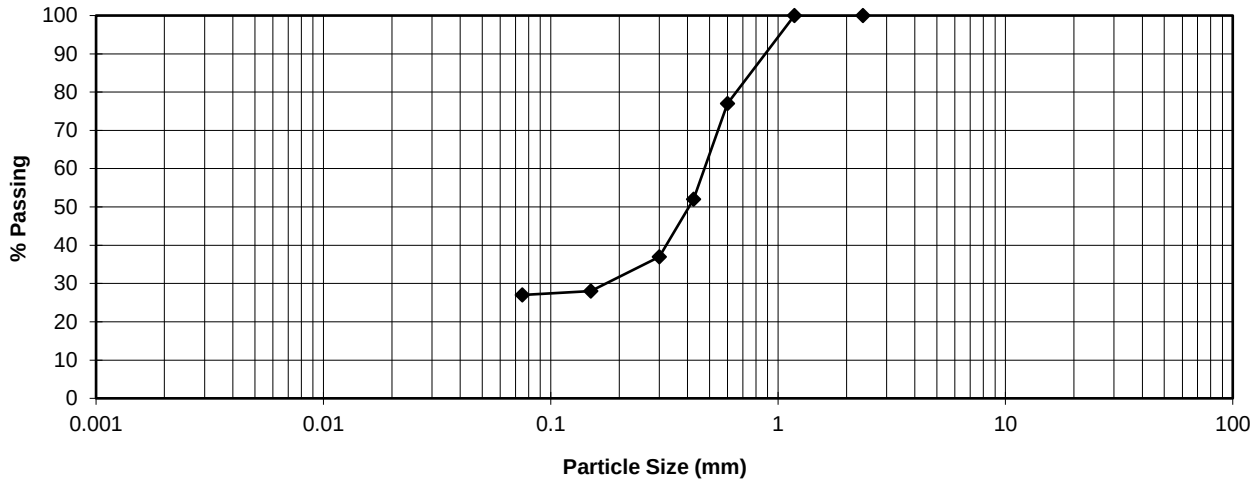
Email: matt@mcgeotest.com.au

Job No:	60083
Report No:	60083-P14/1007
Sample No:	P14/1007
Issue Date:	23 April 2014

Client: Galt Geotechnics (J1401062)
Project: Proposed Residential Subdivision
Location: Lot 682 Rowley Road, Mandopalup

Sample ID: TP46
Sample Depth: 0.6-0.9



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	100
0.600	77
0.425	52
0.300	37
0.150	28
0.075	27

Plasticity index tests
AS 1289

Liquid limit 3.1.1	50	%
Plastic limit 3.2.1	20	%
Plasticity index 3.3.1	30	%
Linear shrinkage 3.4.1	10.5	%

Cracked ☑
Curled ☑

Client Address: 2/39 Flynn Street, Wembley WA

Sampling Procedure: Tested as received

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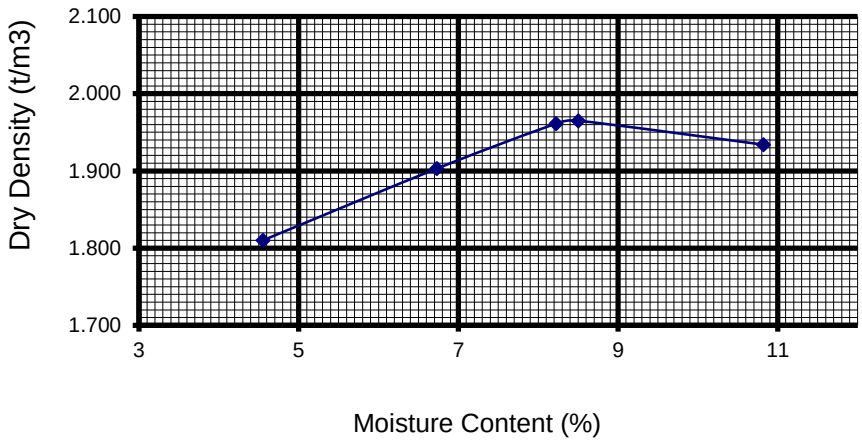
Fax (08)9414 8011
Email matt@mcgeotest.com.au

Maximum Dry Density (AS 1289.5.2.1) & California Bearing Ratio (AS 1289.6.1.1) Test Report

Certificate No:	60083-P14/1007	**Project:**	Proposed Residential Subdivision
Sample No:	P14/1007	**Client:**	Galt Geotechnics (J1401062)
Location:	Lot 682 Rowley Road, Mandopalup	**Date of Issue:**	23 April 2014
	TP46 0.6-0.9	**Job No:**	60083

Maximum Dry Density t/m^3:	1.965	**Conditions at Test**	
Optimum Moisture Content %:	8.5	Soaking Period (Days)	4
Desired Conditions:	95/100	Surcharge (kg)	4.5
Compactive Effort		Entire Moisture Content %	15.5
Mass of hammer kg	4.9	Entire Moisture Ratio %	182.0
Number of layers	5	Top 30mm Moisture Content %	18.9
Number of blows/layer	20	Top 30mm Moisture Ratio %	222.0
Conditions after Compaction		Swell %	3.0
Dry Density t/m^3	1.865	C.B.R. at 5.0 mm Penetration %	5
Moisture Content %	8.3	**Conditions after Soaking**	
Density Ratio %	95.0	Dry Density t/m^3	1.811
Moisture Ratio %	97.5	Moisture Content %	15.7
Soaked / Unsoaked	Soaked	Dry Density Ratio %	92.0
		Moisture Ratio %	184.5

Comments:



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Appendix G: Understanding Your Geotechnical Engineering Report

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UNDERSTANDING YOUR GEOTECHNICAL ENGINEERING REPORT

GALT FORM PMP11 Rev1

1. EXPECTATIONS OF A GEOTECHNICAL ENGINEERING REPORT

This document has been prepared to clarify what is and is not provided in your geotechnical report. It is intended to inform you of what your realistic expectations of this report should be and how to manage your risks associated with geotechnical conditions.

Geotechnical engineering is a less exact science than other engineering disciplines. We include this information to help you understand where our responsibilities as geotechnical engineers begin and end, to help the client recognise his responsibilities and risks. You should read and understand this information. Please contact us if you do not understand the report or this explanation. We have extensive experience in a wide variety of geotechnical problems and we can help you to manage your risk.

2. THIS REPORT RELATES TO PROJECT-SPECIFIC CONDITIONS

This report was developed for a unique set of project-specific conditions to meet the needs of the nominated client. It took into account the following :

- The project objectives as we understood them and as described in this report;
- the specific site mentioned in this report; and
- the current and proposed development at the site.

It should not be used for any purpose other than that indicated in the report. You should not rely on this geotechnical report if any of the following conditions apply:

- the report was not written for you;
- the report was not written for the site specific to your development;
- the report was not written for your project (including a development at the correct site but other than that listed in the report); or
- the report was written before significant changes occurred at the site (such as a development or a change in ground conditions).

You should always inform us of changes in the proposed project (including minor changes) and request an assessment of their impact.

Where we are not informed of developments relevant to your geotechnical engineering report, we cannot be held responsible or liable for problems that may arise as a consequence.

Where design is to be carried out by others using information provided by us, we recommend that we be involved in the design process by being engaged for consultation with other members of the design team and by being able to review work produced by other members of the design team which relies on geotechnical information provided in our report.

3. GEOTECHNICAL ENGINEERING LOGS

Our reports often include logs of intrusive and non-intrusive geotechnical investigation techniques. These logs are based on our interpretation of field data and laboratory results. The logs should only be read in conjunction with the report they were issued with and should not be re-drawn for inclusion in other documents not prepared by us.

4. THIRD PARTY RELIANCE

We have prepared this report for use by the client. This report must be regarded as confidential to the client and the client's professional advisors. We do not accept any responsibility for contents of this document from any party other than the nominated client. We take no responsibility for any damages suffered by a third party as a consequence of any decisions or actions they may make based on this report. Any reliance or decisions made by a third party based on this report are the responsibility of the third party and not of us.

5. CHANGE IN SUBSURFACE CONDITIONS

The geotechnical recommendations in this report are based on the ground conditions that existed at the time when the study was undertaken. Changes in ground conditions can occur in numerous ways including as a result of anthropogenic events (such as construction on or adjacent to the site) or natural events (such as floods, groundwater fluctuations or earthquakes). We should be consulted prior to use of this report so that we can comment on its reliability. It is important to note that where ground conditions have changed, additional sampling, testing or analysis may be required to fully assess the changed conditions.

6. SUBSURFACE CONDITIONS DURING CONSTRUCTION

Practical constraints mean that we cannot know every minute detail about the subsurface conditions at a particular site. We use engineering judgement to form an opinion about the subsurface conditions at the site. Some variation to our evaluated conditions is likely and significant variation is possible. Accordingly, our report should not be considered as final as it is developed from engineering judgement and opinion.

The most effective means of dealing with unanticipated ground conditions is to engage us for construction support. We can only finalise our recommendations by observing actual subsurface conditions encountered during construction. We cannot accept liability for a report's recommendations if we cannot observe construction.

7. ENVIRONMENTAL ISSUES

Unless specifically mentioned otherwise in our report, environmental considerations are not included. The investigation techniques used by us in developing our report differ from those for an environmental investigation. Our report was not prepared with environmental considerations in mind and it is the client's responsibility to satisfy himself that environmental considerations have been taken into account for the site. If you require guidance on how to proceed on evaluating environmental risk at the site, we can provide further information and contacts.

Appendix D

Local Water Management Strategy

(JDA)

Prepared for:

QUBE PROPERTY GROUP

Apsley Estate South

Mandogalup West Local Structure Plan Amendment

Local Water Management Strategy





July 2025

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J7489a	30 May 2024
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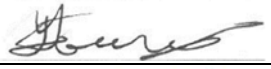
	Name	Signature	Date
Author	Michael Ioannidis		4 July 2025
Checked by	Matthew Yan		4 July 2025
Approved by	Jim Davies		4 July 2025

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1. EXECUTIVE SUMMARY

JDA has been appointed by QUBE Property Group to prepare a Local Water Management Strategy (LWMS) for the balance of the former Lot 682 Rowley Road, now referred to as Lot 9015 Rowley Road, and herein referenced as the Study Area, Figure 1.

This Local Water Management Strategy (LWMS) has been prepared to support the proposed amendment to the *Mandogalup West Local Structure Plan* (Roberts Day, 2017). The LWMS provides the framework for the application of total water cycle management to the proposed residential structure within the LSP amendment, consistent with the District Water Management Strategy (JDA, 2011), adjacent *Mandogalup West Local Water Management Strategy* (JDA, 2018a), Department of Water and Environmental Regulation's principles of Water Sensitive Urban Design as described in the *Stormwater Management Manual for Western Australia* (DWER, 2022), and *Better Urban Water Management* (WAPC, 2008).

A summary of the DWMS objectives and the LWMS design principles is presented in Table 1.

TABLE 1: SUMMARY OF LWMS DESIGN PRINCIPLES AND CRITERIA

Key Guiding Principles		
• Facilitate implementation of sustainable best practice in urban water management • Provide integration with planning processes and clarity for agencies involved with implementation • To minimise public risk, including risk of injury or loss of life. • Protection of infrastructure and assets from flooding and inundation. • To maintain the total water cycle.		
Category	**DWMS Objectives**	**LWMS Criteria**
Water Conservation and Sustainability	• Minimise the use of potable water where drinking water is not essential by considering all potential water sources and water demand requirements in water supply and land use planning. • Water efficiency initiatives include waterwise landscaping packages, public POS area to be at least 50% native vegetation. • Buildings are to comply with water efficiency standards introduced into the building code.	• Consider alternative fit for purpose water sources where appropriate and cost-effective. • Aim to achieve the State Water Plan target for water use of 100 kL/person/yr. • POS areas to be at least 50% native plants. • Buildings are to comply with water efficiency standards introduced into the building code.
Surface Water Management	• Minimise changes in hydrology to prevent impacts on receiving environments. • Manage water flows from major events to protect infrastructure and assets. • Apply the Principles of WSUD. • Adopt nutrient load reduction design objectives for stormwater runoff. • Floodplain management and urban drainage.	• Runoff from the 'small' event or first 15 mm of rainfall is to be treated and infiltrated at-source where possible. Runoff for urban development is to be detained within drainage areas in POS or in the Western Power Easement. • Area designated as Mandogalup Swamp Regional Flood Storage in DoW (2009) are maintained. • Culverts within and discharging to the Peel Main Drain from the Study Area are as agreed with Water Corporation. • Manage surface water flows from major events in road carriageways and POS to protect infrastructure from flooding and inundation. • Use of subsoil beneath drainage areas to facilitate adequate drainage of stormwater runoff. Subsoil invert levels are to be set at or above the pre-development AAMGL.
Groundwater Management	• Manage groundwater levels to protect infrastructure and assets • Maintain groundwater regimes for the protection of groundwater-dependent ecosystems • Protect the value of groundwater resources. • Adopt nutrient load reduction design objectives for discharges to groundwater.	• Protection of infrastructure and assets from flooding and inundation by high seasonal groundwater levels, perching and/or soil moisture. • Managing and minimising changes in groundwater levels and groundwater quality following development.
Water Quality	• Maintain and/or improve surface water and groundwater quality by implementing water sensitive urban design techniques to meet WQIP targets. • Adopt nutrient load reduction design objectives for stormwater runoff. • Use of amended soils and ephemeral bioretention systems to treat stormwater.	• Establishment of 'small' event bio-retention zones to treat a minimum of 2% of connected impervious areas of road catchments. • Non-structural controls to reduce applied nutrient loads. • Maintain groundwater quality at pre-development levels, mean winter concentrations and, if possible, improve the quality of water leaving the development area to maintain and restore ecological systems.
Monitoring and Implementation	• Adopt an adaptive management approach. • Maintain drainage and treatment structures.	• Groundwater monitoring (levels and quality) to quantitatively assess the hydrological impacts of the proposed development.

A number of assumptions have been made in the preparation of this report. Table 2 highlights a few key assumptions, but not all. Other assumptions and parameters are more comprehensively documented in this report.

TABLE 2: KEY HYDROLOGICAL PARAMETER VALUES USED IN THIS REPORT

Parameters	Section	Value or Source
Design Rainfalls	5	Bureau of Meteorology (2016)
Rainfall temporal patterns	5	Australian Rainfall & Runoff (Ball et al., 2019)
Hydraulic conductivity of imported fill	5,6	Minimum 5 m/day

2. INTRODUCTION

2.1 Background

This Local Water Management Strategy (LWMS) has been prepared by JDA Consultant Hydrologists on behalf of QUBE Property Group in support of the proposed amendment to the *Mandogalup West Local Structure Plan* [LSP] (Roberts Day, 2017). The existing LSP covers an area of 68.5 ha ('Apsley Estate') and this amendment proposes to include the balance of the former Lot 682 Rowley Road (26.7 ha), referenced to in this LWMS as 'Apsley Estate South', Figure 1.

The LWMS provides the framework for the application of total water cycle management to the proposed residential development, consistent with the *Mandogalup District Water Management Strategy* [DWMS] (JDA, 2011), *QUBE Land (Mandogalup West) LWMS* (JDA, 2018), and Department of Water and Environmental Regulation (DWER) principles of Water Sensitive Urban Design (WSUD) described in the *Stormwater Management Manual for Western Australia* (DWER, 2022). This document details stormwater, groundwater and water quality management, at a level of detail suitable for the purpose of the local planning scheme.

2.2 Statutory Framework

2.2.1 Regional Planning

The Study Area is currently zoned *Urban* in the Metropolitan Region Scheme and Development in the City of Kwinana Town Planning Scheme No. 2 (City of Kwinana, 1992).

The Western Australian Planning Commission [WAPC], in conjunction with the City of Kwinana prepared and adopted the Jandakot District Structure Plan [DSP] to provide a broad framework for land use, conservation and development of land within rezoning cells of Mandogalup, Wandi, Anketell, Casuarina and Wellard (East).

In support of the DSP, the Department of Water prepared the *Jandakot drainage and water management plan – Peel Main Drain Catchment* [DWMP] (DoW, 2009). It presented a district scale hydrological strategy to guide urban development which included regional groundwater and surface water modelling for both pre-development and post development conditions. Peak runoff compensation volumes for district sub-catchments discharging into the Peel Main Drain and guidelines for controlled groundwater levels are provided. The DWMP covered total water cycle management and ensures development can progress within the growing south-west corridor of the Perth Metro Area whilst still protecting groundwater resources associated with the Jandakot Mound and significant environmental assets.

The south-west corner of the Study Area intersects the subject boundary of the Mandogalup Improvement Scheme No. 1 (Improvement Plan 47 [IP47]) which was gazetted on 8 November 2024. The LWMS area within IP47 is designated as Residential, consistent with the existing regional planning.

2.2.2 District Planning

The Study Area is located within the Mandogalup development cell.

A DWMS for the area was prepared by JDA (2011) which provided guidance on water re-use options, stormwater detention basins, monitoring requirements and structural and non-structural controls for stormwater treatment. The DWMS was approved by the City of Kwinana and the then Department of Water (DoW), now Department of Water and Environmental Regulation [DWER].

2.2.3 Local Planning

This LWMS is presented in support of the proposed amendment to the *Lots 682 and 52 Rowley Road, Mandogalup LSP* (Roberts Day, 2017) and develops surface water and groundwater management strategies at a local scale.

This LWMS has been prepared in accordance with the requirements of the DWMP (DoW, 2009) and DWMS (JDA 2011) and is consistent with the strategies developed in the adjacent LWMS (JDA, 2018a) and subsequent Urban Water Management Plans [UWMPs] for Aspley Estate.

A copy of the LWMS checklist from the *Interim: Developing a local water management strategy* (DoW, 2008b) guidelines is attached as Appendix A.

2.3 Key Design Principles and Objectives

The LWMS employs the following documents to define its content, key principles and objectives:

- Peel Harvey WSUD Local Planning Policy (EPA, 2006)
- Better Urban Water Management (WAPC, 2008);
- Jandakot Drainage and Water Management Plan – Peel Main Drain Catchment (DoW, 2009);
- Guidelines for Subdivision Development (City of Kwinana, 2010);
- Mandogalup District Water Management Strategy (JDA, 2011)
- Local Governmental Guidelines for Subdivision Development (IPWEA, 2017);
- Decision Process for Stormwater Management in Western Australia (DWER, 2017a); and
- QUBE Land (Mandogalup West) Local Water Management Strategy (JDA, 2018a); and
- Stormwater Management Manual for Western Australia (DWER, 2022).

A summary of the key design principles and objectives is provided in Table 1 and summarised below.

2.3.1 Peel Harvey WSUD Local Planning Policy (EPA, 2006)

The Peel Harvey WSUD Local Planning Policy (EPA, 2006) was developed through the Federal Governments Coastal Catchments Initiative and endorsed by the Environmental Protection Authority (EPA). It aims to assist local government to help integrate catchment management objectives with land and resource planning in urban landscapes.

The policy identifies broad policy objectives against which strategic and statutory proposals can be assessed. WSUD principles, in order of priority, are outlined below:

- Provide protection to life and property from flooding that would occur in a 100-year Average Recurrence Interval (ARI) flood event.
- Manage rainfall events to minimise runoff as high in the catchment as possible. Use multiple low cost 'in-system' management measures to reduce runoff volumes and peak flows (for example, maximise infiltration from leaky pipes and stormwater pits installed above pollutant retentive material)
- Retain and restore existing elements of the natural drainage system, including waterway, wetland and groundwater features and processes, and integrate these elements into the urban landscape, possibly through a multiple use corridor.
- Minimise pollutant inputs through implementation of appropriate non-structural source controls (such as town planning controls, strategic planning controls, pollution prevention procedures, education and

participation programs and regulatory controls) and structural controls (that manage the quantity and quality of stormwater runoff and prevent or treat stormwater pollution)

- Maximise water use efficiency, reduce potable water demand, and maximise the re-use of water harvested from impermeable surfaces.

Water quantity management principles and objectives are provided based on post-development discharges being maintained relative to predevelopment levels. Criteria are provided for both ecological protection (1 in 1 year events), and flood protection (1 in 100 year events). Water quality management principles and objectives are based on maintaining or improving water quality relative to existing conditions.

Specific water quality guidelines are provided in the document including limitations on developments where average input rates of nutrients exceed 15 kg/phosphorus/ha per annum or 150 kg/nitrogen/ha per annum.

This policy is stated as holding no legal standing and envisages each local government in the Peel Harvey catchment will customise the model policy to suite its own specific requirements.

2.3.2 Better Urban Water Management (WAPC, 2008)

The guideline document *Better Urban Water Management* (WAPC, 2008), focuses on the process of integration between land use and water planning by specifying the level of investigations and documentation required at various decision points in the planning process. It outlines the requirement for preparation of a Local Water Management Strategy to guide and support water management concepts at the local structure plan level. This LWMS complies with the Better Urban Water Management process.

2.3.3 Jandakot Drainage and Water Management Plan (DoW, 2009)

The *Jandakot Drainage and Water Management Plan* provides guidance on the management of stormwater in the Peel Main Drain Catchment, and was prepared by DoW to support the Jandakot Structure Plan (WAPC, 2007)

The scope of the DWMP is to cover aspects of total water cycle management, including;

- Protection of significant environmental assets within the structure plan, including meeting their water requirements, managing potential impacts from development and protecting their cultural value.
- Alternative water supply options, opportunities for conservation and demand management measures, and wastewater management.
- Surface runoff, including both peak event (flood) management and the application of water sensitive urban design principles to frequent events.
- Groundwater, including the impact of urbanisation, variation in climate, installation of drainage to manage groundwater levels, potential impacts on the environment and the potential to use groundwater as a resource.
- Water quality management, which includes source control of pollution inputs by catchment management, acid sulphate soil management, control of contaminated discharges from industrial areas and management of nutrient exports from surface runoff and groundwater through structural measures.

2.3.4 Guidelines for Subdivision Development (City of Kwinana, 2010)

The City of Kwinana (CoK) Guidelines for Subdivision Development (CoK, 2010) provides details of the City's requirements regarding stormwater drainage management. The document provides both general guidelines at the strategic conceptual design level and also more specific detailed criteria for design of drainage systems (grades, subsoil drainage).

At the strategic level key design guidelines are citied as follows:

- Australian Rainfall and Runoff (Ball et al. 2019).
- Stormwater Drainage Design in Small Urban Catchments (J Argue, ARRB Special Report No 34).
- Subsurface Drainage of Road Structures (RJ Gerke, ARRB Special Report No 35).
- Water Sensitive Urban (Residential) Design Guidelines for Perth Metropolitan Region (Whelans et al, 1993).
- Stormwater Quality Management Manual (Water and Rivers Commission, 1998).

Specific criteria in relation to stormwater/groundwater are detailed as:

- Examine the total drainage catchment area and ensure that any upstream drainage is able to pass through the subdivision.
- Drainage network is designed to 10 year ARI except for arterial drainage and compensating storages to be designed to a 20 year ARI.
- Floor levels minimum 500 mm above 100 year ARI flood level in storages, main drains and watercourses.
- The pre-development AAMGL generally be maintained following development. Where AAMGL is within 1.2m of the design surface level, subsoils will be installed at AAMGL and fill imported. Subsoils are generally provided as a separate system.
- Water Sensitive Urban Design principles incorporated into the design.
- Open Drainage facilities have 1:6 side slopes.
- Nutrient filtration to occur prior to drainage water being released to a Water Corporation Main Drain.

2.3.5 Mandogalup District Water Management Strategy (JDA, 2011)

The *Mandogalup District Water Management Strategy* was prepared on behalf of QUBE Property Group and Satterley Property Group to support rezoning of Satterley (east) and QUBE (west) landholdings in Mandogalup and demonstrate that the area was capable of supporting the proposed urban zoning. The aims of the DWMS were to:

1. Define land area requirements for conveyance of flood flows and protection of future development from peak flood events.
2. Propose a drainage design strategy appropriate for local conditions in the strategy area that incorporates best practice water sensitive urban design measures. The strategy identifies Water Sensitive Urban Design practices to be implemented within both private allotments and the public domain, and the legal mechanisms by which all identified practices will be implemented.
3. Prescribe the design criteria for water quantity and water quality for each catchment.
4. Outline the hydrologic and hydraulic framework parameters and subsequently develop the overall drainage network concept.
5. Define an implementation framework for the drainage design objectives.
6. Recommend monitoring programs for water quantity and quality pre- and post-development as well as for ensuring hydraulic performance over the lifetime of the drainage structure.

2.3.6 QUBE Land Mandogalup Local Water Management Strategy (JDA, 2018)

The *QUBE Land Mandogalup Local Water Management Strategy* was prepared on behalf of QUBE Property Group to support the *Lots 682 and 52 Rowley Road, Mandogalup LSP* (Roberts Day, 2017). This LSP formed the western portion of the Mandogalup development cell with the balance falling within the adjacent Satterley Property Group landholding ('Mandogalup East').

The aims of the LWMS were to provide a framework for the application of total water cycle management at the local scale for the Roberts Day (2017) LSP and describe the integration of water management between this LSP and the adjacent Mandogalup East LSP and included:

- Ensuring the profile of the Peel Main Drain was consistent between the two developments;
- Ensuring the profile of the North-South connector road central median swale originating from the Satterley landholding appropriately transitioned at the QUBE landholding boundary;
- Drainage within the Primary School site was consistent between the LSPs;
- Drainage within the Playing Field was consistent between the two LSPs; and
- Ensuring the development interfaced with Retained Vegetation in the Satterley landholding.

2.3.7 Stormwater Management Manual for Western Australia (DWER, 2022)

The Water and Rivers Commission (Department of Water, DoW, 2006-2017; Department of Water and Environmental Regulation, DWER, 2017-present) released *A Manual for Managing Urban Stormwater Quality in Western Australia* in 1998 to define and practically describe Best Management Practices (BMP's) to reduce pollutant and nutrient inputs to stormwater drainage systems. The Manual also aimed to provide guidelines for the incorporation of water sensitive design principles into urban planning and design, which would enable the achievement of improved water quality from urban development.

The document was released to provide a guideline for best planning and management practices and was intended for use by Water and Rivers Commission, but also by other State and Local Government Authorities and sectors of the urban development industry.

In consultation with a working team comprising industry and government representatives a major review of the manual was completed in 2007. The revised manual was officially launched in August 2007.

Principle objectives for managing urban water in WA are stated as:

- Water Quality: To maintain or improve the surface and groundwater quality within development areas relative to pre-development conditions.
- Water Quantity: To maintain the total water cycle balance within development areas relative to the pre-development conditions.
- Water Conservation: To maximise the reuse of stormwater.
- Ecosystem Health: To retain natural drainage systems and protect ecosystem health.
- Economic Viability: To implement stormwater systems that are economically viable in the long term.
- Public Health: To minimise the public risk, including risk of injury or loss of life to the community.
- Protection of Property: To protect the built environment from flooding and waterlogging.
- Social Values: To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater.

- Development: To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles

The manual was reviewed and updated in 2022 from the August 2007 version to ensure all information contained in the document was correct and up-to-date.

3. PROPOSED DEVELOPMENT

Apsley Estate is a residential development located within the south-west corridor of the Perth Metropolitan Region in the City of Kwinana, approximately 25 km south of the Perth CBD and 15 km north-east of Rockingham, Figure 1. Development of Apsley Estate has progressed in the Mandogalup West LSP area as detailed in various approved UWMPs (JDA, 2018b, 2021 & 2024; Water Technology, 2022).

The Study Area, 26.7 ha, represents the south-west corner of Aspley Estate and is bound by residential development to the north and east and Mandogalup Swamp and rural lots to the south and west. The Peel Main Drain flows east to west through the Study Area.

The proposed Study Area land use in the LSP amendment (Hatch, 2024) is residential development, consistent with regional planning for the area. The land use for the LSP amendment is shown on Figure 2.

Key elements of the LSP amendment related to urban water management include:

- Retention and infiltration of frequently occurring rainfall events ('small' event) at-source within residential lots or within planted bio-retention areas in the down-gradient POS (road reserves).
- A pit- and pipe-system to convey minor stormwater event runoff from lots and roads to down-gradient drainage management areas. Road carriageways will be used as an overland flow path to convey stormwater runoff from major rainfall events to the drainage management areas.
- Realignment of the Peel Main Drain through the Study Area to the existing drainage corridor whilst maintaining the existing hydraulic capacity of the drain.
- Maintaining the proposed Mandogalup Swamp district flood storage within the Study Area.
- Retention of existing trees where possible, within open spaces, road reserves and within the Peel Main Drain drainage corridor.
- Use of local native species in open spaces and streetscapes to reduce nutrient input and conserve water resources.

A breakdown of the land use within the Study Area is presented in Table 3 below.

TABLE 3: LAND USE BREAKDOWN

Land Use Description	Area (ha)
Residential Lots	12.73
Road Reserve	6.20
Public Open Space (POS)	2.36
Western Power Easement	3.98
Peel Main Drain/District Flood Storage	1.39
Total	**26.66**

4. PRE-DEVELOPMENT ENVIRONMENT

4.1 Existing Land Use

The Study Area is currently undeveloped and extensively cleared of native vegetation. The southern portion of the Study Area primarily intersects Mandogalup Swamp and has been used primarily for market gardens and grazing. There are also two rows of tree windbreaks. The northern portion of the Study Area consists primarily of degraded bushland with a portion cleared for the Western Power Easement, Figure 1.

4.2 Topography

The pre-development topography (DoW, 2008a) of the Study Area is shown on Figure 3. Land north of the Peel Main Drain grades north to south/south-east from 35mAHD to 16 mAHD. Land south of the Peel Main Drain generally grades north-east to south-west from 19 mAHD to 13 mAHD with Mandogalup Swamp relatively flat at 13 to 14 mAHD.

The topography contours east of the Study Area on Figure 3 predate urban development.

4.3 Climate

The Mandogalup area is characterised by a Mediterranean climate with warm dry summers and cool wet winters.

Rainfall data is provided by the nearby Bureau of Meteorology *Anketell* rain gauge (Site ID. 009258), 3.4 km south-east of the Study Area, and the *Medina Research Centre* gauge (Site ID. 009194), 4.5 km south-west, Figure 4. The Medina Research Station gauge was closed in 2018 and formed part of a larger weather station operated by the Department of Primary Industries and Regional Development [DPIRD]. This weather station was relocated in 2018 to Harry Waring Marsupial Reserve in Wattleup, 3 km north-west of the Study Area and 6.9 km north-east of the previous location.

The average annual rainfall, 1984 to 2017, for Medina Research Station was 746 mm and for Anketell, 2002 to 2023, was 791 mm. The annual rainfall totals recorded at Anketell gauge were generally 50 to 100 mm higher than at the Medina Research Station. The 10-year average annual rainfall for Anketell, 2014 to 2023, is 779 mm, similar to the total station average. There is a general decreasing rainfall trend across south-west Western Australian since the 1970s (DoW, 2015), however, the nearest rain gauges to the Study Area predate this general shift. Monthly average totals show no significant trends. Across south-western Australia, there has also generally been a shift in rainfall distribution with reduction in winter rainfall but reductions or increases in rainfall in the drier summer months.

Average annual pan evaporation for the Study Area is estimated at 1,680 mm from monthly pan evaporation data at DPIRD's Wattleup weather station (2018-2023). This is similar to estimated average annual pan evaporation of 1,700 mm in Luke *et al.* (1987).

4.4 Geology and Soils

Surface geology mapping by Gozzard (1983) is shown on Figure 5.

The Study Area is mostly mapped as "Ms5" *Sandy Silt* with some "S8" *Sand* in the north. "Ms5" soils are dark brownish grey silt, with disseminated fine-grained quartz sand, firm, variable clay content and of lacustrine origin. "S8" *Sand* consists of fine to medium-grained sands, moderately well sorted and of aeolian origin.

A geotechnical investigation of the then Lot 682 Rowley Road was undertaken by Galt Geotechnics in 2014 involving the excavation of 60 test pits, TP01 to TP60, up to 2.5 m depth, Dynamic Cone Penetrometer testing adjacent to each test pit and in-situ permeability testing at 5 boreholes, P01 to P05, at depths of 0.41 to 0.57 m. Testing locations are shown on Figure 5 of which 16 test pits were within the Study Area.

The subsurface profile of the area was generally summarised in Galt Geotechnics (2014) as "*Sand: fine to coarse grained, sub-angular to sub-rounded, generally grey becoming pale yellow/white with depth, trace non-plastic fines in top 100 to 200 mm, trace rootlets/roots (up to 90 mm in diameter) in top 2.0 m, generally dry, generally very loose to medium dense, present from the surface extending to the maximum depth of investigation 2.5 m".*

The exception was the south-west corner of the area, as represented by test pits TP16, TP29, TP30 and TP32 within the Study Area which was summarised in Galt Geotechnics (2014) as "*Silty Sand / Sand: fine to coarse grained, sub-angular to sub-rounded, grey, trace non-plastic fines in top 100 to 200 mm, generally 5-20% non-plastic fines, locally trace non-plastic fines, dry to moist, generally loose to dense, locally very dense, present from the surface extending to depths of between 0.3 m to 0.6 m*" which overlay *"Clay: low to medium plasticity, pale grey becoming brown, trace rootlets, with some fine grained sand generally firm to stiff, locally hard, dry to moist, extending to the maximum depth of investigation of 2.5 m"*. Locally iron-cemented coffee rock was also encountered within test pits TP31 and TP43 within the south of the Study Area at depths of 1.3 m and 2.2 m, respectively.

In-situ permeability testing by Galt Geotechnics (2014) using the inverse auger hole method, derived unsaturated permeabilities ranging from 0.2 to 30 m/day. All testing was within sand except for P04 in peaty sand and none were within the Study Area.

In general, soils assessed in Galt Geotechnics (2014) were consistent with the regional mapping (Gozzard, 1983) except the sandy silt mapped across the southern extent (Ms5) of the site was clayey rather than silty.

The Geotechnical Report (Galt Geotechnics, 2014) is attached as Appendix B.

4.5 Acid Sulphate Soils

The Study Area is generally classified as Class 2, having a high to moderate risk of Acid Sulphate Soils (A.S.S.) occurring within 3 m of natural surface soils, and which generally aligns with mapped silty soils, Section 4.4 and Figure 5. The north of the Study Area is classified as Class 1, having a moderate to low risk of Acid Sulphate Soils (A.S.S) occurring less than 3 m from surface but high to moderate risk of A.S.S beyond 3 m of natural soil surface (DWER, 2017b).

An Acid Sulphate Soils Investigation and Management Plan was prepared for Roberts Day (2017) LSP (Strategen, 2018) in similar soils to the Study Area. Only 2 samples of the 279 sampled collected in Strategen (2018) exceeded the SPOCAS Net Acidity criteria of 0.03%. CRS analysis undertaken of these samples indicated that the acidity is likely due to organic acidity (from sulfidic peat soils) and not due to mineral acidity (Strategen, 2018).

A detailed A.S.S. Management Plan should be prepared for the Study Area at time of subdivision.

4.6 Groundwater

4.6.1 Regional Hydrogeology

Superficial Aquifer

The superficial aquifer in the vicinity of the Study Area is referred to as the Jandakot Mound. The aquifer has a maximum thickness of 40 m and includes three formations which are, in order of increasing depth: Bassendean Sand; Gnangara Sand; and Ascot Formation. Aquifer transmissivities range between 200 to 1,000 m^2/day (Davidson & Yu, 2008). The base of the superficial formation at the Study Area is at approximately -20 mAHD.

The Bassendean Sand consists of fine- to coarse-grained, moderately-sorted, sub-rounded to rounded quartz sand. The sand is mapped as highly permeable with horizontal hydraulic conductivity ranging between 10 m to 50 m/day.

Gnangara Sand beneath the Bassendean Sand consists of pale-grey, fine- to very coarse-grained, very poorly-sorted, sub-rounded to rounded quartz and feldspar (Davidson & Yu, 2008).

The Ascot Formation beneath the Gnangara Sand consists of hard to friable, grey calcarenite with thinly interbedded sand, with shell fragments commonly near the base of the formation. Sands are fine- to coarse-grained and are poorly sorted and angular to rounded in shape (Davidson, 1995).

Ascot Formation overlies the Kardinya Shale (part of the Osborne Formation) and which is a confining bed, consisting of moderately to tightly consolidated, interbedded siltstones and shales (Davidson, 1995).

Vertical fluctuations in the groundwater table may be several metres and occur seasonally, consistent with Perth's winter-dominated Mediterranean rainfall pattern. Rainfall recharge to the superficial aquifer is 15 to 25% of total annual rainfall (Davidson, 1995).

Leederville Aquifer

The Osborne Formation overlies the Leederville Formation with the base of the formation at the Study Area approximately -50 mAHD to -20 mAHD and includes the Kardinya Shale (confining bed) and Henley Sandstone formations. The Henley Sandstone formation is included in the Leederville Aquifer (Davidson & Yu, 2008).

The Leederville Aquifer is a major drinking water resource with groundwater salinity beneath the Jandakot Mound typically < 500 mg/L TDS ('fresh').

Yarragadee Aquifer

The South Perth Shale underlies the Leederville Aquifer and acts as the confining bed between the Leederville and Yarragadee aquifers (Davidson & Yu, 2008).

The Yarragadee aquifer is a major water resource with groundwater salinities south of Perth typically 1,000 to 2,000 mg/L TDS.

4.6.2 Groundwater Levels

Pre-development groundwater level monitoring was conducted by JDA for the DWMS (JDA, 2011) and reported in JDA (2010) from April 2007 to May 2009 and involved the drilling of 8 bores across Lots 52 & 682 Rowley Road. Of these, 3 bores were within the LWMS area, D3, D5(s) and D5(d), with the remaining 5 bores, D1, D2(s), D2(d), D4(s) and D4(d), located within the adjacent JDA (2018a) LWMS area to the east. Five additional bores were installed by JDA in May 2018, P01 to P05, and monitored between June 2018 and March 2019 for the JDA (2018a) LWMS. Three nearby DWER bores, JE12C, JM42 and JM49, were also monitored across the monitoring periods. Bore details are summarised in Table 4 with locations shown on Figure 6. The pre-development monitoring report, JDA (2010) and groundwater levels measured at the P-bores series are attached in Appendix C.

TABLE 4: DETAILS OF GROUNDWATER MONITORING BORES

Bore ID	Coordinates[1]		Natural Surface (mAHD)	Total Depth (mbToC)	Top of Casing (mAHD)	Screened Interval (mbNS)	AAMGL (mAHD)	MGL (mAHD)	Installation Date
	Easting	Northing							
D1	391871	6438874	26.96	11.0	27.5	8-11	20.55	21.30	24 July 2018
D2	391964	6438425	21.65	8.5	22.11	10.5-13.5	20.53	21.28	15 February 2022
D3	391341	6437726	25.92	15.0	26.38	12-15	14.63	15.38	15 February 2022
D4	391971	6437636	19.48	13.0	20.07	10-13	18.68	19.43	15 February 2022
D5	391267	6437342	13.21	8.0	13.81	10-13	13.00	13.21[2]	15 February 2022
P01	391671	6437778	16.59	4.0	17.19	1-4	-	-	15 February 2022
P02	391914	6438213	20.23	4.0	20.83	1-4	-	-	05 December 2022
P03	391453	6438032	25.99	17.7	36.59	14.7-17.7	-	-	05 December 2022
P04	391941	6437915	19.64	4.0	20.24	1-4	-	-	05 December 2022
P05	391675	6438020	19.28	5.0	19.88	2-5	-	-	05 December 2022
JE12C	391646	6438958	-	22.0	37.08	14-22	19.86	20.70	06 June 1975
JM42	393326	6437620	25.80	16.7	25.80	4.7-16.7	22.70	23.64	14 July 1975
JM49	393769	6439016	-	14.25	26.48	-	23.82	24.36	14 July 1975

Notes: mbNS = metres below natural surface; mAHD = metres Australian Height Datum;

1. Coordinates in GDA 1994.
2. MGL set to natural surface.

A pre-development Average Annual Maximum Groundwater Level (AAMGL) was calculated in the JDA (2018a) LWMS based on groundwater levels recorded at bores D1 to D5 on 07 August 2008 and correlated to long-term groundwater levels recorded at DWER bores JE12C, JM42 and JM49. The AAMGL calculated at each DWER bore, Table 5, had an average correction of +0.66 m which was applied to groundwater levels measured at bores D1 to D5 on the same date, Table 4. AAMGL contours were produced which extend across both the JDA (2018a) area and the Study Area, Figure 6 *left*.

TABLE 5: LONG-TERM DWER MONITORING BORE SUMMARY

Bore ID	Data Range	Water level 07 August 2007	AAMGL (mAHD)	MGL (mAHD)	Adjustment (MGL -AAMGL)
JE12C	1984 – 2007	19.05	19.86	20.70	0.84
JM42	1975 – 2007	21.48	22.70	23.64	0.94
JM49	1980 - 2007	23.86	23.82	24.36	0.54

Groundwater flow is generally north-east to south-west across Study Area from 17 mAHD to 13 mAHD. Pre-development AAMGL contours, Figure 6 *left,* show localised influences of a swale upgradient of the Study Area and the Peel Main Drain. The depth to pre-development AAMGL, Figure 6 *right* based on DoW (2008a) LiDAR DEM, shows groundwater is generally at or near natural surface south of the Peel Main Drain and greater than 3 m below natural surface north of the Peel Main Drain, Figure 6 *right*.

Pre-development Maximum Groundwater Levels (MGLs) are estimated to be about +0.75 m above pre-development AAMGL, based on the difference between AAMGL and MGL at DWER bores, with estimated MGLs at bores D1 to D5 summarised in Table 4.

Groundwater levels were measured at bores D3 and D5(s) on 02 October 2024 during a monitoring snapshot. The groundwater level at D3 was 15.13 mAHD and between the estimated AAMGL and MGL for the bore. At D5(s), there was an upward head in the bore with a groundwater level of 13.45 mAHD measured, 0.24 m above natural surface.

4.6.3 Groundwater Quality

Pre-development groundwater quality monitoring was conducted monthly for the DWMS (JDA, 2011) from April 2007 to March 2009 and reported in JDA (2010). Mean groundwater concentrations in DWMS bores within the Study Area (D3, D5(s) & D5(d)) are summarised in Table 6 from JDA (2010). A snapshot sampling event was conducted on 02 October 2024 to confirm the JDA (2010) results and summarised in Table 6.

The P-bore series in the JDA (2018) LWMS area (Table 4 and Figure 6) were sampled three times in 2018 on 25 June, 04 October and 12 December except P03 which was dry with mean results summarised in Table 6.

TABLE 6: GROUNDWATER QUALITY RESULTS SUMMARY

Bore	pH	EC (µS/cm)	TP (mg/L)	FRP[3] (mg/L)[3]	TN (mg/L)	TKN (mg/L)	NH_3-N (mg/L)	NO_x-N (mg/L)
2007 to 2009 Monitoring Program (JDA, 2010) – Mean results								
D3	5.72	1,230	0.19	0.03	3.60	1.97	0.29	1.65
D5(s)	6.97	710	0.16	0.06	1.25	1.16	0.46	0.09
D5(d)	6.75	850	0.36	0.04	1.71	1.64	0.34	0.07
2018 P-series Monitoring – Mean results								
P01	6.5	1,970	0.35	0.34	2.4	2.4	0.48	0.0037
P02	6.3	770	11	11	13	4.4	0.33	8.3
P04	4.0	910	0.35	0.37	6.2	6.2	0.62	0.026
P05	5.9	840	5	4.6	3.9	3.3	0.51	0.48
02 October 2024 Monitoring Snapshot								
D3	6.9	1,600	3.0	0.78	4.3	4.0	0.65	0.35
D5(s)	6.6	1,200	0.092	0.057	2.3	2.4	0.37	<0.05
Guideline Values								
WQIP[1]	-	-	0.2	-	-	-	-	-
ANZECC[2]	7.0 – 8.5	0.3 – 1.5	0.06	0.03	1.5	-	0.04	0.1

Notes: 1. Water Quality Improvement Plan (WQIP) for the Rivers and Estuary of the Peel-Harvey System (EPA, 2008) short-term target
2. Default trigger values for slightly disturbed wetland ecosystems in south-west Australia (ANZECC & ARMCANZ, 2000)
3. FRP = Filterable Reactive Phosphorus

A summary of the pre-development monitoring results (JDA, 2010) from the Study Area bores is as follows:

- Groundwater was generally fresh to marginally brackish and acidic tending more neutral in Mandogalup Swamp.
- Mean Total Phosphorus (TP) concentrations ranged from 0.16 mg/L (D3) to 0.36 mg/L (D5(s)) and were close to the WQIP (EPA, 2008) short-term target of 0.2 mg/L.
- Mean Total Nitrogen (TN) concentrations ranged from 1.25 mg/L (D5(s)) to 3.60 mg/L (D3) and were generally higher than the ANZECC & ARMCANC (2000) trigger value of 1.5 mg/L.
- Mean TP and TN concentrations in Study Area bores were generally lower than the mean concentrations across the wider monitoring area, as reported in JDA (2010). Nutrient concentrations in areas up-gradient of the Study Area are elevated and likely reflect the historical market garden activities across the area. At bores within the Study Area, nutrient concentrations were generally lower.

Monitoring results from the 02 October 2024 snapshot suggests water quality in these bores are generally within the range of the 2007-2009 pre-development monitoring results (JDA, 2010) albeit in some cases higher than mean results. The TP concentration at bore D3 of 3.0 mg/L on 02 October 2024 was substantially higher than the 2007-2009 range of 0.04 to 0.7 mg/L.

Monitoring results from the P-series bores from 2018 sampling events shows nutrient concentrations are lowest in bores adjacent to the Peel Main Drain, P01 & P04, and highest at upstream bores, P02 & P04, located adjacent to the eastern boundary of Apsley Estate; consistent with the pre-development monitoring trend detailed in JDA (2010).

4.6.4 Groundwater Resources for Irrigation

The Department of Water and Environmental Regulation manages the groundwater of the State under the Rights in Water and Irrigation Act 1914 (RIWI Act). The Study Area is located within the Mandogalup sub-area of the Jandakot Groundwater Management Area. The Mandogalup sub-area comprises areas bound by Rowley Road (north), Lyon Road (east), Anketell Road (south) and native bushland/sand quarry (west).

The superficial aquifer is the most feasible irrigation supply for the Study Area in the area.

The DWER groundwater allocation limit and water allocations from the superficial aquifer are shown in Table 7 based on a Resource Allocation Report from DWER as of 03 June 2025.

TABLE 7: DWER GROUNDWATER RESOURCE ALLOCATION AND LIMIT, JUNE 2025

GW Sub-Area	Aquifer	Allocation Limit Licencable component, (kL/yr)	Allocated volume (kL/yr)	Additional volume committed & requested (kL/yr)	% Allocated
Mandogalup	Superficial Swan	1,990,000	1,693,620	185,720	85.1

Allocations for the *Perth – Leederville* and *Perth – Yarragadee North* in the Jandakot Groundwater Area are solely held by Water Corporation.

As at 03 June 2025, the Resource Allocation Report indicates the superficial aquifer is close to fully allocated with 1,693,620 kL/year allocated, representing 85.1% of the sub-area allocation limit. A further 185,720 kL/year (9.3% of allocation limit) has been requested.

A water source is required for the irrigation of streetscapes and establishment and ongoing irrigation of vegetated and turfed areas within the POS.

QUBE Property Group, along with JJ White Pty Ltd and Greta White Pty Ltd, have a groundwater licence (GWL166922) for various landholdings within Mandogalup, Appendix D. This licence provides an allocation within the superficial aquifer for 724,935 kL/year. This allocation is predominantly related to the remaining market gardens within the area but also comprises irrigation water for earlier stages constructed in Apsley Estate.

As operation of the surrounding market garden continues to decrease with further urban development, the volume of water being abstracted will also decrease. For the existing LSP area (Roberts Day, 2017), JDA (2018a) estimated a long-term irrigation demand of 82,500 kL/year. For the Study Area, the estimated long-term irrigation demand for streetscapes/POS is 23,910 kL/year. The combined estimated irrigation demand for Apsley Estate, 106,410 kL/year, is significantly lower than the licenced groundwater allocation of 724,935 kL/year. Amendments to this licence are required to reflect changes to uses and entitlements.

4.7 Surface Water Hydrology

4.7.1 Existing Surface Hydrology

The Study Area is located within the Peel Main Drain subcatchment of the Peel- Harvey Estuary. The Peel Main Drain subcatchment covers an area of approximately 125 km^2, just over half of which has been cleared for urban development and agriculture (DWER, 2023). The Peel Main Drain is a highly modified system supplied by a number of rural drains which were constructed to remove water quickly from cleared urban and agricultural areas (DWER, 2023). The Drain generally flows in a north to south direction through numerous wetlands and low-lying areas prior to discharging into Serpentine River which in turn flows into the Peel-Harvey Estuary, Figure 7 *insert*.

The pre-development topography indicates that any stormwater runoff generated from the Study Area, such as from saturated areas flows towards the Peel Main Drain. The Peel Main Drain flows through Mandogalup Swamp south of the Study Area before flowing on into the Spectacles Wetland south of Anketell Road, Figure 7.

The Peel Main Drain was modelled in of DoW (2009) as described in Section 2.3.3. DoW (2009) identified Mandogalup Swamp as an important regional flood storage which serves as a buffer for the Spectacles wetlands by reducing peak discharges and moderating fluctuations in water levels. Drainage catchments and peak allowable outflows for the Peel Main Drain are detailed in Section 6.2.

McMullan Nolan Group (MNG, 2008) conducted a survey of the Peel Main Drain between Lyon Road and Mandogalup Road and found survey inverts differed from those presented in the Jandakot DWMP (DoW, 2009). Subsequent survey (MNG, 2017) was conducted of the drainage reserve within the Study Area. Both surveys are attached as Appendix E.

4.7.2 Peel Main Drain Water Levels and Flows

JDA conducted monitoring of the Peel Main Drain at 3 sites, PMD1 to PMD3, between April 2007 and May 2009 using water level data loggers and visual estimation of flow rate. Site locations are shown on Figure 7 with results detailed in JDA (2010).

The Peel Main Drain flowed for 22 out of the 24 months at PMD1 across the April 2007 and May 2009 monitoring period but only after the winter months in the same period at PMD3. Of these flows, there was only one significant period at PMD3 where the water level was above the station cease to flow level. This was between 30 July 2008 and 19 August 2008, and a flow estimate of 46 L/s was recorded by JDA on 7 August 2008. The maximum water depth recorded was 0.15 m. The water level at site PMD2 at the south-west corner of the Study Area was largely controlled by groundwater seepage rather than upstream flows and was generally stagnant at depths of less than 0.30 m for approximately 90% of the monitoring period.

Additional monitoring was undertaken by JDA from October 2018 to November 2019 on the request of DWER and City of Kwinana. Water level loggers were reinstalled at sites PMD1 to PMD3 and quarterly manual water level measurements were captured. Logged water levels for this period are shown on Figure 8.

4.7.3 Peel Main Drain Water Quality

Water quality in the Peel Main Drain is monitored by DWER at site 614121 at Karnup Road, just upstream of the confluence of the Peel Main Drain and Serpentine River, Figure 7 *insert*. Nutrient concentrations (total nitrogen and total phosphorus) are classified as high (nitrogen) and very high (phosphorus), representing the high-intensity agricultural and urban land use within the catchment and highly modified drainage system (DWER, 2023). The estimated average annual nutrient loading, 2007 to 2019, at site 614121 is 10.9 tonnes TN and 1.6 tonnes TP (DWER, 2023). Nitrogen was mostly present in the form of dissolved organic nitrogen, consisting mainly of degrading plant and animal matter, with concentrations following a seasonal pattern and highest in the wetter months (July to

September) (DWER, 2023). Phosphorus was mostly present in the form of highly bioavailable phosphate which was likely sourced from fertilisers and animal waste as well as natural sources (DWER, 2023). Surface water in the Peel Main Drain at site 614121 mostly fluctuated around neutral pH (range of 6 to 8) and were marginally brackish with salinity of 500 to 1,000 mg/L (DWER, 2023).

Water quality in the Peel Main Drain was sampled by JDA at 3 sites, PMD1 to PMD3, between April 2007 and March 2009 when flowing and reported in JDA (2010). Additional samples were collected by JDA at PMD1 (October and December 2018, June and September 2019), PMD2 (June 2019) and PMD 3 (October 2018, June and September 2019) and analysed for pH, EC and nutrients. JDA water quality results are summarised in Table 8.

A snapshot sampling event was conducted on 02 October 2024 at site PMD3 and new locations at the upstream and downstream boundary of the Study Area, sites PMD4 and PMD5 as shown on Figure 7. Results of this sampling event are summarised in Table 9.

TABLE 8: PEEL MAIN DRAIN WATER QUALITY RESULTS

Analyte	Location	Sampling Date							
		18-Sep-07	11-Oct-07	07-Aug-08	22-Oct-08	04-Oct-18	12-Dec-18	27-Jun-19	11-Sep-19
pH	PMD1	6.9	6.7	6.5	5.9	6.9	6.5	6.9	7.0
	PMD2	-	-	-	-	-	-	6.7	-
	PMD3	6.1	5.5	5.9	5.5	6.7	-	-	6.6
	PMD4	-	-	-	-	-	-	-	-
EC (mS/cm)	PMD1	0.57	0.53	1.08	0.32	0.79	0.69	0.82	1.1
	PMD2	-	-	-	-	-	-	1.7	-
	PMD3	1.08	0.77	0.88	0.67	0.82	-	-	1.0
	PMD4	-	-	-	-	-	-	-	-
TN (mg/L)	PMD1	0.85	0.49	1.9	0.97	1.7	2.6	1.4	2.2
	PMD2	-	-	4.5	-	-	-	6.5	-
	PMD3	1.8	1.3	2.9	2.9	2.2	-	-	2.0
	PMD4	-	-	-	-	-	-	-	-
TP (mg/L)	PMD1	0.06	0.11	0.18	0.16	0.26	2.4	0.07	0.23
	PMD2	-	-	-	-	-	-	0.19	-
	PMD3	0.15	0.12	0.12	0.76	0.19	-	-	0.16
	PMD4	-	-	-	-	-	-	-	-

TABLE 9: PEEL MAIN DRAIN WATER QUALITY - 02 OCTOBER 2024 SNAPSHOT

Bore	PMD3	PMD4 (U/S boundary)	PMD5 (D/S boundary)
Physico-chemical			
pH	6.6	7.0	7.0
EC (mS/cm)	0.55	0.50	0.49
TSS (mg/L)	42	8.5	7.5
Nutrients (mg/L)			
TP	0.10	0.89	0.87
FRP	0.041	0.94	0.96
TN	2.6	2.7	2.3
TKN	2.6	2.3	2.1
NH_3_N	0.15	0.11	0.045
NO_x_N	0.013	0.45	0.19

Surface water sampling results suggest the surface water flows within the Peel Main Drain at sites PMD1 to PMD3 are slightly acidic and fresh to marginally brackish, similar to regional monitoring (DWER, 2023). Monitoring results in the 02 October 2024 snapshot (Table 9) are generally consistent with previous monitoring in the Peel Main Drain (Table 8) except Phosphorus concentrations are elevated adjacent to the Study Area (PMD4 & PMD5) compared to the

upstream site (PMD3) and may relate to nearby disturbances to site PMD4 from dewatering and construction activities.

The Water Quality Improvement Plan (WQIP) for the Rivers and Estuary of the Peel-Harvey System (EPA, 2008) provides Total Phosphorus (TP) targets for the Peel Main Drain. The target median winter TP concentration is 0.2 mg/L in the short-term and 0.1 mg/L in the long-term. The Median TP at PMD1 and PMD3 was approximately at the short-term target level. There was insufficient winter data for PMD2 to calculate a median TP concentration.

The WQIP does not provide targets for Total Nitrogen (TN). ANZECC & ARMCANZ (2000) gives a default trigger value of 1.2 mg/L for TN for slightly disturbed lowland river ecosystems in south-west Australia. The Median TN at PMD1 and PMD3 exceeds this trigger value with insufficient data for PMD2 to calculate a median TN concentration. This aligns with nutrient modelling in Hennig et al. (2021) which suggests the flow-weighted nutrient concentration (2006 to 2015) for the Peel Main Drain catchment is 1.7 mg/L. Elevated TN concentrations in the Peel Main Drain are consistent with groundwater quality (Section 4.6.3) and former agricultural land use of the area.

TN and TP concentrations at JDA surface water sites PMD1 to PM3 are similar to regional monitoring at DWER site 614121 as reported in DWER (2023).

4.8 Wetlands and Vegetation

Geomorphic Wetland mapping of the Swan Coastal Plain (DBCA, 2016), Figure 7, generally shows areas south of the Peel Main Drain through the Study Area as Multiple Use wetland (UFI 6530). Multiple Use wetlands do not preclude development and no wetlands are proposed for retention within the Study Area.

Approximately 3 km to the south of the Study Area is the Spectacles Wetland, a Conservation Category Wetland containing significant flora, a number of significant mammal and reptile species and an important waterflow breeding site. The Peel Main Drain contributes approximately 48% of the water entering the Spectacles, with the remainder from groundwater throughflow (DoW, 2009).

There is no Bush Forever within the Study Area.

A Flora, Vegetation, Fauna and Wetland Assessment and survey was conducted over the Mandogalup West LSP area (Roberts Day, 2017) with a subsequent study conducted by Plantecology Consulting in 2012. During the surveys, no Declared Rare, Priority or Significant flora species were located within the LSP area, and no Threatened Ecological Communities were located during the survey and are not thought to occur within a 5km radius of the area (Roberts Day, 2017).

4.9 Contaminated Sites

A search of DWER's publicly available Contaminated Site Database (accessed 01 May 2024) indicated no contaminated sites within a 1 km radius of the Study Area.

The Alcoa Residue Storage Area, located 1.2 km down-gradient of the Study Area, is classified as *Contaminated – Remediation required* due to an alkali groundwater contamination which extends up to 100 m up-gradient (DWER, 2023; Rockwater, 2019).

JDA notes the publicly available database only identifies 3 of the 7 contaminated sites classifications: *Contaminated – restricted use; Contaminated – remediation required*; *and Remediated for restricted use*. The remaining classifications are *Report not substantiated*; *Possibly contaminated – investigation required*, *Not contaminated – unrestricted use;* and *Decontaminated*.

4.10 Aboriginal Heritage

There are no registered aboriginal places within a 2 km radius of the Study Area.

The nearest registered place is *Wattleup Road Swamp* (ID: 4357) and is located 2.5 km down-gradient of the Study Area. The Aboriginal Cultural Heritage Enquiry System (DPLH, 2024) denotes this area as "*artefacts / scatter*".

5. WATER SUSTAINABILITY

5.1 Water Supply and Wastewater

Scheme and wastewater services will be extended from existing services with a new connection for the Study Area with sewer and water supply lines to be contained within a common services alignment.

Current Water Corporation [Water Corp] planning indicates the Study Area will be serviced by extension of an existing DN500 distribution main. This extension is a Water Corp capital project and would be extended south as demand requires (Cossill & Webley, 2024).

The Study Area forms part of Water Corp's Thompson's Lake wastewater reticulation system and will be serviced via construction of a new Type 90 Pump Station that will service all future development west of Kwinana Freeway (Cossill & Webley, 2024). This new pump station will include a pressure main north through the existing Western Power easement up to Barfield Road to connect to an existing sewer discharge tower near the intersection of Jackadder Avenue (Cossill & Webley, 2024).

Servicing of the proposed development is further detailed in the Engineering Report (Cossill & Webley, 2024).

5.2 Water Efficiency Measures

Lot Efficiency Measures

The State Planning Policy 2.9 regarding water resources (WAPC, 2006) requires new developments to employ a total water cycle approach to the consideration of water resources. Water Conservation initiatives are vital in reducing water demand and can reduce strain or delay timing of potable water supply infrastructure. JDA notes that a draft State Planning Policy (SPP) 2.9 was released for public comment in September 2021 which amalgamates and synthesises various SPPs into a single planning document including SPP 2.9. The revised SPP 2.9, once published as final, should be used to further inform appropriate water management measures.

Water Conservation initiatives are vital in reducing water demand and can reduce strain or delay timing of potable water supply infrastructure.

The Water Conservation Strategy for the development is detailed below. Water Conservation initiatives to be considered for adoption are to be outlined below.

- Use of water-wise practices at the lot scale, including water efficient fixtures and fittings (WELD rated taps, showerheads, toilets, appliances, rainwater tanks) and water-wise landscaping including native plant species;
- Initiatives to encourage waterwise landscaping of residential lots including use of native plant species, hydrozoning, mulching, soil amendments, water retention products and installation of appropriate irrigation fixtures; and

  Buildings constructed to current 7-star building standards as per the current National Construction Code [NCC]. The NCC 2022 was published on 01 October 2022 and incorporates a minimum 7-star energy efficient rating for new dwellings. NCC 2022 was adopted on 01 May 2023 by the WA Government with the residential energy efficiency provisions mandatory from 01 May 2025

Conservation measures aim to reduce scheme water consumption in the development area within the constraints of the site.

Public Open Space (POS) Efficiency Measures

The POS will incorporate turfed areas, remnant trees and plantings of low water use-vegetation. Mulches and ground covers will be used to increase the efficiency of irrigation and conserve water. Where appropriate, native species will be used in drainage and other landscaped areas. The irrigation system will be designed to water wise principles.

The estimated irrigation area within the Study Area is approximately 2.95 ha, including POS, bio-retention areas and irrigation of major streetscapes. Establishment only irrigation, 2 to 3 years, is proposed for bio-retention areas. Irrigation of POS, including larger drainage areas (> 'small event'), and road verges and medians will have establishment and ongoing irrigation of turfed areas. The Landscape Masterplan for Apsley Estate South (Plan E, 2025) is attached as Appendix F.

QUBE Property Group, along with JJ White Pty Ltd and Greta White Pty Ltd, have a groundwater licence (GWL166922) for various landholdings within Mandogalup, Appendix D. This licence provides an allocation within the superficial aquifer for 724,935 kL/year. Assuming an irrigation application rate of 7,500 kL/ha/year, the estimated irrigation requirement for the Study Area is 23,910 kL/year. Combined with the existing estimated irrigation demand for Apsley Estate, 82,500 kL/year in JDA (2018a), the estimated irrigation demand for Apsley Estate of 106,410 kL/year is significantly lower than the licenced groundwater allocation of 724,935 kL/year. Amendments to this licence are required to reflect changes to uses and entitlements.

6. STORMWATER MANAGEMENT

6.1 District Drainage

6.1.1 Peel Main Drain

The current Peel Main Drain alignment will mostly be preserved through the Study Area except within the centre of the Study Area where the drain doesn't align with the drainage easement, Figure 1. This section will be realigned to the drainage easement with the channel constructed similar to existing, Figure 2. The final Drain profile must achieve sufficient hydraulic capacity to convey the post-development 1% AEP flow, as specified in DoW (2009) and shown on Figure 9 *right*, and maintain the current Drain easement width of 20 m. The realignment is to be approved by both Water Corporation and the City of Kwinana.

Note the post-development Peel Main Drain peak water levels in this report will differ from those shown in DoW (2009) as incorrect drain inverts were used in DoW (2009). JDA's modelling of the Peel Main Drain has used MNG (2008 & 2017) survey of the drain, Appendix E.

6.1.2 Mandogalup Swamp

The south-west corner of the Study Area is part of Mandogalup Swamp, a highly modified wetland currently used for agriculture. DoW (2009) identified Mandogalup Swamp as an important regional flood storage area which serves as a buffer for the downstream Spectacles wetlands.

DoW (2009) assessed four scenarios for post-development land use to quantify the impact of partial or full filling of the Swamp on the hydraulic capacity of the Peel Main Drain and flood protection within the area. Based on the magnitude of impact of the filling of the Swamp, the then Department of Water and Town of Kwinana identified *Scenario 3 – Mandogalup Swamp north partially retained* – only power line and pipeline corridors undeveloped, shown on Figure 9, as the preferred scenario in DoW (2009) due to minimal and manageable effect on the Spectacles Wetlands. Adoption of Scenario 3 allows for an increase in discharge from pre-development flows and a reduction in storage volume in Mandogalup Swamp, Table 10.

The water level and volume in Mandogalup Swamp North for the 100 year ARI (1% AEP) storm event with pre- and post-development land use is summarised in Table 10. Ultimate Development in DoW (2009) assumed adoption of Scenario 3.

TABLE 10: 1% AEP PRE- AND POST-DEVELOPMENT LEVELS AND VOLUME OF MANDOGALUP SWAMP (DOW, 2009)

	Water Level (mAHD)		Storage Volume, Mandogalup Swamp (m^3)	Peak Discharge, Mandogalup Road (m^3/s)
	Mandogalup North	Spectacles North		
Pre-Development	13.5	9.4	85,900	1.5
Ultimate Development Scenario 3 (Swamp partially retained; power line and pipeline corridors undeveloped)	13.7	9.6	68,700	2.0

The proposed portion of the Mandogalup Swamp flood storage within the Study Area based on DoW (2009) is shown on Figure 9. The flood storage area has been refined in the IP47 plan and will be retained at pre-development surface levels which range from 13.1 to 13.5 mAHD and is wholly retained within the Western Power easement within the Study Area.

In the 100 year ARI (1% AEP) event and a peak water level of 13.7 mAHD, ponded depths in the flood storage within the Study Area will range from 0.2 to 0.6 m, similar to the flood depth across the proposed Scenario 3 Mandogalup Swamp area.

6.2 Design Criteria

Surface water drainage catchments for the Peel Main Drain from DoW (2009) are shown on Figure 9 and detailed in Table 11. The Study Area intersects parts of subcatchments CAT17A, CAT17B, CAT18A and CAT19. Where a proposed development forms a part of one or more of the subcatchments, allowable peak flows for that development are calculated based on the subcatchment surface area as a percentage of the total subcatchment surface area (DoW, 2009).

TABLE 11: DRAINAGE CATCHMENTS AND ALLOWABLE OUTFLOW

Catchment	DoW (2009) Catchment Area (ha)	DoW (2009) Peak Discharge (m^3/s)	Area within/draining via LWMS	LWMS Pro-rata Allowable Outflow (m^3/s)
CAT17A	85.2	0.16	19.4[1]	0.036
CAT17B	31.7	0.09	3.9	-
CAT18A	81.6	0.30	3.1	-
CAT19	97.4	0.10	3.1	-
Total	295.9	0.65	29.5	0.036

Note: 1. Includes section of JDA (2018) LWMS (2.9 ha) which is within CAT17B (Figure 9 *right*).

The allowable peak flow rate from the Study Area for catchment CAT17A (0.036 m^3/s) is calculated on a pro-rata basis from the DoW (2009) catchment peak flow shown in Table 11 (0.16 m^3/s), which is also presented in the DWMS (JDA, 2011). A section of the JDA (2018a) LWMS area (2.9 ha) discharges into the regional flood storage via the Study Area, Figure 9 *right*, and is included in the computation of the pro-rata peak allowable outflow, Table 11.

Catchment 17B intersects the Mandogalup Swamp regional flood storage within the Study Area. Peak flows generated within the catchment are predominantly due to direct rainfall, therefore there is no allowable outflow from the development area within the Study Area.

Catchment 18A intersects the Western Power easement within the Study Area. This area will largely remain undeveloped and post-development flows to the Peel Main Drain and regional flood storage will be similar to pre-development. Therefore, there is no allowable outflow from the development area within the Study Area.

Catchment 19A only partially intersects the north-west corner of the Study Area, however, most of this catchment drains via the Study Area as detailed in the JDA (2018a) LWMS for the Roberts Day (2017) LSP. In the DoW (2009) model, runoff from this catchment is input into the model at node PMD94, Figure 9 *right*, near the upstream boundary of the Study Area. Therefore, there is no pro-rata allowable outflow from the development area within the Study Area.

Catchment 19 represents the majority of the JDA (2018) LWMS area and a small 3.1 ha segment within the Study Area north of the Peel Main Drain. Following discussions between JDA and Water Corporation, agreement was reached with regard to outlet sizes to the Peel Main Drain with a Ø300 outlet allowable for the area north of the Peel Main Drain (post-development catchment c4; Section 6.3) and a Ø225 outlet for the south-west area south of the Peel Main

Drain (post-development catchment D). There was also agreement with Water Corporation on culvert crossings for the Peel Main Drain; sizes and locations shown on Figure 11.

The proposed stormwater management strategy for the Study Area incorporates the two allowable pipe outlets to the Peel Main Drain (Ø300 north and Ø225 south) and culvert crossings as agreed with Water Corporation and a discharge into the Mandogalup Swamp regional flood storage at the allowable rate of 0.036 m^3/s.

6.3 Local Stormwater Management

Local stormwater management is proposed to be consistent with water sensitive design practices and to meet key objectives and criteria as detailed in Table 1 and the stormwater design approach presented in the DWMS (JDA 2011) and the adjoining LWMS (JDA, 2018a).

Drainage catchments from the Study Area and adjoining LWMS (JDA, 2018a) are shown on Figure 10. Peak flows from the existing Apsley Estate development are currently attenuated in drainage basins prior to discharge via a Ø600 pipe to a temporary storage basin at the eastern boundary of the Study Area (JDA, 2024). This existing Ø600 pipe will discharge to a swale and connect to the c4 bio-retention area, Figure 11.

The local stormwater management system has been designed according based on small events, minor drainage and major drainage.

Small event management concentrates on the first 15 mm of rainfall (approximately the 1 EY 1 hour event) and will comprise lot retention and bio-retention areas.

The minor drainage system is defined as a system of drains, pipes, culverts, kerbs, gutters etc. designed to convey runoff generated by low frequency storms, typically less than the 20% AEP for residential areas.

The major drainage system is defined as the arrangement of roads, drainage reserves and attenuation areas planned to provide safe passage of stormwater runoff from extreme rainfall events.

The drainage system is described in more detail below with the key elements of the drainage system shown on Figures 11 to 13.

6.3.1 Small Event Management

The following strategies are proposed to meet the criteria for small event management:

- All residential lots are to retain and infiltrate the first 15 mm of rainfall from connected impervious areas. This can be achieved by means of systems such as soakwells and/or other underground storage devices.
- Stormwater runoff from roads for the first 15 mm of rainfall will be piped to bio-retention areas (BRAs) within POS adjacent to the Peel Main Drain and regional flood storage and is retained and infiltrated. There is no discharge to the Peel Main Drain from developed areas within the Study Area.
- BRAs will be underlain with amended soils and planted with suitable plant species, consistent with Vegetation Guidelines for Biofilters in South-West Western Australia (Monash University, 2014).

6.3.2 Minor Drainage

To meet the design criteria for the minor drainage system (for events up to the 20% AEP event), the following strategies are proposed:

- Stormwater flow, similar to the small event, will be conveyed as piped flow to drainage basins in POS. The road pipe network will be sized to convey the 20% AEP flow.

- Runoff generated within residential lots in excess of underground storage devices (e.g. soakwells) will flow overland into the road drainage network.
- Flood storage areas (basins) will be located at the catchment low-point to attenuate catchment peak flows prior to discharge to the Peel Main Drain and regional flood storage. Flood storages will generally have minimum 1:6 (v:h) side slopes except the c6 swale and c7 basin (within Western Power easement) which have 1:4 side slopes.
- Where bio-retention areas are co-located within drainage basins, outlet pipes are set at or above the 'small' event top water level.

6.3.3 Major Drainage

The major drainage system is designed to manage rainfall events greater than the 20% AEP event up to the 1% AEP event. Key points of the major drainage system strategy are as follows:

- Management will include infiltration of stormwater into in-situ soils and additional sand fill (as in small and minor events) together with runoff from lots (excess of underground storage systems) and road stormwater runoff.
- Road reserves will provide flood storage and conveyance. In major storm events, the minor drainage pit and pipe system will be full with excess stormwater bypassing the minor drainage structures and flowing overland within the road carriageway, with roads graded towards the downstream drainage basins; located at the catchment lows.
- Drainage basins will have a minimum clearance of 500 mm (0.5 m) from the controlled groundwater level (Section 5.4). Drainage basin outlets to the Peel Main Drain are as agreed with Water Corporation (Section 6.2) and all basin outlets will be free flowing and set above the 1% peak flood levels in the Peel Main Drain and regional flood storage.
- Minimum habitable building floor levels will have a 300 mm (0.3 m) clearance from the 1% AEP peak water levels in drainage basins within the development and 500 mm (0.5 m) clearance from the 1% AEP peak water levels in the Peel Main Drain and the regional flood storage, consistent with DWER (2017a).

6.4 Stormwater Model Parameters

The stormwater management system, including the drainage detention basins and the Peel Main Drain, has been modelled using XP-STORM based on the methodology in Australian Rainfall and Runoff (Ball et al., 2019). The drainage basin locations were determined based on existing topography, pre-development AAMGL and local structure plan constraints.

The rainfall temporal pattern was assumed spatially uniform across the catchment with storms modelled ranging from 1 hour to 24 hours. Catchment slopes were calculated from road earthwork levels. A breakdown of the rainfall-runoff loss model parameters for each land use is presented in Table 12 below for the land use areas shown in Figures 2 and 10 to 20. Stormwater modelling has conservatively assumed no infiltration. Modelling parameters are summarised in Appendix G.

The Peel Main Drain has been modelled using cross-sections derived from 1 m gridded LiDAR DEM (DoW, 2008) and assuming the drain will be re-graded as per Cossill & Webley (2025) drawings. For the 1% AEP event, JDA has used an inflow hydrograph at the interface of Apsley Estate and Florence Estate, DoW (2009) Node PMD96, and a tailwater level hydrograph downstream of the Study Area, DoW (2009) Node PMD91, as provided by Water Corporation.

For the 20% AEP, JDA has assumed a constant upstream inflow of 0.8 m^3/s and downstream tailwater depth of 0.54 m based on the 10 year ARI results detailed in DoW (2009).

For the purposes of drainage calculations, JDA divided residential lots into 2 categories: 'Traditional' (> 350 m^2) and 'Compact' (< 350 m^2) lots. Traditional lots are assumed to contribute 40% runoff to the street drainage system as overland flow (i.e. runoff at the rear of the lot will not enter the piped drainage system) whereas 100% of the Compact lots are assumed to contribute runoff to the street drainage system. This loss model is consistent with the adjacent LWMS (JDA, 2018a) and approved UWMPs (JDA, 2018b, 2021 & 2024; Water Technology, 2022). For the stormwater modelling in this LWMS, JDA has assumed 80% of lots will be 'Traditional' and the remaining 20% 'Compact', and is to be refined in the UWMP based on subdivision planning.

The Western Power easement south of the Peel Main Drain is predominantly the regional flood storage and does not interact with either the Peel Main Drain channel section within the Study Area nor the proposed drainage basins. For areas north of the Peel Main Drain, runoff that occurs during large storm events will be stored by informal depressions and reinfiltrated on-site and not directly discharge into the Peel Main Drain due to the highly permeable sandy nature of this vegetated area with high clearance to groundwater (Figure 6 *right*).

TABLE 12: CATCHMENT RAINFALL-RUNOFF LOSS MODEL

Land Use	Initial Loss (mm)	Continuing Loss (mm/hr)	Proportional Loss (%)
Residential Lots[1]	15	8	-
Road Reserve	1.5	-	20
Public Open Space	-	-	90
Drainage[2]	-	-	10

Note: 1. 100% of lot area modelled for Compact lots (< 350 m^2); 40% of lot area modelled for Traditional lots (> 350 m^2)
2. Includes drainage basin areas and the Peel Main Drain.

6.5 Stormwater Modelling Results

Details of the Small Event (15 mm) rainfall management areas for each catchment are presented in Table 13. Note that these areas can be refined during detail design to incorporate other management infrastructure in the upper catchment if feasible.

Stormwater modelling results for the minor (20% AEP) and major (1% AEP) events for each catchment is summarised in Table 13. All pipe discharge was modelled with free outfall condition.

Drainage areas c7 and c8 adjacent to the Mandogalup Swamp regional flood storage are both located outside of, and above the 1% AEP top water level of 13.7 mAHD. Peak discharge into the regional flood storage is similar to the allowable outflow rate and will be refined during detail design.

Concept landscape plans (Appendix F) demonstrate there is sufficient space allocated within the structure plan to integrate drainage area requirements within the allocated POS areas.

Stormwater Event Plans for the 'small', minor and major events are shown on Figures 12 and 13 with a model long-section of the Peel Main Drain shown on Figure 14. Cross-section concepts of the drainage basins/swale are shown on Figures 15 to 19.

TABLE 13: XP-STORM MODELLING RESULTS

	D Basin	c4 Basin	c6 Swale	c7 Basin	c8 Basin
Storage Details					
Invert Level (mAHD)	17.20	16.50	17.1-17.45	13.7	14.00
Base Area (ha)	0.09	0.14	150 m x 0.5 m	0.056	0.08
Outlet Size/Type	Ø225 Pipe (to PMD) Ø225 Pipe (to c6)	Ø300 Pipe (to PMD)	Ø225/300 Pipe (to c8)	Ø100 Orifice (to RFS)	Ø100 Orifice (to RFS)
Outlet Invert (mAHD)	17.4 (to PMD) 17.6 (to c6)	16.8	17.6	14.0	14.3
Side Slopes (v:h)	1:6	1:6	1:4	1:4	1:6
1% AEP (Major)					
Peak Water Level (mAHD)	18.13	17.62	17.89	15.13	15.20
Critical Storm Duration (hours)	2	9	3	6	9
Maximum Depth (m)	0.93	1.12	0.44-0.79	1.43	1.20
Peak Water Level Area (ha)	0.16	1.11	0.081	0.13	0.28
Peak Storage Volume (m^3)	1,150	6,800	273	1,315	2,530
Peak Outflow (m^3/s)	0.079 (to PMD) 0.041 (to c6)	0.17	0.036	0.036	0.037
20% AEP (Minor)					
Peak Water Level (mAHD)	17.71	17.17	17.67	14.47	14.51
Critical Duration (hours)	2	12	3	3	24
Maximum Depth (m)	0.51	0.67	0.22-0.57	0.77	0.51
Peak Water Level Area (ha)	0.13	0.42	0.055	0.093	0.17
Peak Water Storage Volume (m^3)	540	2,470	123	570	760
Peak Outflow (m^3/s)	0.056 (to PMD) 0.010 (to c6)	0.125	0.006	0.021	0.014
First 15 mm (Small)					
Peak Water Level (mAHD)	17.35	16.65	-	13.90	14.20
Storm Duration (hour)	1	1	1	1	1
Maximum Depth (m)	0.15	0.15	0.15	0.20	0.20
Peak Water Level Area (ha)	0.10	0.36	-	0.07	0.15
Peak Water Storage Volume (m^3)	225	760	50	180	260
Peak Outflow (m3/s)	0[1]	0[1]	0[1]	0	0[1]

Notes: 1. Subsoil only; PMD = Peel Main Drain; RFS = Regional Flood Storage.

The final configuration (areas, side slopes, etc.) and exact location of the bio-retention areas and drainage basins will be dependent on the final earthworks and road design levels for the development. The details will be refined at the subdivision stage and reported in the relevant Urban Water Management Plan(s).

7. GROUNDWATER MANAGEMENT

7.1 Design Criteria

Groundwater management for the Study Area has been prepared in line with the design criteria presented in the *Stormwater Management Manual for Western Australia* (DWER, 2022):

- Protect infrastructure and assets from flooding and inundation by high seasonal groundwater levels, perching and/or soil moisture.
- Protect groundwater-dependent ecosystems from the impacts of urban runoff.
- Manage and minimise changes in groundwater levels and groundwater quality following development.
- Adopt nutrient load reduction design objectives for discharges to groundwater.

7.2 Managing Changes to Groundwater Levels

The estimated pre-development AAMGL, Figure 6, generally shows groundwater within the Study Area at or near natural surface south of the Peel Main Drain and greater than 3 m below natural surface north of the Peel Main Drain. A rise in groundwater levels is anticipated due to the clearing of large areas of native bushland within urban development across the Mandogalup locality.

Groundwater management is required to ensure there is a minimum separation of 1.5 m between finished lot levels and the controlled groundwater level (CGL) or pre-development AAMGL, whichever higher, to protect infrastructure from high seasonal groundwater levels, generally achieved through the use of imported fill and/or subsoil drainage.

For the Study Area, JDA recommends clean sand fill with a minimum saturated hydraulic conductivity of 5 m/day (Table 2) is used to provide the required separation to the CGL across the Study Area. A lower saturated hydraulic conductivity than 5 m/day would result in a risk of saturation of the soil profile beneath the Study Area.

Areas north of the Peel Main Drain are assumed to have sufficient clearance to groundwater to not require groundwater management, however, this should be reviewed in conjunction with the detailed engineering design in the UWMP.

South of the Peel Main Drain, groundwater is generally at or near surface across the current extent of Mandogalup Swamp within the Study Area, Figure 6 *right*. Post-development, substantial sand fill will be imported to these areas with preliminary earthworks showing a general 2 to 3 m clearance to the pre-development AAMGL and underlying clayey in-situ soils. Consequently, subsoil drainage within road reserves will likely not be required but this should be reviewed during detailed design for the UWMP.

Subsoil drainage will be required beneath drainage basins and the c6 swale to ensure adequate empty times of POS areas. Subsoils beneath drainage basins will collect treated, infiltrated water and will discharge directly to the Peel Main Drain or regional flood storage. Groundwater levels beneath drainage basin locations will be mostly controlled by the lower-lying Peel Main Drain through the centre of the Study Area and the district flood storage in the west. Indicative subsoil layouts and inverts are shown on Figure 20. Subsoils have been set 0.5 m below the basin/swale inverts and at or above the pre-development AAMGL; with drains at approximately 1:500 grade; and a free outfall to the Peel Main Drain or regional flood storage. For the Peel Main Drain, the subsoil outlets are generally at or above the modelled 20% AEP flood level for the Peel Main Drain, Figure 20.

The post-development groundwater level will be determined at the UWMP stage and will account for groundwater rise post-development. Groundwater management will be reviewed during detailed design as part of the UWMP with due consideration to final road earthwork levels and finished lot levels.

8. WATER QUALITY MANAGEMENT

8.1 Nutrient Source Controls

The effective implementation of the structural and non-structural controls as part of the residential development will enhance water quality from the Study Area as a result of land use change.

Non-structural source controls to reduce nutrient export from the Study Area will focus on reducing the need for nutrient inputs into the landscape. The following strategies are proposed:

- Local native plants make up a minimum 50% of the planted areas and streetscape treatments. Any non-local species will be selected for drought tolerance and low fertiliser requirements;
- Community education to inform correct landscaping and fertiliser application rates; and
- Maintenance practices such as street sweeping and pit eductions to remove sediment build-up, particularly during the development and construction phase. The UWMP will outline the schedule and cleaning requirements for street sweeping, which will be co-ordinated with the City of Kwinana.

Structural source controls are proposed to complement the non-structural source controls and provide a complete stormwater treatment train and will include flush kerbing and bio-retention areas within POS.

The *Stormwater Management Manual for Western Australia* (DWER, 2022) outlines expected pollutant removal efficiencies for detention/retention systems. While DWER (2022) does not provide expected pollutant removal efficiencies for all BMPs, application of a treatment train approach such as in this UWMP by using a combination of non-structural and structural measures will achieve BMP outcomes for water quality (Table 14).

TABLE 14: BMP WATER QUALITY PERFORMANCE

Parameter	Structural Controls Nutrient Output Reduction[1]
	Detention/Retention Measures
Total Suspended Solids	65-99%
Total Phosphorus	40-80%
Total Nitrogen	50-70%
Gross Pollutants	> 90%

Note 1. Typical Performance Efficiencies via DWER (2022)

Flush kerbing bordering POS allows stormwater runoff from frequently occurring 'small' rainfall events to be flow directly into POS across grassed verge/areas maximising infiltration at-source. Flush kerbing should be implemented, where appropriate, and should not impede footpaths or POS access points.

Bio-retention areas (BRAs) are designed to capture and infiltrate stormwater runoff from roads during the 'small' event rainfall and are underlain with amended soil and planted with water-tolerant vegetation to provide water quality treatment. They are typically 0.3 to 0.5 m deep and are to provide a minimum treatment capacity of approximately 2% of the connected impervious area from road catchments as recommended in FAWB (2009).

BRAs are proposed within POS as shown in Figures 11 and 12 *left*. Subsoil drainage will be required beneath bio-retention areas and should be set a minimum 500 mm below the BRA invert at the base of a modified soil profile, which includes the amended soil media.

The desired saturated hydraulic conductivity is in the range of 200 to 300 mm/hr (~5 to 7.2 m/day), to allow infiltration of stormwater while retaining sufficient moisture to support the vegetation. Clogging may occur in the first few years,

however once the vegetation is established, the roots and associated biological activity will maintain the hydraulic conductivity of the soil media over time (FAWB, 2009).

Minimum specifications for all bio-retention areas are presented in Table 15.

TABLE 15: MINIMUM SPECIFICATIONS FOR BIO-RETENTION AREAS

Item	Specification
Amended soil media	• Minimum 300 mm thick. • Hydraulic conductivity between 5 and 7.2 m/day. • PRI >10 • Light compaction only. • Total clay and silt fraction <3% in total (w/w). • Organic matter content <5% (w/w). • Phosphorus content <80 mg/kg.
Plant selection, planting density and distribution.	• Tolerant of periodic inundation and extended dry periods. • Preferential selection of endemic and local native species (Monash, 2014). • As per Vegetation Guidelines for Stormwater Biofilters in the South-west of Western Australia (Monash University, 2014).
Maintenance	• 24 months following initial planting.

8.2 Land Use Change Nutrient Impacts

The UNDO (Urban Nutrient Decision Outcomes) decision support tool (DoW, 2016) is used to help quantify the nutrient inputs and nutrient exports for the post-development scenario. The UNDO tool analyses inputs for Total Phosphorus and Total Nitrogen only. The UNDO tool was used to model the Study Area with outputs provided in Appendix H.

Implementation of the proposed structural and non-structural controls results in a reduction of 49% for Nitrogen and 41% for Phosphorus, compared to urban development without WSUD. These estimates correspond to a reduced Nitrogen input of 1.45 kg/ha/year (down from 2.85 kg/ha/year) and a reduced Phosphorus input of 0.04 kg/ha/year (down from 0.06 kg/ha/year). The current land use is a combination of bushland and cleared land with low nutrient inputs and the estimated nitrogen and phosphorus inputs following urban development is also relatively low. Due to infiltration of stormwater on-site, the estimated nitrogen and phosphorus exports following development are also relatively low.

8.3 Disease Vector and Nuisance Insect Management

Structural stormwater management systems are designed to minimise the risk of chironomid midge and mosquito breeding. Infiltration, evapotranspiration or drawing down of water via subsoils underlying basins to prevent pooling for longer than four days (96 hours) in late spring to early autumn will prevent completion of the larval stages of the mosquito life cycle (DWER, 2022), as per requirement of the Department of Health.

9. IMPLEMENTATION

9.1 Roles and Responsibilities

Table 16 details the roles and responsibilities to undertake the implementation plan.

The operation and maintenance of the stormwater management system will initially be the responsibility of the developer but will ultimately be accepted by the Local Authority. Preparation of the UWMP will be the responsibility of the developer.

TABLE 16: IMPLEMENTATION RESPONSIBILITIES

IMPLEMENTATION		RESPONSIBILITY	
LWMS Section	**Action**	**Developer**	**City of Kwinana**
6.2	Preparation of an Urban Water Management Plan to support subdivision	✓	
6.4	Construction of stormwater system	✓	
6.4	Stormwater system operation and maintenance Initially Following handover	✓	✓

9.2 Urban Water Management Plan (Subdivision)

Better Urban Water Management (WAPC, 2008) requires an Urban Water Management Plan (UWMP) at subdivision stage. With an approved LWMS, a UWMP is required as a condition of subdivision and prior to any subdivision activities.

Further work that is identified for inclusion in the UWMP:

- Design of treatment structures and flood storages as outlined in the Stormwater Management Manual (DWER, 2022);
- Refinement of catchment areas and the final configuration (storage side slopes, etc) and exact location of the flood detention storage areas, dependent on final earthworks, drainage and road design levels;
- Refine the groundwater management plan including location and inverts of proposed subsoil drainage beneath drainage areas;
- Confirm irrigation areas and volumes for Public Open Space and any amendments required to the groundwater licence to reflect changes to uses and entitlements.
- Confirm Peel Main Drain works and maintenance responsibilities. Maintenance responsibilities should be with the City of Kwinana and be similar to those in the existing Apsley Estate and Florence Estate development up-gradient of the Study Area.

9.3 Construction Management

9.3.1 Dewatering

Dewatering will be required for some elements of subdivision construction including sewer installation. Given the depth of construction, dewatering will only be in the superficial aquifer.

Prior to commencement of any dewatering, the construction contractor may need to apply for and obtain from DWER a "Licence to Take Water". A licence is not required for dewatering if the pump rate does not exceed 10 L/s over a period of less than 30 days and the volume of water taken over the period does not exceed 25,000 kL.

Dewatering will be carried out in accordance with the licence conditions should a licence to take water be required. Where possible, construction will be timed to minimise impacts on groundwater and any dewatering requirement.

9.3.2 Acid Sulphate Soils

Figure 5 generally shows a high to moderate risk of A.S.S across most of the Study Area.

A.S.S, if encountered, will be investigated and managed in accordance with the applicable DWER Acid Sulphate Guidelines for Identification and Investigation (DER, 2015a) and Treatment and Management (DER, 2015b) of Disturbed Acid Sulphate Soils. Specific methods for treatment and holding times for A.S.S are specified in these guidelines.

An Acid Sulphate Soil Investigation and Management Plan should be prepared for the Study Area prior to subdivision.

9.4 Stormwater and Subsoil System Operation and Maintenance

The stormwater and subsoil drainage system within the proposed development will require maintenance to ensure correct operation and minimise risk to the receiving Peel Main Drain. It is considered the following operating and maintenance practices will be required periodically:

- Inspection and removal of debris, litter and sediments surrounding pipe inlets/outlets and in gross pollutant traps (GPTs). GPTs are recommended upstream of the pipe inlets to the BRAs.
- Inspection of system for erosion.
- Street sweeping to reduce particular build-up on road surface and gutters.
- Maintenance of planted areas (flood storages and POS) including plant condition and weeds as outlined in the UWMP
- Cleaning of sediment build up and litter layer on the bottom of swales as specified in the UWMP.
- Arrange education campaigns regarding source control practise to minimise pollution runoff into the stormwater drainage system.
- Assess function of subsoil drainage system.
- Detail post-development monitoring program for drainage structures (e.g. bio-retention/drainage basins).

The operating and maintenance schedule required is presented in Table 17.

TABLE 17: MAINTENANCE SCHEDULE FOR DRAINAGE INFRASTRUCTURE

Item	Maintenance Interval		
	Quarterly	Bi-annually	As required
Street Drainage			
Street sweeping to reduce particulate build-up	✓		
Removal of debris to prevent blockages	✓		
Eduction of sediment and rubbish in manholes/GPTs	✓		
Planted Areas (BRAs)			
Inspect for erosion + sediment accumulation		✓	
Assess health of vegetation. Remove dead plants and replace where necessary.		✓	
Inspect for standing water 1 day after rainfall events			✓
Removal of sediment and leaf litter layer build up.			✓
Detention Storage			
Removal of debris from pipe inlets to prevent blockages	✓		
Use of slow release/low Phosphorus fertilisers in turfed areas.		✓	

9.5 Monitoring Program

The monitoring program has been designed to allow a quantitative assessment of hydrological impacts of the proposed development.

The post-development monitoring program is designed to operate over a 3 year period. The program will be periodically reviewed to ensure suitability and practicality. The program may need to be modified as data is collected to increase or decrease the monitoring effect in a particular area or alter the scope of the program itself.

The proposed post-development monitoring is to monitor groundwater levels and quality at two pre-development groundwater bores, D3 and D5(s), for comparison to pre-development (Section 4.6.2 & 4.6.3 and Figure 21) and surface water quality at the upstream and downstream boundaries of the Study Area, sites PMD4 and PMD5. Post-development groundwater quality trigger values are provided in Table 18 and are based on the 80th percentile of pre-development data, commensurate with monitoring and reporting guidelines in ANZECC & ARMCANZ (2000). The surface water quality trigger values are based on the 02 October 2024 monitoring snapshot (Section 4.7.3) and post-development water quality results should also be compared against historical water quality results in the Peel Main Drain.

Should pre-development bores be destroyed during construction works associated with development, replacement bores should be drilled as close to the original bore locations as feasible and to similar specifications.

A summary of the proposed monitoring program and reporting schedule is shown in Table 19 with the frequency of water quality target review and the contingency action plan detailed in Table 20.

Groundwater levels post-development will rise, particularly in the southern areas formerly occupied by Mandogalup Swamp, as infiltrating stormwater will perch above the underlying silty sand profile. Preliminary earthworks suggest there will be an average 2.5 m clearance from AAMGL to finished lots levels. The 1 m criterion specified in Table 20 as an acceptable rise post-development reflects the level above which (i.e. average 1.5 m clearance) the efficacy of lot soakwells would be impacted and further actions may be required.

All sampling is to be conducted according to Australian Standards and all water quality sample testing is to be conducted by a NATA-approved laboratory.

Monitoring of the performance of constructed drainage structures (e.g. bio-retention/drainage basins) including surface water levels, quality and flow should be outlined in the UWMP and will be in addition to the LWMS monitoring. Results of the UWMP monitoring program, as with the LWMS monitoring program, is to be reported to the City of Kwinana and Department of Water and Environmental Regulation.

TABLE 18: GUIDELINE VALUES FOR POST-DEVELOPMENT MONITORING

Parameter	Groundwater Bore		Surface Water Sites	
	D3	D5(s)	PMD4	PMD5
pH[1]	4.82 – 6.18	6.13 – 7.46	5.5 – 6.7[2]	
EC (mS/cm)	1.51	0.75	0.67 – 1.08[2]	
TN (mg/L)	4.3	1.4	2.7	2.3
TKN (mg/L)	2.4	1.4	2.3	2.1
NO_x_N (mg/L)	3.0	0.16	0.45	0.19
TP (mg/L)	0.30	0.17	0.89	0.87
PO_4_P/FRP (mg/L)	0.024	0.091	0.94	0.96

1. pH values to be between range provided
2. pH and EC averages based on results at site PMD3 (Table 8)

TABLE 19: MONITORING SCHEDULE AND REPORTING

Monitoring Type	Location	Method	Frequency, Timing & Responsibility	Parameter	Reporting
Groundwater Level	Bores D3 & D5(s)	Electrical depth probe (manual measurement) and data logger	Quarterly manual measurements for 3 years by Developer (typically Jan, April, July, October). Continuous recording on data loggers	Water Level (mAHD)	Annual reports to be provided by the developer for a period of 3 years. Reports will be submitted to CoK/DWER within 3 months of completion of the reporting period.
Groundwater Quality	Bores D3 & D5(s)	Pumped bore samples	Quarterly for 3 years by Developer (typically Jan, April, July, October)	In-situ: pH, EC, temp Lab: Nutrients, TDS, Dissolved Metals	
Surface Water Quality	Sites PMD4 & PMD5	Grab samples	Minimum three times per year, when flowing	In-situ: pH, EC, temperature Lab: pH, EC, Nutrients, TSS	

TABLE 20: CONTINGENCY PLANNING

Monitoring Type	Criteria for Assessment	Criteria Assessment Frequency	Contingency Action
Groundwater Level	Groundwater levels not to exceed the estimated post-development groundwater levels by more than 1 m	After monitoring occasion	1. Check recent rainfall data at nearby gauges to assess whether groundwater rise was temporary as a result of a rare rainfall event and compare monitoring results to nearby DWER bores. 2. Review design and operation of basin subsoil and stormwater drainage system. 3. Perform maintenance of basin subsoil/stormwater as required. 4. Install monitoring bores within areas of concern and sample collected sand fill from bore cuttings to determine sand fill meets minimum design requirements (Table 2). 5. Consider remedial actions to areas of concern including any potential retrospective installation of subsoil drainage.
Groundwater and Surface Water Quality	Nutrient concentrations should not exceed pre-development guideline values.	Annual review of water quality targets	1. Identify and remove any point sources. 2. Consider reinforcement of Community Education/Awareness program. 3. Review operational and maintenance (e.g. fertilising, cleaning) practices. 4. Consider alterations to POS areas including landscape regimes and soil amendment. 5. Consider modifications to the stormwater system. 6. Consider initiation of community based projects.

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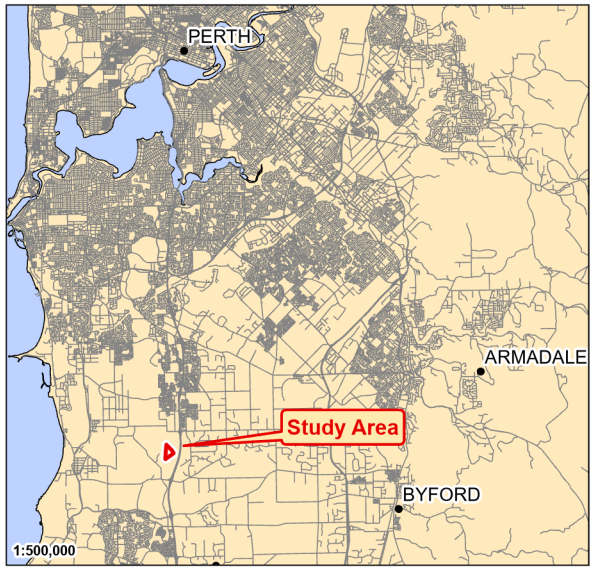
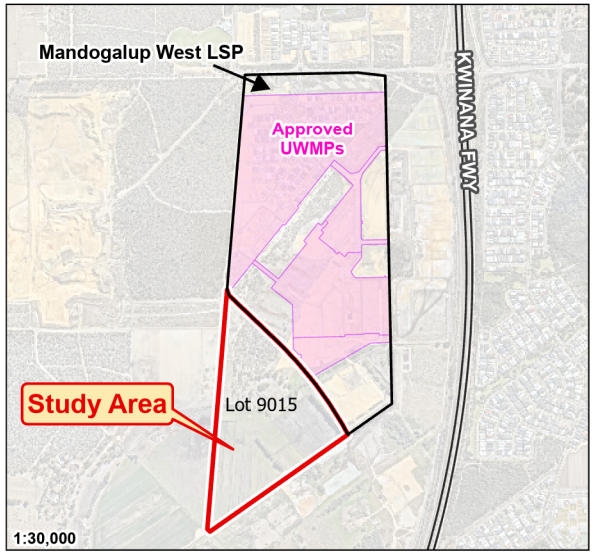
FIGURES





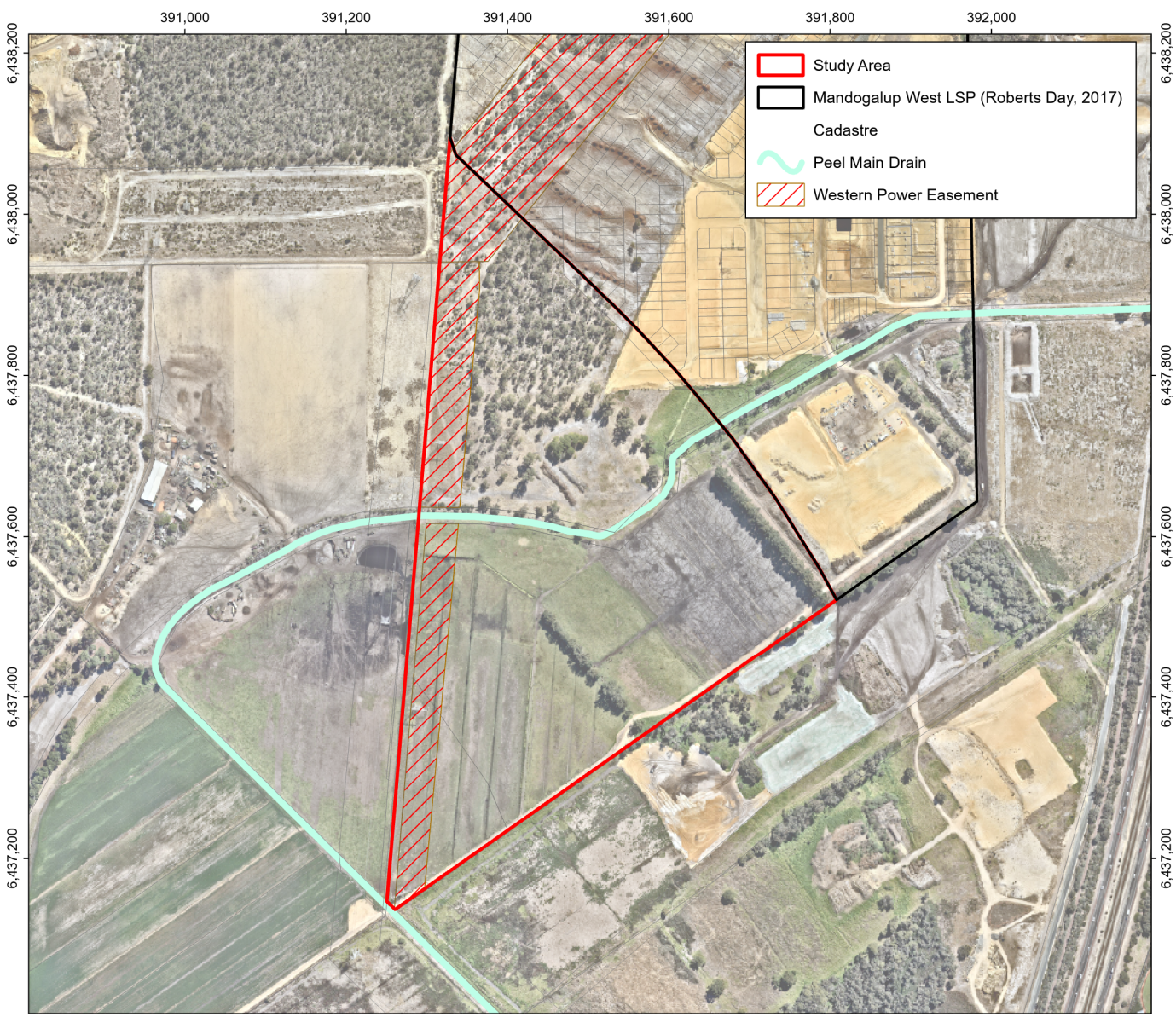


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Figure 1: Location Plan

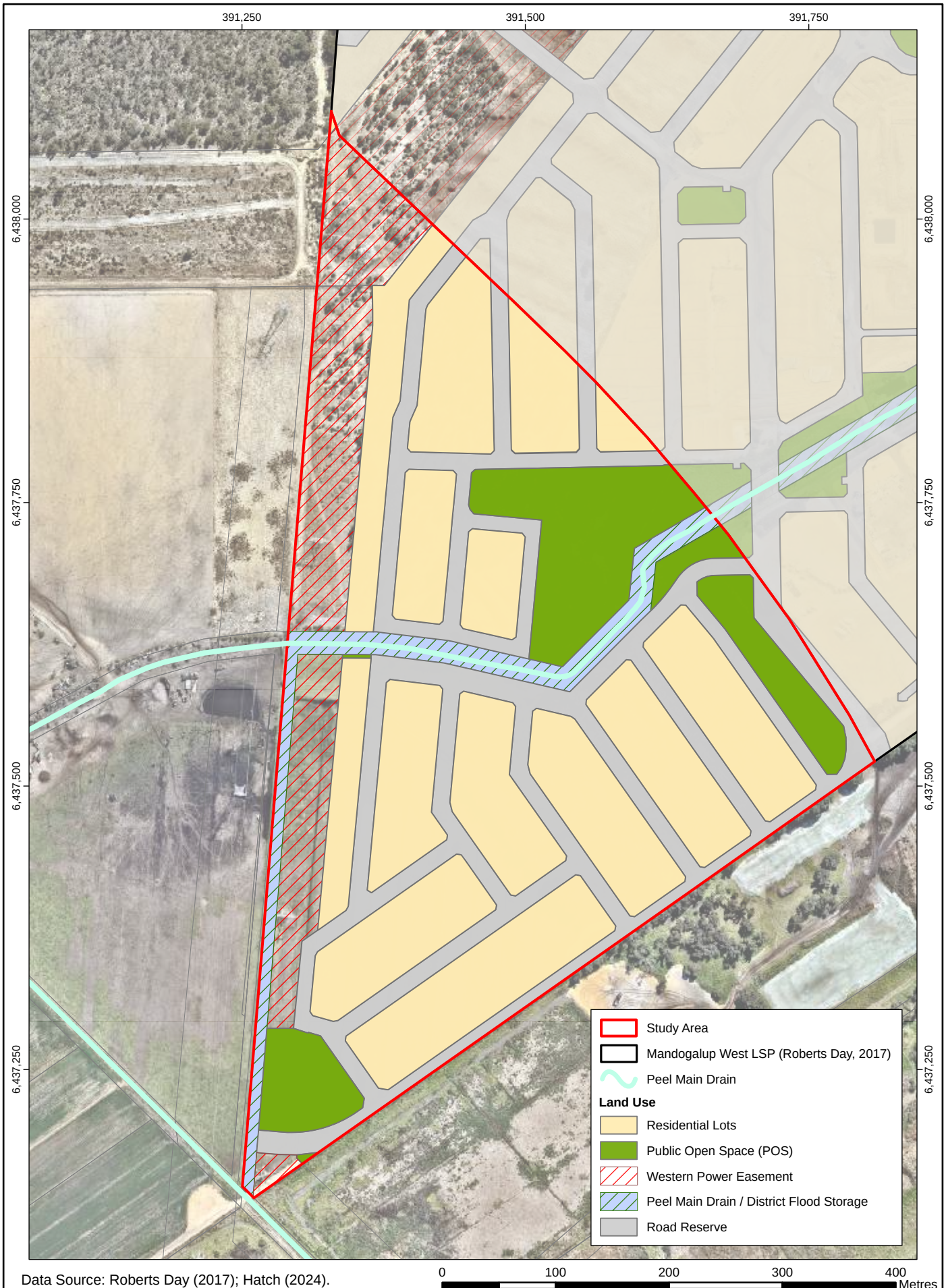

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Figure 2: Proposed Structure Plan Amendment



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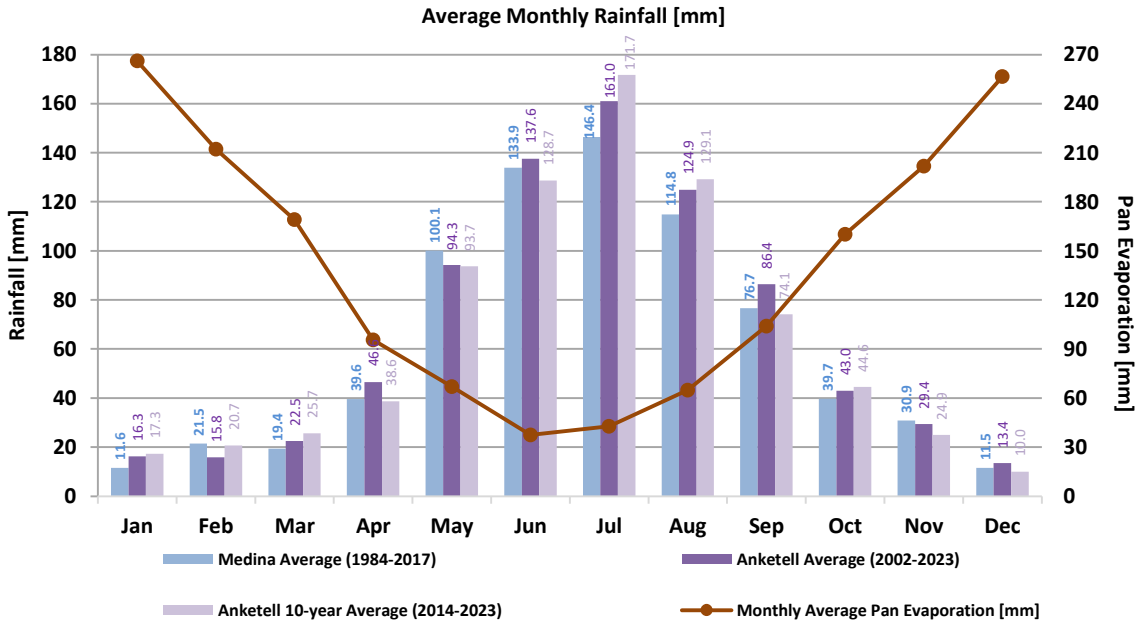
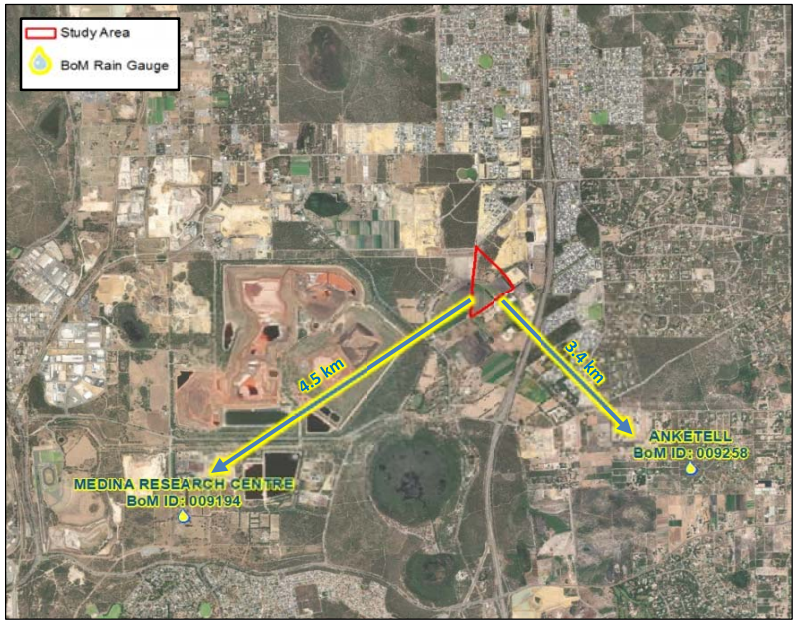
Figure 3: Topography





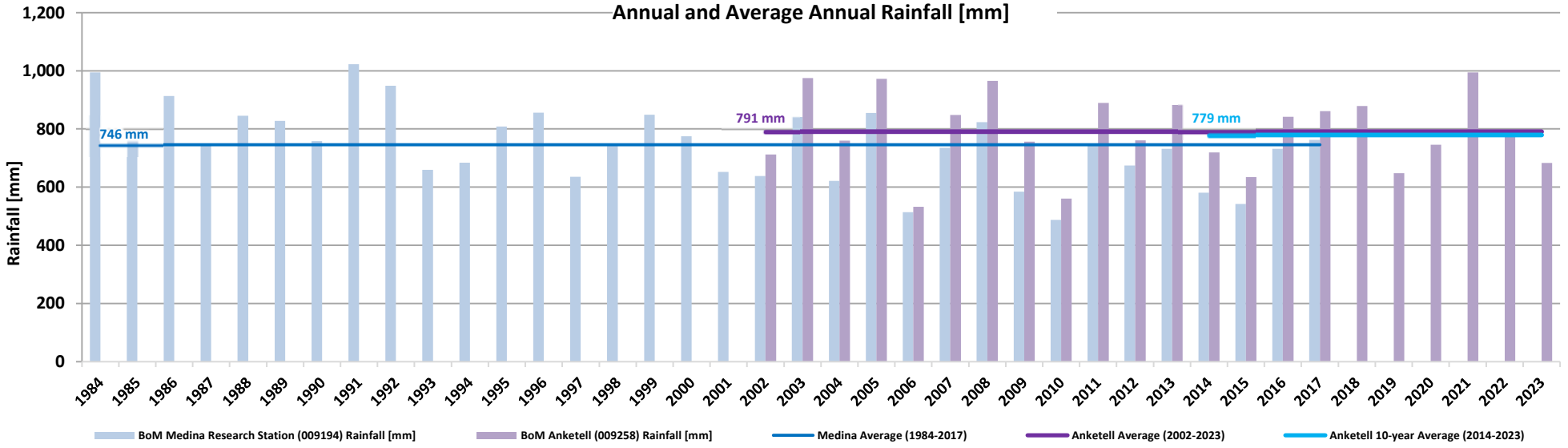


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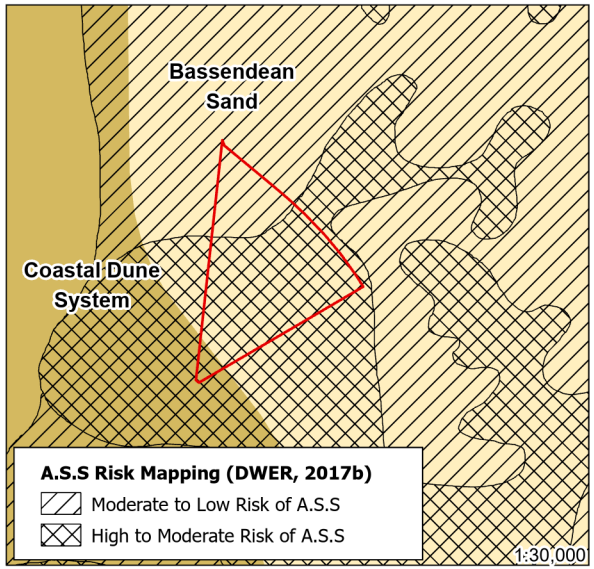
Figure 4: Rainfall and Evapoation



Lithological Classification

Ms5 - sandy silt, dark brownish grey silt, with disseminated fine-grained quartz sand, firm, variable clay content, of lacustrine origin

S8 - sand, very light grey at surface, yellow at depth, fine to medium-grained, sub-rounded quartz, moderately well sorted, of aeolian origin

Surface Geology

Bassendean Sand- Basal conglomerate overlain by dune quartz sand with heavy mineral concentrations

Coastal Dune Systems
Beach sand, sand dunes, coastal dunes, beaches, and beach ridges; calcareous and siliceous, locally shelly and/or cemented (beach rock); locally reworked

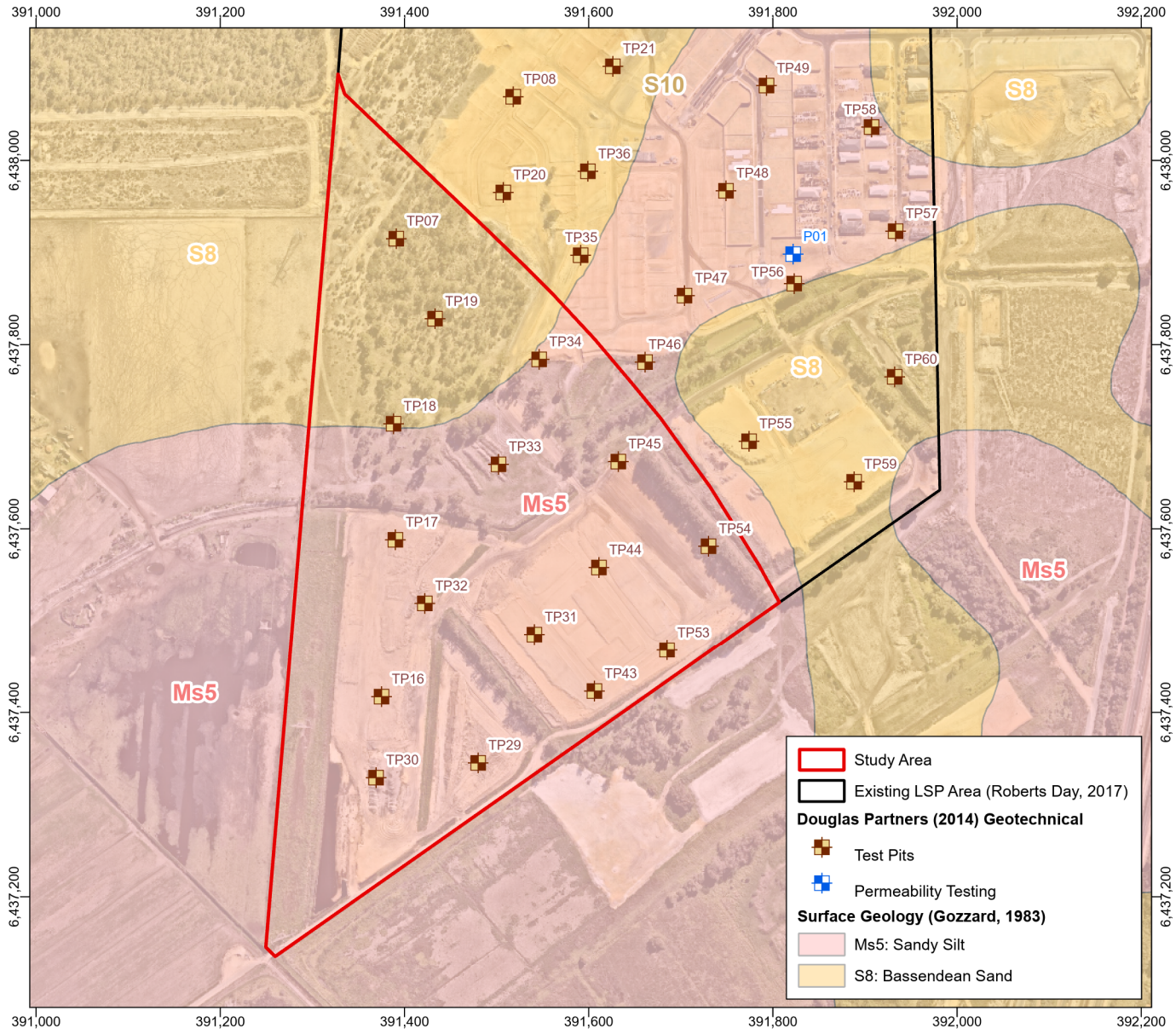


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Figure 5: Surface Geology, Geotechnical and A.S.S Mapping

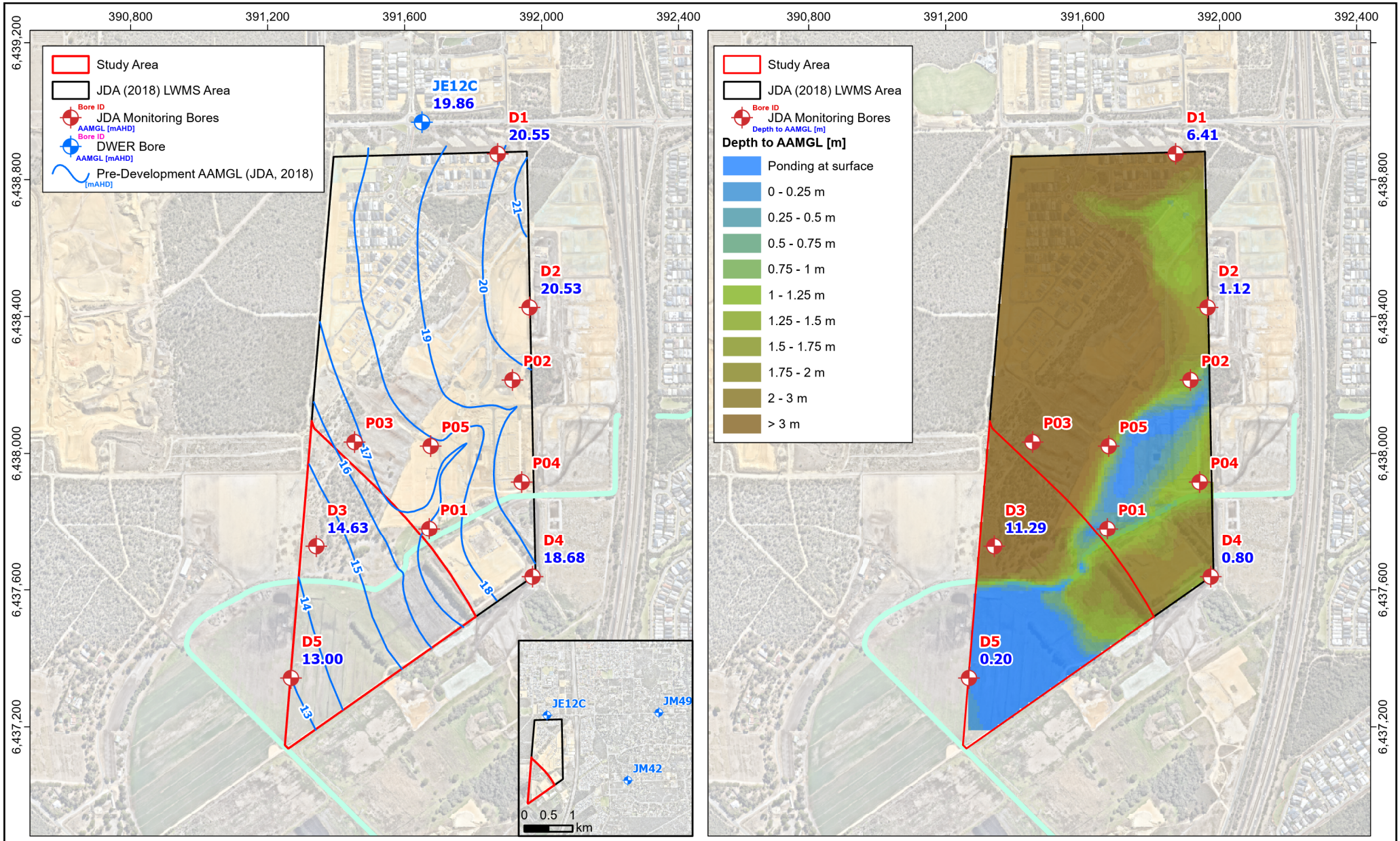

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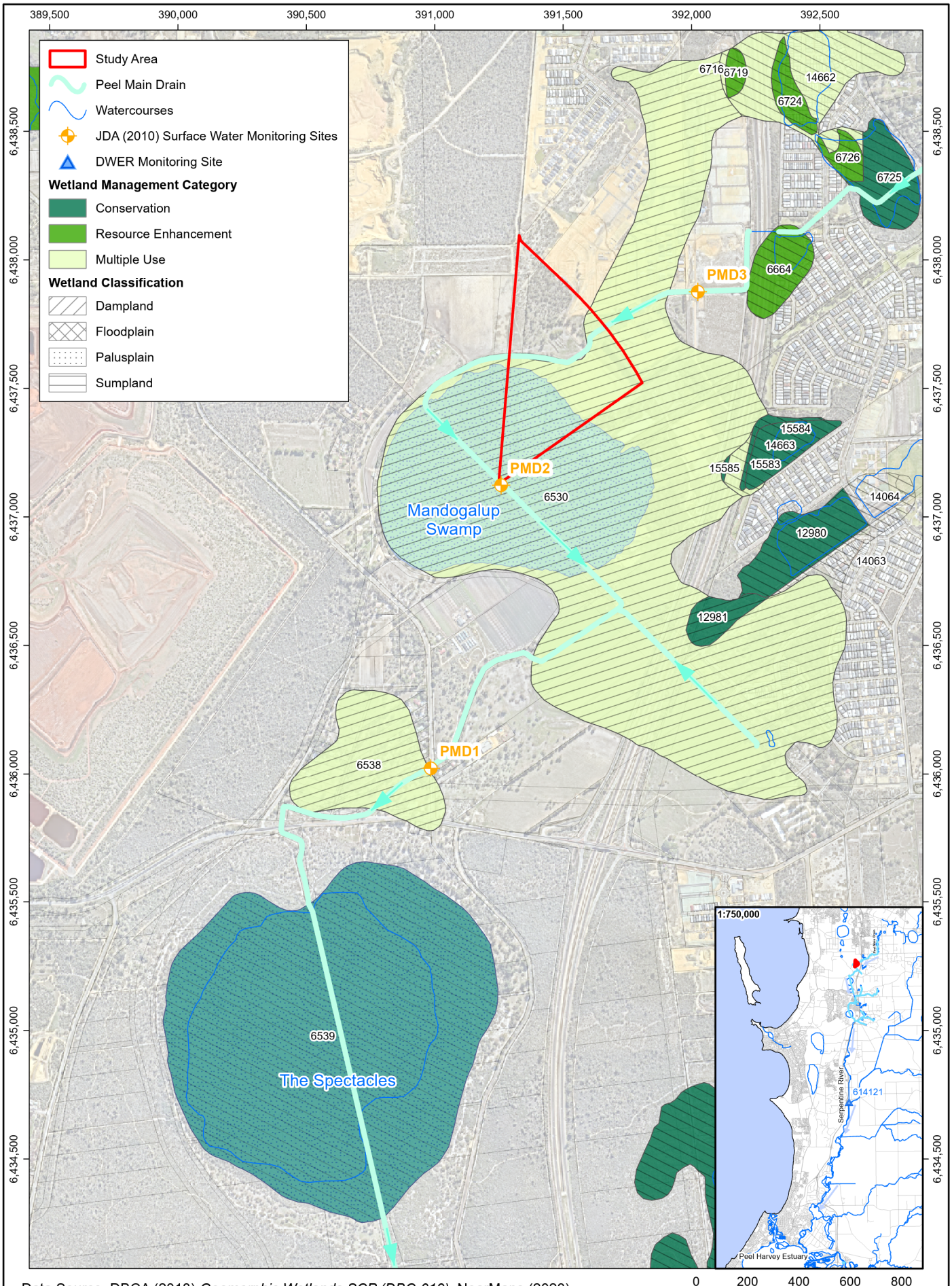
Figure 6: Groundwater Monitoring Locations and Pre-Development AAMGL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Study Area
Peel Main Drain
Watercourses
JDA (2010) Surface Water Monitoring Sites
DWER Monitoring Site
Wetland Management Category
Conservation
Resource Enhancement
Multiple Use
Wetland Classification
Dampland
Floodplain
Palusplain
Sumpland
6716
6719
14662
6724
6726
6725
6664
PMD3
15584
14663
15585
15583
PMD2
6530
Mandogalup Swamp
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Peel Harvey Estuary
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Figure 7: Regional Surface Hydrology and Wetlands

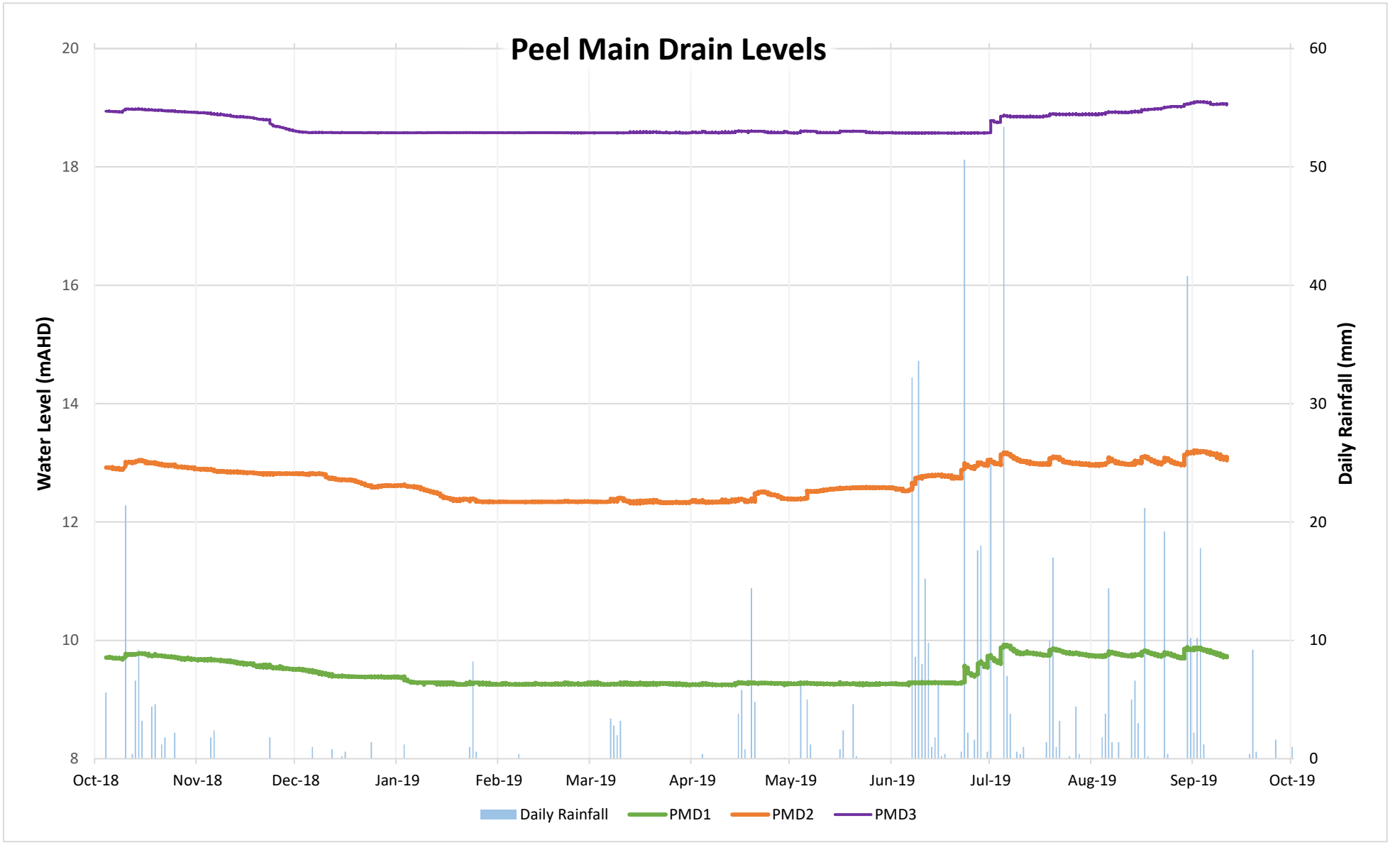

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Figure 8: Peel Main Drain Water Levels – October 2018 to September 2019

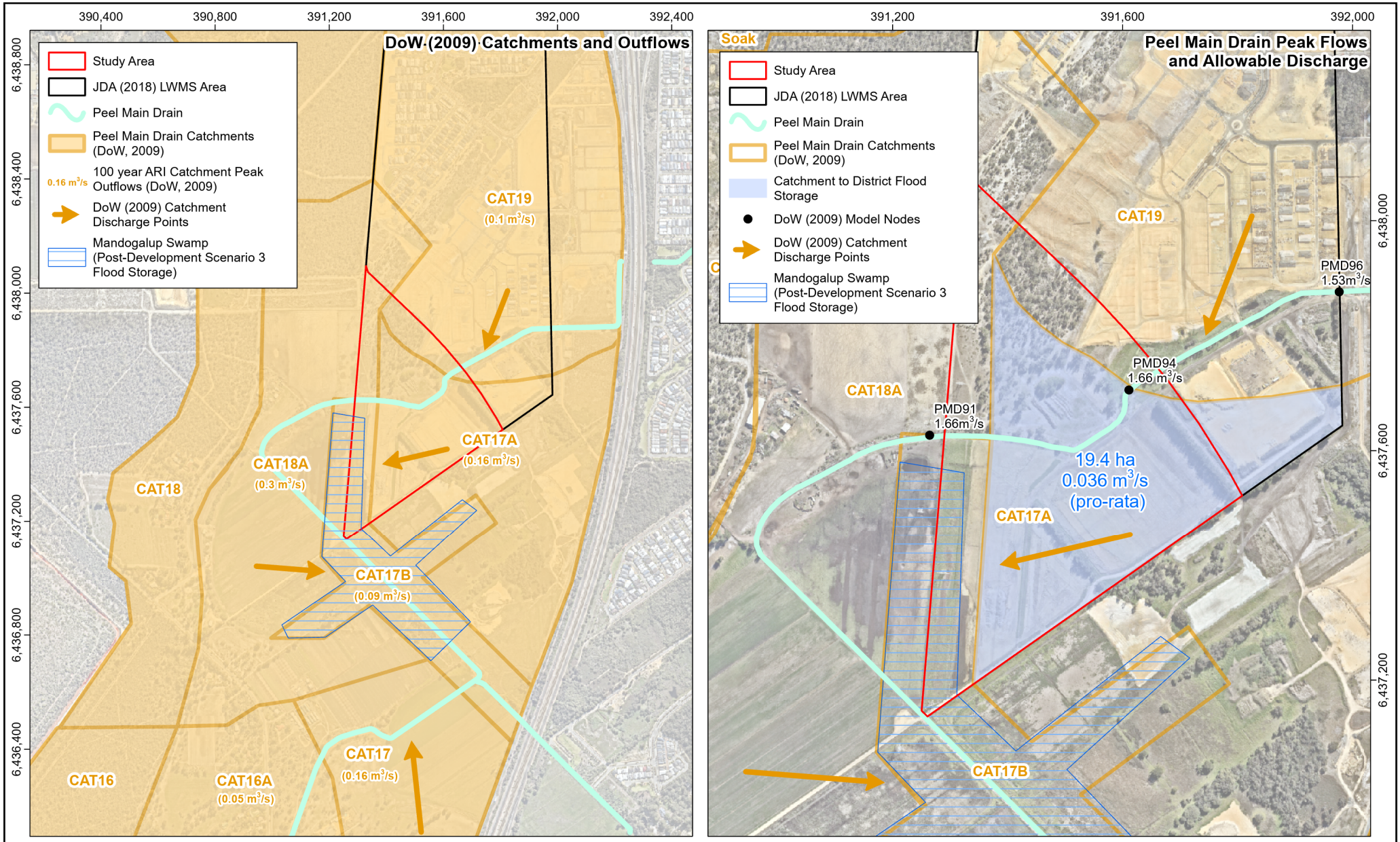

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Figure 9: Pre-Development Catchments, Allowable Outflows and Peel Main Drain Peak Flows



Data Source: Hatch (2025); Cossill & Webley (2025); NearMaps (2024).

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Figure 10: Post-Development Land Use and Drainage Catchments

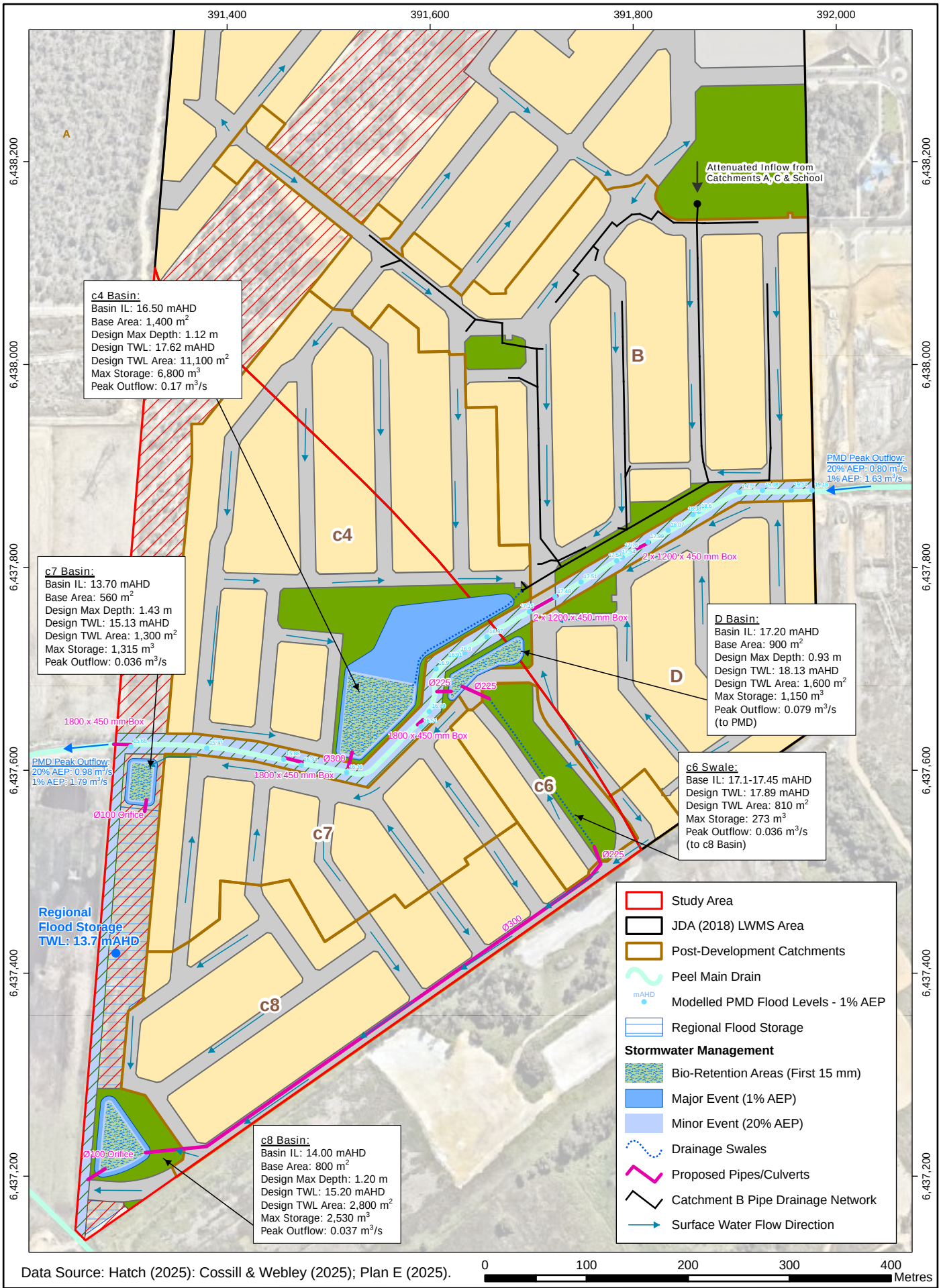

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Figure 11: Stormwater Management Plan

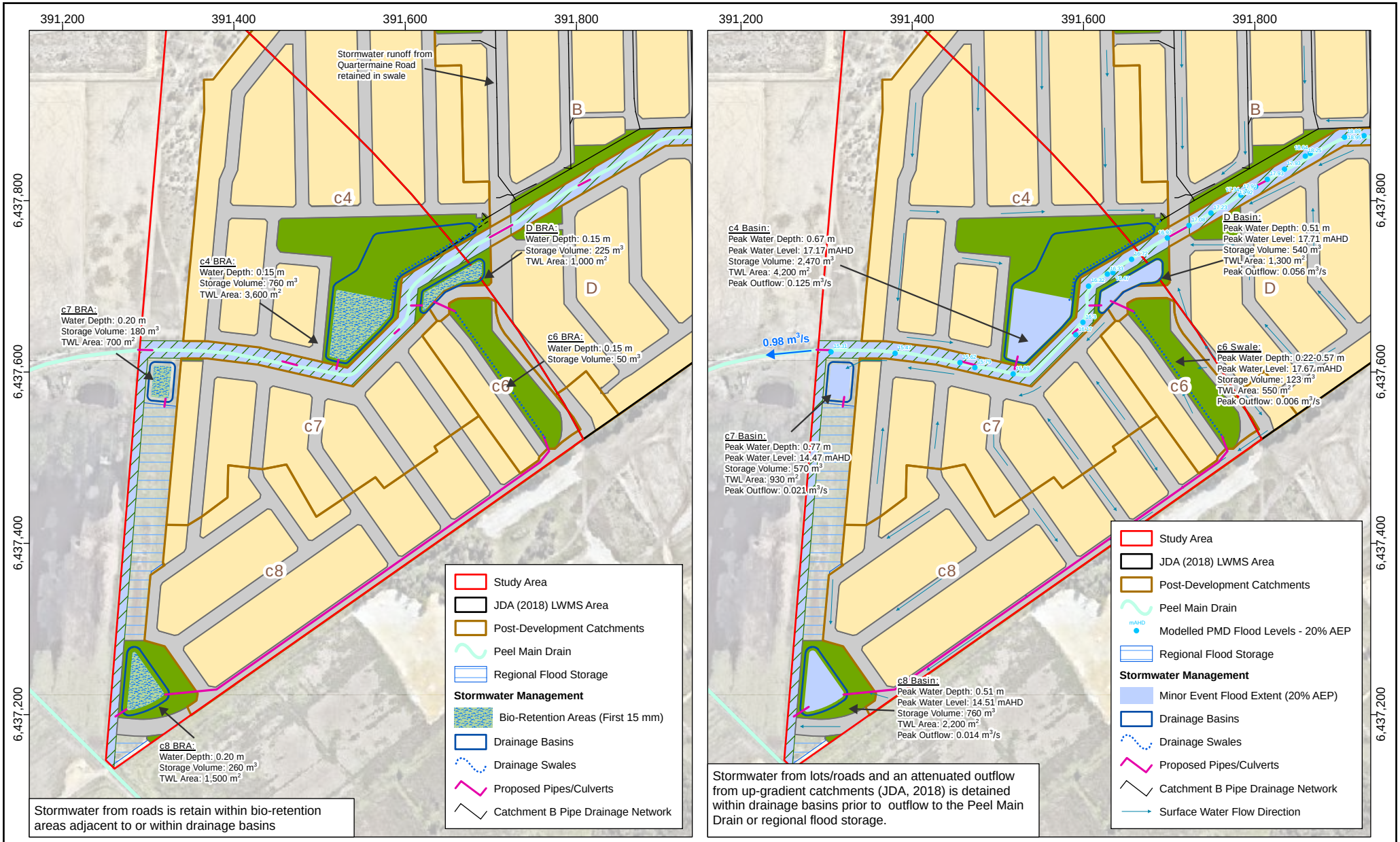

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Figure 12: Small (First 15 mm) and Minor (20% AEP) Stormwater Event Plans

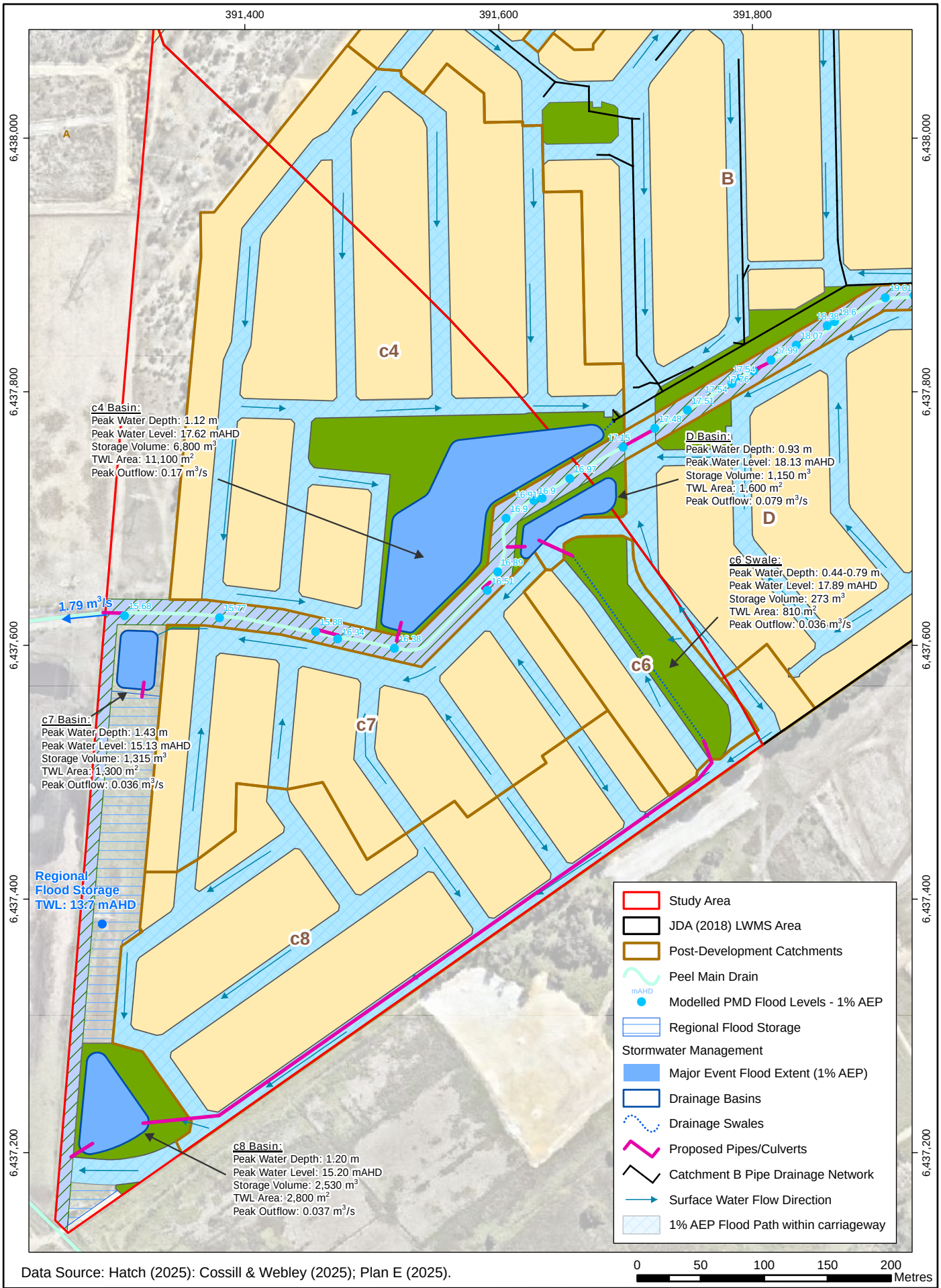

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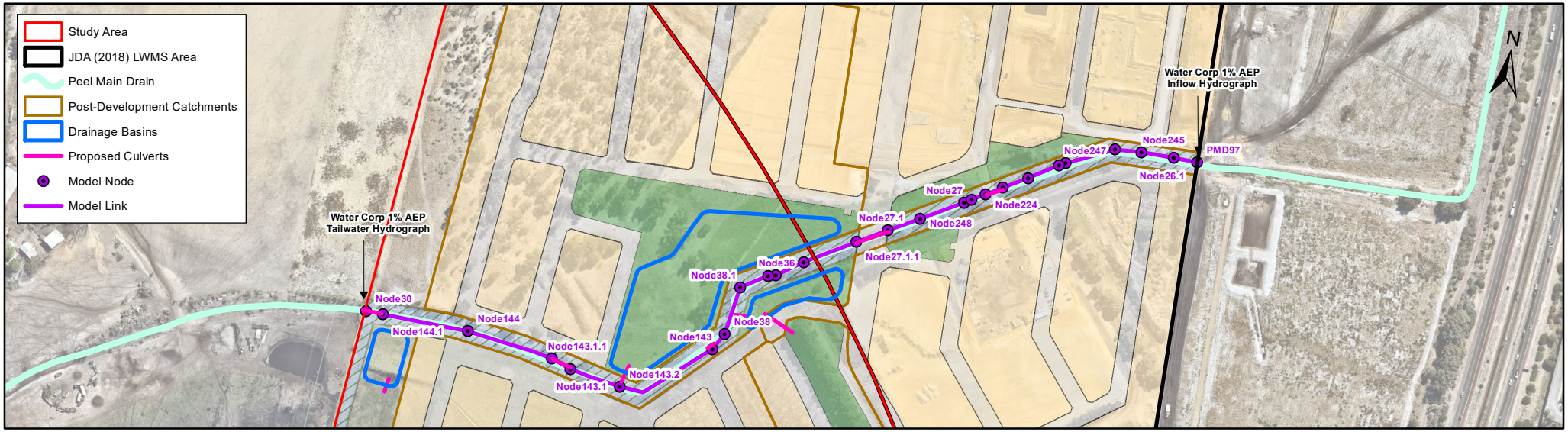
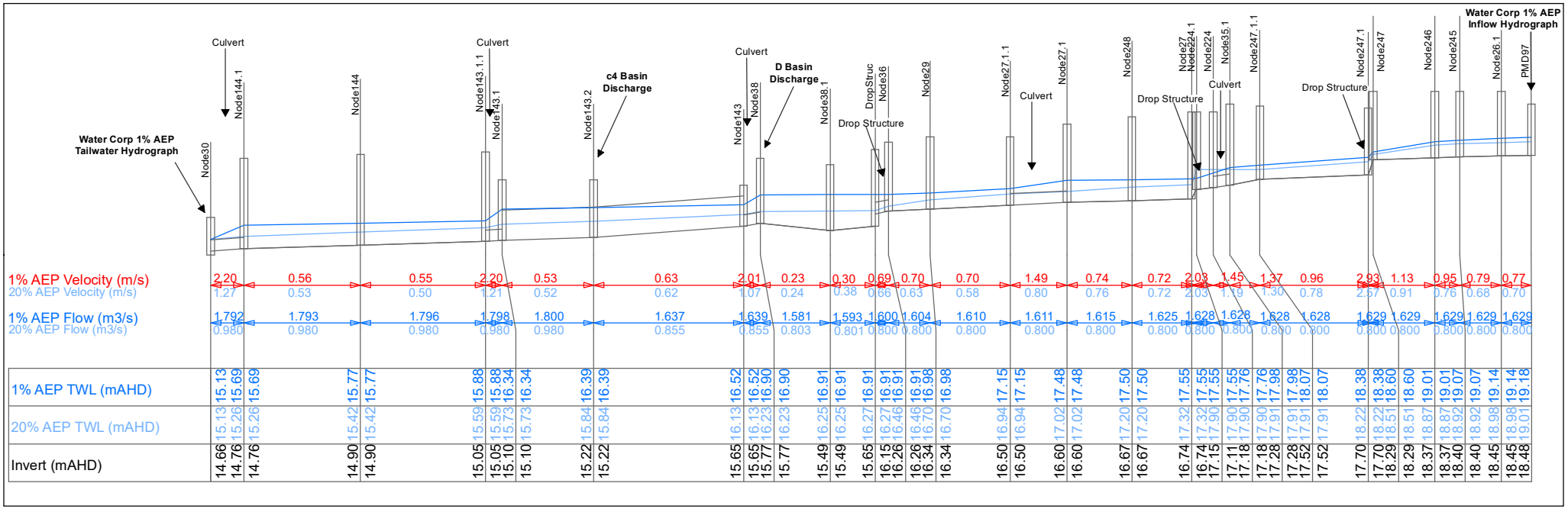
Figure 13: Major (1% AEP) Stormwater Event Plan





Data Source: XP-STORM Model (Modelling results for TP9 for 20% AEP 3 hour critical duration and TP5 for 1% AEP 12 hour critical duration).

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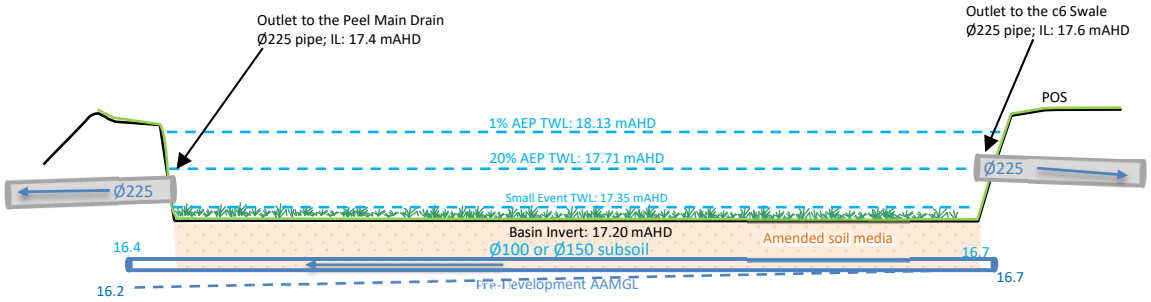
Figure 14: Peel Main Drain Model Long-Section

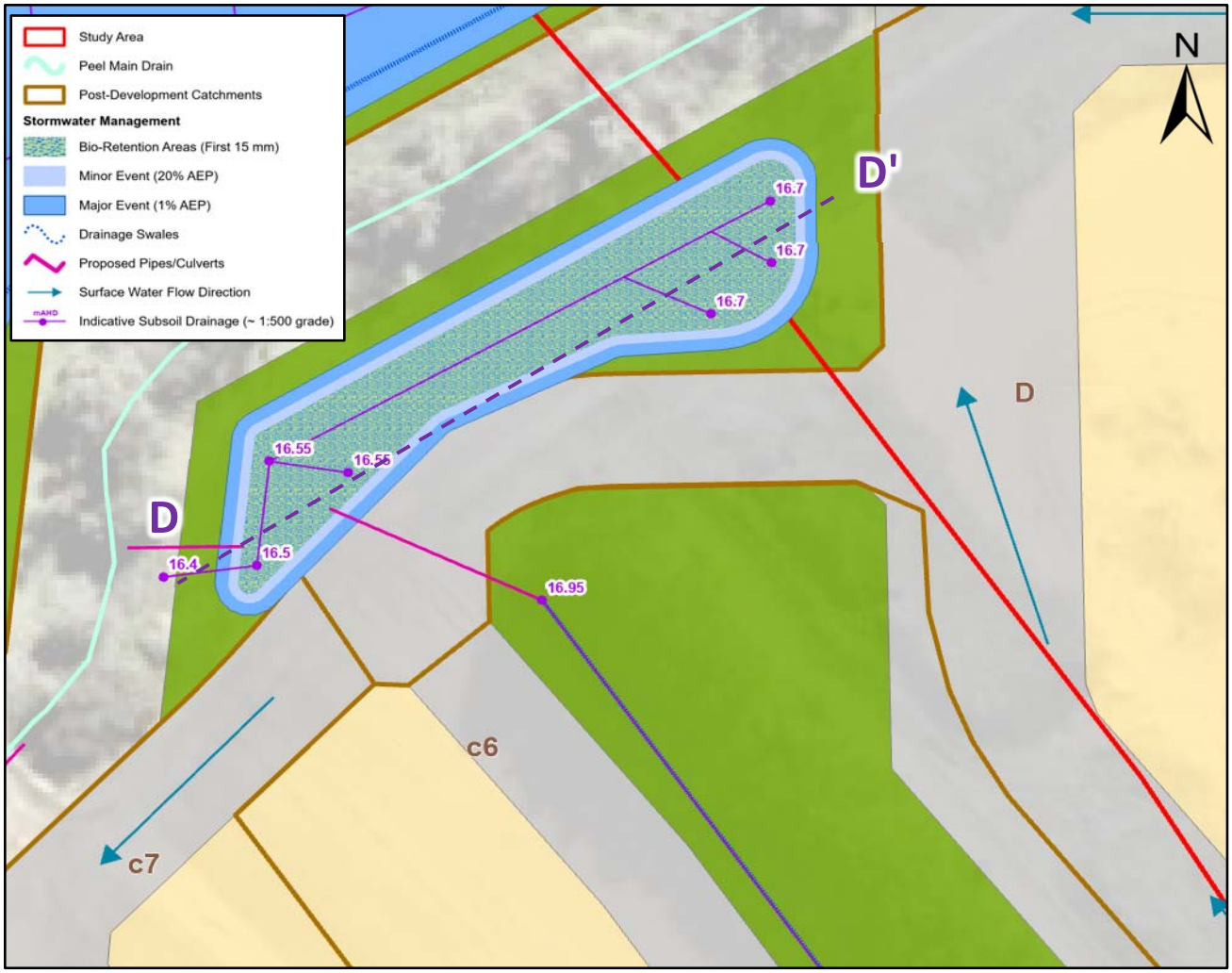
Cross-Section

Catchment D
Drainage Basin

D **D'**



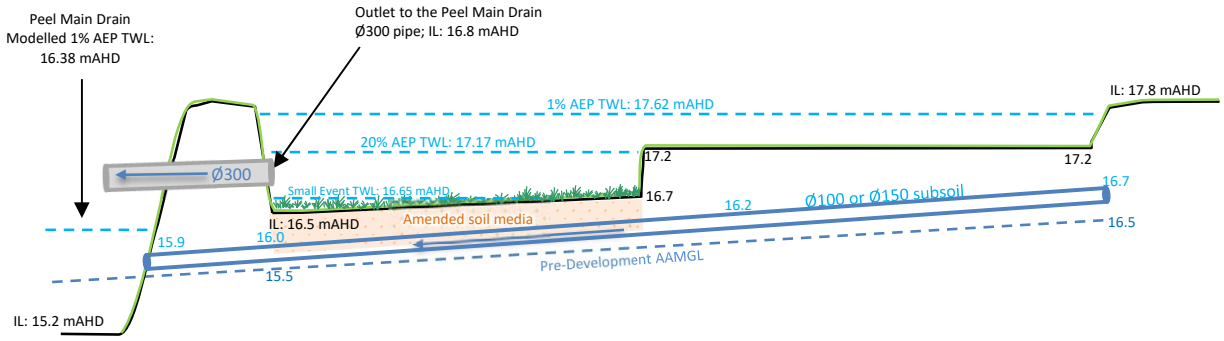
Note: Drawing not to scale



JDA Consultant Hydrologists	Job No. J7489	QUBE Property Group
		Apsley Estate South: Local Water Management Strategy
	© COPYRIGHT JIM DAVIES & ASSOCIATES PTY. LTD. 2025	**Figure 15: Catchment D Basin Cross-Sectional Concept**

Cross-Section

c4 **Catchment c4 Drainage Basin** **c4'**



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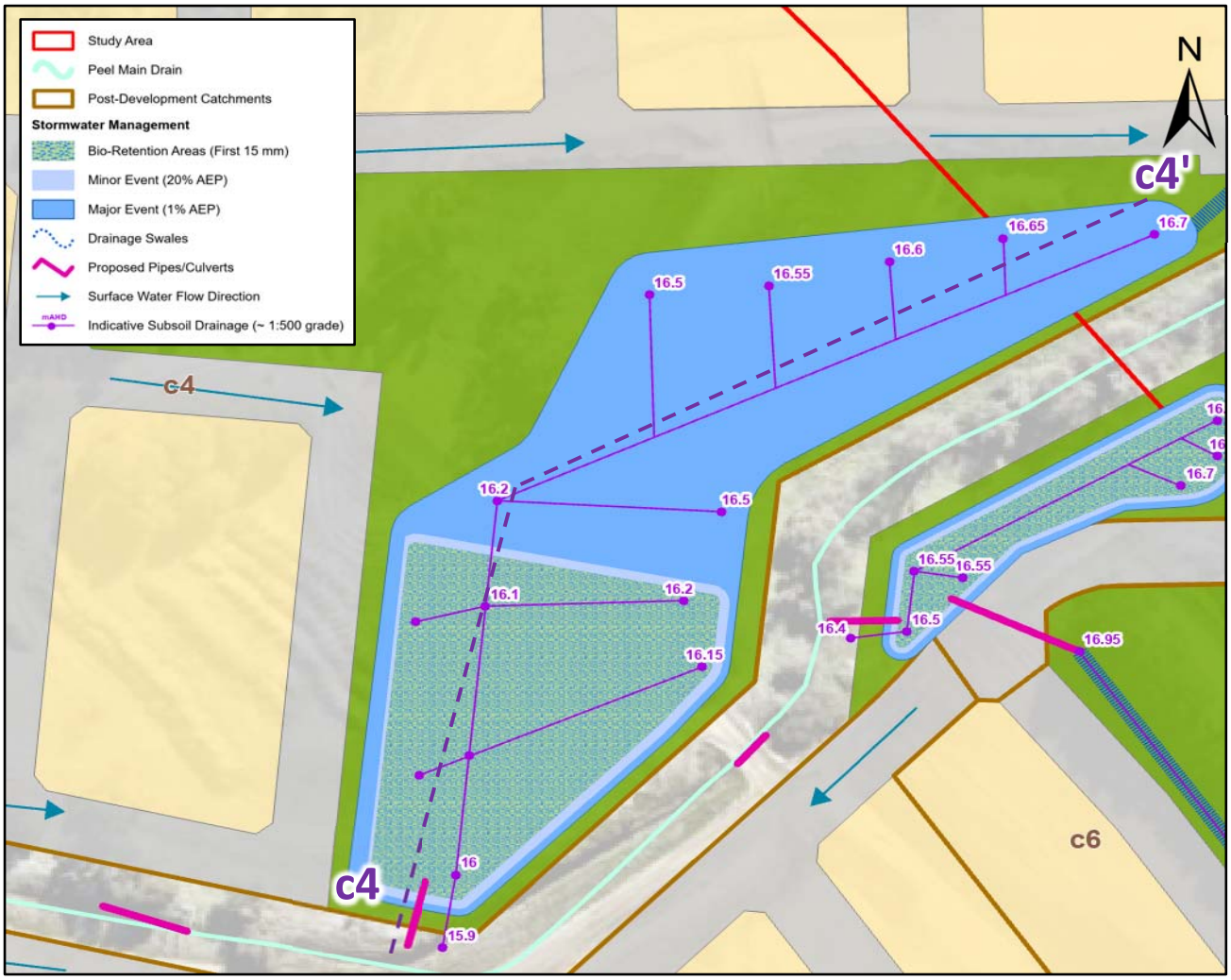

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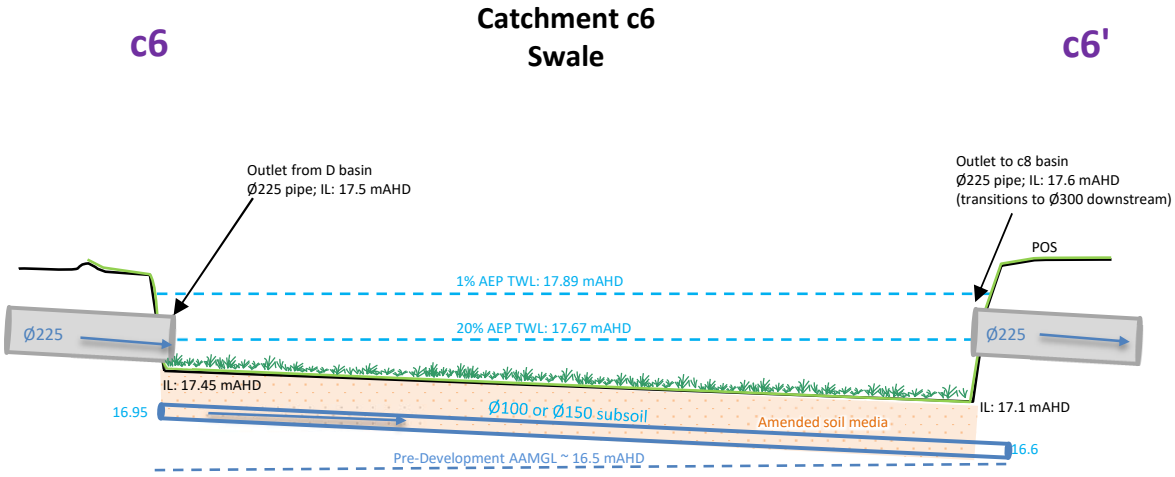
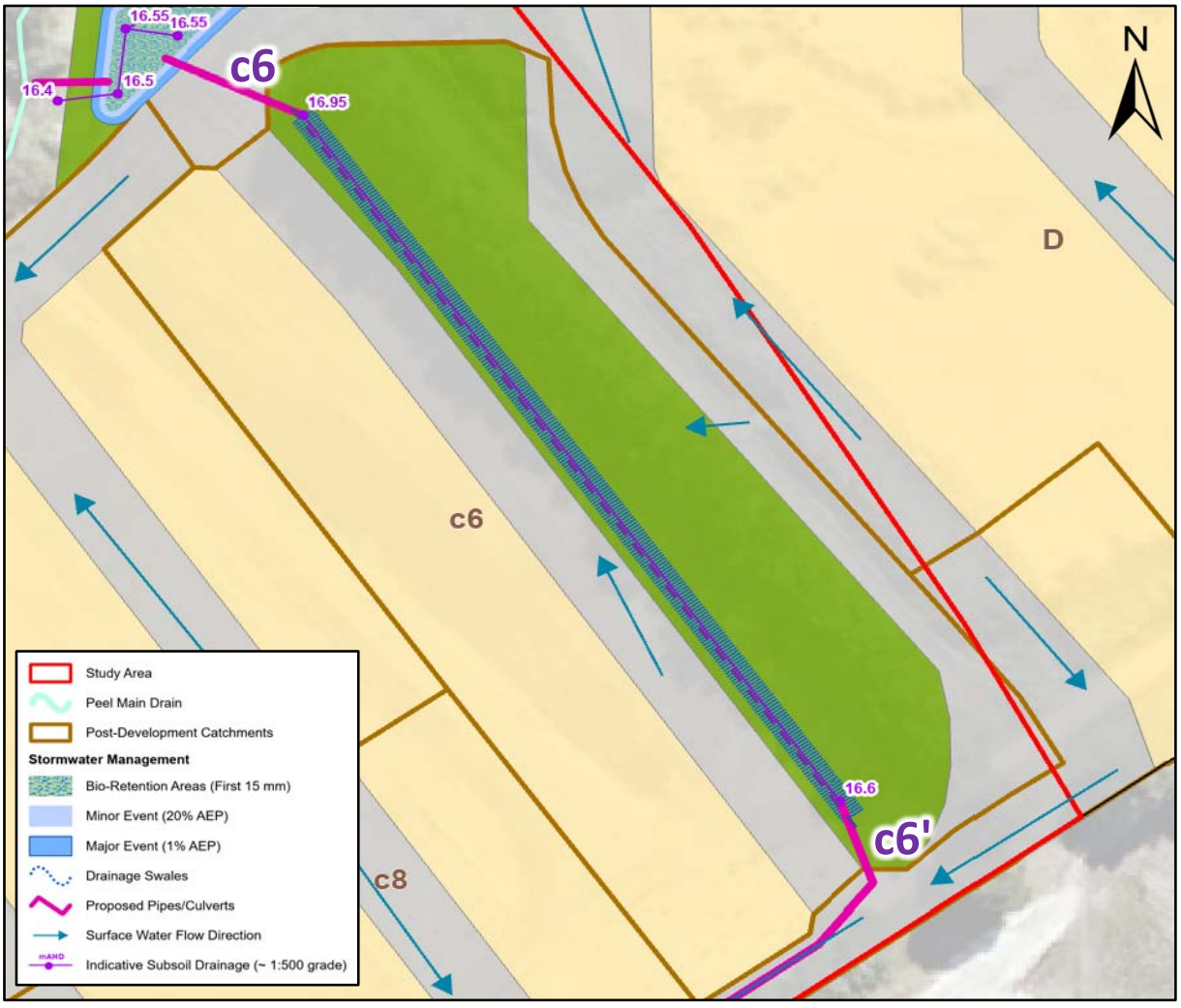
Apsley Estate South: Local Water Management Strategy
Figure 16: Catchment c4 Basin Cross-Sectional Concept

Cross-Section



Note: Drawing not to scale



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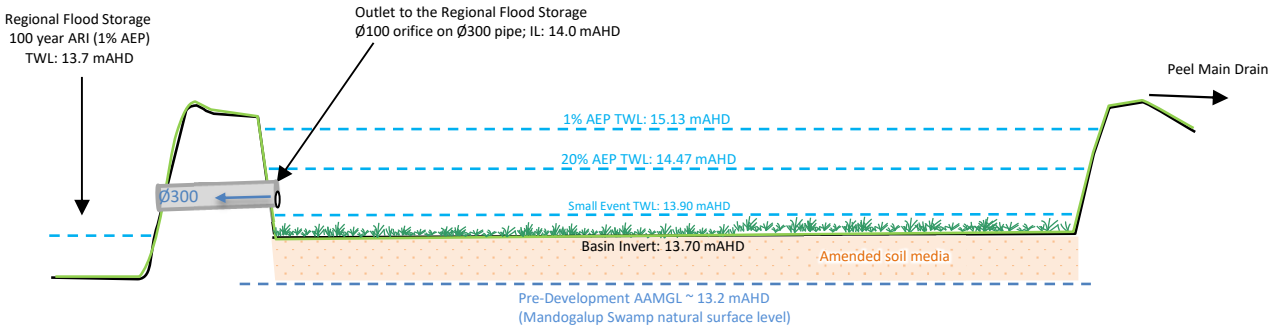
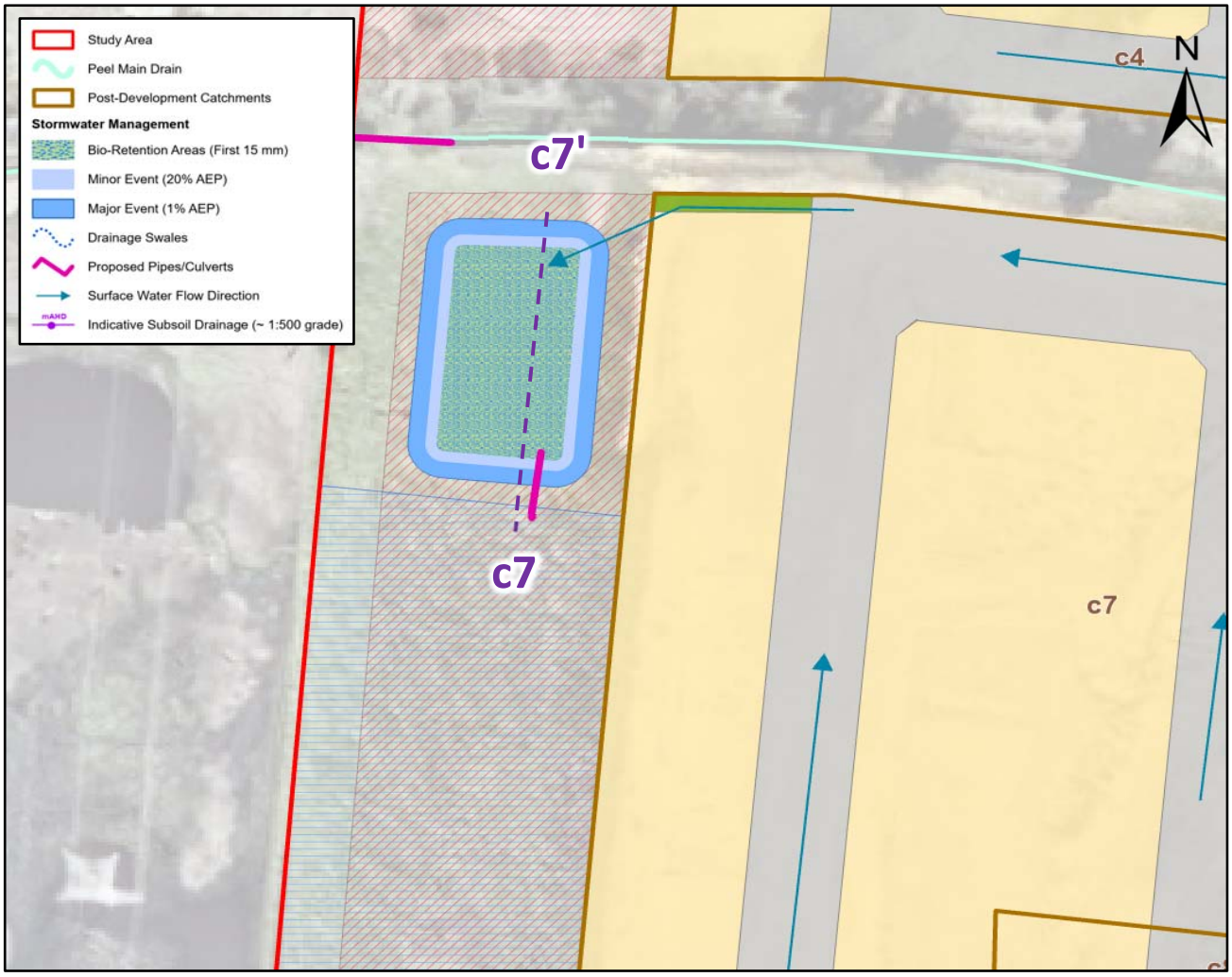
Cross-Section

c7 **Catchment c7 Drainage Basin** **c7'**



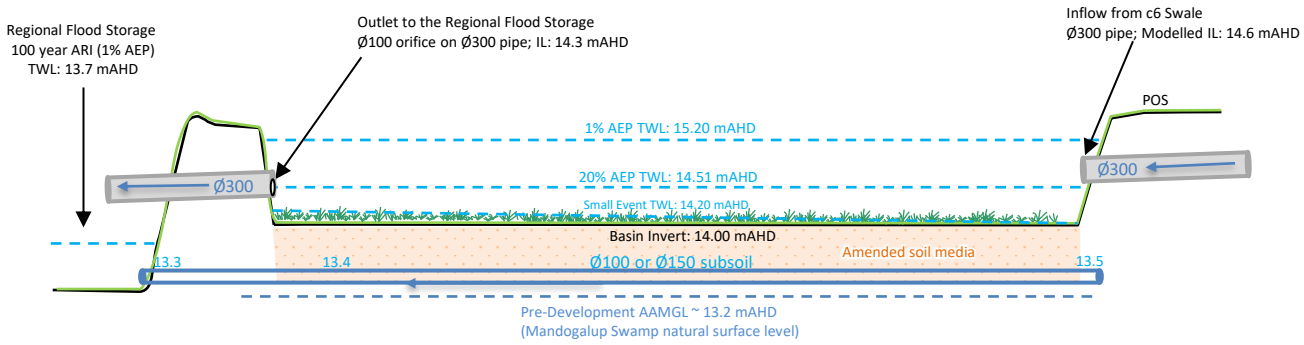
Note: Drawing not to scale



Cross-Section

Catchment c8
Drainage Basin

c8 **c8'**



Note: Drawing not to scale

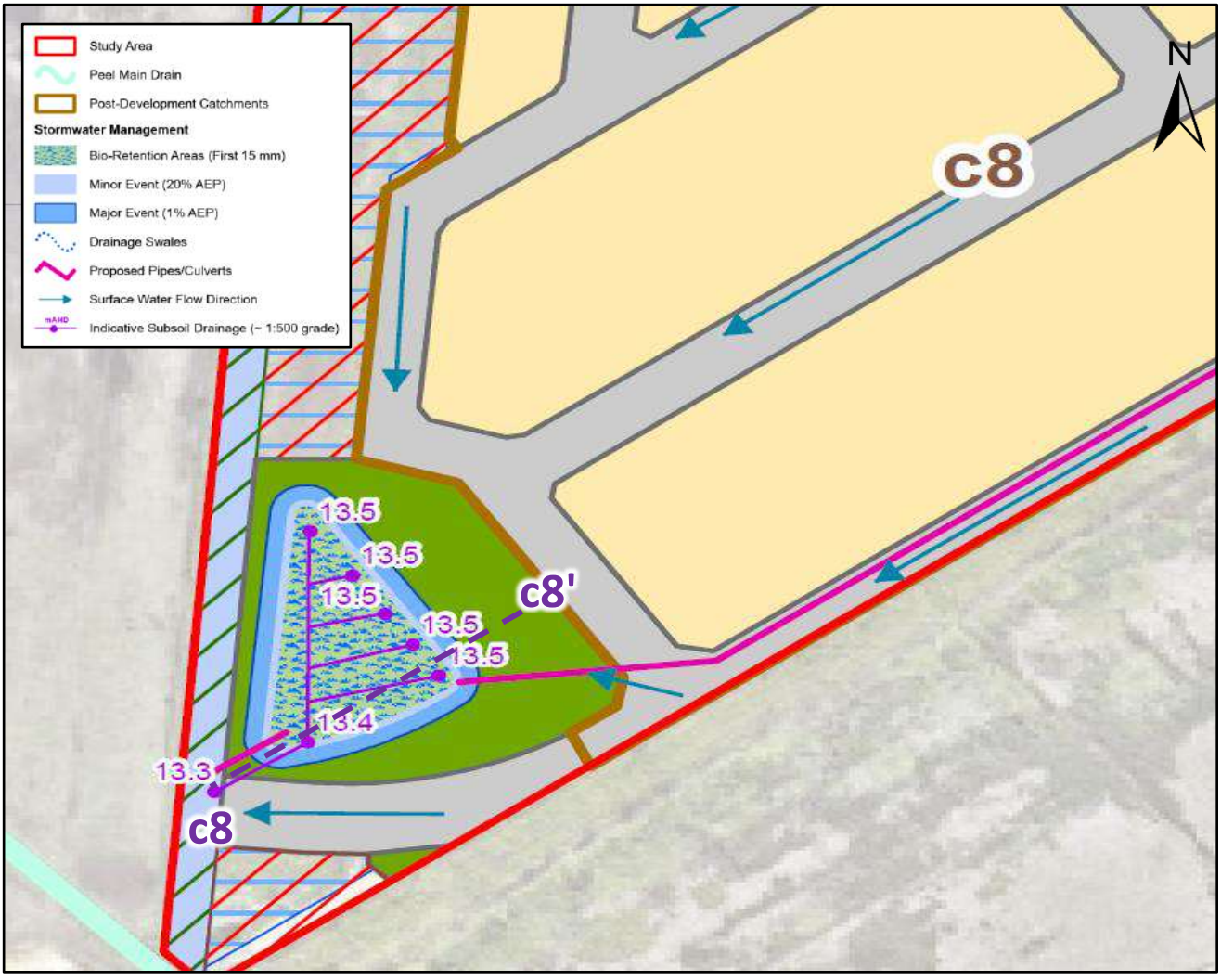


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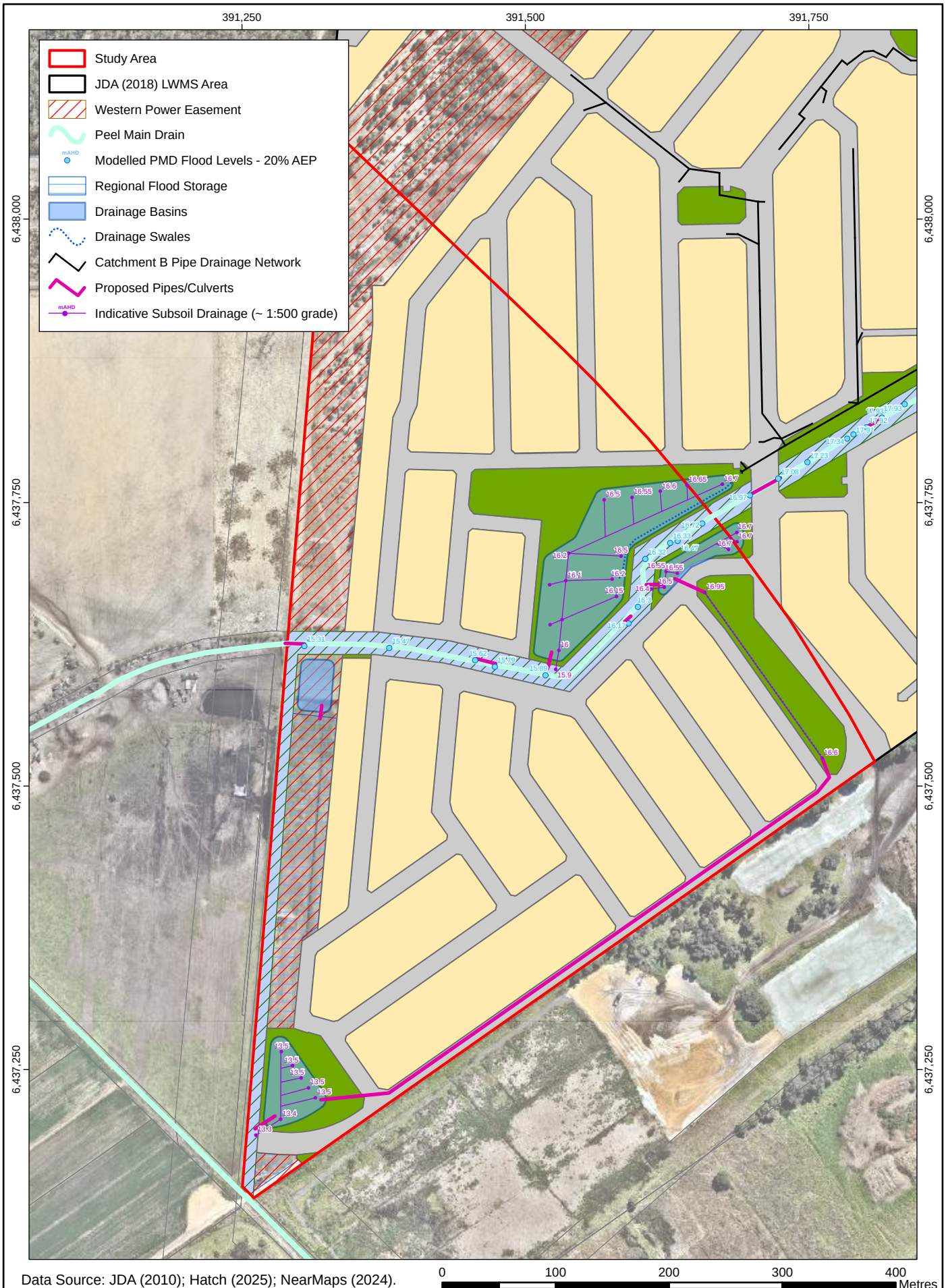
Figure 19: Catchment c8 Basin Cross-Sectional Concept



Data Source: JDA (2010); Hatch (2025); NearMaps (2024).

Job No. J7489
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Coordinate System: GDA2020 MGA Zone 50
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Apsley Estate South: Local Water Management Strategy

Figure 20: Groundwater Management Strategy



Data Source: JDA (2010); Hatch (2025); NearMaps (2024).

JDA

Job No. J7489
Scale: 1:4,500 @A4
Coordinate System: GDA2020 MGA Zone 50

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Apsley Estate South: Local Water Management Strategy

Figure 21: Post-Development Monitoring Locations

APPENDICES

APPENDIX A

Local Water Management Strategy Checklist for Developers

Appendix 2 Local water management strategy checklist

Local water management strategy item	Deliverable	☑	Notes
Executive summary			
Summary of the development design strategy, outlining how the design objectives are proposed to be met	Table 1: Design elements and requirements for best management practices and critical control points	☑	Chapter 1, Table 1.
Introduction			
Total water-cycle management – principles and objectives Planning background Previous studies		☑ ☑	Section 2
Proposed development			
Structure plan, zoning and land use Key landscape features Previous land use	Site context plan Structure plan	☑ ☑	Sections 2 and 3; Figure 1 Figure 2; Section 4.1
Landscape – proposed public open space areas, public open space credits, water source, bore(s), lake details, irrigation areas (if applicable)	Landscape plan	☑	Section 5.2 Appendix G
Design criteria			
Agreed design objectives and source of objectives		☑	Table 1
Pre-development environment			
Existing information and more detailed assessments (monitoring). How do the site characteristics affect the design?		☑	Section 4.
Site conditions – existing topography/contours, aerial photo underlay, major physical features	Site condition plan	☑	Section 4.1 and 4.2 Figures 1 and 3
Geotechnical – topography, soils including acid sulfate soils and infiltration capacity, test pit locations	Geotechnical plan	☑	Section 4.4-4.5 Figure 5; Appendix B.
Environmental – areas of significant flora and fauna, wetlands and buffers, waterways and buffers, contaminated sites	Environmental plan plus supporting data where appropriate	☑	Sections 4.8-4.10 Figure 7.
Surface water – topography, 100-year floodways and flood fringe areas, water quality of flows entering and leaving (if applicable)	Surface-water plan		Section 4.7 Figures 7 and 8 Appendices C and E
Groundwater – topography, pre-development groundwater levels and water quality, test bore locations	Groundwater plan plus site investigations	☑	Section 4.6 Figure 6 and Appendix C

Local water management strategy item	Deliverable	☑	Notes
Water sustainability initiatives			
Water efficiency measures – private and public open spaces including method of enforcement		☑	Section 5.2
Water supply (fit-for-purpose) strategy, agreed actions and implementation		☑	Section 5.1
Wastewater management		☑	Section 5.1
Stormwater management strategy			
Flood protection – peak flow rates, volumes and top water levels at control points, 100-year flowpaths and100-year detention storage areas	100-year-event plan Long section of critical points	☑	Section 6.3-6.5 and Figures 11, 13 and 14. Appendices F and G.
Manage serviceability – storage and retention required for the critical 5-year ARI storm events Minor roads should be passable in the 5-year ARI event	5-year-event plan	☑	Section 6.3.2 and Figure 12 Appendices F and G.
Protect ecology – detention areas for the 1-year 1-hour ARI event, areas for water quality treatment and types of agreed structural and non-structural best management practices and treatment trains (including indicative locations). Protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages	1-year-event plan Typical cross sections	☑	Section 6.3.3 and Figure 12 Appendices F and G. Cross-sections on Figures 15-19
Groundwater management strategy			
Post-development groundwater levels, existing and likely final surface levels, outlet controls, and subsoil drain areas/exclusion zones	Groundwater/subsoil plan	☑	Section 7 and Figure 20
Actions to address acid sulfate soils or contamination		☑	Section 9.3
The next stage – subdivision and urban water management plans			
Content and coverage of future urban water management plans to be completed at subdivision. Include areas where further investigations are required before detailed design.		☑	Section 9.2
Monitoring			
Recommended future monitoring plan including timing, frequency, locations and parameters, together with arrangements for ongoing actions		☑	Section 9.5 and Figure 21
Implementation			
Developer commitments		☑	Section 9
Roles, responsibilities, funding for implementation Review		☑	Sections 9.1 and 9.4 Section 9

APPENDIX B

Geotechnical Investigation
(Galt Geotechnics, 2014)

Report on

PRELIMINARY GEOTECHNICAL STUDY
PROPOSED RESIDENTIAL SUBDIVISION
LOT 682 ROWLEY ROAD
MANDOGALUP

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05 May 2014

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APPENDIX B: TEST PIT REPORTS

APPENDIX C: SUMMARY HAND AUGER BOREHOLE REPORTS

APPENDIX D: DYNAMIC CONE PENETROMETER TEST RESULTS

APPENDIX E: PERMEABILITY TEST RESULTS

APPENDIX F: LABORATORY TEST RESULTS

APPENDIX G: UNDERSTANDING YOUR GEOTECHNICAL ENGINEERING REPORT

1. INTRODUCTION

This report presents the outcomes of the preliminary geotechnical study for the proposed residential subdivision at Lot 682 Rowley Road, Mandogalup ("the site"). The location of the site relative to the surrounding area is shown on Figure 1, Site and Location Plan.

The investigation was requested by Brad Marshall of Cossill & Webley and authorised by Nathan James of Qube Property Group in an email dated 2 April 2014.

2. SITE DESCRIPTION AND PROPOSED DEVELOPMENT

Based on the supplied information, the site is roughly trapezoidal in plan and covers approximately 85.3 ha. It is bounded by Rowley Road to the north and bushland and cultivated land on the other sides. The Kwinana Freeway is about 200 m east of the site.

From the provided contour plans, the surface elevation ranges from about RL 13 m AHD at the southern boundary, rising to about RL 30 m AHD towards the northern part. There are low hills over the western and northwest part with elevations of up to RL 40 m AHD.

Historical aerial photographs indicate that the southern part of the site was under cultivation prior to 1953. By about 2000, the southern 1/3 of the site was under cultivation, with little change up to the present time. A Western Power easement crosses the site diagonally, from the middle of the western boundary to the northeast corner. There is dense bushland on either side of this easement. The "Peel Main Drain" crosses the southern part of the site.

We understand that the lot is to be sub-divided into residential lots with associated roads and public open space (POS). A primary school is planned (possibly in the southern or eastern parts of the site).

According to the provided preliminary earthworks strategy (July 2011), bulk earthworks will comprise fill up to about 4 m over the lower-lying area (southern and eastern parts of the site) and cut of up to about 7 m over the western parts of the site.

3. PROJECT OBJECTIVES

The specified objectives of this preliminary study were to:

- assess subsurface soil and groundwater conditions across the site, in particular:
  - the thickness of topsoil across the site;
  - assess the depth and extents of peaty clay within the north-eastern portion of the site;
  - assess the depth and extents of sandy silt within the southern portion of the site;
  - assess the extent of previously disturbed areas and identification of any loose sand zones or uncontrolled fill
- provide preliminary site classification(s) in accordance with AS 2870-2011 "Residential Slabs and Footings" and advise on measures required to improve the site classification and/or remediate zones of uncontrolled fill, loose/soft soils etc. (if necessary);
- provide recommendations and geotechnical design parameters for earth retaining structures;
- advise on safe temporary and permanent batter slopes for in-situ soils;
- recommend appropriate site preparation procedures including compaction criteria, including
  - suitability of soils for re-use as fill;

- comment on the suitability of the use of topsoil in blending with clean sand, including a recommended blending ratio and proposed construction technique for achieving a blended material suitable for use as structural fill;
- comment and make recommendations regarding the suitability of blending sandy silt for use in general fill areas, including blending ratio and techniques;
- comment on excavatability;
- comment on the suitability of soils where subsoil drainage may be required (e.g. southern portion of the site)

- assess the permeability of the soils at the site for potential on-site disposal of stormwater by infiltration; and
- provide a preliminary subgrade California bearing ratio (CBR) value for pavement thickness design by others.

4. FIELDWORK

Fieldwork was carried out on 9 to 11 April 2014 and comprised:

- excavation of 60 test pits (TP01 to TP60) (approximately one test pit per 1.5 ha), extending to depths of between 1.5 m and 2.5 m;
- testing with a dynamic cone penetrometer (DCP) adjacent to each test pit, extending to a depth of 1.0 m in each instance;
- drilling of hand auger boreholes at 5 locations (P01 to P05), extending to depths of between 1.0 m and 1.5 m; and
- infiltration tests using the 'inverse auger hole' technique in the hand augered boreholes, at a depth of between 0.41 m to 0.57 m below ground.

General

A geotechnical engineer from Galt located the test positions, observed the test pitting, drilled the hand auger boreholes, logged the materials encountered in the test pits and boreholes, collected samples for inspection and possible laboratory testing, and performed the infiltration testing and penetrometer testing.

The test locations are shown on Figure 1, Site and Location Plan and details are summarised in Table A1, Summary of Tests at the end of text. Photographs of the site are presented in Appendix A, Site Photographs.

Test Pits

Test pits were excavated using a Komatsu 97R 9 tonne tractor mounted backhoe fitted with a 600 mm wide toothed bucket. The excavator was supplied and operated by Erskine Backhoe Low Loader Hire.

Test pit reports are presented in Appendix B, Test Pit Reports, along with the method of soil description and cementation classification, and a list of explanatory notes and abbreviations used on the reports. Photographs of the test pit excavation are included with the test pit reports.

Boreholes

Borehole reports are included in Appendix C, Summary Hand Auger Borehole Reports, along with the method of soil description used on the reports.

Dynamic Cone Penetrometer Testing

DCP tests were carried out adjacent to each test pit. Results of the DCP testing are presented in Appendix D, Dynamic Cone Penetrometer Test Results. The tests were conducted in accordance with test method AS 1289 6.3.2.

Permeability Testing

The permeability testing was undertaken using the inverse auger hole method described by Cocks[1]. The results of the permeability testing are presented in Appendix E, Permeability Test Results, and the results are summarised in Table 1: Summary of Permeability Test Results.

Table 1: Summary of Permeability Test Results

Test No.	Soil Description	Test Depth (m)	Minimum Unsaturated Permeability, k (m/day)		
			Test 1	Test 2	Test 3
P01	SAND	0.55	10.2	8.6	4.7
P02	SAND	0.54	8.5	4.2	3.9
P03	SAND	0.51	8.0	6.7	6.4
P04	Peaty SAND	0.41	0.6	0.3	0.2
P05	SAND	0.57	29.8	32.8	25.9

Note: The minimum unsaturated permeabilities shown are typically recorded towards the end of the test, with pressure head varying between about 0.16 m and 0.39 m.

5. LABORATORY TESTING

Laboratory testing on soil samples was undertaken by Mining & Civil Geotest in their NATA accredited laboratory and comprised determination of:

- particle size distribution on 4 samples;
- Atterberg limits and linear shrinkage on 4 samples;
- dry density-moisture content relationship using Modified compactive effort on 2 samples; and
- soaked California bearing ratio (CBR) on 2 remoulded samples.

Laboratory test results along with the test methods followed are included in Appendix F, Laboratory Test Results and are summarised in Table 2, Summary of Laboratory Test Results.

Table 2: Summary of Laboratory Test Results

Test Pit	Depth (m)	% Gravel	% Sand	% Fines	LL (%)	PI (%)	LS (%)	MMDD (t/m^3)	OMC (%)	CBR @ 95%
TP16	0.5 – 0.7	0	25	75	100	24	7.0	-	-	-
TP16	1.5 – 1.7	0	17	83	82	56	13.5	-	-	-
TP41	0.2 – 0.5	0	98	2	NO	NP	0.0	1.73	14.5	11
TP46	0.6 – 0.9	0	73	27	50	30	10.5	1.965	8.5	5

LL: Liquid Limit PI: Plasticity Index LS: Linear Shrinkage
MC: Moisture Content MMDD: Maximum Dry Density (using modified compaction energy)
OMC: Optimum Moisture Content NO: Not Obtainable NP: Non-Plastic
CBR @ 95%: California bearing ratio (soaked) of samples remoulded to a dry density ratio of 95% MMDD, 4.5 kg surcharge

[1] Cocks, G (2007), "Disposal of Stormwater Runoff by Soakage in Perth Western Australia", Journal and News of the Australian Geomechanics Society, Volume 42 No. 3, pp 101-114

6. SITE CONDITIONS

6.1 Geology

The Fremantle sheet of the 1:50,000 scale Environmental Geology series map indicates that the area is underlain by:

- Bassendean Sand over the northwestern part, described as "*very light grey at surface, yellow at depth, fine to medium-grained, moderately sorted, subangular to subrounded, minor heavy minerals, of eolian origin*";
- Lacustrine Deposits over the lower-lying southern and eastern parts of the site, described as "*Sandy Silt – dark brownish grey silt, with disseminated fine-grained quartz sand, firm, variable clay content; and*
- Peaty lacustrine deposits over the north-east part, described as "*Peaty Clay - dark grey and black, soft, variable organic content, some quartz sand in places".*

The findings of our investigation are generally in accordance with the geological mapping. However, the lacustrine deposits found towards the southern end of the site are clayey rather than silty.

6.2 Sub-surface Conditions

Geotechnically, the site can be very broadly separated into two areas. The typical soil profiles for the two areas generally comprise:

Majority of the Site

- SAND (SP), fine to coarse grained, sub-angular to sub-rounded, generally grey becoming pale yellow/white with depth, trace non-plastic fines in top 100 to 200 mm, trace rootlets/roots (up to 90 mm in diameter) in top 2.0 m, generally dry, generally very loose to medium dense, present from the surface extending to the maximum depth of investigation 2.5 m.

Southwest Corner of the Site (TP16, TP29, TP30, TP31)

- Silty SAND/SAND (SM/SP), fine to coarse grained, sub-angular to sub-rounded, grey, trace non-plastic fines in top 100 to 200 mm, generally 5-20% non-plastic fines, locally trace non-plastic fines , dry to moist, generally loose to dense, locally very dense, present from the surface extending to depths of between 0.3 m to 0.6 m; overlying
- CLAY (CI), low to medium plasticity, pale grey becoming brown, trace rootlets, with some fine grained sand, generally firm to stiff, locally hard, dry to moist, extending to the maximum depth of investigation of 2.5 m.

Notes:

1. The test pit reports should be referred to for more detail on the subsurface conditions at each test location.
2. Peaty sand was encountered within one of the hand auger boreholes (P04). This was located within the Western Power easement.
3. Clayey sand was encountered below the sand within one test pit (TP13) towards the north of the site at a depth of 1.8 m.
4. Clayey sand was encountered above the sand at two locations (TP46 and TP47) towards the middle of the site.
5. Some localised areas with increased non-plastic fines (~5-20%) in the top 0.5 m are present within the market garden areas of the site.
6. Locally iron-cemented sandy soil (often termed "coffee rock") was encountered within two of the test pits (TP31 and TP 43) towards the south of the site.
7. Those test pits that did not reach target depth were terminated due to either refusal on the iron-cemented sand ("coffee rock") or due to collapse of the test pit walls.

6.3 Groundwater

According to the Department of Water database, the maximum historical groundwater elevation varies from RL 13 m AHD over the southern part to about RL 22 m AHD towards the northern part of the site. This is between 1 m and 8 m below the current surface elevation. These elevations are similar to those indicated in the Jim Davies and Associates (JDA) Mandogalup District Water Management Strategy (report reference J4931f dated 27 September 2011) provided to us.

Figure 2 shows the historical groundwater elevations across the site.

Groundwater was encountered within 7 of the test pits (TP13, TP43, TP46, TP47, TP48, TP49 and TP56) and 1 hand auger borehole (P04) at depths of between 1.0 m and 1.8 m. These locations were generally in lower lying areas of the site. In one case (TP13), this water was likely perched water on top of a clayey layer.

7. GEOTECHNICAL ASSESSMENT

7.1 Preliminary Site Classification

The preliminary site classification is based on AS 2870-2011 "Residential Slabs and Footings" which defines the site classes as such in Table 3.

Table 3: Summary of Site Classifications (AS 2870-2011)

Class	Description	Characteristic Surface Movement (y_s)
A	Most sand and rock site with little or no ground movement from moisture change	Not Defined (typically <5 mm)
S	Slightly reactive clay sites with only slight ground movement from moisture changes	0 – 20 mm
M	Moderately reactive clay sites, which may experience moderate ground movements from moisture change	20 – 40 mm
H1	Highly reactive sites, which may experience high ground movements from moisture change	40 – 60 mm
H2	Highly reactive sites, which may experience very high ground movements from moisture change	60 – 75 mm
E	Extremely reactive sites, which may experience extreme ground movements from moisture change	>75 mm
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise	Not Defined

We consider that the preliminary site classifications shown in Figure 2, Site Classifications, are appropriate for the site, provided site preparation measures outlined in Section 7.2 are followed. Site classifications considered appropriate are:

- "Class A" for the majority of the site;
- "Class S" for a localised area within the market garden areas; and
- "Class M" for the low-lying clayey areas towards the southwest of the site.

Note: In its current state, most of the site would be classified as Class P due to the presence of very loose and loose sand to depths of over 1 m. In addition, we note that the historical groundwater elevation over the southern part of the site is close to ground surface.

Improvement of the entire site to "Class A" is possible with importation and placement of sand fill to produce a total thickness of about 1.8 m (in-situ sand and inert fill) overlying clayey material (except peaty areas discussed below).

We consider that a preliminary site classification of "Class P" is appropriate for part of the Western Power easement due to the presence of Peaty SAND. Excavation and removal of the Peaty SAND material will improve this area to a "Class A" or "Class S" (depending on the thickness of the underlying sand layer).

7.2 Site Preparation

The site preparation measures outlined below are aimed at improvement of the site in preparation for construction of the structures including on-ground slabs, shallow footings, retaining walls and pavements.

- Demolish and remove all infrastructure associated with farming activities.
- Strip vegetation from the site including grubbing out of tree roots.
- Strip and stockpile topsoil from the site for potential re-use in non-structural applications or for possible blending with clean sand (generally only a thin layer of topsoil was noted at the time of our investigation over a majority of the site). Topsoil strip is only necessary to remove roots. We recommend a 100 mm topsoil strip or as otherwise necessary to remove all roots from the soil. Topsoil may be retained for screening and re-use as structural fill (refer to Section 7.7).
- Compact ground surface to achieve the level of compaction specified in Section 7.5 to a minimum depth of 0.9 m below surface. **Note:** Where there is more than 1 m of bulk fill to be placed over the in-situ sand, the depth of compaction can be reduced to 0.45 m.
- Where fill is required to raise site surface levels, approved fill must be used (refer to Section 7.6), placed and compacted in layers of no greater than 300 mm loose thickness.

Note: Where soakwells are to be used for stormwater disposal, surface levels must be raised to at least 1.2 m above the historical maximum groundwater elevation.

The above are only preliminary site preparation procedures based on limited geotechnical information. The final site procedures are also likely to depend to a large extent on the actual development. Additional geotechnical and groundwater studies will enable a better appreciation of the nature and extent of the clayey and peaty soils present across the site. This information will enable more definitive site procedures to be provided.

7.3 Retaining Structures

Retaining structures must be designed in accordance with AS 4678-2002 "Earth-Retaining Structures". We recommend that all retaining walls at the site be backfilled with free-draining fill, e.g. sand (either site-derived or imported free draining sand fill with less than 5% fines).

For the design of retaining structures, the following parameters are considered appropriate for *in situ* medium dense sand and compacted sand backfill:

- angle of internal friction, $\phi = 36°$;
- coefficient of active earth pressure $K_a = 0.26$;
- coefficient of passive earth pressure $K_p = 3.85$;
- at rest coefficient of earth pressure $K_0 = 0.41$;
- bulk density: 18 kN/m^3; and

Compaction plant can augment the lateral earth pressure acting on retaining walls. Hand operated compaction equipment is recommended within 2 m of any retaining walls to minimise compaction pressures.

It is important to note that some ground movement is to be expected behind any soil retaining system, including gravity retaining walls.

7.4 Excavations

Based on the soil profile encountered, we expect that excavations on site will be readily achievable using conventional earthmoving equipment (i.e. with a 10 tonne or larger excavator).

Excavations in sand are prone to instability particularly below the water table. Above the water table, we recommend batter angles no steeper than 1V:2H for temporary slopes and 1V:3H for permanent slopes where no external restraint is provided to the slope. Even at these slope angles, rilling and erosion of the slope may occur. Where steeper slopes are required, temporary or permanent slope retention must be employed.

Below groundwater, either temporary dewatering or shoring will be required. We can advise further on this if required.

Temporary slopes up to 1V:1.5H can be considered where:

- No surcharge (machinery, stockpiles, etc) is present at the crest of the slope.
- The maximum slope height is 2 m.
- The slope is thoroughly dewatered to at least 1 m below the toe of the slope.

A geotechnical engineer must be consulted where there is any doubt regarding the stability or safety of unsupported excavations.

7.5 Compaction

Approved granular fill must be compacted using suitable compaction equipment to achieve a dry density ratio of at least 95% of maximum modified dry density (MMDD) as determined in accordance with AS 1289 5.2.1.

If sand is used as fill, a Perth sand penetrometer (PSP) may be used for compaction control. We consider a minimum blow count of 8 blows per 0.3 m penetration to correspond to 95% MMDD. If difficulty arises in achieving the specified PSP blow counts, then a calibration must be established between PSP blow count and the *in situ* density. This will allow confirmation of the blow count required to achieve the required density ratio.

Over-excavation and replacement of loose materials must be carried out where the minimum density cannot be achieved.

Fill must be placed in horizontal layers of not greater than 0.3 m loose thickness. Each layer must be compacted by suitable compaction equipment, and carefully controlled to ensure even compaction over the full area and depth of each layer.

TESTING

After compaction, verify that the required level of compaction has been achieved by testing within any fill and to a minimum depth of 0.9 m below foundations.

- on each lift of fill at the rate of 1 test per 500 m^3;
- at each spread footing location (unless footings are in clayey soil);
- at 7.5 m centres below on-ground slabs;
- at 15 m centres along retaining wall footings (where present);
- at 15 m centres in backfill behind retaining walls; and

- at 10 m centres on pavement subgrades (on the road centreline or on a grid below car parks/hardstanding).

7.6 Approved Fill

Imported granular fill must comply with the material requirements as stated in AS 3798-2007, "Guidelines on Earthworks for Commercial and Residential Developments". Sand fill must comprise clean sand that is free of organic matter and have a fines content of less than 5%.

The *in situ* sand present at the site is geotechnically suitable for re-use as inert structural fill. Any organic-rich sand or sand containing significant proportions of fines (material less than 0.075 mm in size) must not be used as structural fill. Topsoil may be re-used as structural fill when appropriately screened and blended as discussed in Section 7.7.

Where doubt exists, a geotechnical engineer must be engaged to inspect and approve the use of potential fill materials.

7.7 Re-use of Topsoil

Stripped topsoil may be re-used as structural fill providing the following steps are taken:

- Topsoil material is screened to remove all deleterious material (i.e. grass, roots, construction rubbish etc.). The use of a 50 mm or finer screen should ensure that a majority of the root matter is removed. After the material has been screened, samples should be taken for fines and organic testing of the material;
- Any topsoil or stockpile material with an organic content greater than 5% or fines content greater than 10% must be set aside for re-use in non-structural applications;
- Screened material should be blended at a nominal ratio of 1:2 or greater (topsoil : clean fill). The ratio of topsoil to clean fill depends on the organic content of the blended material (must be less than 2%) and permeability requirements. Trial pads should be formed with materials of different blend ratio to assess the permeability prior to employing topsoil blending on a large scale;
- Quality control testing (fines content and organic content testing) of the blended material should be undertaken to ensure its suitability for re-use as structural fill.

It is noted that localised topsoil in the lower-lying market garden areas of the site (encountered in TP16, TP17, TP29 to TP30, TP43, TP46 and TP47) was visually assessed to have organic contents greater than 5% or fines content greater than 12% and is not considered suitable for topsoil blending. This material should be stockpiled for use in non-structural applications or removed from the site. It is identifiable by its brown colour in contrast to generally grey topsoil in other parts of the site.

7.8 Stormwater Disposal and Site Drainage

We consider that the natural sandy soils at the site will be suitable for on-site disposal of stormwater by the use of soak wells or soakage basins. This is applicable only where the ground surface is at least 1.2 m above the maximum groundwater level. A preliminary permeability of no greater than 4 m/day can be used for design of soakage systems.

The permeability of any stormwater disposal system may be expected to decrease over time due to compaction of sands during site preparation and clogging of the pore spaces by fines deposited during the life of the stormwater disposal system.

In-situ permeability tests must be done on the completed bulk fill to confirm the design permeability.

Where possible, soak wells should not be placed within 3 m of footings (subject to local council regulations). Discharge from soakwells has been known to cause densification of loose sandy soils, leading to settlements of

footings and slabs. Where soakwells are placed closer to footings, they must be carefully wrapped with geotextile to prevent migration of sand and fines into the soakwell.

Subsoil Drainage

We understand that significant fill is to be placed during bulk earthworks (up to about 4 m over the lower-lying areas southern and eastern parts of the site). We do not consider that subsoil drainage will be required, provided at least 1.2 m of clean draining sand fill is present overlying the clayey material and above the maximum historic groundwater table.

Additionally, we do not consider the north east portion of the Western Power easement to be a suitable location for site drainage due to the presence of shallow peaty sand unless this material is removed.

7.9 Pavement Design

Where adequate site preparation measures have been completed (i.e. pavement subgrades comprise compacted *in situ* sand or sand backfill), pavement thickness design may be undertaken assuming a subgrade California bearing ratio, CBR=10%.

We do not consider the clayey material present on-site to be suitable for use as pavement subgrades, unless it can be kept dry, as we would expect a CBR value of 3% to 5% when the material becomes saturated.

8. CLOSURE

We draw your attention to Appendix G of this report, Understanding Your Geotechnical Engineering Report. The information provided within is intended to inform you as to what your realistic expectations of this report should be. Guidance is also provided on how to minimise risks associated with groundworks for this project. This information is provided not to reduce the level of responsibility accepted by Galt, but to ensure that all parties who rely on this report are aware of the responsibilities each assumes in so doing.

GALT GEOTECHNICS PTY LTD





Rick Piovesan CPEng

Geotechnical Engineer

James Harris

Geotechnical Engineer

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Tables

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Table A1: Summary of Tests

Test Names	Test Depth (m)	Depth to Groundwater (m)	Reason for Termination	Stratigraphy
TP01	2.5	GNE[1]	Target Depth	SAND
TP02	2.5	GNE	Target Depth	SAND
TP03	2.5	GNE	Target Depth	SAND
TP04	2.5	GNE	Target Depth	SAND
TP05	2	GNE	Collapse	SAND
TP06	2	GNE	Collapse	SAND
TP07	2.5	GNE	Target Depth	SAND
TP08	2	GNE	Collapse	SAND
TP09	2.5	GNE	Target Depth	SAND
TP10	2	GNE	Collapse	SAND
TP11	2.5	GNE	Target Depth	SAND
TP12	2.5	GNE	Target Depth	SAND
TP13	2.5	1.8	Target Depth	SAND overlying Clayey SAND
TP14	1.8	GNE	Collapse	SAND
TP15	2	GNE	Collapse	SAND
TP16	2.5	GNE	Target Depth	Silty SAND overlying CLAY
TP17	2.5	GNE	Target Depth	Silty SAND/SAND overlying CLAY
TP18	2	GNE	Collapse	SAND
TP19	2	GNE	Collapse	SAND
TP20	2.5	GNE	Target Depth	SAND
TP21	2	GNE	Collapse	SAND
TP22	2.5	GNE	Target Depth	SAND
TP23	2.5	GNE	Target Depth	SAND
TP24	2.5	GNE	Target Depth	SAND
TP25	2	GNE	Collapse	SAND
TP26	2.5	GNE	Target Depth	SAND
TP27	2.5	GNE	Target Depth	SAND
TP28	2.5	GNE	Target Depth	SAND
TP29	2.5	GNE	Target Depth	Silty SAND overlying CLAY
TP30	2.5	GNE	Target Depth	SAND
TP31	2.2	GNE	Refusal	Silty SAND overlying CLAY overlying Cemented SAND
TP32	2.2	GNE	Collapse	Silty SAND overlying SAND
TP33	2	GNE	Collapse	SAND
TP34	2.1	GNE	Collapse	SAND
TP35	2.2	GNE	Collapse	SAND
TP36	2	GNE	Collapse	SAND

Test Names	Test Depth (m)	Depth to Groundwater (m)	Reason for Termination	Stratigraphy
TP37	2.1	GNE	Collapse	SAND
TP38	2	GNE	Collapse	SAND
TP39	1.9	GNE	Collapse	SAND
TP40	2.5	GNE	Target Depth	SAND
TP41	2	GNE	Collapse	SAND
TP42	2.5	GNE	Target Depth	SAND
TP43	2.2	1.5	Refusal	Silty SAND overlying SAND overlying Cemented SAND
TP44	2.5	GNE	Target Depth	SAND
TP45	2.5	GNE	Target Depth	FILL: Gravelly SAND overlying SAND
TP46	2.5	2.3	Target Depth	Clayey SAND overlying SAND
TP47	2.5	1.5	Target Depth	Clayey SAND overlying SAND
TP48	2.5	1.2	Target Depth	SAND
TP49	2.5	1.0	Target Depth	SAND
TP50	2.5	GNE	Target Depth	SAND
TP51	2.5	GNE	Target Depth	SAND
TP52	2.5	GNE	Target Depth	SAND
TP53	2.3	GNE	Collapse	SAND
TP54	2.5	GNE	Target Depth	SAND
TP55	1.9	GNE	Collapse	SAND
TP56	2.5	1.8	Target Depth	SAND
TP57	2.5	GNE	Target Depth	SAND
TP58	2.3	GNE	Collapse	SAND
TP59	2.5	GNE	Target Depth	SAND
TP60	2.5	GNE	Target Depth	SAND
P01	1	GNE	Target Depth	SAND
P02	1	GNE	Target Depth	SAND
P03	1	GNE	Target Depth	SAND
P04	1.5	1.05	Target Depth	Peaty SAND
P05	1	GNE	Target Depth	SAND

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Figures

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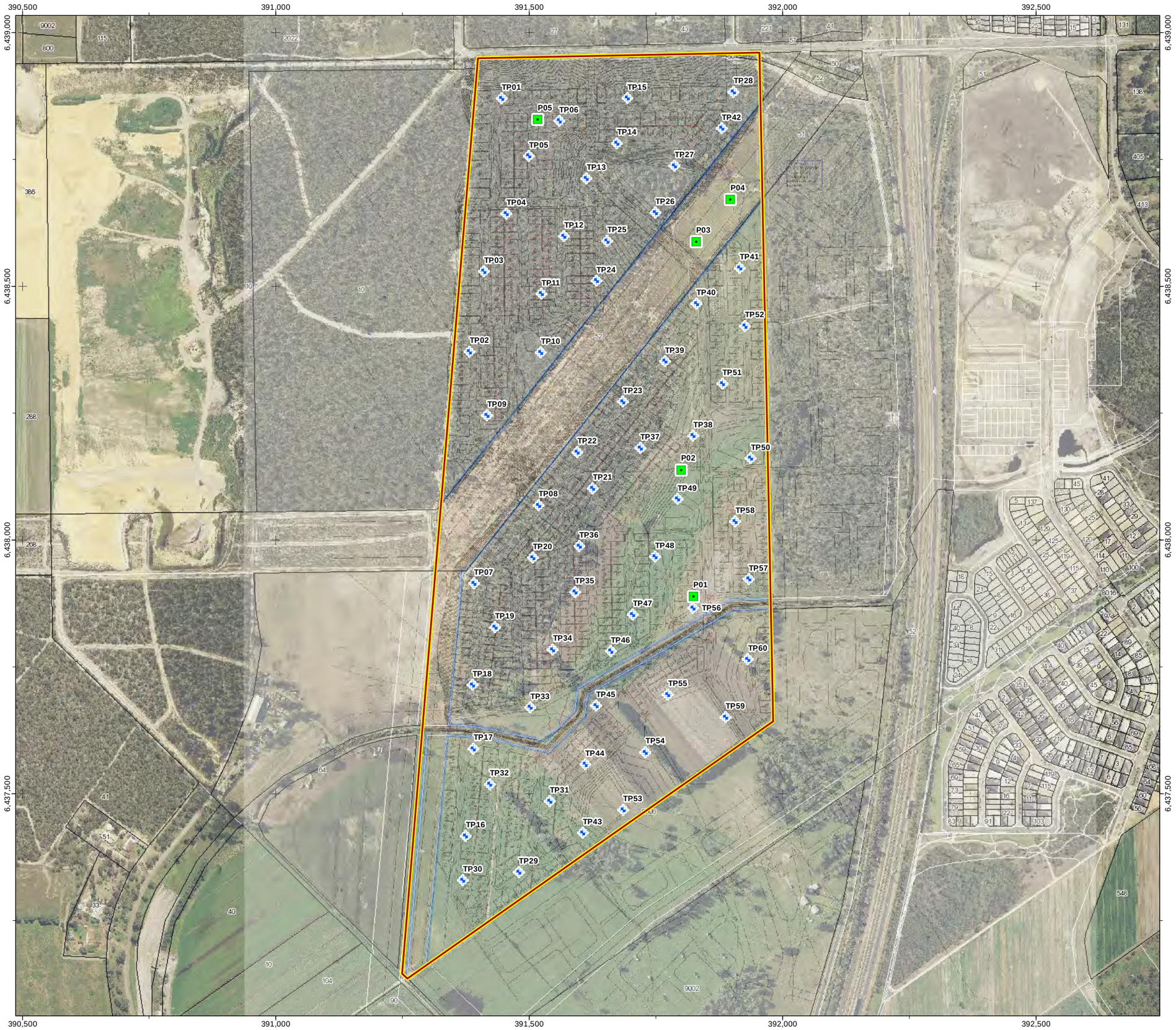




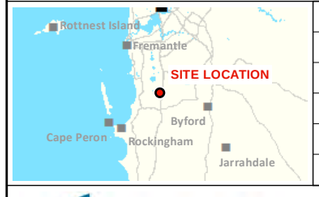
Legend

- Site Boundary
- EASEMENT
- Permeability Test
- Test Pit

N

0 120 240 360 480 600

Meters



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DATE DRAWN	29/04/2014	
CHECKED	RP	
DATE CHECKED	29/04/2014	
PROJECTION	GDA 1994 MGA Zone 50	

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CLIENT	**QUBE PROPERTY GROUP**
PROJECT	PROPOSED RESIDENTIAL SUBDIVISION
LOCATION	LOT 682 ROWLEY ROAD MANDOGALUP
TITLE	SITE & LOCATION PLAN

Job No	Fig No	Rev
J1401062	FIGURE 1	**A**

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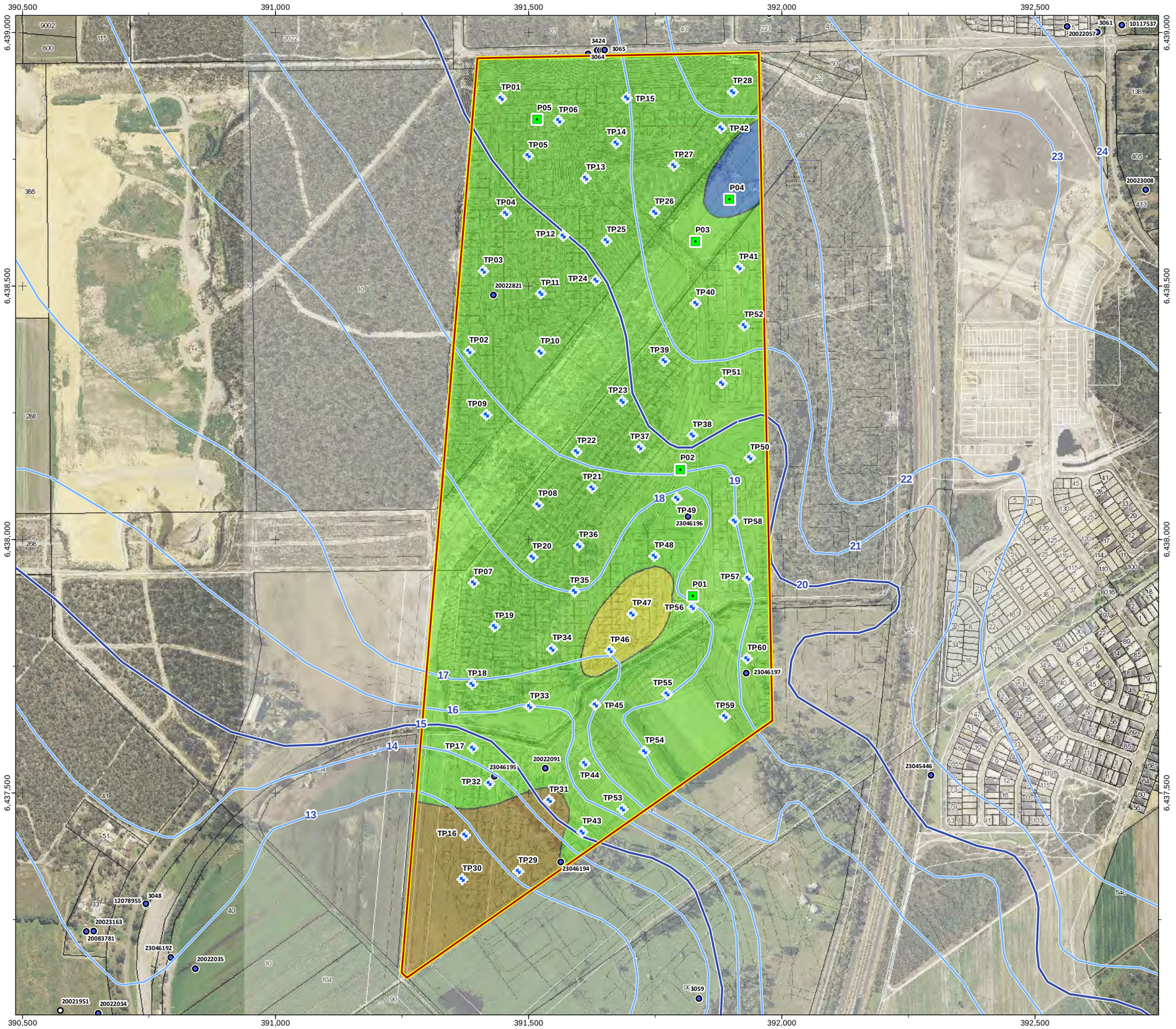

Legend

Site Boundary

SITE CLASSIFICATION

- CLASS 'A' *
- CLASS 'M'
- CLASS 'P'
- CLASS'S'

* subject to compaction of thick loose in-situ sand layer

- Permeability Test
- Test Pit

Historical maximum groundwater elevations (mAHD) (Perth Groundwater Atlas (1997))

- 5
- 1

WINSITES

- Ground, Borehole or Well
- Other

N

0 120 240 360 480 600

Meters

SCALE	1:7,500	(A3)
DRAWN	DAC	
DATE DRAWN	5/05/2014	
CHECKED	RP	
DATE CHECKED	29/04/2014	
PROJECTION	GDA 1994 MGA Zone 50	

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CLIENT	**QUBE PROPERTY GROUP**
PROJECT	PROPOSED RESIDENTIAL SUBDIVISION
LOCATION	LOT 682 ROWLEY ROAD MANDOGALUP
TITLE	SITE CLASSIFICATION
Job No	J1401062
Fig No	FIGURE 2
Rev	A

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Appendix A: Site Photographs

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Photograph 1: Dense vegetation present towards the north of the site



Photograph 2: Test pit excavation at TP45 location



Photograph 3: Looking northwest across market garden area of site from TP59



Photograph 4: Looking north from TP40

Appendix B: Test Pit Reports

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EXPLANATORY NOTES TO BE READ WITH BOREHOLE AND TEST PIT REPORTS

METHOD OF DRILLING OR EXCAVATION

AC	Air Core	E	Excavator	PQ3	PQ3 Core Barrel
AD/T	Auger Drilling with TC-Bit	EH	Excavator with Hammer	PT	Push Tube
AD/V	Auger Drilling with V-Bit	HA	Hand Auger	R	Ripper
AT	Air Track	HMLC	HMLC Core Barrel	RR	Rock Roller
B	Bulldozer Blade	HQ3	HQ3 Core Barrel	SON	Sonic Rig
BH	Backhoe Bucket	N	Natural Exposure	SPT	Driven SPT
CT	Cable Tool	NMLC	NMLC Core Barrel	WB	Washbore
DT	Diatube	PP	Push Probe	X	Existing Excavation

SUPPORT

T	Timbering

PENETRATION EFFORT (RELATIVE TO THE EQUIPMENT USED)

VE	Very Easy	E	Easy	F	Firm
H	Hard	VH	Very Hard		

WATER

►	Water Inflow	▼	Water Level
◄	Water Loss (complete)		
◁	Water Loss (partial)		

SAMPLING AND TESTING

B	Bulk Disturbed Sample	P	Piston Sample
BLK	Block Sample	PBT	Plate Bearing Test
C	Core Sample	U	Undisturbed Push-in Sample
CBR	CBR Mould Sample		U50: 50 mm diameter
D	Small Disturbed Sample	SPT	Standard Penetration Test
ES	Environmental Soil Sample		Example: 3, 4, 5 N=9
EW	Environmental Water Sample		3,4,5: Blows per 150 mm
G	Gas Sample		N=9: Blows per 300 mm after
HP	Hand Penetrometer		150 mm seating interval
LB	Large Bulk Disturbed Sample	VS	Vane Shear; P = Peak
M	Mazier Type Sample		R = Remoulded (kPa)
MC	Moisture Content Sample	W	Water Sample

ROCK CORE RECOVERY

TCR = Total Core Recovery (%) $= \frac{CRL}{TCL} \times 100$

SCR = Solid Core Recovery (%) $= \frac{CCR}{TCL} \times 100$

RQD = Rock Quality Designation (%) $= \frac{ALC>100}{TCL} \times 100$

TCL	Length of Core Run
CRL	Recovered Length of Core
CCR	Total Length of Cylindrical Pieces of Core Recovered
ALC>100	Total Length of Axial Lengths of Core Greater than 100 mm Long

METHOD OF SOIL DESCRIPTION
BOREHOLE AND TEST PIT REPORTS

GRAPHIC LOG & UNIFIED SOIL CLASSIFICATION SYSTEM (USCS) SYMBOLS

Graphic	USCS	Soil Name
		FILL (various types)
		COBBLES
		BOULDERS
	GP	GRAVEL (poorly graded)
	GW	GRAVEL (well graded)
	GC	Clayey GRAVEL
	SP	SAND (poorly graded)
	SW	SAND (well graded)
	SC	Clayey SAND

Graphic	USCS	Soil Name
	SM	Silty SAND
	ML	SILT (low liquid limit)
	MH	SILT (high liquid limit)
	CL	CLAY (low plasticity)
	CI	CLAY (medium plasticity)
	CH	CLAY (high plasticity)
	OL	Organic SILT (low liquid limit)
	OH	Organic SILT (high liquid limit)
	Pt	PEAT

RESISTANCE TO EXCAVATION

Symbol	Term	Description
VE	Very easy	All resistances are relative to the selected method of excavation
E	Easy	
F	Firm	
H	Hard	
VH	Very hard	

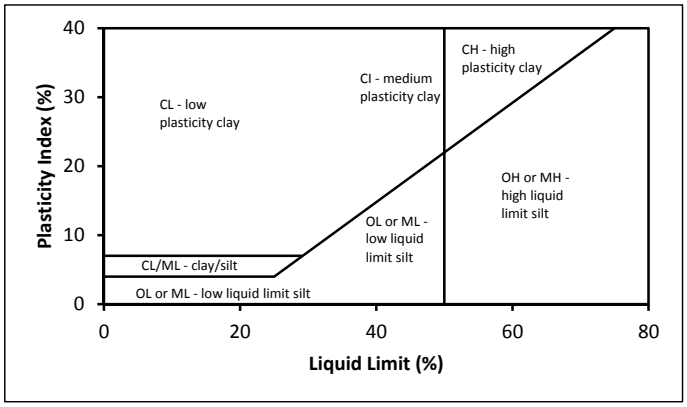
SOIL CLASSIFICATION AND INFERRED STRATIGRAPHY

Soil descriptions are based on AS1726-1993, Appendix A. Material properties are assessed in the field by visual/tactile methods in combination with field testing techniques (where used).

PARTICLE SIZE

Soil Name		Particle Size (mm)
BOULDERS		>200
COBBLES		63 to 200
GRAVEL	Coarse	20 to 63
	Medium	6 to 20
	Fine	2 to 6
SAND	Coarse	0.6 to 2.0
	Medium	0.2 to 0.6
	Fine	0.075 to 0.2
FINES	SILT	0.002 to 0.075
	CLAY	<0.002

PLASTICITY PROPERTIES



MOISTURE CONDITION

AS1726-1993

Symbol	Term	Description
D	Dry	Sands and gravels are free flowing. Clays and silts may be brittle or friable and powdery.
M	Moist	Soils are darker than in the dry condition and may feel cool. Sands and gravels tend to cohere.
W	Wet	Soils exude free water. Sands and gravels tend to cohere.

CONSISTENCY AND DENSITY

AS1726-1993 and HB160-2006

Symbol	Term	Undrained Shear Strength (kPa)	SPT "N"	DCP blows per 100 mm
VS	Very Soft	0 to 12	0 to 2	<1
S	Soft	12 to 25	2 to 4	<1
F	Firm	25 to 50	4 to 8	1 to 2
St	Stiff	50 to 100	8 to 15	3 to 4
VSt	Very Stiff	100 to 200	15 to 30	5 to 10
H	Hard	>200	>30	>10

Symbol	Term	Density Index (%)	SPT "N"	DCP blows per 100 mm	PSP Blows per 300 mm
VL	Very Loose	<15	0 to 4	<1	0 to 2
L	Loose	15 to 35	4 to 10	1 to 2	2 to 6
MD	Medium Dense	35 to 65	10 to 30	2 to 3	6 to 8
D	Dense	65 to 85	30 to 50	4 to 8	8 to 15
VD	Very Dense	>85	>50	>8	>15

Note: PSP correlations only valid to 450 mm depth

Consistency and density may also be inferred from excavation performance and material behaviour.

TEST PIT: TP01

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391446 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438871 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, pale grey becoming yellow with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 90 mm in diameter) in top 1.5 m	D	L	
			0.5									MD	
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GG_EXCAVATION J1401062.GPJ <<DrawingFile>> 05/05/2014 16:02 8.30.003 Datgal DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

TEST PIT: TP02

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391382 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438371 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming yellow with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 20 mm in diameter) in top 1.5 m	D	VL - L	
			0.5									MD	
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GG_EXCAVATION J1401062.GPJ <<DrawingFile>> 05/05/2014 16:02 8.30.003 Datgel DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

TEST PIT: TP03

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391411 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438530 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming pale yellow with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 20 mm in diameter) in top 2.0 m	D	L	
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GG_EXCAVATION J1401062.GPJ <<DrawingFile>> 05/05/2014 16:02 8.30.003 Datgal DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

TEST PIT: TP04

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391455 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438643 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming pale yellow with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 60 mm in diameter) in top 1.8 m	D	VL	
			0.5									L	
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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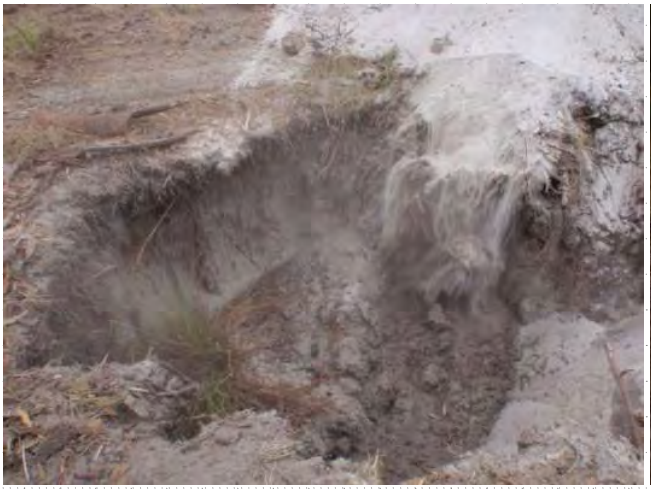
TEST PIT: TP05

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391499 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438757 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines in top 200 mm, trace rootlets/roots (up to 50 mm in diameter) in top 0.5 m	D	L MD	
			2.0							Hole Terminated at 2.00 m Collapse Groundwater Not Encountered			

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GG_EXCAVATION J1401062.GPJ <<DrawingFile>> 05/05/2014 16:02 8.30.003 Datgal DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

TEST PIT: TP06

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391559 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438826 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 80 mm in diameter) in top 2.0 m	D	VL L	
			2.0							Hole Terminated at 2.00 m Collapse Groundwater Not Encountered			

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP07

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391391 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6437915 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming pale yellow with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 20 mm in diameter) in top 2.0 m	D	L	
			0.5									L - MD	
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP08

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391518 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438069 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming pale yellow with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 100 mm in diameter) in top 1.0 m	D	L L - MD	
			2.0							Hole Terminated at 2.00 m Collapse Groundwater Not Encountered			

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP09

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391417 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438246 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming pale yellow with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 30 mm in diameter) in top 1.5 m	D	VL	
			0.5									L	
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP10

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391523 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438370 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 50 mm in diameter) in top 1.0 m	D	L	
			0.5										
			1.0									MD	
			1.5										
			2.0							Hole Terminated at 2.00 m Collapse Groundwater Not Encountered			
			2.5										
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP11

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391525 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438485 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming pale yellow with depth, trace non-plastic fines, trace rootlets/roots (up to 50 mm in diameter) in top 1.8 m	D	VL	
			0.5									L	
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP12

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391569 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438599 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming pale yellow with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 30 mm in diameter) in top 1.8 m	D	VL L MD	
			0.5										
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP13

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391613 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438713 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace non-plastic fines in top 200 mm, trace rootlets/roots (up to 30 mm in diameter)	D	VL - L	
			0.5									MD	
			1.0							As above, becoming brown			Slight sulfidic odour
		▼	1.5								M - W		
			2.0						SC	Clayey SAND: fine to coarse grained, 15-25% low to medium plasticity clay fines, pale brown			
			2.5							Hole Terminated at 2.50 m Target depth Groundwater encountered at 1.8m			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP14

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391673 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438782 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 40 mm in diameter) in top 1.2 m	D	VL	
			0.5									L	
			1.0										
			1.5										
			2.0							Hole Terminated at 1.80 m Collapse Groundwater Not Encountered			
			2.5										
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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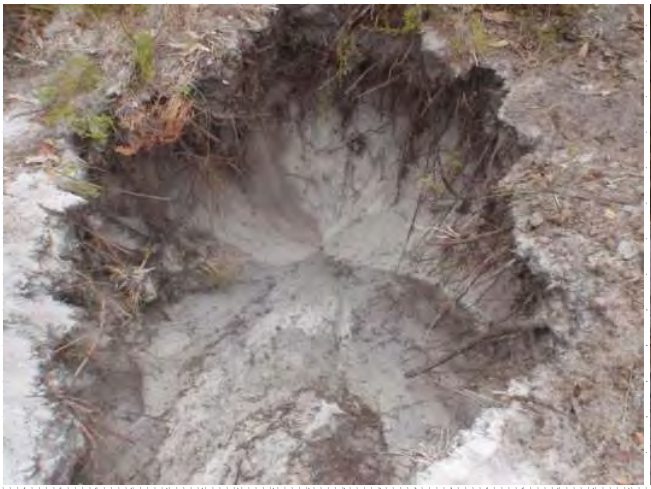
TEST PIT: TP15

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391694 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438871 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 40 mm in diameter) in top 1.8 m	D	VL	
			0.5									L	
			1.0										
			1.5										
			2.0							Hole Terminated at 2.00 m Collapse Groundwater Not Encountered			
			2.5										
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP16

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391375 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437417 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description						
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SM	Silty SAND: fine to coarse grained, brown, 15% silt fines, trace rootlets	M	L	
	F		0.5		B(TP16-01)					CLAY: medium to high plasticity, with some sand (15-25%), trace rootlets, pale grey	D	St	
			1.0										
	E		1.5		B(TP16-01)				CI	As above, becoming brown	M	F	
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP17

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391390 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437588 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, grey, with some non-plastic fines, trace rootlets	D	D	
			0.5						SM	Silty SAND: fine to coarse grained, 15-20% silt fines, brown trace rootlets	D	D - VD	
			1.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, white/grey	M		
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP18

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391388 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6437714 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming pale yellow with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 40 mm in diameter) in top 1.0 m	D	L	
			0.5										
			1.0										
			1.5										
			2.0							Hole Terminated at 2.00 m Collapse Groundwater Not Encountered			
			2.5										
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP19

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391433 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6437828 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming pale yellow with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 50 mm in diameter) in top 0.5 m	D	L	
			2.0							Hole Terminated at 2.00 m Collapse Groundwater Not Encountered			

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP20

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391507 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6437965 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width: 0.7 m	**Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey-brown, trace rootlets to 0.2 m	D	L	
			0.5							Becoming yellow			
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP21

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Job Number:	J1401062	**Easting:**	391626 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438102 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 50 mm in diameter) in top 1.0 m	D	VL L MD	
			0.5										
			1.0										
			1.5										
			2.0							Hole Terminated at 2.00 m Collapse Groundwater Not Encountered			
			2.5										
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP22

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391595 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438173 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming pale yellow with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 60 mm in diameter) in top 1.5 m	D	L	
			0.5									L - MD	
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP23

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391685 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438273 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming pale yellow with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 20 mm in diameter) in top 2.0 m	D	L	
			0.5									MD	
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP24

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Job Number:	J1401062	**Easting:**	391633 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438511 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming pale yellow with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 30 mm in diameter) in top 1.8 m	D	VL L MD	
			0.5										
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP25

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391654 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438590 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming pale yellow with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 60 mm in diameter) in top 1.8 m	D	L	
			0.5										
			1.0										
			1.5										
			2.0							Hole Terminated at 2.00 m Collapse Groundwater Not Encountered			
			2.5										
			3.0										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP26

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Job Number:	J1401062	**Easting:**	391749 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438645 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white, with some organic fines in top 300 mm, with some roots/rootlets (up to 80 mm in diameter) in top 800 mm	D	L	
			0.5							Trace rootlets down to 1.8 m			
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP27

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Job Number:	J1401062	**Easting:**	391787 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438738 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace fines with some rootlets/roots (up to 40 mm in diameter) in top 1.0 m	D	VL	
			0.5									L	
			1.0							White			
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP28

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Job Number:	J1401062	**Easting:**	391903 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438883 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace fines, trace rootlets/roots (up to 25 mm in diameter)	D	VL	
			0.5							Becoming yellow		L	
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP29

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Job Number:	J1401062	**Easting:**	391480 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437345 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SM	Silty SAND: fine to coarse grained, 15% silt fines, brown, trace rootlets		D	
			0.5							CLAY: medium to high plasticity, grey/pale grey, with some sand (15-25%), trace rootlets	D		
			1.0										
										As above, grey			
			1.5						CL			F - St	
											M		
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP30

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Job Number:	J1401062	**Easting:**	391369 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437329 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SM	Silty SAND: fine to coarse grained, 15% silt fines, brown, trace rootlets	M	L - MD	
			0.5							CLAY: medium to high plasticity, pale grey, with some sand (15-25%), trace rootlets	M - D		
			1.0							As above, becoming brown			
			1.5						CI			F	
			2.0								M		
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP31

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Job Number:	J1401062	**Easting:**	391541 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437485 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SM	Silty SAND: fine to coarse grained, 20-30% silt fines, trace roots in top 300 mm, brown	D	VD	
			0.5		B(TP31-01)				CI	CLAY: medium to high plasticity, pale grey, with some sand (15-25%), trace rootlets		H	
			1.0										
			1.5						SP	CEMENTED SAND: fine to coarse grained, brown/black, very weakly to moderately cemented			
			2.0										
			2.5							Hole Terminated at 2.20 m Refusal on "Coffee Rock" Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP32

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Job Number:	J1401062	**Easting:**	391422 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437519 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SM	Silty SAND: fine to coarse grained, 15-20% silt fines, dark grey, trace rootlets	D	MD - D	
			0.5							SAND: fine to coarse grained, sub-angular to sub-rounded, white			
			1.0										
			1.5						SP	Becoming brown			
			2.0										
			2.5							Hole Terminated at 2.20 m Collapse Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP33

Job Number:	J1401062	**Easting:**	391502 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437670 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines/rootlets in top 200 mm	D	L	
			0.5										
			1.0										
			1.5										
			2.0							Hole Terminated at 2.00 m Collapse Groundwater Not Encountered			
			2.5										
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP34

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Job Number:	J1401062	**Easting:**	391546 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437784 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines in top 300 mm, trace rootlets in top 300 mm	D	VL	
			0.5									L	
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.10 m Collapse Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP35

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391591 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437897 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines in top 300 mm	D	VL L - MD	
			2.0							Hole Terminated at 2.00 m Collapse Groundwater Not Encountered			

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP36

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391599 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6437988 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 60 mm in diameter) in top 1.0 m	D	L	
			2.0							Hole Terminated at 2.00 m Collapse Groundwater Not Encountered			

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP37

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391719 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438181 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines in top 200 mm, trace rootlets/roots (up to 30 mm in diameter) in top 1.5 m	D	L MD	
			0.5										
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.10 m Collapse Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP38

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391824 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438205 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, dark grey, trace rootlets in top 0.1 m	D	VL	White pipe in pit (not in use)
			0.5							Becoming white Roots are 30 mm in diameter at 0.5 m		MD	
			1.0										
			1.5										
			2.0							Hole Terminated at 2.00 m Slow progress due to collapse Groundwater Not Encountered			
			2.5										
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP39

Job Number:	J1401062	**Easting:**	391768 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438352 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines in top 100 mm, trace rootlets/roots (up to 20 mm in diameter) in top 0.5 m	D	VL L	
			2.0							Hole Terminated at 1.90 m Collapse Groundwater Not Encountered			

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP40

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391830 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438466 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines in top 200 mm, trace roots in top 400 mm (occasionally down to 1.5 m)	D	L	
			0.5									MD	
			1.0										
			1.5							Becoming grey			
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP41

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391916 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438536 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0							SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines in top 200 mm, trace rootlets in top 100 mm	D	MD	
					B(TP41-01)								
			0.5										
			1.0						SP				
			1.5							Becoming grey	M		
			2.0							Hole Terminated at 2.00 m Collapse Groundwater Not Encountered			
			2.5										
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP42

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391880 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6438812 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace roots/rootlets (up to 40 mm in diameter), trace fines	D	VL	
			0.5									L	
			1.0							White			
			1.5										
			2.0								M		
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP43

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391606 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437423 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description						
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0		B(TP43-01)				SM	Silty SAND: fine to coarse grained, brown, 15-20% silt, trace rootlets			
			0.5						SP	SAND: fine to coarse grained, grey becoming white, trace non-plastic fines in top 200 mm	D		
			1.0								M		
			1.5								W		Slight sulfidic odour
	H		2.0						SP	CEMENTED SAND: fine to coarse grained, brown/black, weakly to moderately cemented			
			2.5							Hole Terminated at 2.30 m Refusal on "Coffee Rock" Groundwater encountered at 1.5m			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP44

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391611 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437558 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines/rootlets in top 500 mm	D	VL	
			0.5									L	
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP45

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391632 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437673 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description						
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	FILL: Gravelly SAND, fine to coarse grained, fine to medium grained limestone gravel, pale yellow	D	MD	
			0.5						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white with depth, trace non-plastic fines in top 200 mm, trace rootlets in top 500 mm			
			1.0										
			1.5										
			2.0								M		
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP46

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391661 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6437781 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0							Clayey SAND: fine to coarse grained, 20-30% medium to high plasticity clay fines, desiccated, grey	D	St - VSt	
			0.5		B(TP46-01)				SC	Becoming moist, dark grey, soft	M	S	
			1.0										
			1.5							SAND: fine to coarse grained, sub-angular to sub-rounded, grey-brown, slight odour			
		▼	2.0						SP		M - W		Groundwater is seeping through test pit walls
			2.5							Hole Terminated at 2.50 m Target depth Groundwater encountered at 2.3m			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP47

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391704 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6437853 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width: 0.7 m	**Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SC	Clayey SAND: fine to coarse grained, grey, 20-30% medium to high plasticity fines, trace rootlets	St - VSt	D	
			0.5							Becoming dark grey, moisture increase	S	M	
			1.0										
			1.5						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, brown			Slow seepage through test pit wall
			2.0									W	
			2.5							Hole Terminated at 2.50 m Target depth Groundwater encountered at 1.5m			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP48

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Job Number:	J1401062	**Easting:**	391749 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6437967 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description						
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E	▼	0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, dark grey becoming white, trace non-plastic fines, trace rootlets, slight sulfidic odour	MD	D	
										No fines			
			0.5								L		
										No rootlets		M	
			1.0							Becoming pale brown			Slow seepage through test pit wall
			1.5										
			2.0									W	
			2.5							Hole Terminated at 2.50 m Target depth Groundwater encountered at 1.2m			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

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TEST PIT: TP49

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391793 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438081 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E	▼	0.0		B(TP49-01)				SP	SAND: fine to coarse grained, sub-angular to sub-rounded, dark grey, with some organic fines (5-6%), trace rootlets		D	
			0.5							SAND: fine to coarse grained, sub-angular to sub-rounded, grey	MD	M	
			1.0							Becoming pale brown			Slow seepage through test pit wall
			1.5						SP			M-W	
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater encountered at 1m			
			3.0										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GG_EXCAVATION J1401062.GPJ <<DrawingFile>> 05/05/2014 16:04 8.30.003 Datgal DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

TEST PIT: TP50

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391937 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438161 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey to white, trace non-plastic fines, trace rootlets No fines or rootlets	L	D	
			0.5										
			1.0							Becoming pale brown		M	
			1.5										
			2.0									W	
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GG_EXCAVATION J1401062.GPJ <<DrawingFile>> 05/05/2014 16:04 8.30.003 Datgal DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

TEST PIT: TP51

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391882 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438308 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description						
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS	
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, dark grey	L	D		
										No rootlets	MD			
			0.5											
			1.0							Becoming white mottled grey				
			1.5									M		
			2.0							Becoming grey				
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered				
			3.0											

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GG_EXCAVATION J1401062.GPJ <<DrawingFile>> 05/05/2014 16:04 8.30.003 Datgal DGD_CPT_Photo_Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

TEST PIT: TP52

Job Number:	J1401062	**Easting:**	391926 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438422 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white, trace non plastic fines, trace rootlets No fines or rootlets	L		
			0.5								MD	D	
			1.0										
			1.5										
			2.0									M	
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations



Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GG_EXCAVATION J1401062.GPJ <<DrawingFile>> 05/05/2014 16:04 8.30.003 Datgal DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

TEST PIT: TP53

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391685 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437468 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white, trace non plastic fines, trace rootlets	L	D	
			0.5							No rootlets	MD - D		
			1.0								MD		
			1.5										
			2.0										
			2.5							Hole Terminated at 2.30 m Collapse Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GG_EXCAVATION J1401062.GPJ <<DrawingFile>> 05/05/2014 16:04 8.30.003 Datgal DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

TEST PIT: TP54

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391730 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6437581 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white, trace non-plastic fines, trace rootlets/roots up to 40 mm in diameter	L	D	
										No fines	MD		
			0.5										
			1.0										
			1.5										
			2.0							No rootlets/roots			
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GG_EXCAVATION J1401062.GPJ <<DrawingFile>> 05/05/2014 16:04 8.30.003 Datgal DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

TEST PIT: TP55

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391774 m	**Contractor:**	Erskine Earthmoving	**Date:**	09/04/2014
Client:	Qube Property Group	**Northing:**	6437695 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white, trace non-plastic fines, trace rootlets	VL - L	D	
			0.5							No fines or rootlets	L - MD		
			1.0										
			1.5										
			2.0							Hole Terminated at 1.90 m Collapse Groundwater Not Encountered			
			2.5										
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GG_EXCAVATION J1401062.GPJ <<DrawingFile>> 05/05/2014 16:04 8.30.003 Datgal DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

TEST PIT: TP56

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391823 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6437866 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description						
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey, trace non plastic fines, trace rootlets	L	D	
			0.5								MD		
			1.0							Becoming white		M	Slight sulfidic odour
		▼	1.5										Water seeping through test pit wall
			2.0							Becoming pale brown		W	
			2.5							Hole Terminated at 2.50 m Target depth Groundwater encountered at 1.8m			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GG_EXCAVATION J1401062.GPJ <<DrawingFile>> 05/05/2014 16:04 8.30.003 Datgal DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

TEST PIT: TP57

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391933 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6437923 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white, trace non-plastic fines, trace rootlets	L	D	
			0.5							No fines or rootlets			
			1.0							Becoming pale grey/brown			
			1.5									M	
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GG_EXCAVATION J1401062.GPJ <<DrawingFile>> 05/05/2014 16:04 8.30.003 Datgal DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

TEST PIT: TP58

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391907 m	**Contractor:**	Erskine Earthmoving	**Date:**	10/04/2014
Client:	Qube Property Group	**Northing:**	6438036 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white, trace non-plastic fines, trace rootlets	L	D	
			0.5							No fines or rootlets	MD		
			1.0							Becoming pale grey/brown		M	
			1.5										
			2.0										
			2.5							Hole Terminated at 2.30 m Collapse Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GG_EXCAVATION J1401062.GPJ <<DrawingFile>> 05/05/2014 16:04 8.30.003 Datgal DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

TEST PIT: TP59

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391888 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437651 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey becoming white, trace non-plastic fines, trace rootlets	L	D	
			0.5							No fines or rootlets	L - MD		
			1.0										
			1.5										
			2.0										
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GG_EXCAVATION J1401062.GPJ <<DrawingFile>> 05/05/2014 16:04 8.30.003 Datgal DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

TEST PIT: TP60

Sheet 1 OF 1

Job Number:	J1401062	**Easting:**	391932 m	**Contractor:**	Erskine Earthmoving	**Date:**	11/04/2014
Client:	Qube Property Group	**Northing:**	6437765 m	**Machine:**	Komatsu 97R	**Logged:**	JH
Project:	Proposed Residential Subdivision	**Datum:**	MGA94 Zone 50	**Operator:**	James	**Checked Date:**	05/05/2014
Location:	Lot 682 Rowley Road, Mandogalup			**Bucket:**	600 mm Toothed	**Checked By:**	RP
				Width:	0.7 m **Length:** 3 m		

Excavation					Sampling			Field Material Description					
METHOD	EXCAVATION RESISTANCE	WATER	DEPTH (metres)	*DEPTH* RL	SAMPLE OR FIELD TEST	ACID SULPHATE SAMPLE	RECOVERED	GRAPHIC LOG	USCS SYMBOL	SOIL/ROCK MATERIAL DESCRIPTION	MOISTURE CONDITION	CONSISTENCY DENSITY	STRUCTURE AND ADDITIONAL OBSERVATIONS
BH	E		0.0						SP	SAND: fine to coarse grained, sub-angular to sub-rounded, grey-white, trace non-plastic fines, trace rootlets, roots up to 30 mm diameter			
			0.5							No rootlets	L		
			1.0									D	
			1.5										
			2.0									M	
			2.5							Hole Terminated at 2.50 m Target depth Groundwater Not Encountered			
			3.0										

Sketch & Other Observations





Comments:

See Explanatory Notes and Method of Soil Description sheets for details of abbreviations and basis of descriptions

GALT LIB 1.01.GLB Log GG_EXCAVATION J1401062.GPJ <<DrawingFile>> 05/05/2014 16:05 8.30.003 Datgal DGD, CPT, Photo, Monitoring Tools | Lib: GALT 1.01 2013-02-21 Prj: GALT 1.01 2013-02-21

Appendix C: Summary Hand Auger Borehole Reports

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6014

ABN: 73 292 586 155

SUMMARY BOREHOLE REPORTS

Job Number:	J1401062	**Date Performed:**	9 & 10 April 2014
Client:	Qube Property Group	**Drilled By:**	AW/MW
Project::	Proposed Residential Subdivision	**Logged By:**	AW/MW
Location:	Lot 682 Rowley Road, Mandogalup		

Hand Auger Borehole P01

Test Depth (m)	Stratigraphy
0.0 – 1.0	SAND (SP), fine to coarse grained, sub-angular to sub-rounded, dark grey becoming white, dry
End of borehole at 1.0 m Target depth Groundwater not encountered	

Hand Auger Borehole P02

Test Depth (m)	Stratigraphy
0.0 – 1.0	SAND (SP), fine to coarse grained, sub-angular to sub-rounded, dark grey becoming grey mottled white, dry
End of borehole at 1.0 m Target depth Groundwater not encountered	

Hand Auger Borehole P03

Test Depth (m)	Stratigraphy
0.0 – 1.0	SAND (SP), fine to coarse grained, sub-angular to sub-rounded, grey becoming pale grey, trace non-plastic fines, dry
End of borehole at 1.0 m Target depth Groundwater not encountered	

Hand Auger Borehole P04

Test Depth (m)	Stratigraphy
0.0 – 1.3	Peaty SAND (SP), fine to medium grained, sub-angular to sub-rounded, dark brown/black, 15-20% organic fines, fibrous, sand content increasing with depth
1.3 – 1.5	SAND (SP), fine to coarse grained, sub-angular to sub-rounded, grey becoming pale grey, trace non-plastic fines, dry
End of borehole at 1.5 m Target depth Groundwater at 1.05 m	

Hand Auger Borehole P05

Test Depth (m)	Stratigraphy
0.0 – 1.0	SAND (SP), fine to coarse grained, sub-angular to sub-rounded, grey becoming pale grey, trace non-plastic fines, dry
End of borehole at 1.0 m Target depth Groundwater not encountered	

Appendix D: Dynamic Cone Penetrometer Test Results

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6014
ABN: 73 292 586 155

DYNAMIC CONE PENETROMETER FIELD TEST DATA
(AS12896.3.2)

Client:	Qube Property Group	**Job No:**	J1401062
Project:	Proposed Residential Subdivision	**Date:**	9, 10 & 11 April 2014
Location:	Lot 682 Rowley Road, Mandogalup	**Engineer:**	JH

Test No:	1	2	3	4	5	6
Location:	TP01	TP02	TP03	TP04	TP05	TP06
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**					
0-100	-	-	-	-	-	-
100-200	1	1	1	0	1	0
200-300	1	0	1	1	1	0
300-400	2	1	1	0	1	1
400-500	2	1	1	1	1	0
500-600	2	1	2	1	2	1
600-700	2	1	2	2	2	1
700-800	3	2	1	1	2	2
800-900	3	2	2	2	2	1
900-1000	3	3	2	2	3	1

Test No:	7	8	9	10	11	12
Location:	TP07	TP08	TP09	TP10	TP11	TP12
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**					
0-100	-	-	-	-	-	-
100-200	1	1	0	0	0	0
200-300	1	1	1	1	0	1
300-400	2	1	1	1	1	1
400-500	2	1	1	1	0	1
500-600	2	2	1	1	1	1
600-700	2	1	2	1	1	2
700-800	2	2	2	1	2	2
800-900	2	2	2	2	1	2
900-1000	2	2	2	3	2	3

Test No:	13	14	15	16	17	18
Location:	TP13	TP14	TP15	TP16	TP17	TP18
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**					
0-100	-	-	-	-	-	-
100-200	1	0	0	2	3	1
200-300	0	1	1	2	3	1
300-400	1	1	1	4	9	1
400-500	0	1	1	4	12	1
500-600	1	1	1	3	6	1
600-700	1	2	1	4	4	1
700-800	2	1	1	4	6	1
800-900	3	2	2	3	6	2
900-1000	4	2	2	3	4	2

Dynamic Cone Penetrometer tests done in accordance with AS 1289.6.3.2
HB: Hammer bounce (refusal)
HW: Penetration due to hammer weight only
R: Refusal

DYNAMIC CONE PENETROMETER FIELD TEST DATA
(AS12896.3.2)

Client:	Qube Property Group	**Job No:**	J1401062
Project:	Proposed Residential Subdivision	**Date:**	9, 10 & 11 April 2014
Location:	Lot 682 Rowley Road, Mandogalup	**Engineer:**	JH

Test No:	19	20	21	22	23	24
Location:	TP19	TP20	TP21	TP22	TP23	TP24
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**					
0-100	-	-	-	-	-	-
100-200	1	1	1	1	1	0
200-300	1	1	0	1	1	1
300-400	1	1	1	1	1	1
400-500	1	2	1	1	2	2
500-600	1	1	1	1	1	2
600-700	1	2	1	2	2	2
700-800	1	1	1	2	1	3
800-900	1	2	2	2	2	2
900-1000	2	1	2	2	3	3

Test No:	25	26	27	28	29	30
Location:	TP25	TP26	TP27	TP28	TP29	TP30
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**					
0-100	-	-	-	-	-	-
100-200	1	1	0	0	5	2
200-300	1	1	0	1	4	2
300-400	1	1	1	1	4	2
400-500	1	1	1	1	4	2
500-600	2	1	1	1	2	2
600-700	1	1	1	1	2	2
700-800	2	2	1	2	4	1
800-900	1	1	2	2	3	2
900-1000	2	2	2	2	3	2

Test No:	31	32	33	34	35	36
Location:	TP31	TP32	TP33	TP34	TP35	TP36
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**					
0-100	-	-	-	-	-	-
100-200	3	2	1	0	0	1
200-300	3	3	1	0	0	1
300-400	10	3	2	2	2	1
400-500	9	3	2	2	2	1
500-600	15R	3	2	3	3	1
600-700		4	2	3	2	1
700-800		4	2	2	3	1
800-900		5	2	1	2	2
900-1000		4	2	1	3	1

Dynamic Cone Penetrometer tests done in accordance with AS 1289.6.3.2
HB: Hammer bounce (refusal)
HW: Penetration due to hammer weight only
R: Refusal

DYNAMIC CONE PENETROMETER FIELD TEST DATA
(AS12896.3.2)

Client:	Qube Property Group	**Job No:**	J1401062
Project:	Proposed Residential Subdivision	**Date:**	9, 10 & 11 April 2014
Location:	Lot 682 Rowley Road, Mandogalup	**Engineer:**	JH

Test No:	37	38	39	40	41	42
Location:	TP37	TP38	TP39	TP40	TP41	TP42
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**					
0-100	-	-	-	-	-	-
100-200	1	0	0	1	2	1
200-300	1	1	1	2	2	1
300-400	1	2	1	2	2	0
400-500	2	3	1	2	2	1
500-600	1	3	1	3	2	1
600-700	2	2	1	3	3	1
700-800	2	3	2	4	3	2
800-900	2	2	2	3	3	1
900-1000	2	2	2	3	4	2

Test No:	43	44	45	46	47	48
Location:	TP43	TP44	TP45	TP46	TP47	TP48
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**					
0-100	-	-	-	-	-	-
100-200	2	0	3	6	5	4
200-300	4	1	4	5	6	3
300-400	3	2	3	5	6	3
400-500	3	3	3	3	4	2
500-600	3	2	4	4	4	2
600-700	2	2	3	4	4	1
700-800	2	1	3	6	5	2
800-900	2	2	3	4	3	1
900-1000	3	2	3	2	2	2

.

Test No:	49	50	51	52	53	54
Location:	TP49	TP50	TP51	TP52	TP53	TP54
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**					
0-100	-	-	-	-	-	-
100-200	2	2	1	2	1	1
200-300	2	2	2	2	2	1
300-400	2	2	2	3	3	2
400-500	2	2	2	3	5	4
500-600	3	2	3	3	5	4
600-700	2	1	4	2	4	4
700-800	2	2	3	2	3	4
800-900	2	1	3	2	3	4
900-1000	2	2	4	3	2	3

Dynamic Cone Penetrometer tests done in accordance with AS 1289.6.3.2
HB: Hammer bounce (refusal)
HW: Penetration due to hammer weight only
R: Refusal

DYNAMIC CONE PENETROMETER FIELD TEST DATA
(AS12896.3.2)

Client:	Qube Property Group	**Job No:**	J1401062
Project:	Proposed Residential Subdivision	**Date:**	9, 10 & 11 April 2014
Location:	Lot 682 Rowley Road, Mandogalup	**Engineer:**	JH

Test No:	55	56	57	58	59	60
Location:	TP55	TP56	TP57	TP58	TP59	TP60
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**					
0-100	-	-	-	-	-	-
100-200	0	2	2	1	1	1
200-300	1	2	2	1	1	1
300-400	2	2	2	1	2	1
400-500	2	2	2	2	2	2
500-600	3	1	1	3	3	1
600-700	3	1	2	3	3	1
700-800	2	1	2	3	2	1
800-900	3	2	1	3	2	1
900-1000	2	3	2	3	2	1

Test No:						
Location:						
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**					
0-100						
100-200						
200-300						
300-400						
400-500						
500-600						
600-700						
700-800						
800-900						
900-1000						

Test No:						
Location:						
Depth (mm)	**N° of Penetrometer Blows per 100 mm Depth Interval**					
0-100						
100-200						
200-300						
300-400						
400-500						
500-600						
600-700						
700-800						
800-900						
900-1000						

Dynamic Cone Penetrometer tests done in accordance with AS 1289.6.3.2
HB: Hammer bounce (refusal)
HW: Penetration due to hammer weight only
R: Refusal

Appendix E: Permeability Test Results

www.galtgeo.com.au
2/39 Flynn St, WEMBLEY WA 6014

ABN: 73 292 586 155

Permeability Calculation - Inverse Auger Hole Method

Galt Geotechnics

Job No:	J1401062
Client:	QUBE
Site:	Lot 682 Rowley Road
Location:	Mandogalup
Calc by:	JH 11-Apr-14
BH Name:	P01
Test Depth:	0.55 m

Spreadsheet author:	ORW	17-Oct-09

$$K = 1.15r\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114

Spreadsheet Legend

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	Comment field
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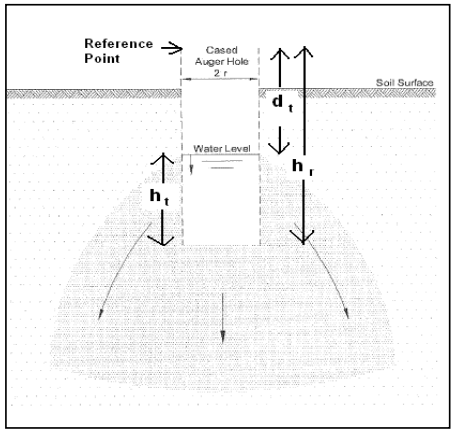
Parameter	Description	Value	Units
K	Permeability		m/s
r	radius of test hole	0.045	m
t	time since start of measurement		s
h_r	reference point height above base	0.61	m
d_t	depth from reference point to water at time t		m
h_t	Water column height at time t		m
h_0	h_t at t=0		m



Test 1

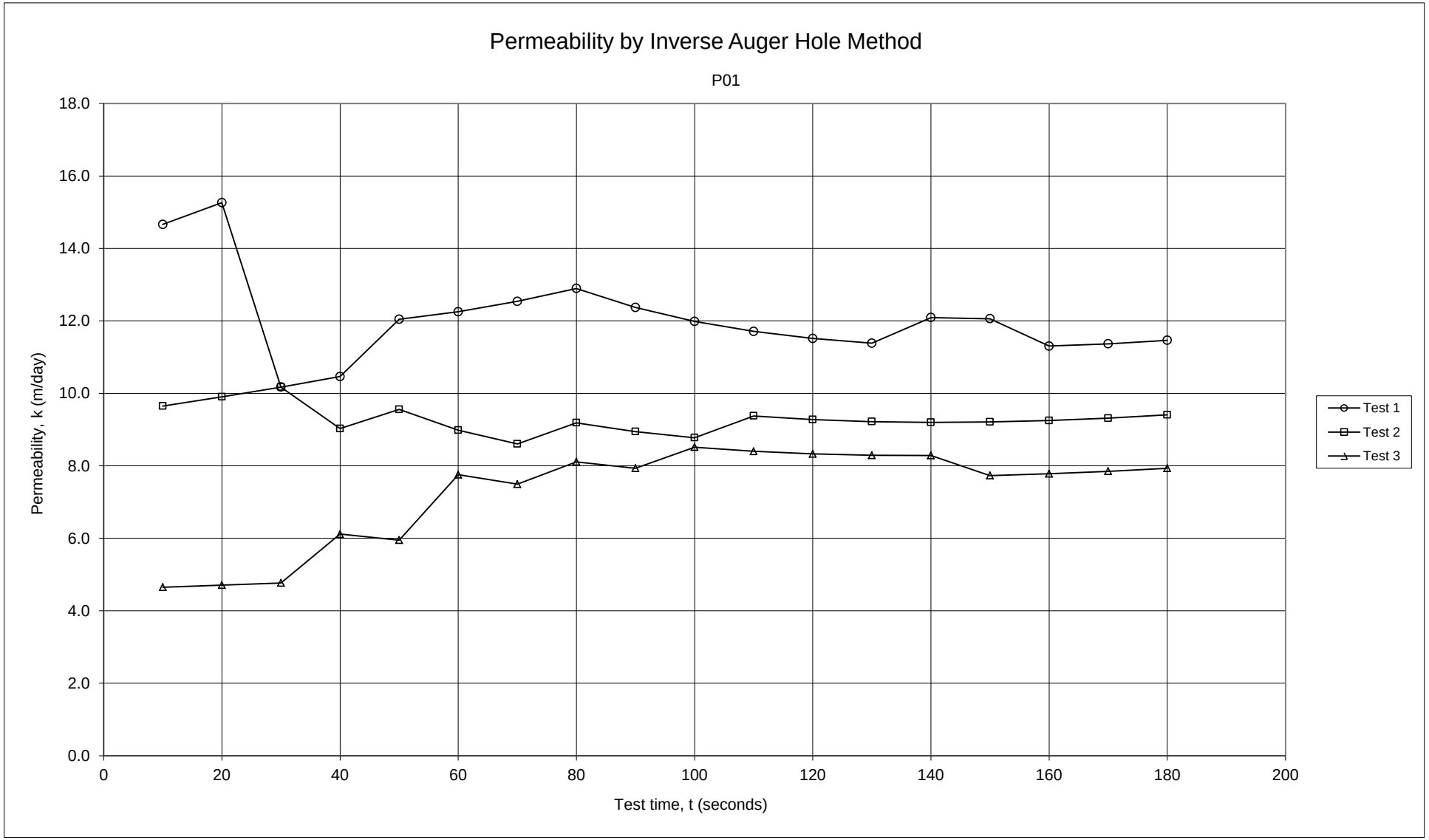
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.22	0.39		
10	0.25	0.36	1.7E-04	14.7
20	0.28	0.33	1.8E-04	15.3
30	0.28	0.33	1.2E-04	10.2
40	0.3	0.31	1.2E-04	10.5
50	0.33	0.28	1.4E-04	12.0
60	0.35	0.26	1.4E-04	12.3
70	0.37	0.24	1.5E-04	12.5
80	0.39	0.22	1.5E-04	12.9
90	0.4	0.21	1.4E-04	12.4
100	0.41	0.2	1.4E-04	12.0
110	0.42	0.19	1.4E-04	11.7
120	0.43	0.18	1.3E-04	11.5
130	0.44	0.17	1.3E-04	11.4
140	0.46	0.15	1.4E-04	12.1
150	0.47	0.14	1.4E-04	12.1
160	0.47	0.14	1.3E-04	11.3
170	0.48	0.13	1.3E-04	11.4
180	0.49	0.12	1.3E-04	11.5
		AVERAGE	1.4E-04	12.1

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.22	0.39		
10	0.24	0.37	1.1E-04	9.7
20	0.26	0.35	1.1E-04	9.9
30	0.28	0.33	1.2E-04	10.2
40	0.29	0.32	1.0E-04	9.0
50	0.31	0.3	1.1E-04	9.6
60	0.32	0.29	1.0E-04	9.0
70	0.33	0.28	1.0E-04	8.6
80	0.35	0.26	1.1E-04	9.2
90	0.36	0.25	1.0E-04	8.9
100	0.37	0.24	1.0E-04	8.8
110	0.39	0.22	1.1E-04	9.4
120	0.4	0.21	1.1E-04	9.3
130	0.41	0.2	1.1E-04	9.2
140	0.42	0.19	1.1E-04	9.2
150	0.43	0.18	1.1E-04	9.2
160	0.44	0.17	1.1E-04	9.2
170	0.45	0.16	1.1E-04	9.3
180	0.46	0.15	1.1E-04	9.4
		AVERAGE	1.1E-04	9.3

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.21	0.4		
10	0.22	0.39	5.4E-05	4.7
20	0.23	0.38	5.4E-05	4.7
30	0.24	0.37	5.5E-05	4.8
40	0.26	0.35	7.1E-05	6.1
50	0.27	0.34	6.9E-05	5.9
60	0.3	0.31	9.0E-05	7.8
70	0.31	0.3	8.7E-05	7.5
80	0.33	0.28	9.4E-05	8.1
90	0.34	0.27	9.2E-05	7.9
100	0.36	0.25	9.9E-05	8.5
110	0.37	0.24	9.7E-05	8.4
120	0.38	0.23	9.6E-05	8.3
130	0.39	0.22	9.6E-05	8.3
140	0.4	0.21	9.6E-05	8.3
150	0.4	0.21	8.9E-05	7.7
160	0.41	0.2	9.0E-05	7.8
170	0.42	0.19	9.1E-05	7.9
180	0.43	0.18	9.2E-05	7.9
		AVERAGE	8.4E-05	7.3


Permeability by Inverse Auger Hole Method
P01
Permeability, k (m/day)
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
20
40
60
80
100
120
140
160
180
200
Test time, t (seconds)
Test 1
Test 2
Test 3

Permeability Calculation - Inverse Auger Hole Method

Galt Geotechnics

Job No:	J1401062
Client:	QUBE
Site:	Lot 682 Rowley Road
Location:	Mandogalup
Calc by:	JH 11-Apr-14
BH Name:	P02
Test Depth:	0.54 m

Spreadsheet author:	ORW	17-Oct-09

$$K = 1.15r\,\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114

Spreadsheet Legend

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	Calculated field
	Comment field
	Field not used
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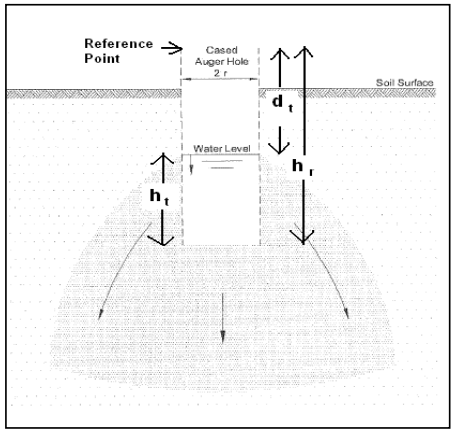
Parameter	Description	Value	Units
K	Permeability		m/s
r	radius of test hole	0.045	m
t	time since start of measurement		s
h_r	reference point height above base	0.61	m
d_t	depth from reference point to water at time t		m
h_t	Water column height at time t		m
h_0	h_t at t=0		m



Test 1

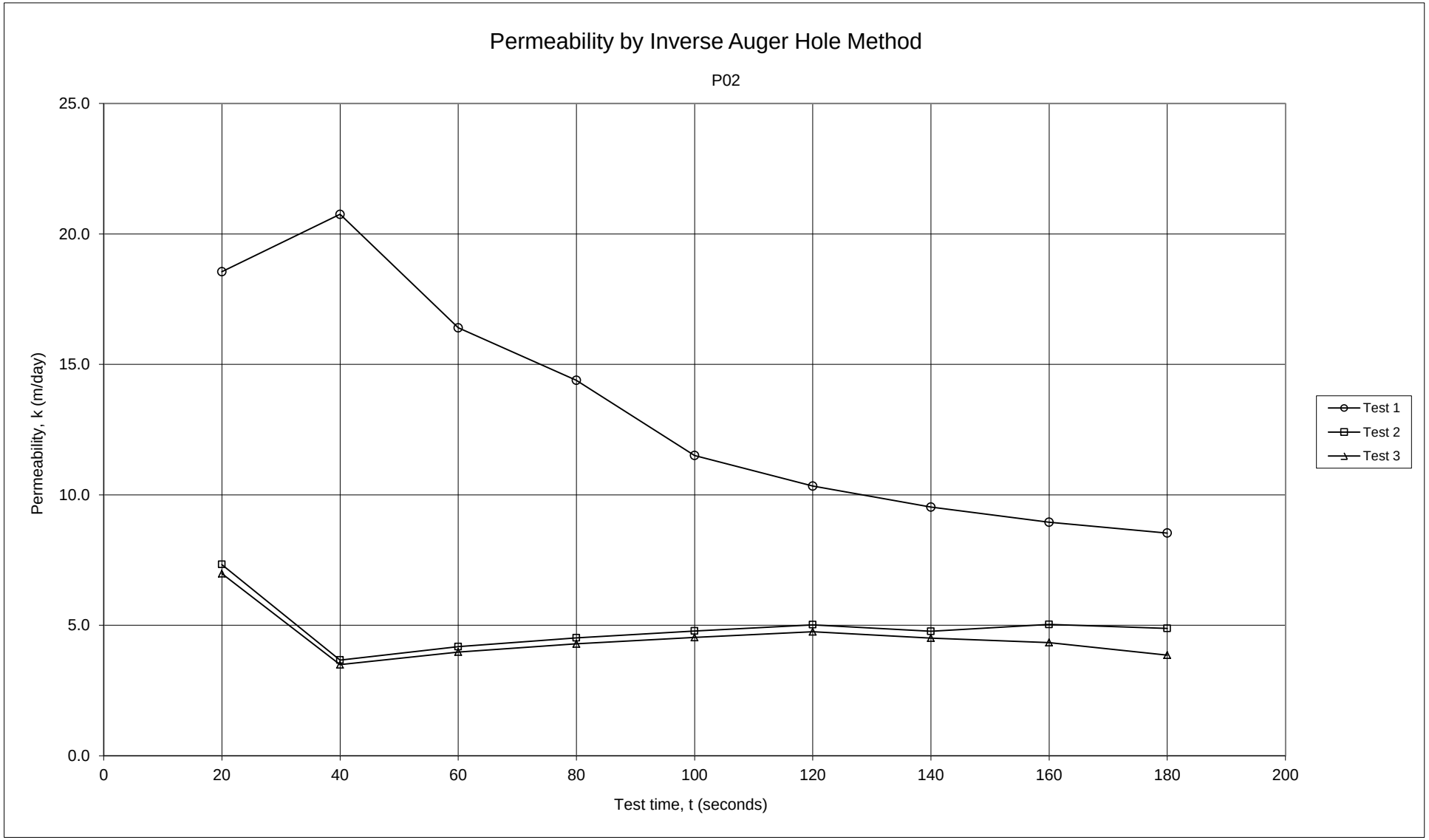
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.23	0.38		
20	0.3	0.31	2.1E-04	18.5
40	0.37	0.24	2.4E-04	20.8
60	0.39	0.22	1.9E-04	16.4
80	0.41	0.2	1.7E-04	14.4
100	0.41	0.2	1.3E-04	11.5
120	0.42	0.19	1.2E-04	10.3
140	0.43	0.18	1.1E-04	9.5
160	0.44	0.17	1.0E-04	9.0
180	0.45	0.16	9.9E-05	8.5
		AVERAGE	1.5E-04	13.2

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.22	0.39		
20	0.25	0.36	8.5E-05	7.3
40	0.25	0.36	4.2E-05	3.7
60	0.27	0.34	4.8E-05	4.2
80	0.29	0.32	5.2E-05	4.5
100	0.31	0.3	5.5E-05	4.8
120	0.33	0.28	5.8E-05	5.0
140	0.34	0.27	5.5E-05	4.8
160	0.36	0.25	5.8E-05	5.0
180	0.37	0.24	5.6E-05	4.9
		AVERAGE	5.7E-05	4.9

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.2	0.41		
20	0.23	0.38	8.1E-05	7.0
40	0.23	0.38	4.0E-05	3.5
60	0.25	0.36	4.6E-05	4.0
80	0.27	0.34	5.0E-05	4.3
100	0.29	0.32	5.2E-05	4.5
120	0.31	0.3	5.5E-05	4.7
140	0.32	0.29	5.2E-05	4.5
160	0.33	0.28	5.0E-05	4.3
180	0.33	0.28	4.5E-05	3.9
		AVERAGE	5.2E-05	4.5


Permeability by Inverse Auger Hole Method
P02
Permeability, k (m/day)
25.0
20.0
15.0
10.0
5.0
0.0
0
20
40
60
80
100
120
140
160
180
200
Test time, t (seconds)
Test 1
Test 2
Test 3

Permeability Calculation - Inverse Auger Hole Method

Galt Geotechnics

Job No:	J1401062
Client:	QUBE
Site:	Lot 682 Rowley Road
Location:	Mandogalup
Calc by:	JH 11-Apr-14
BH Name:	P03
Test Depth:	0.51 m

Spreadsheet author:	ORW	17-Oct-09

$$K = 1.15r\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114

Spreadsheet Legend

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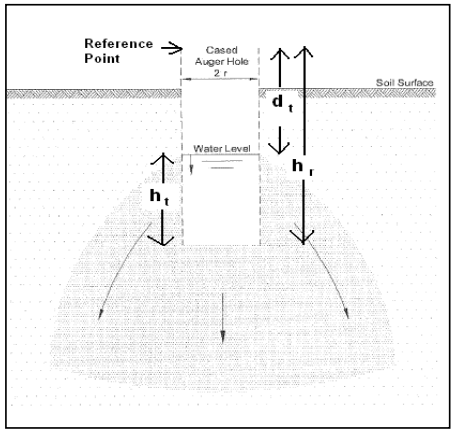
	Calculated field
	Comment field
	Field not used
	Fixed field

Parameter	Description	Value	Units
K	Permeability		m/s
r	radius of test hole	0.045	m
t	time since start of measurement		s
h_r	reference point height above base	0.61	m
d_t	depth from reference point to water at time t		m
h_t	Water column height at time t		m
h_0	h_t at t=0		m



Test 1

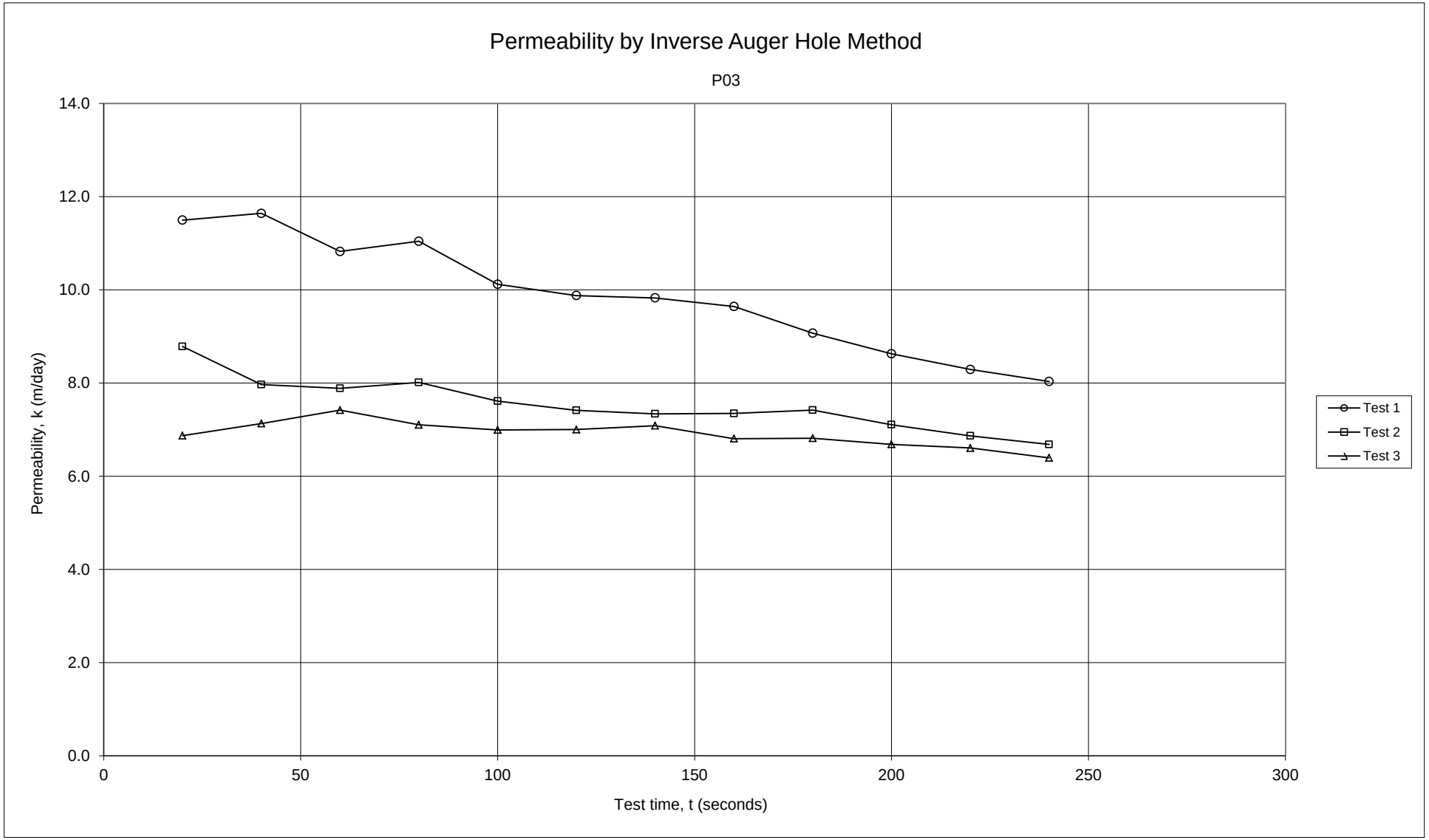
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.14	0.47		
20	0.195	0.415	1.3E-04	11.5
40	0.245	0.365	1.3E-04	11.6
60	0.28	0.33	1.3E-04	10.8
80	0.32	0.29	1.3E-04	11.0
100	0.34	0.27	1.2E-04	10.1
120	0.365	0.245	1.1E-04	9.9
140	0.39	0.22	1.1E-04	9.8
160	0.41	0.2	1.1E-04	9.6
180	0.42	0.19	1.0E-04	9.1
200	0.43	0.18	1.0E-04	8.6
220	0.44	0.17	9.6E-05	8.3
240	0.45	0.16	9.3E-05	8.0
		AVERAGE	1.1E-04	9.9

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.17	0.44		
20	0.21	0.4	1.0E-04	8.8
40	0.24	0.37	9.2E-05	8.0
60	0.27	0.34	9.1E-05	7.9
80	0.3	0.31	9.3E-05	8.0
100	0.32	0.29	8.8E-05	7.6
120	0.34	0.27	8.6E-05	7.4
140	0.36	0.25	8.5E-05	7.3
160	0.38	0.23	8.5E-05	7.3
180	0.4	0.21	8.6E-05	7.4
200	0.41	0.2	8.2E-05	7.1
220	0.42	0.19	7.9E-05	6.9
240	0.43	0.18	7.7E-05	6.7
		AVERAGE	8.7E-05	7.5

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.12	0.49		
20	0.155	0.455	7.9E-05	6.9
40	0.19	0.42	8.3E-05	7.1
60	0.225	0.385	8.6E-05	7.4
80	0.25	0.36	8.2E-05	7.1
100	0.275	0.335	8.1E-05	7.0
120	0.3	0.31	8.1E-05	7.0
140	0.325	0.285	8.2E-05	7.1
160	0.34	0.27	7.9E-05	6.8
180	0.36	0.25	7.9E-05	6.8
200	0.375	0.235	7.7E-05	6.7
220	0.39	0.22	7.6E-05	6.6
240	0.4	0.21	7.4E-05	6.4
		AVERAGE	8.0E-05	6.9



O:\Jobs\2014\J1401062 - C&W SI Mandogalup\08 Analysis\J1401062 Permeability Inverse Auger Hole Method

Permeability Calculation - Inverse Auger Hole Method

Galt Geotechnics

Job No:	J1401062
Client:	QUBE
Site:	Lot 682 Rowley Road
Location:	Mandogalup
Calc by:	JH 11-Apr-14
BH Name:	P04
Test Depth:	0.41 m

Spreadsheet author:	ORW	17-Oct-09

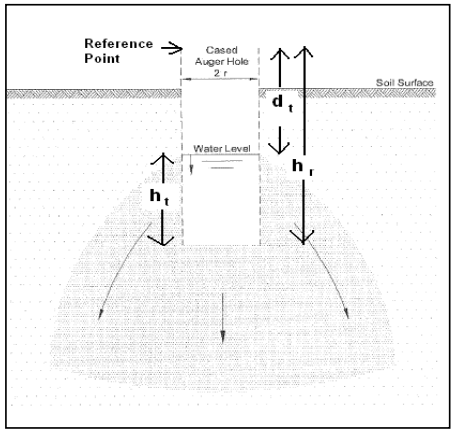
$$K = 1.15r\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114

Spreadsheet Legend

	Required input
	Calculated field
	Comment field
	Field not used
	Fixed field

Parameter	Description	Value	Units
K	Permeability		m/s
r	radius of test hole	0.045	m
t	time since start of measurement		s
h_r	reference point height above base	0.61	m
d_t	depth from reference point to water at time t		m
h_t	Water column height at time t		m
h_0	h_t at t=0		m



Test 1

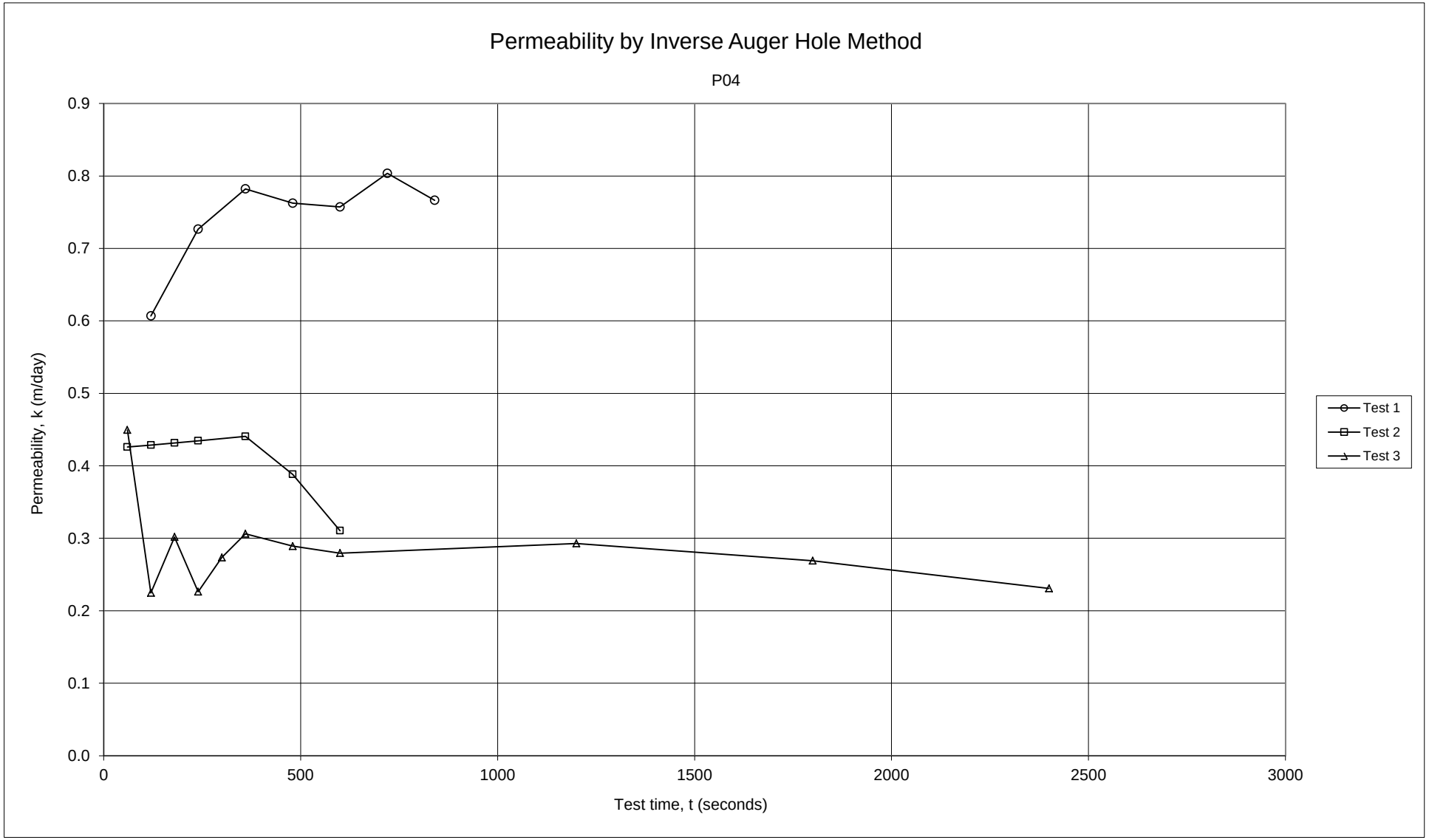
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.225	0.385		
120	0.24	0.37	7.0E-06	0.6
240	0.26	0.35	8.4E-06	0.7
360	0.28	0.33	9.1E-06	0.8
480	0.295	0.315	8.8E-06	0.8
600	0.31	0.3	8.8E-06	0.8
720	0.33	0.28	9.3E-06	0.8
840	0.34	0.27	8.9E-06	0.8
		AVERAGE	8.6E-06	0.7

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.25	0.36		
60	0.255	0.355	4.9E-06	0.4
120	0.26	0.35	5.0E-06	0.4
180	0.265	0.345	5.0E-06	0.4
240	0.27	0.34	5.0E-06	0.4
360	0.28	0.33	5.1E-06	0.4
480	0.285	0.325	4.5E-06	0.4
600	0.285	0.325	3.6E-06	0.3
		AVERAGE	4.7E-06	0.4

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.27	0.34		
60	0.275	0.335	5.2E-06	0.4
120	0.275	0.335	2.6E-06	0.2
180	0.28	0.33	3.5E-06	0.3
240	0.28	0.33	2.6E-06	0.2
300	0.285	0.325	3.2E-06	0.3
360	0.29	0.32	3.5E-06	0.3
480	0.295	0.315	3.3E-06	0.3
600	0.3	0.31	3.2E-06	0.3
1200	0.33	0.28	3.4E-06	0.3
1800	0.35	0.26	3.1E-06	0.3
2400	0.36	0.25	2.7E-06	0.2
		AVERAGE	3.3E-06	0.3


Permeability by Inverse Auger Hole Method
P04
Permeability, k (m/day)
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
0
500
1000
1500
2000
2500
3000
Test time, t (seconds)
Test 1
Test 2
Test 3

Permeability Calculation - Inverse Auger Hole Method

Galt Geotechnics

Job No:	J1401062
Client:	QUBE
Site:	Lot 682 Rowley Road
Location:	Mandogalup
Calc by:	JH 11-Apr-14
BH Name:	P05
Test Depth:	0.57 m

Spreadsheet author:	ORW	17-Oct-09

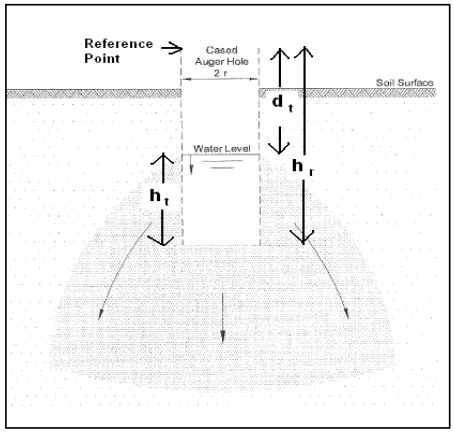
$$K = 1.15r\,\frac{\log_{10}(h_0 + \frac{1}{2}r) - \log_{10}(h_t + \frac{1}{2}r)}{t - t_0}$$

REFERENCE: Cocks, G. *Disposal of Stormwater Runoff by Soakage in Perth Western Australia*, Journal and News of the Australian Geomechanics Society, Volume 42 No 3 September 2007, pp101-114

Spreadsheet Legend

	Required input
	Calculated field
	Comment field
	Field not used
	Fixed field

Parameter	Description	Value	Units
K	Permeability		m/s
r	radius of test hole	0.045	m
t	time since start of measurement		s
h_r	reference point height above base	0.61	m
d_t	depth from reference point to water at time t		m
h_t	Water column height at time t		m
h_0	h_t at t=0		m



Test 1

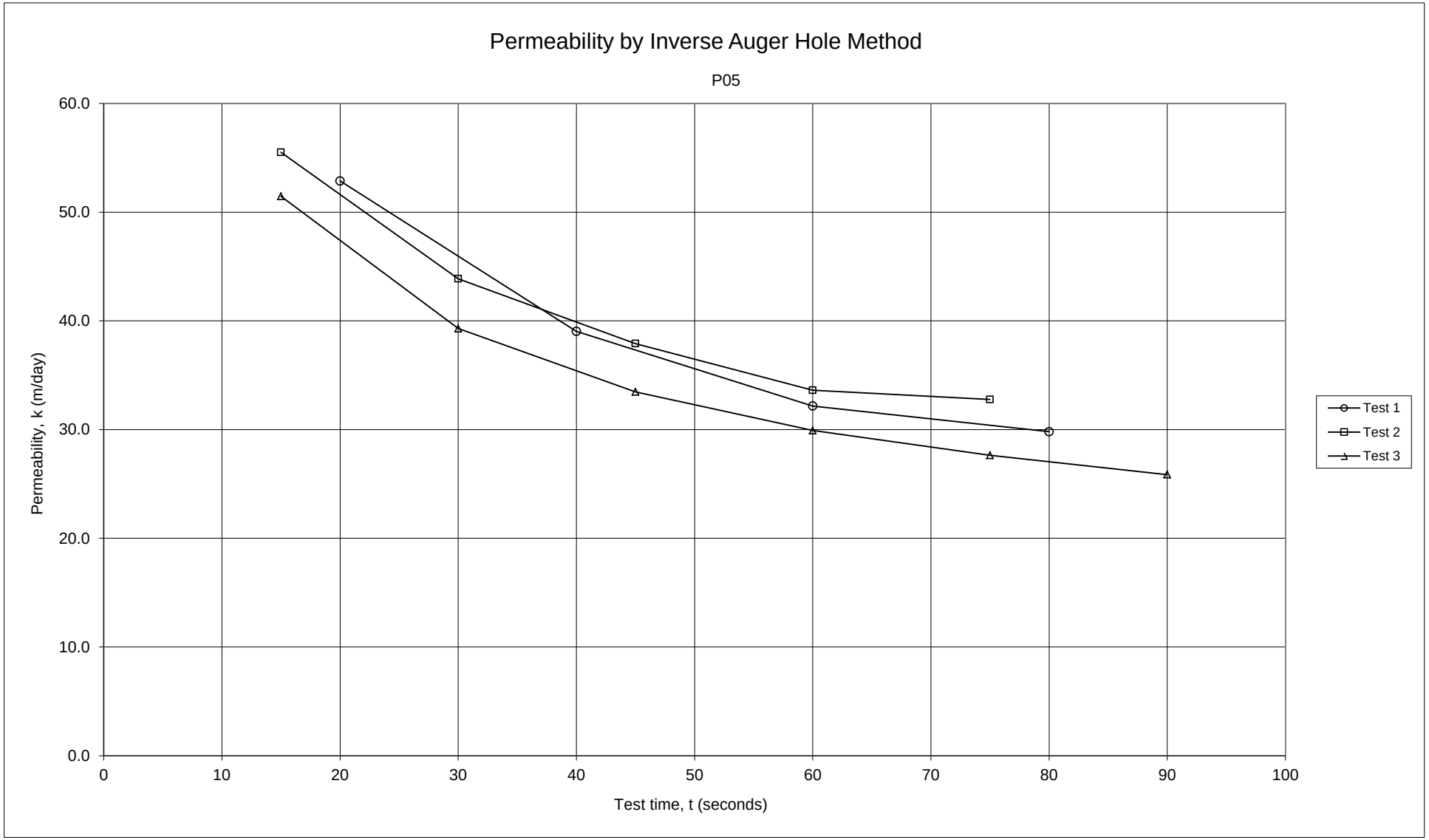
t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.18	0.43		
20	0.37	0.24	6.1E-04	52.9
40	0.43	0.18	4.5E-04	39.0
60	0.465	0.145	3.7E-04	32.2
80	0.5	0.11	3.5E-04	29.8
		AVERAGE	4.5E-04	38.5

Test 2

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.145	0.465		
15	0.315	0.295	6.4E-04	55.5
30	0.385	0.225	5.1E-04	43.9
45	0.43	0.18	4.4E-04	37.9
60	0.46	0.15	3.9E-04	33.6
75	0.495	0.115	3.8E-04	32.8
		AVERAGE	4.7E-04	40.7

Test 3

t (s)	d_w (m)	h_t (m)	K (m/s)	K (m/day)
0	0.16	0.45		
15	0.315	0.295	6.0E-04	51.5
30	0.375	0.235	4.5E-04	39.3
45	0.415	0.195	3.9E-04	33.5
60	0.445	0.165	3.5E-04	29.9
75	0.47	0.14	3.2E-04	27.6
90	0.49	0.12	3.0E-04	25.9
		AVERAGE	4.0E-04	34.6


Permeability by Inverse Auger Hole Method
P05
Permeability, k (m/day)
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
10
20
30
40
50
60
70
80
90
100
Test time, t (seconds)
Test 1
Test 2
Test 3

Appendix F: Laboratory Test Results

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ABN: 73 292 586 155

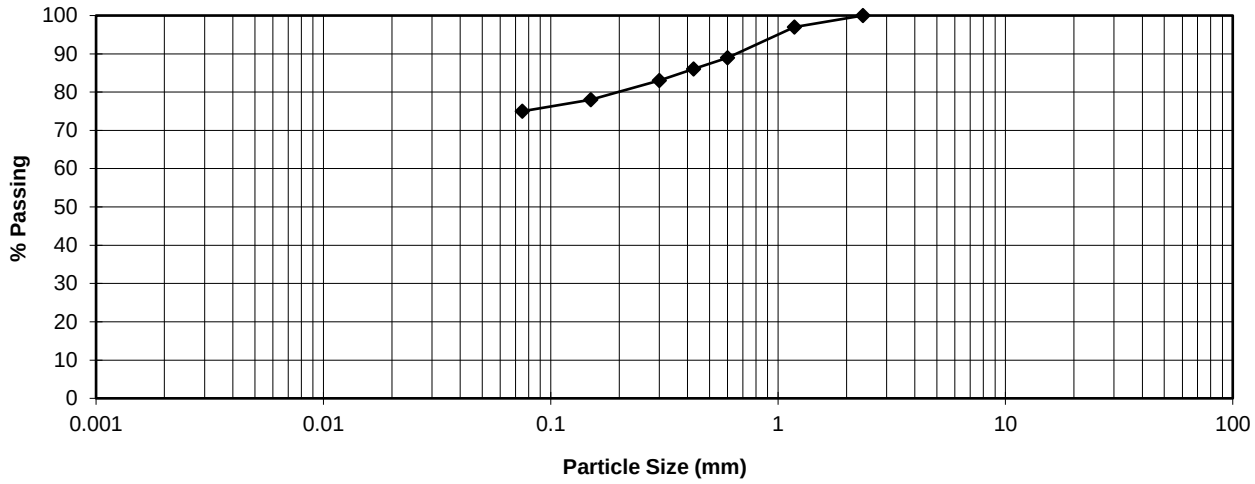
Particle Size Distribution & Plasticity Index tests

Mining & Civil
Geotest Pty Ltd
unit1/1 Pusey Road, Jandakot, WA 6164
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: matt@mcgeotest.com.au

Job No:	60083
Report No:	60083-P14/1005
Sample No:	P14/1005
Issue Date:	23 April 2014

Client: Galt Geotechnics (J1401062)
Project: Proposed Residential Subdivision
Location: Lot 682 Rowley Road, Mandopalup

Sample ID: TP16
Sample Depth: 0.5-0.7



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	97
0.600	89
0.425	86
0.300	83
0.150	78
0.075	75

Plasticity index tests
AS 1289

Liquid limit 3.1.1	100	%
Plastic limit 3.2.1	76	%
Plasticity index 3.3.1	24	%
Linear shrinkage 3.4.1	7.0	%

Cracked ☐
Curled ☐

Client Address: 2/39 Flynn Street, Wembley WA

Sampling Procedure: Tested as received

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Matthew van Herk
AS PSDPI May 2009

Particle Size Distribution & Plasticity Index tests

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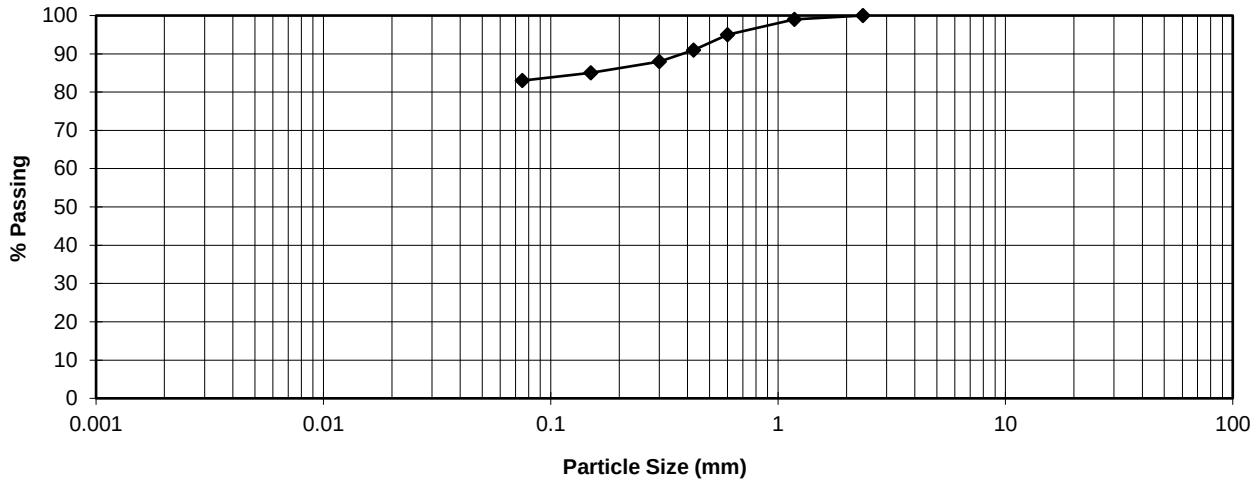
Email: matt@mcgeotest.com.au

Job No:	60083
Report No:	60083-P14/1004
Sample No:	P14/1004
Issue Date:	23 April 2014

Client: Galt Geotechnics (J1401062)
Project: Proposed Residential Subdivision
Location: Lot 682 Rowley Road, Mandopalup

Sample ID: TP16
Sample Depth: 1.5-1.7



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	99
0.600	95
0.425	91
0.300	88
0.150	85
0.075	83

Plasticity index tests
AS 1289

Liquid limit 3.1.1	82	%
Plastic limit 3.2.1	26	%
Plasticity index 3.3.1	56	%
Linear shrinkage 3.4.1	13.5	%

Cracked ☐
Curled ☑

Client Address: 2/39 Flynn Street, Wembley WA

Sampling Procedure: Tested as received

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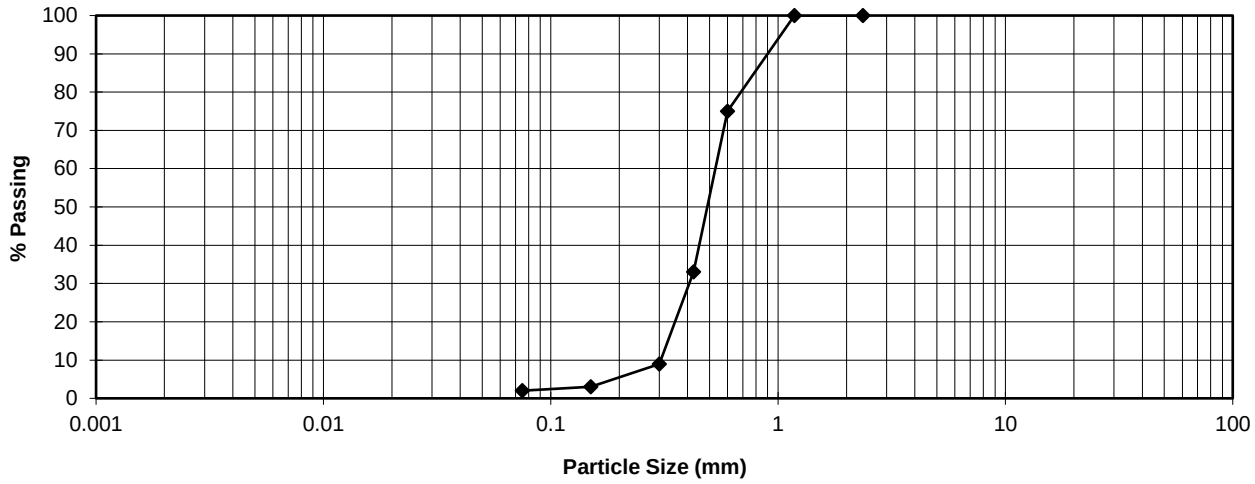
Job No:	60083
Report No:	60083-P14/1006
Sample No:	P14/1006
Issue Date:	23 April 2014

Client: Galt Geotechnics (J1401062)
Project: Proposed Residential Subdivision
Location: Lot 682 Rowley Road, Mandopalup

Sample ID: TP41
Sample Depth: 0.2-0.5



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	100
0.600	75
0.425	33
0.300	9
0.150	3
0.075	2

Plasticity index tests
AS 1289

Liquid limit 3.1.1	SIC	%
Plastic limit 3.2.1	NP	%
Plasticity index 3.3.1	NP	%
Linear shrinkage 3.4.1	0.0	%

Cracked ☐
Curled ☐

Client Address: 2/39 Flynn Street, Wembley WA

Sampling Procedure: Tested as received

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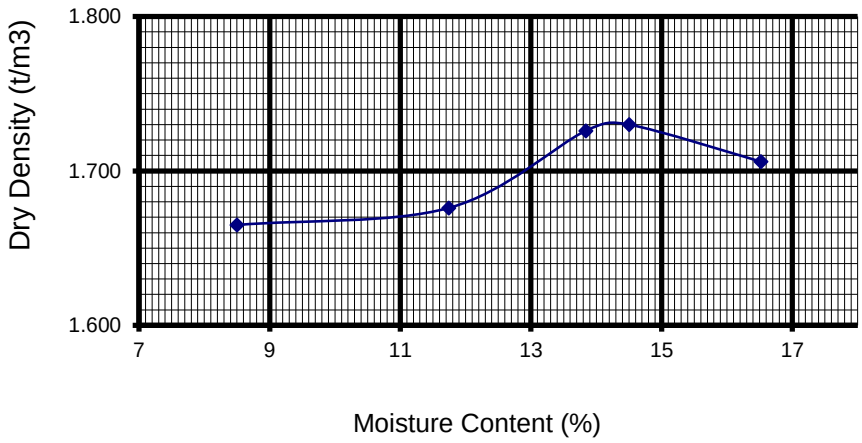
Fax (08)9414 8011
Email matt@mcgeotest.com.au

Maximum Dry Density (AS 1289.5.2.1) & California Bearing Ratio (AS 1289.6.1.1) Test Report

Certificate No:	60083-P14/1006	**Project:**	Proposed Residential Subdivision
Sample No:	P14/1006	**Client:**	Galt Geotechnics (J1401062)
Location:	Lot 682 Rowley Road, Mandopalup	**Date of Issue:**	23 April 2014
	TP41 0.2-0.5	**Job No:**	60083

Maximum Dry Density t/m^3:	1.730	**Conditions at Test**	
Optimum Moisture Content %:	14.5	Soaking Period (Days)	4
Desired Conditions:	95/100	Surcharge (kg)	4.5
Compactive Effort		Entire Moisture Content %	16.8
Mass of hammer kg	4.9	Entire Moisture Ratio %	116.0
Number of layers	5	Top 30mm Moisture Content %	16.2
Number of blows/layer	20	Top 30mm Moisture Ratio %	111.5
Conditions after Compaction		Swell %	0.0
Dry Density t/m^3	1.644	C.B.R. at 5.0 mm Penetration %	11
Moisture Content %	13.9	**Conditions after Soaking**	
Density Ratio %	95.0	Dry Density t/m^3	1.644
Moisture Ratio %	96.0	Moisture Content %	17.3
Soaked / Unsoaked	Soaked	Dry Density Ratio %	95.0
		Moisture Ratio %	119.0

Comments:



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Particle Size Distribution & Plasticity Index tests

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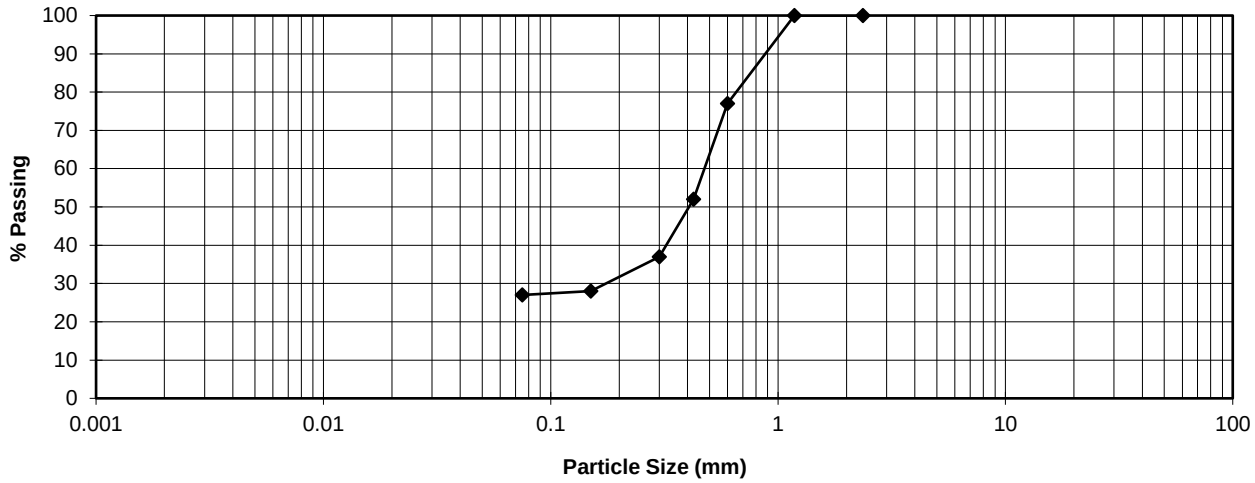
Ph (08) 9414 8022 Fax (08) 9414 8011
Email: matt@mcgeotest.com.au

Job No:	60083
Report No:	60083-P14/1007
Sample No:	P14/1007
Issue Date:	23 April 2014

Client: Galt Geotechnics (J1401062)
Project: Proposed Residential Subdivision
Location: Lot 682 Rowley Road, Mandopalup

Sample ID: TP46
Sample Depth: 0.6-0.9



SIEVE ANALYSIS AS 1289.3.6.1

Sieve Size (mm)	% Passing
75.0	
37.5	
19.0	
9.5	
4.75	
2.36	100
1.18	100
0.600	77
0.425	52
0.300	37
0.150	28
0.075	27

Plasticity index tests
AS 1289

Liquid limit 3.1.1	50	%
Plastic limit 3.2.1	20	%
Plasticity index 3.3.1	30	%
Linear shrinkage 3.4.1	10.5	%

Cracked ☑
Curled ☑

Client Address: 2/39 Flynn Street, Wembley WA

Sampling Procedure: Tested as received

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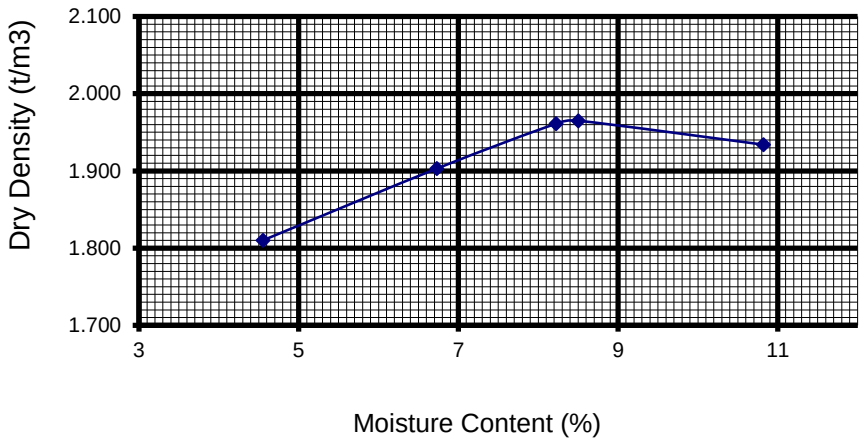
Ph (08) 9414 8022
Fax (08)9414 8011
Email matt@mcgeotest.com.au

Maximum Dry Density (AS 1289.5.2.1) & California Bearing Ratio (AS 1289.6.1.1) Test Report

Certificate No:	60083-P14/1007	**Project:**	Proposed Residential Subdivision
Sample No:	P14/1007	**Client:**	Galt Geotechnics (J1401062)
Location:	Lot 682 Rowley Road, Mandopalup	**Date of Issue:**	23 April 2014
	TP46 0.6-0.9	**Job No:**	60083

Maximum Dry Density t/m^3:	1.965	**Conditions at Test**	
Optimum Moisture Content %:	8.5	Soaking Period (Days)	4
Desired Conditions:	95/100	Surcharge (kg)	4.5
Compactive Effort		Entire Moisture Content %	15.5
Mass of hammer kg	4.9	Entire Moisture Ratio %	182.0
Number of layers	5	Top 30mm Moisture Content %	18.9
Number of blows/layer	20	Top 30mm Moisture Ratio %	222.0
Conditions after Compaction		Swell %	3.0
Dry Density t/m^3	1.865	C.B.R. at 5.0 mm Penetration %	5
Moisture Content %	8.3	**Conditions after Soaking**	
Density Ratio %	95.0	Dry Density t/m^3	1.811
Moisture Ratio %	97.5	Moisture Content %	15.7
Soaked / Unsoaked	Soaked	Dry Density Ratio %	92.0
		Moisture Ratio %	184.5

Comments:



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Appendix G: Understanding Your Geotechnical Engineering Report

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ABN: 73 292 586 155

UNDERSTANDING YOUR GEOTECHNICAL ENGINEERING REPORT

GALT FORM PMP11 Rev1

1. EXPECTATIONS OF A GEOTECHNICAL ENGINEERING REPORT

This document has been prepared to clarify what is and is not provided in your geotechnical report. It is intended to inform you of what your realistic expectations of this report should be and how to manage your risks associated with geotechnical conditions.

Geotechnical engineering is a less exact science than other engineering disciplines. We include this information to help you understand where our responsibilities as geotechnical engineers begin and end, to help the client recognise his responsibilities and risks. You should read and understand this information. Please contact us if you do not understand the report or this explanation. We have extensive experience in a wide variety of geotechnical problems and we can help you to manage your risk.

2. THIS REPORT RELATES TO PROJECT-SPECIFIC CONDITIONS

This report was developed for a unique set of project-specific conditions to meet the needs of the nominated client. It took into account the following :

- The project objectives as we understood them and as described in this report;
- the specific site mentioned in this report; and
- the current and proposed development at the site.

It should not be used for any purpose other than that indicated in the report. You should not rely on this geotechnical report if any of the following conditions apply:

- the report was not written for you;
- the report was not written for the site specific to your development;
- the report was not written for your project (including a development at the correct site but other than that listed in the report); or
- the report was written before significant changes occurred at the site (such as a development or a change in ground conditions).

You should always inform us of changes in the proposed project (including minor changes) and request an assessment of their impact.

Where we are not informed of developments relevant to your geotechnical engineering report, we cannot be held responsible or liable for problems that may arise as a consequence.

Where design is to be carried out by others using information provided by us, we recommend that we be involved in the design process by being engaged for consultation with other members of the design team and by being able to review work produced by other members of the design team which relies on geotechnical information provided in our report.

3. GEOTECHNICAL ENGINEERING LOGS

Our reports often include logs of intrusive and non-intrusive geotechnical investigation techniques. These logs are based on our interpretation of field data and laboratory results. The logs should only be read in conjunction with the report they were issued with and should not be re-drawn for inclusion in other documents not prepared by us.

4. THIRD PARTY RELIANCE

We have prepared this report for use by the client. This report must be regarded as confidential to the client and the client's professional advisors. We do not accept any responsibility for contents of this document from any party other than the nominated client. We take no responsibility for any damages suffered by a third party as a consequence of any decisions or actions they may make based on this report. Any reliance or decisions made by a third party based on this report are the responsibility of the third party and not of us.

5. CHANGE IN SUBSURFACE CONDITIONS

The geotechnical recommendations in this report are based on the ground conditions that existed at the time when the study was undertaken. Changes in ground conditions can occur in numerous ways including as a result of anthropogenic events (such as construction on or adjacent to the site) or natural events (such as floods, groundwater fluctuations or earthquakes). We should be consulted prior to use of this report so that we can comment on its reliability. It is important to note that where ground conditions have changed, additional sampling, testing or analysis may be required to fully assess the changed conditions.

6. SUBSURFACE CONDITIONS DURING CONSTRUCTION

Practical constraints mean that we cannot know every minute detail about the subsurface conditions at a particular site. We use engineering judgement to form an opinion about the subsurface conditions at the site. Some variation to our evaluated conditions is likely and significant variation is possible. Accordingly, our report should not be considered as final as it is developed from engineering judgement and opinion.

The most effective means of dealing with unanticipated ground conditions is to engage us for construction support. We can only finalise our recommendations by observing actual subsurface conditions encountered during construction. We cannot accept liability for a report's recommendations if we cannot observe construction.

7. ENVIRONMENTAL ISSUES

Unless specifically mentioned otherwise in our report, environmental considerations are not included. The investigation techniques used by us in developing our report differ from those for an environmental investigation. Our report was not prepared with environmental considerations in mind and it is the client's responsibility to satisfy himself that environmental considerations have been taken into account for the site. If you require guidance on how to proceed on evaluating environmental risk at the site, we can provide further information and contacts.

APPENDIX C

Pre-Development Monitoring (JDA, 2010)

QUBE Property Group

Mandogalup Pre-Development Hydrological Monitoring

April 2007 - March 2009

January 2010

JDA Consultant Hydrologists

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JDA provides quality assurance through all aspects of the company operation and is endorsed to AS/NZS ISO 9001:2000 Quality Assurance Accreditation, with third party certification to Bureau Veritas Quality International.

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1. INTRODUCTION

1.1 Background

In October 2006 JDA Consultant Hydrologists was commissioned by the QUBE Property Group to commence pre-development groundwater monitoring for Lots 16, 663, 664, 668, 669, 682 and 791, Mandogalup, as shown in Figure 1. The land is currently undeveloped and used for semi-rural purposes including grazing and horticulture. There is a section of bushland in the northern portion of Lot 682. The status of the Water Management Strategy (WMS) being prepared for the Jandakot Structure Plan (JSP) was uncertain at the time JDA was commissioned to conduct the monitoring program. Hence, JDA negotiated with the Department of Water (DoW) a monitoring program to fulfil the intentions of the WMS. The 2 year monitoring program was endorsed by the DoW in a letter to JDA dated 27 January 2007 (see Appendix A).

The endorsed monitoring program includes monitoring of groundwater and surface water quality. The groundwater component is via a series of eight 'nested' bores and 2 single shallow bores in ten locations. The bores have been located to account for the groundwater flow direction and potential nutrient point sources. The surface water component includes flow estimates and grab samples from designated points along the Peel Main Drain, the main drainage line passing through the Study Area.

This report presents a summary of the results from the 2 year monitoring program, from April 2007 to March 2009. The following tasks have been completed as a part of the program:

- Installation of monitoring bores,
- Monthly groundwater monitoring,
- Monthly surface water monitoring,
- Reporting.

1.2 Regional Water Quality Objectives

Water quality targets for the Peel Main Drain catchment are documented in the *Environmental Protection (Peel Inlet – Harvey Estuary) Policy 1992*.

The EPP has mean phosphorus load targets for the Serpentine River to manage the impact of nutrients on the Peel Inlet – Harvey Estuary (Table 1). The EPP (1992) defines the 'median load of total phosphorus' as "the middle observed phosphorus load in the observed series of measured annual phosphorus loads, measured over the immediately preceding 10 year period".

TABLE 1. EPP (1992) PEEL INLET – HARVEY ESTUARY MEDIAN LOAD (MASS) TOTAL PHOSPHORUS TARGETS

	Median Load (mass) Total Phosphorus Targets (tonnes)
Whole Peel Inlet - Harvey Estuary	< 75 tonnes
From Serpentine River	< 21 tonnes
From Murray River	< 16 tonnes
From Harvey River	< 38 tonnes

The Peel Main Drain discharges to the Peel Inlet via the Serpentine River. The total catchment area for the Serpentine River is approximately 1128 km^2 giving a median load mass discharge for the catchment of 0.19 kg P/ha/yr based on the target for Serpentine River shown in Table 1.

The Water Quality Improvement Plan (WQIP) for the Rivers and Estuary of the Peel-Harvey System was released November 2008 (EPA, 2008). The WQIP has been developed to address catchment management measures and control phosphorus in the Peel-Harvey system. The water quality objectives adopted by the WQIP are consistent with the EPP (1992) and provides targets for Peel Main Drain of median winter concentration 0.2mg/L short term and 0.1mg/L long term.

The EPP and WQIP do not describe any criteria for Nitrogen.

2. GROUNDWATER AND SURFACE WATER MONITORING SITES

Groundwater monitoring bores were installed at ten sites, labelled D1 to D10, over the study area (Figure 2). At each site two bores were installed, a shallow bore (7.5-13 m below natural surface) and a deep bore (12.5 -18.0 m below natural surface), with the exception of sites D1 and D3, where there is one shallow bore at each respective location due to their location within native vegetation pockets.

The natural surface level and top of casing for each bore was surveyed to Australian Height Datum (m AHD) by McMullen Nolan and Partners Surveyors. The position of each bore was also obtained using GPS.

Three surface water monitoring sites, PMD1-PMD3 were established on the property along the Peel Main Drain which passes through the study area (Figure 2). Depth of flow was logged at the surface water sites along the Peel Main Drain using an Odyssey data logger. The data loggers were positioned in the invert of the drain at each site and recorded depth of water every six minutes.

At each surface water monitoring site the drain invert level, drain bank level and logger top of casing level was surveyed in metres AHD by McMullen Nolan and Partners Surveyors (Table 2).

TABLE 2. MONITORING SITE DETAILS

Bore	GDA Coordinates		Top of Casing [m AHD]	Total Depth [m BNS]	Screened Interval [m BNS]
	Easting	Northing			
D1	391871	6438875	27.50	11.0	26.96
D2(s)	391964	6438425	22.11	8.5	21.65
D2(d)	391964	6438424	22.04	13.5	21.63
D3	391342	6437726	26.38	15.0	25.92
D4(s)	391973	6437637	20.06	8.0	19.48
D4(d)	391971	6437636	20.07	13.0	19.48
D5(s)	391267	6437341	13.77	8.0	13.20
D5(d)	391267	6437342	13.81	13.0	13.21
D6(s)	390954	6437416	14.03	7.5	13.46
D6(d)	390955	6437417	14.01	12.5	13.48
D7(s)	390829	6436906	13.78	8.0	13.25
D7(d)	390828	6436906	13.81	13.0	13.24
D8(s)	391837	6436441	14.12	8.0	13.60
D8(d)	391838	6436443	14.18	13.0	13.60
D9(s)	391412	6436082	21.68	13.0	21.13
D9(d)	391413	6436082	21.65	18.0	21.08
D10(s)	391172	6436139	19.66	12.0	19.10
D10(d)	391171	6436142	19.63	17.0	19.10
Drain Site	**Easting**	**Northing**	**Invert Level (m AHD)**		
PMD1	391968	6437875	18.49	–	–
PMD2	391255	6437133	12.26	–	–
PMD3	391001	6436041	11.60	–	–

Notes

1. m AHD: metres Australian Height Datum
2. m BNS: metres below natural surface

3. MONITORING PROCEDURE

Water level monitoring and water quality sampling was completed monthly.

Groundwater levels were measured in monitoring bores D1 and D3 (shallow) and D2, D4-D10 (shallow & deep) prior to sampling for water quality. Samples were then taken by pumping from the bore.

Surface drain water samples were collected from sites PMD1, PMD2 and PMD3 when they were flowing. During base flow conditions grab samples for nutrient analysis were taken from the drains, along with in-situ pH and EC measurements, and flow rates were estimated visually. The data from the loggers at each site was also downloaded.

For both groundwater and surface water samples, pH and Electrical Conductivity (EC) were measured on site by JDA and samples were submitted to MPL Laboratories for analysis of nutrients. The Total Dissolved Salts concentration has been estimated by multiplying the measured Electrical Conductivity value (mS/cm) by a factor of 550 (Davidson, 1995). Nutrient analysis included NO_x-N (or else Nitrate-N & Nitrite-N), Total Kjeldahl Nitrogen (TKN), Total Nitrogen (TN), Ammonium-N (NH_4-N), Filterable Reactive Phosphorus (FRP) and Total Phosphorus (TP).

Water levels were also recorded in Department of Water long-term monitoring bores JE12C, JM41, JM42, JM49 and SP1-2B.

4. RESULTS

4.1 Groundwater Levels

Monthly water levels for the WAM Series and DoW bores for the monitoring period are shown in Table 3 & 4 with a time series plot presented as Figure 3.

Water levels recorded on 7 August 2008 showed peak water levels for 14 out of 23 bores with levels varying from 11.59 m AHD (D7 deep) to 19.88 m AHD (D1).

The seasonal variation in groundwater levels measured over the monitoring period varies between bores, ranging from 0.94 m to 3.18 m. The difference in water levels between the shallow and deep bores was insignificant, suggesting the bores are hydraulically connected (no aquitard layers).

Bores D4 & D5, shallow and deep, show a larger variation in watertable levels compared to other bores (D4(s) 2.60 m and D4(d) 3.18 m, and D5(s) 2.40 m and D5(d) 2.42 m).

DoW monitoring bores JE12C, JM41, JM42, JM49 and SP1-2B show a seasonal variation ranging from 0.76 to 0.94 m.

TABLE 3. APRIL 2007- MARCH 2008 WATER LEVELS IN JDA AND DOW GROUNDWATER MONITORING BORES

JDA Bore	Water Level (m AHD)														
	9/4/08	16/5/08	11/6/08	9/7/08	7/8/08	10/9/08	22/10/08	18/11/08	19/12/08	13/1/09	11/2/09	10/3/09	Min	Max	Difference
D1	19.29	19.20	19.12	19.25	19.40	19.40	19.47	19.51	19.50	19.38	19.31	19.27	19.12	19.51	0.39
D2(s)	18.93	18.86	18.84	19.32	19.33	19.37	19.40	19.33	19.20	19.06	19.04	18.93	18.84	19.40	0.56
D2(d)	18.92	18.86	18.83	19.27	19.30	19.34	19.38	19.31	19.18	19.04	19.02	18.91	18.83	19.38	0.55
D3	N/M	12.80	12.79	12.94	13.18	13.25	13.32	13.32	13.24	13.12	13.02	12.95	12.79	13.32	0.53
D4(s)	16.22	16.72	16.89	17.25	17.43	17.51	17.58	17.47	17.36	17.12	17.22	17.03	16.22	17.58	1.36
D4(d)	15.70	16.42	16.65	17.24	17.56	17.51	17.69	17.56	17.47	16.78	16.50	16.49	15.70	17.69	1.99
D5(s)	10.69	11.81	11.95	12.71	12.82	12.84	12.83	12.50	11.73	11.83	11.37	11.76	10.69	12.84	2.15
D5(d)	10.71	11.81	11.98	12.76	12.87	12.91	12.89	12.55	11.81	11.88	11.43	11.78	10.71	12.91	2.20
D6(s)	11.69	11.75	11.93	12.69	12.56	12.53	12.57	12.27	12.05	11.87	11.87	11.77	11.69	12.69	1.00
D6(d)	11.37	11.83	11.91	12.47	12.60	12.58	12.56	12.25	11.99	11.77	11.24	11.77	11.24	12.60	1.36
D7(s)	10.97	10.96	10.96	11.18	11.42	11.40	11.43	11.22	11.38	10.69	11.16	10.63	10.63	11.43	0.80
D7(d)	10.92	10.94	10.94	11.15	11.33	11.29	11.24	10.84	11.37	10.46	11.14	10.41	10.41	11.37	0.96
D8(s)	12.05	12.57	12.81	13.37	13.55	13.56	13.64	13.15	13.12	12.84	12.78	12.68	12.05	13.64	1.59
D8(d)	12.04	12.58	12.82	13.39	13.56	13.58	13.66	13.15	13.14	12.85	12.79	12.68	12.04	13.66	1.62
D9(s)	11.94	11.78	11.71	11.80	12.14	12.27	12.38	12.39	12.34	12.23	12.12	12.04	11.71	12.39	0.68
D9(d)	11.95	11.79	11.70	11.79	12.12	12.28	12.37	12.38	12.22	12.22	12.11	12.03	11.70	12.38	0.68
D10(s)	11.56	11.40	11.37	11.66	12.03	12.09	12.13	12.06	11.96	11.91	11.76	11.68	11.37	12.13	0.76
D10(d)	11.55	11.41	11.36	11.68	12.03	12.04	12.12	12.06	11.87	11.90	11.75	11.64	11.36	12.12	0.76
DoW Bore															
JE12C	N/M	18.69	N/M	18.70	18.81	18.88	N/M	18.95	18.94	18.91	18.83	18.82	18.69	18.95	0.26
JM41	11.37	11.21	11.27	11.48	11.73	11.78	11.77	11.76	11.78	11.54	11.50	11.40	11.21	11.78	0.57
SP1-2B	N/M	10.99	11.07	11.25	11.39	11.46	11.46	11.38	11.26	11.15	11.19	11.09	10.99	11.46	0.47
JM49	N/M	22.92	22.97	23.42	23.67	23.73	23.81	23.70	23.51	23.37	23.37	23.20	22.92	23.81	0.89
JM42	N/M	20.88	20.86	21.10	21.26	21.27	21.34	21.32	21.19	21.02	20.64	20.81	20.64	21.34	0.70

TABLE 4. APRIL 2008- MARCH 2009 WATER LEVELS IN JDA AND DOW GROUNDWATER MONITORING BORES

JDA Bore	Water Level (m AHD)														
	9/4/08	16/5/08	11/6/08	9/7/08	7/8/08	10/9/08	22/10/08	18/11/08	19/12/08	13/1/09	11/2/09	10/3/09	Min	Max	Difference
D1	19.25	19.25	19.32	19.49	19.88	20.01	20.06	20.04	19.96	19.86	19.75	19.65	19.12	20.06	0.94
D2(s)	18.89	18.89	19.02	19.34	19.86	19.80	19.74	19.67	19.60	19.46	19.33	19.21	18.84	19.86	1.02
D2(d)	18.88	18.88	19.01	19.31	19.81	19.77	19.73	19.64	19.55	19.43	19.30	19.20	18.83	19.81	0.98
D3	12.91	12.88	12.92	13.11	13.96	13.92	13.84	13.69	13.60	13.51	13.38	13.24	12.79	13.96	1.17
D4(s)	17.07	17.01	17.15	17.45	18.01	18.82	17.81	17.75	17.70	17.57	17.28	17.10	16.22	18.82	2.60
D4(d)	16.49	16.79	17.07	17.50	18.10	18.88	17.94	17.85	17.74	17.59	17.12	17.13	15.70	18.88	3.18
D5(s)	11.83	12.00	12.36	12.74	13.09	12.85	12.72	12.63	12.53	12.19	11.91	11.73	10.69	13.09	2.40
D5(d)	11.84	12.02	12.38	12.78	13.13	12.89	12.76	12.67	12.56	12.23	11.95	11.76	10.71	13.13	2.42
D6(s)	11.85	11.85	12.47	12.57	12.78	12.59	12.46	12.45	12.37	12.20	12.08	12.00	11.69	12.78	1.09
D6(d)	11.85	11.92	12.18	12.51	12.85	12.72	12.64	12.59	12.50	12.12	11.96	11.80	11.24	12.85	1.61
D7(s)	11.01	11.02	11.04	11.24	11.94	11.83	11.73	11.67	11.63	11.01	10.91	10.76	10.63	11.94	1.31
D7(d)	10.97	11.00	11.00	11.22	11.59	11.63	11.58	11.59	11.55	10.71	10.80	10.53	10.41	11.63	1.22
D8(s)	12.79	12.89	13.17	13.49	13.79	13.49	13.39	13.40	13.34	13.03	12.13	12.13	12.05	13.79	1.74
D8(d)	12.80	12.89	13.19	13.50	13.80	13.51	13.41	13.41	13.36	13.06	12.14	12.14	12.04	13.80	1.76
D9(s)	11.96	11.89	11.90	12.03	12.43	12.91	12.78	12.59	12.51	12.44	12.34	12.24	11.71	12.91	1.20
D9(d)	11.96	11.89	11.85	12.01	12.42	12.90	12.69	12.58	12.50	12.43	12.33	12.23	11.70	12.90	1.20
D10(s)	11.60	11.53	11.61	11.93	12.38	12.37	12.20	12.13	12.09	12.03	11.95	11.83	11.37	12.38	1.01
D10(d)	11.60	11.52	11.60	11.92	12.37	12.34	12.20	12.13	12.09	12.02	11.95	11.83	11.36	12.37	1.01
DoW Bore															
JE12C	18.78	18.76	18.78	18.88	19.05	19.27	19.43	19.46	19.36	19.34	19.26	19.16	18.69	19.46	0.77
JM41	11.41	11.47	11.47	11.66	N/M	12.05	12.04	12.07	11.98	11.81	11.72	11.57	11.21	12.07	0.86
SP1-2B	11.13	11.12	11.08	11.41	11.75	11.58	11.58	11.56	11.53	11.43	11.30	11.20	10.99	11.75	0.76
JM49	23.19	23.13	23.32	23.61	23.86	23.74	23.75	23.74	23.66	23.55	23.46	23.34	22.92	23.86	0.94
JM42	20.78	20.81	20.90	21.07	21.48	21.49	21.53	21.51	21.45	21.32	21.12	21.06	20.64	21.53	0.89

TABLE 5. GROUNDWATER QUALITY SUMMARY

	Mean (April 2007 to May 2009)								
Bore	**pH**	**EC (mS/cm)**	**TDS (mg/L)**	**TP (mg/L)**	**FRP (mg/L)**	**TN (mg/L)**	**TKN (mg/L)**	**Ammonia-N (mg/L)**	**NO_x –N (mg/L)**
D1	5.43	0.20	112	0.20	0.00	0.91	0.81	0.14	0.11
D2(s)	5.37	0.61	335	1.87	1.59	5.04	3.42	0.53	1.62
D2(d)	5.61	0.47	259	0.05	0.02	1.53	1.49	0.31	0.05
D3	5.72	1.23	676	0.19	0.03	3.60	1.97	0.29	1.65
D4(s)	4.76	1.02	561	3.52	1.66	25.38	7.73	0.20	17.61
D4(d)	6.15	0.46	255	0.14	0.06	1.64	1.15	0.37	0.49
D5(s)	6.97	0.71	392	0.16	0.06	1.25	1.16	0.46	0.09
D5(d)	6.75	0.85	469	0.36	0.04	1.71	1.64	0.34	0.07
D6(s)	6.37	0.96	530	0.89	0.48	5.10	4.81	2.50	0.29
D6(d)	6.50	0.83	458	0.10	0.01	1.58	1.52	0.45	0.05
D7(s)	4.64	2.44	1341	0.06	0.00	9.06	3.96	1.81	5.09
D7(d)	6.56	1.97	1083	0.03	0.00	3.54	3.43	2.60	0.10
D8(s)	6.90	0.54	296	0.52	0.03	1.07	1.03	0.32	0.04
D8(d)	7.23	0.64	354	0.15	0.06	0.96	0.89	0.33	0.08
D9(s)	3.90	0.61	334	0.02	0.00	2.51	1.02	0.29	1.50
D9(d)	5.77	0.72	396	0.01	0.00	1.14	0.88	0.52	0.26
D10(s)	4.95	0.70	387	0.04	0.00	1.59	0.64	0.10	1.28
D10(d)	4.99	0.61	338	0.02	0.00	1.21	0.92	0.51	0.31
Summary of All Bores (2007/2008)									
Mean	5.81	0.87	479	0.57	0.230	3.82	2.14	0.670	1.710
Minimum	2.66	0.08	44	<0.01	<0.005	0.17	0.05	<0.005	<0.005
Maximum	10.20	3.63	1997	31.00	1.660	88.00	57.00	7.100	88.000
Guideline Values									
ANZECC (2000)	6.5	0.12-0.13	-	0.065	0.04	1.2	-	0.08	0.15
Peel WQIP (2008)	-	-	-	0.1	-	1.0	-	-	-

TABLE 6. NUTRIENT CONCENTRATIONS FOR PEEL MAIN DRAIN SITES WHEN FLOWING (APRIL 2007 – MAY 2008)

Surface Water Site	Parameter	4/4/07	24/5/07	27/6/07	1/8/07	30/8/07	18/9/07	11/10/07	7/11/07	18/12/07	15/1/08	12/2/08	11/3/08
PMD1	TDS (mg/L)	-	116	187	242	253	314	292	182	165	171	171	-
	pH	-	6.32	6.12	6.21	6.08	6.87	6.72	6.68	6.51	6.56	6.36	-
	TN (mg/L)	-	0.37	0.92	1.50	1.10	0.85	0.49	0.61	0.01	0.75	0.79	-
	TKN (mg/L)	-	0.37	0.64	1.10	0.90	0.75	0.45	0.61	0.65	0.72	0.79	-
	NO_x-N (mg/L)	-	<.005	0.28	0.38	0.20	0.10	0.04	<0.005	0.01	0.029	<0.005	-
	NH_4-N (mg/L)	-	0.08	0.08	0.14	0.04	0.07	<0.005	0.09	0.05	0.04	0.07	-
	TP (mg/L)	-	0.14	0.05	0.16	0.11	0.06	0.11	0.08	0.13	0.08	0.11	-
	FRP (mg/L)	-	0.13	0.02	0.06	0.07	0.03	0.06	0.04	0.06	0.02	0.08	-
PMD3	TDS (mg/L)	-	-	-	-	-	594	424	-	-	-	-	-
	pH	-	-	-	-	-	6.08	5.48	-	-	-	-	-
	TN (mg/L)	-	-	-	-	-	1.80	1.30	-	-	-	-	-
	TKN (mg/L)	-	-	-	-	-	1.80	1.30	-	-	-	-	-
	NOx-N (mg/L)	-	-	-	-	-	0.01	0.01	-	-	-	-	-
	NH4-N (mg/L)	-	-	-	-	-	0.05	<0.005	-	-	-	-	-
	TP (mg/L)	-	-	-	-	-	0.15	0.12	-	-	-	-	-
	FRP (mg/L)	-	-	-	-	-	0.09	0.06	-	-	-	-	-

TABLE 7. NUTRIENT CONCENTRATIONS FOR PEEL MAIN DRAIN SITES WHEN FLOWING (APRIL 2008 – MAY 2009)

Surface Water Site	Parameter	9/4/08	16/5/08	11/6/08	9/7/08	7/8/08	10/9/08	22/10/08	18/11/08	19/12/08	13/1/09	11/2/09	10/3/09	Min	Max	Mean	Median
PMD1	TDS (mg/L)	143	149	270	215	594	264	176	138	154	154	165	176	116	594	218	179
	pH	5.97	5.93	6.1	6.3	6.45	6.02	5.93	6.21	6.1	5.48	6.32	6.85	5.48	6.87	6.27	6.21
	TN (mg/L)	0.62	1.2	2.1	0.26	1.9	0.89	0.97	0.65	0.83	1.4	<0.05	2.6	<0.05	2.6	1.02	0.85
	TKN (mg/L)	0.61	0.98	1.9	0.61	1.5	0.61	0.88	0.56	0.72	1.3	<0.05	2.6	<0.05	2.6	0.92	0.72
	NO_x-N (mg/L)	0.011	0.18	0.17	0.3	0.37	0.29	0.97	0.087	0.11	0.083	<0.005	0.017	<0.005	0.97	0.19	0.11
	NH_4-N (mg/L)	<0.005	0.016	0.081	0.055	0.013	<0.005	0.12	0.055	0.05	0.26	0.066	0.027	<0.005	0.26	0.06	0.055
	TP (mg/L)	0.12	0.19	0.07	0.08	0.18	0.16	0.16	0.1	0.06	0.13	0.09	0.4	0.05	0.4	0.13	0.11
	FRP (mg/L)	0.057	0.042	0.033	0.040	0.150	0.080	0.130	0.063	0.059	0.019	0.026	0.021	0.017	0.15	0.06	0.057
PMD3	TDS (mg/L)	-	-	-	-	484	-	369	-	-	-	-	-	369	594	468	454
	pH	-	-	-	-	5.93	-	5.45	-	-	-	-	-	5.45	6.08	5.74	5.71
	TN (mg/L)	-	-	-	-	2.9	-	2.9	-	-	-	-	-	1.30	2.9	2.23	2.35
	TKN (mg/L)	-	-	-	-	2.8	-	2.9	-	-	-	-	-	1.30	2.9	2.90	2.3
	NOx-N (mg/L)	-	-	-	-	0.072	-	2.9	-	-	-	-	-	<0.005	2.9	0.75	0.041
	NH4-N (mg/L)	-	-	-	-	<0.005	-	0.019	-	-	-	-	-	<0.005	0.047	0.02	0.010
	TP (mg/L)	-	-	-	-	0.12	-	0.76	-	-	-	-	-	0.12	0.76	0.29	0.135
	FRP (mg/L)	-	-	-	-	0.092	-	0.39	-	-	-	-	-	0.03	0.39	0.16	0.092

4.2 Groundwater Quality

Water quality results for the sampling in the JDA Bores, D1-D10, are shown in Figures 4 to 11. Box plots showing the statistical minimum, maximum, median, and 25th and 75th percentiles of the levels of nutrient concentrations in each bore are displayed in Figures 12 to 17. Average values for the monitoring period are presented in Table 5. Some results of interest include;

- The TDS in the bores is generally below 900 mg/L. Bores D7(s), D7(d) and D4(s) are the exception showing higher salinities (Figure 4).
- The lowest pH was 2.66, recorded at bore D9(s) on 11 October 2007, the highest 10.2 recorded at D7(d) on 27 June 2007 (Figure 5). Out of the 18 bores, the pH values of 11 bores were generally below 7.
- Thirteen of the 18 bores exceeded the EPA Interim target for TP of 0.2 mg/L for the Serpentine River. Extremely elevated levels of TP were evident in bore D4(s) and bores D2(s), D5(d), D6(s) and D8(s) had maximum levels of TP in the 1.7 mg/L to 2.5 mg/L range.
- The mean Filterable Reactive Phosphorus (FRP) levels were generally below 0.06 mg/L with the exception of bores D4(s) and D2(s), reaching FRP levels of 2.8 mg/L and 2.0 mg/L, respectively (Table 5, Figure 11).The Filterable Reactive Phosphorus (FRP) concentrations generally represent a low proportion of the Total Phosphorus.
- The average Total Nitrogen (TN) levels vary significantly between bores indicating local affects from different land uses (Figure 6 and Figure 12). Total Nitrogen (TN) mean values range from 0.91 to 25.38 mg/L (Table 5) and median concentrations range from 0.88 to 13 mg/L (Figure 12).
- Total Nitrogen levels at D4 (s) (maximum 88 mg/L) and D7(s) (maximum 50 mg/L) are extremely high (Figure 6). Bore D2(s) also shows a very high TN reading on 30 August 2007 (Figure 6). These bores are all located on land used for market gardening.
- The mean NO_x-N levels range from 0.06 to 17.61 mg/L (Table 5) and median values are from 0.02 to 8.75 mg/L. The significant variation is consistent with the results for Total Nitrogen.
- Bores D6(s), D7(s) and D7(d) had high levels of Ammonium-N. There were levels of Ammonium-N reaching 2.3 mg/L at D10(d). All other bores had Ammonium-N levels below 1.5mg/L (Figure 9). Ammonium-N mean concentrations range from 0.11 to 2.60 mg/L (Table 5).

4.3 Surface Water Flow

Peel Main Drain Flow Estimates

- Site PMD2 remained either dry or stagnant during the monitoring program to date (Table 8), so no flow estimates or nutrient samples were taken for this site.
- Drain site PMD1 flowed for 22 out of the 24 month sampling period, from May 2007 to March 2009. Drain site PMD3 only flowed after the winter months: September and October 2007, and August and October 2008.

4.4 Surface Water Quality

A summary of the results of water quality for the surface drains is presented in Tables 6 and 7. The results show the following;

- The pH is slightly acidic, consistent with most of the groundwater sampling locations.
- The mean TP concentrations range from 0.13 to 0.29 mg/L. The median TP concentration for PMD1 and PMD3 are below the WQIP phosphorus interim target for the Serpentine River of 0.2 mg/L.
- The mean TN concentrations are elevated, consistent with the groundwater sampling locations and the existing agricultural land use.
- There was similar seasonal variation in water quality shown by the monitoring bores and at site PMD1. However, lower levels of the nitrogen were measured at PMD1 compared to groundwater bores.
- The water quality results are representative of base-flow conditions. The drains may have a greater flow rate following rainfall events.

Peel Main Drain Flow Volumes

- Surface water flows at site PMD1 were reliable and flow volumes can be produced over the monitoring period (Table 9). There was an annual average flow volume of 74,313 m^3/year seen at site PMD1.
- Recorded water levels at surface water site PMD3 were variable. Only one significant period where the water level was above the cease to flow level was recorded. This period was from the 30th July 2008 to 19th August 2008, with a flow estimate of 46 L/s recorded by JDA on the 7th August 2008. As this site has only one significant flow rate (7/08/08), a reliable discharge rating curve could not be produced.
- Surface water site PMD2 flows were also variable. Monitoring results indicate the water level at PMD2 is largely controlled by the downstream backwater flows than from the upstream flows. Approximately 700 metres downstream of PMD2 is a surface water drain that joins into the Peal Main Drain. At this merging site is a water level controlling drop structure. As such, it is difficult to distinguish the flow regime at this site as there will be periods where the water level at this site is dominated by upstream and downstream flows. A reliable discharge rating curve could not be produced for this site.

A summary of the results of surface water flow for the surface drains is summarised in Tables 8 and 9.

TABLE 8. APRIL 2008- MARCH 2009 SURFACE WATER FLOW RATES

Flow Rates (L/s)	Surface Water Sites		
	PMD1	PMD2	PMD3
4/04/2007	N/M	N/M	N/M
24/05/2007	10.0	NQ	Dry
27/06/2007	20.0	NQ	Dry
1/08/2007	30.0	NQ	Dry
30/08/2007	20.0	NQ	Dry
18/09/2007	20.0	NQ	3.0
11/10/2007	5.0	NQ	5.0
7/11/2007	3.0	NQ	Dry
18/12/2007	1.0	NQ	Dry
15/01/2008	1.0	NQ	Dry
12/02/2008	0.01	NQ	Dry
11/03/2008	Stagnant	NQ	Dry
9/04/2008	3.0	NQ	Dry
16/05/2008	3.0	NQ	Dry
11/06/2008	20.0	NQ	Dry
9/07/2008	10.0	NQ	Dry
7/08/2008	52.0	NQ	46.0
10/09/2008	12.0	NQ	No Flow
22/10/2008	8.0	NQ	<1.0
18/11/2008	6.0	NQ	Dry
19/12/2008	6.0	NQ	Dry
13/01/2009	3.0	NQ	Dry
11/02/2009	1.0	NQ	Dry
10/03/2009	1.5	Dry	Dry
Min	**Stagnant**	**Dry**	**Dry**
Max	**52.0**	**Stagnant**	**46.0**

Note: NQ = No quantifiable flow due to the downstream water level controls in the Peel Main Drain.

TABLE 9. APRIL 2008- OCTOBER 2009 MONTHLY FLOW VOLUMES (m^3/MONTH)

Flow (m^3 / month)	Surface Water Sites		
	PMD1	PMD2	PMD3
Apr-07	N/A	No quantifiable flow due to the downstream water level controls in the Peel Main Drain	No Flow
May-07	6		
Jun-07	21		
Jul-07	2,180		
Aug-07	30,000		
Sep-07	40,050		Small flow, but not gauged
Oct-07	22,800		
Nov-07	160		No Flow
Dec-07	130		
Jan-08	8		
Feb-08	16		
Mar-08	19		
TOTAL	**95,390**	**N/A**	**N/A**
Apr-08	25	No quantifiable flow due to the downstream water level controls in the Peel Main Drain	No Flow
May-08	30		
Jun-08	54		
Jul-08	18,050		
Aug-08	12,850		Flowed, but not gauged
Sep-08	2,180		No Flow
Oct-08	1,170		
Nov-08	1,240		
Dec-08	48		
Jan-09	37		
Feb-09	64		
Mar-09	123		
TOTAL	**35,871**	**N/A**	**N/A**
Apr-09	275	No quantifiable flow due to the downstream water level controls in the Peel Main Drain	No Flow
May-09	640		
Jun-09	5,100		
Jul-09	21,300		
Aug-09	N/A		
Sep-09	30,600		
Oct-09	2,800		
TOTAL	**60,715**	**N/A**	**N/A**
AVERAGE TOTAL	**74,313**	**N/A**	**N/A**

5. CONCLUSIONS

- The Study Area is currently undeveloped and used for semi-rural purposes including grazing and horticulture.
- Eight pairs of groundwater monitoring bores and two single groundwater bores were installed to measure temporal, spatial and vertical nutrient concentrations. The data presented in this report is for the two years of pre-development monitoring consistent with the monitoring program agreed with by the DoW including groundwater and surface water analysis.
- The seasonal variation in groundwater levels measured over the monitoring period range from 0.94 to 3.18 m.
- Base-flow in Peel Main drain occurred over the winter period at sites PMD1, PMD2 & PMD3. Base-flow at PMD1 is continuous over 10 to 12 months of the year.
- The median TP concentration for PMD1 and PMD3 are below the WQIP interim phosphorus target for the Serpentine River of 0.2 mg/L.
- There was a large range in the pH of the groundwater from 2.66 (D9(s)) to 10.2 (D7(d)). Most water samples were acidic with the exception of bores D7(d), D5(d), D5(s), D8(s) and D8 (d), which had pH>7 for part or all of the 24 month monitoring period.
- The median Total Phosphorus (TP) concentration in the groundwater bores ranged between 0.01 to 2.4 mg/L for bores D1 to D10. Fourteen of the eighteen bores recorded TP values above the EPA Interim Target for the Serpentine River (0.2 mg/L). Bore D4(s) had a maximum TP concentration of 31 mg/L which is extremely high.
- TN values in the groundwater at sites D4(s) and D7(s) during both years of reporting are extremely high. As land use changes in the future from annual horticulture to urban, Nitrogen concentrations in the groundwater should decrease.
- The volume of water exiting the study area via the Peel Main Drain averaged 74,313m^3 per annum.

6. REFERENCES

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Western Australian Planning Commission (2007) *Jandakot Structure Plan.*

FIGURES

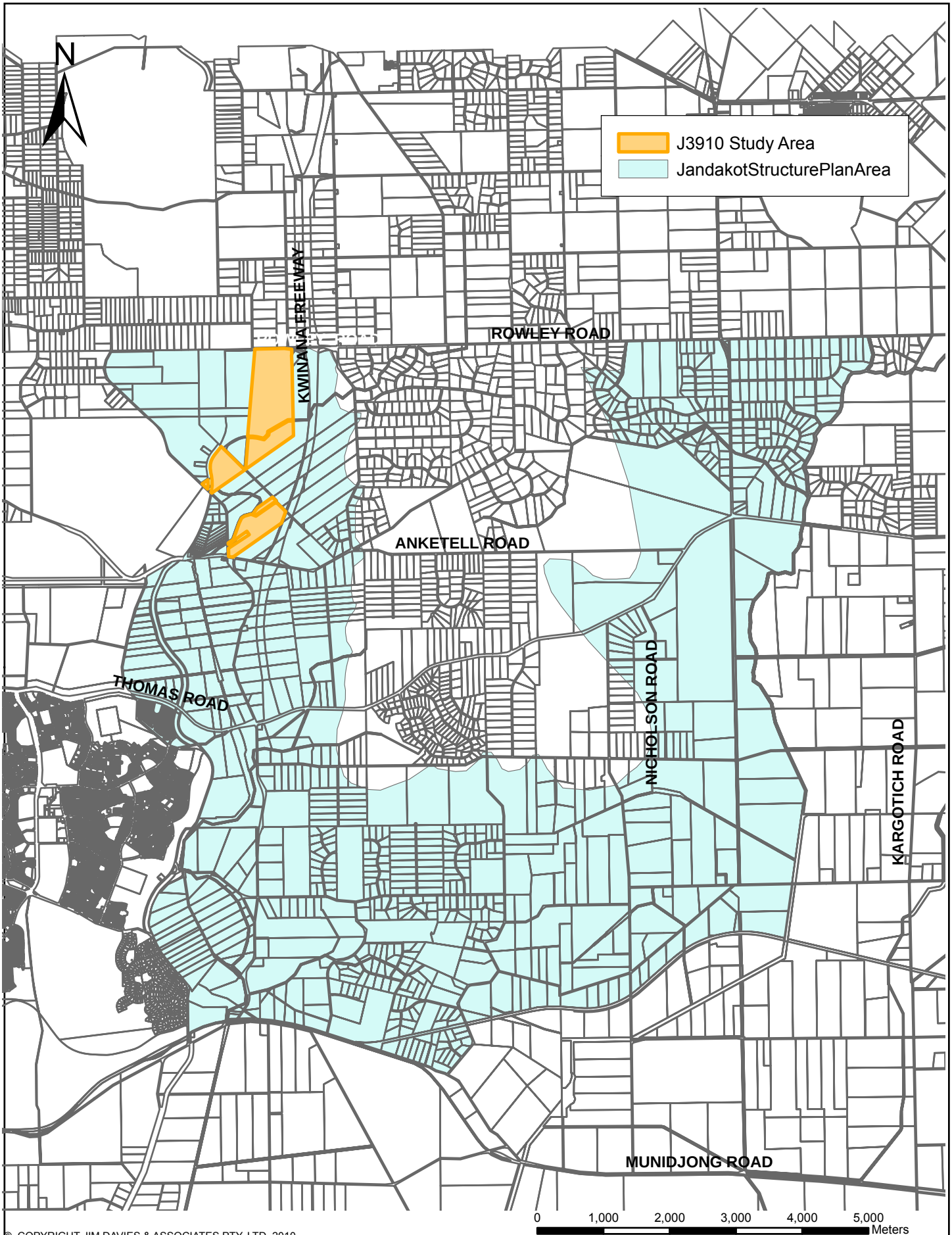

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Figure 1: Location Plan

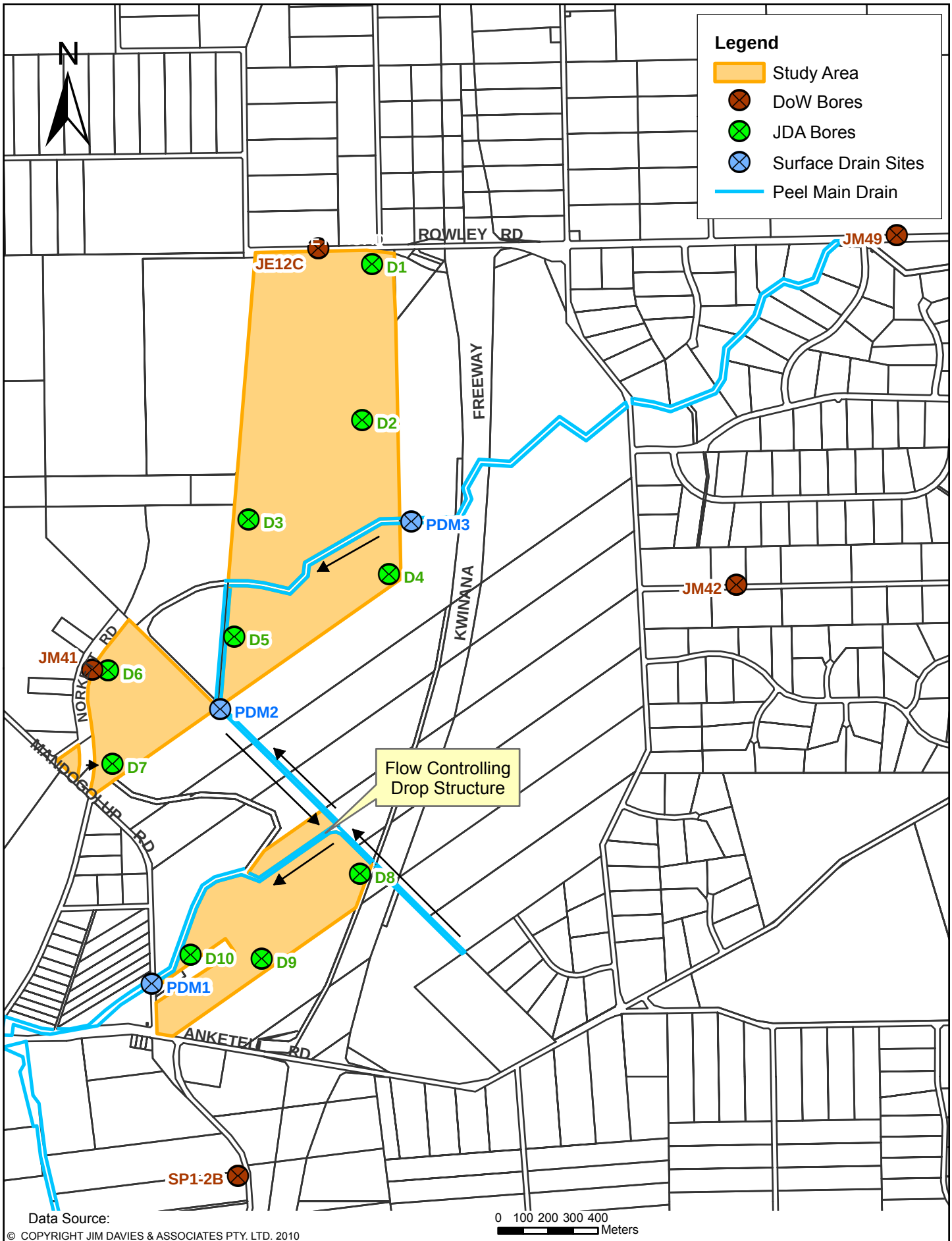

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Figure 2: Monitoring Site Location Plan

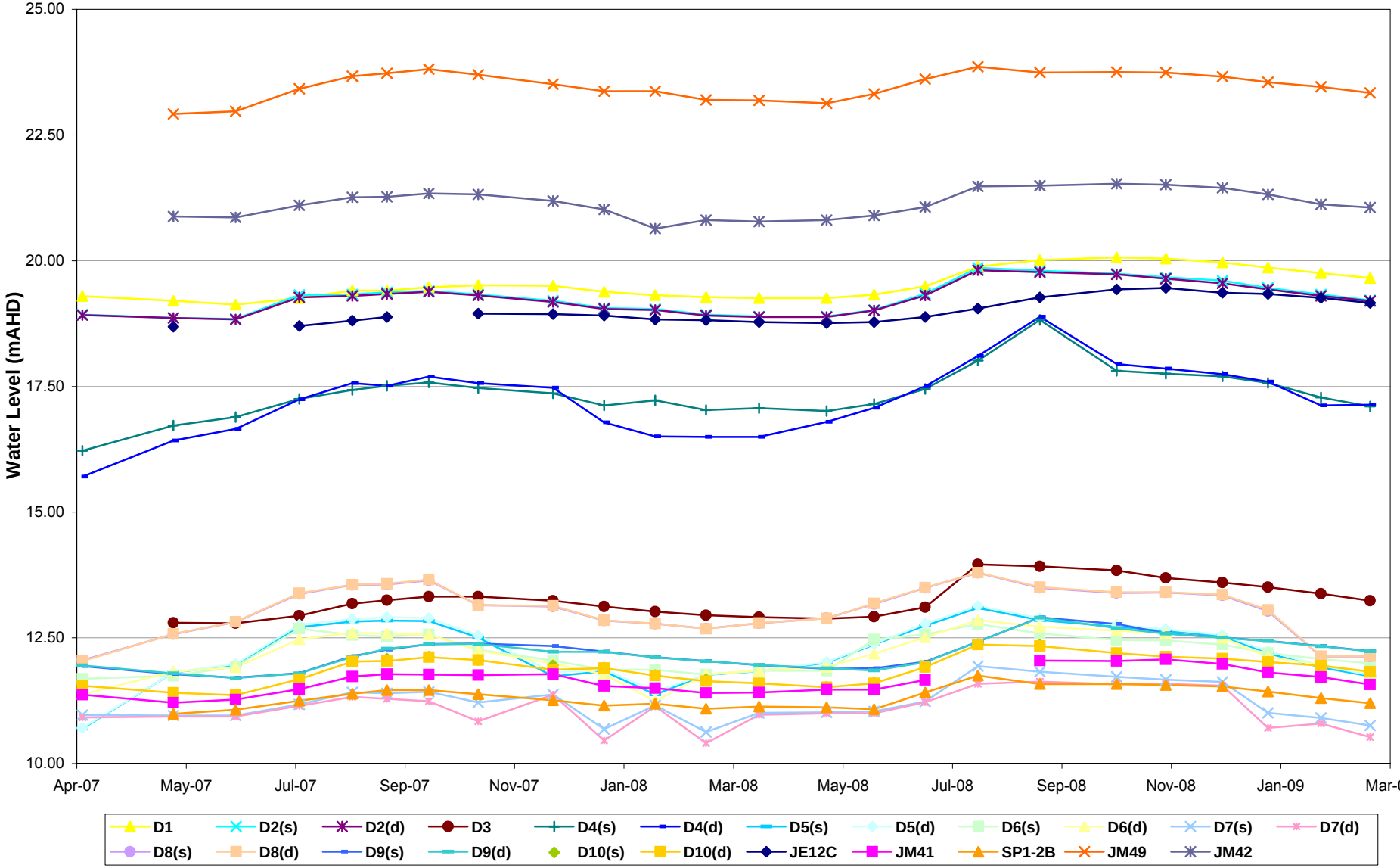

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Figure 3: Water Levels of JDA and DoW Groundwater Monitoring Bores

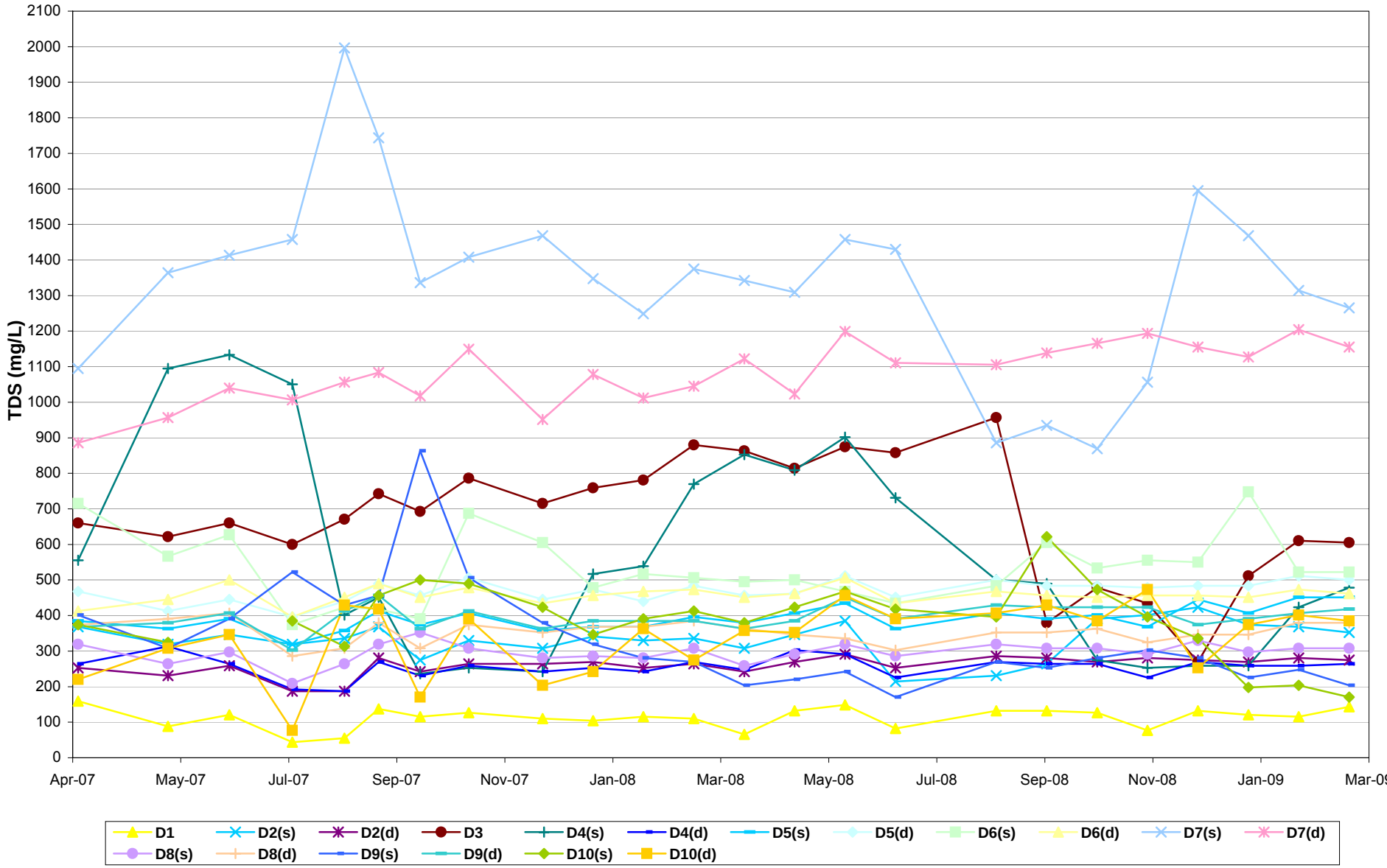

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Figure 4: Total Dissolved Salts in JDA Monitoring Bores

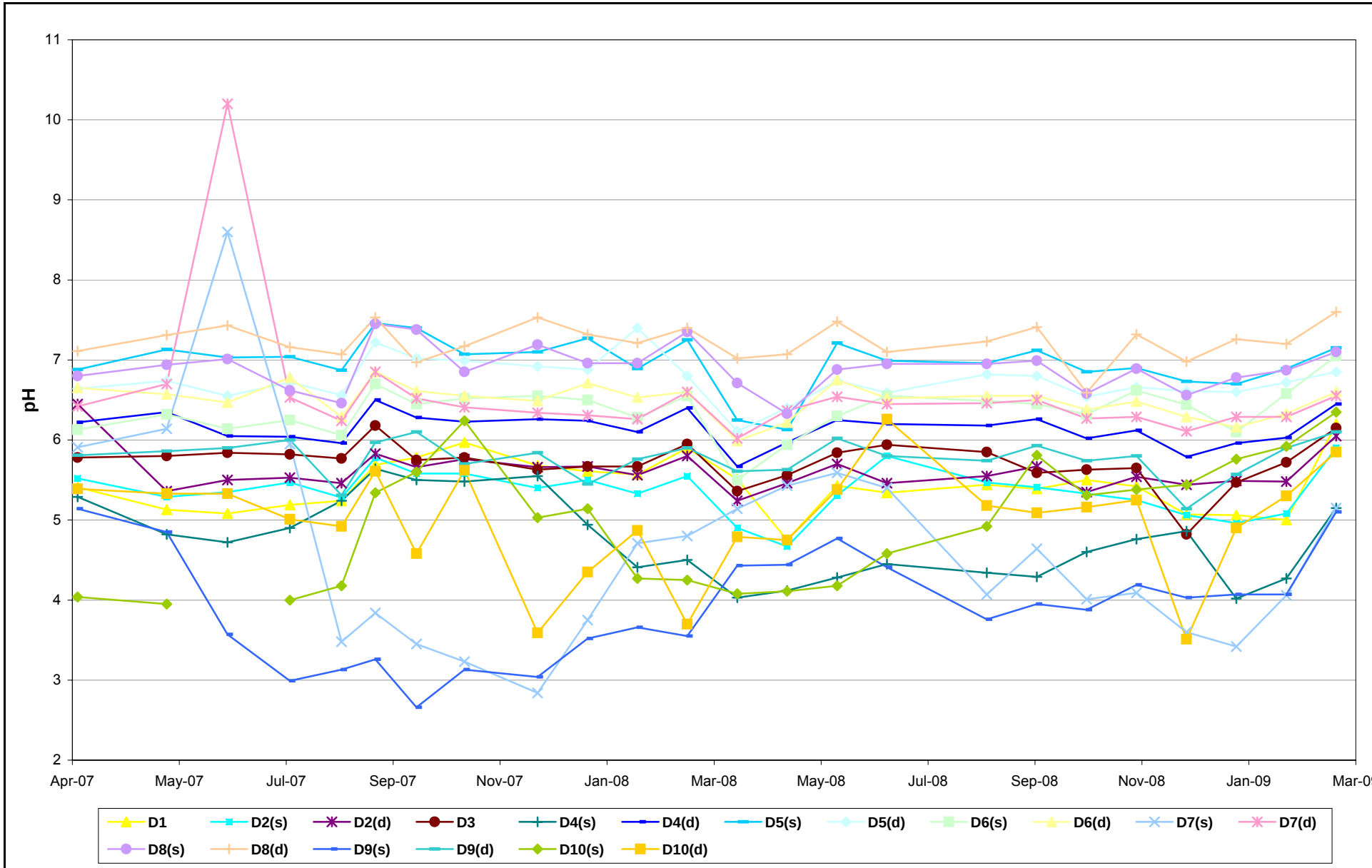

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Figure 5: pH of JDA Monitoring Bores

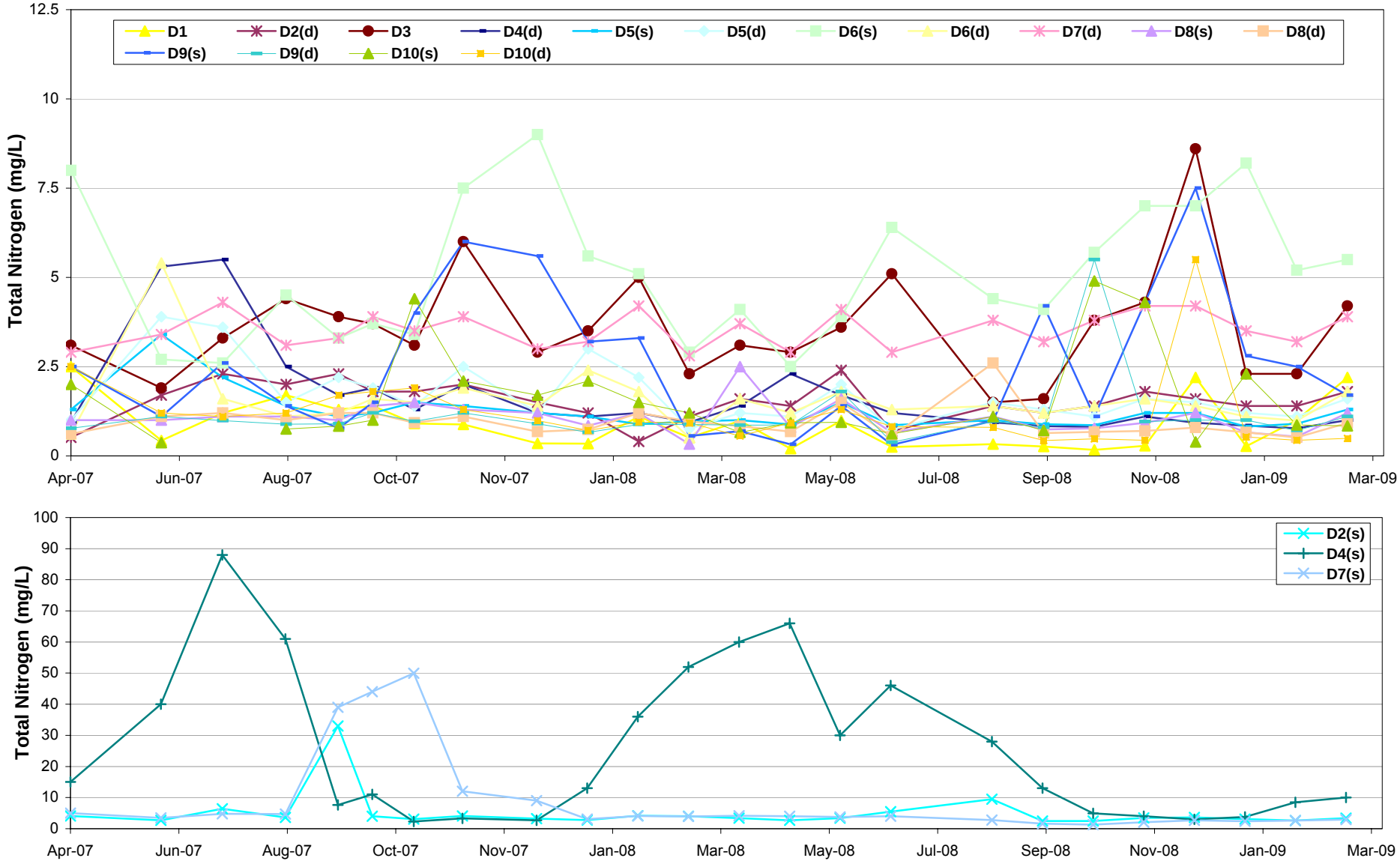

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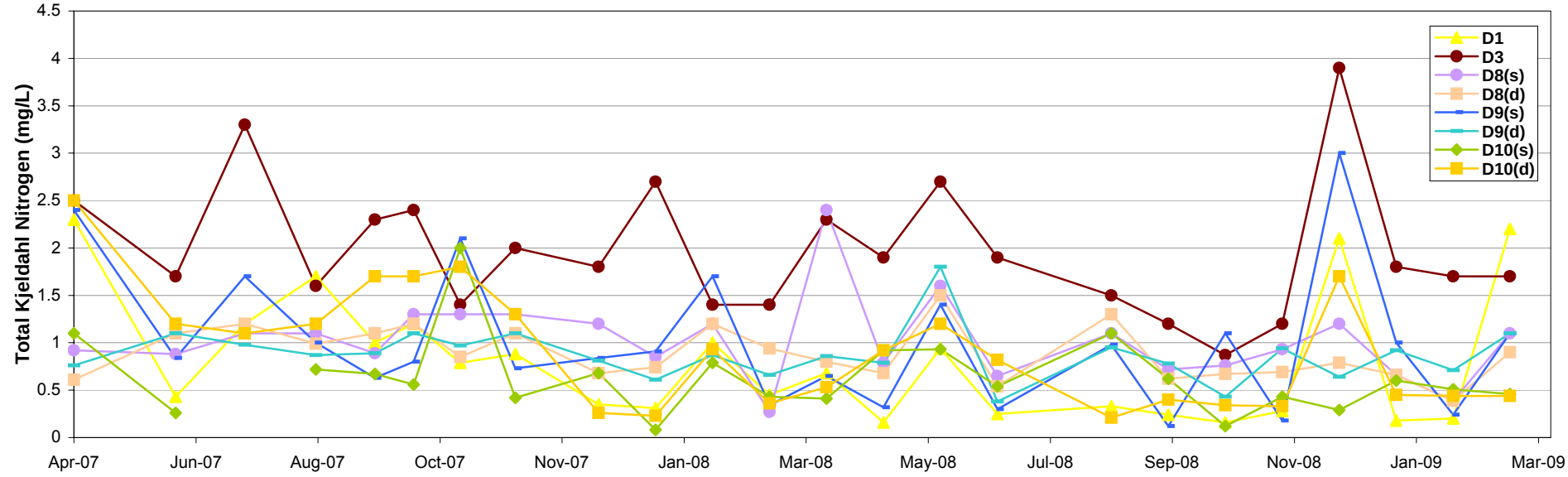
Figure 6: Total Nitrogen of JDA Monitoring Bores



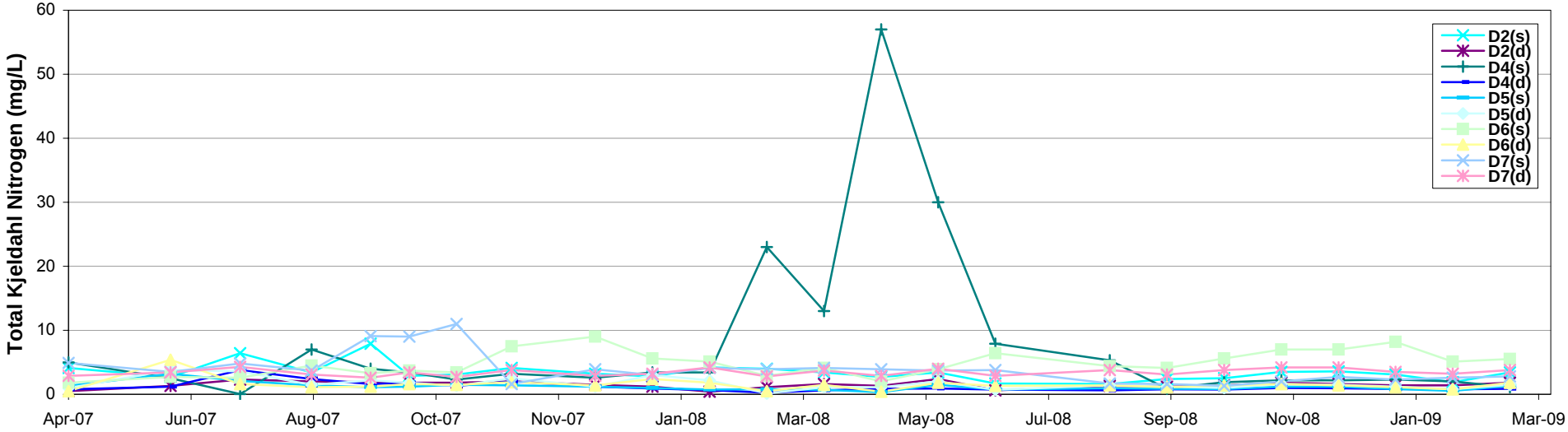


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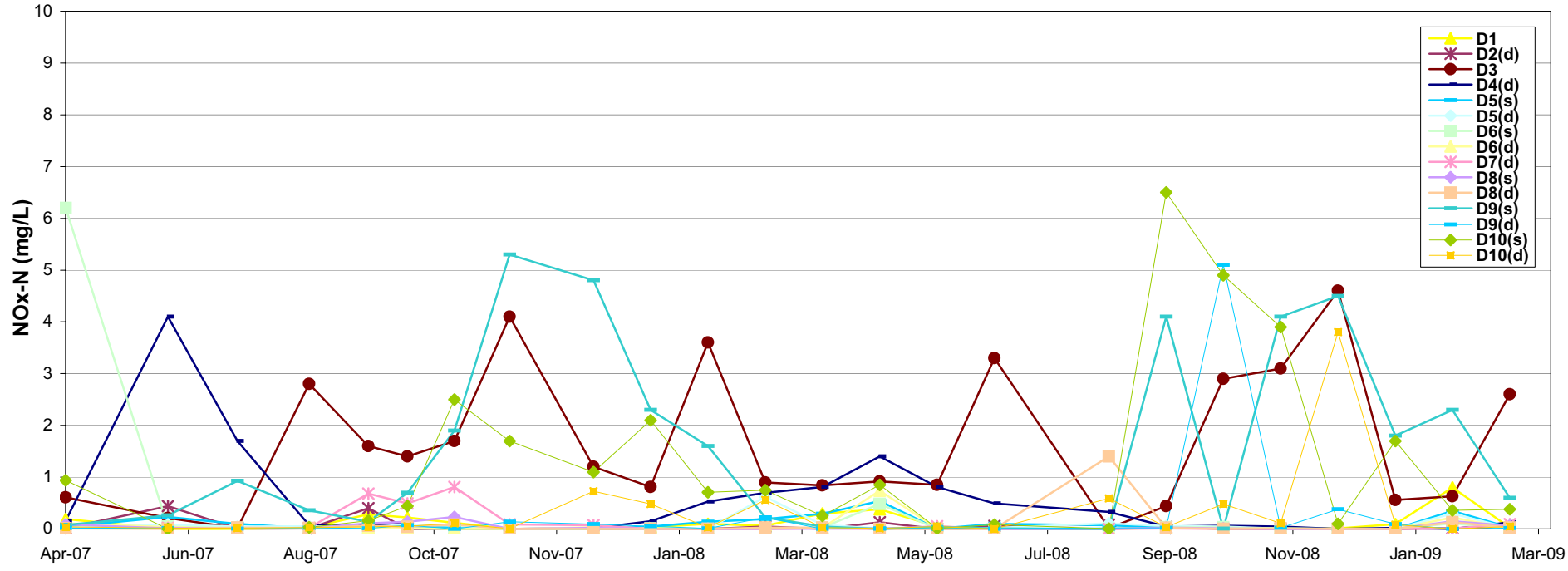
Figure 7: Total Kjeldahl Nitrogen for JDA Bores



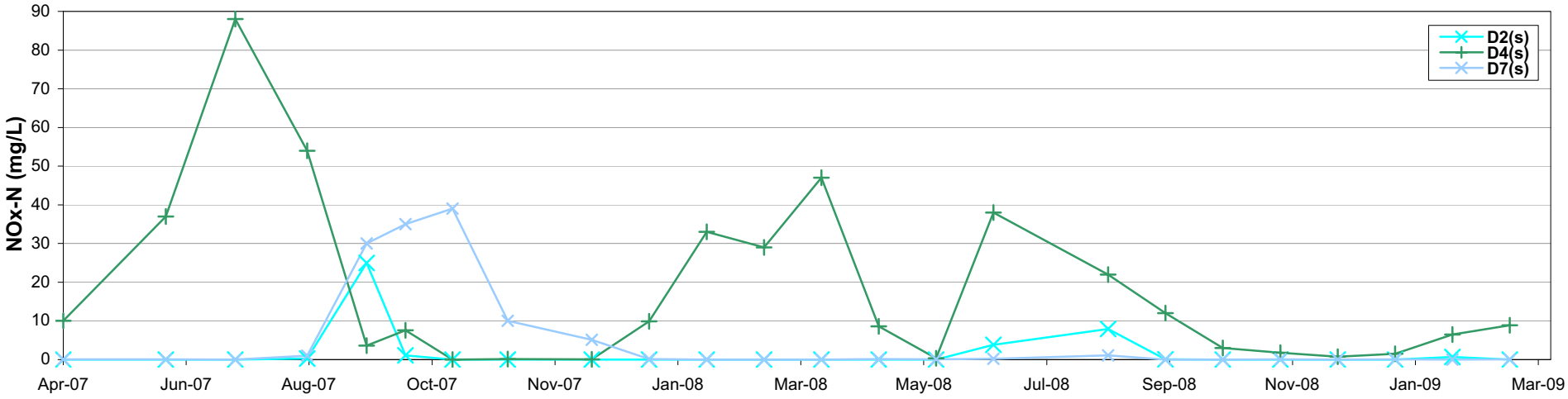


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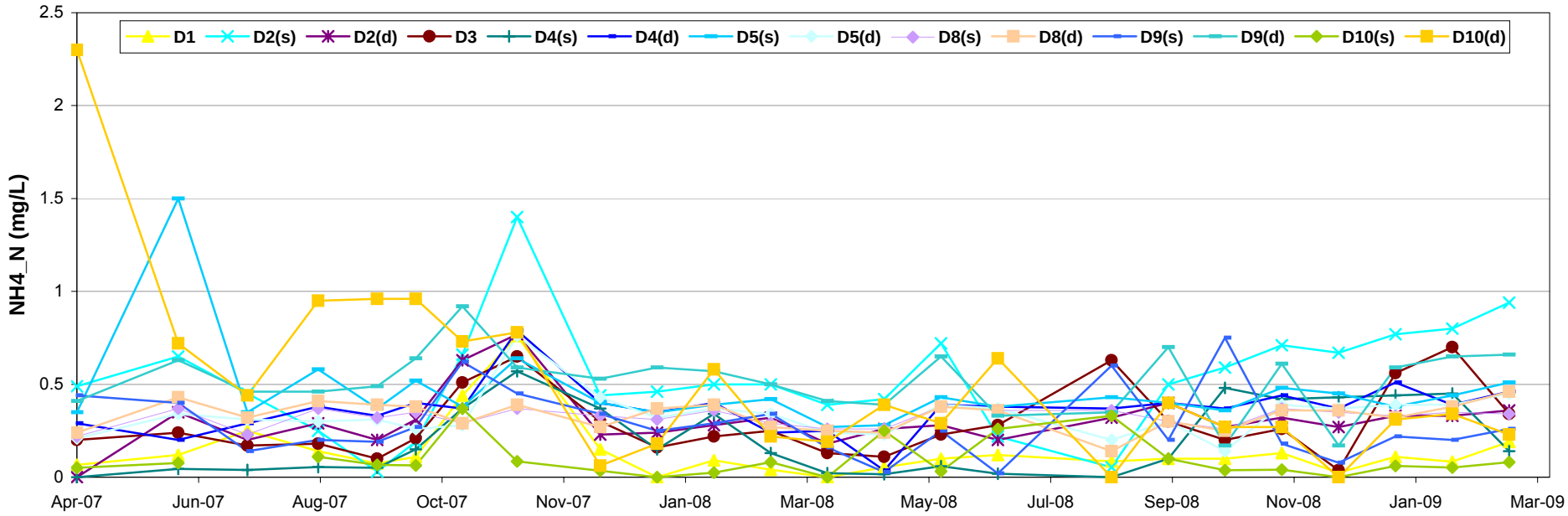
Figure 8: NOx_N for JDA Monitoring Bores



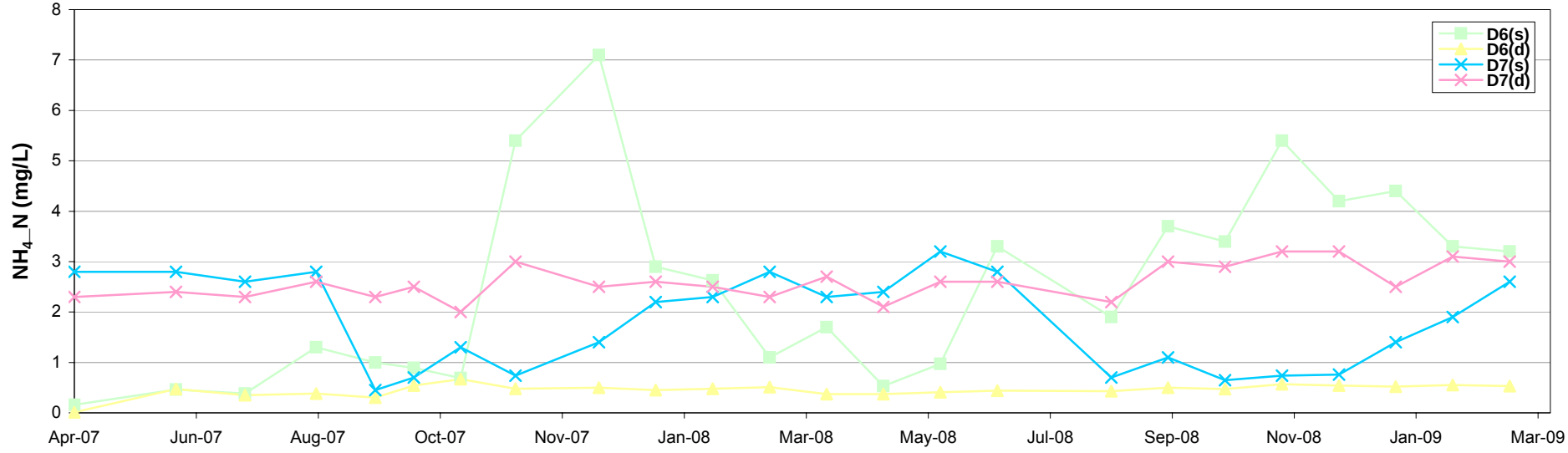


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Figure 9: Ammonium Nitrogen for JDA Monitoring Bores.

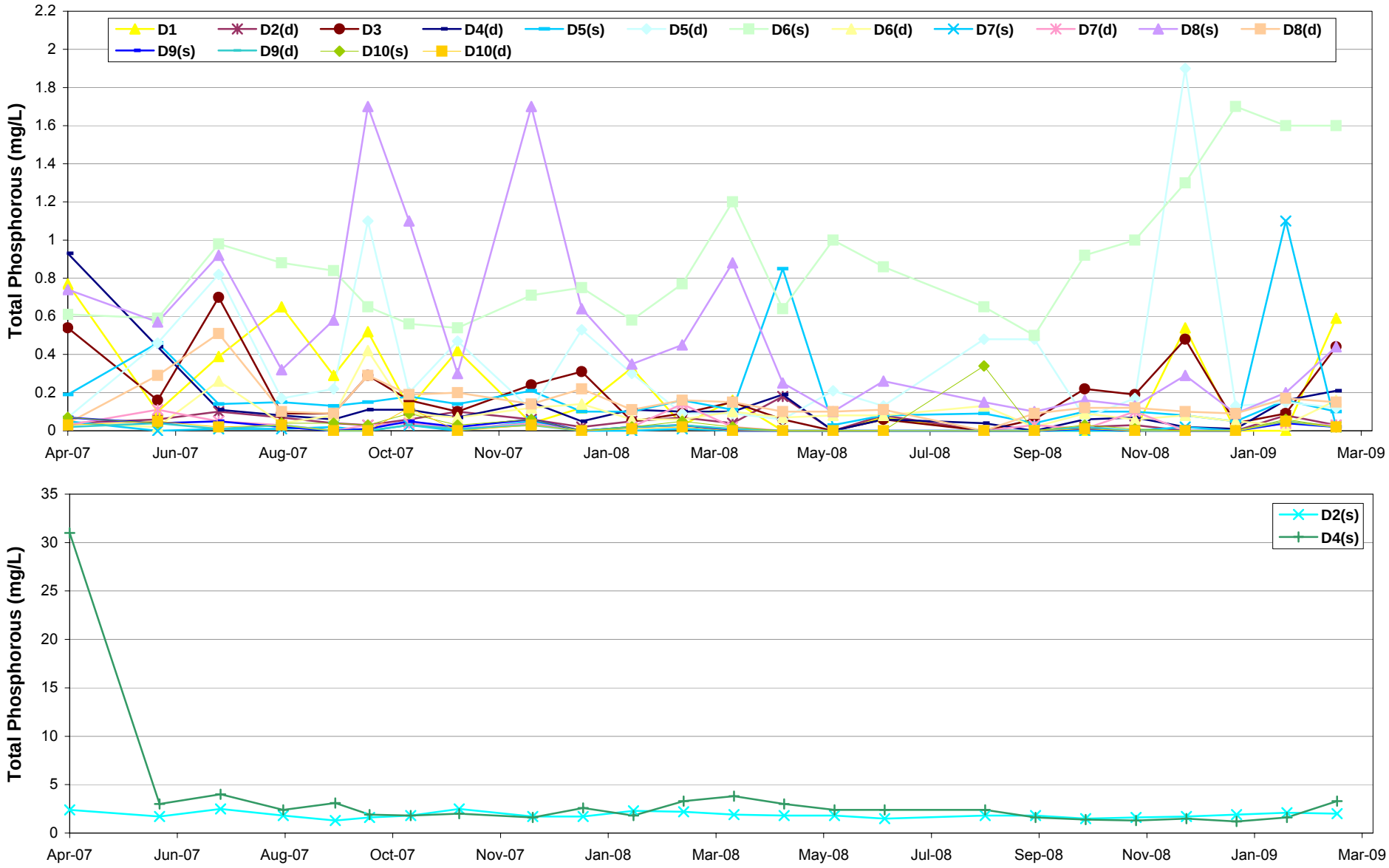

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Figure 10: Total Phosphorous for JDA Monitoring Bores

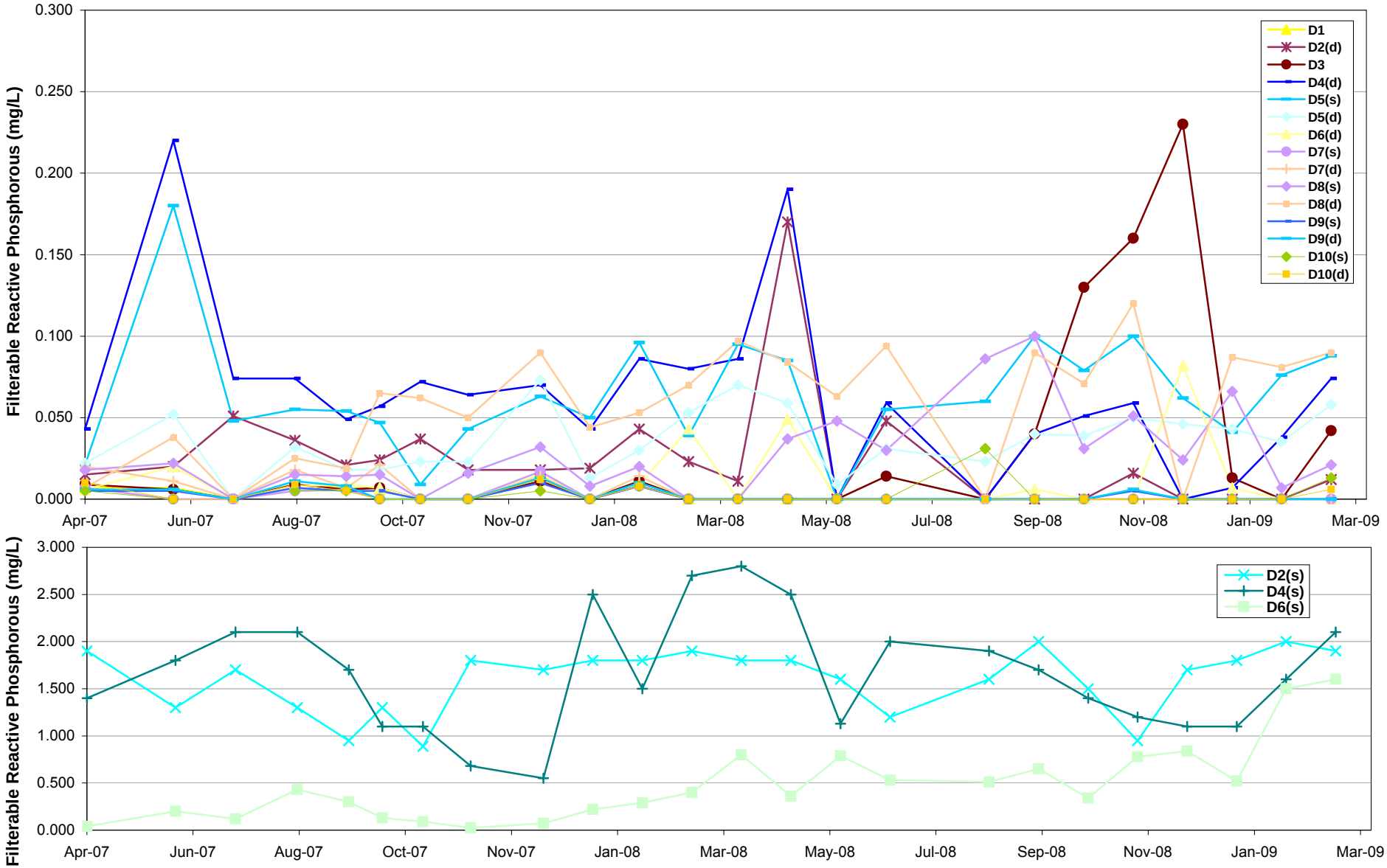

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Figure 11: Filterable Reactive Phosphorous for JDA Monitoring Bores

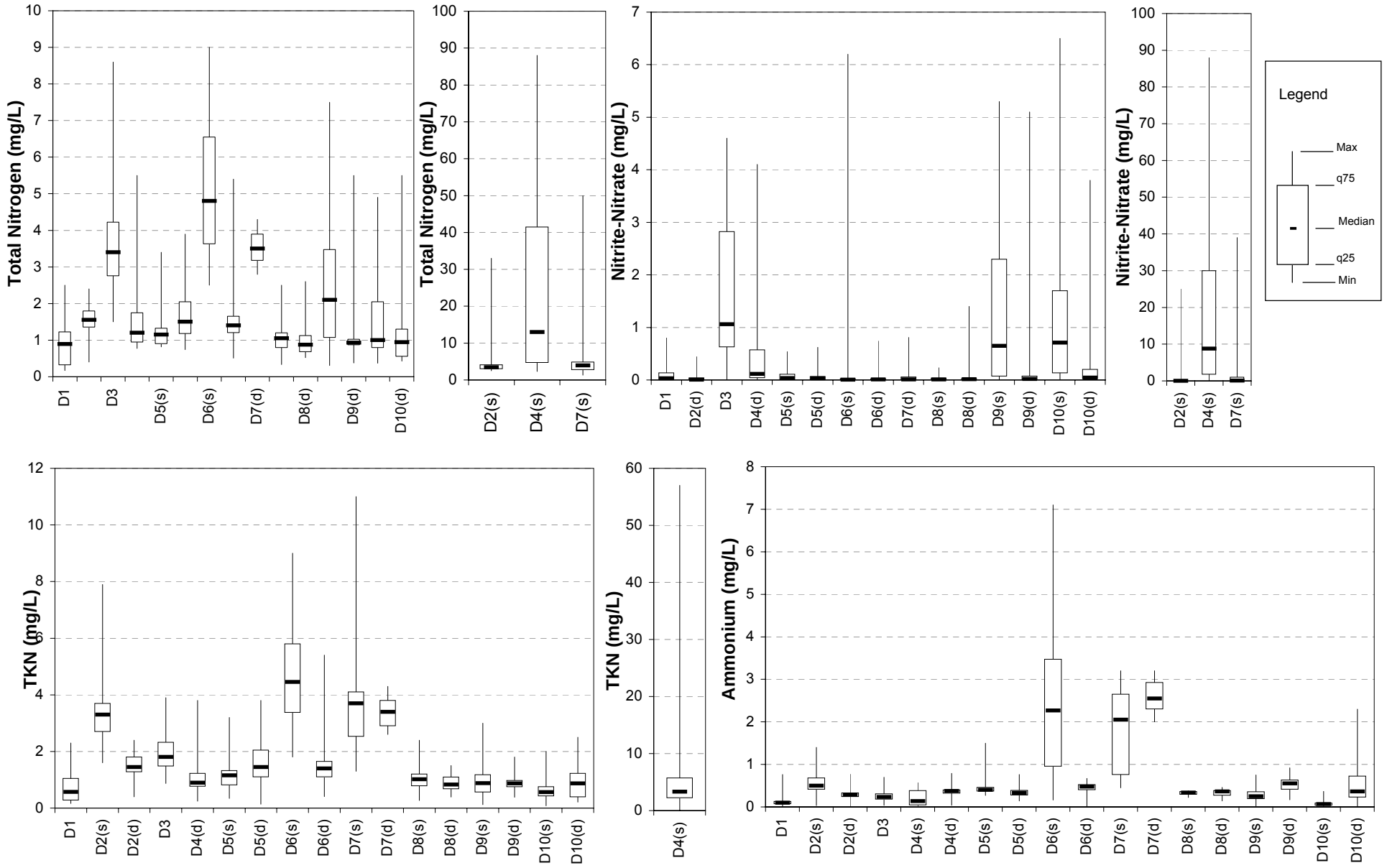

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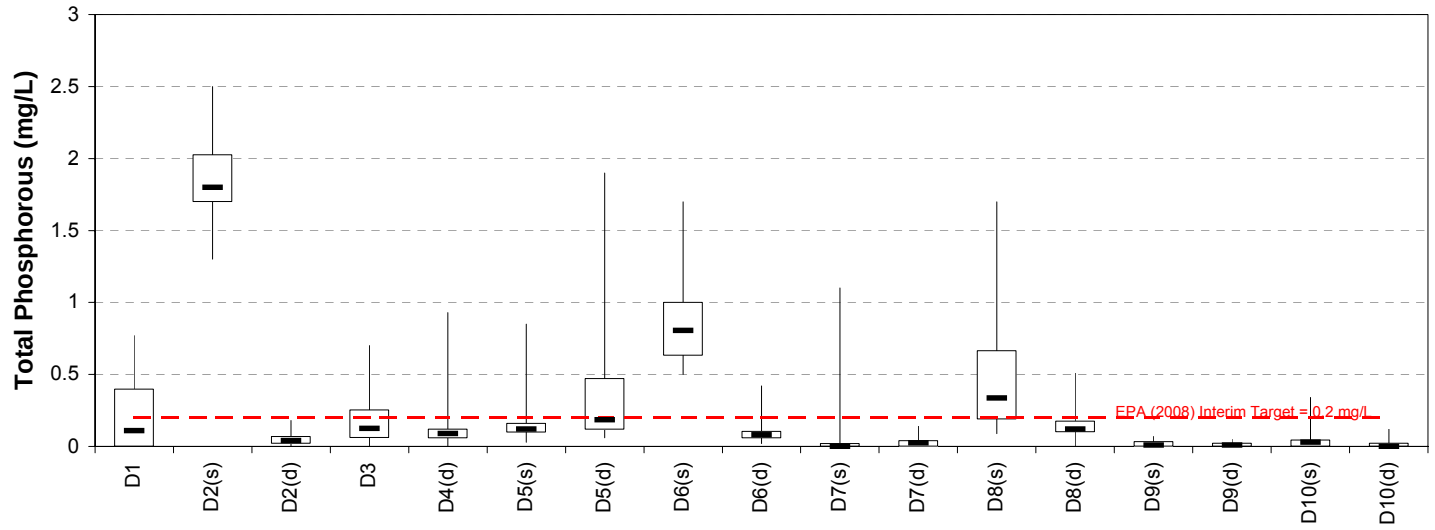
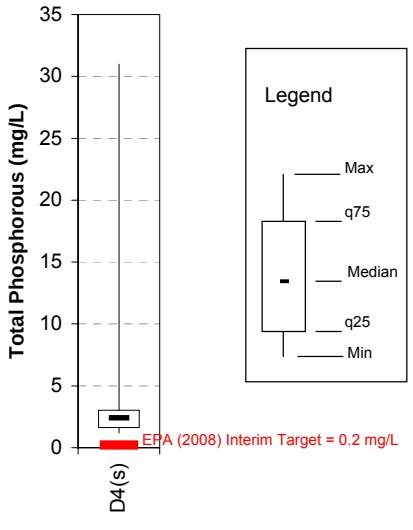
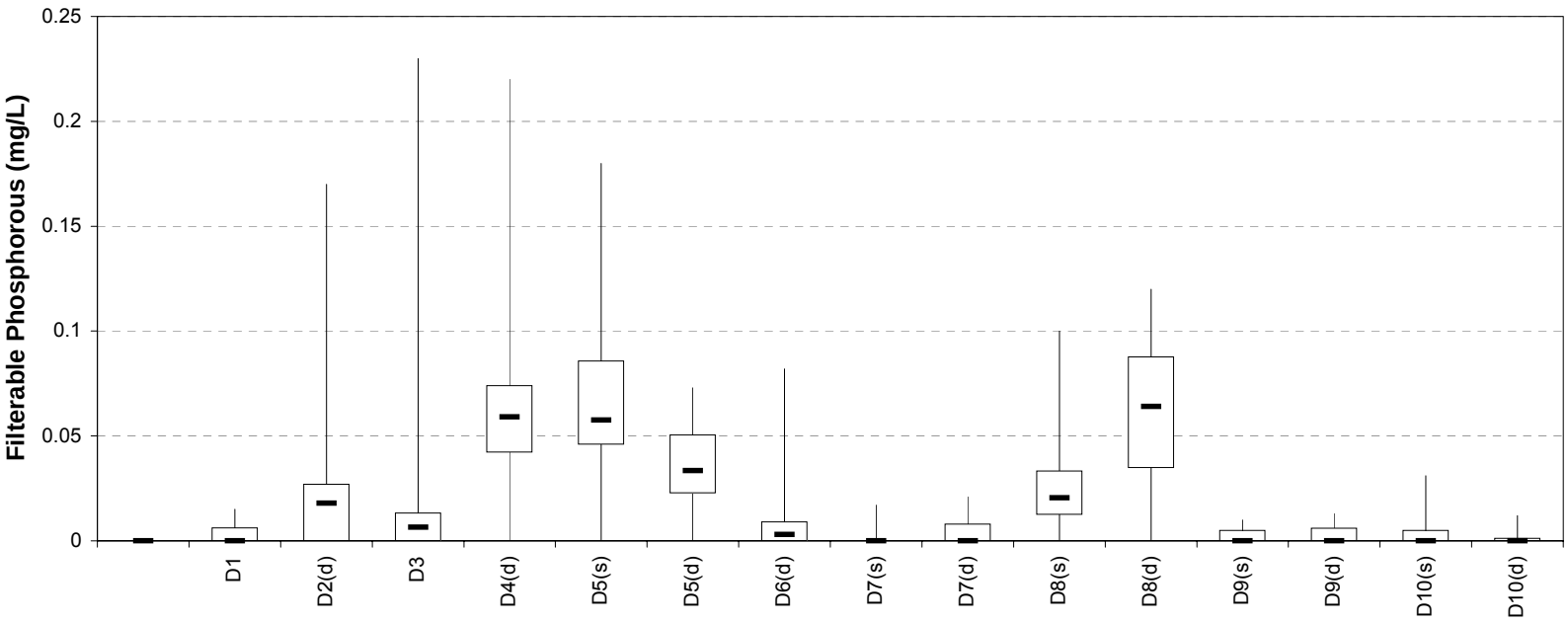
Figure 12: Nitrogen Statistics for JDA Bores







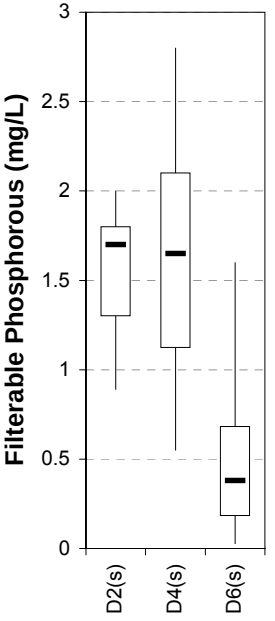


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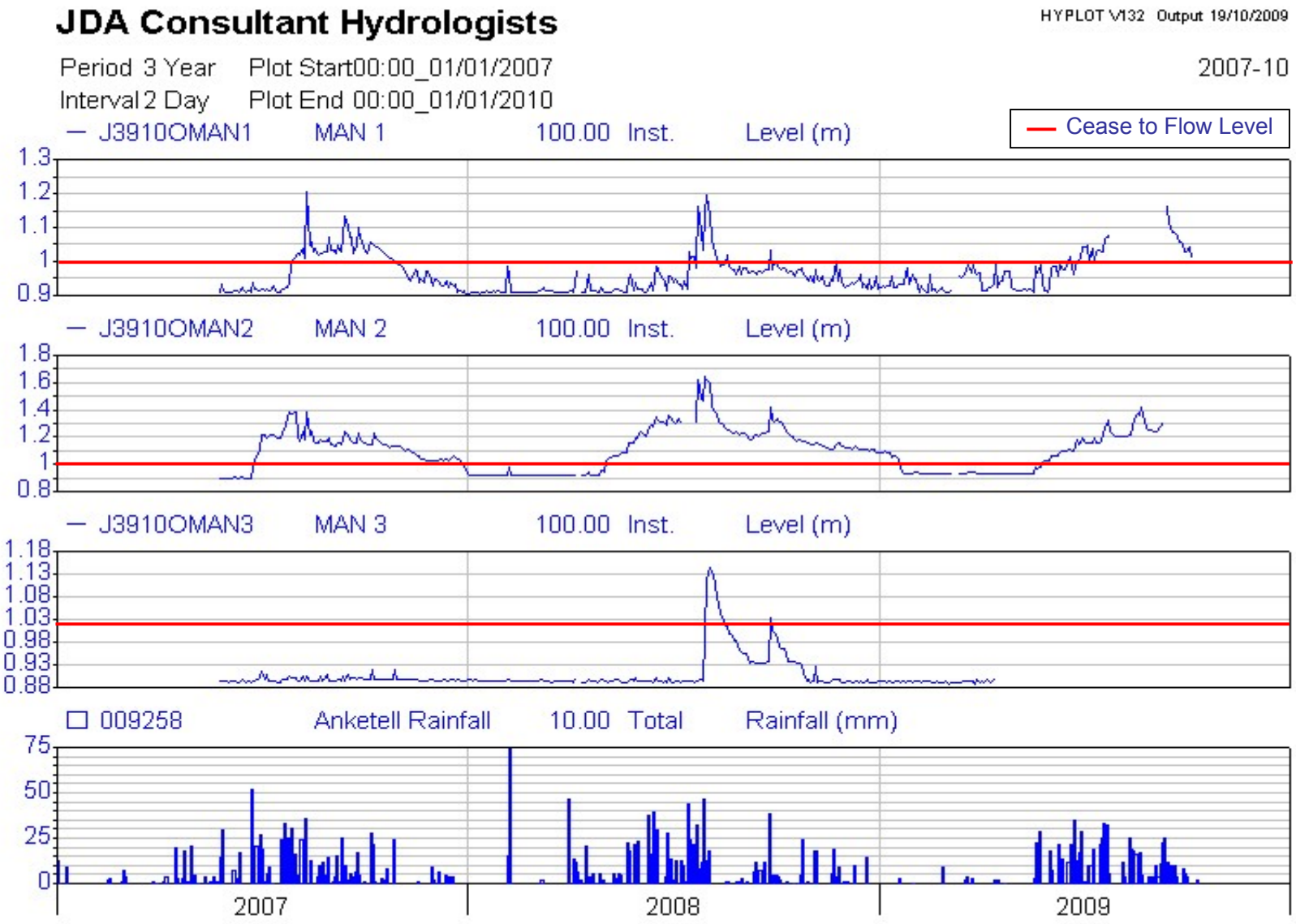
Figure 13: Phosphorous Statistics for JDA Bores



Data Source: Rainfall from BoM site 009258 (2009)

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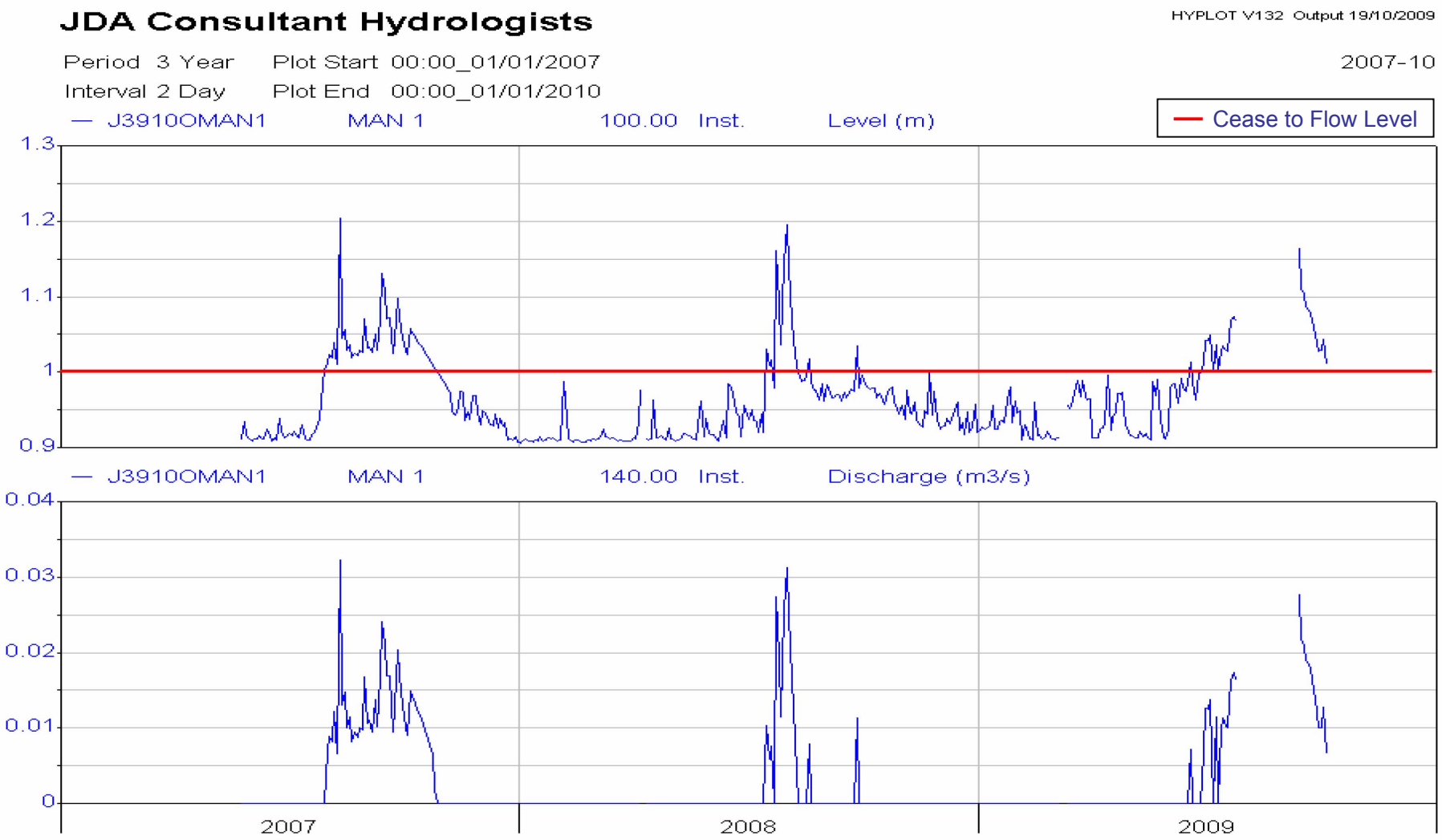
Figure 14: Surface Water Levels with Rainfall



Note: JDA surveys in a water level of 1.0m to represent the cease to flow level.

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Figure 15: Surface Water Site PMD1 Water Level and Flow

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APPENDIX D

Groundwater Licence

Government of **Western Australia**
Department of **Water and Environmental Regulation**

Instrument No. GWL166922(4)

LICENCE TO TAKE WATER

Granted by the Minister under section 5C of the Rights in Water and Irrigation Act 1914

Licensee(s)	JJ White Pty Ltd Greta White Pty Ltd Qube Mandogalup Development Pty Ltd		
Description of Water Resource	Jandakot Perth - Superficial Swan	**Annual Water Entitlement**	724,935kL
Location of Water Source	Lot 663 on Plan 202790 Volume/Folio 2229/938 Lot 663 Norkett Rd Mandogalup Lot 668 On Plan 202618 Volume/Folio 2229/954 Lot 668 Mandogalup Rd Mandogalup Lot 682 On Plan 3475 Volume/Folio 2229/984 Lot 682 Mandogalup		

Authorised Activities	**Taking of water for**	**Location of Activity**
	Dust suppression for earthworks and construction purposes	Lot 682 On Plan 3475 Volume/Folio 2229/160 Lot 682 Mandogalup; Lot 52 On Plan 9780 Volume/Folio 2229/950 Lot 52 Rowley Rd Mandogalup Lot 682 On Plan 3475 Volume/Folio 2229/984 Lot 682 Mandogalup
	Irrigation of up to 1.5 ha of vegetables	Lot 663 on Plan 202790 Volume/Folio 2229/938 Lot 663 Norkett Rd Mandogalup
	Irrigation of up to 10.2 ha of pasture	Lot 682 On Plan 3475 Volume/Folio 2229/984 Lot 682 Mandogalup
	Irrigation of up to 11 ha of public open space	Lot 682 On Plan 3475 Volume/Folio 2229/160 Lot 682 Mandogalup; Lot 52 On Plan 9780 Volume/Folio 2229/950 Lot 52 Rowley Rd Mandogalup Lot 682 On Plan 3475 Volume/Folio 2229/984 Lot 682 Mandogalup
	Irrigation of up to 14.5 ha of lucerne	Lot 668 On Plan 202618 Volume/Folio 2229/954 Lot 668 Mandogalup Rd Mandogalup
	Irrigation of up to 18.0 ha of vegetables	Lot 682 On Plan 3475 Volume/Folio 2229/160 Lot 682 Mandogalup; Lot 52 On Plan 9780 Volume/Folio 2229/950 Lot 52 Rowley Rd Mandogalup
	Irrigation of up to 7.1 ha of lucerne	Lot 682 On Plan 3475 Volume/Folio 2229/984 Lot 682 Mandogalup
	Irrigation of up to 7.8 ha of lucerne	Lot 663 on Plan 202790 Volume/Folio 2229/938 Lot 663 Norkett Rd Mandogalup Lot 664 On Plan 202790 Volume/Folio 2229/156 Lot 664 Mandogalup Rd Mandogalup Lot 791 On Plan 202790 Volume/Folio 2229/949 Lot 791Norkett Rd Mandogalup
	Stock watering	Lot 668 On Plan 202618 Volume/Folio 2229/954 Lot 668 Mandogalup Rd Mandogalup
	Stock watering	Lot 682 On Plan 3475 Volume/Folio 2229/160 Lot 682 Mandogalup; Lot 52 On Plan 9780 Volume/Folio 2229/950 Lot 52 Rowley Rd Mandogalup
	Washdown for commercial purposes	Lot 668 On Plan 202618 Volume/Folio 2229/954 Lot 668 Mandogalup Rd Mandogalup
Duration of Licence	From 2 March 2018 to 2 March 2028	

This Licence is granted subject to the Rights in Water and Irrigation Regulations 2000.

LICENCE TO TAKE WATER

Granted by the Minister under section 5C of the Rights in Water and Irrigation Act 1914

This Licence is subject to the following terms, conditions and restrictions:

1. Between 1 June and 31 August in any year, the licence-holder must not water a lawn, garden, or grass-covered area ("turf") by reticulation, provided always that this restriction shall not apply; watering with a hand held hose; or watering, by way of reticulation: golf course tees and greens, turf wickets, bowling greens and active sporting areas; newly planted areas for a period of up to 28 days from the date of planting; for renovating turf; or for maintenance of reticulation systems

2. The licensee shall not use water for sprinkler irrigation between 9 am and 6 pm except for the establishment of newly planted areas. For newly planted areas water may be used within these hours for a period of up to 28 consecutive days, commencing from the date of planting.

3. The volume of all water taken under this licence must be metered using an approved meter fitted to each drawpoint.

4. The annual water year for water taken under this licence is defined as 1 October to 30 September.

5. The licensee must take and record the reading from each meter required under this licence, at the end of each month.

6. The licensee must submit to the Department of Water and Environmental Regulation the volume of water taken within the water year, every 12 Months commencing 07/10/2018.

7. The licensee must not, in any water year, take more water than the annual water entitlement specified in this licence.

8. The licensee must ensure the installed meter(s) accuracy is maintained to within plus or minus 5% of the volume metered, in field conditions.

9. The licensee must notify the Department of Water in writing of any water meter malfunction within seven days of the malfunction being noticed.

10. The licensee shall comply with the commitments of the operating strategy Mandogalup Farm, as prepared by CADsult and approved by the Department of Water on 5 May 2012 including any modifications to the commitments as approved during the term of the licence.

End of terms, conditions and restrictions

COPY

APPENDIX E

Peel Main Drain Survey (MNG, 2008 & 2017)

52500 53000 53500 54000 54500

238000 237500 237000 236500 236000 235500 235000

1 2 682 303 683 MAN_40 54210.85 237818.40 23.903m 1 2 12 13 11 14 3 10 4 15 9 5 16 6 8 7 703 25 126 38 62 63 63 64 86 84 83 85 1 888 10 41 43 42 44 45 1 2 21 24 22 25 23 26 1 2 3 7 6 5 4 8 9 17 18 10 16 19 11 15 20 14 88 1431

683 682 680 679 678 677 675 674 669 670 313

53106.75 237348.24 36.896m

Cross Section 1 - 3

LONG SECTION 'A'

3 X 1350mm Ø Concrete Pipes

IL19.99 IL20.26 IL 22.50 IL 22.35

1050mm X1250mm BOX CULVERT

PEG

1350mm Ø CONC. PIPE

IL 19.76 IL18.35

225 Ømm CONC. PIPE EASTERN END NOT VISIBLE

2 X 600mm Ø. CONC. PIPES

IL17.58 IL17.14

Cross Section 4 - 7

Drop Structure

1200mm Ø CONC. PIPE

IL15.17 IL15.11 IL14.52 IL14.48

1200mm Ø CONC. PIPE

IL14.70 IL14.58

End Of Pipe Not Visible 750mm Ø Conc. Pipe

IL12.68

Cross Section 8 - 12

4 X 750mm Ø Conc. Pipes

IL12.37 IL12.39

53718.08 236269.92 20.355m

1050mm Ø CONC. PIPE IL12.69

Small Conc. Wall Top Of Wall Level At Lowest Point : 12.93m 1350mm Ø Concrete Pipe IL12.79

600mm Ø. CONC. PIPE IL13.66

STORMWATER GRATE

IL13.75 IL13.63 IL12.88

IL12.11 IL12.06

2 X 1200mm x1200mm Box Culverts

Cross Section 13 - 16

LONG SECTION 'B'

52505.96 235718.17 21.101m

1550mm Ø Concrete Pipe

Small Concrete Wall Top Of Wall Level At Lowest Point : 11.68m

IL11.44m IL11.27m

Cross Section 17 - 21

LONG SECTION 'B'

53090.59 234887.13 26.696m

Note : All Cross Sections Are From East (Freeway Side) To West And The View Is Shown Looking Northwards.

Rev.	Description	Drawn	Date	Checked
B	Long Section Annotated	SAH	11/11/2008	
A	Initial Issue	SAH	10/10/2008	

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NORTH

PEEL MAIN DRAIN

WANDI / MANDOGALUP

CROSS SECTIONS

SCALE 1 : 1000 @ A1 - 1 : 2000 @ A3

20 0 80

ALL DISTANCES ARE IN METRES

The boundaries depicted on this plan were not re-established as part of this survey, therefore this plan does not guarantee their accuracy. Re-establishment of the cadastral boundaries recommended for any proposed works on or near existing boundaries.

FILES
Survey: 93834G
Plan No: 93834de-020b

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PO Box 117, South Perth, WA 6951, Australia
Tel: (08) 6436 1599, Fax: (08) 6436 1500, maps@mapsurvey.com.au, www.mapsurvey.com.au
McMullen Nolan and Partners Surveyors Pty Ltd, ABN 90 009 363 311
Quality Assured Company

Scale	1:5000 @ A1	Datum	PCG94/AHD
Drawn	SAH	Job No.	93834
Surveyor	AN	Drawing	93834-020
Surveyed	OCTOBER 2008	Revision	B

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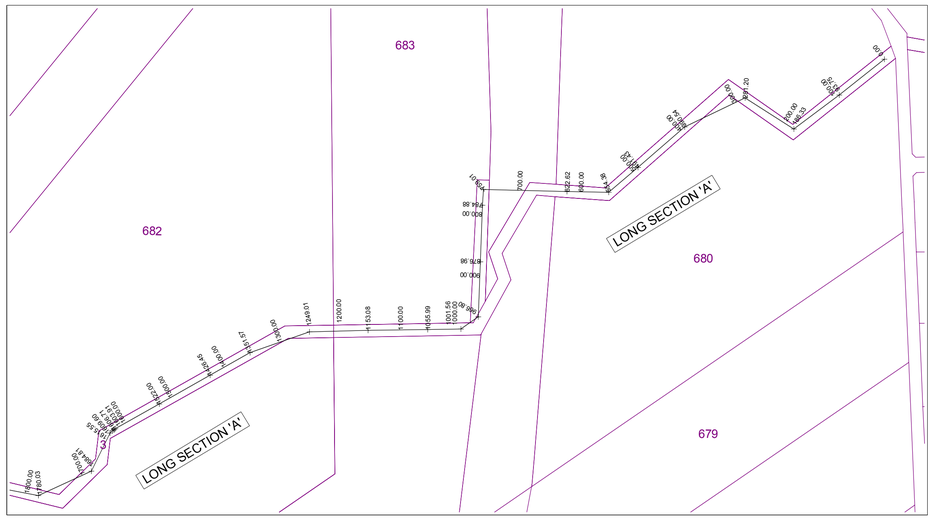

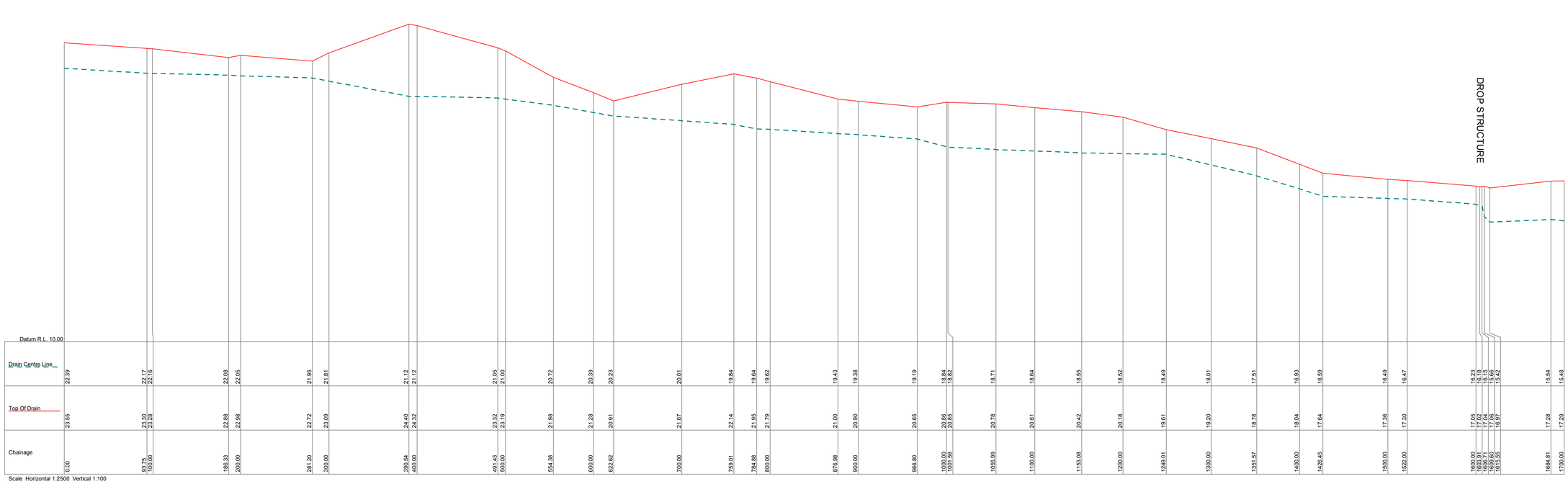

Rev.	Description	Drawn	Date	Checked
A	Initial Issue	SAH	11/11/2008	

SCALE 1 : 1000 @ A1 - 1 : 2000 @ A3

20 0 80

ALL DISTANCES ARE IN METRES

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FILES
Survey: 93834G
Plan No: 93834de-023a

NORTH

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WANDI SUBDIVISION

PEEL MAIN DRAIN - LONGSECTION 'A'

CHAINAGE : 00m - 1700m

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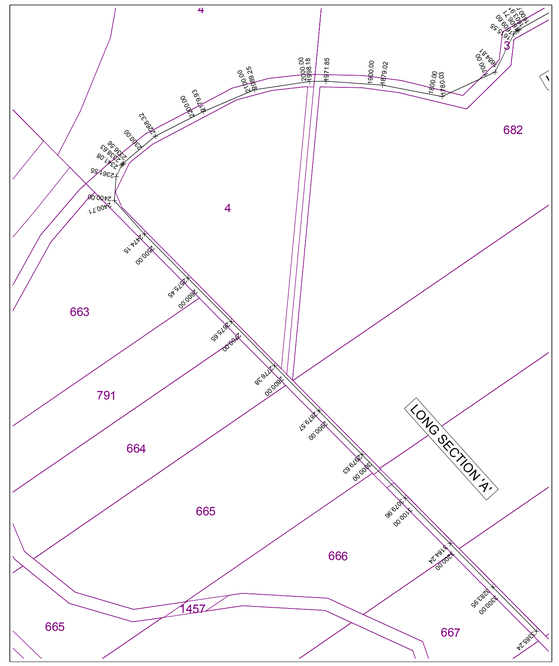
Scale	1:1000 @ A1	Datum	PCG94/AHD
Drawn	SAH	Job No.	93834
Surveyor	AMN	Drawing	93834-023
Surveyed	OCTOBER_2008	Revision	A

A1 ORIGINAL



Rev.	Description	Drawn	Date	Checked
A	Initial Issue	SAH	11/11/2008	

SCALE 1 : 1000 @ A1 - 1 : 2000 @ A3

20 0 80

ALL DISTANCES ARE IN METRES

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FILES
Survey: 93834G
Plan No: 93834de-024a

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Mapping Solid Terrain Models Cartographics GIS

WANDI SUBDIVISION

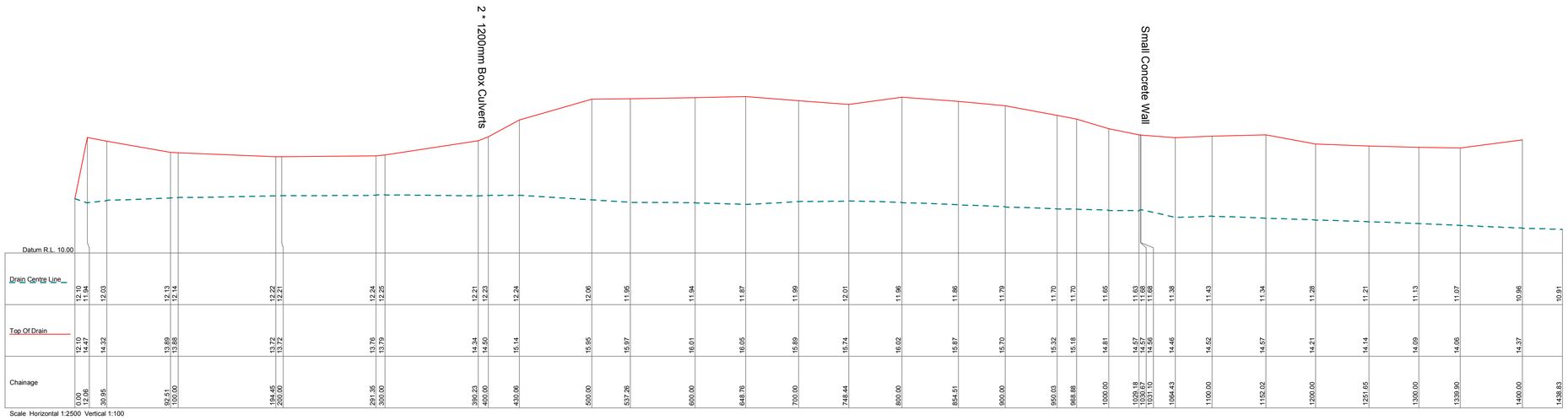
PEEL MAIN DRAIN - LONGSECTION 'A'

CHAINAGE : 1700m - 3385m

Scale	1:1000 @ A1	Datum	PCG94/AHD
Drawn	SAH	Job No.	93834
Surveyor	AMN	Drawing	93834-024
Surveyed	OCTOBER_2008	Revision	A

A1 ORIGINAL





Scale Horizontal 1:2500 Vertical 1:100

Rev.	Description	Drawn	Date	Checked
A	Initial Issue	SAH	11/11/2008	

SCALE 1 : 1000 @ A1 - 1 : 2000 @ A3

20 0 80

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FILES
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Plan No: 93834de-025a

NORTH

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WANDI SUBDIVISION

PEEL MAIN DRAIN - LONG SECTION 'B'

CHAINAGE : 00m - 1400m

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Scale	1:1000 @ A1	Datum	PCG94/AHD
Drawn	SAH	Job No.	93834
Surveyor	AMN	Drawing	93834-025
Surveyed	OCTOBER_2008	Revision	A

A1 ORIGINAL

53200 53300 53400 53500

237000 236900 236800

682

P003475

9902
53167.760
236933.477
R.L 16.62m

Culvert
2x600Ø

Culvert
1400Ø

Culvert
1200Ø

682

P003475

Rev.	Description	Drawn	Date	Checked
A	Initial Issue	SAH	18/04/2017	TAV

SCALE 1:1000 @ A3

0 25 50

ALL DISTANCES ARE IN METRES

For a true to scale reproduction of this plan, plot it to A3 with the Paging Scaling set to None.

The contents of this plan are current and correct as of the date stated within the revision panel. All consultants and persons wishing to utilise this data should satisfy themselves of this plans currency by contacting the McMullen Nolan Group.

Surveyor:- PJ
Survey Date:- 12/04/2017
Precal/Cad:- 24/05/2016

bsi. ISO 9001 Quality Management FS 565311
AS/NZS 4801:2001 Occupational Health and Safety Management OSH 591267

N

The boundaries shown on this plan were not re-established as part of this survey, therefore this plan does not guarantee their accuracy. Existing easements, encumbrance or interest are not depicted and a title search is recommended to obtain this information. Re-establishment of the cadastral boundaries is recommended for any proposed works on or near existing boundaries.

MNG.

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info@mngsurvey.com.au
www.mngsurvey.com.au
ABN 90 009 363 311

MANDOGALUP
PEEL MAIN DRAIN
DRAIN & TREE SURVEY

CLIENT: QUBE

Project Mngr	Trevor Veen	Datum	PCG94 / AHD

96755 - DE - 012 - A
Job Number | Type | Plan Number | Revision

APPENDIX F

Stormwater Modelling Parameters

TABLE 1: XP-Storm Modelling Assumptions

Key Elements	Parameter			Value
IFD Data	BOM IFD Calculator			BoM (2016)
Temporal Patterns				ARR Storm Generator Lat: -32.185, Long: 115.85
Runoff Assumptions	Land Use	Residential Lots	Initial Loss (mm)	15
			Continuing Loss (mm/hr) all EY/AEP	8
			Manning's n	0.020
		Road Reserve	Initial Loss (mm)	1.5
			Proportional Loss (%) all EY/AEP	20
			Manning's n	0.014
		Public Open Space	Initial Loss (mm)	0.00
			Proportional Loss (%) all EY/AEP	90
			Manning's n	0.050
		Drainage	Proportional Loss (%) all EY/AEP	10
			Manning's n	0.050
	Catchment Grade			Variable, from site earthworks (Cossill & Webley, 2024)
	Runoff routing method used			Laurenson's method ($S=BQ^{n+1}$)
	Evaporation			None Assumed
Simulation Parameters	Dry time step			86400 Seconds (1 day)
	Transition time Step			30 Seconds
	Wet time step			30 Seconds
	Simulation period			3 Days
Hydraulics	Culverts		Manning's n	0.014
			Headwall type	Circular
			Entrance/Exit loss Coefficients	0.5/1.0
	Peel Main Drain		Centre/overbank channel Manning's n	0.05
			Base Width	2.5 m
			Batter Slopes	Variable (Natural section)
	Drainage Basins / Bio-retention Areas		Infiltration (m/day)	None Assumed
			Minimum side slopes	1:6 (v:h)

APPENDIX G

Landscaping Plans and Street Tree Masterplan
(Plan E, 2024)

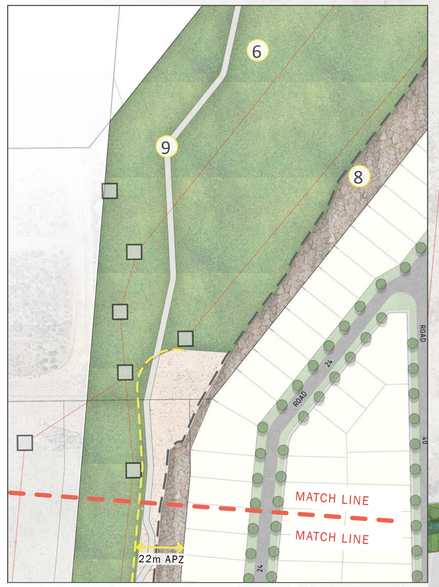


APSLEY ESTATE

1403302 apsley south - landscape concept plan [G]

PLAN E

02 | APSLEY SOUTH
LANDSCAPE MASTER PLAN



INSET PLAN
WESTER POWER EASEMENT

MATCH LINE
MATCH LINE
22m APZ
17m APZ
12m APZ
FERDINAND STR
FERDINAND STREET
WALKER RD
MCMILLAN RD
QUARTERMAINE BLVD
QUARTERMAINE BOULEVARD
LUDWIG LANE
TASMAN CRESCENT
WARBURTON
WARBURTON STREET
HARTOG CRESCENT
GREGORY STREET
ROAD
POWER DISTRIBUTION
BATTER
APZ LINE

LEGEND

01 POS H- REFER DRAWING M1.103

02 POS J - REFER DRAWING M1.105

03 POS F&G - REFER DRAWING M1.107

04 PEEL MAIN DRAIN - REFER DRAWING M1.103 & M1.107 :
20m WIDE EASEMENT WITH REALIGNED PEEL MAIN DRAIN WHERE THERE ARE NO EXISTING TREES

05 POS I - NATIVE SHRUB AND TREE PLANTING:
PLANTED WITH NATIVE LOW SHRUBS AND TREES AS BUFFER TO PEEL MAIN DRAIN

06 WESTERN POWER EASEMENT :
PLANTED WITH NATIVE VEGETATION (<1M MATURE HEIGHT) OUTSIDE APZ AREAS

07 WESTERN POWER EASEMENT DRAINAGE BASIN :
PLANTED WITH NATIVE RUSHES AND SEDGES TOLERANT OF WINTER WET AND SUMMER DRY CONDITIONS

08 WESTERN POWER EASEMENT APZ :
PLANTED WITH LOW FUEL LOAD NATIVE VEGETATION (<0.5M MATURE HEIGHT) WITHIN APZ AREAS

09 DUAL USE PATH

10 POS K DRAINAGE BASIN:
PLANTED WITH NATIVE RUSHES AND SEDGES TOLERANT OF WINTER WET AND SUMMER DRY CONDITIONS

ASSET PROTECTION ZONE (APZ)

PEEL MAIN DRAIN EASEMENT (20.0M WIDE)

APSLEY ESTATE

PREPARED FOR QUBE PROPERTY GROUP

APSLEY SOUTH - LANDSCAPE MASTER PLAN
JUNE 2025

JOB NO. 1403302
1:1250 @ A1

M1.102

0 25 50 72 125m

REV G

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03 | POS H & PEEL MAIN DRAIN

LANDSCAPE CONCEPT PLAN



LEGEND

01 INSITU CONCRETE PEDESTRIAN PATH NETWORK

02 3.0M WIDE CONCRETE PEDESTRIAN PATH AND MAINTENANCE VEHICLE ACCESS

03 NATIVE LOW SHRUB AND GROUNDCOVER PLANTING

04 OPEN TURF AREA

05 20% AEP DRAINAGE BASIN FOR STORMWATER CATCHMENT TO BE FULLY PLANTED WITH SUITABLE INDIGENOUS NATIVE TREE AND SHRUB SPECIES

06 SHELTER WITH SEATING AND BBQ FACILITIES

07 TODDLER (1-3 YRS) NATURE PLAYGROUND UNDER EXISTING TREE CANOPY

08 JUNIOR (3-8 YRS) NATURE PLAYGROUND

09 SEATING NODE

10 FOOTBRIDGE ACROSS PEEL MAIN DRAIN

11 PEEL MAIN DRAIN CHANNEL - RETAIN EXISTING TREES AND FULLY VEGETATED

12 EXISTING TREES TO BE RETAINED

13 PROPOSED NEW STREET TREES

14 PROPOSED POS TREE PLANTING

15 LOW RETAINING WALL (500MM HIGH)

16 TRANSFORMER

PEEL MAIN DRAIN EASEMENT (20.0M WIDE)

LOCATION MAP

APSLEY ESTATE

PREPARED FOR QUBE PROPERTY GROUP

LANDSCAPE CONCEPT PLAN

JUNE 2025

JOB NO. 1403302

1:400 @ A1

M1.103

REV G

0 8 16 24 40m

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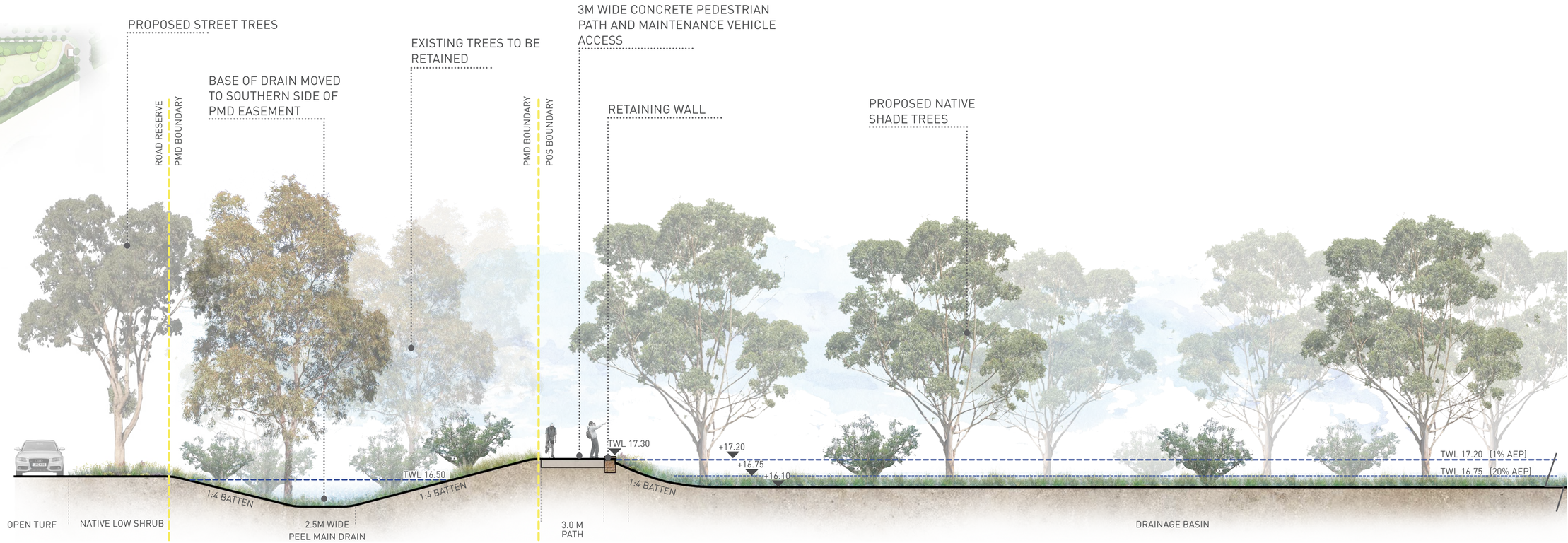
04 | POS H & PEEL MAIN DRAIN

SECTION A



LOCATION MAP



SECTION A-A'



APSLEY ESTATE

PREPARED FOR QUBE PROPERTY GROUP

LANDSCAPE CONCEPT PLAN

JUNE 2025

JOB NO. 1403302

1: 100 @ A1

M1.104

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05 | POS J

LANDSCAPE CONCEPT PLAN



LEGEND

01 INSITU CONCRETE PEDESTRIAN PATH NETWORK TO ACCOMMODATE PEDESTRIAN AND MAINTENANCE ACCESS

02 GRAVEL PATH WITH ROCK BOULDERS

03 NATIVE LOW SHRUB AND GROUNDCOVER PLANTING

04 OPEN TURF AREA

05 DRAINAGE BASIN FOR STORMWATER CATCHMENT TO BE FULLY VEGETATED WITH SUITABLE INDIGENOUS TREE AND SHRUB SPECIES

06 SEATING NODE

07 LARGE BOULDER STEPPERS ACROSS SWALE

08 STEP ACCESS TO POS

09 SMALL PLAYGROUND

10 SHELTER WITH SEATING FACILITIES

11 SMALL NATURE PLAYGROUND

12 RETAINING WALL

13 PEDESTRIAN FOOTPATH CONNECTING INTO ESTATE NETWORK

14 DRAINAGE SWALE WITHIN MEDIAN ISLAND

15 OPEN IRRIGATED TURF TO CORNER TO PROMOTE VIEW INTO POS

16 DUAL USE PATH CONNECTING INTO ESTATE NETWORK

17 EXISTING TREES TO BE RETAINED

18 PROPOSED NEW STREET TREES

19 PROPOSED POS TREE PLANTING

20 BOARDWALK CONNECTION ACROSS SWALE



LOCATION MAP

APSLEY ESTATE

PREPARED FOR QUBE PROPERTY GROUP

LANDSCAPE CONCEPT PLAN
JUNE 2025

JOB NO. 1403302
1:400 @ A1

M1.105 REV E
0 8 16 24 40m

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PLAN E

LANDSCAPE ARCHITECTS

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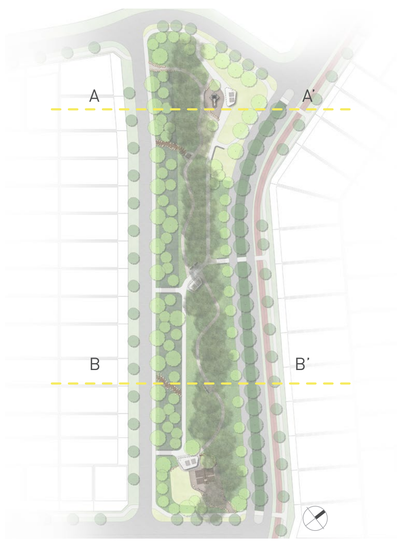
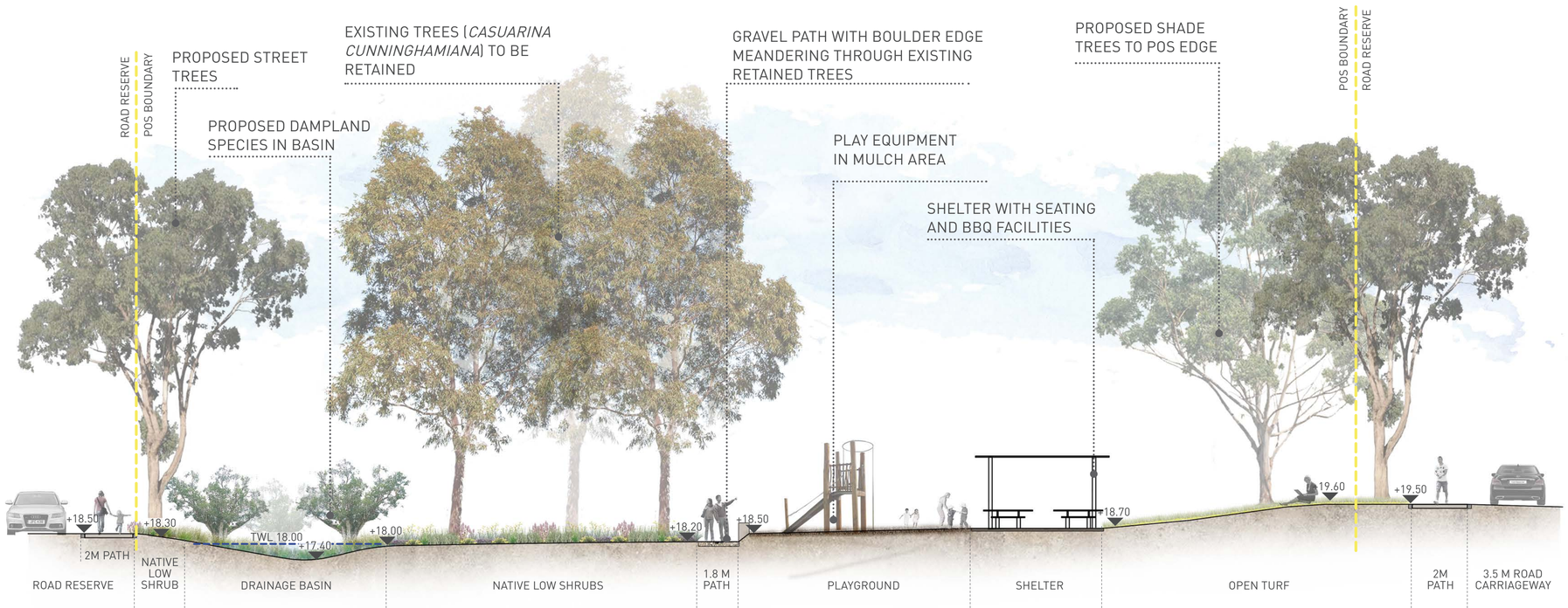
06 | POS J

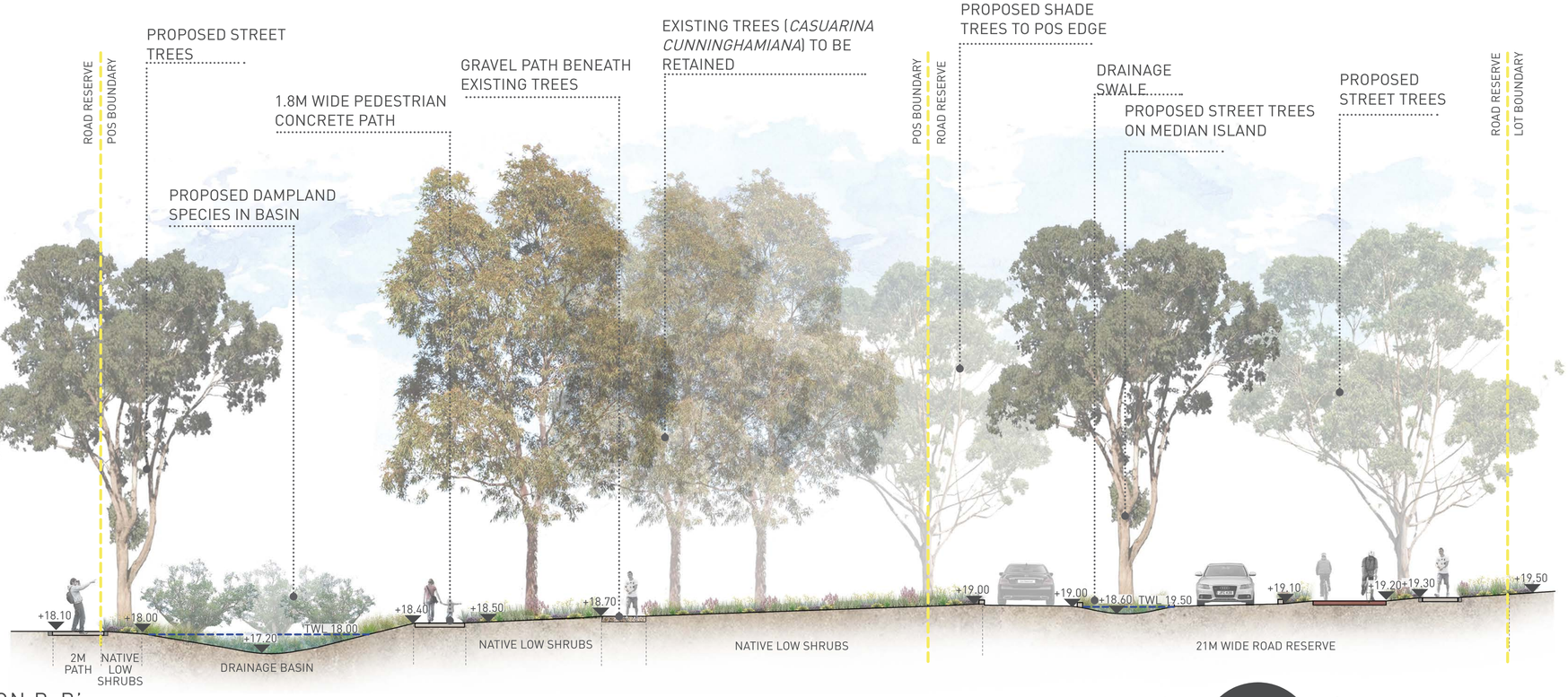
SECTION A & B



LOCATION MAP



SECTION A-A'



SECTION B-B'

APSLEY ESTATE

PREPARED FOR QUBE PROPERTY GROUP

LANDSCAPE CONCEPT PLAN

JUNE 2025

JOB NO. 1403302

1: 100 @ A1

M1.106

REV E

0 2 4 6 10m

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07 | POS F & POS G & PEEL MAIN DRAIN

LANDSCAPE CONCEPT PLAN



LEGEND

01 INSITU CONCRETE PEDESTRIAN PATH NETWORK TO ACCOMMODATE PEDESTRIAN AND MAINTENANCE ACCESS

02 DUAL USE PATH CONNECTING INTO ESTATE NETWORK

03 OPEN TURF AREA

04 NATIVE LOW SHRUB AND GROUNDCOVER PLANTING

05 EXISTING PEEL MAIN DRAIN CHANNEL - RETAIN EXISTING TREES AND FULLY VEGETATED

06 SHELTER WITH SEATING FACILITIES

07 NATURE PLAYGROUND

08 SEATING NODE

09 EXISTING TREES TO BE RETAINED

PEEL MAIN DRAIN EASEMENT (20.0M WIDE)



LOCATION MAP

APSLEY ESTATE

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JUNE 2025

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1: 500 @ A1

M1.107 REV E

0 10 20 30 50m

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08 | POS F & POS G & PEEL MAIN DRAIN

SECTION A



LOCATION MAP



SECTION A-A'
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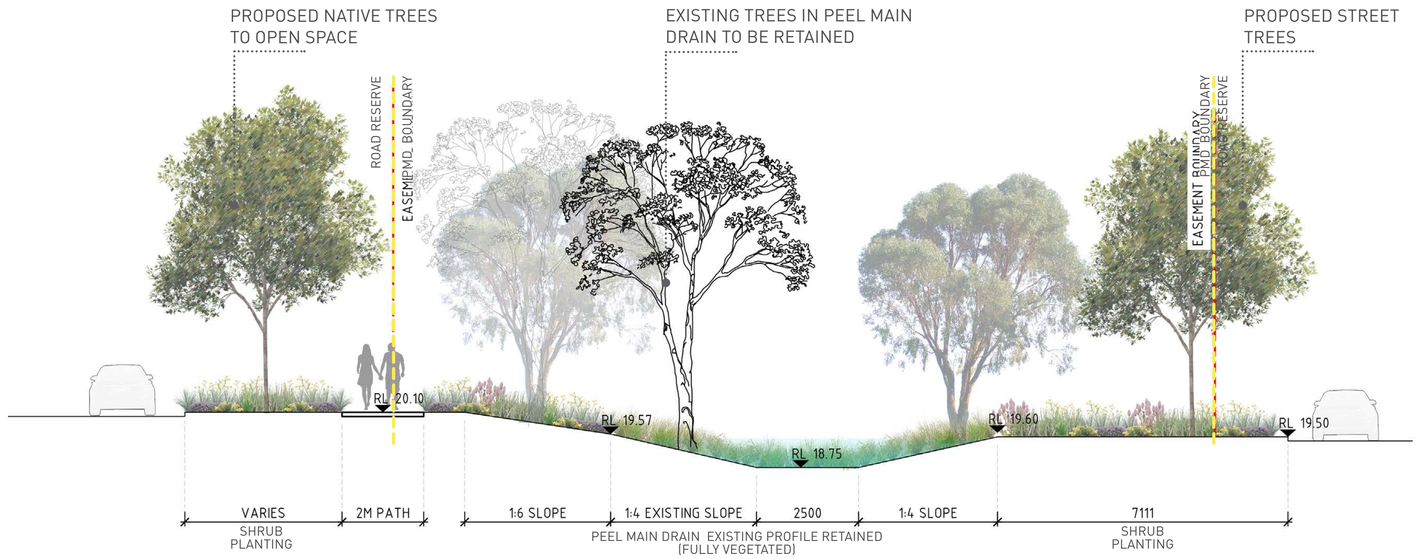
SECTION B & C



LOCATION MAP



SECTION B-B'
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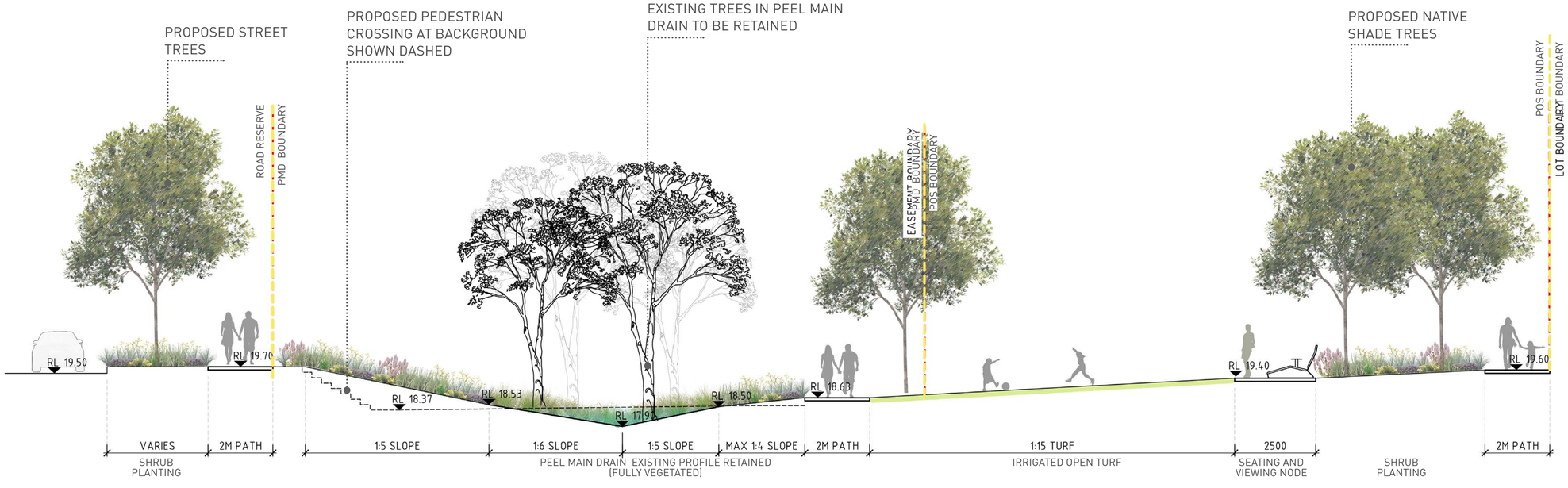

SECTION C-C'
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POS K & WESTERN POWER EASEMENT SOUTH

PROPOSED TREATMENT CONCEPT PLAN





LEGEND

01 PROPOSED SHRUBLAND PLANTING (<1M MATURE HEIGHT TO COMPLY WITH WP CRITERIA, NOTING THE 17M APZ ALLOWS FOR SHRUBS UP TO 2.0M HEIGHT).

02 SHARED USE PATH

03 CRUSHED COMPACTED LIMESTONE SURFACE WITH SCATTERED POCKETS OF LOW PLANTING TO COMPLY WITH APZ CRITERIA

04 DRAINAGE BASIN

05 LIMESTONE PITCHING ON BATTERS

06 POWER LINE PYLONS

07 PROPOSED POS H, REFER TO M1.102

08 PROPOSED POS K

09 PROPOSED SHRUBLAND PLANTING (<1M MATURE HEIGHT TO COMPLY WITH WP CRITERIA, NOTING 22M APZ ALLOWS FOR SHRUBS UP TO 6.0M HEIGHT)

10 PROPOSED GRASSLAND SEDGES AND RUSHES OUTSIDE 12M APZ (<1M MATURE HEIGHT TO COMPLY WITH WP CRITERIA)

11 PROPOSED GRASSLAND SEDGES AND RUSHES IN THIS SECTION OF PEEL MAIN DRAIN, TO EXTEND 13M BEYOND THE CORNERS OF THE RESIDENTIAL LOT BOUNDARIES ON EITHER SIDE OF PMD

BATTER BOUNDARY

APZ LINE

PEEL MAIN DRAIN

D D SECTIONS



LOCATION MAP

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11 | POS K & WESTERN POWER EASEMENT SOUTH

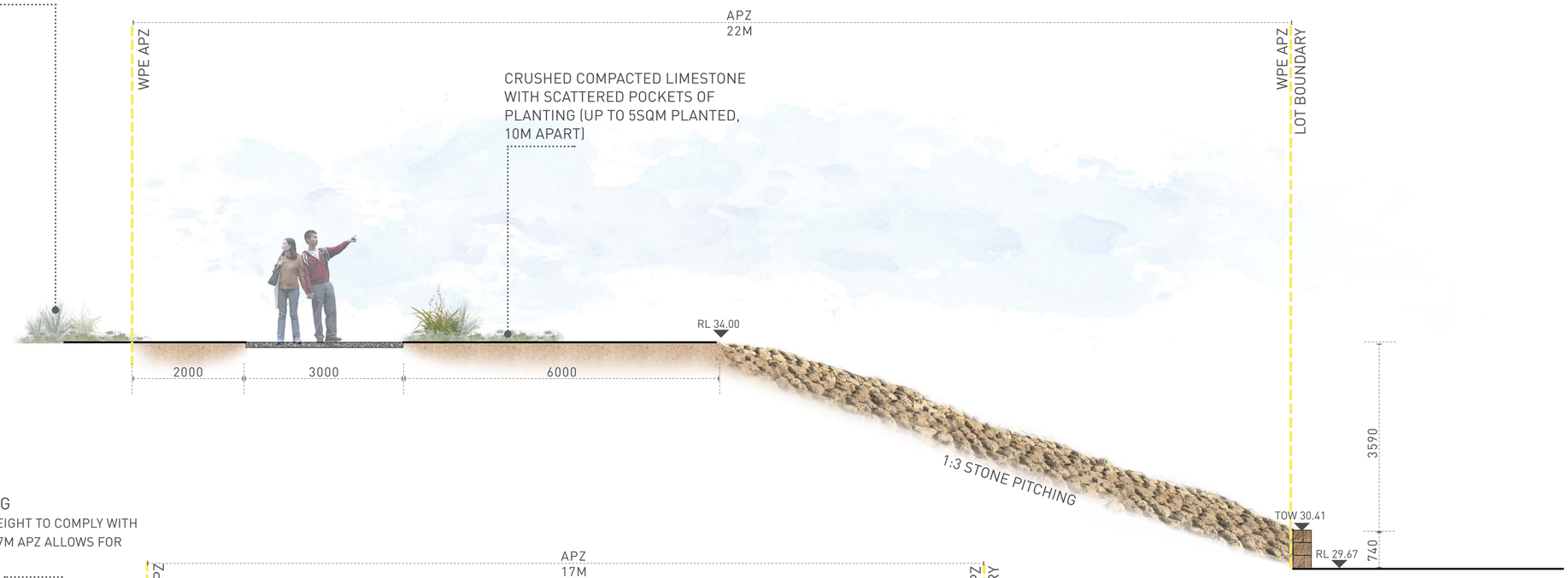
SECTION A & B



LOCATION MAP

SHRUBLAND PLANTING
(LESS THAN 1.0M HEIGHT TO COMPLY WITH WP CRITERUA, NOTING THE 22M APZ ALLOWS FOR SHRUBS UP TO 6M HEIGHT)

SECTION A-A'



SHRUBLAND PLANTING
(LESS THAN 1.0M MATURE HEIGHT TO COMPLY WITH WP CRITERIA, NOTING THE 17M APZ ALLOWS FOR SHRUBS UP TO 2.0M HEIGHT)

SECTION B-B'



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M1.111

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0 1 2 3 5m

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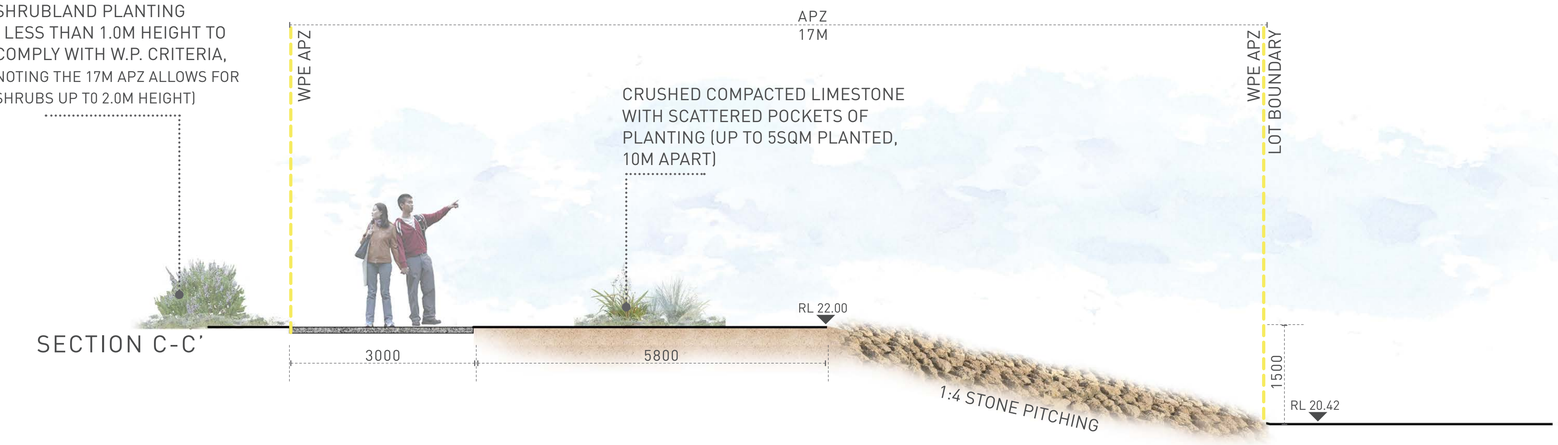
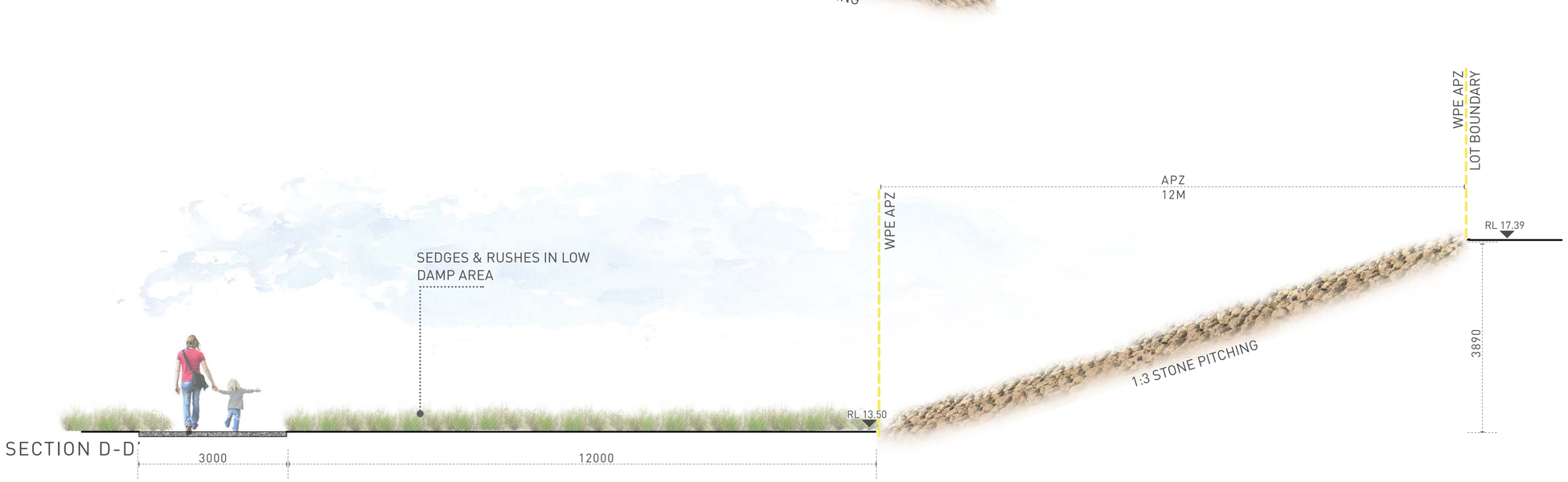
SECTION C, D & E



LOCATION MAP



SECTION C-C'



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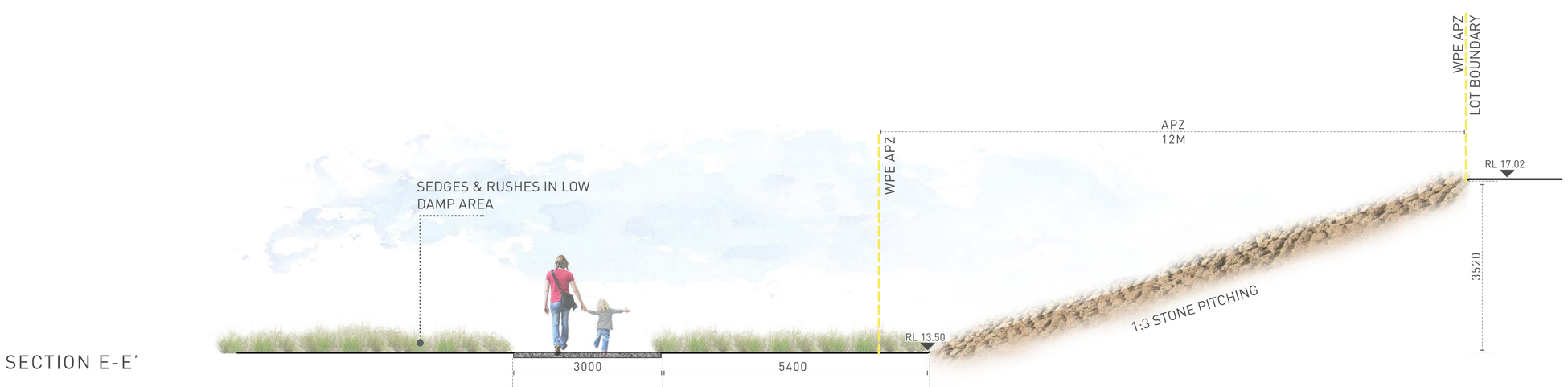

SECTION E-E'

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APPENDIX H

UNDO Nutrient Modelling Outputs

Government of **Western Australia**
Department of **Water and Environmental Regulation**

Project: Apsley Estate South

Date: 07/05/2024

Version: Version 1.2.0.19289

Subregion name: Residential Lots

Landuse	Percent (%)	Area (ha)	Input load Nitrogen (kg)	Input load Phosphorus (kg)
Residential	100	12.55	400.51	111.16
Industrial, commercial & schools	0	0.00	0.00	0.00
Rural living	0	0.00	0.00	0.00
Public open space	0	0.00	0.00	0.00
Road reserve	0	0.00	0.00	0.00

Total area (ha)	Total percent (%)
12.55	47

Nitrogen input (kg/ha/yr)	Phosphorus input (kg/ha/yr)
37.15	9.01

Nitrogen export (kg/ha/yr)	Phosphorus (kg/ha/yr)
3.83	0.08

Residential

Size (m²)	Percent (%)	Area (ha)	Input load Nitrogen (kg)	Input load Phosphorus (kg)
<400	80	10.04	235.85	69.10
400-500 m²	20	2.51	164.66	42.07
501-600 m²	0	0.00	0.00	0.00
601-730 m²	0	0.00	0.00	0.00
>730 m²	0	0.00	0.00	0.00
Multiple dwellings	0	0.00	0.00	0.00

Total area (ha)	Total percent (%)
12.549	100

Nitrogen input (kg)	Phosphorus input (kg)
400.51	111.16

Soil and drainage information

Type of drainage	**Subsoil drainage**	**Does it contain imported fill?**	**Yes**
Soil type	**Bassendean**	Type of fill imported	**White sands (Bassendean)**
Depth to groundwater (m)	**4**	Fill depth (m)	**2**
Groundwater slope (%)	**1**	Approximate PRI of imported fill	**5**
Soil PRI	**5.0**	**Does subregion contain onsite sewage diposal system?**	**No**

Note: Please attach the results of soil tests to this report when submitting.

Subregion name: Roads

Landuse	Percent (%)	Area (ha)	Input load Nitrogen (kg)	Input load Phosphorus (kg)
Residential	0	0.00	0.00	0.00
Industrial, commercial & schools	0	0.00	0.00	0.00
Rural living	0	0.00	0.00	0.00
Public open space	0	0.00	0.00	0.00
Road reserve	100	5.87	65.79	8.81

Total area (ha)	Total percent (%)
5.87	**22**

Nitrogen input (kg/ha/yr)	Phosphorus input (kg/ha/yr)
16.43	**1.65**

Nitrogen export (kg/ha/yr)	Phosphorus (kg/ha/yr)
1.06	**0.08**

Road reserve

Landuse	Percent (%)	Area (ha)
Roads	80	4.70
Road reserve - impervious	0	0.00
Road reserve - native garden	0	0.00
Road reserve - non-native garden	0	0.00
Road reserve - turf	10	0.59
Road reserve - not fertilised	10	0.59

Total area (ha)	Total percent (%)
5.874	**100**

Nitrogen input (kg)	Phosphorus input (kg)
65.79	**65.79**

Soil and drainage information

Type of drainage	**Piped drainage**	**Does it contain imported fill?**	**Yes**
Soil type	**Bassendean**	Type of fill imported	**White sands (Bassendean)**
Depth to groundwater (m)	**4**	Fill depth (m)	**2**
Groundwater slope (%)	**1**	Approximate PRI of imported fill	**5**
Soil PRI	**5.0**	**Does subregion contain onsite sewage diposal system?**	**No**

Note: Please attach the results of soil tests to this report when submitting.

Subregion name: **POS / PMD / Easement**

			Input load	
Landuse	**Percent (%)**	**Area (ha)**	**Nitrogen (kg)**	**Phosphorus (kg)**
Residential	0	0.00	0.00	0.00
Industrial, commercial & schools	0	0.00	0.00	0.00
Rural living	0	0.00	0.00	0.00
Public open space	100	8.28	166.53	8.32
Road reserve	0	0.00	0.00	0.00

Total area (ha)	Total percent (%)
8.28	**31**

Nitrogen input (kg/ha/yr)	Phosphorus input (kg/ha/yr)
25.35	**1.16**

Nitrogen export (kg/ha/yr)	Phosphorus (kg/ha/yr)
2.63	**0.03**

Public Open Space (POS)

Landuse	Percent (%)	Area (ha)
Native gardens	25	2.07
Non-native gardens	2	0.17
Not fertilised	0	0.00
Nature	42	3.48
Sport	0	0.00
Recreation	15	1.24
Golf course	0	0.00
Bowling green	0	0.00
Impervious	5	0.41
Water body	11	0.91

Total area (ha)	Total percent (%)
8.28	**100**

Nitrogen input (kg)	Phosphorus input (kg)
166.53	**8.32**

Soil and drainage information

Type of drainage	**Subsoil - partial lot connection**	**Does it contain imported fill?**	**Yes**
Soil type	**Bassendean**	Type of fill imported	**White sands (Bassen**
Depth to groundwater (m)	**3**	Fill depth (m)	**1**
Groundwater slope (%)	**1**	Approximate PRI of imported fill	**5**
Soil PRI	**5.0**	**Does subregion contain onsite sewage diposal sy**	

Note: Please attach the results of soil tests to this report when submitting.

Summary: Nutrient stripping devices

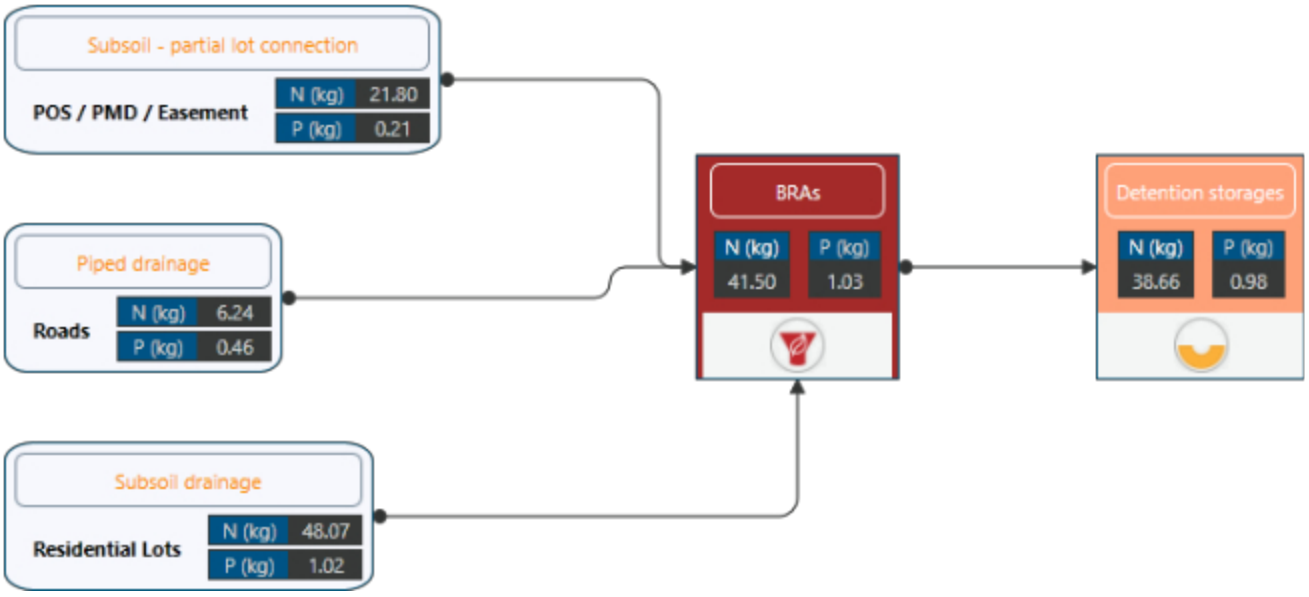
Treatment	Name	Size (m²)	Treated area (ha)	Treating	N removed (kg/ha/yr)	P removed (kg/ha/yr)
Biofilter	BRAs	2500.00	26.70	Sandy soils – Runoff and subsoil drains	3.42	0.07
Detention / infiltration basin	Detention storages	10000.00	26.70	Sandy soils – Runoff and subsoil drains	0.28	0.00
Load removed					**1.40**	**0.03**
Net export					**1.45**	**0.04**

Summary: Nutrient load exports

Region	Area (ha)	P export (kg/ha/yr)	N export (kg/ha/yr)
Residential Lots	12.55	0.08	3.83
Roads	5.87	0.08	1.06
POS / PMD / Easement	8.28	0.03	2.63

PRE-TREATMENT LOAD (kg/ha/yr)		LOAD REMOVED (kg/ha/yr)		NET LOAD EXPORT (kg/ha/yr)	
NITROGEN	PHOSPHORUS	NITROGEN	PHOSPHORUS	NITROGEN	PHOSPHORUS
2.85	0.06	1.40	0.03	1.45	0.04

Treatment diagram



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QUBE Property Group Pty Ltd

QUBE Land (Mandogalup West)

Local Water Management Strategy

Lots 682 & 52 Rowley Road, Mandogalup

August 2017



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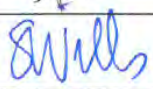
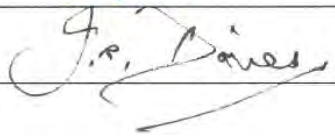
	Name	Signature	Date
Author	Joycelyn Siew		28 August 2017
Checked by	Scott Wills		28 August 2017
Approved by	Jim Davies		28 August 2017

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1. EXECUTIVE SUMMARY

JDA has been engaged by Qube Property Group Pty Ltd to complete a Local Water Management Strategy (LWMS) for Lot 682 Mandogalup Road, Mandogalup. In total, the development occupies an area of 68 ha (including Lot 52 which is occupied by a Western Power transmission line easement) within the City of Kwinana (CoK). This lot is herein referred to as the Study Area (Figure 1).

This Local Water Management Strategy (LWMS) has been prepared in support of the Mandogalup West Local Structure Plan (MWLSP). The LWMS provides the framework for the application of total water cycle management to the proposed urban structure within the MWLSP, consistent with the District Water Management Strategy (DWMS) and Department of Water (DoW) principles of Water Sensitive Urban Design (WSUD) described in the Stormwater Management Manual (DoW, 2007).

The MWLSP forms the western portion of the Mandogalup development cell (Qube Land) with the balance falling within the Mandogalup East Local Structure Plan (MELSP). The LWMS documents the integration of water management between the two LSP's, with the primary constraints being:

- Ensuring the profile of the Peel Main Drain (PMD) is consistent between the two developments (Figure 1).
- Ensuring the profile of the North-South connector road central median swale originating from the MELSP (Satterley Land) appropriately transition at the MWLSP (Qube Land) boundary (Figure 1).
- Drainage within the Primary School site consistent between the two Structure Plans (Figure 1).
- Drainage within the Playing Field is consistent between the two Structure Plans (Figure 1).
- Interface between the Retained Vegetation in the MELSP (Figure 1).

Integration of the above constraints can be demonstrated, as follows:

- The MWLSP is adopting a 20 m wide PMD easement with a 2.5 m wide base channel with 1:3 side slopes and a meandering overflow channel with 1:6 side slopes. This channel profile will be adopted in the MELSP.
- A transitional section of the central median swale in the North-South connector road will be created at the interface of the MWLSP and MELSP.
- The total area of the school site is accounted for within the two structure plans. Both Structure Plans make provision for an outflow from the school site until the final school layout is resolved.
- The Playing Field has a catchment divide located at the boundary of the MWLSP and MELSP, with drainage managed independently.
- The MWLSP will have Public Open Space (POS) fronting the retained vegetation located within the MELSP. Drainage within the MWLSP POS will be independent of the retained vegetation, with a catchment divide located at the boundary of the two developments.

A summary of the Mandogalup West LWMS design principles and objectives are presented in Table 1.

TABLE 1: SUMMARY OF LWMS DESIGN PRINCIPLES AND OBJECTIVES

Key Guiding Principles		
• Facilitate implementation of sustainable best practice in urban water management • Provide integration with planning processes and clarity for agencies involved with implementation • Minimise public risk, including risk of injury or loss of life. • Protection of infrastructure and assets from flooding and inundation • Encourage environmentally responsible development. • Facilitate adaptive management responses to the monitored outcomes of development		
Category	**DWMS Objectives**	**LWMS Criteria**
Surface Water Management	• Minimise changes in hydrology to prevent impacts on receiving environments. • Manage water flows from major events to protect infrastructure and assets. • Apply the Principles of WSUD. • Adopt nutrient load reduction design objectives for stormwater runoff. • Floodplain management and urban drainage.	• Post-development critical 1yr ARI and 100yr ARI peak flow shall be consistent with pre-development peak flow at the discharge point of each catchment where possible and at all discharge points of all subdivisions into waterways. • All 1yr 1hr ARI event runoff to be infiltrated at source where possible. • Maintain the alignment and hydraulic capacity of the Peel Main Drain, as specified in the Jandakot DWMP, but redefine the profile of the drain to an urban standard, within the Study Area. • Manage surface water flows from major events to protect infrastructure and assets from flooding and inundation.
Groundwater Management	• Manage groundwater levels to protect infrastructure and assets • Maintain groundwater regimes for the protection of groundwater-dependent ecosystems • Protect the value of groundwater resources. • Adopt nutrient load reduction design objectives for discharges to groundwater.	• Manage and minimise changes in groundwater levels and groundwater quality following development. • Subsurface drainage (sub-soils) and drainage infrastructure set at or above the AAMGL, although existing inverts below this level may remain. • Subsoil drainage outlets to be free draining.
Monitoring and Implementation	• Adopt an adaptive management approach. • Maintain drainage and treatment structures.	• Design based on methodology in Stormwater Management Manual of adopting a treatment train including: • Retention of 1yr ARI 1hr events, • Structural treatment measures (infiltration storages, plus bio-retention/ treatment structures sized to min 2% of connected impervious area) • Non-structural measures to reduce applied nutrient loads. • Maintain groundwater quality at pre-development levels (median winter concentrations) and, if possible, improve the quality of water leaving the development area to maintain and restore ecological systems.
Water Conservation	• Minimise the use of potable water where drinking water is not essential by considering all potential water sources and water demand requirements in water supply and land use planning. • Water efficiency initiatives include waterwise landscaping packages, public POS area to be at least 50% native vegetation. • Buildings are to comply with water efficiency standards introduced into the building code.	• Aim to achieve the State Water Plan target for water use of 100 kL/person/yr. • Consider alternative fit for purpose water sources where appropriate and cost effective. • POS areas to be at least 50% native plants.

2. INTRODUCTION

2.1 Background

This Local Water Management Strategy (LWMS) has been prepared by JDA Consultant Hydrologists on behalf of QUBE Property Group Pty Ltd in support of the Local Structure Plan (LSP) for Lots 682 and 52 Rowley Rd, Mandogalup, herein referred to as the Study Area (Figure 1).

The LWMS provides the framework for the application of total water cycle management to the proposed urban structure, consistent with the Department of Water (DoW) principles of Water Sensitive Urban Design (WSUD) described in the Stormwater Management Manual (DoW, 2007).

2.2 Statutory Framework

2.2.1 Regional Planning

Lot 682, owned by QUBE Property Group Pty Ltd, is zoned 'Urban' and 'Urban deferred' under the Metropolitan Region Scheme (WAPC, 2014). The Study Area is located within the portion of land zoned Urban (Figure 1). It is bounded along the north by Planning Control Area No. 112, and on the southwest by the former Kwinana Industrial (including air quality) Buffer (as of 21 September 2010). The remainder of Lot 682 is zoned 'Urban deferred' (Figure 1).

2.2.2 District Planning

The Study Area lies within the Mandogalup development cell. A District Water Management Strategy (DWMS) was prepared by JDA (2011) and provides guidance on water reuse options, stormwater detention basins, monitoring requirements and structural and non-structural controls for stormwater treatment. The DWMS is approved by City of Kwinana and Department of Water (DoW).

2.2.3 Local Structure Plan

This LWMS document is a revision of the previously approved LWMS (J5679j) and is presented in support of the revised Local Structure Plan (LSP) as part of the Better Urban Water Management Framework.

The LWMS addresses the LSP area and provides a refinement of the flood modelling and surface water and groundwater management strategy to a local scale. This LWMS is consistent with the DWMS (JDA, 2011) and water sensitive urban design practices as described in the Stormwater Management Manual of WA (DoW, 2007).

2.3 Key Design Principles and Objectives

The LWMS employs the following key documents to define its content, key principles and objectives:

- Peel Harvey WSUD Local Planning Policy (Peel Development Commission, 2006)
- Stormwater Quantity Management Manual for Western Australia (DoW, 2007)

- Better Urban Water Management (WAPC, 2008)
- Guidelines for Subdivision Development (Town of Kwinana, 2010)
- Jandakot Drainage and Water Management Plan – Peel Main Drain Catchment (DoW, 2009)
- Mandogalup District Water Management Strategy (JDA, 2011)

A summary of the key design principles and objectives from these documents is provided in Table 1 and summarised below.

2.3.1 Peel Harvey WSUD Local Planning Policy (Peel Development Commission, 2006)

The Peel Harvey WSUD Local Planning Policy (Peel Development Commission, 2006) was developed through the Federal Government's Coastal Catchments Initiative and endorsed by the Environmental Protection Authority (EPA). It aims to assist local government to help integrate catchment management objectives with land and resource planning in urban landscapes.

The policy identifies broad policy objectives against which strategic and statutory proposals can be assessed.

Water quantity management principles and objectives are provided based on post-development discharges being maintained relative to predevelopment levels. Criteria are provided for both ecological protection (1 in 1 year events), and flood protection (1 in 100 year events). Water quality management principles and objectives are based on maintaining or improving water quality relative to existing conditions.

Specific water quality guidelines are provided in the document including limitations on developments where average input rates of nutrients exceed 15 kg/phosphorus/ha per annum or 150 kg/nitrogen/ha per annum.

The policy is consistent with the *Decision Process for Stormwater Management in WA* (Department of Environment and Swan River Trust, 2005) which is appended to the policy and is consistent with the objectives of the Environmental Protection Policy (Peel Inlet – Harvey Estuary) 1992.

This policy is stated as holding no legal standing and envisages each local government in the Peel Harvey catchment will customise the model policy to suite its own specific requirements.

2.3.2 Stormwater Management Manual for Western Australia (DoW, 2007)

The Water and Rivers Commission (now Department of Water, DoW) released *A Manual for Managing Urban Stormwater Quality in Western Australia* in 1998 to define and practically describe Best Management Practices (BMP's) to reduce pollutant and nutrient inputs to stormwater drainage systems. The Manual also aims to provide guidelines for the incorporation of water sensitive design principles into urban planning and design, which would enable the achievement of improved water quality from urban development.

The document was released to provide a guideline for best planning and management practices and was intended for use by Water and Rivers Commission, but also by other State and Local Government Authorities and sectors of the urban development industry.

DoW completed a major review of the Manual in consultation with a working team comprising industry and government representatives, published in August 2007.

Principle objectives for managing urban water in WA are stated as:

- Water Quality: To maintain or improve the surface and groundwater quality within development areas relative to pre-development conditions
- Water Quantity: To maintain the total water cycle balance within development areas relative to the pre-development conditions
- Water Conservation: To maximise the reuse of stormwater
- Ecosystem Health: To retain natural drainage systems and protect ecosystem health
- Economic Viability: To implement stormwater systems that are economically viable in the long term
- Public Health: To minimise the public risk, including risk of injury or loss of life to the community
- Protection of Property: To protect the built environment from flooding and waterlogging
- Social Values: To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater
- Development: To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles

2.3.3 Better Urban Water Management (WAPC, 2008)

The guideline document Better Urban Water Management (WAPC, 2008), focuses on the process of integration between land use and water planning and specifying the level of investigations and documentations required at various decision points in the planning process, rather than the provision of any specific design objectives and criteria for urban water management.

This LWMS complies with the BUWM process.

2.3.4 Guidelines for Subdivision Development (Town of Kwinana, 2010)

The Town of Kwinana (ToK) Guidelines for Subdivision Development (ToK, 2010) provides details of the Town's requirements regarding stormwater drainage management. The document provides both general guidelines at the strategic conceptual design level and also more specific detailed criteria for design of drainage of systems (grades, subsoil drainage etc).

At the strategic level key design guidelines are citied as follows:

- Australian Rainfall and Runoff (Institution of Engineers Australia, 1987).
- Stormwater Drainage Design in Small Urban Catchments (J Argue, ARRB Special Report No 34).
- Subsurface Drainage of Road Structures (RJ Gerke, ARRB Special Report No 35).

- Water Sensitive Urban (Residential) Design Guidelines for the Perth Metropolitan Region (Whelans et al, 1993).

- Stormwater Quality Management Manual (Water and Rivers Commission, 1998).

Specific criteria in relation to stormwater/groundwater are detailed as:

- Examine the total drainage catchment area and ensure that any upstream drainage may pass through the subdivision.

- Drainage network is designed to 10yr ARI except for arterial drainage and compensating storages to be designed to a 20yr ARI.

- Floor levels minimum 500 mm above 100yr flood level in storages, main drains and watercourses.

- The pre-development AAMGL generally be maintained following development. Where AAMGL is within 1.2 m of the design surface level, subsoils will be installed at AAMGL and fill will generally be imported. Subsoils are generally provided as a separate system.

- Water Sensitive Urban Design principles incorporated into the design.

- Open Drainage facilities have 1:6 side slopes.

- Nutrient filtration to occur prior to drainage water being released to a Water Corporation Main Drain.

2.3.5 Jandakot Drainage and Water Management Plan (DoW, 2009)

The Jandakot Drainage and Water Management Plan (DWMP) provides guidance on the management of stormwater in the Peel Main Drain Catchment, and was prepared by DoW to support the Jandakot Structure Plan (WAPC, 2007)

The scope of the DWMP is to cover aspects of total water cycle management, including;

- Protection of significant environmental assets within the structure plan, including meeting their water requirements, managing potential impacts from development and protecting their cultural value.

- Alternative water supply options, opportunities for conservation and demand management measures, and wastewater management.

- Surface runoff, including both peak event (flood) management and the application of water sensitive urban design principles to frequent events.

- Groundwater, including the impact of urbanisation, variation in climate, installation of drainage to manage groundwater levels, potential impacts on the environment and the potential to use groundwater as a resource.

- Water quality management, which includes source control of pollution inputs by catchment management, acid sulphate soil management, control of contaminated discharges from industrial areas and management of nutrient exports from surface runoff and groundwater through structural measures.

2.3.6 Mandogalup District Water Management Strategy (JDA, 2011)

The DWMS was prepared to support rezoning of Satterley (MELSP) and QUBE (MWLSP) landholdings in Mandogalup (refer to Figure 1) and demonstrate that the area was capable of supporting the proposed urban zoning.

The aim of the DWMS as summarised in the strategy is to:

1. Define land area requirements for conveyance of flood flows and protection of future development from peak flood events;

2. Propose a drainage design strategy appropriate for local conditions in the strategy area that incorporates best practice water sensitive urban design measures. The strategy identifies Water Sensitive Urban Design (WSUD) practices to be implemented within both private allotments and the public domain, and the legal mechanisms by which all identified practices will be implemented;

3. Prescribe the design criteria for water quantity and water quality for each catchment;

4. Outline the hydrologic and hydraulic framework parameters and subsequently develop the overall drainage network concept;

5. Define an implementation framework for the drainage design objectives; and

6. Recommend monitoring programs for water quantity and water quality pre and post development as well as for ensuring hydraulic performance over the lifetime of the drainage structure.

2.4 Application of Key Design Principles and Objectives

When comparing the MELSP and the MWLSP water management strategies, both have adopted the principles and objectives outlined in Section 2.3 to achieve the best water management outcome given site constraints. The drainage strategy in this LWMS for MWLSP differs from the MELSP in that MWLSP has less separation to groundwater, thus a less intensive infiltration strategy has been proposed.

The key design strategies adopted at MWLSP and MELSP are as follows:

- MWLSP – Infiltration of the 1yr 1hr ARI in local parks using structural treatment measures. All events >1yr ARI will be detained within POS areas and discharged into the PMD at allowable peak outflow rates.

- MELSP - Infiltration of 5yr ARI event runoff as close to source as possible using a variety of structural treatment measures located throughout the catchment. All events >5yr ARI will be detained within POS areas and discharge into the PMD at allowable peak outflow rates (see Section 5.5).

3. PROPOSED DEVELOPMENT

The Study Area considered in this LWMS is 68 ha and situated within the southern corridor of the Perth Metropolitan Region, approximately 23 km south of the Perth CBD. The previous LWMS document prepared by JDA (2015) for Qube Land, Mandogalup, included the 28 ha 'Urban deferred' area (see Figure 1). Development of this area is currently on hold other than for drainage purposes.

The site is bound by Kwinana Freeway to the east, Rowley Rd to the north and existing bushland and pasture to the east and south (Figure 1).

The proposed land use is for residential development, consistent with regional planning. The Structure Plan for the Study Area is shown on Figure 1.

Key elements of the Structure Plan related to urban water management include:

- Use of bio-retention treatment systems for detention and treatment of stormwater;
- Retention of the existing Peel Main Drain alignment and hydraulic capacity through the Study Area, but redefine the drain to an urban standard;
- Utilise the Western Power Easement for provision of some drainage detention storage;
- Use of higher density urban residential zonings to reduce landscape nutrient input at a domestic scale (eg. less lawn and garden area corresponds to lower fertiliser application); and
- The extensive use of local native species in open spaces, streetscapes and wetland buffers to reduce nutrient input and conserve water resources.

4. PRE-DEVELOPMENT ENVIRONMENT

4.1 Existing Land Use

The Study Area is currently undeveloped with the southern portion extensively cleared. The southern portion is used for market gardens and grazing, primarily consisting of degraded bushland and pasture. The northern portion of the site consists primarily of degraded bushland with a portion cleared for the Western Power Easement (Figure 2).

4.2 Topography

The existing topography of the Study Area is shown on Figure 2. The Study Area generally slopes from north to south, with a high point of 41 mAHD at the north western edge of the Study Area and a low point of 19 mAHD at the south western corner.

4.3 Climate

The Mandogalup area is characterised by a Mediterranean climate with warm dry summers and cool wet winters.

Rainfall data provided is from the nearby Bureau of Meteorology Medina Research Station (Site No. 9194).

The long term average annual rainfall is 760 mm (1986 to 2013). This average has decreased between 2000 to present, to an average annual rainfall of 639 mm, reflecting a 18% reduction compared to the long term average.

The seasonal distribution has also altered since 2000, with a reduction of average monthly totals in the winter months, but no reduction in monthly rainfall in summer months.

The average annual pan evaporation is approximately 1900 mm (Luke et al, 1987).

4.4 Geology and Soils

Surface geology mapping by Gozzard (1983) is shown on Figure 3.

The Study Area is situated within the Bassendean Dune system (S7, S8 and S10) and is overlaid in places by swamp deposits (Cps and Ms5). The thickness of the Bassandean Sands varies and overlies clays of the Guildford Formation. The Bassendean Sands are characterised as “very light at surface, yellow at depth, fine to medium grained, sub-rounded quartz moderately well sorted of aeolian origin” (Gozzard, 1983).

A geotechnical investigation was carried out by Galt Geotechnics (2014) with results generally in accordance with Gozzard (1983) mapping:

- Majority of the site: Sand, fine to coarse grained, sub-angular to sub-rounded, generally grey becoming pale yellow/white with depth.

- Southwest corner of the site: Silty sand/sand, fine to coarse grained, sub-angular to sub-rounded, grey, trace non-plastic fines in top 100 to 200mm.

4.5 Acid Sulphate Soils

According to mapping published by the Department of Environment and Conservation (2010), the Study Area consists of:

- High to moderate risk of Acid Sulphate Soils (ASS) occurring less than 3m from surface in the southern portion of the Study Area.
- Moderate to low risk of ASS occurring less than 3m from surface in the central to northern portion of the Study Area.

Regional Acid Sulphate Soil mapping is shown on Figure 3.

Detailed ASS investigations will be undertaken at the time of subdivision. In the event that any ASS is encountered an Acid Sulphate Soil Management Plan will be prepared and implemented as part of the subdivision process in accordance with WAPC Bulletin No. 64 (WAPC, 2003).

4.6 Surface Water Hydrology

4.6.1 Existing Surface Drainage

The existing local drainage network in relation to the Study Area is shown on Figure 4.

The Peel Main Drain (PMD) runs east to west through the southern part of the Study Area, and discharges into Mandogalup Swamp at the southern boundary of the Study Area and the Spectacles Wetland south of Anketell Rd. The PMD outlets at the Serpentine River, which flows to the Peel Harvey Estuary (Figure 4).

The Peel Main Drain has been modelled by DoW in the Jandakot DWMP (DoW, 2009) as described in Section 2.3.5. A maximum flood level for the 100yr ARI was established at 16.1 mAHD upstream of the Mandogalup Swamp, causing inundation of the Mandogalup Swamp area along the southern boundary of the Study Area. The balance of the Study Area is not expected to be affected by flooding.

4.6.2 Surface Water Quality

Surface water quality in PMD was measured by JDA as part of pre-development monitoring from April 2007 to March 2009 (JDA, 2010). Results indicate the PMD is characterised by high nutrient concentrations and pH levels generally less than 6.5, consistent with other drains in the area and historic land use. Water quality data is provided in Appendix B.

4.7 Wetlands

The Department of Environment and Conservation Geomorphic Wetlands of the Swan Coastal Plain Wetland mapping shows the boundaries and locations of wetlands in the Study Area (Figure 6). The majority of Study Area is classified as Multiple Use Dampland. The Multiple Use category does not preclude urban development.

No wetlands will be retained within the Study Area.

To the south of the Study Area is the Spectacles Wetland, an Environmental Protection Policy (EPP) listed lake containing significant flora, a number of significant mammal and reptile species and an important waterfowl breeding site. The Peel Main Drain contributes approximately 48% of the water entering the Spectacles, with the remainder from groundwater through-flow (DoW, 2009).

4.8 Groundwater Hydrology

There are two aquifers of significance underlying the Study Area; each assigned the name of the major geological unit in which the aquifer occurs. In descending order of depth from natural surface they are:

- Superficial Aquifer (unconfined, +20 to -25 mAHD)
- Leederville Aquifer (confined, -25 to -250 mAHD)

4.8.1 Superficial Aquifer

The Superficial Formation is of quaternary age and consists of a thin veneer of sand (Bassendean Sand) overlying sandy clay and clay (Guildford Formation). The Superficial Formation forms an unconfined aquifer containing generally fresh to slightly brackish groundwater (500 to 1500 mg/L Total Dissolved Solids), with slightly acid to neutral pH (5 to 7) (Davidson, 1995). The water table is shallow, rising in places to the surface during winter, depending on surface elevation.

Pre-development groundwater monitoring was completed by JDA from April 2007 to March 2009 with a total of 8 bores installed by JDA during February and March 2007. Of the 8 bores installed 5 reside within the Study Area discussed within this report; D1, D2(s), D2(d), D4(s) and D4(d) (JDA, 2010) with the remaining three located in the southern portion of the greater development area (D3, D5(s) and D5(d)). The highest water level in all bores was recorded on 7 August 2008.

Bore details and location are presented in Table 2 and shown in Figure 7. A time series plot of water levels recorded in the bores is included as Appendix C, along with the lithological logs for each bore provided in Appendix D.

TABLE 2: DETAILS OF GROUNDWATER MONITORING BORES

Bore ID	GDA Coordinates		Top of Casing (mAHD)	Water Levels 7 August 2008 (mAHD)	Estimated Pre-development AAMGL (mAHD)	Estimated Pre-development MGL (mAHD)
	Easting	Northing				
D1	391871	6438874	27.50	19.88	20.55	21.49
D2(s)	391964	6438425	22.11	19.86	20.53	21.47
D2(d)	391964	6438424	22.04	19.81	20.48	21.42
D3	391341	6437726	26.38	13.96	14.63	15.57
D4(s)	391973	6437637	20.06	18.01	18.68	19.62
D4(d)	391971	6437636	20.07	18.10	18.77	19.71
D5(s)	391267	6437341	13.77	13.09	13.00*	13.00*
D5(d)	391267	6437342	13.81	13.13	13.00*	13.00*

Notes: m BNS = metres Below Natural Surface
m AHD = metres Australian Height Datum
(s) shallow (d) deep
* Corrected back to existing ground elevation

To correlate the groundwater levels measured 18 September 2007 to long-term groundwater monitoring, groundwater levels were also recorded in Department of Water (DoW) monitoring bores JE12C, JM41, JM42 and JM49.

TABLE 3: DETAILS OF DOW MONITORING BORES

Bore ID	Record Period	Top of Casing (mAHD)	Water Level 7 August 2008 (mAHD)	AAMGL (mAHD)	Difference (m)	MGL (mAHD)	Difference (m)
JM42	1975 - 2007	25.80	21.48	22.70	+1.22	23.64	+2.37
JM49	1980 - 2007	26.67	23.86	23.82	-0.04	24.36	+0.63
JE12C	1984 - 2007	37.08	19.05	19.86	+0.81	20.70	+1.82
Average					+0.66		+1.61

For each of the DoW monitoring bores an Average Annual Maximum Groundwater Level (AAMGL) was calculated, which is an average of the winter peak levels over the period of record. Based on the water levels recorded in the DoW bores (Table 3) a correction of 0.66 m was applied to the water levels measured in the JDA bores on the same date to estimate the AAMGL for the JDA bores. AAMGL contours and depth to AAMGL from the existing natural surface are shown on Figure 7.

For each of the DoW monitoring bores a Maximum Groundwater Level (MGL) is presented in Table 3; this represents the peak measured groundwater level over the period of record. The maximum difference between MGL and AAMGL was 0.94 m (in bore JM42). This value has been used to calculate the estimated pre-development MGL in Table 2.

Groundwater controls used to manage post-development groundwater levels will be set at AAMGL as described in Section 5.5.

Groundwater quality monitoring of bores D1, D2(s), D2(d) D3, D4(s), D4(d), D5(s) and D5(d) was completed monthly by JDA from April 2007 to March 2009 (JDA, 2010). Samples were analysed for physical parameters and nutrients. Groundwater quality results are attached as Appendix E.

ANZECC 95% guideline values for wetlands of south west Australia (ANZECC, 2000) have been used for water quality parameter comparison where no local reference data is available. When assessing phosphorus results the Peel Harvey Water Quality Improvement Plan (Peel Harvey WQIP) (EPA, 2008) total phosphorus targets for the rivers and estuary of the Peel-Harvey System have been used in preference to ANZECC 2000 guideline values.

A summary of the monitoring results are as follows:

- Average Total Nitrogen (TN) concentrations for all bores were above the ANZECC 2000 TN guideline of 1.2 mg/L.
- Average Total Phosphorus (TP) concentrations for all bores were above the Peel-Harvey WQIP TP target value of 0.1 mg/L.
- The pH is slightly acidic to neutral (4.7 to 7.1) and below ANZECC guideline values.

The Study Area is characterised by high nutrient concentrations and pH levels generally less than 6.0. Groundwater quality at the water table, within the Bassendean Sand, is generally acidic due to organic acids generated by decomposition of vegetation in swampy environments. High nitrate and phosphorous

levels are present in the superficial aquifer in areas of intensive horticulture as a direct result of fertiliser leaching (Davidson, 1995).

4.8.2 Leederville Aquifer

The Leederville Aquifer is of Cretaceous age and consists of inter-bedded sandstone, siltstone and shale made up by the Mariginiup, Wanneroo and Pinjar members and the Henley Sandstone Formation. The Leederville Aquifer is a major regional aquifer, from which large yields of fresh groundwater can be obtained. The groundwater in the Leederville Formation is under pressure (confined) with the potentiometric surface in this area at approximately ground level (Davidson, 1995).

The South Perth Shale is present from -260 to -310 mAHD and forms the confining layer between the Leederville Aquifer and Yarragadee Aquifer.

4.8.3 Groundwater Resources for Irrigation

The Superficial Aquifer is the most cost effective groundwater source for irrigation of POS for the development.

The Study Area is located within the Jandakot Groundwater Area and the Mandogalup Groundwater Sub-area. As of 3 June 2014, DoW reported 1,626,265 kL/yr available for allocation.

A groundwater licence (GWL166922) is current for Lots 23, 663, 791 Norkett Rd, Lots 664, 668, 682 Mandogalup Rd and Lot 52 Rowley Rd, Mandogalup, issued to the Mandogalup Land Development Company Pty Ltd. The licence allocation is 724,935 kL/yr and expires 29 May 2022.

5. LOCAL WATER MANAGEMENT STRATEGY

5.1 Water Balance

The water balance of the Study Area will be influenced by the frequency and intensity of rainfall and evapotranspiration. As the most reliable estimates of rainfall, evaporation, transpiration and recharge are at a regional scale, for the purpose of this water balance assessment average annual values have been assumed and the site has been considered as a whole.

Pre-development Water Balance

The pre-development water balance assumptions are as follows;

- Rainfall based on the long term annual average for Medina Research Station of 760 mm.
- Recharge is 20% of rainfall as estimated in Davidson and Yu (2008).
- The balance of inputs is discharged as surface runoff to the Peel Main Drain.

Post-development Water Balance

Assumptions for the post-development water balance are as follows;

- Water supply for all POS irrigation will be met by local groundwater supplies. Irrigation rate of 7,500 kL/ha/yr is assumed consistent with DoW allocation.
- 10% of landowners assumed to have a private bore for irrigation supply, and gardens make up 7.5% of a lot.
- Recharge is maintained at the pre-development volume.
- Surface runoff matches pre-development flows.
- The balance of inputs will be discharged via subsoil drainage.

Results of the water balance are presented in Table 4.

TABLE 4: STUDY AREA WATER BALANCE

Pre Development		Use	Area (ha)	Quantity mm/yr		Total kl/yr	% (Approx)
Inputs	**Rainfall**		68	760		516800	100
					Input total	516800	
Outputs							
	Evapotranspiration	*Degraded Bush*	31	500		155000	30
		Cleared Pasture	37	600		222000	43
	Superficial aquifer recharge					103360	20
	Surface Runoff					36440	7
					Output total	516800	100
					Balance	0	
Post Development		**Use**	**Area (ha)**	**Quantity mm/yr**		**Total kl/yr**	
Inputs	**Rainfall**		68	760		516800	91
	Water supply						
	Groundwater abstraction	*POS*	6.8			51000	9.0
		Domestic	0.24			1800	0.3
					Input total	569600	100
Outputs							
	Evapotranspiration	*Urban*	2.4	1200		28800	5
		Parks	6.8	1200		81600	14
	Superficial aquifer recharge					103360	18
	Surface Runoff					40163	7
	Subsoil Discharge					315677	55
					Output total	569600	100
					Balance	0	

5.2 Water Sustainability Initiatives

5.2.1 Water Supply

Public Open Spaces

Considering the fit for purpose strategy, the water supply for the public open spaces is proposed to be from local groundwater resources.

Residential Lots

Water supply to households will be via extension of the scheme water system. The project civil engineer will negotiate extension of the system with Water Corporation. The LSP has been advertised and Water

Corporation raised no objections. Water Corporation have adopted water and wastewater conveyance planning to guide servicing of the Study Area (Appendix F).

5.2.2 Water Efficiency Measures

Public Open Spaces

The estimated irrigation area for the development is approximately 10 ha, which includes POS, POS verges, Peel Main Drain, main boulevards and an entry statement off Rowley Rd. Approximately 75,000 kL/yr would be required, based on DoW recommendation for 7,500 kL/ha/yr. A further 7,500 kL/yr will also be required for the primary school site based on an approximate irrigation area of 1 ha. This will be sourced from the unconfined groundwater reserves consistent with a fit for purpose strategy.

Where appropriate, native species will be used in selected garden bed areas within landscaped Public Open Space. Native species should make up at least 50% of the total plants across the development. The irrigation system will be designed to water wise principles.

Residential Lots

To achieve water efficiency targets, it is envisaged that households will be built consistent with current BCA water efficiency standards.

5.3 Wetland Management

The following key measures will be implemented to ensure the wetlands and watercourses to the south and east of the site, including Mandogalup Swamp, will not be negatively impacted by urban runoff:

- All stormwater and groundwater discharge from the estate will be treated prior to discharging to the Peel Main Drain (Refer Section 5.6).
- Peak outflows will be consistent with Jandakot DWMP.

5.4 Stormwater Management

5.4.1 District Drainage

The alignment of the Peel Main Drain will be preserved through the Study Area. It is proposed to redefine the drain to an urban standard, which will require re-grading of the batters to more gentle grades so the drain can be incorporated into POS areas without boundary fencing. The final drain profile must achieve sufficient hydraulic capacity to convey the post-development 100 yr ARI flow, as specified in the Jandakot DWMP, and maintain the current Drain easement width of 20m.

The Drain's final urban form is expected to be similar to the recently modified drain in North Wandi, which utilises 1:3 (v:h) and 1:6 batter slopes (Figure 9). It is envisaged that the maintenance requirements and responsibilities will also be the same as North Wandi. QUBE will consult with Water Corporation and the City of Kwinana in regards to treatment and approval of the Peel Main Drain design (including final drain profile). Landscaping of the Peel Main Drain will be undertaken by the developer.

It should be noted that levels presented for both pre and post-development scenarios differ from those shown in the Jandakot DWMP (DoW, 2009). The Peel Main Drain invert information provided in the

DWMP is incorrect. A drain survey completed by McMullen Nolan (2009) has been utilised in JDA's modelling. Figures 8 and 9 show the post-development HGL matches the pre-development HGL.

Mandogalup Swamp

The DWMS Study Area covers Mandogalup Swamp, a highly modified wetland currently used for agriculture. The Jandakot DWMP identifies Mandogalup Swamp as a regional flood storage area, reducing peak flows to the Spectacles Wetland.

The DWMP assessed four scenarios for post-development land use and associated changes with the Swamp. Based on the magnitude of impact of the removal of the Swamp, the Department of Water and Town of Kwinana agreed that the Mandogalup Swamp can be developed in line with Scenario 3, i.e. Mandogalup Swamp North is partially retained – only the power line and pipeline corridors remain undeveloped. Adoption of this Scenario allows for an increase in discharge from pre-development flows and a reduction in storage volume in Mandogalup Swamp (Figure 4).

The water level and volume in Mandogalup Swamp North for 100 year storm event with pre- and post-development land use is summarised in Table 5. The Mandogalup DWMS was prepared on the basis of the adoption of Scenario 3.

TABLE 5: WATER LEVEL AND VOLUME IN MANDOGALUP SWAMP NORTH

Scenario	Water Level (mAHD)		Storage Volume in Mandogalup Swamp (m^3)	PMD Discharge at Mandogalup Road (m^3/s)
	Mandogalup North	Spectacles North		
Pre- Development Scenario	13.5	9.4	85,900	1.5
Post-development Scenario 3, (swamp partially retained – power line and pipeline corridors only)	13.7	9.6	68,700	2.0

5.4.2 Allowable Flow Rates

The Study Area is located within sub-catchments CAT17A, CAT18A and CAT19 of the DWMP (DoW, 2009), as shown on Figure 5. The allowable peak flow rates from the Study Area have been calculated based on a pro-rata analysis of the peak flows shown in Table 6, which is also presented in the DWMS (JDA, 2011).

TABLE 6: PEAK ALLOWABLE OUTFLOW RATES

Catchment	DWMS Catchment Area (ha)	Peak Allowable Outflow (m^3/s)	Area within LWMS (ha)	LWMS Pro-rata Allowable Outflow (m^3/s)
CAT17A	85.2	0.16	2.85	0.005
CAT18a	77.6	0.29	4.88	0.018
CAT19	97.4	0.10	60.60	0.062
Total	**260.2**	**0.55**	**68.3**	**0.085**

Flow rates presented in Table 7 below are based on the total allowable outflow of 0.085 m^3/s and shown on Figure 5.

TABLE 7: LWMS CATCHMENTS AND ALLOWABLE OUTFLOW RATES

Catchments	Area (ha)	Peak 100yr ARI Allowable Outflow (m^3/s)
A	32.1	0.040
B	16.0	0.020
C	10.6	0.013
D	7.3	0.009
School	2.0	0.003
Total	**68.0**	**0.085**

5.4.3 Local Stormwater Management

The stormwater drainage system will be designed using a major/minor approach. The major drainage system is defined as the arrangement of roads, drainage reserves, detention basins and open space planned to provide safe passage of stormwater runoff from major events which exceed the capacity of the minor system, typically greater than 5yr ARI. The major drainage system is described below with the key elements of the drainage system shown in Figure 10.

The minor drainage system is defined as the series of pipes, kerbs and gutters etc. designed to carry runoff generated by low frequency ARI storms, typically less than 5yr ARI. The minor drainage system incorporates a treatment train of best management practice (BMP) water quality structural controls that provide water quality treatment from the proposed development.

JDA and the project engineers Cossill & Webley have negotiated with Western Power to utilise the power transmission corridor for flood storage attenuation. A meeting on 21 March 2014 clarified minimum requirements and further information required for Western Power to consider the proposal. As a result an Earth Potential Rise/Low Frequency Induction Report was provided to Western Power by QUBE which approved the use of the power easement for flood storage attenuation. Correspondence with Western Power is provided in Appendix G. Additionally, Western Power have reviewed the previous version of this LWMS (JDA, 2016; ref. J6313a) and approved the drainage concept within the easement (Appendix G).

Major Drainage System

The major drainage system is designed to manage rainfall events greater than the 5yr ARI, up to the 100yr ARI.

The design strategy is consistent with the objectives provided in the DWMS. Key points of the major drainage system strategy are as follows:

- Discharge rates from detention basins will be controlled to allowable peak flow rates where possible. All outflow into the Peel Main Drain will meet allowable peak flow rates (Table 7).
- All lot finished levels will have a minimum 0.5m clearance above the estimated 100yr ARI flood level of the detention storages.
- Storage areas to have a minimum separation of 0.5 m from post development Controlled Groundwater Level (CGL).

- In Catchment A, events above the 1 yr 1 hr ARI will be stored within the Western Power easement (Figure 11).

- In Catchments B to D, events above the 1 yr 1 hr ARI will be diverted to a separate detention basin. Detail of the diversion structure is shown in Figures 12 to 14.

- A provision has been made for an outflow from the portion of the school within the Study Area until the final school layout is resolved.

The design strategy is consistent with the objectives provided in the DWMS (JDA, 2011). Results for the major drainage system are presented in Table 11 and shown in Figures 10 to 15.

It is important to note that storage basins for catchments B and D, depicted in Figure 10, currently reside outside of the Study Area within QUBE landholdings. An easement will be created over the basins in favour of the City of Kwinana, to be extinguished when the land is subdivided.

Minor Drainage System

The minor drainage system is designed to manage rainfall events up to the 5yr ARI. To meet the design criteria for the minor drainage system, the following strategies are proposed:

- All lots to have soakwells to infiltrate the 1 yr 1 hr ARI rainfall event.

- Where lot area is 350m^2 or less, soakwells are to be interconnected within the lot.

- The roadside pipe network will be sized to convey the 5 yr ARI flow.

- Drainage treatment train systems will have the minimum capacity to treat the 3 month ARI event.

- The 1 yr 1 hr will have a free flowing outlet into a bioretention basin. Flows above the 1 yr 1 hr will be diverted to a separate detention basin. Detail of the diversion structure is shown in Figures 12 to 14.

- In Catchment A, events above the 1 yr 1 hr ARI will be stored within the Western Power easement (Figure 11).

- A provision has been made for an outflow for events above the 1 yr 1 hr ARI from the portion of the school within the Study Area until the final school layout is resolved.

The design strategy is consistent with the objectives provided in the DWMS (JDA, 2011). Results for the minor drainage system are presented in Table 11 and shown in Figures 10 to 15.

As mentioned above the storage basins for catchments B and D, depicted in Figure 10, currently reside outside of the Study Area within QUBE landholdings. An easement will be created over the basins in favour of the City of Kwinana, to be extinguished when the land is subdivided.

5.4.4 Surface Water Modelling

The bioretention and detention storages have been modelled using XP-STORM. The storage locations were determined based on existing topographic contours, survey levels, depth to groundwater mapping and local structure plan constraints (Figure 10). Storage elevations were set at least 0.5 m above the

CGL for modelling purposes. Basin side slopes of 1:6 were assumed. Existing drain inverts were maintained as per Section 5.4.1.

The design storms modelled in XP-STORM were calculated according to the methodology in Australian Rainfall & Runoff (AR&R) (Institution of Engineers Australia, 1987). The rainfall temporal pattern was assumed to be spatially uniform across the catchment. Storm durations modelled ranged from 10 minutes to 72 hours.

For the purposes of drainage calculations the residential lots have been categorised into 'standard' (>350 m^2) and 'compact' lots (<350 m^2) with the smaller compact lots contributing a greater volume of runoff to the council drainage system compared to the larger standard lots.

The runoff coefficients adopted in the model are presented in Table 8 with calculations presented in Appendix I. Modelling parameters are shown in Appendix H. Catchment land use breakdown is provided in Table 10.

TABLE 8: RUNOFF PARAMETERS FOR XP-STORM MODEL

Land Use	Initial Loss (mm)	Continuing Loss (mm/hr)	Proportional Loss (%)
Standard Lots (> 350m^2)	15	8	-
Compact Lots (≤ 350m^2)	15	8	-
Road	-	-	0.2
Public Open Space	-	-	0.9
Peel Main Drain	-	-	0.65
Western Power Easement	47.6	-	0.9

TABLE 9: POST-DEVELOPMENT LWMS CATCHMENT LAND USE BREAKDOWN

Land Use (ha)	A	B	C	D	Primary School
Standard Lots (> 350m^2)	11.09	7.46	3.91	2.86	-
Compact Lots (≤ 350m^2)	2.61	1.92	1.05	1.65	-
Retail	0.15	-	-	-	-
Road	7.36[1]	4.25[2]	3.14	2.22[3]	-
Public Open Space	4.26	0.69	1.63	0.21	-
Western Power Easement	6.67	1.35[2]	0.91	-	-
Peel Main Drain	-	0.34	-	0.31	-
Primary School	-	-	-	-	2.01
Total Area (ha)	**32.14**	**16.01**	**10.63**	**7.25**	**2.01**

1. Includes 0.20 ha external road.
2. Includes 0.34 ha external road and 0.30 ha external undeveloped rural land.
3. Includes 0.45 ha external North-South connector road.

XP-STORM modelling results are presented in Table 10 and shown on Figure 10.

TABLE 10: XP-STORM MODEL RESULTS FOR DETENTION STORAGE A, B, C, D & E

Post-Development Storage: (see Figure 10)	A		B		C		D		Primary School
	1yr 1hr Basin	>1yr Basin	1yr 1hr Basin	>1yr Basin	1yr 1hr Basin	>1yr Basin	1yr 1hr Basin	>1yr Basin	
Storage Data									
Storage Invert (mAHD)	20.80	20.80	17.00	16.50	20.00	19.55	17.25	17.00	22.00
Outlet Level (mAHD)	21.30	20.80	-	16.50	-	19.55	-	17.00	22.30
100yr									
Critical Storm Duration (hrs)	24		48		24		6		48
Storm Rainfall (mm)	133		177		177		80		176
Runoff Volume (m^3)	10,170		7330		4075		2265		1056
Water level rise (m)	0.55	0.50	0.50*	0.95*	0.60	0.95	0.60	0.75	1.00
Top Water Level (mAHD)	21.35	21.30	17.50*	17.45*	20.60	20.50	17.85	17.75	23.00
TWL Surface Area (m^2)	2250	11,610	1890*	7890*	940	2820	700	2660	1024
Stored Volume (m^3)	1000	5200	900*	6400*	500	2000	300	1600	690
Peak Outflow (m^3/s)	1.30	0.056	-	0.076*	-	0.012	-	0.008	0.003
Stored Volume/ Runoff Volume (%)	61		#		61		84		65
5yr									
Critical Storm Duration (hrs)	24		48		24		6		24
Storm Rainfall (mm)	78		98		78		48		78
Runoff Volume (m^3)	5445		3750		2225		1225		780
Water level rise (m)	0.55	0.25	0.50*	0.45*	0.55	0.45	0.55	0.35	0.60
Top Water Level (mAHD)	21.35	21.05	17.50*	16.95*	20.55	20.00	17.80	17.35	22.60
TWL Surface Area (m^2)	2230	10,820	1890*	6830*	930	2240	690	2190	740
Stored Volume (m^3)	1000	2600	900*	2700*	400	800	300	700	340
Peak Outflow (m^3/s)	0.87	0.029	-	0.052*	-	0.010	-	0.005	0.002
Stored Volume/ Runoff Volume (%)	66		#		54		82		43
1yr									
Storm Duration (hrs)	1		1		1		1		1
Storm Rainfall (mm)	15.7		15.7		15.7		15.7		21
Runoff Volume (m^3)	965		550 (1360[#])		410		290		157
Water level rise (m)	0.50	-	0.45*	-	0.50	-	0.50	-	0.30
Top Water Level (mAHD)	21.30	-	17.45*	-	20.50	-	17.75	-	22.30
TWL Surface Area (m^2)	2170	-	1890*	-	870	-	630	-	557
Stored Volume (m^3)	900	-	800*	-	340	-	230	-	140
Stored Volume/ Runoff Volume (%)	93	-	#	-	83	-	79	-	90

* Includes attenuated outflow from Catchments A, C and School

\# Not calculated as storage includes inflow from Catchments A, C and School.

The final configuration (side slopes etc) and exact location of the storage areas will be dependent on final earthworks, drainage and road design levels for the development. The details will be refined at the sub-division stage and reported in the relevant Urban Water Management Plan (UWMP).

5.5 Groundwater Management

Groundwater Management for the Study Area has been prepared in line with design criteria presented in the Mandogalup DWMS (JDA, 2011) and the Stormwater Management Manual for Western Australia (DoW, 2007):

- Manage groundwater levels to protect infrastructure and assets.
- Maintain groundwater regime for the protection of groundwater-dependent ecosystems.
- Protect the value of groundwater resources.
- Reduce nutrients infiltrating to groundwater.

5.5.1 Managing Changes to Groundwater Levels

To protect infrastructure from high seasonal groundwater levels, subsoil drainage will be required as part of the development with the following criteria adopted:

- Subsoils laid in the road network will have free draining outlets to bio-retention basins for treatment prior to discharge to Peel Main Drain.
- Subsoils installed where required to ensure sufficient clearance to lot finished level;
- Subsoils will be set at or above pre-development AAMGL.

Water table mounding will occur between subsoil drain inverts, and will be allowed for in detailed design. Groundwater mounding should be calculated from the nearest subsoil invert level.

Lot finished levels should have a clearance of 1.0 m to the post development groundwater level, which will account for groundwater rise post development and mounding between subsoils. The post development groundwater level will be determined at UWMP stage. Figure 16 shows an indication of where subsoils may be required.

Final subsoil layout will be determined during detailed design, and will affect final post development groundwater levels. Subsoil pipes located in road reserves will discharge into bio-retention areas via free flowing outlets. Bio-retention subsoils will capture infiltrated stormwater and discharge directly to the Peel Main Drain (Catchments B and D) or to the downstream catchment via the basin outlet pipe (Primary School, Catchments A and C), before discharging to the Peel Main Drain.

5.6 Water Quality Management

5.6.1 Nutrient Source Controls

The effective implementation of the structural and non-structural controls as part of the urban development will enhance water quality from this site as a result of the land use change.

Non-structural source controls to reduce nutrient export from the site will focus on reducing the need for nutrient inputs into the landscape. The following strategies are proposed;

- Local native plants make up a minimum 50% of the planted areas and streetscape treatments. Any non-local species will be selected for drought tolerance and low fertiliser requirements.

- Street sweeping and GPT eductions. The UWMP will outline the schedule and cleaning requirements for street sweeping and GPT eductions, which will be co-ordinated with the City of Kwinana.

Structural source controls are proposed to complement the non-structural source controls and provide a complete treatment train for stormwater movement through the development. The following structural controls are considered appropriate for the development area:

- The use of bio-retention systems to treat road runoff. A minimum treatment capacity of approximately 2% of the connected impervious area must be provided.

- A GPT will be installed prior to stormwater discharge in retention basins. The GPT will be sized to treat the 3 month ARI but with capacity to bypass the 5yr ARI.

Subsoils are to be laid at the base of a 500 mm soil profile, which includes 300 mm amended soil media and 200 mm drainage layer. The minimum specifications for all bio-retention systems (swales and storages) are presented in Table 11.

TABLE 11: MINIMUM SPECIFICATIONS FOR BIO-RETENTION SYSTEMS

Item	Specification
Amended soil media	• Minimum 300mm thick. • Phosphorus Retention Index (PRI) >10. • Hydraulic Conductivity in the range of 2.5 and 7.5m/day, once compacted. • Total clay and silt fraction <3% in total (w/w). • Organic matter content <5% (w/w). • Phosphorus content <100mg/kg. • Infiltration testing of material prior to installation and again once construction is complete. On-going testing as per the monitoring program.
Plant selection, planting density and distribution	• As per south-west vegetation guidelines (Monash University, 2014).

Recent research conducted by the Facility for Advancing Water Bio-filtration (FAWB, 2008) indicates that the desired Ksat is in the range of 2.5 to 7m/day, to fulfil the drainage requirements as well as retain sufficient moisture to support the vegetation. The FAWB (2008) research also specifies that for vegetated systems some clogging will occur in the first few years until the vegetation is established. Once the plants are established, the roots and associated biological activity maintain the conductivity of the soil media over time.

It should be recognised that data currently guiding the design of bio-retention systems is only recent and largely based on laboratory testing. Details of plant selection, maintenance and likely nutrient uptake in the Mandogalup environment are not well known at this stage. The specifications provided in this document should be considered as the best available information at the time. Some flexibility in the specifications will be required as the knowledge base increases.

5.6.2 Land Use Change Nutrient Impacts

The UNDO (Urban Nutrient Decision Outcomes) decision support tool (DoW, 2016) has been used to help quantify the nutrient inputs for the post-development scenario. The UNDO tool analyses inputs for Total Phosphorus and Total Nitrogen only. The calculation is provided in Appendix J.

With the implementation of the proposed structural and non-structural control, a reduction of 38% for Phosphorus and 45% for Nitrogen is achieved compared to urban development without WSUD. These estimates correspond to a reduced Phosphorus input of 6.5 kg/ha/yr and a reduced Nitrogen input of 105 kg/ha/yr.

6. IMPLEMENTATION

6.1 Urban Water Management Plan (Subdivision)

Processes defined in Better Urban Water Management (WAPC, 2008) require an Urban Water Management Plan (UWMP) at subdivision stage. With an approved LWMS, a UWMP is required as a condition of subdivision and prior to any subdivision activities.

Further work that is identified for inclusion in the UWMP:

- Design of treatment structures, vegetated swales and dry/ephemeral storages as outlined in the Stormwater Management Manual (DoW, 2007);
- Refinement of catchment areas and configuration (storage side slopes etc) and locations of flood storages once final earthworks, drainage and road design levels are determined for the development;
- Confirmation of subsoil location and levels; and
- Peel Main Drain works and maintenance responsibilities. Maintenance responsibilities should be with the City of Kwinana and be similar to the Honeywood Estate development upstream of the Kwinana Freeway. A maintenance agreement between the City of Kwinana and the Water Corporation will be required.

6.2 Construction Management

6.2.1 Dewatering

Dewatering will be required for some elements of subdivision construction. Given the depth of construction, dewatering will only be in the Superficial Aquifer.

Prior to the commencement of any dewatering, the construction contractor will apply for and obtain from DoW a “Licence to Take Water”. All dewatering will be carried out in accordance with the conditions of this licence. Where possible, construction will be timed to minimise impacts on groundwater and any dewatering requirement.

6.2.2 Acid Sulphate Soils

Management of Acid Sulphate Soils (ASS) will be addressed as a separate process to the urban water management document approvals process (LWMS/UWMP).

ASS will be investigated and managed in accordance with the applicable DEC Acid Sulphate Soil Guideline Series and requirements of dewatering licences as they arise.

6.3 Stormwater System Operation and Management

The re-construction, operation and maintenance of the Peel Main Drain will initially be the responsibility of the developer, ultimately reverting to the City of Kwinana.

The surface and subsoil drainage system will require regular maintenance to ensure correct operation. It is considered the following operating and maintenance practices will be required periodically:

- Removal of debris to prevent blockages.
- Street sweeping to reduce particulate build up on road surfaces and gutters.
- Maintenance of vegetation in Bio-retention Systems/ Storages as outlined in the UWMP.
- Cleaning of sediment build up and litter layer on the bottom of Storages as specified in the UWMP.
- Undertake education campaigns regarding source control practices to minimise pollution runoff into stormwater drainage system.
- Checks on subsoil drainage function.

6.4 Monitoring Programme

The monitoring program has been designed to allow a quantitative assessment of hydrological impacts of the proposed development.

The post-development monitoring program is designed to operate over a 3 year period. The program will be periodically reviewed to ensure suitability and practicality. The program may need to be modified as data is collected to increase or decrease the monitoring effort in a particular area or alter the scope of the programme itself.

The proposed post-development monitoring is to:

- Monitor groundwater levels and quality for 5 (D1, D2, D3, D4 and D5) pre-development groundwater sites for comparison to predevelopment data (Figure 7). Trigger values are provided in Table 12.
- Measure peak outflows and water quality at the main surface water discharge points (S1, S2; see Figure 4). Trigger values are provided in Table 12.

A summary of the proposed monitoring program and reporting schedule is shown in Table 13, with the frequency of water quality target review and the contingency action plan detailed in Table 14.

All sampling is to be conducted according to Australian Standards and all water quality sample testing will be conducted by a NATA approved laboratory.

TABLE 12: GUIDELINE VALUES FOR POST-DEVELOPMENT MONITORING

Parameter		Groundwater					Surface Water	
		D1	D2	D3	D4	D5	S1	S2
Water Level (mAHD)	Max	21.55	21.53	15.63	19.77	14.00	-	-
Peak Flow (m^3/s)	Max	-	-	-	-	-	0.141[2]	
pH[1]	Min[3]	3.80	3.74	3.85	3.22	4.90	4.36	4.36
	Max[3]	7.44	7.08	7.42	6.77	8.95	7.30	7.30
	Median[4]	5.63	5.53	5.84	5.17	7.14	5.97	5.97
EC (ms/cm)	Min	0.08	0.39	0.49	0.43	0.58	-	-
	Max[3]	0.35	0.92	2.09	2.47	0.98	-	-
	Median[4]	0.24	0.67	1.44	1.42	0.74	-	-
TDS (mg/L)	Min	-	-	-	-	-	369	369
	Max[3]	-	-	-	-	-	581	581
	Median[4]	-	-	-	-	-	455	455
TN (mg/L)	Min	0.17	2.50	1.50	2.30	0.82	1.30	1.30
	Max[3]	3.00	39.60	10.32	105.6	4.08	3.48	3.48
	Median[4]	1.23	4.10	4.23	41.50	1.33	2.90	2.90
TP (mg/L)	Min	0.01	1.3	0.04	1.2	0.03	0.12	0.12
	Max[3]	0.92	3.00	0.84	4.8	1.02	0.48	0.48
	Median[4]	0.41	2.03	0.28	3.03	0.16	0.30	0.30

1. pH values to be between range provided
2. Change in peak flow between sites S1 and S2 (Figure 4)
3. 20% applied to maximum recorded pre-development level
4. Third quartile of pre-development results

TABLE 13: MONITORING SCHEDULE AND REPORTING

Monitoring Type	Location	Method	Frequency, Timing & Responsibility	Parameter	Reporting
Groundwater Level	5 monitoring sites (D1 to D5)	Electrical depth probe or similar	Quarterly for 3 years by Developer (Jan, April, July, October)	Water Level (m AHD)	Annual reports to be provided by the developer for a period of 3 years. Reports will be submitted to DoW/CoK within 3 months of completion of the reporting period.
Surface Water Quantity	4 outlets to Peel Main Drain	Continuous logger	Downloaded 3 times per year	Stage (Flow inferred)	
Groundwater Quality	5 monitoring sites (D1 to D5)	Pumped bore samples	Quarterly for 3 years by Developer (typically Jan, April, July, October)	In-situ: pH, EC, temp Lab: TN, TKN, NO_X, Ammonia, TP, FRP, selected metals	
Surface Water Quality	4 outlets to Peel Main Drain	Collected grab samples or rising stage sampler	3 times per year while flowing	In-situ: pH, EC, temp Lab: TN, TKN, NO_X, Ammonia, TP, FRP, selected metals, TDS	

TABLE 14: CONTINGENCY PLANNING

Monitoring Type	Criteria for Assessment	Criteria Assessment Frequency	Contingency Action
Groundwater Level	Groundwater levels not to exceed the estimated post-development phreatic line by more than 1 m	After monitoring occasion	1. Review design and operation of subsoil and stormwater drainage system. 2. Perform maintenance as required.
Surface Water Quantity	Peak flow from Study Area to be consistent with peak flows shown in Table 12.	Annual review of water quantity targets	1. Confirm peak flow from upstream catchment has not increased 2. Review design and operation of detention storage areas 3. Perform maintenance as required
Groundwater Quality	Nutrient concentrations in shallow bores should not exceed 20% of the maximum recorded pre-development level.	Annual review of water quality targets	1. Identify and remove any point sources. 2. Consider reinforcement of Community Education/Awareness program. 3. Review operational and maintenance (e.g. fertilising, cleaning) practices. 4. Consider alterations to POS areas including landscape regimes and soil amendment. 5. Consider modifications to the stormwater system. 6. Consider initiation of community based projects.
Surface Water Quality	Assess performance of vegetated detention storages in nutrient reduction. (Water quality discharging from the Study Area should not exceed 20% of the maximum recorded pre-development level).		

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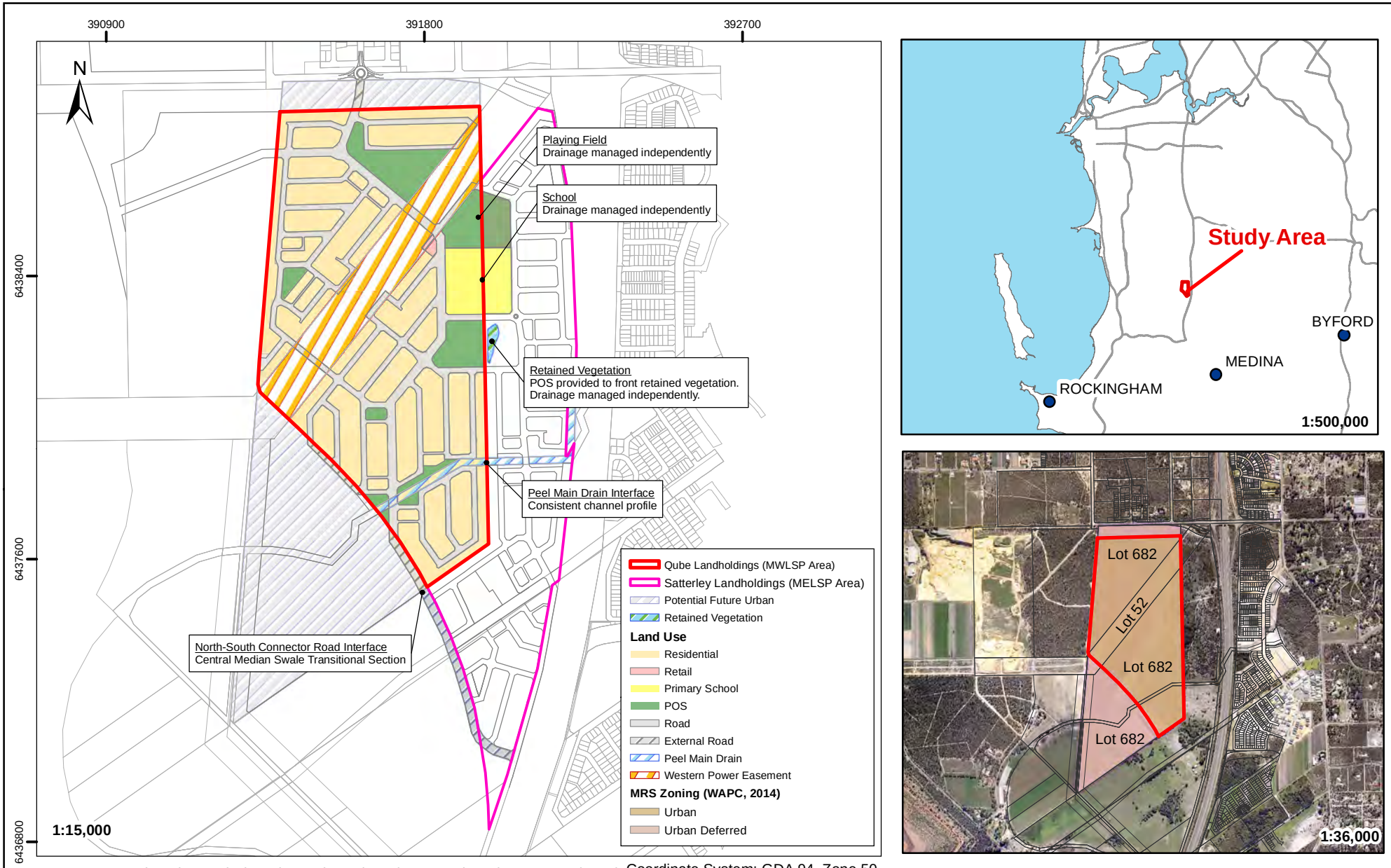
FIGURES



Data Source: Perth Main Roads (2010), Landgate (2012), WAPC (2014), NearMap (2016) Coordinate System: GDA 94, Zone 50

Job No. J6313

0 250 500 750 1,000 Metres

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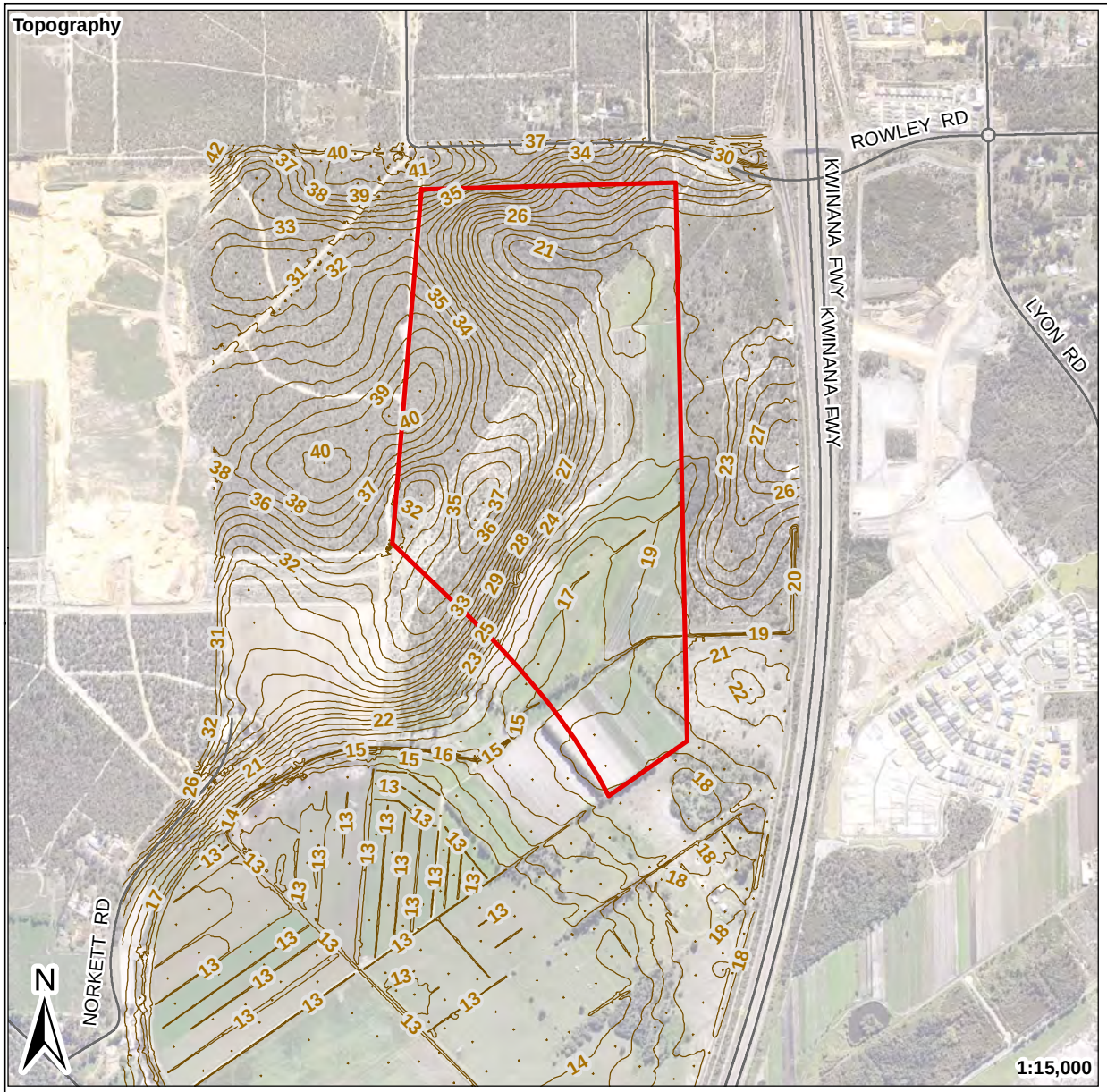
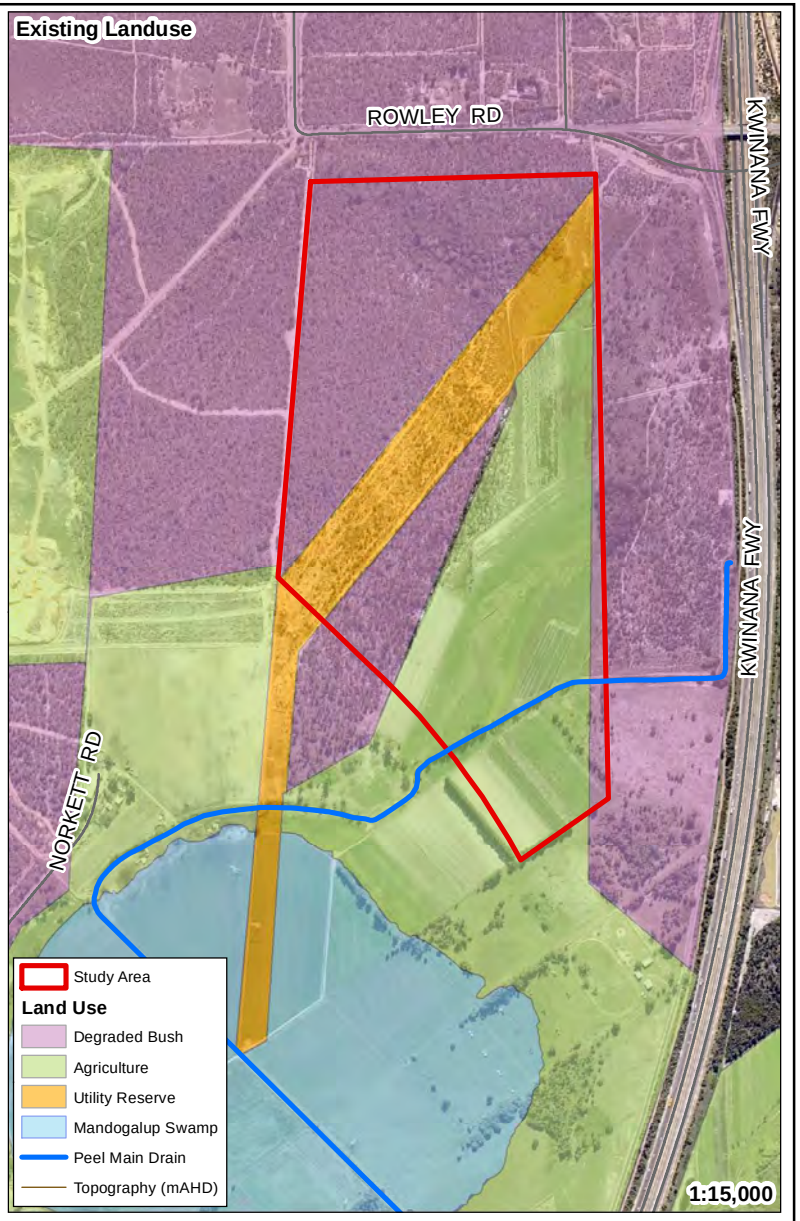
QUBE Property Group Pty Ltd

QUBE Land, Mandogalup West - LWMS

Figure 1: Location and Structure Plan





Job No. J6313
Scale:1:15,000

0 100 200 300 400
Metres

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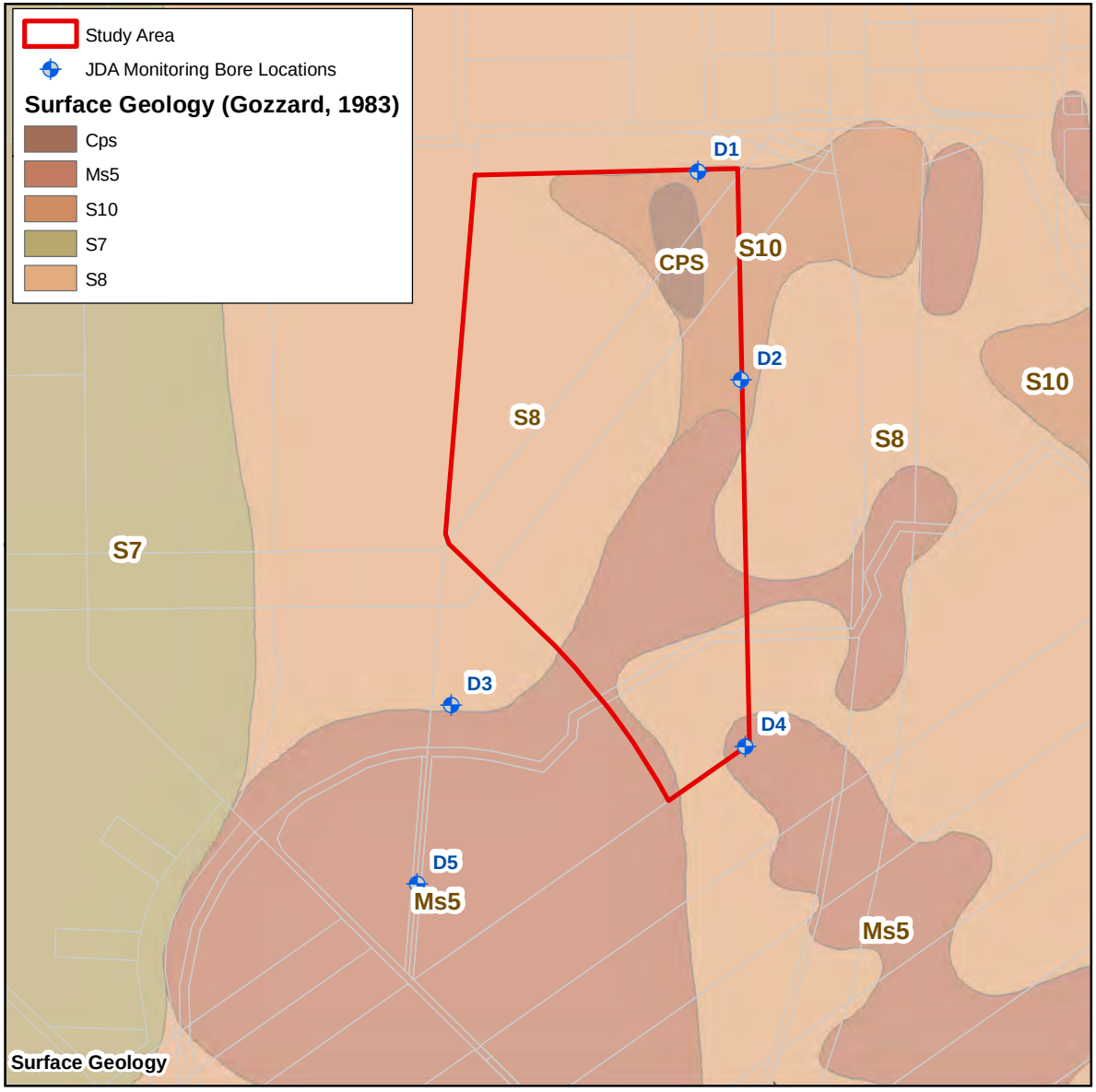
Figure 2: Existing Land Use and Topography



Surface Geology

Cps:PEATY CLAY - dark grey and black, soft, variable organic content, some quartz and sand in places, of lacustrine origin.

Ms5: SANDY SILT - dark brownish grey silt, with disseminated fine grained quartz sand, firm, variable clay content, of lacustrine origin.

S7: SAND - pale yellowish brown, medium to coarse grained, sub angular quartz, trace of feldspar, moderately sorted, of residual origin.

S8: SAND - very light grey at surface, yellow at depth, fine to medium grained, sub-rounded quartz, moderately well sorted, of eolian origin as relatively thin veneer over C2, M4 and Mc2.

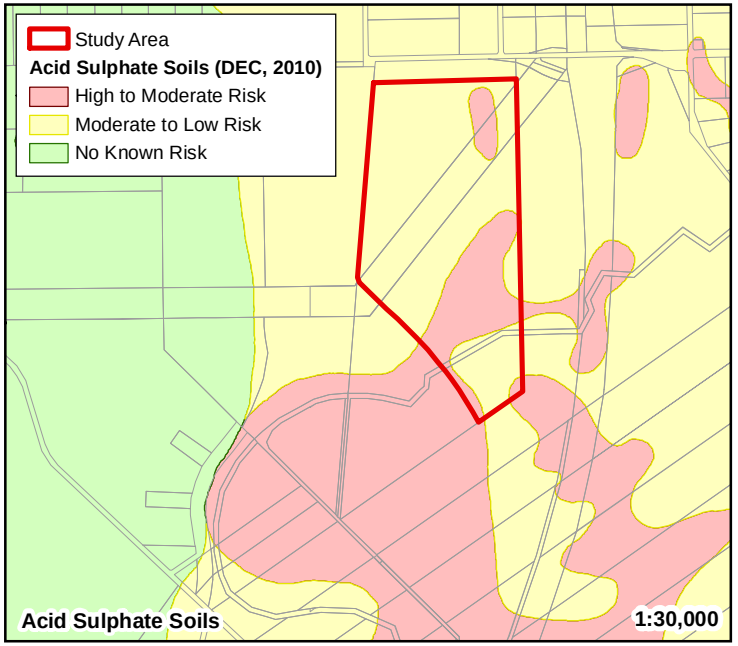
S10: SAND - as S8 relatively thin veneer over stron, blocky, brown silts and clays

ACID SULPHATE SOILS - RISK DEFINITIONS:

High to moderate risk of ASS occurring within 3m of natural soil surface:
ASS in these environments can be widespread or sporadic. They may be very close to the surface or buried by many metres of alluvium or windblown sand. Base sediments of estuaries, rivers, creeks and lakes are also considered areas of high risk of ASS occurrence.

Moderate to low risk of ASS occurring within 3m of natural soil surface:
Where environments have not generally been suitable for ASS formation or ASS are highly localised or sporadic, they have been classed as having a moderate to low risk of occurrence. Where ASS is present, it may be close to the surface or buried by many metres of alluvium or windblown sand. Most of these landforms are not expected to contain ASS.

No known risk of ASS occurring within 3m of natural soil surface (or deeper):
ASS are not known or expected to occur in these environments



Data Source: Gozzard (1983) Fremantle Environmental Geology Map, DEC (2010) ASS Mapping

Job No. J6313
Scale:1:15,000
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Metres

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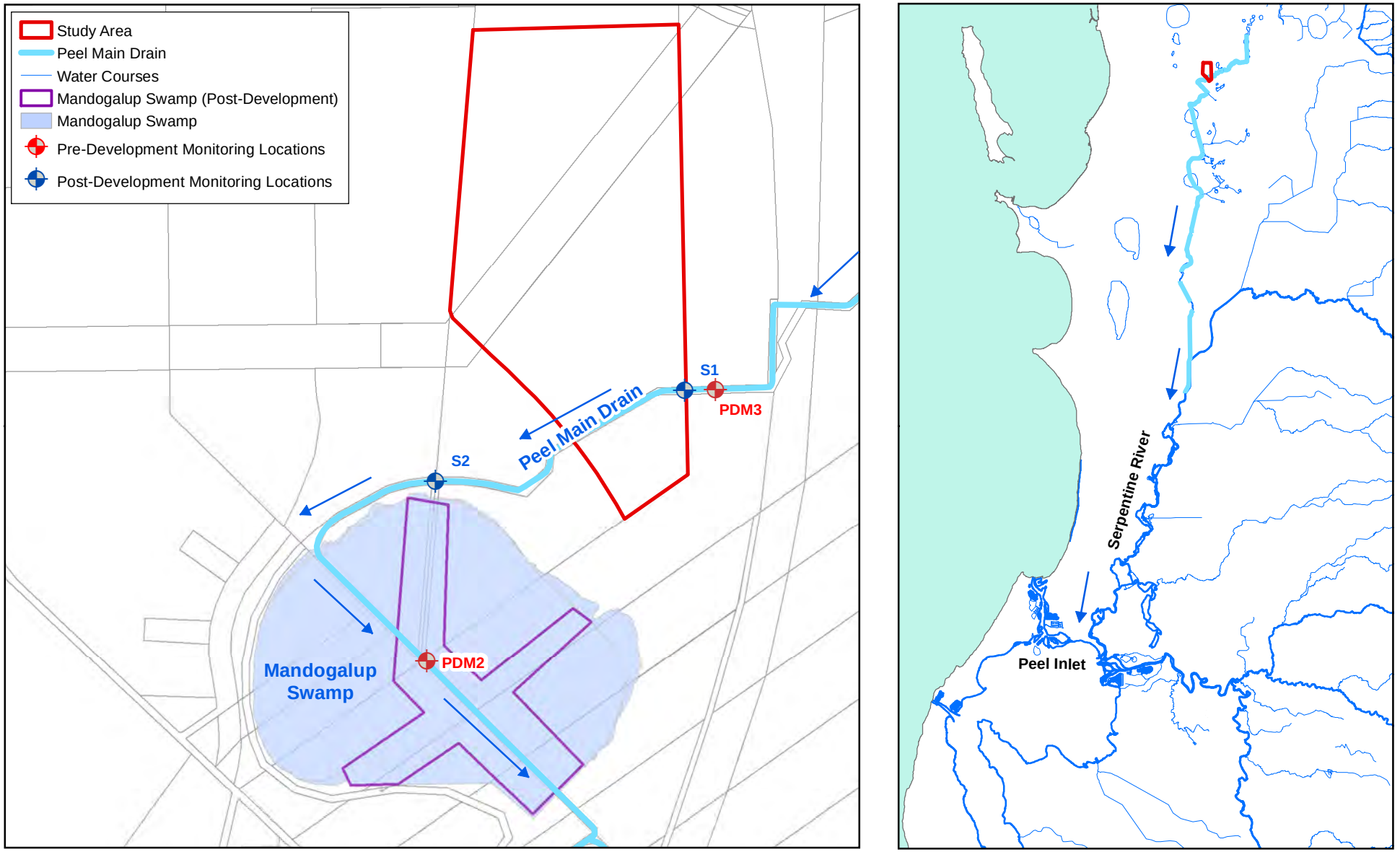
Figure 3: Surface Geology and ASS



Data Source: Department of Water (2009) Rivers

Job No. J6313

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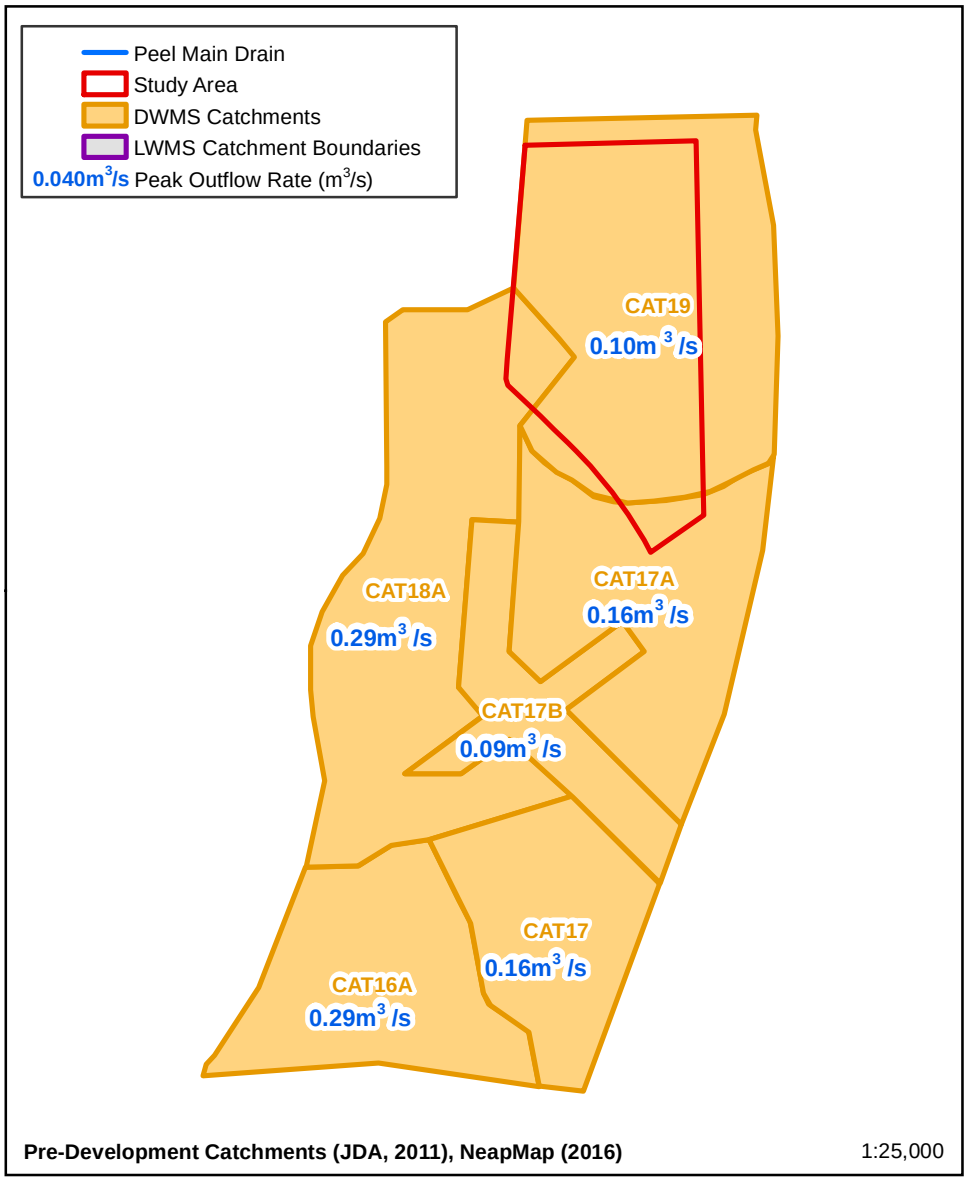
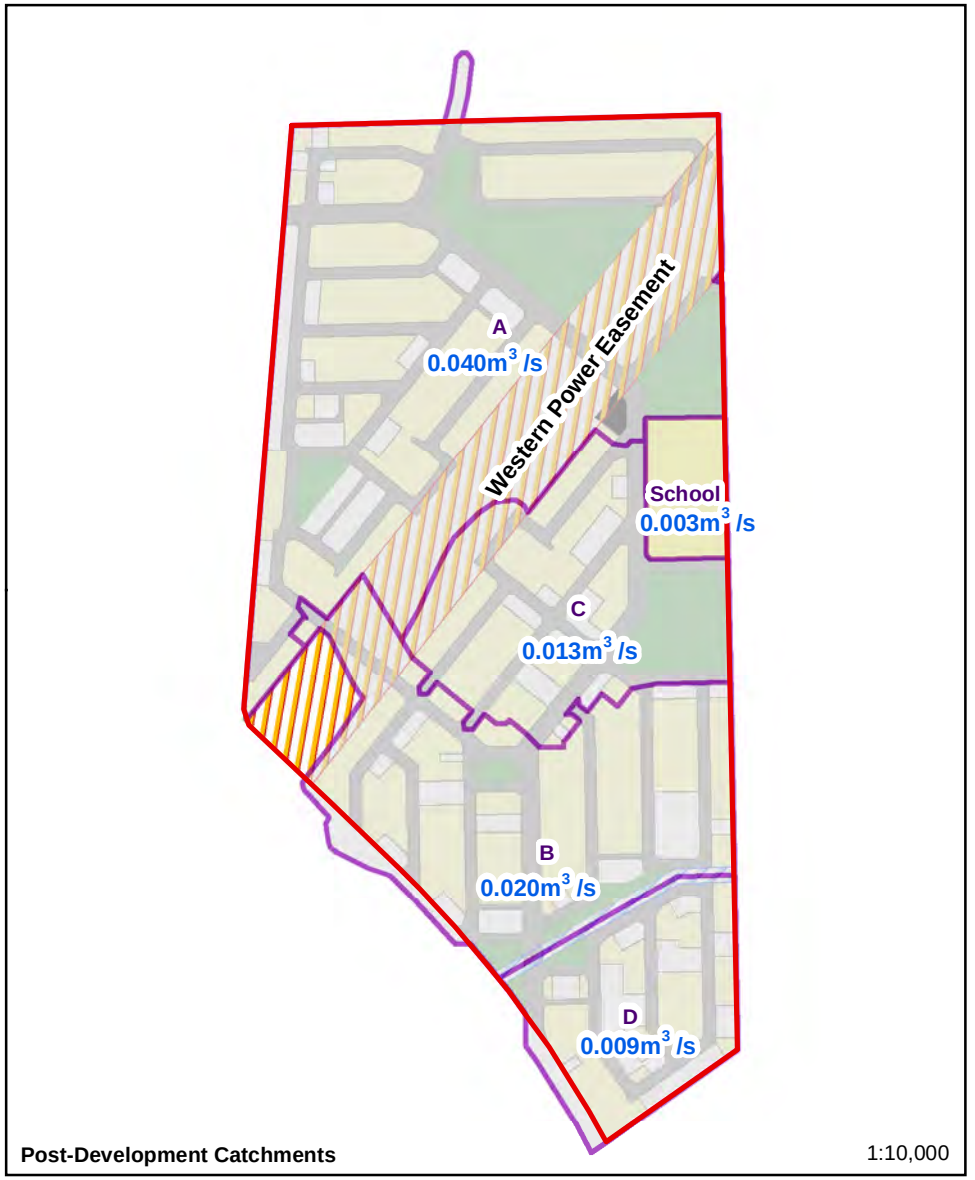
Figure 4: Existing Surface Drainage



Pre-Development Catchments (JDA, 2011), NeapMap (2016) 1:25,000



Post-Development Catchments 1:10,000

JDA

Job No. J6313
Scale: 1:10,000

0 100 200 300 400 Metres

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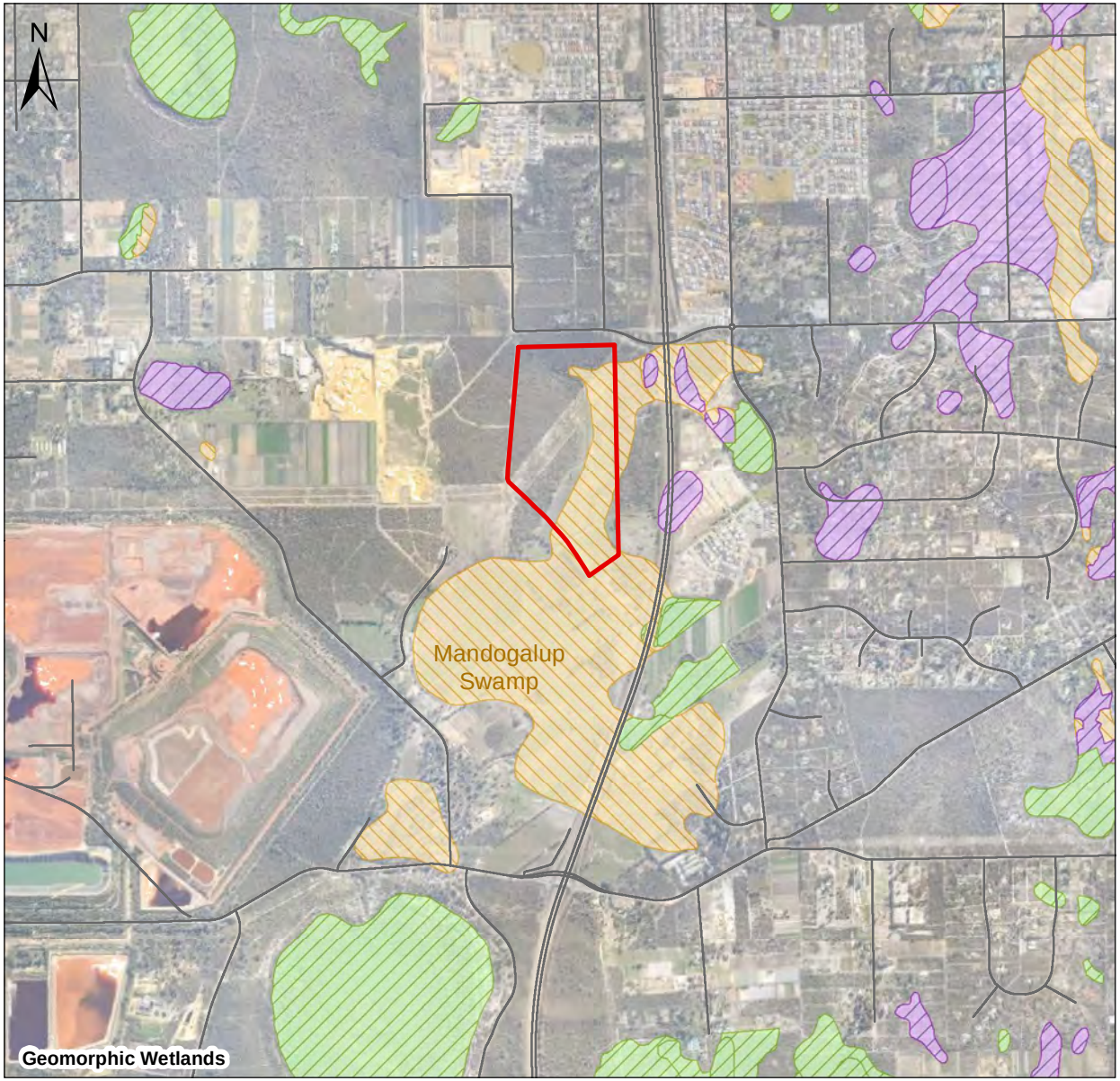
Figure 5: 100yr ARI Pre and Post-Development Outflow and Catchment Mapping



Study Area

Geomorphic Wetlands (DEC, 2012)

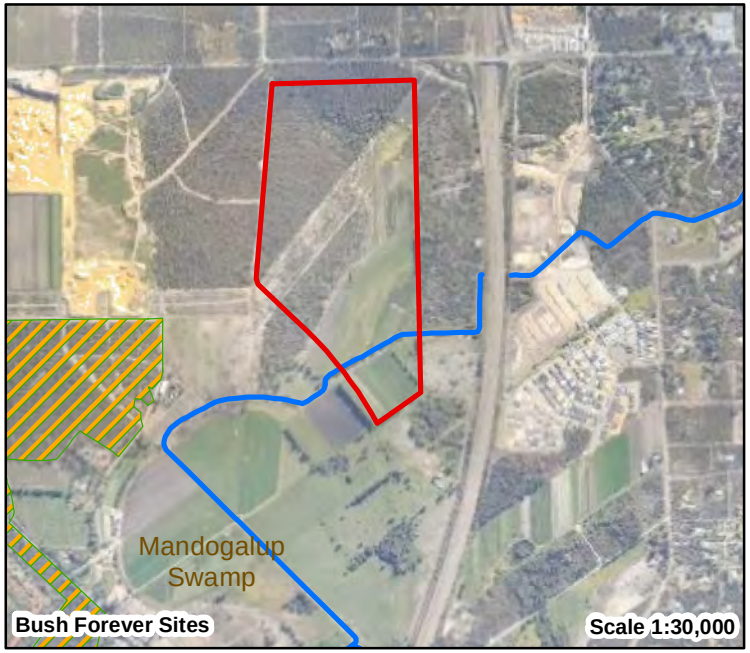
- Conservation Category Wetland (CCW)
- Resource Enhancement Wetland (REW)
- Multiple Use Dampland
- Bush Forever Sites

WETLAND DEFINITIONS:

Conservation Wetland:
Wetlands that support a high level of ecological attributes and functions.

Resource Enhancement Wetland:
Wetlands which may have been partially modified but still support substantial ecological attributes and functions.

Multiple Use Dampland:
Wetlands with few ecological attributes and functions remaining.



JDA

Job No. J6313
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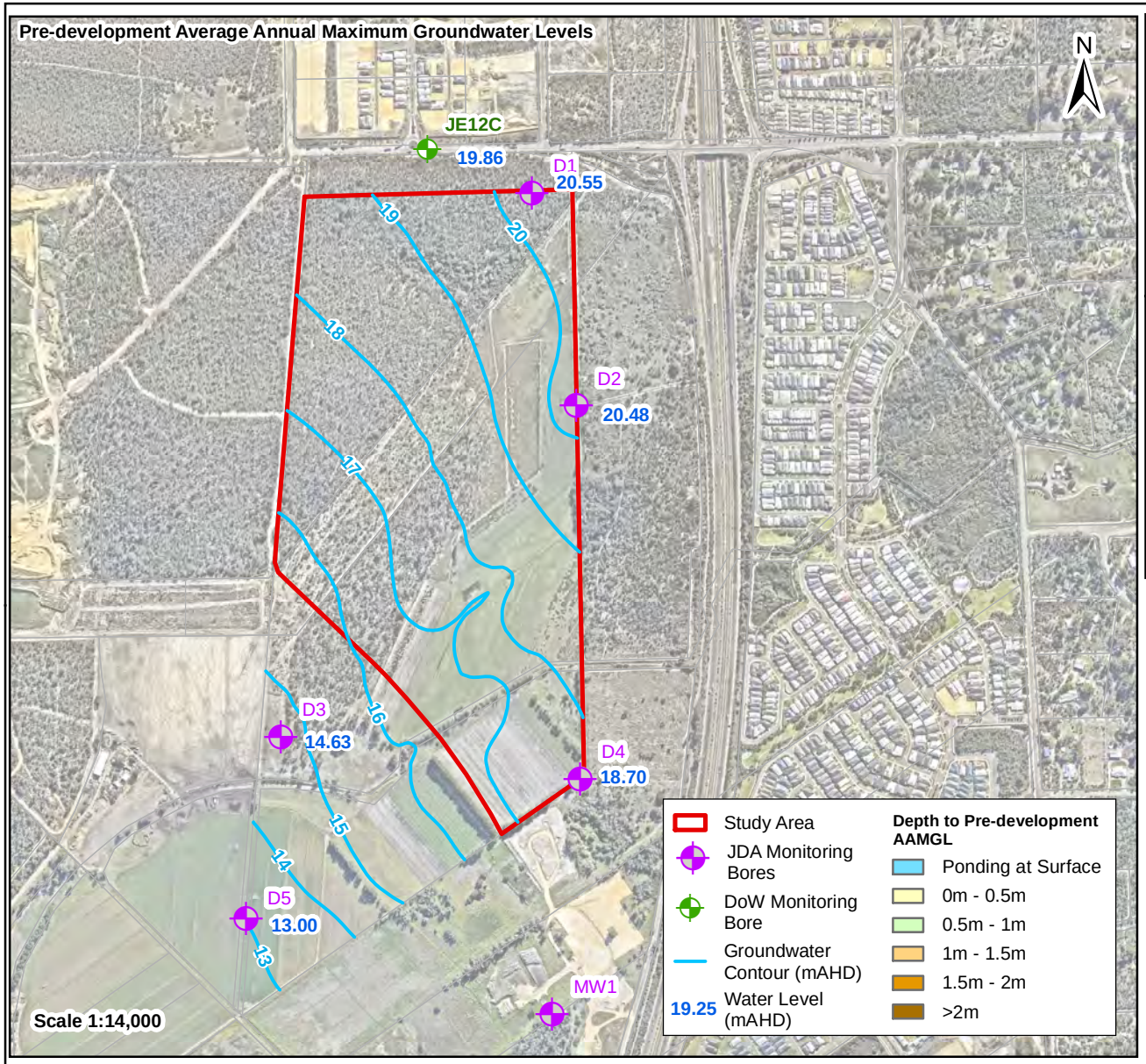
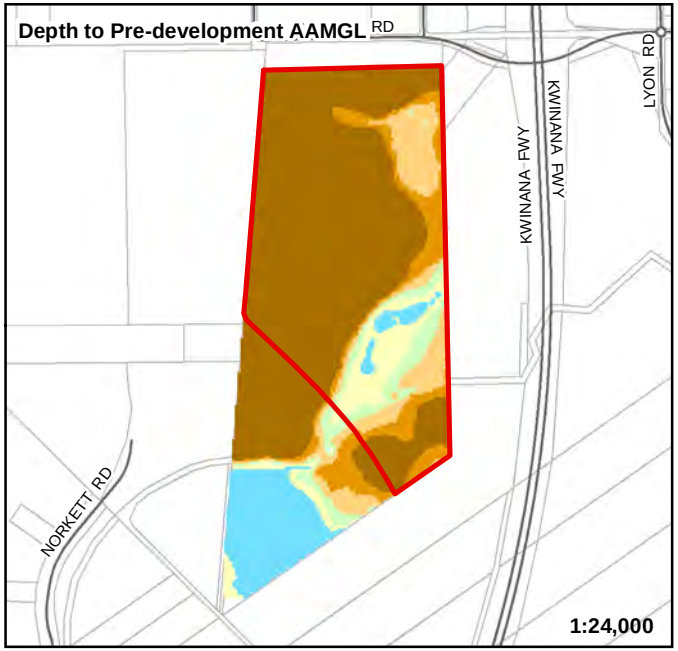
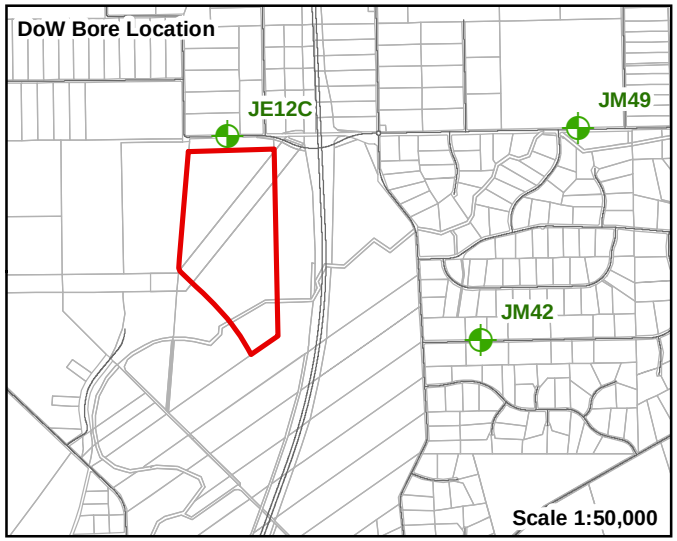
Figure 6: Wetland Mapping







Job No. J6313

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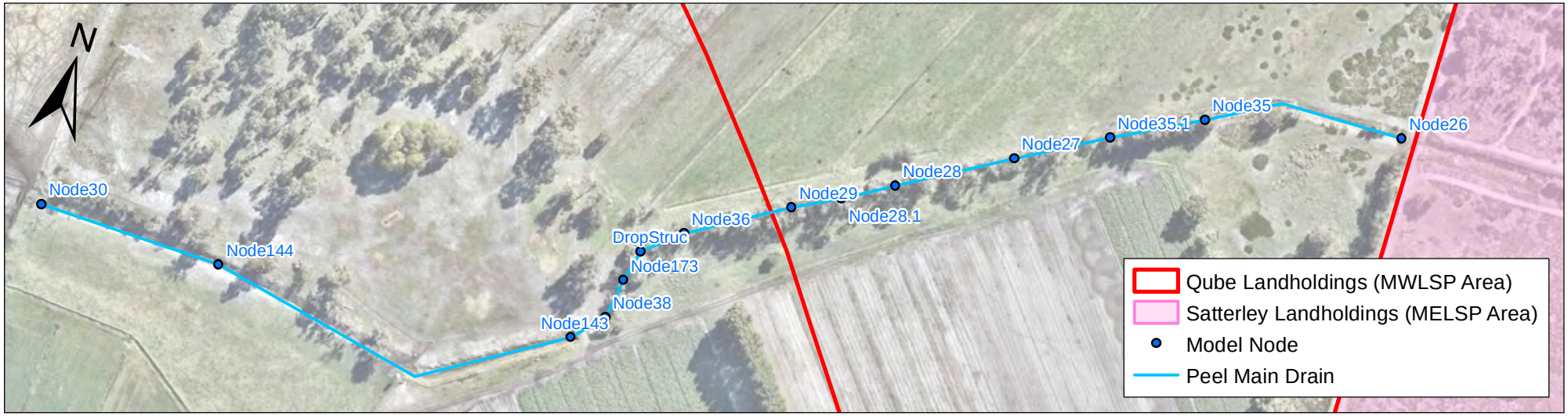
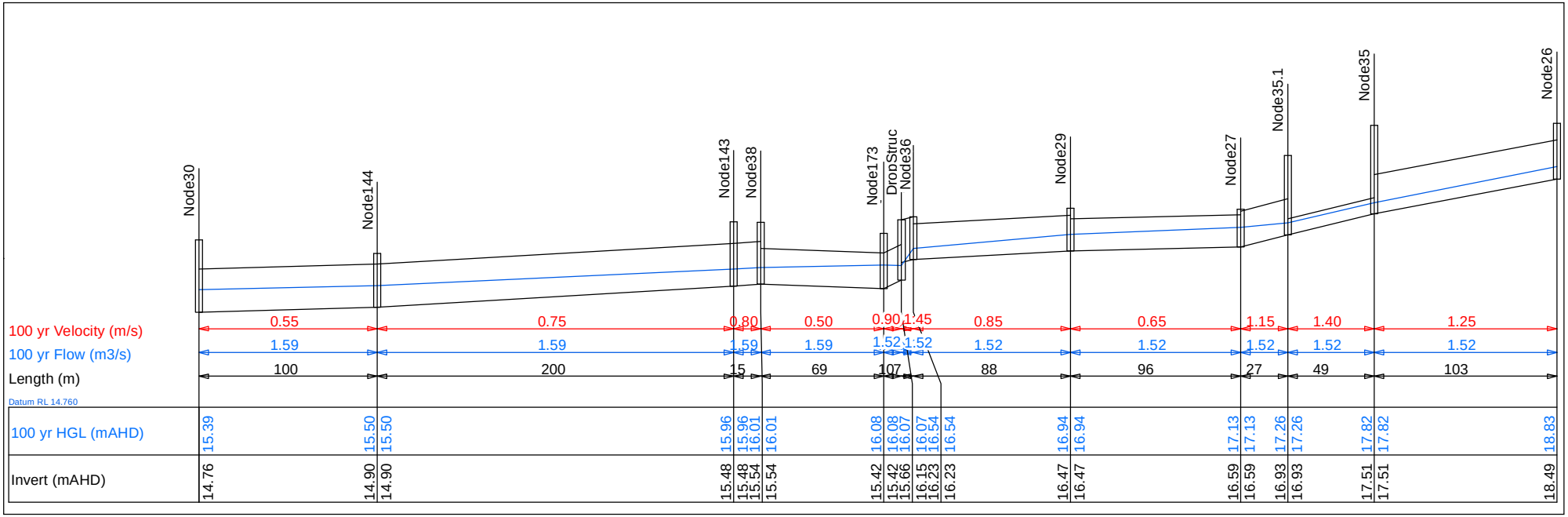
Figure 7: Pre-development Groundwater Levels





Data Source: McMullenNolan (2008) Peel Main Drain Survey; JDA (2017) XP STORM Model

Coordinate System: GDA 94, Zone 50

Job No. J6238
Scale:1:3,127 @A4

0 100 200 300 Meters

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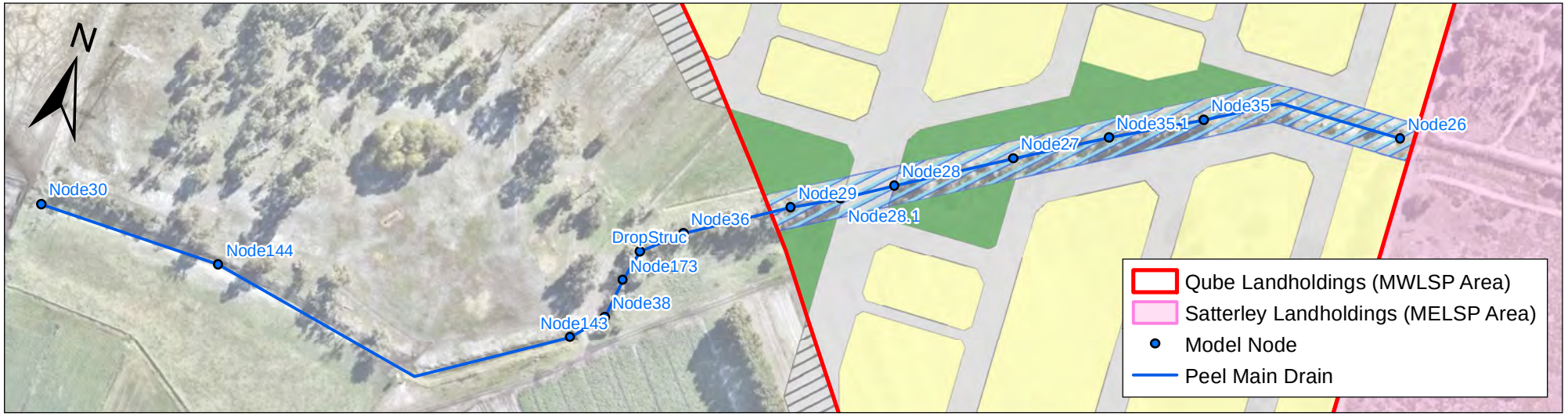
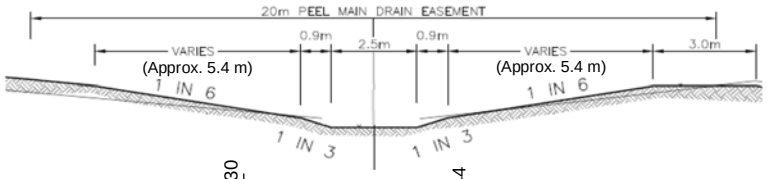
Figure 8: Peel Main Drain Pre-Development Long Section



TYPICAL CROSS SECTION



Data Source: McMullenNolan (2008) Peel Main Drain Survey; JDA (2017) XP STORM Model

Coordinate System: GDA 94, Zone 50

Job No. J6238
Scale:1:3,127 @A4

0 100 200 300 Meters

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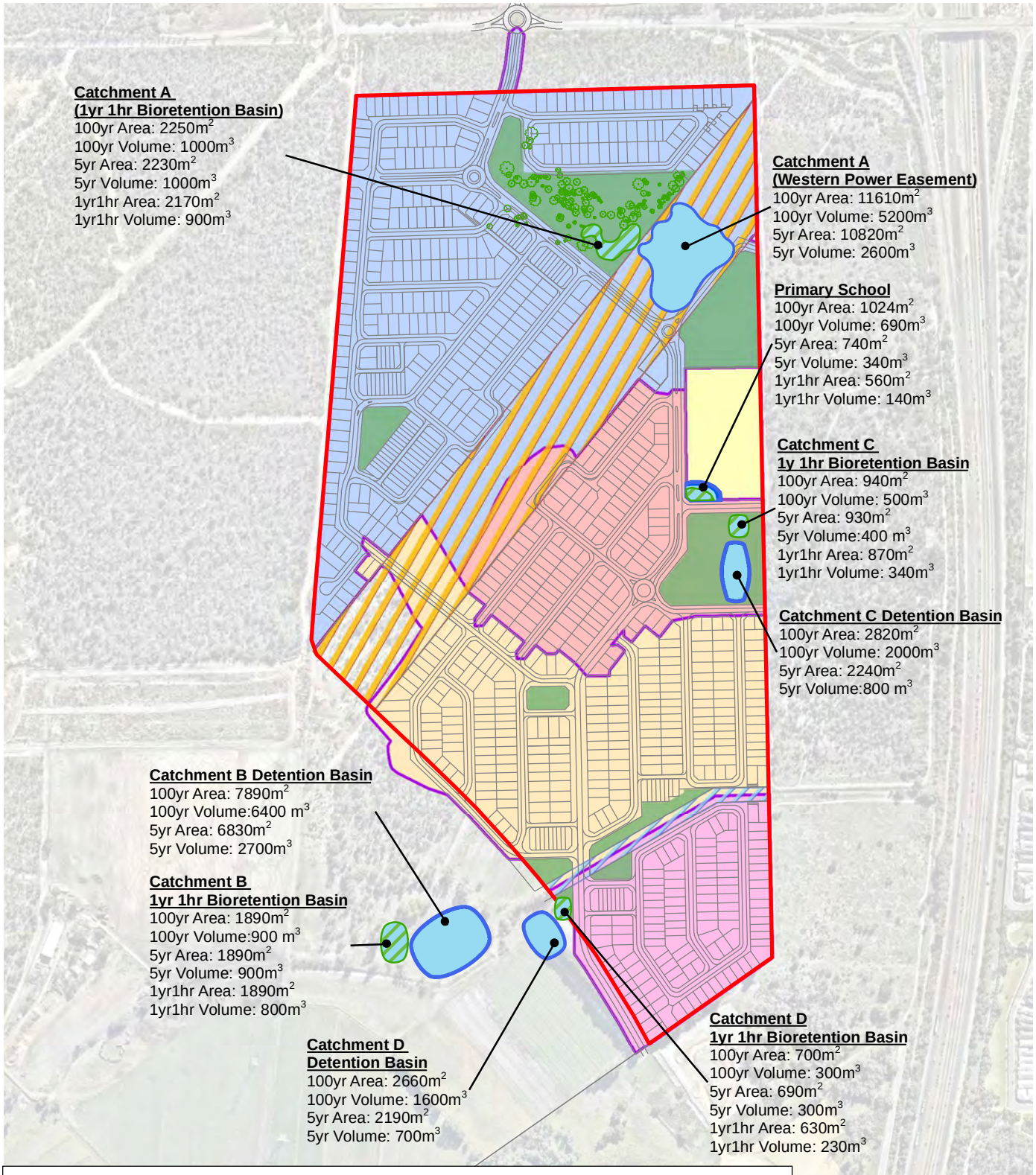
Figure 9: Peel Main Drain Post-Development Long Section



Note: Storage basins for catchments B & D are positioned in POS areas planned for future development.

Job No. J6313
Scale 1:8,000 @A4

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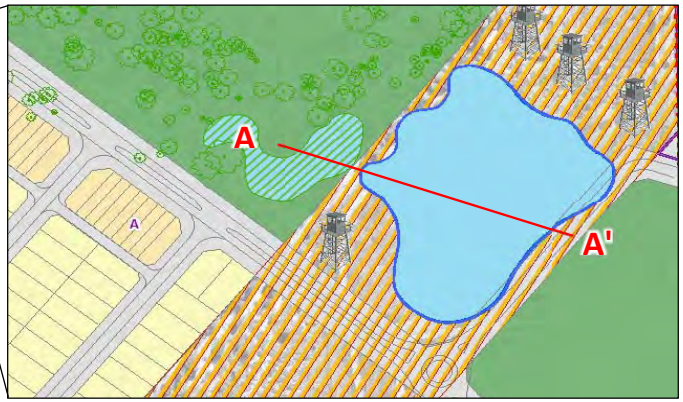
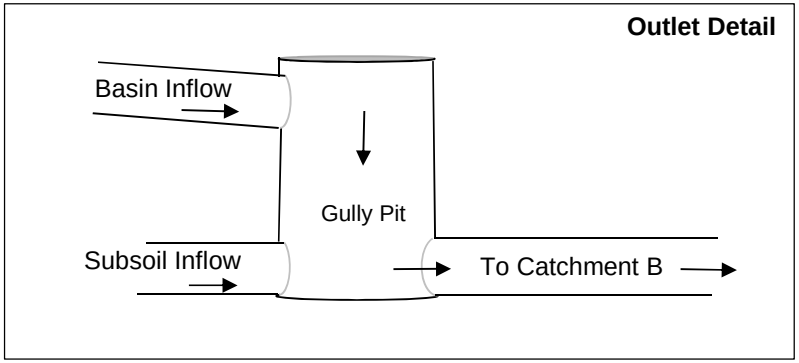
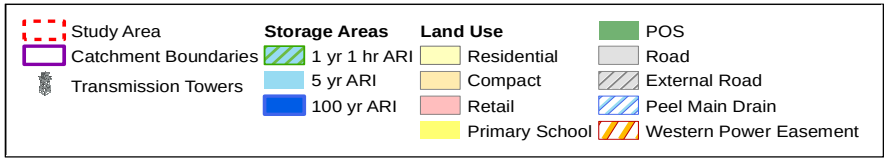
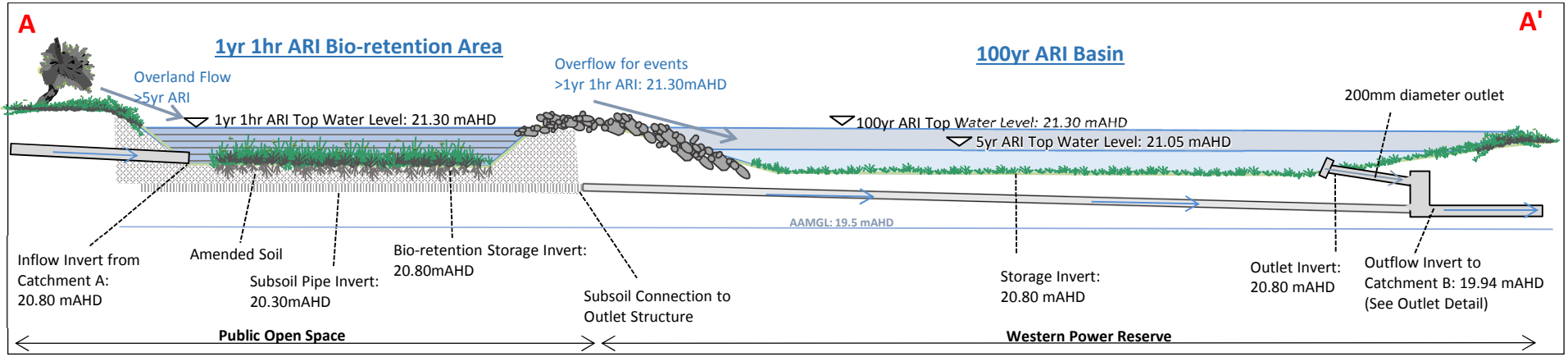
Figure 10: Stormwater Management Strategy











Note: Concept indicative only

Rainfall Event	Top Water Level (mAHD)	Ponding Depth (m)	Top Water Level Surface Area (m^2)	Storage Volume (m^3)
100yr	21.35	0.55	2250	1000
5yr	21.35	0.55	2230	1000
1yr 1hr	21.30	0.50	2170	900

Rainfall Event	Top Water Level (mAHD)	Ponding Depth (m)	Top Water Level Surface Area (m^2)	Storage Volume (m^3)
100yr	21.30	0.50	11610	5200
5yr	21.05	0.25	10820	2600

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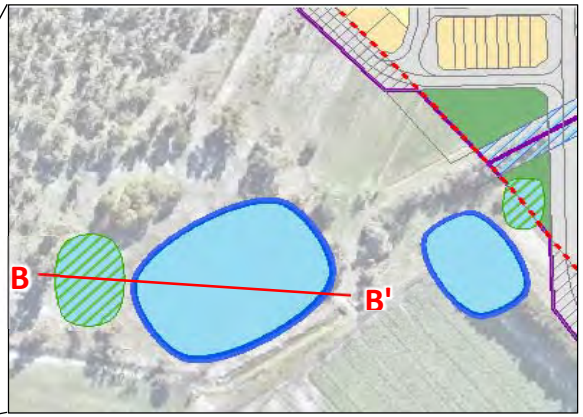
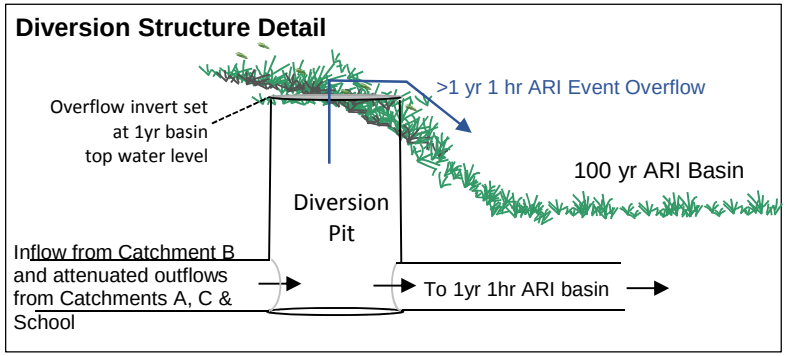
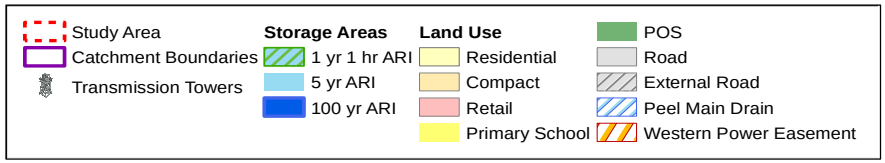
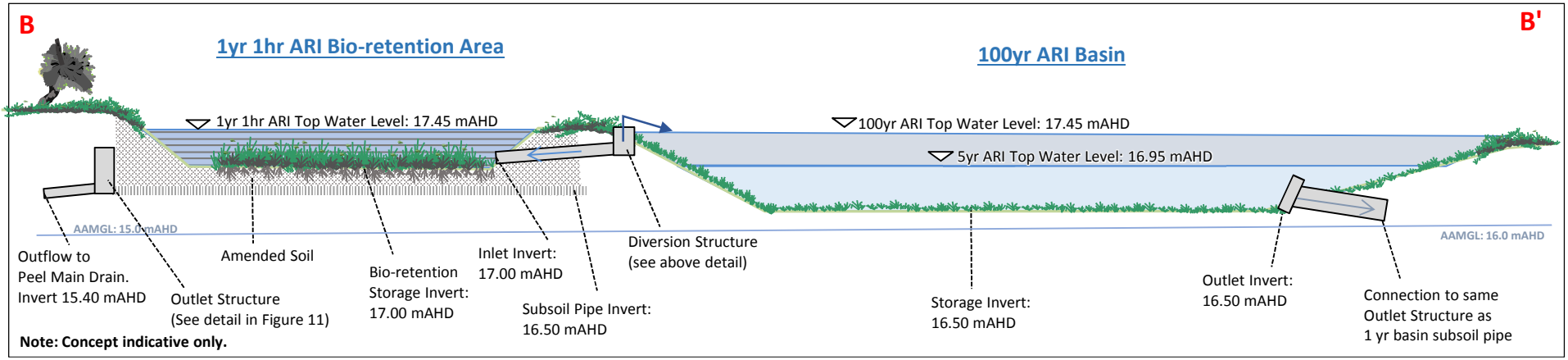
Figure 11: Catchment A Storage Basin Concept











Rainfall Event	Top Water Level (mAHD)	Ponding Depth (m)	Top Water Level Surface Area (m^2)	Storage Volume (m^3)
100yr	17.50	0.40	1890	900
5yr	17.50	0.40	1890	900
1yr 1hr	17.45	0.30	1890	800

Rainfall Event	Top Water Level (mAHD)	Ponding Depth (m)	Top Water Level Surface Area (m^2)	Storage Volume (m^3)
100yr	17.45	0.95	7890	6400
5yr	16.95	0.45	6830	2700

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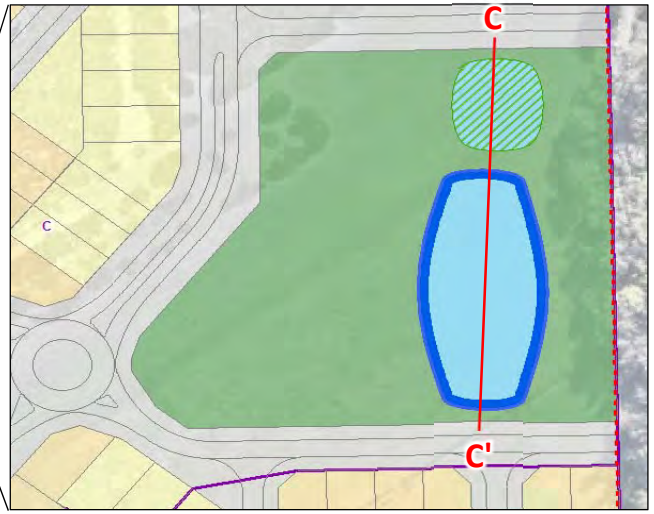
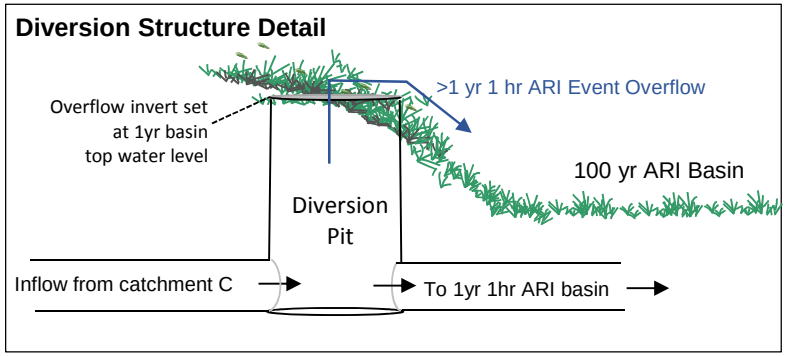
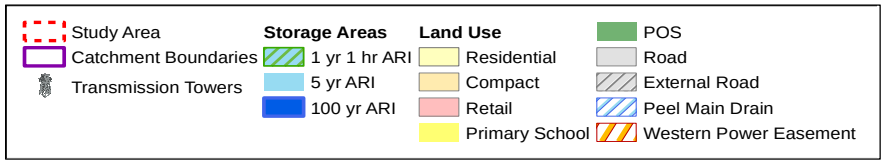
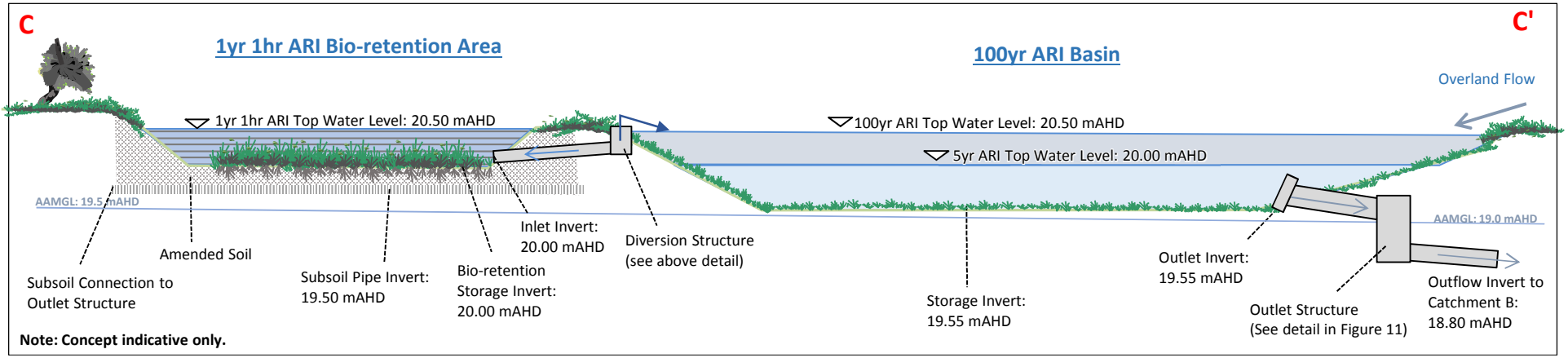
Figure 12: Catchment B Storage Basin Concept











Note: Concept indicative only.

Rainfall Event	Top Water Level (mAHD)	Ponding Depth (m)	Top Water Level Surface Area (m^2)	Storage Volume (m^3)
100yr	20.60	0.60	940	500
5yr	20.55	0.55	930	400
1yr 1hr	20.50	0.50	870	340

Rainfall Event	Top Water Level (mAHD)	Ponding Depth (m)	Top Water Level Surface Area (m^2)	Storage Volume (m^3)
100yr	20.50	0.95	2820	2000
5yr	20.00	0.45	2240	800

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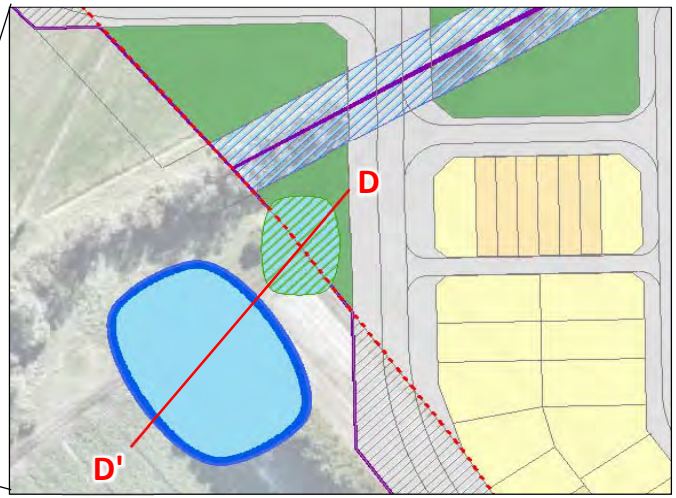
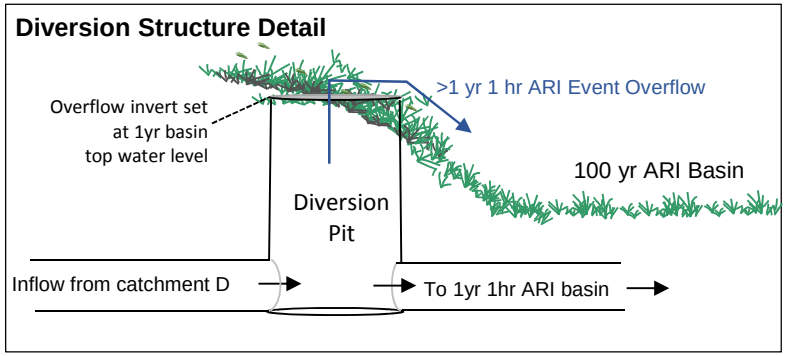
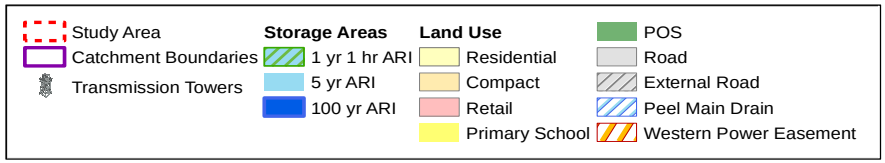
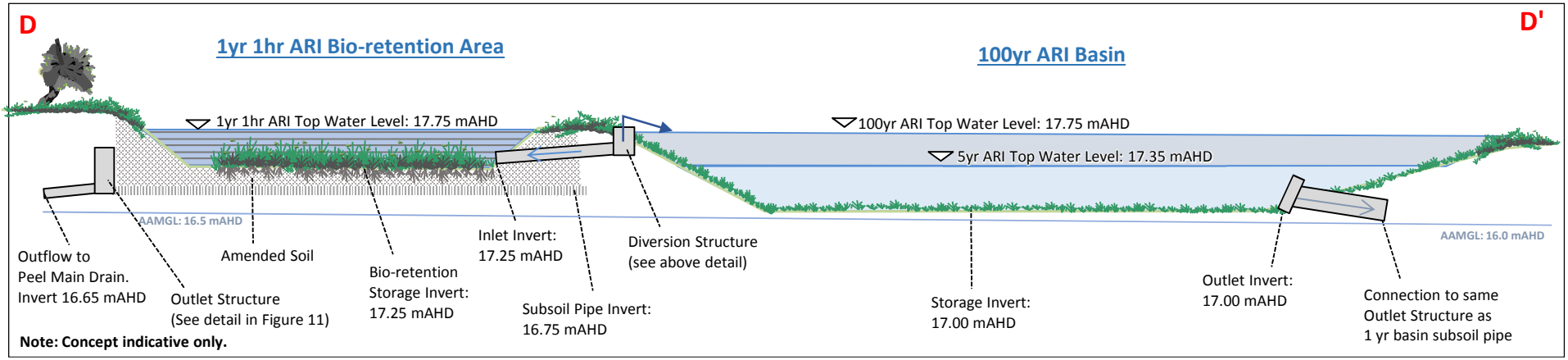
Figure 13: Catchment C Storage Basin Concept











Rainfall Event	Top Water Level (mAHD)	Ponding Depth (m)	Top Water Level Surface Area (m^2)	Storage Volume (m^3)
100yr	17.85	0.60	700	300
5yr	17.80	0.55	690	300
1yr 1hr	17.75	0.50	630	230

Rainfall Event	Top Water Level (mAHD)	Ponding Depth (m)	Top Water Level Surface Area (m^2)	Storage Volume (m^3)
100yr	17.75	0.75	2660	1600
5yr	17.35	0.35	2190	700

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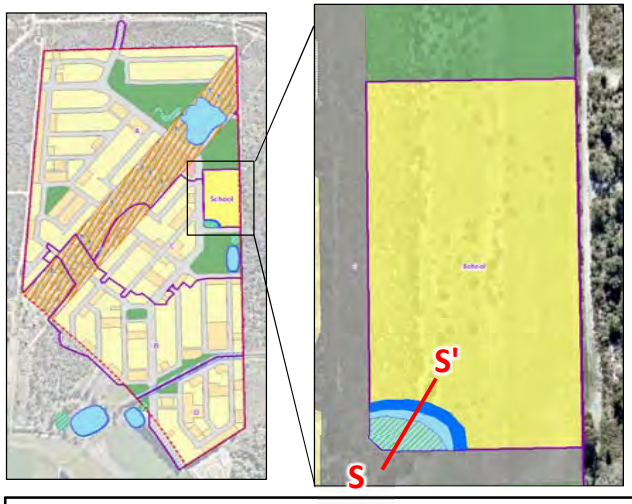
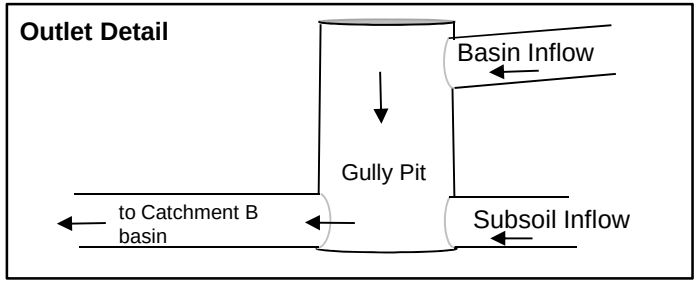
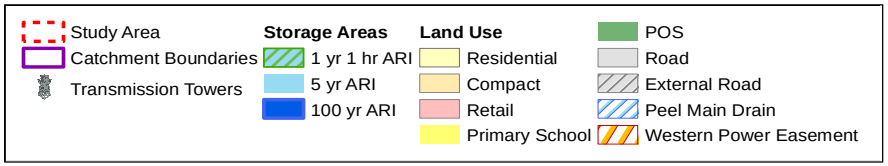
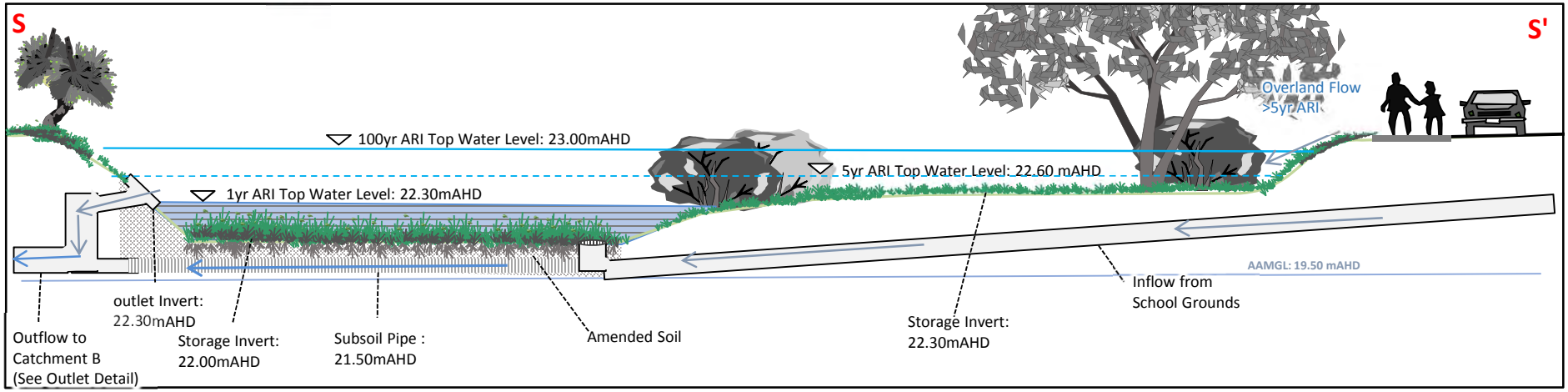
Figure 14: Catchment D Storage Basin Concept









Note: Concept indicative only.

ARI	Top Water Level (mAHD)	Ponding Depth (m)	Top Water Level Surface Area (m^2)	Storage Volume (m^3)
100yr	23.00	1.00	1024	688
5yr	22.60	0.60	740	336
1yr 1hr	22.30	0.30	557	142

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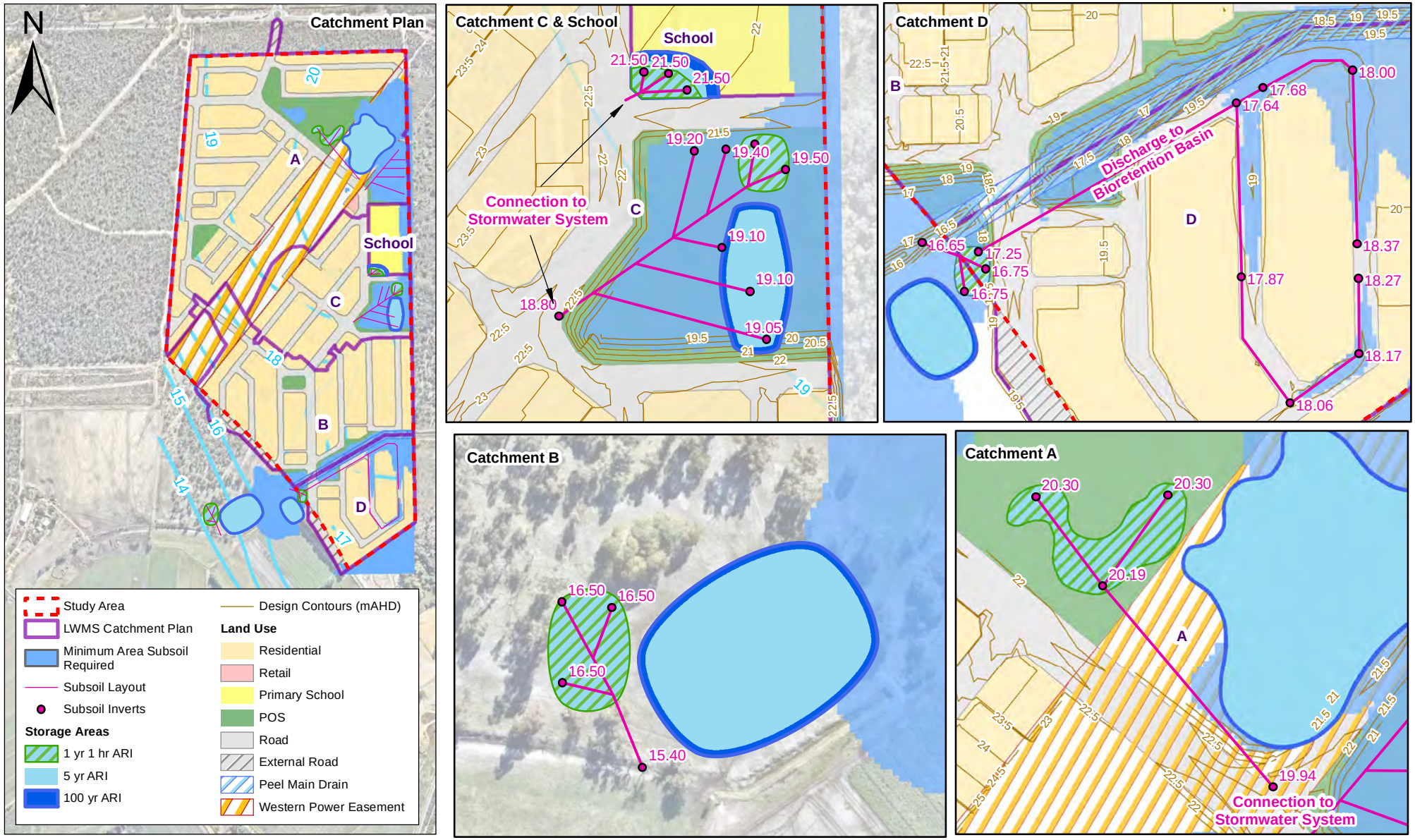
Figure 15: Primary School Storage Basin Concept



Note: Minimum area of subsoil shown as clearance from AAMGL to finished level <2m. Subsoils are indicative only.

JDA

Job No. J6313
Scale:1:14,000 @A4

0 200 400 600 800 Metres

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Figure 16: Groundwater Management Strategy

APPENDIX A

Local Water Management Strategy Checklist for Developers

Checklist for integrated water cycle management assessment of local structure plan or local planning scheme amendment

1. Tick the status column for items for which information is provided.
2. Enter N/A in the status column if the item is not appropriate and enter the reason in the comments column.
3. Provide brief comments on any relevant issues.
4. Provide brief description of any proposed best management practices, eg. multi-use corridors, community based-social marketing, water re-use proposals.

Local water management strategy item	Deliverable	X	Comments
Executive summary			
Summary of the development design strategy, outlining how the design objectives are proposed to be met	Table 1: Design elements & requirements for BMPs and critical control points	X	
Introduction			
Total water cycle management – principles & objectives Planning background Previous studies		X	
Proposed development			
Structure plan, zoning and land use. Key landscape features Previous land use	Site context plan Structure plan	X X	
Landscape - proposed POS areas, POS credits, water source, bore(s), lake details (if applicable), irrigation areas	Landscape Plan	X	
Design criteria			
Agreed design objectives and source of objective		X	
Pre-development environment			
Existing information and more detailed assessments (monitoring). How do the site characteristics affect the design?		X	
Site Conditions - existing topography/ contours, aerial photo underlay, major physical features	Site condition plan	X	
Geotechnical - topography, soils including acid sulfate soils and infiltration capacity, test pit locations	Geotechnical plan	X	
Environmental - areas of significant flora and fauna, wetlands and buffers, waterways and buffers, contaminated sites	Environmental Plan plus supporting data where appropriate	X	
Surface Water – topography, 100 year floodways and flood fringe areas, water quality of flows entering and leaving (if applicable)	Surface Water Plan	X	
Groundwater – topography, pre development groundwater levels and water quality, test bore locations	Groundwater Plan plus details of groundwater monitoring and testing	X	
Water use sustainability initiatives			
Water efficiency measures – private and public open spaces including method of enforcement		X	
Water supply (fit-for-purpose strategy), agreed actions and implementation. If non-potable supply, support with water balance		X	
Wastewater management		X	
Stormwater management strategy			
Flood protection - peak flow rates, volumes and top water levels at control points,100 year flow paths and 100 year detentions storage areas	100yr event Plan Long section of critical points	X X	
Manage serviceability - storage and retention required for the critical 5 year ARI storm events Minor roads should be passable in the 5 year ARI event	5yr event Plan	X	

Local water management strategy item	Deliverable	X	Comments
Protect ecology – detention areas for the 1 yr 1 hr ARI event, areas for water quality treatment and types of (including indicative locations for) agreed structural and non-structural best management practices and treatment trains. Protection of waterways, wetlands (and their buffers), remnant vegetation and ecological linkages	1yr event plan Typical cross sections	X X	
Groundwater management strategy			
Post development groundwater levels, fill requirements (including existing and likely final surface levels), outlet controls, and subsoils areas/exclusion zones	Groundwater/subsoil Plan	X	
Actions to address acid sulfate soils or contamination		X	
The next stage – subdivision and urban water management plans			
Content and coverage of future urban water management plans to be completed at subdivision. Include areas where further investigations are required prior to detailed design.		X	
Monitoring			
Recommended future monitoring plan including timing, frequency, locations and parameters, together with arrangements for ongoing actions		X	
Implementation			
Developer commitments		X	
Roles, responsibilities, funding for implementation		X	
Review		X	

APPENDIX B

Pre-Development Monitoring April 2007 to March 2009: Surface Water Monitoring Results

Extracted from
Mandogalup District Water Management Strategy
(JDA, 2011)

APPENDIX B: NUTRIENT CONCENTRATION AT PEEL MAIN DRAIN SITES WHEN FLOWING (APRIL 2007 TO MARCH 2009)

Location 1: PMD1	Monitoring Date in 2007									Monitoring Date in 2008					
Parameter	**04/04/07**	**24/05/07**	**27/06/07**	**01/08/07**	**30/08/07**	**18/09/07**	**11/10/07**	**07/11/07**	**18/12/07**	**15/01/08**	**12/02/08**	**11/03/08**	**09/04/08**	**15/05/08**	**11/06/08**
TDS, mg/L	N/M	116	187	242	253	314	292	182	165	171	171	N/M	143	149	270
pH	N/M	6.32	6.12	6.21	6.08	6.87	6.72	6.68	6.51	6.56	6.36	N/M	5.97	5.93	6.10
TN, mg/L	N/M	0.37	0.92	1.50	1.10	0.85	0.49	0.61	0.66	0.75	0.79	N/M	0.62	1.20	2.10
TKN, mg/L	N/M	0.37	0.64	1.10	0.90	0.75	0.45	0.61	0.65	0.72	0.79	N/M	0.61	0.98	1.90
NOx_N, mg/L	N/M	<0.005	0.280	0.380	0.200	0.100	0.043	<0.005	0.006	0.029	<0.005	N/M	0.011	0.180	0.170
NH4_N, mg/L	N/M	0.081	0.081	0.140	0.040	0.072	<0.005	0.085	0.045	0.035	0.073	N/M	<0.005	0.016	0.081
TP, mg/L	N/M	0.140	0.050	0.160	0.110	0.060	0.110	0.080	0.130	0.080	0.110	N/M	0.120	0.190	0.070
FRP, mg/L	N/M	0.130	0.017	0.069	0.070	0.027	0.057	0.038	0.064	0.017	0.078	N/M	0.057	0.042	0.033
Parameter	**Monitoring Date in 2008**						**Monitoring Date in 2009**			**Statistics**					
	09/07/08	**07/08/08**	**10/09/08**	**22/10/08**	**18/11/08**	**19/12/08**	**13/01/09**	**11/02/09**	**10/03/09**	**Average**	**Median**	**Min**	**Max**	**Q_1**	**Q_3**
TDS, mg/L	215	594	264	176	138	154	154	165	176	213	176	116	594	161	250
pH	6.30	6.45	6.02	5.93	6.21	6.10	5.48	6.32	6.85	6.31	6.30	5.93	6.87	6.09	6.54
TN, mg/L	0.91	1.90	0.89	0.97	0.65	0.83	1.40	<0.05	2.60	1.03	0.85	0.37	2.60	0.65	1.20
TKN, mg/L	0.61	1.50	0.61	0.88	0.56	0.72	1.30	<0.05	2.60	0.79	0.69	0.05	1.90	0.61	0.92
NOx_N, mg/L	0.300	0.370	0.290	0.092	0.087	0.110	0.083	<0.005	0.017	0.128	0.092	<0.005	0.380	0.006	0.200
NH4_N, mg/L	0.055	0.013	<0.001	0.120	0.055	0.050	0.260	0.066	0.027	0.062	0.072	<0.005	0.140	0.041	0.081
TP, mg/L	0.08	0.18	0.16	0.16	0.10	0.06	0.13	0.09	0.40	0.10	0.11	0.05	0.19	0.08	0.12
FRP, mg/L	0.040	0.150	0.080	0.130	0.063	0.059	0.019	0.026	0.021	0.058	0.057	0.017	0.150	0.027	0.069
Location 3: PMD3	**Monitoring Date in 2007**									**Monitoring Date in 2008**					
Parameter	**04/04/07**	**24/05/07**	**27/06/07**	**01/08/07**	**30/08/07**	**18/09/07**	**11/10/07**	**07/11/07**	**18/12/07**	**15/01/08**	**12/02/08**	**11/03/08**	**09/04/08**	**16/05/08**	**11/06/08**
TDS, mg/L	N/M	N/M	N/M	N/M	N/M	594	424	N/M	N/M	N/M	N/M	N/M	N/M	N/M	N/M
pH	N/M	N/M	N/M	N/M	N/M	6.08	5.48	N/M	N/M	N/M	N/M	N/M	N/M	N/M	N/M
TN, mg/L	N/M	N/M	N/M	N/M	N/M	1.80	1.30	N/M	N/M	N/M	N/M	N/M	N/M	N/M	N/M
TKN, mg/L	N/M	N/M	N/M	N/M	N/M	1.80	1.30	N/M	N/M	N/M	N/M	N/M	N/M	N/M	N/M
NOx_N, mg/L	N/M	N/M	N/M	N/M	N/M	0.01	0.01	N/M	N/M	N/M	N/M	N/M	N/M	N/M	N/M
NH4_N, mg/L	N/M	N/M	N/M	N/M	N/M	0.05	<0.005	N/M	N/M	N/M	N/M	N/M	N/M	N/M	N/M
TP, mg/L	N/M	N/M	N/M	N/M	N/M	0.15	0.12	N/M	N/M	N/M	N/M	N/M	N/M	N/M	N/M
FRP, mg/L	N/M	N/M	N/M	N/M	N/M	0.09	0.06	N/M	N/M	N/M	N/M	N/M	N/M	N/M	N/M
Parameter	**Monitoring Date in 2008**						**Monitoring Date in 2009**			**Statistics**					
	09/07/08	**07/08/08**	**10/09/08**	**22/10/08**	**18/11/08**	**19/12/08**	**13/01/09**	**11/02/09**	**10/03/09**	**Average**	**Median**	**Min**	**Max**	**Q_1**	**Q_3**
TDS, mg/L	N/M	484	N/M	369	N/M	N/M	N/M	N/M	N/M	426	426	369	484	397	455
pH	N/M	5.93	N/M	5.45	N/M	N/M	N/M	N/M	N/M	5.74	5.71	5.45	6.08	5.47	5.97
TN, mg/L	N/M	2.90	N/M	2.90	N/M	N/M	N/M	N/M	N/M	2.23	2.35	1.30	2.90	1.68	2.90
TKN, mg/L	N/M	2.80	N/M	2.90	N/M	N/M	N/M	N/M	N/M	2.20	2.30	1.30	2.90	1.68	2.83
NOx_N, mg/L	N/M	0.072	N/M	0.014	N/M	N/M	N/M	N/M	N/M	0.026	0.012	0.009	0.072	0.009	0.028
NH4_N, mg/L	N/M	<0.005	N/M	0.019	N/M	N/M	N/M	N/M	N/M	0.033	0.033	0.019	0.047	0.026	0.040
TP, mg/L	N/M	0.120	N/M	0.760	N/M	N/M	N/M	N/M	N/M	0.280	0.135	0.120	0.760	0.120	0.302
FRP, mg/L	N/M	0.092	N/M	0.390	N/M	N/M	N/M	N/M	N/M	0.150	0.092	0.060	0.390	0.084	0.160

Notes: (1) N/M: not measured, (2) values lower than Limit of Reporting (LoR) are shaded and treated as value at LoR in statistics calculation.

APPENDIX C

Pre-Development Monitoring April 2007 to March 2009: Groundwater Level Monitoring Results

Extracted from
Mandogalup District Water Management Strategy
(JDA, 2011)

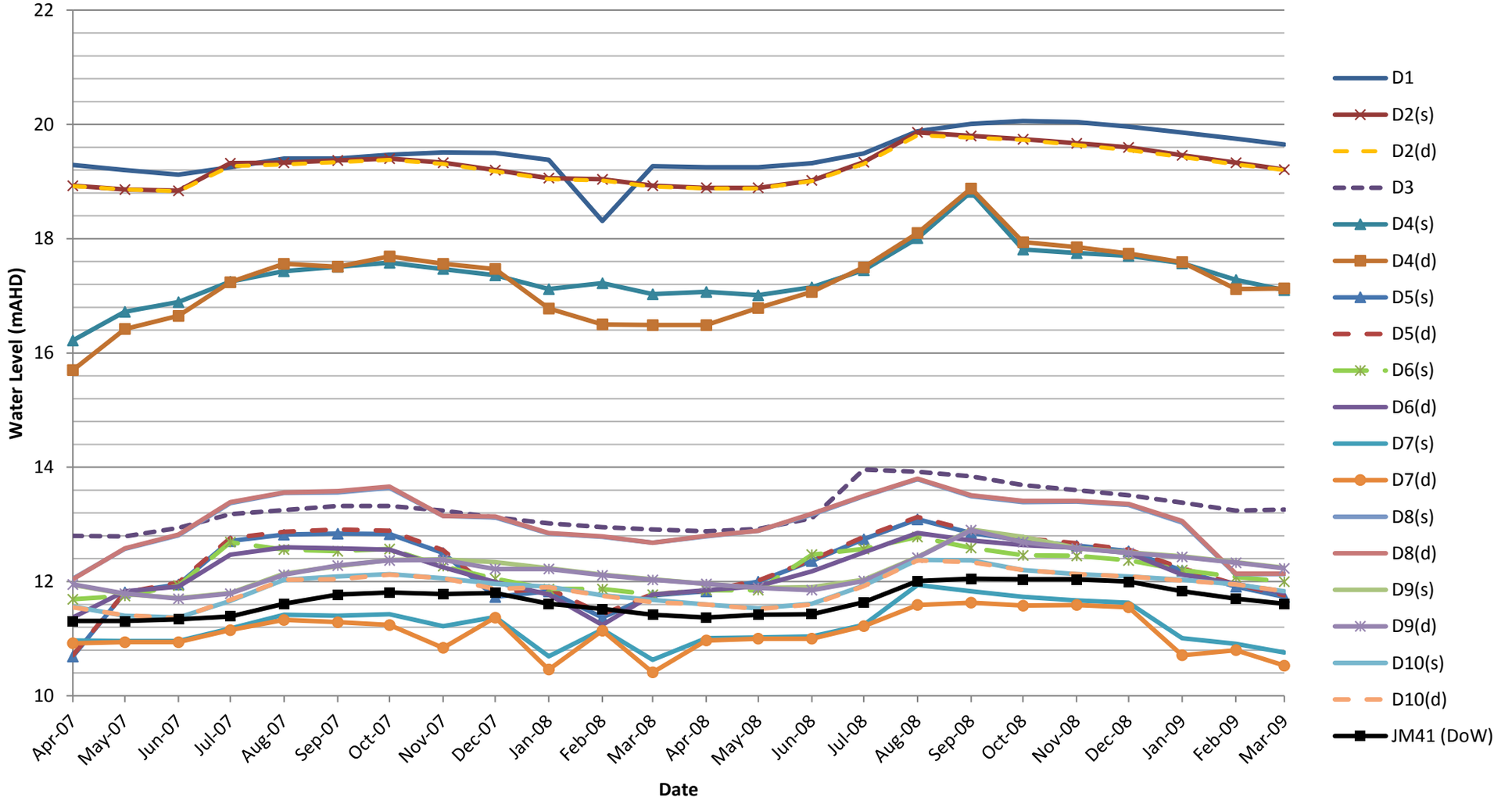
APPENDIX C-i: WATER LEVELS IN JDA AND DOW GROUNDWATER MONITORING BORES (APRIL 2007 TO MARCH 2009)

Water Level (mAHD) in JDA Bore	Monitoring Date in 2007									Monitoring Date in 2008					
	04/04/07	24/05/07	27/06/07	01/08/07	30/08/07	18/09/07	11/10/07	07/11/07	18/12/07	15/01/08	12/02/08	11/03/08	09/04/08	16/05/08	11/06/08
D1	19.29	19.20	19.12	19.25	19.40	19.40	19.47	19.51	19.50	19.38	18.31	19.27	19.25	19.25	19.32
D2(s)	18.93	18.86	18.84	19.32	19.33	19.37	19.40	19.33	19.20	19.06	19.04	18.93	18.89	18.89	19.02
D2(d)	18.92	18.86	18.83	19.27	19.30	19.34	19.38	19.31	19.18	19.04	19.02	18.91	18.88	18.88	19.01
D3	N/M	12.80	12.79	12.94	13.18	13.25	13.32	13.32	13.24	13.12	13.02	12.95	12.91	12.88	12.92
D4(s)	16.22	16.72	16.89	17.25	17.43	17.51	17.58	17.47	17.36	17.12	17.22	17.03	17.07	17.01	17.15
D4(d)	15.70	16.42	16.65	17.24	17.56	17.51	17.69	17.56	17.47	16.78	16.50	16.49	16.49	16.79	17.07
D5(s)	10.69	11.81	11.95	12.71	12.82	12.84	12.83	12.50	11.73	11.83	11.37	11.76	11.83	12.00	12.36
D5(d)	10.71	11.81	11.98	12.76	12.87	12.91	12.89	12.55	11.81	11.88	11.43	11.78	11.84	12.02	12.38
D6(s)	11.69	11.75	11.93	12.69	12.56	12.53	12.57	12.27	12.05	11.87	11.87	11.77	11.85	11.85	12.47
D6(d)	11.37	11.83	11.91	12.47	12.60	12.58	12.56	12.25	11.99	11.77	11.24	11.77	11.85	11.92	12.18
D7(s)	10.97	10.96	10.96	11.18	11.42	11.40	11.43	11.22	11.38	10.69	11.16	10.63	11.01	11.02	11.04
D7(d)	10.92	10.94	10.94	11.15	11.33	11.29	11.24	10.84	11.37	10.46	11.14	10.41	10.97	11.00	11.00
D8(s)	12.05	12.57	12.81	13.37	13.55	13.56	13.64	13.15	13.12	12.84	12.78	12.68	12.79	12.89	13.17
D8(d)	12.04	12.58	12.82	13.39	13.56	13.58	13.66	13.15	13.14	12.85	12.79	12.68	12.80	12.89	13.19
D9(s)	11.94	11.78	11.71	11.80	12.14	12.27	12.38	12.39	12.34	12.23	12.12	12.04	11.96	11.89	11.90
D9(d)	11.95	11.79	11.70	11.79	12.12	12.28	12.37	12.38	12.22	12.22	12.11	12.03	11.96	11.89	11.85
D10(s)	11.56	11.40	11.37	11.66	12.03	12.09	12.13	12.06	11.96	11.91	11.76	11.68	11.60	11.53	11.61
D10(d)	11.55	11.41	11.36	11.68	12.03	12.04	12.12	12.06	11.87	11.90	11.75	11.64	11.60	11.52	11.60

Water Level (mAHD) in JDA Bore	Monitoring Date in 2008						Monitoring Date in 2009			Statistics					
	09/07/08	07/08/08	10/09/08	22/10/08	18/11/08	19/12/08	13/01/09	11/02/09	10/03/09	Average	Median	Min	Max	Q_1	Q_3
D1	19.49	19.88	20.01	20.06	20.04	19.96	19.86	19.75	19.65	19.45	19.44	18.31	20.06	19.25	19.78
D2(s)	19.34	19.86	19.80	19.74	19.67	19.60	19.46	19.33	19.21	19.27	19.33	18.84	19.86	19.00	19.42
D2(d)	19.31	19.81	19.77	19.73	19.64	19.55	19.43	19.30	19.20	19.24	19.29	18.83	19.81	18.99	19.39
D3	13.11	13.96	13.92	13.84	13.69	13.60	13.51	13.38	13.24	13.26	13.24	12.79	13.96	12.95	13.45
D4(s)	17.45	18.01	18.82	17.81	17.75	17.70	17.57	17.28	17.10	17.36	17.32	16.22	18.82	17.09	17.57
D4(d)	17.50	18.10	18.88	17.94	17.85	17.74	17.59	17.12	17.13	17.24	17.36	15.70	18.88	16.75	17.62
D5(s)	12.74	13.09	12.85	12.72	12.63	12.53	12.19	11.91	11.73	12.23	12.28	10.69	13.09	11.83	12.73
D5(d)	12.78	13.13	12.89	12.76	12.67	12.56	12.23	11.95	11.76	12.26	12.31	10.71	13.13	11.83	12.77
D6(s)	12.57	12.78	12.59	12.46	12.45	12.37	12.20	12.08	12.00	12.21	12.23	11.69	12.78	11.87	12.53
D6(d)	12.51	12.85	12.72	12.64	12.59	12.50	12.12	11.96	11.80	12.17	12.15	11.24	12.85	11.85	12.57
D7(s)	11.24	11.94	11.83	11.73	11.67	11.63	11.01	10.91	10.76	11.21	11.17	10.63	11.94	10.96	11.42
D7(d)	11.22	11.59	11.63	11.58	11.59	11.55	10.71	10.80	10.53	11.09	11.07	10.41	11.63	10.90	11.34
D8(s)	13.49	13.79	13.49	13.39	13.40	13.34	13.03	12.13	12.13	13.05	13.14	12.05	13.79	12.79	13.42
D8(d)	13.50	13.80	13.51	13.41	13.41	13.36	13.06	12.14	12.14	13.06	13.14	12.04	13.80	12.79	13.43
D9(s)	12.03	12.43	12.91	12.78	12.59	12.51	12.44	12.34	12.24	12.24	12.23	11.71	13.49	11.95	12.40
D9(d)	12.01	12.42	12.90	12.69	12.58	12.50	12.43	12.33	12.23	12.20	12.22	11.70	12.90	11.96	12.39
D10(s)	11.93	12.38	12.37	12.20	12.13	12.09	12.03	11.95	11.83	11.88	11.94	11.37	12.38	11.64	12.09
D10(d)	11.92	12.37	12.34	12.20	12.13	12.09	12.02	11.95	11.83	11.87	11.91	11.36	12.37	11.63	12.06

Notes: (1) N/M: not measured, (2) values lower than Limit of Reporting (LoR) are shaded and treated as value at LoR in statistics calculation, reported in maximum 2 significant number.

Groundwater Levels - Time Series



Data Source: Department of Water Monitoring Bore Water Levels - JM41 (DoW, 2015)

Job No. J5679

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Figure C1: Time Series - Groundwater Levels in JDA Bores and DoW Bore (JM41)

APPENDIX C-i: (Cont')

Water Level (mAHD) in DoW Bore	Monitoring Date in 2007									Monitoring Date in 2008					
	04/04/07	24/05/07	27/06/07	01/08/07	30/08/07	18/09/07	11/10/07	07/11/07	18/12/07	15/01/08	12/02/08	11/03/08	09/04/08	16/05/08	11/06/08
JE12C	N/M	18.69	N/M	18.70	18.81	18.88		18.95	18.94	18.91	18.83	18.82	18.78	18.76	18.78
JM41	11.37	11.21	11.27	11.48	11.73	11.78	11.77	11.76	11.78	11.54	11.50	11.40	11.41	11.47	11.47
SP1-2B	N/M	10.99	11.07	11.25	11.39	11.46	11.46	11.38	11.26	11.15	11.19	11.09	11.13	11.12	11.08
JM49	N/M	22.92	22.97	23.42	23.67	23.73	23.81	23.70	23.51	23.37	23.37	23.20	23.19	23.13	23.32
JM42	N/M	20.88	20.86	21.10	21.26	21.27	21.34	21.32	21.19	21.02	20.64	20.81	20.78	20.81	20.90

Water Level (mAHD) in DoW Bore	Monitoring Date in 2008						Monitoring Date in 2009			Statistics					
	09/07/08	07/08/08	10/09/08	22/10/08	18/11/08	19/12/08	13/01/09	11/02/09	10/03/09	Average	Median	Min	Max	Q_1	Q_3
JE12C	18.88	19.05	19.27	19.43	19.46	19.36	19.34	19.26	19.16	19.00	18.91	18.69	19.46	18.81	19.26
JM41	11.66	N/M	12.05	12.04	12.07	11.98	11.81	11.72	11.57	11.65	11.66	11.21	12.07	11.47	11.78
SP1-2B	11.41	11.75	11.58	11.58	11.56	11.53	11.43	11.30	11.20	11.32	11.30	10.99	11.75	11.14	11.46
JM49	23.61	23.86	23.74	23.75	23.74	23.66	23.55	23.46	23.34	23.48	23.51	22.92	23.86	23.33	23.72
JM42	22.07	21.48	21.49	21.53	21.51	21.45	21.32	21.12	21.06	21.18	21.19	20.64	22.07	20.89	21.40

Notes: (1) N/M: not measured, (2) values lower than Limit of Reporting (LoR) are shaded and treated as value at LoR in statistics calculation, reported in maximum 2 significant number.

APPENDIX C-iii: GROUDWATER QUALITY MEASURED IN JDA GROUNDWATER MONITORING BORES (APRIL 2007 TO MARCH 2009)

A. Electrical Conductivity (EC) mS/cm

JDA Bore	Monitoring Date in 2007									Monitoring Date in 2008					
	04/04/07	24/05/07	27/06/07	01/08/07	30/08/07	18/09/07	11/10/07	07/11/07	18/12/07	15/01/08	12/02/08	11/03/08	09/04/08	16/05/08	11/06/08
D1	0.29	0.16	0.22	0.08	0.1	0.25	0.21	0.23	0.2	0.19	0.21	0.20	0.12	0.24	0.27
D2(s)	0.67	0.58	0.63	0.58	0.61	0.67	0.5	0.6	0.56	0.62	0.6	0.61	0.56	0.63	0.70
D2(d)	0.46	0.42	0.47	0.34	0.34	0.51	0.44	0.48	0.48	0.49	0.46	0.48	0.44	0.49	0.53
D3	1.2	1.13	1.2	1.09	1.22	1.35	1.26	1.43	1.3	1.38	1.42	1.60	1.57	1.48	1.59
D4(s)	1.01	1.99	2.06	1.91	0.73	0.82	0.43	0.46	0.44	0.94	0.98	1.40	1.55	1.47	1.64
D4(d)	0.48	0.57	0.48	0.35	0.34	0.49	0.42	0.47	0.44	0.46	0.44	0.49	0.45	0.55	0.53
D5(s)	0.7	0.66	0.71	0.58	0.65	0.75	0.68	0.74	0.65	0.67	0.67	0.72	0.69	0.74	0.79
D5(d)	0.85	0.75	0.81	0.72	0.8	0.89	0.83	0.92	0.81	0.86	0.8	0.88	0.83	0.84	0.93
D6(s)	1.3	1.03	1.14	0.68	0.77	0.76	0.71	1.25	1.1	0.87	0.94	0.92	0.90	0.91	0.85
D6(d)	0.75	0.81	0.91	0.72	0.82	0.89	0.82	0.87	0.79	0.83	0.85	0.86	0.82	0.84	0.92
D7(s)	1.99	2.48	2.57	2.65	3.63	3.17	2.43	2.56	2.67	2.45	2.27	2.50	2.44	2.38	2.65
D7(d)	1.61	1.74	1.89	1.83	1.92	1.97	1.85	2.09	1.73	1.96	1.84	1.90	2.04	1.86	2.18
D8(s)	0.58	0.48	0.54	0.38	0.48	0.58	0.64	0.56	0.51	0.52	0.51	0.56	0.47	0.53	0.58
D8(d)	0.68	0.71	0.74	0.52	0.56	0.69	0.56	0.68	0.64	0.67	0.67	0.70	0.66	0.63	0.61
D9(s)	0.73	0.56	0.71	0.95	0.78	0.83	1.57	0.92	0.69	0.58	0.51	0.49	0.37	0.40	0.44
D9(d)	0.67	0.69	0.74	0.55	0.75	0.83	0.66	0.75	0.66	0.7	0.7	0.70	0.66	0.70	0.82
D10(s)	0.68	0.59	N/M	0.7	0.57	0.83	0.91	0.89	0.77	0.63	0.71	0.75	0.69	0.77	0.85
D10(d)	0.4	0.56	0.63	0.14	0.78	0.76	0.31	0.71	0.37	0.44	0.66	0.50	0.65	0.64	0.83

JDA Bore	Monitoring Date in 2008						Monitoring Date in 2009			Statistics					
	09/07/08	07/08/08	10/09/08	22/10/08	18/11/08	19/12/08	13/01/09	11/02/09	10/03/09	Average	Median	Min	Max	Q_1	Q_3
D1	0.15	0.24	0.24	0.23	0.14	0.24	0.22	0.21	0.26	0.20	0.22	0.08	0.29	0.18	0.24
D2(s)	0.39	0.42	0.48	0.71	0.73	0.77	0.68	0.67	0.64	0.61	0.62	0.39	0.77	0.58	0.67
D2(d)	0.46	0.52	0.51	0.49	0.51	0.50	0.49	0.51	0.50	0.47	0.49	0.34	0.53	0.46	0.50
D3	1.56	1.74	0.69	0.87	0.79	0.49	0.93	1.11	1.1	1.23	1.24	0.49	1.74	1.10	1.44
D4(s)	1.33	0.91	0.89	0.50	0.46	0.47	0.47	0.77	0.87	1.02	0.90	0.43	2.06	0.49	1.42
D4(d)	0.41	0.49	0.48	0.48	0.41	0.49	0.47	0.47	0.48	0.46	0.48	0.34	0.57	0.44	0.49
D5(s)	0.66	0.74	0.71	0.73	0.67	0.81	0.74	0.82	0.82	0.71	0.71	0.58	0.82	0.67	0.74
D5(d)	0.82	0.91	0.88	0.88	0.87	0.88	0.88	0.93	0.91	0.85	0.87	0.72	0.93	0.82	0.88
D6(s)	0.79	0.88	1.1	0.97	1.01	1.00	1.36	0.95	0.95	0.96	0.95	0.68	1.36	0.87	1.05
D6(d)	0.79	0.85	0.83	0.82	0.83	0.83	0.82	0.86	0.84	0.83	0.83	0.72	0.92	0.82	0.85
D7(s)	2.60	1.61	1.7	1.58	1.92	2.9	2.67	2.39	2.3	2.44	2.47	1.58	3.63	2.29	2.65
D7(d)	2.02	2.01	2.07	2.12	2.17	2.1	2.05	2.19	2.1	1.97	1.99	1.61	2.19	1.86	2.09
D8(s)	0.52	0.58	0.56	0.56	0.53	0.6	0.54	0.56	0.56	0.54	0.55	0.38	0.64	0.52	0.57
D8(d)	0.55	0.64	0.64	0.66	0.59	0.63	0.63	0.69	0.69	0.64	0.65	0.52	0.74	0.63	0.68
D9(s)	0.31	0.49	0.46	0.51	0.55	0.51	0.41	0.45	0.37	0.61	0.51	0.31	1.57	0.45	0.72
D9(d)	0.71	0.78	0.77	0.77	0.77	0.68	0.71	0.74	0.76	0.72	0.71	0.55	0.83	0.69	0.76
D10(s)	0.76	0.72	1.13	0.86	0.72	0.61	0.36	0.37	0.31	0.70	0.72	0.31	1.13	0.62	0.80
D10(d)	0.71	0.74	0.78	0.7	0.86	0.46	0.68	0.73	0.7	0.61	0.67	0.14	0.86	0.49	0.73

B. pH

JDA Bore	Monitoring Date in 2007									Monitoring Date in 2008					
	04/04/07	24/05/07	27/06/07	01/08/07	30/08/07	18/09/07	11/10/07	07/11/07	18/12/07	15/01/08	12/02/08	11/03/08	09/04/08	16/05/08	11/06/08
D1	5.41	5.13	5.08	5.19	5.24	5.69	5.78	5.97	5.68	5.61	5.57	5.9	5.51	4.75	5.43
D2(s)	5.52	5.29	5.35	5.47	5.28	5.78	5.58	5.58	5.4	5.5	5.33	5.55	4.9	4.67	5.31
D2(d)	6.45	5.36	5.5	5.53	5.46	5.83	5.66	5.76	5.66	5.67	5.56	5.8	5.24	5.46	5.7
D3	5.78	5.8	5.84	5.82	5.77	6.18	5.75	5.78	5.63	5.67	5.67	5.95	5.36	5.56	5.84
D4(s)	5.29	4.82	4.72	4.9	5.24	5.64	5.5	5.48	5.55	4.94	4.41	4.5	4.03	4.12	4.28
D4(d)	6.22	6.35	6.05	6.04	5.96	6.5	6.28	6.23	6.26	6.24	6.1	6.4	5.67	5.97	6.25
D5(s)	6.88	7.13	7.03	7.04	6.87	7.46	7.4	7.07	7.1	7.27	6.89	7.25	6.25	6.13	7.21
D5(d)	6.64	6.74	6.55	6.72	6.56	7.22	7.02	6.99	6.92	6.88	7.4	6.8	6.11	6.4	6.74
D6(s)	6.13	6.32	6.14	6.25	6.06	6.7	6.45	6.52	6.55	6.50	6.28	6.55	5.5	5.94	6.3
D6(d)	6.65	6.57	6.47	6.78	6.29	6.85	6.61	6.55	6.49	6.71	6.53	6.6	5.99	6.22	6.75
D7(s)	5.91	6.14	8.6	5.95	3.48	3.84	3.45	3.23	2.84	3.75	4.71	4.8	5.14	5.43	5.59
D7(d)	6.42	6.70	10.2	6.53	6.24	6.85	6.52	6.41	6.34	6.31	6.26	6.6	6.02	6.37	6.54
D8(s)	6.8	6.94	7.01	6.62	6.46	7.45	7.38	6.85	7.19	6.96	6.96	7.35	6.71	6.33	6.88
D8(d)	7.11	7.31	7.43	7.16	7.07	7.53	6.97	7.17	7.53	7.32	7.21	7.4	7.02	7.07	7.48
D9(s)	5.14	4.85	3.57	2.99	3.13	3.26	2.66	3.13	3.04	3.52	3.66	3.55	4.43	4.44	4.77
D9(d)	5.81	5.86	5.9	6	5.31	5.97	6.1	5.7	5.84	5.45	5.76	5.9	5.61	5.63	6.02
D10(s)	4.04	3.95	N/M	4	4.18	5.34	5.6	6.24	5.03	5.14	4.27	4.25	4.08	4.11	4.18
D10(d)	5.39	5.33	5.33	5.01	4.92	5.61	4.58	5.62	3.59	4.35	4.87	3.7	4.79	4.75	5.38

JDA Bore	Monitoring Date in 2008						Monitoring Date in 2009			Statistics					
	09/07/08	07/08/08	10/09/08	22/10/08	18/11/08	19/12/08	13/01/09	11/02/09	10/03/09	Average	Median	Min	Max	Q_1	Q_3
D1	5.34	5.44	5.39	5.5	5.42	5.07	5.06	50	6.2	5.43	5.43	4.75	6.2	5.18	5.63
D2(s)	5.8	5.47	5.41	5.33	5.25	5.06	4.96	5.08	5.9	5.37	5.38	4.67	5.9	5.27	5.53
D2(d)	5.46	5.55	5.67	5.35	5.54	5.44	5.49	5.48	6.05	5.61	5.55	5.24	6.45	5.46	5.68
D3	5.94	5.85	5.59	5.63	5.65	4.82	5.47	5.72	6.15	5.72	5.76	4.82	6.18	5.63	5.84
D4(s)	4.45	4.34	4.29	4.6	4.76	4.86	4.02	4.27	5.15	4.76	4.74	4.02	5.64	4.33	5.17
D4(d)	6.2	6.18	6.26	6.02	6.12	5.79	5.96	6.03	6.45	6.15	6.19	5.67	6.5	6.03	6.26
D5(s)	6.99	6.96	7.12	6.85	6.9	6.73	6.7	6.89	7.15	6.97	7.01	6.13	7.46	6.88	7.14
D5(d)	6.59	6.82	6.8	6.54	6.66	6.61	6.6	6.72	6.85	6.75	6.73	6.11	7.4	6.60	6.86
D6(s)	6.55	6.49	6.45	6.32	6.62	6.44	6.1	6.58	7.05	6.37	6.45	5.5	7.05	6.22	6.55
D6(d)	6.52	6.55	6.55	6.38	6.48	6.29	6.16	6.33	6.6	6.5	6.54	5.99	6.85	6.37	6.60
D7(s)	5.4	4.07	4.64	4.01	4.09	3.60	3.42	4.06	5.15	4.64	4.37	2.84	8.6	3.71	5.41
D7(d)	6.45	6.46	6.5	6.27	6.29	6.11	6.29	6.29	6.55	6.56	6.42	6.02	10.2	6.29	6.53
D8(s)	6.95	6.95	6.99	6.58	6.89	6.56	6.78	6.87	7.1	6.9	6.92	6.33	7.45	6.76	7
D8(d)	7.1	7.23	7.41	6.59	7.32	6.98	7.26	7.2	7.6	7.23	7.22	6.59	7.6	7.09	7.4
D9(s)	4.41	3.76	3.95	3.88	4.19	4.03	4.07	4.07	5.1	3.9	3.92	2.66	5.14	3.46	4.42
D9(d)	5.8	5.74	5.93	5.74	5.8	5.14	5.57	5.9	6.1	5.77	5.81	5.14	6.1	5.68	5.91
D10(s)	4.58	4.92	5.81	5.31	5.38	5.44	5.76	5.92	6.35	4.95	5.03	3.95	6.35	4.18	5.52
D10(d)	6.26	5.18	5.09	5.16	5.25	3.51	4.90	5.3	5.85	4.99	5.13	3.51	6.26	4.78	5.34

Notes: (1) N/M: not measured, (3) values lower than Limit of Reporting (LoR) are shaded and treated as value at LoR in statistics calculation, reported in maximum 2 significant number.

C. Total Nitrogen (TN) mg/L

JDA Bore	Monitoring Date in 2007									Monitoring Date in 2008					
	04/04/07	24/05/07	27/06/07	01/08/07	30/08/07	18/09/07	11/10/07	07/11/07	18/12/07	15/01/08	12/02/08	11/03/08	09/04/08	16/05/08	11/06/08
D1	2.5	0.43	1.2	1.7	1.3	1.4	0.91	0.88	0.35	0.34	1.1	0.51	0.98	0.2	0.99
D2(s)	4.1	2.7	6.4	3.6	33	4	3.1	4.1	3.2	2.8	4.2	4	3.4	2.7	3.4
D2(d)	0.52	1.7	2.3	2	2.3	1.8	1.8	2	1.5	1.2	0.4	1.1	1.6	1.4	2.4
D3	3.1	1.9	3.3	4.4	3.9	3.7	3.1	6	2.9	3.5	5	2.3	3.1	2.9	3.6
D4(s)	15	40	88	61	7.6	11	2.3	3.3	2.7	13	36	52	60	66	30
D4(d)	0.94	5.3	5.5	2.5	1.7	1.9	1.3	2	1.2	1.1	1.2	0.94	1.4	2.3	1.7
D5(s)	1.3	3.4	2.2	1.4	1.1	1.2	1.5	1.4	1.2	1.1	0.89	0.97	1	0.88	1.5
D5(d)	1	3.9	3.6	1.5	2.2	1.9	1.4	2.5	1.2	3	5.1	0.76	1.2	1.1	2
D6(s)	8	2.7	2.6	4.5	3.3	3.7	3.4	7.5	9	5.6	2.2	2.9	4.1	2.5	3.9
D6(d)	0.61	5.4	1.6	1.1	1.2	1.6	1.5	1.9	1.4	2.4	1.8	0.51	1.6	1.2	1.8
D7(s)	5	3.5	4.8	4.7	39	44	50	12	9	3.1	4.1	3.9	4.2	4	3.8
D7(d)	2.9	3.4	4.3	3.1	3.3	3.9	3.5	3.9	3	3.2	4.2	2.8	3.7	2.9	4.1
D8(s)	1	1	1.1	1.1	1	1.4	1.5	1.3	1.2	0.85	1.2	0.33	2.5	0.8	1.6
D8(d)	0.62	1.1	1.2	1	1.2	1.2	0.93	1.1	0.68	0.74	1.2	0.97	0.83	0.68	1.5
D9(s)	2.5	1.1	2.6	1.4	0.77	1.5	4	6	5.6	3.2	3.3	0.56	0.69	0.32	1.4
D9(d)	0.77	1.1	0.99	0.89	0.9	1.2	0.97	1.2	0.9	0.66	0.88	0.88	0.86	0.87	1.8
D10(s)	2	0.37		0.75	0.83	1	4.4	2.1	1.7	2.1	1.5	1.2	0.66	0.93	0.94
D10(d)	2.5	1.2	1.1	1.2	1.7	1.8	1.9	1.3	0.99	0.71	0.95	0.92	0.56	0.93	1.3

JDA Bore	Monitoring Date in 2008						Monitoring Date in 2009			Statistics					
	09/07/08	07/08/08	10/09/08	22/10/08	18/11/08	19/12/08	13/01/09	11/02/09	10/03/09	Average	Median	Min	Max	Q_1	Q_3
D1	0.25	0.33	0.26	0.17	0.28	2.2	0.27	1	2.2	0.91	0.90	0.17	2.50	0.32	1.23
D2(s)	5.5	9.5	2.5	2.5	3.5	3.6	3.1	2.6	3.4	5.04	3.45	2.50	33.00	3.03	4.10
D2(d)	0.69	1.4	1.2	1.4	1.8	1.6	1.4	1.4	1.8	1.53	1.55	0.40	2.40	1.35	1.80
D3	5.1	1.5	1.6	3.8	4.3	8.6	2.3	2.3	4.2	3.60	3.40	1.50	8.60	2.75	4.23
D4(s)	46	28	13	4.9	4	3	3.8	8.5	10	25.38	13.00	2.30	88.00	4.68	41.50
D4(d)	1.2	0.94	0.83	0.81	1.1	0.93	0.85	0.77	1	1.64	1.20	0.77	5.50	0.94	1.75
D5(s)	0.86	1	0.89	0.86	1.2	1.2	0.82	0.9	1.3	1.25	1.15	0.82	3.40	0.90	1.33
D5(d)	0.74	1.5	1.3	1.1	1.6	1.5	1.2	1.1	1.6	1.83	1.50	0.74	5.10	1.18	2.05
D6(s)	6.4	4.4	4.1	5.7	7	7	8.2	5.2	5.5	4.98	4.45	2.20	9.00	3.38	6.55
D6(d)	1.3	1.4	1.2	1.4	1.6	1.4	1.1	0.99	1.8	1.58	1.40	0.51	5.40	1.20	1.65
D7(s)	4	2.8	1.6	1.3	2.1	2.7	2.4	2.6	2.9	9.06	3.95	1.30	50.00	2.78	4.85
D7(d)	2.9	3.8	3.2	3.8	4.2	4.2	3.5	3.2	3.9	3.54	3.50	2.80	4.30	3.18	3.90
D8(s)	0.65	1.1	0.74	0.77	0.93	1.2	0.66	0.54	1.2	1.07	1.05	0.33	2.50	0.79	1.20
D8(d)	0.54	2.6	0.64	0.67	0.7	0.79	0.66	0.52	0.92	0.96	0.88	0.52	2.60	0.68	1.13
D9(s)	0.31	0.98	4.2	1.1	4.3	7.5	2.8	2.5	1.7	2.51	2.10	0.31	7.50	1.07	3.48
D9(d)	0.38	0.97	0.8	5.5	0.96	1	1	0.71	1.1	1.14	0.93	0.38	5.50	0.87	1.03
D10(s)	0.62	1.1	0.71	4.9	4.3	0.39	2.3	0.87	0.84	1.59	1.00	0.37	4.90	0.79	2.05
D10(d)	0.82	0.8	0.43	0.48	0.44	5.5	0.53	0.44	0.49	1.21	0.94	0.43	5.50	0.55	1.30

Notes: (1) N/M: not measured, (3) values lower than Limit of Reporting (LoR) are shaded and treated as value at LoR in statistics calculation, reported in maximum 2 significant number.

D. Total Kjeldahl Nitrogen (TKN) mg/L

JDA Bore	Monitoring Date in 2007									Monitoring Date in 2008					
	04/04/07	24/05/07	27/06/07	01/08/07	30/08/07	18/09/07	11/10/07	07/11/07	18/12/07	15/01/08	12/02/08	11/03/08	09/04/08	16/05/08	11/06/08
D1	2.3	0.43	1.2	1.7	1	1.2	0.79	0.88	0.35	0.31	1	0.45	0.68	0.16	0.94
D2(s)	4.1	2.7	6.4	3.4	7.9	2.9	3.1	4.1	3.2	2.8	4.2	4	3.4	2.7	3.4
D2(d)	0.51	1.3	2.3	2	1.9	1.8	1.8	2	1.5	1.2	0.4	1.1	1.6	1.3	2.4
D3	2.5	1.7	3.3	1.6	2.3	2.4	1.4	2	1.8	2.7	1.4	1.4	2.3	1.9	2.7
D4(s)	5	2.5	<0.05	7	4	3.4	2.3	3.2	2.6	3.4	3.4	23	13	57	30
D4(d)	0.78	1.2	3.8	2.4	1.6	1.8	1.3	2	1.2	0.9	0.67	0.24	0.61	0.88	0.9
D5(s)	1.3	3.2	2.1	1.4	1.1	1.2	1.5	1.4	1.2	1	0.75	0.78	0.71	0.34	1.5
D5(d)	0.98	3.8	3.6	1.5	2.2	1.8	1.3	2.5	1.2	3	5.1	0.14	1.1	1.1	2
D6(s)	1.8	2.7	2.6	4.5	3.3	3.7	3.4	7.5	9	5.6	2.2	2.9	4.1	2	3.9
D6(d)	0.5	5.4	1.6	1.1	1.2	1.6	1.5	1.9	1.4	2.4	1.8	0.51	1.5	0.41	1.8
D7(s)	4.9	3.5	4.8	3.7	9.1	9	11	1.6	3.9	3	4.1	3.9	4.1	3.9	3.7
D7(d)	2.9	3.4	4.3	3.1	2.6	3.4	2.7	3.8	2.9	3.2	4.2	2.8	3.7	2.9	4
D8(s)	0.92	0.88	1.1	1.1	0.89	1.3	1.3	1.3	1.2	0.85	1.2	0.27	2.4	0.79	1.6
D8(d)	0.61	1.1	1.2	0.99	1.1	1.2	0.85	1.1	0.68	0.74	1.2	0.94	0.8	0.68	1.5
D9(s)	2.4	0.84	1.7	1	0.63	0.8	2.1	0.73	0.84	0.91	1.7	0.34	0.65	0.32	1.4
D9(d)	0.76	1.1	0.98	0.87	0.89	1.1	0.97	1.1	0.81	0.61	0.87	0.66	0.86	0.79	1.8
D10(s)	1.1	0.26	N/M	0.72	0.67	0.56	2	0.42	0.68	0.08	0.79	0.43	0.41	0.92	0.93
D10(d)	2.5	1.2	1.1	1.2	1.7	1.7	1.8	1.3	0.26	0.23	0.93	0.36	0.53	0.92	1.2

JDA Bore	Monitoring Date in 2008						Monitoring Date in 2009			Statistics					
	09/07/08	07/08/08	10/09/08	22/10/08	18/11/08	19/12/08	13/01/09	11/02/09	10/03/09	Average	Median	Min	Max	Q_1	Q_3
D1	0.25	0.33	0.24	0.16	0.28	2.1	0.18	0.2	2.2	0.81	0.57	0.16	2.3	0.27	1.05
D2(s)	1.7	1.6	2.4	2.5	3.5	3.6	3.1	1.9	3.4	3.42	3.3	1.6	7.9	2.7	3.7
D2(d)	0.63	1.3	1.2	1.4	1.8	1.6	1.4	1.4	1.80	1.49	1.45	0.4	2.4	1.28	1.8
D3	1.9	1.5	1.2	0.87	1.2	3.9	1.8	1.7	1.7	1.97	1.8	0.87	3.9	1.48	2.33
D4(s)	7.9	5.3	0.85	1.9	2.2	2.2	2.3	2	1.1	7.73	3.3	0.05	57	2.2	5.73
D4(d)	0.73	0.61	0.78	0.75	1	0.93	0.83	0.77	0.87	1.15	0.89	0.24	3.8	0.77	1.23
D5(s)	0.76	0.94	0.86	0.84	1.2	1.2	0.82	0.55	1.3	1.16	1.15	0.34	3.2	0.81	1.33
D5(d)	0.72	1.4	1.20	1	1.6	1.5	1.2	0.8	1.5	1.76	1.45	0.14	5.1	1.1	2.05
D6(s)	6.4	4.4	4.10	5.6	7	7	8.2	5.1	5.50	4.69	4.25	1.8	9	3.2	5.8
D6(d)	1.3	1.4	1.1	1.4	1.6	1.4	1.1	0.77	1.8	1.52	1.4	0.41	5.4	1.1	1.65
D7(s)	3.8	1.7	1.6	1.3	2	2.7	2.3	2.6	2.8	3.96	3.7	1.3	11	2.53	4.1
D7(d)	2.9	3.8	3.1	3.8	4.2	4.2	3.5	3.2	3.8	3.43	3.4	2.6	4.3	2.9	3.8
D8(s)	0.65	1.1	0.72	0.76	0.93	1.2	0.66	0.39	1.1	1.03	1.02	0.27	2.4	0.78	1.2
D8(d)	0.54	1.3	0.62	0.67	0.69	0.79	0.66	0.39	0.9	0.89	0.83	0.39	1.5	0.68	1.1
D9(s)	0.3	0.98	0.12	1.1	0.18	3	1	0.24	1.1	1.02	0.88	0.12	3	0.56	1.18
D9(d)	0.38	0.95	0.78	0.43	0.94	0.64	0.92	0.71	1.1	0.88	0.87	0.38	1.8	0.75	0.97
D10(s)	0.54	1.1	0.62	0.12	0.43	0.29	0.6	0.51	0.46	0.64	0.56	0.08	2	0.43	0.76
D10(d)	0.82	0.21	0.4	0.34	0.33	1.7	0.45	0.44	0.44	0.92	0.87	0.21	2.5	0.39	1.23

Notes: (1) N/M: not measured, (2) values lower than Limit of Reporting (LoR) are shaded and treated as value at LoR in statistics calculation, reported in maximum 2 significant number.

E. Nitrates and Nitrites (NO_x_N) mg/L

JDA Bore	Monitoring Date in 2007									Monitoring Date in 2008					
	04/04/07	24/05/07	27/06/07	01/08/07	30/08/07	18/09/07	11/10/07	07/11/07	18/12/07	15/01/08	12/02/08	11/03/08	09/04/08	16/05/08	11/06/08
D1	0.19	<0.005	<0.005	0.027	0.28	0.22	0.12	<0.005	<0.005	0.035	0.097	0.063	0.3	0.38	0.046
D2(s)	0.014	<0.005	<0.005	0.24	25	1.1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
D2(d)	0.01	0.44	0.005	0.011	0.4	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.046	<0.005	0.13	<0.005
D3	0.61	0.21	0.015	2.8	1.6	1.4	1.7	4.1	1.2	0.81	3.6	0.9	0.84	0.92	0.85
D4(s)	10	37	88	54	3.6	7.6	0.031	0.12	0.047	9.9	33	29	47	8.6	0.34
D4(d)	0.16	4.1	1.7	0.073	0.084	0.1	<0.005	<0.005	0.013	0.15	0.53	0.7	0.81	1.4	0.81
D5(s)	0.04	0.23	0.1	0.009	0.008	0.034	0.042	<0.005	<0.005	0.046	0.14	0.19	0.29	0.54	0.005
D5(d)	0.024	0.088	0.046	0.049	0.038	0.087	0.063	<0.005	0.015	<0.005	<0.005	0.62	0.077	0.008	<0.005
D6(s)	6.2	0.045	0.013	0.008	0.018	0.012	<0.005	<0.005	<0.005	0.009	<0.005	<0.005	0.026	0.48	<0.005
D6(d)	0.11	0.037	<0.005	0.02	0.021	0.015	<0.005	<0.005	0.03	0.009	<0.005	<0.005	0.019	0.74	0.012
D7(s)	0.053	0.035	0.006	1	30	35	39	10	5.1	0.12	0.017	<0.005	0.024	0.11	0.068
D7(d)	0.009	0.021	0.011	0.022	0.68	0.49	0.81	0.088	0.07	<0.005	<0.005	<0.005	0.011	<0.005	0.052
D8(s)	0.085	0.008	0.008	0.016	0.11	0.14	0.23	<0.005	0.02	<0.005	<0.005	0.006	0.006	0.011	<0.005
D8(d)	0.011	<0.005	0.026	0.013	0.061	0.039	0.083	<0.005	<0.005	<0.005	<0.005	0.026	0.028	<0.005	<0.005
D9(s)	0.079	0.26	0.93	0.36	0.14	0.7	1.9	5.3	4.8	2.3	1.6	0.22	0.044	<0.005	0.035
D9(d)	0.013	0.016	0.007	0.023	0.011	0.07	<0.005	0.14	0.094	0.053	0.012	0.22	<0.005	0.012	<0.005
D10(s)	0.94	<0.005	N/M	0.032	0.16	0.44	2.5	1.7	1.1	2.1	0.71	0.75	0.25	0.85	0.012
D10(d)	0.042	0.015	0.013	0.025	0.042	0.052	0.11	0.006	0.73	0.48	0.024	0.56	0.028	0.012	0.048

JDA Bore	Monitoring Date in 2008						Monitoring Date in 2009			Statistics					
	09/07/08	07/08/08	10/09/08	22/10/08	18/11/08	19/12/08	13/01/09	11/02/09	10/03/09	Average	Median	Min	Max	Q_1	Q_3
D1	<0.005	<0.005	0.02	0.012	<0.005	0.008	0.093	0.8	0.024	0.1146	0.0310	<0.005	0.8	<0.005	0.137
D2(s)	3.8	7.9	0.066	<0.005	0.006	<0.005	<0.005	0.69	<0.005	1.6205	0.0050	<0.005	25	<0.005	0.109
D2(d)	0.058	0.084	0.036	<0.005	<0.005	<0.005	<0.005	0.015	0.016	0.0546	0.0050	0.005	0.44	<0.005	0.038
D3	3.3	0.015	0.44	2.9	3.1	4.6	0.56	0.63	2.6	1.6542	1.0600	0.015	4.6	0.625	2.825
D4(s)	38	22	12	3	1.8	0.73	1.5	6.5	8.9	17.6112	8.7500	0.031	88	1.725	30
D4(d)	0.49	0.33	0.044	0.061	0.046	<0.005	0.018	<0.005	0.13	0.4904	0.1150	<0.005	4.1	0.0375	0.572
D5(s)	0.096	0.07	0.028	0.022	0.011	<0.005	<0.005	0.35	0.026	0.0957	0.0370	<0.005	0.54	0.0088	0.11
D5(d)	0.022	0.11	0.054	0.046	0.005	<0.005	<0.005	0.3	0.014	0.0707	0.0310	<0.005	0.62	<0.005	0.066
D6(s)	<0.005	<0.005	0.029	0.029	<0.005	<0.005	<0.005	0.11	<0.005	0.2933	0.0065	<0.005	6.2	<0.005	0.026
D6(d)	0.005	<0.005	0.023	0.012	0.009	<0.005	<0.005	0.22	0.009	0.0555	0.0105	<0.005	0.74	<0.005	0.021
D7(s)	0.19	1.1	0.026	0.008	0.079	<0.005	0.072	0.007	0.051	5.0865	0.0700	<0.005	39	0.0223	1.025
D7(d)	<0.005	<0.005	0.009	<0.005	<0.005	<0.005	<0.005	0.009	0.092	0.1010	0.0090	<0.005	0.81	<0.005	0.056
D8(s)	<0.005	<0.005	0.024	0.009	<0.005	<0.005	<0.005	0.15	0.064	0.0388	0.0080	<0.005	0.23	<0.005	0.034
D8(d)	<0.005	1.4	0.02	<0.005	0.011	<0.005	<0.005	0.13	0.024	0.0803	0.0110	<0.005	1.4	<0.005	0.026
D9(s)	0.012	<0.005	4.1	0.006	4.1	4.5	1.8	2.3	0.6	1.5040	0.6500	<0.005	5.3	0.07	2.3
D9(d)	<0.005	0.02	0.023	5.1	0.022	0.38	0.094	<0.005	0.013	0.2645	0.0180	<0.005	5.1	0.01	0.076
D10(s)	0.083	0.005	6.5	4.9	3.9	0.1	1.7	0.36	0.38	1.2816	0.7100	<0.005	6.5	0.13	1.7
D10(d)	<0.005	0.59	0.034	0.48	0.11	3.8	0.081	<0.005	0.047	0.3058	0.0445	<0.005	3.8	0.021	0.202

Notes: (1) N/M: not measured, (2) values lower than Limit of Reporting (LoR) are shaded and treated as value at LoR in statistics calculation, reported in maximum 2 significant number.

F. Ammonia in water (NH_4_N) mg/L

JDA Bore	Monitoring Date in 2007									Monitoring Date in 2008					
	04/04/07	24/05/07	27/06/07	01/08/07	30/08/07	18/09/07	11/10/07	07/11/07	18/12/07	15/01/08	12/02/08	11/03/08	09/04/08	16/05/08	11/06/08
D1	0.067	0.12	0.25	0.14	0.073	0.11	0.44	0.76	0.15	<0.005	0.091	0.04	<0.005	0.053	0.1
D2(s)	0.49	0.65	0.45	0.25	0.030	0.19	0.66	1.4	0.44	0.46	0.5	0.5	0.39	0.42	0.72
D2(d)	<0.005	0.35	0.2	0.29	0.200	0.31	0.63	0.77	0.23	0.24	0.28	0.32	0.18	0.26	0.28
D3	0.2	0.24	0.17	0.18	0.099	0.21	0.51	0.65	0.3	0.16	0.22	0.25	0.13	0.11	0.23
D4(s)	<0.005	0.045	0.039	0.055	0.050	0.15	0.37	0.57	0.37	0.15	0.34	0.13	0.022	0.016	0.059
D4(d)	0.29	0.2	0.29	0.38	0.330	0.4	0.37	0.79	0.4	0.35	0.4	0.24	0.25	0.036	0.39
D5(s)	0.35	1.5	0.35	0.58	0.370	0.52	0.38	0.64	0.4	0.35	0.39	0.42	0.27	0.28	0.43
D5(d)	0.21	0.34	0.31	0.3	0.310	0.26	0.28	0.76	0.43	0.32	2.3	0.34	0.24	0.23	0.39
D6(s)	0.16	0.46	0.38	1.3	1.000	0.89	0.69	5.4	7.1	2.9	0.37	1.1	1.7	0.53	0.97
D6(d)	0.012	0.47	0.35	0.38	0.300	0.54	0.67	0.48	0.5	0.45	0.48	0.51	0.37	0.37	0.41
D7(s)	2.8	2.8	2.6	2.8	0.450	0.7	1.3	0.74	1.4	2.2	2.3	2.8	2.3	2.4	3.2
D7(d)	2.3	2.4	2.3	2.6	2.300	2.5	2	3	2.5	2.6	2.5	2.3	2.7	2.1	2.6
D8(s)	0.22	0.37	0.23	0.37	0.320	0.35	0.29	0.37	0.33	0.31	0.36	0.29	0.26	0.26	0.38
D8(d)	0.24	0.43	0.32	0.41	0.390	0.38	0.29	0.39	0.27	0.37	0.39	0.27	0.25	0.24	0.38
D9(s)	0.44	0.4	0.14	0.2	0.190	0.27	0.62	0.45	0.34	0.25	0.29	0.34	0.16	0.028	0.25
D9(d)	0.41	0.63	0.46	0.46	0.490	0.64	0.92	0.59	0.53	0.59	0.57	0.5	0.41	0.39	0.65
D10(s)	0.051	0.076		0.11	0.067	0.064	0.37	0.085	0.035	<0.005	0.025	0.081	<0.005	0.25	0.032
D10(d)	2.3	0.72	0.44	0.95	0.960	0.96	0.73	0.78	0.062	0.18	0.58	0.22	0.19	0.39	0.29

JDA Bore	Monitoring Date in 2008						Monitoring Date in 2009			Statistics					
	09/07/08	07/08/08	10/09/08	22/10/08	18/11/08	19/12/08	13/01/09	11/02/09	10/03/09	Average	Median	Min	Max	Q_1	Q_3
D1	0.12	0.085	0.1	0.1	0.13	0.025	0.11	0.083	0.19	0.139	0.1	0.005	0.76	0.071	0.132
D2(s)	0.22	0.053	0.5	0.59	0.71	0.67	0.77	0.8	0.94	0.533	0.5	0.03	1.4	0.412	0.68
D2(d)	0.2	0.32	0.4	0.27	0.32	0.27	0.33	0.33	0.36	0.306	0.285	0.005	0.77	0.237	0.33
D3	0.28	0.63	0.3	0.2	0.26	0.038	0.56	0.7	0.34	0.29	0.235	0.038	0.7	0.177	0.31
D4(s)	0.019	<0.005	0.1	0.48	0.42	0.43	0.44	0.45	0.14	0.202	0.135	0.005	0.57	0.043	0.382
D4(d)	0.38	0.37	0.4	0.37	0.44	0.37	0.51	0.39	0.46	0.366	0.375	0.036	0.79	0.32	0.4
D5(s)	0.38	0.43	0.4	0.36	0.48	0.45	0.38	0.44	0.51	0.46	0.4	0.27	1.5	0.367	0.457
D5(d)	0.37	0.2	0.3	0.14	0.39	0.37	0.39	0.39	0.45	0.417	0.33	0.14	2.3	0.275	0.39
D6(s)	3.3	1.9	3.7	3.4	5.4	4.2	4.4	3.3	3.2	2.406	1.8	0.16	7.1	0.84	3.475
D6(d)	0.44	0.43	0.5	0.47	0.57	0.54	0.52	0.55	0.53	0.4518	0.475	0.012	0.67	0.402	0.522
D7(s)	2.8	0.7	1.1	0.65	0.74	0.76	1.4	1.9	2.6	1.81	2.05	0.45	3.2	0.755	2.65
D7(d)	2.6	2.2	3	2.9	3.2	3.2	2.5	3.1	3	2.6	2.55	2	3.2	2.3	2.925
D8(s)	0.36	0.36	0.3	0.26	0.37	0.35	0.33	0.35	0.34	0.322	0.335	0.22	0.38	0.29	0.36
D8(d)	0.36	0.14	0.3	0.25	0.36	0.36	0.32	0.38	0.46	0.331	0.36	0.14	0.46	0.27	0.382
D9(s)	0.02	0.6	0.2	0.75	0.18	0.078	0.22	0.2	0.26	0.286	0.25	0.02	0.75	0.1875	0.355
D9(d)	0.33	0.35	0.7	0.17	0.61	0.17	0.59	0.65	0.66	0.519	0.55	0.17	0.92	0.41	0.632
D10(s)	0.26	0.33	0.1	0.037	0.04	<0.005	0.06	0.052	0.081	0.096	0.064	0.005	0.37	0.036	0.092
D10(d)	0.64	<0.005	0.4	0.27	0.27	<0.005	0.31	0.34	0.23	0.509	0.365	0.005	2.3	0.227	0.722

Notes: (1) N/M: not measured, (2) values lower than Limit of Reporting (LoR) are shaded and treated as value at LoR in statistics calculation, reported in maximum 2 significant number.

G. Total Phosphorus (TP) mg/L

JDA Bore	Monitoring Date in 2007									Monitoring Date in 2008					
	04/04/07	24/05/07	27/06/07	01/08/07	30/08/07	18/09/07	11/10/07	07/11/07	18/12/07	15/01/08	12/02/08	11/03/08	09/04/08	16/05/08	11/06/08
D1	0.77	0.1	0.39	0.65	0.29	0.52	0.12	0.42	0.04	0.12	0.33	0.03	0.16	<0.01	<0.01
D2(s)	2.4	1.7	2.5	1.8	1.3	1.6	1.8	2.5	1.7	1.7	2.3	2.2	1.9	1.8	1.8
D2(d)	0.04	0.06	0.1	0.07	0.04	0.03	0.06	0.1	0.06	0.02	0.05	0.07	0.04	0.18	<0.01
D3	0.54	0.16	0.7	0.09	0.09	0.29	0.16	0.1	0.24	0.31	0.05	0.09	0.15	0.06	<0.01
D4(s)	3.1	3	4	2.4	3.1	1.9	1.8	2	1.6	2.6	1.8	3.3	3.8	3	2.4
D4(d)	0.93	0.44	0.11	0.08	0.06	0.11	0.11	0.07	0.15	0.05	0.11	0.1	0.1	0.19	<0.01
D5(s)	0.19	0.46	0.14	0.15	0.13	0.15	0.18	0.14	0.21	0.1	0.1	0.16	0.11	0.85	0.03
D5(d)	0.07	0.46	0.82	0.17	0.22	1.1	0.2	0.47	0.11	0.53	0.58	0.09	0.09	0.06	0.21
D6(s)	0.61	0.59	0.98	0.88	0.84	0.65	0.56	0.54	0.71	0.75	0.3	0.77	1.2	0.64	1
D6(d)	0.04	0.02	0.26	0.04	0.08	0.42	0.09	0.07	0.12	0.14	0.06	0.06	0.1	0.07	0.08
D7(s)	0.05	<0.01	0.01	0.01	0.02	<0.01	0.03	<0.01	0.05	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
D7(d)	0.03	0.11	0.05	0.03	<0.01	0.03	0.04	0.01	0.04	<0.01	0.02	0.14	0.02	<0.01	<0.01
D8(s)	0.74	0.57	0.92	0.32	0.58	1.7	1.1	0.3	1.7	0.64	0.35	0.45	0.88	0.25	0.1
D8(d)	0.04	0.29	0.51	0.1	0.09	0.29	0.19	0.2	0.14	0.22	0.11	0.16	0.15	0.1	0.1
D9(s)	0.07	0.04	0.05	0.02	<0.01	0.01	0.05	0.02	0.06	<0.01	0.02	0.03	<0.01	<0.01	<0.01
D9(d)	0.02	0.04	0.01	0.03	<0.01	<0.01	0.03	0.01	0.03	<0.01	0.02	0.03	0.01	<0.01	<0.01
D10(s)	0.07	0.04	N/M	0.04	0.04	0.03	0.09	0.03	0.06	<0.01	0.02	0.05	0.02	<0.01	<0.01
D10(d)	0.03	0.05	0.02	0.03	<0.01	<0.01	0.12	<0.01	0.03	<0.01	0.01	0.02	<0.01	<0.01	<0.01

JDA Bore	Monitoring Date in 2008						Monitoring Date in 2009			Statistics					
	09/07/08	07/08/08	10/09/08	22/10/08	18/11/08	19/12/08	13/01/09	11/02/09	10/03/09	Average	Median	Min	Max	Q_1	Q_3
D1	0.07	<0.01	<0.01	0.01	<0.01	0.54	<0.01	<0.01	.59	0.286	0.225	<0.01	0.77	0.105	0.412
D2(s)	1.5	1.8	1.8	1.5	1.6	1.7	1.9	2.1	2	1.87	1.8	1.3	2.5	1.7	2.025
D2(d)	0.08	<0.01	<0.01	0.02	0.03	<0.01	<0.01	0.08	0.03	0.061	0.06	<0.01	0.18	0.035	0.075
D3	0.06	<0.01	0.06	0.22	0.19	0.48	0.04	0.09	0.44	0.209	0.155	0.04	0.7	0.09	0.277
D4(s)	2.4	2.4	1.6	1.4	1.3	1.5	1.2	1.6	3.3	2.354	2.4	1.2	4	1.6	3.025
D4(d)	0.06	0.04	<0.01	0.06	0.07	0.02	0.01	0.16	0.21	0.147	0.1	0.01	0.93	0.06	0.14
D5(s)	0.08	0.09	0.04	0.1	0.1	0.08	0.05	0.16	0.1	0.162	0.12	0.03	0.85	0.097	0.16
D5(d)	0.13	0.48	0.48	0.07	0.17	1.9	0.13	0.15	0.12	0.367	0.185	0.06	1.9	0.117	0.48
D6(s)	0.86	0.65	0.5	0.92	1	1.3	1.7	1.6	1.6	0.881	0.805	0.3	1.7	0.632	1
D6(d)	0.08	0.13	0.02	0.09	0.06	0.08	0.05	0.03	0.16	0.097	0.08	0.02	0.42	0.057	0.105
D7(s)	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	1.1	0.02	0.132	0.02	0.01	1.1	0.012	0.045
D7(d)	<0.01	<0.01	0.03	0.01	0.1	<0.01	<0.01	0.04	0.03	0.045	0.03	0.01	0.14	0.027	0.042
D8(s)	0.26	0.15	0.1	0.16	0.13	0.29	0.09	0.2	0.44	0.517	0.335	0.09	1.7	0.19	0.665
D8(d)	0.11	<0.01	0.09	0.12	0.12	0.1	0.09	0.17	0.15	0.158	0.12	0.04	0.51	0.1	0.18
D9(s)	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.04	0.02	0.033	0.03	<0.01	0.07	0.02	0.05
D9(d)	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	0.05	0.02	0.024	0.02	<0.01	0.05	0.02	0.03
D10(s)	<0.01	0.34	<0.01	0.03	0.01	<0.01	<0.01	0.06	0.02	0.059	0.04	<0.01	0.34	0.0275	0.06
D10(d)	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.05	0.02	0.0380	0.03	<0.01	0.12	0.02	0.045

Notes: (1) N/M: not measured, (2) values lower than Limit of Reporting (LoR) are shaded and treated as value at LoR in statistics calculation, reported in maximum 2 significant number.

H. Filterable Reactive Phosphorus (FRP) mg/L

JDA Bore	Monitoring Date in 2007									Monitoring Date in 2008					
	04/04/07	24/05/07	27/06/07	01/08/07	30/08/07	18/09/07	11/10/07	07/11/07	18/12/07	15/01/08	12/02/08	11/03/08	09/04/08	16/05/08	11/06/08
D1	0.007	0.007	<0.005	0.009	0.007	0.006	<0.005	<0.005	0.015	<0.005	0.011	<0.005	<0.005	<0.005	<0.005
D2(s)	1.9	1.3	1.7	1.3	0.95	1.3	0.89	1.8	1.7	1.8	1.8	1.9	1.8	1.8	1.6
D2(d)	0.015	0.02	0.051	0.036	0.021	0.024	0.037	0.018	0.018	0.019	0.043	0.023	0.011	0.17	<0.005
D3	0.009	0.006	<0.005	0.009	0.006	0.007	<0.005	<0.005	0.011	<0.005	0.011	<0.005	<0.005	<0.005	<0.005
D4(s)	1.4	1.8	2.1	2.1	1.7	1.1	1.1	0.68	0.55	2.5	1.5	2.7	2.8	2.5	1.13
D4(d)	0.043	0.22	0.074	0.074	0.049	0.057	0.072	0.064	0.07	0.043	0.086	0.08	0.086	0.19	<0.005
D5(s)	0.021	0.18	0.048	0.055	0.054	0.047	0.009	0.043	0.063	0.05	0.096	0.039	0.095	0.085	<0.005
D5(d)	0.022	0.052	<0.005	0.032	0.018	0.018	0.023	0.023	0.073	0.013	0.29	0.053	0.07	0.059	0.009
D6(s)	0.04	0.2	0.12	0.43	0.3	0.13	0.089	0.026	0.072	0.22	0.03	0.4	0.8	0.36	0.79
D6(d)	0.006	0.02	<0.005	0.008	0.009	0.007	<0.005	<0.005	0.015	<0.005	0.009	0.043	<0.005	0.049	<0.005
D7(s)	0.007	<0.005	<0.005	0.005	0.006	<0.005	<0.005	<0.005	0.017	<0.005	0.008	<0.005	<0.005	<0.005	<0.005
D7(d)	0.02	0.011	<0.005	0.018	0.007	0.021	<0.005	<0.005	0.014	<0.005	0.014	<0.005	<0.005	<0.005	<0.005
D8(s)	0.018	0.022	<0.005	0.015	0.014	0.015	<0.005	0.016	0.032	0.008	0.02	<0.005	<0.005	0.037	0.048
D8(d)	0.007	0.038	0.005	0.025	0.019	0.065	0.062	0.05	0.09	0.044	0.053	0.07	0.097	0.084	0.063
D9(s)	0.005	0.005	<0.005	0.007	0.005	0.005	<0.005	<0.005	0.01	<0.005	0.008	<0.005	<0.005	<0.005	<0.005
D9(d)	0.006	0.006	<0.005	0.011	0.008	<0.005	<0.005	<0.005	0.013	<0.005	0.01	<0.005	<0.005	<0.005	<0.005
D10(s)	0.005	<0.005	N/M	0.005	0.005	<0.005	<0.005	<0.005	0.005	<0.005	0.008	<0.005	<0.005	<0.005	<0.005
D10(d)	0.01	<0.005	<0.005	0.009	0.005	<0.005	<0.005	<0.005	0.012	<0.005	0.008	<0.005	<0.005	<0.005	<0.005

JDA Bore	Monitoring Date in 2008						Monitoring Date in 2009			Statistics					
	09/07/08	07/08/08	10/09/08	22/10/08	18/11/08	19/12/08	13/01/09	11/02/09	10/03/09	Average	Median	Min	Max	Q_1	Q_3
D1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.006	0.005	<0.005	0.015	0.005	0.0063
D2(s)	1.2	1.6	2	1.5	0.95	1.7	1.8	2	1.9	1.591	1.7	0.89	2	1.3	1.8
D2(d)	0.048	<0.005	<0.005	<0.005	0.016	<0.005	<0.005	<0.005	0.012	0.025	0.018	<0.005	0.17	<0.005	0.027
D3	0.014	<0.005	0.04	0.13	0.16	0.23	0.013	<0.005	.042	0.03	0.006	<0.005	0.23	<0.005	0.012
D4(s)	2	1.9	1.7	1.4	1.2	1.1	1.1	1.6	2.1	1.656	1.65	0.55	2.8	1.122	2.1
D4(d)	0.059	<0.005	0.04	0.051	0.059	<0.005	0.007	0.038	0.074	0.064	0.059	<0.005	0.22	0.042	0.074
D5(s)	0.055	0.06	0.1	0.079	0.1	0.062	0.041	0.076	0.088	0.064	0.0575	<0.005	0.18	0.046	0.085
D5(d)	0.031	0.023	0.04	0.039	0.05	0.046	0.043	0.035	0.058	0.046	0.037	<0.005	0.29	0.022	0.052
D6(s)	0.53	0.51	0.65	0.34	0.78	0.84	0.52	1.5	1.6	0.469	0.38	0.026	1.6	0.127	0.682
D6(d)	<0.005	<0.005	0.006	<0.005	<0.005	0.082	0.007	<0.005	<0.005	0.013	0.0055	<0.005	0.082	<0.005	0.009
D7(s)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	0.005	<0.005	0.017	<0.005	<0.005
D7(d)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.007	<0.005	<0.005	0.021	0.005	0.008
D8(s)	0.03	0.086	0.1	0.031	0.051	0.024	0.066	0.007	0.021	0.028	0.02	<0.005	0.1	0.0125	0.033
D8(d)	0.094	<0.005	0.09	0.071	0.12	<0.005	0.087	0.081	0.09	0.059	0.064	<0.005	0.12	0.0348	0.087
D9(s)	<0.005	<0.005	<0.01	<0.005	0.005	<0.005	<0.005	<0.005	<0.005	0.005	<0.005	<0.005	0.01	<0.005	0.005
D9(d)	<0.005	<0.005	0.003	<0.005	0.006	<0.005	<0.005	<0.005	<0.005	0.006	<0.005	<0.005	0.013	<0.005	0.006
D10(s)	<0.005	0.031	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.013	0.006	<0.005	<0.005	0.031	<0.005	<0.005
D10(d)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.006	0.005	<0.005	<0.005	0.012	<0.005	<0.005

APPENDIX D

Groundwater Bore Lithological Logs

JDA Consultant Hydrologists
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Subiaco WA 6008
Tel: 9388 2436
Fax: 9381 9279

LITHOLOGICAL LOG

Client: QUBE Property Group Pty Ltd.
Project: Mandogalup Predevelopment Monitoring
Bore location: 391871.21E 6438874.67N

Job No: J3910
Hole commenced: 01/03/07
Hole completed: 01/03/07
Logged by: Direct Push Probing

Bore Name: D1
Drill type: Push Probe
Hole diameter: 50mm

Total Depth: 11.0m
R.L. TOC: 27.50 mAHD
Natural Surface: 26.96 mAHD

method	1 2 3 penetration	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
						COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
		PVC (Class 9) 50 mm			0.5m 1.0m 1.5m 2.0m 2.5m 3.0m 3.5m 4.0m 4.5m 5.0m 5.5m 6.0m 6.5m 7.0m 7.5m 8.0m 8.5m 9.0m 9.5m 10.0m 10.5m 11.0m 11.5m 12.0m 12.5m 13.0m 13.5m 14.0m	Black Grey Grey White Yellow Pale Yellow Brown Brown	Medum	Sand	Medium Low	Dry Moist	

End of Hole

Light : Brown, Red, Orange, Yellow, Grey, Blue

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

Date: ……

WL below TOC ……

Stickup above NS: ……m

WL …….. m below NS

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LITHOLOGICAL LOG

Client: QUBE Property Group Pty Ltd.
Project: Mandogalup Predevelopment Monitoring
Bore location: 391963.69E 6438425.33N

Job No: J3910
Hole commenced: 07/02/07
Hole completed: 07/02/07
Logged by: Direct Push Probing

Bore Name: D2
Drill type: Push Probe
Hole diameter: 50mm

Total Depth: 13.5m
R.L. TOC: 22.04 mAHD
Natural Surface: 21.63 mAHD

method	1 2 3 penetration	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
						COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
		PVC (Class 9) 50 mm	▽		0.5m	Black Sand	Fine		Medium	Dry	
					1.0m					Moist	
					1.5m						
					2.0m						
					2.5m						
					3.0m						Small Layer Coffee Rock
					3.5m						
					4.0m						
					4.5m						
					5.0m						
					5.5m						
					6.0m						
					6.5m						
					7.0m	Light Brown Grey	Medium	Sand	Low	Saturated	
					7.5m						
					8.0m						
					8.5m						
					9.0m						
					9.5m						
					10.0m						
					10.5m						
					11.0m						
					11.5m						
					12.0m						
					12.5m						
					13.0m						
					13.5m						
					14.0m	*End of Hole*					

Light : Brown, Red, Orange, Yellow, Grey, Blue

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

Date: ……

WL below TOC ……

Stickup above NS: ……m

WL …….. m below NS

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LITHOLOGICAL LOG

Client: QUBE Property Group Pty Ltd.
Project: Mandogalup Predevelopment Monitoring
Bore location: 391963.77E 6438424.08N

Job No: J3910
Hole commenced: 01/03/07
Hole completed: 01/03/07
Logged by: Direct Push Probing

Bore Name: D3
Drill type: Push Probe
Hole diameter: 50mm

Total Depth: 15.0m
R.L. TOC: 26.38 mAHD
Natural Surface: 25.92 mAHD

method	1 2 3 penetration	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
		PVC (Class 9) 50 mm	▽		0.5m	Grey			Medium		
					1.0m						
					1.5m						
					2.0m						
					2.5m						
					3.0m						
					3.5m						
					4.0m						
					4.5m						
					5.0m						
					5.5m					Dry	
					6.0m	Yellow					
					6.5m						
					7.0m						
					7.5m		Medium	Sand	Low		
					8.0m						
					8.5m						
					9.0m						
					9.5m						
					10.0m						
					10.5m						
					11.0m						
					11.5m						
					12.0m	White				Moist	
					12.5m						
					13.0m						
					13.5m	Light Brown					
			▽		14.0m						
					14.5m	Brown				Saturated	
					15.0m						
											End of Hole

Light : Brown, Red, Orange, Yellow, Grey, Blue

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

Date: ……

WL below TOC ……

Stickup above NS: ……m

WL …….. m below NS

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LITHOLOGICAL LOG

Client: QUBE Property Group Pty Ltd.
Project: Mandogalup Predevelopment Monitoring
Bore location: 391971.49E 6437636.10N

Job No: J3910
Hole commenced: 07/02/07
Hole completed: 07/02/07
Logged by: Direct Push Probing

Bore Name: D4
Drill type: Push Probe
Hole diameter: 50mm

Total Depth: 13.0m
R.L. TOC: 20.07 mAHD
Natural Surface: 19.48 mAHD

method	1 2 3 penetration	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
		PVC (Class 9) 50 mm	▽		0.5m	Black	Medium	Sand	Medium	Dry	
					1.0m						
					1.5m					Moist	
					2.0m	Light Brown			Low		
					2.5m					Saturated	
					3.0m						
					3.5m						
					4.0m	Consolidated Sand/Coffe Rock					
					4.5m	Dark Brown	Medium	Sand	Low	Saturated	Running Sand
					5.0m						
					5.5m						
					6.0m						
					6.5m						
					7.0m						
					7.5m						
					8.0m						
					8.5m						
					9.0m						
					9.5m						
					10.0m						
					10.5m						
					11.0m						
					11.5m						
					12.0m						
					12.5m						
					13.0m						*End of Hole*
					13.5m						
					14.0m						

Light : Brown, Red, Orange, Yellow, Grey, Blue

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

Date: ……

WL below TOC ……

Stickup above NS: ……m

WL …….. m below NS

JDA Consultant Hydrologists
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LITHOLOGICAL LOG

Client: QUBE Property Group Pty Ltd.
Project: Mandogalup Predevelopment Monitoring
Bore location: 391267.04E 64373423.27N

Job No: J3910
Hole commenced: 07/02/07
Hole completed: 07/02/07
Logged by: Direct Push Probing

Bore Name: D5
Drill type: Push Probe
Hole diameter: 50mm

Total Depth: 13.0m
R.L. TOC: 19.81 mAHD
Natural Surface: 13.21 mAHD

method	1 2 3 penetration	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
		PVC (Class 9) 50 mm	▽		0.5m	Brown	Fine	Silt/Clay	Fine	Dry	
					1.0m						
					1.5m			Clay		Moist	
					2.0m						
					2.5m						
					3.0m	Yellow		Sandy Clay	Medium	Saturated	
					3.5m						
					4.0m	Green					
					4.5m						
					5.0m	Grey Green		Clay	Fine		
					5.5m						
					6.0m						
					6.5m						
					7.0m						
					7.5m						
					8.0m						
					8.5m						
					9.0m						
					9.5m						
					10.0m						
					10.5m						
					11.0m						
					11.5m						
					12.0m						
					12.5m						
					13.0m						*End of Hole*
					13.5m						
					14.0m						

Light : Brown, Red, Orange, Yellow, Grey, Blue

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATE

Date: ……

WL below TOC ……

Stickup above NS: ……m

WL …….. m below NS

APPENDIX E

Pre-Development Monitoring April 2001 to March 2009: Groundwater Quality Monitoring Results

Extracted from Mandogalup District Water Management Strategy (JDA, 2011)

APPENDIX E-1: GROUDWATER QUALITY MEASURED IN JDA GROUNDWATER MONITORING BORES (APRIL 2007 TO MARCH 2009)

A. Electrical Conductivity (EC) mS/cm

JDA Bore	Monitoring Date in 2007									Monitoring Date in 2008					
	04/04/07	24/05/07	27/06/07	01/08/07	30/08/07	18/09/07	11/10/07	07/11/07	18/12/07	15/01/08	12/02/08	11/03/08	09/04/08	16/05/08	11/06/08
D1	0.29	0.16	0.22	0.08	0.1	0.25	0.21	0.23	0.2	0.19	0.21	0.20	0.12	0.24	0.27
D2(s)	0.67	0.58	0.63	0.58	0.61	0.67	0.5	0.6	0.56	0.62	0.6	0.61	0.56	0.63	0.70
D2(d)	0.46	0.42	0.47	0.34	0.34	0.51	0.44	0.48	0.48	0.49	0.46	0.48	0.44	0.49	0.53
D3	1.2	1.13	1.2	1.09	1.22	1.35	1.26	1.43	1.3	1.38	1.42	1.60	1.57	1.48	1.59
D4(s)	1.01	1.99	2.06	1.91	0.73	0.82	0.43	0.46	0.44	0.94	0.98	1.40	1.55	1.47	1.64
D4(d)	0.48	0.57	0.48	0.35	0.34	0.49	0.42	0.47	0.44	0.46	0.44	0.49	0.45	0.55	0.53
D5(s)	0.7	0.66	0.71	0.58	0.65	0.75	0.68	0.74	0.65	0.67	0.67	0.72	0.69	0.74	0.79
D5(d)	0.85	0.75	0.81	0.72	0.8	0.89	0.83	0.92	0.81	0.86	0.8	0.88	0.83	0.84	0.93
D6(s)	1.3	1.03	1.14	0.68	0.77	0.76	0.71	1.25	1.1	0.87	0.94	0.92	0.90	0.91	0.85
D6(d)	0.75	0.81	0.91	0.72	0.82	0.89	0.82	0.87	0.79	0.83	0.85	0.86	0.82	0.84	0.92
D7(s)	1.99	2.48	2.57	2.65	3.63	3.17	2.43	2.56	2.67	2.45	2.27	2.50	2.44	2.38	2.65
D7(d)	1.61	1.74	1.89	1.83	1.92	1.97	1.85	2.09	1.73	1.96	1.84	1.90	2.04	1.86	2.18
D8(s)	0.58	0.48	0.54	0.38	0.48	0.58	0.64	0.56	0.51	0.52	0.51	0.56	0.47	0.53	0.58
D8(d)	0.68	0.71	0.74	0.52	0.56	0.69	0.56	0.68	0.64	0.67	0.67	0.70	0.66	0.63	0.61
D9(s)	0.73	0.56	0.71	0.95	0.78	0.83	1.57	0.92	0.69	0.58	0.51	0.49	0.37	0.40	0.44
D9(d)	0.67	0.69	0.74	0.55	0.75	0.83	0.66	0.75	0.66	0.7	0.7	0.70	0.66	0.70	0.82
D10(s)	0.68	0.59	N/M	0.7	0.57	0.83	0.91	0.89	0.77	0.63	0.71	0.75	0.69	0.77	0.85
D10(d)	0.4	0.56	0.63	0.14	0.78	0.76	0.31	0.71	0.37	0.44	0.66	0.50	0.65	0.64	0.83

JDA Bore	Monitoring Date in 2008						Monitoring Date in 2009			Statistics					
	09/07/08	07/08/08	10/09/08	22/10/08	18/11/08	19/12/08	13/01/09	11/02/09	10/03/09	Average	Median	Min	Max	Q_1	Q_3
D1	0.15	0.24	0.24	0.23	0.14	0.24	0.22	0.21	0.26	0.20	0.22	0.08	0.29	0.18	0.24
D2(s)	0.39	0.42	0.48	0.71	0.73	0.77	0.68	0.67	0.64	0.61	0.62	0.39	0.77	0.58	0.67
D2(d)	0.46	0.52	0.51	0.49	0.51	0.50	0.49	0.51	0.50	0.47	0.49	0.34	0.53	0.46	0.50
D3	1.56	1.74	0.69	0.87	0.79	0.49	0.93	1.11	1.1	1.23	1.24	0.49	1.74	1.10	1.44
D4(s)	1.33	0.91	0.89	0.50	0.46	0.47	0.47	0.77	0.87	1.02	0.90	0.43	2.06	0.49	1.42
D4(d)	0.41	0.49	0.48	0.48	0.41	0.49	0.47	0.47	0.48	0.46	0.48	0.34	0.57	0.44	0.49
D5(s)	0.66	0.74	0.71	0.73	0.67	0.81	0.74	0.82	0.82	0.71	0.71	0.58	0.82	0.67	0.74
D5(d)	0.82	0.91	0.88	0.88	0.87	0.88	0.88	0.93	0.91	0.85	0.87	0.72	0.93	0.82	0.88
D6(s)	0.79	0.88	1.1	0.97	1.01	1.00	1.36	0.95	0.95	0.96	0.95	0.68	1.36	0.87	1.05
D6(d)	0.79	0.85	0.83	0.82	0.83	0.83	0.82	0.86	0.84	0.83	0.83	0.72	0.92	0.82	0.85
D7(s)	2.60	1.61	1.7	1.58	1.92	2.9	2.67	2.39	2.3	2.44	2.47	1.58	3.63	2.29	2.65
D7(d)	2.02	2.01	2.07	2.12	2.17	2.1	2.05	2.19	2.1	1.97	1.99	1.61	2.19	1.86	2.09
D8(s)	0.52	0.58	0.56	0.56	0.53	0.6	0.54	0.56	0.56	0.54	0.55	0.38	0.64	0.52	0.57
D8(d)	0.55	0.64	0.64	0.66	0.59	0.63	0.63	0.69	0.69	0.64	0.65	0.52	0.74	0.63	0.68
D9(s)	0.31	0.49	0.46	0.51	0.55	0.51	0.41	0.45	0.37	0.61	0.51	0.31	1.57	0.45	0.72
D9(d)	0.71	0.78	0.77	0.77	0.77	0.68	0.71	0.74	0.76	0.72	0.71	0.55	0.83	0.69	0.76
D10(s)	0.76	0.72	1.13	0.86	0.72	0.61	0.36	0.37	0.31	0.70	0.72	0.31	1.13	0.62	0.80
D10(d)	0.71	0.74	0.78	0.7	0.86	0.46	0.68	0.73	0.7	0.61	0.67	0.14	0.86	0.49	0.73

B. pH

JDA Bore	Monitoring Date in 2007									Monitoring Date in 2008					
	04/04/07	24/05/07	27/06/07	01/08/07	30/08/07	18/09/07	11/10/07	07/11/07	18/12/07	15/01/08	12/02/08	11/03/08	09/04/08	16/05/08	11/06/08
D1	5.41	5.13	5.08	5.19	5.24	5.69	5.78	5.97	5.68	5.61	5.57	5.9	5.51	4.75	5.43
D2(s)	5.52	5.29	5.35	5.47	5.28	5.78	5.58	5.58	5.4	5.5	5.33	5.55	4.9	4.67	5.31
D2(d)	6.45	5.36	5.5	5.53	5.46	5.83	5.66	5.76	5.66	5.67	5.56	5.8	5.24	5.46	5.7
D3	5.78	5.8	5.84	5.82	5.77	6.18	5.75	5.78	5.63	5.67	5.67	5.95	5.36	5.56	5.84
D4(s)	5.29	4.82	4.72	4.9	5.24	5.64	5.5	5.48	5.55	4.94	4.41	4.5	4.03	4.12	4.28
D4(d)	6.22	6.35	6.05	6.04	5.96	6.5	6.28	6.23	6.26	6.24	6.1	6.4	5.67	5.97	6.25
D5(s)	6.88	7.13	7.03	7.04	6.87	7.46	7.4	7.07	7.1	7.27	6.89	7.25	6.25	6.13	7.21
D5(d)	6.64	6.74	6.55	6.72	6.56	7.22	7.02	6.99	6.92	6.88	7.4	6.8	6.11	6.4	6.74
D6(s)	6.13	6.32	6.14	6.25	6.06	6.7	6.45	6.52	6.55	6.50	6.28	6.55	5.5	5.94	6.3
D6(d)	6.65	6.57	6.47	6.78	6.29	6.85	6.61	6.55	6.49	6.71	6.53	6.6	5.99	6.22	6.75
D7(s)	5.91	6.14	8.6	5.95	3.48	3.84	3.45	3.23	2.84	3.75	4.71	4.8	5.14	5.43	5.59
D7(d)	6.42	6.70	10.2	6.53	6.24	6.85	6.52	6.41	6.34	6.31	6.26	6.6	6.02	6.37	6.54
D8(s)	6.8	6.94	7.01	6.62	6.46	7.45	7.38	6.85	7.19	6.96	6.96	7.35	6.71	6.33	6.88
D8(d)	7.11	7.31	7.43	7.16	7.07	7.53	6.97	7.17	7.53	7.32	7.21	7.4	7.02	7.07	7.48
D9(s)	5.14	4.85	3.57	2.99	3.13	3.26	2.66	3.13	3.04	3.52	3.66	3.55	4.43	4.44	4.77
D9(d)	5.81	5.86	5.9	6	5.31	5.97	6.1	5.7	5.84	5.45	5.76	5.9	5.61	5.63	6.02
D10(s)	4.04	3.95	N/M	4	4.18	5.34	5.6	6.24	5.03	5.14	4.27	4.25	4.08	4.11	4.18
D10(d)	5.39	5.33	5.33	5.01	4.92	5.61	4.58	5.62	3.59	4.35	4.87	3.7	4.79	4.75	5.38

JDA Bore	Monitoring Date in 2008						Monitoring Date in 2009			Statistics					
	09/07/08	07/08/08	10/09/08	22/10/08	18/11/08	19/12/08	13/01/09	11/02/09	10/03/09	Average	Median	Min	Max	Q_1	Q_3
D1	5.34	5.44	5.39	5.5	5.42	5.07	5.06	50	6.2	5.43	5.43	4.75	6.2	5.18	5.63
D2(s)	5.8	5.47	5.41	5.33	5.25	5.06	4.96	5.08	5.9	5.37	5.38	4.67	5.9	5.27	5.53
D2(d)	5.46	5.55	5.67	5.35	5.54	5.44	5.49	5.48	6.05	5.61	5.55	5.24	6.45	5.46	5.68
D3	5.94	5.85	5.59	5.63	5.65	4.82	5.47	5.72	6.15	5.72	5.76	4.82	6.18	5.63	5.84
D4(s)	4.45	4.34	4.29	4.6	4.76	4.86	4.02	4.27	5.15	4.76	4.74	4.02	5.64	4.33	5.17
D4(d)	6.2	6.18	6.26	6.02	6.12	5.79	5.96	6.03	6.45	6.15	6.19	5.67	6.5	6.03	6.26
D5(s)	6.99	6.96	7.12	6.85	6.9	6.73	6.7	6.89	7.15	6.97	7.01	6.13	7.46	6.88	7.14
D5(d)	6.59	6.82	6.8	6.54	6.66	6.61	6.6	6.72	6.85	6.75	6.73	6.11	7.4	6.60	6.86
D6(s)	6.55	6.49	6.45	6.32	6.62	6.44	6.1	6.58	7.05	6.37	6.45	5.5	7.05	6.22	6.55
D6(d)	6.52	6.55	6.55	6.38	6.48	6.29	6.16	6.33	6.6	6.5	6.54	5.99	6.85	6.37	6.60
D7(s)	5.4	4.07	4.64	4.01	4.09	3.60	3.42	4.06	5.15	4.64	4.37	2.84	8.6	3.71	5.41
D7(d)	6.45	6.46	6.5	6.27	6.29	6.11	6.29	6.29	6.55	6.56	6.42	6.02	10.2	6.29	6.53
D8(s)	6.95	6.95	6.99	6.58	6.89	6.56	6.78	6.87	7.1	6.9	6.92	6.33	7.45	6.76	7
D8(d)	7.1	7.23	7.41	6.59	7.32	6.98	7.26	7.2	7.6	7.23	7.22	6.59	7.6	7.09	7.4
D9(s)	4.41	3.76	3.95	3.88	4.19	4.03	4.07	4.07	5.1	3.9	3.92	2.66	5.14	3.46	4.42
D9(d)	5.8	5.74	5.93	5.74	5.8	5.14	5.57	5.9	6.1	5.77	5.81	5.14	6.1	5.68	5.91
D10(s)	4.58	4.92	5.81	5.31	5.38	5.44	5.76	5.92	6.35	4.95	5.03	3.95	6.35	4.18	5.52
D10(d)	6.26	5.18	5.09	5.16	5.25	3.51	4.90	5.3	5.85	4.99	5.13	3.51	6.26	4.78	5.34

Notes: (1) N/M: not measured, (3) values lower than Limit of Reporting (LoR) are shaded and treated as value at LoR in statistics calculation, reported in maximum 2 significant number.

C. Total Nitrogen (TN) mg/L

JDA Bore	Monitoring Date in 2007									Monitoring Date in 2008					
	04/04/07	24/05/07	27/06/07	01/08/07	30/08/07	18/09/07	11/10/07	07/11/07	18/12/07	15/01/08	12/02/08	11/03/08	09/04/08	16/05/08	11/06/08
D1	2.5	0.43	1.2	1.7	1.3	1.4	0.91	0.88	0.35	0.34	1.1	0.51	0.98	0.2	0.99
D2(s)	4.1	2.7	6.4	3.6	33	4	3.1	4.1	3.2	2.8	4.2	4	3.4	2.7	3.4
D2(d)	0.52	1.7	2.3	2	2.3	1.8	1.8	2	1.5	1.2	0.4	1.1	1.6	1.4	2.4
D3	3.1	1.9	3.3	4.4	3.9	3.7	3.1	6	2.9	3.5	5	2.3	3.1	2.9	3.6
D4(s)	15	40	88	61	7.6	11	2.3	3.3	2.7	13	36	52	60	66	30
D4(d)	0.94	5.3	5.5	2.5	1.7	1.9	1.3	2	1.2	1.1	1.2	0.94	1.4	2.3	1.7
D5(s)	1.3	3.4	2.2	1.4	1.1	1.2	1.5	1.4	1.2	1.1	0.89	0.97	1	0.88	1.5
D5(d)	1	3.9	3.6	1.5	2.2	1.9	1.4	2.5	1.2	3	5.1	0.76	1.2	1.1	2
D6(s)	8	2.7	2.6	4.5	3.3	3.7	3.4	7.5	9	5.6	2.2	2.9	4.1	2.5	3.9
D6(d)	0.61	5.4	1.6	1.1	1.2	1.6	1.5	1.9	1.4	2.4	1.8	0.51	1.6	1.2	1.8
D7(s)	5	3.5	4.8	4.7	39	44	50	12	9	3.1	4.1	3.9	4.2	4	3.8
D7(d)	2.9	3.4	4.3	3.1	3.3	3.9	3.5	3.9	3	3.2	4.2	2.8	3.7	2.9	4.1
D8(s)	1	1	1.1	1.1	1	1.4	1.5	1.3	1.2	0.85	1.2	0.33	2.5	0.8	1.6
D8(d)	0.62	1.1	1.2	1	1.2	1.2	0.93	1.1	0.68	0.74	1.2	0.97	0.83	0.68	1.5
D9(s)	2.5	1.1	2.6	1.4	0.77	1.5	4	6	5.6	3.2	3.3	0.56	0.69	0.32	1.4
D9(d)	0.77	1.1	0.99	0.89	0.9	1.2	0.97	1.2	0.9	0.66	0.88	0.88	0.86	0.87	1.8
D10(s)	2	0.37		0.75	0.83	1	4.4	2.1	1.7	2.1	1.5	1.2	0.66	0.93	0.94
D10(d)	2.5	1.2	1.1	1.2	1.7	1.8	1.9	1.3	0.99	0.71	0.95	0.92	0.56	0.93	1.3

JDA Bore	Monitoring Date in 2008						Monitoring Date in 2009			Statistics					
	09/07/08	07/08/08	10/09/08	22/10/08	18/11/08	19/12/08	13/01/09	11/02/09	10/03/09	Average	Median	Min	Max	Q_1	Q_3
D1	0.25	0.33	0.26	0.17	0.28	2.2	0.27	1	2.2	0.91	0.90	0.17	2.50	0.32	1.23
D2(s)	5.5	9.5	2.5	2.5	3.5	3.6	3.1	2.6	3.4	5.04	3.45	2.50	33.00	3.03	4.10
D2(d)	0.69	1.4	1.2	1.4	1.8	1.6	1.4	1.4	1.8	1.53	1.55	0.40	2.40	1.35	1.80
D3	5.1	1.5	1.6	3.8	4.3	8.6	2.3	2.3	4.2	3.60	3.40	1.50	8.60	2.75	4.23
D4(s)	46	28	13	4.9	4	3	3.8	8.5	10	25.38	13.00	2.30	88.00	4.68	41.50
D4(d)	1.2	0.94	0.83	0.81	1.1	0.93	0.85	0.77	1	1.64	1.20	0.77	5.50	0.94	1.75
D5(s)	0.86	1	0.89	0.86	1.2	1.2	0.82	0.9	1.3	1.25	1.15	0.82	3.40	0.90	1.33
D5(d)	0.74	1.5	1.3	1.1	1.6	1.5	1.2	1.1	1.6	1.83	1.50	0.74	5.10	1.18	2.05
D6(s)	6.4	4.4	4.1	5.7	7	7	8.2	5.2	5.5	4.98	4.45	2.20	9.00	3.38	6.55
D6(d)	1.3	1.4	1.2	1.4	1.6	1.4	1.1	0.99	1.8	1.58	1.40	0.51	5.40	1.20	1.65
D7(s)	4	2.8	1.6	1.3	2.1	2.7	2.4	2.6	2.9	9.06	3.95	1.30	50.00	2.78	4.85
D7(d)	2.9	3.8	3.2	3.8	4.2	4.2	3.5	3.2	3.9	3.54	3.50	2.80	4.30	3.18	3.90
D8(s)	0.65	1.1	0.74	0.77	0.93	1.2	0.66	0.54	1.2	1.07	1.05	0.33	2.50	0.79	1.20
D8(d)	0.54	2.6	0.64	0.67	0.7	0.79	0.66	0.52	0.92	0.96	0.88	0.52	2.60	0.68	1.13
D9(s)	0.31	0.98	4.2	1.1	4.3	7.5	2.8	2.5	1.7	2.51	2.10	0.31	7.50	1.07	3.48
D9(d)	0.38	0.97	0.8	5.5	0.96	1	1	0.71	1.1	1.14	0.93	0.38	5.50	0.87	1.03
D10(s)	0.62	1.1	0.71	4.9	4.3	0.39	2.3	0.87	0.84	1.59	1.00	0.37	4.90	0.79	2.05
D10(d)	0.82	0.8	0.43	0.48	0.44	5.5	0.53	0.44	0.49	1.21	0.94	0.43	5.50	0.55	1.30

Notes: (1) N/M: not measured, (3) values lower than Limit of Reporting (LoR) are shaded and treated as value at LoR in statistics calculation, reported in maximum 2 significant number.

D. Total Kjeldahl Nitrogen (TKN) mg/L

JDA Bore	Monitoring Date in 2007									Monitoring Date in 2008					
	04/04/07	24/05/07	27/06/07	01/08/07	30/08/07	18/09/07	11/10/07	07/11/07	18/12/07	15/01/08	12/02/08	11/03/08	09/04/08	16/05/08	11/06/08
D1	2.3	0.43	1.2	1.7	1	1.2	0.79	0.88	0.35	0.31	1	0.45	0.68	0.16	0.94
D2(s)	4.1	2.7	6.4	3.4	7.9	2.9	3.1	4.1	3.2	2.8	4.2	4	3.4	2.7	3.4
D2(d)	0.51	1.3	2.3	2	1.9	1.8	1.8	2	1.5	1.2	0.4	1.1	1.6	1.3	2.4
D3	2.5	1.7	3.3	1.6	2.3	2.4	1.4	2	1.8	2.7	1.4	1.4	2.3	1.9	2.7
D4(s)	5	2.5	<0.05	7	4	3.4	2.3	3.2	2.6	3.4	3.4	23	13	57	30
D4(d)	0.78	1.2	3.8	2.4	1.6	1.8	1.3	2	1.2	0.9	0.67	0.24	0.61	0.88	0.9
D5(s)	1.3	3.2	2.1	1.4	1.1	1.2	1.5	1.4	1.2	1	0.75	0.78	0.71	0.34	1.5
D5(d)	0.98	3.8	3.6	1.5	2.2	1.8	1.3	2.5	1.2	3	5.1	0.14	1.1	1.1	2
D6(s)	1.8	2.7	2.6	4.5	3.3	3.7	3.4	7.5	9	5.6	2.2	2.9	4.1	2	3.9
D6(d)	0.5	5.4	1.6	1.1	1.2	1.6	1.5	1.9	1.4	2.4	1.8	0.51	1.5	0.41	1.8
D7(s)	4.9	3.5	4.8	3.7	9.1	9	11	1.6	3.9	3	4.1	3.9	4.1	3.9	3.7
D7(d)	2.9	3.4	4.3	3.1	2.6	3.4	2.7	3.8	2.9	3.2	4.2	2.8	3.7	2.9	4
D8(s)	0.92	0.88	1.1	1.1	0.89	1.3	1.3	1.3	1.2	0.85	1.2	0.27	2.4	0.79	1.6
D8(d)	0.61	1.1	1.2	0.99	1.1	1.2	0.85	1.1	0.68	0.74	1.2	0.94	0.8	0.68	1.5
D9(s)	2.4	0.84	1.7	1	0.63	0.8	2.1	0.73	0.84	0.91	1.7	0.34	0.65	0.32	1.4
D9(d)	0.76	1.1	0.98	0.87	0.89	1.1	0.97	1.1	0.81	0.61	0.87	0.66	0.86	0.79	1.8
D10(s)	1.1	0.26	N/M	0.72	0.67	0.56	2	0.42	0.68	0.08	0.79	0.43	0.41	0.92	0.93
D10(d)	2.5	1.2	1.1	1.2	1.7	1.7	1.8	1.3	0.26	0.23	0.93	0.36	0.53	0.92	1.2

JDA Bore	Monitoring Date in 2008						Monitoring Date in 2009			Statistics					
	09/07/08	07/08/08	10/09/08	22/10/08	18/11/08	19/12/08	13/01/09	11/02/09	10/03/09	Average	Median	Min	Max	Q_1	Q_3
D1	0.25	0.33	0.24	0.16	0.28	2.1	0.18	0.2	2.2	0.81	0.57	0.16	2.3	0.27	1.05
D2(s)	1.7	1.6	2.4	2.5	3.5	3.6	3.1	1.9	3.4	3.42	3.3	1.6	7.9	2.7	3.7
D2(d)	0.63	1.3	1.2	1.4	1.8	1.6	1.4	1.4	1.80	1.49	1.45	0.4	2.4	1.28	1.8
D3	1.9	1.5	1.2	0.87	1.2	3.9	1.8	1.7	1.7	1.97	1.8	0.87	3.9	1.48	2.33
D4(s)	7.9	5.3	0.85	1.9	2.2	2.2	2.3	2	1.1	7.73	3.3	0.05	57	2.2	5.73
D4(d)	0.73	0.61	0.78	0.75	1	0.93	0.83	0.77	0.87	1.15	0.89	0.24	3.8	0.77	1.23
D5(s)	0.76	0.94	0.86	0.84	1.2	1.2	0.82	0.55	1.3	1.16	1.15	0.34	3.2	0.81	1.33
D5(d)	0.72	1.4	1.20	1	1.6	1.5	1.2	0.8	1.5	1.76	1.45	0.14	5.1	1.1	2.05
D6(s)	6.4	4.4	4.10	5.6	7	7	8.2	5.1	5.50	4.69	4.25	1.8	9	3.2	5.8
D6(d)	1.3	1.4	1.1	1.4	1.6	1.4	1.1	0.77	1.8	1.52	1.4	0.41	5.4	1.1	1.65
D7(s)	3.8	1.7	1.6	1.3	2	2.7	2.3	2.6	2.8	3.96	3.7	1.3	11	2.53	4.1
D7(d)	2.9	3.8	3.1	3.8	4.2	4.2	3.5	3.2	3.8	3.43	3.4	2.6	4.3	2.9	3.8
D8(s)	0.65	1.1	0.72	0.76	0.93	1.2	0.66	0.39	1.1	1.03	1.02	0.27	2.4	0.78	1.2
D8(d)	0.54	1.3	0.62	0.67	0.69	0.79	0.66	0.39	0.9	0.89	0.83	0.39	1.5	0.68	1.1
D9(s)	0.3	0.98	0.12	1.1	0.18	3	1	0.24	1.1	1.02	0.88	0.12	3	0.56	1.18
D9(d)	0.38	0.95	0.78	0.43	0.94	0.64	0.92	0.71	1.1	0.88	0.87	0.38	1.8	0.75	0.97
D10(s)	0.54	1.1	0.62	0.12	0.43	0.29	0.6	0.51	0.46	0.64	0.56	0.08	2	0.43	0.76
D10(d)	0.82	0.21	0.4	0.34	0.33	1.7	0.45	0.44	0.44	0.92	0.87	0.21	2.5	0.39	1.23

Notes: (1) N/M: not measured, (2) values lower than Limit of Reporting (LoR) are shaded and treated as value at LoR in statistics calculation, reported in maximum 2 significant number.

E. Nitrates and Nitrites (NO_x_N) mg/L

JDA Bore	Monitoring Date in 2007									Monitoring Date in 2008					
	04/04/07	24/05/07	27/06/07	01/08/07	30/08/07	18/09/07	11/10/07	07/11/07	18/12/07	15/01/08	12/02/08	11/03/08	09/04/08	16/05/08	11/06/08
D1	0.19	<0.005	<0.005	0.027	0.28	0.22	0.12	<0.005	<0.005	0.035	0.097	0.063	0.3	0.38	0.046
D2(s)	0.014	<0.005	<0.005	0.24	25	1.1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
D2(d)	0.01	0.44	0.005	0.011	0.4	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.046	<0.005	0.13	<0.005
D3	0.61	0.21	0.015	2.8	1.6	1.4	1.7	4.1	1.2	0.81	3.6	0.9	0.84	0.92	0.85
D4(s)	10	37	88	54	3.6	7.6	0.031	0.12	0.047	9.9	33	29	47	8.6	0.34
D4(d)	0.16	4.1	1.7	0.073	0.084	0.1	<0.005	<0.005	0.013	0.15	0.53	0.7	0.81	1.4	0.81
D5(s)	0.04	0.23	0.1	0.009	0.008	0.034	0.042	<0.005	<0.005	0.046	0.14	0.19	0.29	0.54	0.005
D5(d)	0.024	0.088	0.046	0.049	0.038	0.087	0.063	<0.005	0.015	<0.005	<0.005	0.62	0.077	0.008	<0.005
D6(s)	6.2	0.045	0.013	0.008	0.018	0.012	<0.005	<0.005	<0.005	0.009	<0.005	<0.005	0.026	0.48	<0.005
D6(d)	0.11	0.037	<0.005	0.02	0.021	0.015	<0.005	<0.005	0.03	0.009	<0.005	<0.005	0.019	0.74	0.012
D7(s)	0.053	0.035	0.006	1	30	35	39	10	5.1	0.12	0.017	<0.005	0.024	0.11	0.068
D7(d)	0.009	0.021	0.011	0.022	0.68	0.49	0.81	0.088	0.07	<0.005	<0.005	<0.005	0.011	<0.005	0.052
D8(s)	0.085	0.008	0.008	0.016	0.11	0.14	0.23	<0.005	0.02	<0.005	<0.005	0.006	0.006	0.011	<0.005
D8(d)	0.011	<0.005	0.026	0.013	0.061	0.039	0.083	<0.005	<0.005	<0.005	<0.005	0.026	0.028	<0.005	<0.005
D9(s)	0.079	0.26	0.93	0.36	0.14	0.7	1.9	5.3	4.8	2.3	1.6	0.22	0.044	<0.005	0.035
D9(d)	0.013	0.016	0.007	0.023	0.011	0.07	<0.005	0.14	0.094	0.053	0.012	0.22	<0.005	0.012	<0.005
D10(s)	0.94	<0.005	N/M	0.032	0.16	0.44	2.5	1.7	1.1	2.1	0.71	0.75	0.25	0.85	0.012
D10(d)	0.042	0.015	0.013	0.025	0.042	0.052	0.11	0.006	0.73	0.48	0.024	0.56	0.028	0.012	0.048

JDA Bore	Monitoring Date in 2008						Monitoring Date in 2009			Statistics					
	09/07/08	07/08/08	10/09/08	22/10/08	18/11/08	19/12/08	13/01/09	11/02/09	10/03/09	Average	Median	Min	Max	Q_1	Q_3
D1	<0.005	<0.005	0.02	0.012	<0.005	0.008	0.093	0.8	0.024	0.1146	0.0310	<0.005	0.8	<0.005	0.137
D2(s)	3.8	7.9	0.066	<0.005	0.006	<0.005	<0.005	0.69	<0.005	1.6205	0.0050	<0.005	25	<0.005	0.109
D2(d)	0.058	0.084	0.036	<0.005	<0.005	<0.005	<0.005	0.015	0.016	0.0546	0.0050	0.005	0.44	<0.005	0.038
D3	3.3	0.015	0.44	2.9	3.1	4.6	0.56	0.63	2.6	1.6542	1.0600	0.015	4.6	0.625	2.825
D4(s)	38	22	12	3	1.8	0.73	1.5	6.5	8.9	17.6112	8.7500	0.031	88	1.725	30
D4(d)	0.49	0.33	0.044	0.061	0.046	<0.005	0.018	<0.005	0.13	0.4904	0.1150	<0.005	4.1	0.0375	0.572
D5(s)	0.096	0.07	0.028	0.022	0.011	<0.005	<0.005	0.35	0.026	0.0957	0.0370	<0.005	0.54	0.0088	0.11
D5(d)	0.022	0.11	0.054	0.046	0.005	<0.005	<0.005	0.3	0.014	0.0707	0.0310	<0.005	0.62	<0.005	0.066
D6(s)	<0.005	<0.005	0.029	0.029	<0.005	<0.005	<0.005	0.11	<0.005	0.2933	0.0065	<0.005	6.2	<0.005	0.026
D6(d)	0.005	<0.005	0.023	0.012	0.009	<0.005	<0.005	0.22	0.009	0.0555	0.0105	<0.005	0.74	<0.005	0.021
D7(s)	0.19	1.1	0.026	0.008	0.079	<0.005	0.072	0.007	0.051	5.0865	0.0700	<0.005	39	0.0223	1.025
D7(d)	<0.005	<0.005	0.009	<0.005	<0.005	<0.005	<0.005	0.009	0.092	0.1010	0.0090	<0.005	0.81	<0.005	0.056
D8(s)	<0.005	<0.005	0.024	0.009	<0.005	<0.005	<0.005	0.15	0.064	0.0388	0.0080	<0.005	0.23	<0.005	0.034
D8(d)	<0.005	1.4	0.02	<0.005	0.011	<0.005	<0.005	0.13	0.024	0.0803	0.0110	<0.005	1.4	<0.005	0.026
D9(s)	0.012	<0.005	4.1	0.006	4.1	4.5	1.8	2.3	0.6	1.5040	0.6500	<0.005	5.3	0.07	2.3
D9(d)	<0.005	0.02	0.023	5.1	0.022	0.38	0.094	<0.005	0.013	0.2645	0.0180	<0.005	5.1	0.01	0.076
D10(s)	0.083	0.005	6.5	4.9	3.9	0.1	1.7	0.36	0.38	1.2816	0.7100	<0.005	6.5	0.13	1.7
D10(d)	<0.005	0.59	0.034	0.48	0.11	3.8	0.081	<0.005	0.047	0.3058	0.0445	<0.005	3.8	0.021	0.202

Notes: (1) N/M: not measured, (2) values lower than Limit of Reporting (LoR) are shaded and treated as value at LoR in statistics calculation, reported in maximum 2 significant number.

F. Ammonia in water (NH_4_N) mg/L

JDA Bore	Monitoring Date in 2007									Monitoring Date in 2008					
	04/04/07	24/05/07	27/06/07	01/08/07	30/08/07	18/09/07	11/10/07	07/11/07	18/12/07	15/01/08	12/02/08	11/03/08	09/04/08	16/05/08	11/06/08
D1	0.067	0.12	0.25	0.14	0.073	0.11	0.44	0.76	0.15	<0.005	0.091	0.04	<0.005	0.053	0.1
D2(s)	0.49	0.65	0.45	0.25	0.030	0.19	0.66	1.4	0.44	0.46	0.5	0.5	0.39	0.42	0.72
D2(d)	<0.005	0.35	0.2	0.29	0.200	0.31	0.63	0.77	0.23	0.24	0.28	0.32	0.18	0.26	0.28
D3	0.2	0.24	0.17	0.18	0.099	0.21	0.51	0.65	0.3	0.16	0.22	0.25	0.13	0.11	0.23
D4(s)	<0.005	0.045	0.039	0.055	0.050	0.15	0.37	0.57	0.37	0.15	0.34	0.13	0.022	0.016	0.059
D4(d)	0.29	0.2	0.29	0.38	0.330	0.4	0.37	0.79	0.4	0.35	0.4	0.24	0.25	0.036	0.39
D5(s)	0.35	1.5	0.35	0.58	0.370	0.52	0.38	0.64	0.4	0.35	0.39	0.42	0.27	0.28	0.43
D5(d)	0.21	0.34	0.31	0.3	0.310	0.26	0.28	0.76	0.43	0.32	2.3	0.34	0.24	0.23	0.39
D6(s)	0.16	0.46	0.38	1.3	1.000	0.89	0.69	5.4	7.1	2.9	0.37	1.1	1.7	0.53	0.97
D6(d)	0.012	0.47	0.35	0.38	0.300	0.54	0.67	0.48	0.5	0.45	0.48	0.51	0.37	0.37	0.41
D7(s)	2.8	2.8	2.6	2.8	0.450	0.7	1.3	0.74	1.4	2.2	2.3	2.8	2.3	2.4	3.2
D7(d)	2.3	2.4	2.3	2.6	2.300	2.5	2	3	2.5	2.6	2.5	2.3	2.7	2.1	2.6
D8(s)	0.22	0.37	0.23	0.37	0.320	0.35	0.29	0.37	0.33	0.31	0.36	0.29	0.26	0.26	0.38
D8(d)	0.24	0.43	0.32	0.41	0.390	0.38	0.29	0.39	0.27	0.37	0.39	0.27	0.25	0.24	0.38
D9(s)	0.44	0.4	0.14	0.2	0.190	0.27	0.62	0.45	0.34	0.25	0.29	0.34	0.16	0.028	0.25
D9(d)	0.41	0.63	0.46	0.46	0.490	0.64	0.92	0.59	0.53	0.59	0.57	0.5	0.41	0.39	0.65
D10(s)	0.051	0.076		0.11	0.067	0.064	0.37	0.085	0.035	<0.005	0.025	0.081	<0.005	0.25	0.032
D10(d)	2.3	0.72	0.44	0.95	0.960	0.96	0.73	0.78	0.062	0.18	0.58	0.22	0.19	0.39	0.29

JDA Bore	Monitoring Date in 2008						Monitoring Date in 2009			Statistics					
	09/07/08	07/08/08	10/09/08	22/10/08	18/11/08	19/12/08	13/01/09	11/02/09	10/03/09	Average	Median	Min	Max	Q_1	Q_3
D1	0.12	0.085	0.1	0.1	0.13	0.025	0.11	0.083	0.19	0.139	0.1	0.005	0.76	0.071	0.132
D2(s)	0.22	0.053	0.5	0.59	0.71	0.67	0.77	0.8	0.94	0.533	0.5	0.03	1.4	0.412	0.68
D2(d)	0.2	0.32	0.4	0.27	0.32	0.27	0.33	0.33	0.36	0.306	0.285	0.005	0.77	0.237	0.33
D3	0.28	0.63	0.3	0.2	0.26	0.038	0.56	0.7	0.34	0.29	0.235	0.038	0.7	0.177	0.31
D4(s)	0.019	<0.005	0.1	0.48	0.42	0.43	0.44	0.45	0.14	0.202	0.135	0.005	0.57	0.043	0.382
D4(d)	0.38	0.37	0.4	0.37	0.44	0.37	0.51	0.39	0.46	0.366	0.375	0.036	0.79	0.32	0.4
D5(s)	0.38	0.43	0.4	0.36	0.48	0.45	0.38	0.44	0.51	0.46	0.4	0.27	1.5	0.367	0.457
D5(d)	0.37	0.2	0.3	0.14	0.39	0.37	0.39	0.39	0.45	0.417	0.33	0.14	2.3	0.275	0.39
D6(s)	3.3	1.9	3.7	3.4	5.4	4.2	4.4	3.3	3.2	2.406	1.8	0.16	7.1	0.84	3.475
D6(d)	0.44	0.43	0.5	0.47	0.57	0.54	0.52	0.55	0.53	0.4518	0.475	0.012	0.67	0.402	0.522
D7(s)	2.8	0.7	1.1	0.65	0.74	0.76	1.4	1.9	2.6	1.81	2.05	0.45	3.2	0.755	2.65
D7(d)	2.6	2.2	3	2.9	3.2	3.2	2.5	3.1	3	2.6	2.55	2	3.2	2.3	2.925
D8(s)	0.36	0.36	0.3	0.26	0.37	0.35	0.33	0.35	0.34	0.322	0.335	0.22	0.38	0.29	0.36
D8(d)	0.36	0.14	0.3	0.25	0.36	0.36	0.32	0.38	0.46	0.331	0.36	0.14	0.46	0.27	0.382
D9(s)	0.02	0.6	0.2	0.75	0.18	0.078	0.22	0.2	0.26	0.286	0.25	0.02	0.75	0.1875	0.355
D9(d)	0.33	0.35	0.7	0.17	0.61	0.17	0.59	0.65	0.66	0.519	0.55	0.17	0.92	0.41	0.632
D10(s)	0.26	0.33	0.1	0.037	0.04	<0.005	0.06	0.052	0.081	0.096	0.064	0.005	0.37	0.036	0.092
D10(d)	0.64	<0.005	0.4	0.27	0.27	<0.005	0.31	0.34	0.23	0.509	0.365	0.005	2.3	0.227	0.722

Notes: (1) N/M: not measured, (2) values lower than Limit of Reporting (LoR) are shaded and treated as value at LoR in statistics calculation, reported in maximum 2 significant number.

G. Total Phosphorus (TP) mg/L

JDA Bore	Monitoring Date in 2007									Monitoring Date in 2008					
	04/04/07	24/05/07	27/06/07	01/08/07	30/08/07	18/09/07	11/10/07	07/11/07	18/12/07	15/01/08	12/02/08	11/03/08	09/04/08	16/05/08	11/06/08
D1	0.77	0.1	0.39	0.65	0.29	0.52	0.12	0.42	0.04	0.12	0.33	0.03	0.16	<0.01	<0.01
D2(s)	2.4	1.7	2.5	1.8	1.3	1.6	1.8	2.5	1.7	1.7	2.3	2.2	1.9	1.8	1.8
D2(d)	0.04	0.06	0.1	0.07	0.04	0.03	0.06	0.1	0.06	0.02	0.05	0.07	0.04	0.18	<0.01
D3	0.54	0.16	0.7	0.09	0.09	0.29	0.16	0.1	0.24	0.31	0.05	0.09	0.15	0.06	<0.01
D4(s)	3.1	3	4	2.4	3.1	1.9	1.8	2	1.6	2.6	1.8	3.3	3.8	3	2.4
D4(d)	0.93	0.44	0.11	0.08	0.06	0.11	0.11	0.07	0.15	0.05	0.11	0.1	0.1	0.19	<0.01
D5(s)	0.19	0.46	0.14	0.15	0.13	0.15	0.18	0.14	0.21	0.1	0.1	0.16	0.11	0.85	0.03
D5(d)	0.07	0.46	0.82	0.17	0.22	1.1	0.2	0.47	0.11	0.53	0.58	0.09	0.09	0.06	0.21
D6(s)	0.61	0.59	0.98	0.88	0.84	0.65	0.56	0.54	0.71	0.75	0.3	0.77	1.2	0.64	1
D6(d)	0.04	0.02	0.26	0.04	0.08	0.42	0.09	0.07	0.12	0.14	0.06	0.06	0.1	0.07	0.08
D7(s)	0.05	<0.01	0.01	0.01	0.02	<0.01	0.03	<0.01	0.05	<0.01	<0.01	0.01	<0.01	<0.01	<0.01
D7(d)	0.03	0.11	0.05	0.03	<0.01	0.03	0.04	0.01	0.04	<0.01	0.02	0.14	0.02	<0.01	<0.01
D8(s)	0.74	0.57	0.92	0.32	0.58	1.7	1.1	0.3	1.7	0.64	0.35	0.45	0.88	0.25	0.1
D8(d)	0.04	0.29	0.51	0.1	0.09	0.29	0.19	0.2	0.14	0.22	0.11	0.16	0.15	0.1	0.1
D9(s)	0.07	0.04	0.05	0.02	<0.01	0.01	0.05	0.02	0.06	<0.01	0.02	0.03	<0.01	<0.01	<0.01
D9(d)	0.02	0.04	0.01	0.03	<0.01	<0.01	0.03	0.01	0.03	<0.01	0.02	0.03	0.01	<0.01	<0.01
D10(s)	0.07	0.04	N/M	0.04	0.04	0.03	0.09	0.03	0.06	<0.01	0.02	0.05	0.02	<0.01	<0.01
D10(d)	0.03	0.05	0.02	0.03	<0.01	<0.01	0.12	<0.01	0.03	<0.01	0.01	0.02	<0.01	<0.01	<0.01

JDA Bore	Monitoring Date in 2008						Monitoring Date in 2009			Statistics					
	09/07/08	07/08/08	10/09/08	22/10/08	18/11/08	19/12/08	13/01/09	11/02/09	10/03/09	Average	Median	Min	Max	Q_1	Q_3
D1	0.07	<0.01	<0.01	0.01	<0.01	0.54	<0.01	<0.01	.59	0.286	0.225	<0.01	0.77	0.105	0.412
D2(s)	1.5	1.8	1.8	1.5	1.6	1.7	1.9	2.1	2	1.87	1.8	1.3	2.5	1.7	2.025
D2(d)	0.08	<0.01	<0.01	0.02	0.03	<0.01	<0.01	0.08	0.03	0.061	0.06	<0.01	0.18	0.035	0.075
D3	0.06	<0.01	0.06	0.22	0.19	0.48	0.04	0.09	0.44	0.209	0.155	0.04	0.7	0.09	0.277
D4(s)	2.4	2.4	1.6	1.4	1.3	1.5	1.2	1.6	3.3	2.354	2.4	1.2	4	1.6	3.025
D4(d)	0.06	0.04	<0.01	0.06	0.07	0.02	0.01	0.16	0.21	0.147	0.1	0.01	0.93	0.06	0.14
D5(s)	0.08	0.09	0.04	0.1	0.1	0.08	0.05	0.16	0.1	0.162	0.12	0.03	0.85	0.097	0.16
D5(d)	0.13	0.48	0.48	0.07	0.17	1.9	0.13	0.15	0.12	0.367	0.185	0.06	1.9	0.117	0.48
D6(s)	0.86	0.65	0.5	0.92	1	1.3	1.7	1.6	1.6	0.881	0.805	0.3	1.7	0.632	1
D6(d)	0.08	0.13	0.02	0.09	0.06	0.08	0.05	0.03	0.16	0.097	0.08	0.02	0.42	0.057	0.105
D7(s)	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	1.1	0.02	0.132	0.02	0.01	1.1	0.012	0.045
D7(d)	<0.01	<0.01	0.03	0.01	0.1	<0.01	<0.01	0.04	0.03	0.045	0.03	0.01	0.14	0.027	0.042
D8(s)	0.26	0.15	0.1	0.16	0.13	0.29	0.09	0.2	0.44	0.517	0.335	0.09	1.7	0.19	0.665
D8(d)	0.11	<0.01	0.09	0.12	0.12	0.1	0.09	0.17	0.15	0.158	0.12	0.04	0.51	0.1	0.18
D9(s)	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.04	0.02	0.033	0.03	<0.01	0.07	0.02	0.05
D9(d)	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	0.05	0.02	0.024	0.02	<0.01	0.05	0.02	0.03
D10(s)	<0.01	0.34	<0.01	0.03	0.01	<0.01	<0.01	0.06	0.02	0.059	0.04	<0.01	0.34	0.0275	0.06
D10(d)	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	0.05	0.02	0.0380	0.03	<0.01	0.12	0.02	0.045

Notes: (1) N/M: not measured, (2) values lower than Limit of Reporting (LoR) are shaded and treated as value at LoR in statistics calculation, reported in maximum 2 significant number.

H. Filterable Reactive Phosphorus (FRP) mg/L

JDA Bore	Monitoring Date in 2007									Monitoring Date in 2008					
	04/04/07	24/05/07	27/06/07	01/08/07	30/08/07	18/09/07	11/10/07	07/11/07	18/12/07	15/01/08	12/02/08	11/03/08	09/04/08	16/05/08	11/06/08
D1	0.007	0.007	<0.005	0.009	0.007	0.006	<0.005	<0.005	0.015	<0.005	0.011	<0.005	<0.005	<0.005	<0.005
D2(s)	1.9	1.3	1.7	1.3	0.95	1.3	0.89	1.8	1.7	1.8	1.8	1.9	1.8	1.8	1.6
D2(d)	0.015	0.02	0.051	0.036	0.021	0.024	0.037	0.018	0.018	0.019	0.043	0.023	0.011	0.17	<0.005
D3	0.009	0.006	<0.005	0.009	0.006	0.007	<0.005	<0.005	0.011	<0.005	0.011	<0.005	<0.005	<0.005	<0.005
D4(s)	1.4	1.8	2.1	2.1	1.7	1.1	1.1	0.68	0.55	2.5	1.5	2.7	2.8	2.5	1.13
D4(d)	0.043	0.22	0.074	0.074	0.049	0.057	0.072	0.064	0.07	0.043	0.086	0.08	0.086	0.19	<0.005
D5(s)	0.021	0.18	0.048	0.055	0.054	0.047	0.009	0.043	0.063	0.05	0.096	0.039	0.095	0.085	<0.005
D5(d)	0.022	0.052	<0.005	0.032	0.018	0.018	0.023	0.023	0.073	0.013	0.29	0.053	0.07	0.059	0.009
D6(s)	0.04	0.2	0.12	0.43	0.3	0.13	0.089	0.026	0.072	0.22	0.03	0.4	0.8	0.36	0.79
D6(d)	0.006	0.02	<0.005	0.008	0.009	0.007	<0.005	<0.005	0.015	<0.005	0.009	0.043	<0.005	0.049	<0.005
D7(s)	0.007	<0.005	<0.005	0.005	0.006	<0.005	<0.005	<0.005	0.017	<0.005	0.008	<0.005	<0.005	<0.005	<0.005
D7(d)	0.02	0.011	<0.005	0.018	0.007	0.021	<0.005	<0.005	0.014	<0.005	0.014	<0.005	<0.005	<0.005	<0.005
D8(s)	0.018	0.022	<0.005	0.015	0.014	0.015	<0.005	0.016	0.032	0.008	0.02	<0.005	<0.005	0.037	0.048
D8(d)	0.007	0.038	0.005	0.025	0.019	0.065	0.062	0.05	0.09	0.044	0.053	0.07	0.097	0.084	0.063
D9(s)	0.005	0.005	<0.005	0.007	0.005	0.005	<0.005	<0.005	0.01	<0.005	0.008	<0.005	<0.005	<0.005	<0.005
D9(d)	0.006	0.006	<0.005	0.011	0.008	<0.005	<0.005	<0.005	0.013	<0.005	0.01	<0.005	<0.005	<0.005	<0.005
D10(s)	0.005	<0.005	N/M	0.005	0.005	<0.005	<0.005	<0.005	0.005	<0.005	0.008	<0.005	<0.005	<0.005	<0.005
D10(d)	0.01	<0.005	<0.005	0.009	0.005	<0.005	<0.005	<0.005	0.012	<0.005	0.008	<0.005	<0.005	<0.005	<0.005

JDA Bore	Monitoring Date in 2008						Monitoring Date in 2009			Statistics					
	09/07/08	07/08/08	10/09/08	22/10/08	18/11/08	19/12/08	13/01/09	11/02/09	10/03/09	Average	Median	Min	Max	Q_1	Q_3
D1	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.006	0.005	<0.005	0.015	0.005	0.0063
D2(s)	1.2	1.6	2	1.5	0.95	1.7	1.8	2	1.9	1.591	1.7	0.89	2	1.3	1.8
D2(d)	0.048	<0.005	<0.005	<0.005	0.016	<0.005	<0.005	<0.005	0.012	0.025	0.018	<0.005	0.17	<0.005	0.027
D3	0.014	<0.005	0.04	0.13	0.16	0.23	0.013	<0.005	.042	0.03	0.006	<0.005	0.23	<0.005	0.012
D4(s)	2	1.9	1.7	1.4	1.2	1.1	1.1	1.6	2.1	1.656	1.65	0.55	2.8	1.122	2.1
D4(d)	0.059	<0.005	0.04	0.051	0.059	<0.005	0.007	0.038	0.074	0.064	0.059	<0.005	0.22	0.042	0.074
D5(s)	0.055	0.06	0.1	0.079	0.1	0.062	0.041	0.076	0.088	0.064	0.0575	<0.005	0.18	0.046	0.085
D5(d)	0.031	0.023	0.04	0.039	0.05	0.046	0.043	0.035	0.058	0.046	0.037	<0.005	0.29	0.022	0.052
D6(s)	0.53	0.51	0.65	0.34	0.78	0.84	0.52	1.5	1.6	0.469	0.38	0.026	1.6	0.127	0.682
D6(d)	<0.005	<0.005	0.006	<0.005	<0.005	0.082	0.007	<0.005	<0.005	0.013	0.0055	<0.005	0.082	<0.005	0.009
D7(s)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	0.005	<0.005	0.017	<0.005	<0.005
D7(d)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.007	<0.005	<0.005	0.021	0.005	0.008
D8(s)	0.03	0.086	0.1	0.031	0.051	0.024	0.066	0.007	0.021	0.028	0.02	<0.005	0.1	0.0125	0.033
D8(d)	0.094	<0.005	0.09	0.071	0.12	<0.005	0.087	0.081	0.09	0.059	0.064	<0.005	0.12	0.0348	0.087
D9(s)	<0.005	<0.005	<0.01	<0.005	0.005	<0.005	<0.005	<0.005	<0.005	0.005	<0.005	<0.005	0.01	<0.005	0.005
D9(d)	<0.005	<0.005	0.003	<0.005	0.006	<0.005	<0.005	<0.005	<0.005	0.006	<0.005	<0.005	0.013	<0.005	0.006
D10(s)	<0.005	0.031	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.013	0.006	<0.005	<0.005	0.031	<0.005	<0.005
D10(d)	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.006	0.005	<0.005	<0.005	0.012	<0.005	<0.005

APPENDIX F

Water Corporation Correspondence

9.	**Water Corporation** PO Box 100 Leederville WA 6902 Contact: Brett Coombes Senior Town Planner Development Services Branch	NO OBJECTION – COMMENTS / RECOMMEDATION PROVIDED The Water Corporation has adopted water and wastewater conveyance planning to guide the servicing of this and other surrounding land. The staging of water and wastewater infrastructure to service the proposed subdivisions requires close cooperation between the developers regarding sharing of costs, agreement on routes for water mains and large gravity sewers, and provision of a suitable site for a waste water pumping station at the southern end of Satterley's landholding. The Peel Main Drain is operated as a rural standard drain under the conditions of the Drainage Operating Licence, which allows for flooding of the areas abutting the drain for periods up to 72 hours. The Water Corporation cannot guarantee that the surrounding land will not be subject to occasional flooding. The proponent should liaise with the DoW to determine the 100year ARI flood levels and make adequate provision for on-site drainage attenuation and detention to pre-development levels. The proponent should be required to prepare and submit a joint LWMS for assessment by the DoW and the Water Corporation.	• Noted

APPENDIX G

Western Power Correspondence

Riccardo Divita

From: Tania Lund <tania.lund@westernpower.com.au>
Sent: Wednesday, 21 January 2015 4:52 PM
To: Avril Thomson
Cc: Customer Initiated Relocations
Subject: Mandogalup - EPR/LFI Report

Hi Avril

I am pleased to advise that Western Power has no objections to the Earth Potential Rise/Low Frequency Induction Report received on the 17th of December 2014 in relation to Qube's development at Mandogalup.

If you have any questions or would like more information, please do not hesitate to contact me.

Tania Lund
Customer Experience Manager (Acting)
Customer Service
Western Power
363 Wellington Street Perth 6000
T: 9326 4135 | **M:** 046 776 2367 | **F:** 9326 7933
E: tania.lund@westernpower.com.au
W: westernpower.com.au

Electricity Networks Corporation, trading as Western Power
ABN: 18 540 492 861

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Electricity Networks Corporation
ABN 18 540 492 861

enquiry@westernpower.com.au
westernpower.com.au

Our Ref: SF203505 / EDM 42056010
Enquiries: Taryna Glanville (08) 9326 4417

10 February 2017

COMMERCIAL-IN-CONFIDENCE

James Davies
JDA Consultants Hydrologists
Suite 1, 27 York Street
Subiaco WA 6008

Dear James

Work near Transmission & Communication Assets (WTC) – Works Response
Mandogalup Easement Assessment

Further to your WTC Application lodged with Western Power on 10 January 2017, we are pleased to advise you that we have now completed the works relating to the proposed Mandogalup East and West Local Water Management Strategy.

Please find attached the following information:-

i. Easement Assessment

Should you wish to clarify any of the above information or discuss this matter with us, please do not hesitate to contact your Consultant, Taryna Glanville on (08) 9326 4417 and/or at taryna.glanville@westernpower.com.au.

Yours sincerely

DAVE LOWRY
LINE RELOCATION TEAM LEADER
CUSTOMER SERVICE
WESTERN POWER

Attachments

1. Technical Advice/Easement Assessment

ANNEXURE – Easement Assessment

Western Power Scope

The scope of Western Power work is to provide comment on Working near Transmission & Communication Assets Application Reference STYB9M for the proposed Mandogalup East and West Local Water Management Strategy within vicinity of Western Power assets mentioned below

- Double circuit (D/C) 330kV lines:

    a. KW-ST 91/LWT -ST 91 Span 25/212 - 27/214
    b. SHO-ST/OLY 91/KW-ST 92 Span 474/26 – 476/28

- Split phase 132kV line – KW-ST 81 Span 53-55

Customer Provided Information

Customer supplied information and design drawing files:

- JDA Ref - J5483j.pdf – Mandogalup East Local Water Management Strategy
- JDA Ref - J6313a.pdf – QUBE Land (Mandogalup West) Revised Local Water Management Strategy

Western Power Commentary

The Mandogalup East local water management strategy study area is outside of the transmission easement.

The Mandogalup West local water management strategy proposed stormwater basin falls within the transmission line easement.

Based on the information provided Western Power has no objection to the proposed stormwater basin within the transmission easement provided it is in compliance with the following:

- Maintain 30m Transmission Tower buffer
- Developers shall not grow, cultivate or maintain any vegetation exceeding one (1) metre in height from the natural surface of the land within the easement
- No excavation for outlet pipes or drains within 15m on Tower foundations
- The contractor shall comply with WA Occupational Safety & Health Regulation 3.64 for the restriction on working in vicinity of overhead power lines.
- Maintain access for Western Power vehicles for future maintenance

APPENDIX H

Modelling Parameters

TABLE 1: XP-SWMM Modelling Assumptions

Key Elements	Parameter			Value
IFD Data	BOM IFD Calculator			Jandakot
Runoff Assumptions	Land Use	Lots (40% Standard Lots + 100% Compact Lots)	Initial Loss (mm)	15
			Continuing Loss (mm)	8
			Manning's n for pervious area	0.02
		Retail	Initial Loss (mm)	10
			Proportional Loss (%)	50
			Manning's n for pervious area	0.014
		Road Reserve	Initial Loss (mm)	0.00
			Proportional Loss (%)	80
			Manning's n for pervious area	0.014
		POS	Initial Loss (mm)	-
			Proportional Loss (%)	90
			Manning's n for pervious area	0.03
		Western Power Easement	Initial Loss (mm)	47.6
			Proportional Loss (%)	90
			Manning's n for pervious area	0.03
		Peel Main Drain	Initial Loss (mm)	-
			Proportional Loss (%)	65
			Manning's n for pervious area	0.03
		School	Initial Loss (mm)	-
			Proportional Loss (%)	50
			Manning's n for pervious area	0.03
	Catchment Grade (Catchments)			0.03 (A); 0.02 (B & C); 0.008 (D)
	Runoff routing method used			Laurenson's method ($S=BQ^{n+1}$)
	Evaporation			3 mm/day
Simulation Parameters	Dry time step			86400 Seconds (1 day)
	Transition time Step			30 Seconds
	Wet time step			30 Seconds
	Simulation period			4 Days

Hydraulics	Culverts	Manning's n	0.014
		Headwall type	45 degree Wingwall Flare
		Entrance/Exit loss Coefficients	0.5, 1.0
	Subsoil[1]	Manning's n	0.014
		Headwall type	-
		Entrance/Exit loss Coefficients	-
	Creek Channel	Centre channel Manning's n	0.014 – 0.05
		Over bank Manning's n	0.014
		Assumed Creek Infiltration	0.00
	Storages	Assumed Basin Infiltration	0.00
		Minimum side slopes	1:6 (v:h)
Backwater Condition	Peel Main Drain Modelling Jandakot DWMP (DoW, 2009) Hope Valley Road		12.0 mAHD

Notes: [1] Subsoil drains beneath basins are modelled at basin invert.

APPENDIX I

Runoff Coefficient Calculations for XP-Storm Model

TYPICAL STANDARD LOT

User input

Lot design			
Lot area	m^2	400	
Roof area of house	m^2	240	Assumed maximum 60% lot area based on R-Codes
Outdoor living area	m^2	40	Assumed maximum 10% lot area based on R-Codes, greater than minimum of $30m^2$.
Driveway area	m^2	40	Assumed maximum 10% lot area based on R-Codes
Total impervious	m^2	320	
Total impervious contributing	m^2	160	Front of house and driveway

Rainfall contributing to soakwells from impervious area			
Rainfall depth	mm	15	
	m	0.015	
Rainfall volume	m^3	2.40	Rainfall depth (m) times total impervious contributing area (m^2) to soakwells. Min Soakwell Volume.

Soakwell Volume Requirements		soakwell 1	soakwell 2	soakwell 3	soakwell 4	Total	
Soakwell Height	m	0.60	0.60	0.60	0.60		
Soakwell Diameter	m	1.20	1.20	1.20	1.20		
Soakwell Volume	m^3	0.68	0.68	0.68	0.68	**2.71**	Total soakwell volume to equal rainfall volume
Soakwell Surface Area	m^2	1.13	1.13	1.13	1.13		
Soakage Calculation							
Soil conductivity (K)	m/day	5	5	5	5		
Aquifer Depth	m	3	3	3	3		
Connected area per soakwell	m^2	45	45	45	45	**181**	Total connected area per sokwell to equal total impervious contributing
Soakage Rate	m^3/hr	0.76	0.76	0.76	0.76		
Soakage Continuing Loss	mm/hr	17	17	17	17		
Soakwell clogging factor	%	50%	50%	50%	50%		
	mm/hr	8	8	8	8		

Modelling assumptions		
Initial loss	mm	15
Continuing loss	mm/hr	8

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APPENDIX J

UNDO Modelling Output Results

Government of Western Australia
Department of Water

Project: Mandogalup

Date: 19/10/2016

Version: Version 1.1.0.16209

Subregion name: Lots

Landuse	Percent (%)	Area (ha)	Input load Nitrogen (kg)	Input load Phosphorus (kg)
Residential	100	35.88	1145.14	317.83
Industrial, commercial & schools	0	0.00	0.00	0.00
Rural living	0	0.00	0.00	0.00
Public open space	0	0.00	0.00	0.00
Road reserve	0	0.00	0.00	0.00

Total area	Total percent (%)
35.88	52

Nitrogen input (kg/yr)	Phosphorus input (kg/yr)
1332.79	323.22

Nitrogen export (kg/yr)	Phosphorus (kg/yr)
135.69	4.33

Residential

Size (m²)	Percent (%)	Area (ha)	Input load Nitrogen (kg)	Input load Phosphorus (kg)
<400	80	28.70	674.35	197.56
400-500 m²	20	7.18	470.79	120.28
501-600 m²	0	0.00	0.00	0.00
601-730 m²	0	0.00	0.00	0.00
>730 m²	0	0.00	0.00	0.00
Multiple dwellings	0	0.00	0.00	0.00

Total area	Total percent (%)
35.88	100

Nitrogen input (kg)	Phosphorus input (kg)
1145.14	317.83

Soil and drainage information

Type of drainage	**Subsoil - partial lot connection**	**Does it contain imported fill?**	**Yes**
Soil type	**Bassendean**	Type of fill imported	**White sands (Bassen**
Depth to groundwater (m)	**7**	Fill depth (m)	**0.5**
Groundwater slope (%)	**0.5**	Approximate PRI of imported fill	**5**
Soil PRI	**5.0**	**Does subregion contain onsite sewage diposal sy**	

Note: Please attach the results of soil tests to this report when submitting.

Subregion name: Road

Landuse	Percent (%)	Area (ha)	Input load Nitrogen (kg)	Input load Phosphorus (kg)
Residential	0	0.00	0.00	0.00
Industrial, commercial & schools	0	0.00	0.00	0.00
Rural living	0	0.00	0.00	0.00
Public open space	0	0.00	0.00	0.00
Road reserve	100	15.87	177.74	23.81

Total area	Total percent (%)
15.87	23

Nitrogen input (kg/yr)	Phosphorus input (kg/yr)
260.74	26.19

Nitrogen export (kg/yr)	Phosphorus (kg/yr)
16.57	1.23

Road reserve

Landuse	Percent (%)	Area (ha)
Roads	80	12.70
Road reserve - impervious	0	0.00
Road reserve - native garden	0	0.00
Road reserve - non-native garden	0	0.00
Road reserve - turf	10	1.59
Road reserve - not fertilised	10	1.59

Total area	Total percent (%)
15.87	100

Nitrogen input (kg)	Phosphorus input (kg)
177.74	177.74

Soil and drainage information

Type of drainage	**Piped drainage**	**Does it contain imported fill?**	**No**
Soil type	**Bassendean**	**Does subregion contain onsite sewage diposal system?**	**No**
Depth to groundwater (m)	**7**		
Groundwater slope (%)	**0.5**		
Soil PRI	**5.0**		

Note: Please attach the results of soil tests to this report when submitting.

Subregion name: POS

Landuse	Percent (%)	Area (ha)	Input load Nitrogen (kg)	Input load Phosphorus (kg)
Residential	0	0.00	0.00	0.00
Industrial, commercial & schools	0	0.00	0.00	0.00
Rural living	0	0.00	0.00	0.00
Public open space	100	6.21	316.09	36.51
Road reserve	0	0.00	0.00	0.00

Total area	Total percent (%)
6.21	9

Nitrogen input (kg/yr)	Phosphorus input (kg/yr)
348.57	37.45

Nitrogen export (kg/yr)	Phosphorus (kg/yr)
35.74	4.98

Public Open Space (POS)

Landuse	Percent (%)	Area (ha)
Native gardens	20	1.24
Non-native gardens	20	1.24
Not fertilised	0	0.00
Nature	5	0.31
Sport	0	0.00
Recreation	45	2.79
Golf course	0	0.00
Bowling green	0	0.00
Impervious	10	0.62
Water body	0	0.00

Total area	Total percent (%)
6.21	100

Nitrogen input (kg)	Phosphorus input (kg)
316.09	36.51

Soil and drainage information

Type of drainage	**Subsoil drainage**	**Does it contain imported fill?**	**No**
Soil type	**Bassendean**	**Does subregion contain onsite sewage diposal system?**	**No**
Depth to groundwater (m)	**1**		
Groundwater slope (%)	**0.5**		
Soil PRI	**5.0**		

Note: Please attach the results of soil tests to this report when submitting.

Subregion name: **Power Easement**

Landuse	Percent (%)	Area (ha)	Input load Nitrogen (kg)	Input load Phosphorus (kg)
Residential	0	0.00	0.00	0.00
Industrial, commercial & schools	0	0.00	0.00	0.00
Rural living	0	0.00	0.00	0.00
Public open space	100	11.04	0.00	0.00
Road reserve	0	0.00	0.00	0.00

Total area	Total percent (%)
11.04	16

Nitrogen input (kg/yr)	Phosphorus input (kg/yr)
57.74	1.66

Nitrogen export (kg/yr)	Phosphorus (kg/yr)
5.56	0.01

Public Open Space (POS)

Landuse	Percent (%)	Area (ha)
Native gardens	0	0.00
Non-native gardens	0	0.00
Not fertilised	100	11.04
Nature	0	0.00
Sport	0	0.00
Recreation	0	0.00
Golf course	0	0.00
Bowling green	0	0.00
Impervious	0	0.00
Water body	0	0.00

Total area	Total percent (%)
11.04	100

Nitrogen input (kg)	Phosphorus input (kg)
0.00	0.00

Soil and drainage information

Type of drainage	**Infiltration**	**Does it contain imported fill?**	**No**
Soil type	**Bassendean**	**Does subregion contain onsite sewage diposal system?**	**No**
Depth to groundwater (m)	**9**		
Groundwater slope (%)	**0.5**		
Soil PRI	**5.0**		

Note: Please attach the results of soil tests to this report when submitting.

Summary: Nutrient stripping devices

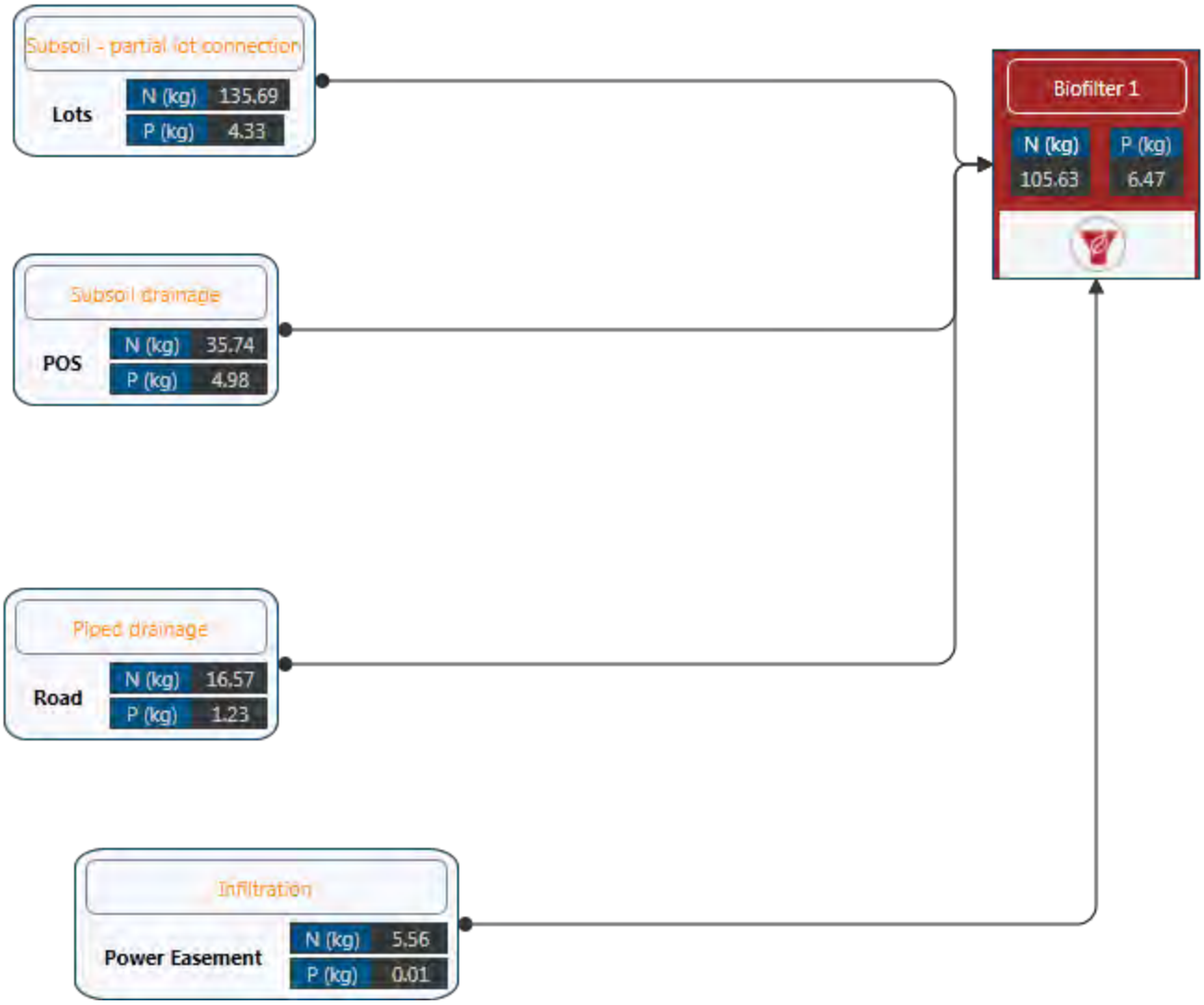
Treatment	Name	Size (m²)	Treated area (ha)	Treating	N removed (kg/yr)	P removed (kg/yr)
Biofilter	Biofilter 1	6225.00	69.00	Sandy soils – Runoff and subsoil drains	87.93	4.08
Load removed					**87.93**	**4.08**
Net export					**105.63**	**6.47**

Summary: Nutrient load exports

Region	Area (ha)	P export (kg/yr)	N export (kg/yr)
Lots	35.88	4.33	135.69
Road	15.87	1.23	16.57
POS	6.21	4.98	35.74
Power Easement	11.04	0.01	5.56

PRE-TREATMENT LOAD (kg/yr)		LOAD REMOVED (kg/yr)		NET LOAD EXPORT (kg/yr)	
NITROGEN	PHOSPHORUS	NITROGEN	PHOSPHORUS	NITROGEN	PHOSPHORUS
193.56	**10.55**	**87.93**	**4.08**	**105.63**	**6.47**

Treatment diagram



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Appendix E

Bushfire Management Plan

(Strategen & JBS&G)

Bushfire Management Plan Coversheet

This Coversheet and accompanying Bushfire Management Plan has been prepared and issued by a person accredited by Fire Protection Association Australia under the Bushfire Planning and Design (BPAD) Accreditation Scheme.

Bushfire Management Plan and Site Details

Site Address / Plan Reference: Lots 3 and 9015 Rowley Road

Suburb: Mandogalup **State:** WA **P/code:** 6167

Local government area: City of Kwinana

Description of the planning proposal: Apsley Structure Plan Amendment

BMP Plan / Reference Number: JBS&G 66636 | 157,868 **Version:** M01 Rev 1 **Date of Issue:** 17/06/2025

Client / Business Name: QUBE PROPERTY GROUP

Reason for referral to DFES	Yes	No
Has the BAL been calculated by a method other than method 1 as outlined in AS3959 (tick no if AS3959 method 1 has been used to calculate the BAL)?	☐	☒
Have any of the bushfire protection criteria elements been addressed through the use of a performance principle (tick no if only acceptable solutions have been used to address all of the BPC elements)?	☐	☒
Is the proposal any of the following special development types (see SPP 3.7 for definitions)?		
Unavoidable development (in BAL-40 or BAL-FZ)	☐	☒
Strategic planning proposal (including rezoning applications)	☒	☐
Minor development (in BAL-40 or BAL-FZ)	☐	☒
High risk land-use	☐	☒
Vulnerable land-use	☐	☒

If the development is a special development type as listed above, explain why the proposal is considered to be one of the above listed classifications (E.g. considered vulnerable land-use as the development is for accommodation of the elderly, etc.)?

The proposed Structure Plan Amendment is a strategic planning proposal.

Note: The decision maker (e.g. local government or the WAPC) should only refer the proposal to DFES for comment if one (or more) of the above answers are ticked "Yes".

BPAD Accredited Practitioner Details and Declaration

Name	Accreditation Level	Accreditation No.	Accreditation Expiry
Zac Cockerill	Level 2	BPAD 37803	31/08/2025
Company		**Contact No.**	
JBS&G Australia Pty Ltd		(08) 9792 4797	

I declare that the information provided within this bushfire management plan is to the best of my knowledge true and correct

Signature of Practitioner **Date** 17/06/2025

Name:	Matt Cousins	Date:	17 June 2025
Company:	QUBE Property Group	Job/Doc. No.:	66636/157,868
Email:	Matt@qubeproperty.com.au	Inquiries:	Zac Cockerill

Bushfire Management Plan Addendum: Apsley Structure Plan Amendment

1. Introduction

QUBE Property Group (QUBE) is lodging a Structure Plan Amendment over Apsley Estate, Mandogalup in the City of Kwinana, to incorporate the balance of Lots 3 and 9015 Rowley Road (hereon referred to as the project area) into the overall Structure Plan area. These landholdings were previously excluded from the original Mandogalup West Local Structure Plan due to the presence of the Kwinana Industrial Buffer. The Structure Plan Amendment, as depicted in **Figure 1**, proposes residential areas, Public Open Space (POS)/drainage, road reserves, powerline easements and the Peel Main Drain throughout the project area.

Strategen (now JBS&G), prepared a comprehensive Bushfire Management Plan (BMP) in 2017 to support QUBE in their original Local Structure Plan submission for Apsley Estate. Subdivision was subsequently approved throughout the Structure Plan area, supported by a detailed subdivision stage BMP (Strategen 2017b). Subdivision renewal throughout the approved Structure Plan area is currently being sought, supported by a BMP addendum (JBS&G 2024).

This BMP has been prepared as an addendum to the original Mandogalup West Local Structure Plan BMP (Strategen 2017a) and provides for an updated strategic level bushfire assessment specific to the project area, as required to support the proposed Structure Plan Amendment. This BMP addendum should be read in conjunction with the original Structure Plan BMP (Strategen 2017a), as well as the updated assessments documented in the subsequent subdivision stage BMP and addendum (Strategen 2017b; JBS&G 2024). This BMP addendum includes the following information:

1. A revised bushfire assessment including:
    a. updated pre and post-development vegetation classification and effective slope maps specific to the project area and current/proposed vegetation conditions (**Figure 2** and **Figure 3**)
    b. updated pre and post-development Bushfire Hazard Level (BHL) assessments specific to the project area and current/proposed vegetation conditions mapped from Item 1a above (**Figure 4** and **Figure 5**)
    c. post-development BAL contour assessment specific to the project area and proposed vegetation conditions mapped from Item 1a above (**Figure 6**).
2. A revised assessment against the bushfire protection criteria of *Guidelines for Planning in Bushfire-Prone Areas Version 1.4* (the Guidelines; WAPC 2021) demonstrating that compliance can be achieved at subsequent planning stages (**Table 5**).
3. A list of responsibilities for implementation of the bushfire management measures to guide future planning stages of the development.

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1.1 Purpose

A portion of the project area is designated bushfire prone on the Map of Bush Fire Prone Areas (refer to **Plate 1**; DFES 2021); therefore, bushfire risk considerations and assessment are required to inform the Structure Plan Amendment as per requirements under Policy Measure 6.3 of *State Planning Policy 3.7 Planning in Bushfire Prone Areas* (SPP3.7; WAPC 2015).

This BMP addendum has been prepared to accompany the proposed Structure Plan Amendment to address strategic planning requirements under Policy Measure 6.3 of SPP3.7 in accordance with the Guidelines.

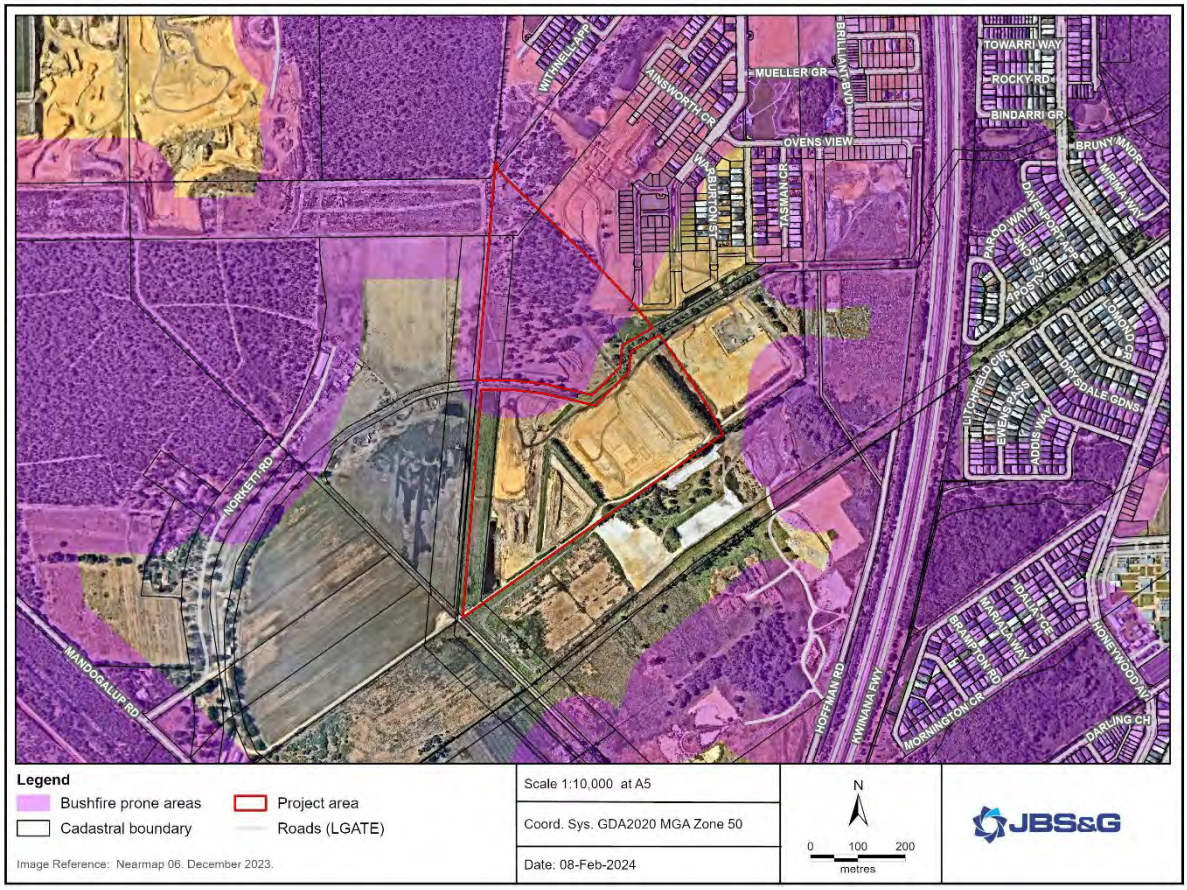

Plate 1: Designated bushfire prone status of the project area (DFES 2021)

N

ROWLEY ROAD

KWINANA HIGHWAY

EASEMENT

WESTERN POWER CORRIDOR

POS

PS

IP47

Neighbourhood Connector A
[20m road reserve as per TIA]

LEGEND

Local Structure Plan Boundary

RESIDENTIAL

Residential (R30-R60)

PUBLIC PURPOSE

PS Educational/Institutional
PS Primary School

PARKS,RECREATION & CONSERVATION

Parks, Recreation and Drainage

Drainage

TRANSPORT

Access Street - Local Road

Neighbourhood Connector A

Temporary Neighbourhood Connector A

Access C

Neighbourhood Connector B

Indicative Cycleway Access

OTHER

Improvement Plan 47

Existing Lot Boundaries

Planning Control Area No.112

Western Power Easement

Local Centre

DBNGP Easement

Transmission Pole and Line

CADASTRAL INFORMATION
SOURCE:MNG
YYMMDD: 250519
DWG REF: 96755lots-9999bj-MGA94z50
PROJECTION: MGA94z50

HATCH

SIZE A3_1:6000

0 metres 60 120 180 240 300

REV	DESCRIPTION	YYMMDD	DRAWN	APPR'D
D	UPDATE POS AREAS	250605	SB	DW
C	UPDATE POS AREAS	240411	SB	DW
B	INCREASE 'POS K'	240318	SB	DRAFT
A	FIRST ISSUE	240315	SB	DRAFT

LOCAL STRUCTURE PLAN
Mandogalup
City of Kwinana

JOB CODE	DRAW NO.	REV.
QUB MAN	**RD1 508**	**D**

DISCLAIMER: ISSUED FOR DESIGN INTENT ONLY. ALL AREAS AND DIMENSIONS ARE SUBJECT TO DETAIL DESIGN AND SURVEY

2. Bushfire assessment results

2.1 Assessment inputs

2.1.1 Vegetation Classification

JBS&G assessed classified vegetation and exclusions within the project area and surrounding 150 m through on-ground verification on 7 September 2023, 10 October 2023, and 21 February 2024.

Vegetation classifications have been assigned in accordance with *AS 3959—2018 Construction of Buildings in Bushfire-Prone Areas* (AS3959; SA 2018) and the *Visual Guide for Bushfire Risk Assessment in Western Australia* (DoP 2016). Georeferenced site photos and a description of the vegetation classifications and exclusions are contained in **Appendix B**. Assessment results are outlined in **Table 1** and **Figure 2** for existing pre-development conditions; and **Table 2** and **Figure 3** for anticipated post-development conditions.

The current pre-development extent of classified vegetation and exclusions is described below and depicted in **Figure 2**:

- Class A forest comprising a multi-tiered fuel structure with a eucalyptus overstorey, shrub midstorey and grassy understorey in the north of the project area
- Class B woodland within and adjacent to the project area in numerous locations comprising sparse overstorey trees over a grassy understorey
- Class D scrub containing shrubs with a horizontal fuel structure at 2–6 m in height:
    - within the power line corridor to the north/northwest and adjacent Lot 2 to the northwest
    - within sections of the Peel Main Drain.
- Class C shrubland containing shrubs with a horizontal fuel structure less than 2 m in height to the southeast of the project area.
- Class G grassland within and adjacent to the project area in numerous locations comprising unmanaged grass greater than 100 mm in height at maturity.

Existing non-vegetated land (e.g. buildings/infrastructure, access tracks, roads, earthworked land, etc), as well as any existing land managed in a low threat state (e.g. urban street verges, low threat staging buffers, etc), were assessed to be excluded from classification under Clauses 2.2.3.2 (e) and (f) of AS 3959.

Post-development conditions, as depicted in **Figure 3**, will require modification to the following areas to a non-vegetated/low threat managed state to achieve exclusion under Clause 2.2.3.2 of AS3959:

- proposed residential areas, including those east of the project area that are subject to existing subdivision approval and BMPs
- proposed roads reserves
- proposed Asset Protection Zones (APZs) ranging from 12–22 m wide into areas of the powerline easement to the west, which aim to deliver a BAL-19 rating for proposed development areas, which is a moderated continuation of the approach adopted under existing planning approvals for Apsley Estate to the northeast of the project area and will be implemented at future planning stages consistent with detailed landscaping design within the powerline easement consistent with the Landscape Masterplan contained in **Appendix A**
- a component of proposed POS that will result in low threat areas such as turf, footpaths, infrastructure, managed gardens and nature strips, as per the Landscape Masterplan contained in **Appendix A** (i.e. POS F&G, H, I and J)
- sections of the Peel Main Drain (PMD) east of Quartermain Boulevard that are subject to existing subdivision approval and BMPs.

Post-development conditions, as depicted in **Figure 3**, may also result in revegetation throughout proposed POS drainage basins (i.e. within POS H and POS K), the Peel Main Drain and the powerline easement, as per the Landscape Masterplan contained in **Appendix A**. Classification of these areas as either Class G grassland, Class C shrubland or Class D scrub is precautionary at this stage based on conceptual landscape design and is subject to change at future planning stages dependent on detailed landscape design.

2.1.2 Effective Slope

JBS&G assessed effective slope under classified vegetation within the assessment area through on ground verification on 7 September 2023, 10 October 2023 and 21 February 2024 in accordance with AS3959. Results were cross referenced with DPIRD 2 m contour data. Effective slope results are outlined in **Table 1** and **Figure 2** for existing pre-development conditions; and **Table 2** and **Figure 3** for anticipated post-development conditions. Results indicate that effective slope within and surrounding the project area is predominantly flat/upslope (0 degrees), while in the north of the project area, a portion of vegetation is downslope ranging from >0–10 degrees.

2.1.3 Pre-development inputs

A summary of the assessed pre-development classified vegetation, exclusions and effective slope within the project area and adjacent 150 m are listed in **Table 1** and illustrated in **Figure 2**.

Table 1: Summary of pre-development vegetation classifications/exclusions and effective slope

Vegetation plot	Vegetation classification	Effective slope	Comments
1	Class A Forest	Downslope >5–10°	Forest vegetation consisting of overstorey trees 10–30 m high, a midstorey and a grassy understorey
2	Class B Woodland	Flat/upslope (0°)	Sparse overstorey trees with a grassy understorey
3	Class B Woodland	Downslope >0–5°	Sparse overstorey trees with a grassy understorey
4	Class D Scrub	Flat/upslope (0°)	Scrub vegetation between 2–6 m high with a continuous horizontal fuel profile
5	Class D Scrub	Downslope >0–5°	Scrub vegetation between 2–6 m high with a continuous horizontal fuel profile
6	Class C Shrubland	Flat/upslope (0°)	Shrub vegetation less than 2 m in height
7	Class G Grassland	Flat/upslope (0°)	Grassland greater than 100 mm in height at maturity
8	Class G Grassland	Downslope >5–10°	Grassland greater than 100 mm in height at maturity
9	Excluded – Non-vegetated and Low threat (Clause 2.2.3.2 [e] and [f])	N/A	Existing non-vegetated land/low threat managed areas including buildings, infrastructure, roads, access tracks, low threat staging buffers, earthworked land, urban street verges, etc

2.1.4 Post-development inputs

A summary of the expected post-development classified vegetation, exclusions and effective slope within the assessment area and adjacent 150 m are listed in **Table 2** and depicted in **Figure 3**.

The post-development vegetation classifications for all land external to the project area are expected to remain the same as pre-development conditions at this time. Land to the south of the project area within Florence Estate is being developed by Satterley and will be modified to a non-vegetated/low threat managed state in an unknown timeframe, so vegetation has been classified as a precautionary measure as part of this assessment.

Table 2: Summary of post-development vegetation classifications, exclusions and effective slope

Vegetation plot	Vegetation classification	Effective slope	Comments
1	Class B Woodland	Flat/upslope (0°)	Sparse overstorey trees with a grassy understorey
2	Class D Scrub	Downslope >0–5°	Scrub vegetation between 2–6 m high with a continuous horizontal fuel profile
3	Class D Scrub	Flat/upslope (0°)	Scrub vegetation between 2–6 m high with a continuous horizontal fuel profile
4	Class C Shrubland	Downslope >5–10°	Shrub vegetation less than 2 m in height (future revegetation within powerline easement)
5	Class C Shrubland	Flat/upslope (0°)	Shrub vegetation less than 2 m in height
6	Class G Grassland	Downslope >5–10°	Grassland greater than 100 mm in height at maturity
7	Class G Grassland	Flat/upslope (0°)	Grassland greater than 100 mm in height at maturity
8	Excluded – Clause 2.2.3.2 [d]	N/A	A strip of vegetation less than 20 m in width regardless of length and not within 20 m of the site, or each other, or other areas of classified vegetation
9	Excluded – Non-vegetated and Low threat (Clause 2.2.3.2 [e] and [f])	N/A	Existing non-vegetated land/low threat managed areas including buildings, infrastructure, roads, access tracks, low threat staging buffers, earthworked land, urban street verges, etc
10	Excluded – Non-vegetated and Low threat (Clause 2.2.3.2 [e] and [f])	N/A	Areas to be modified to a non-vegetated/low threat managed state as part of proposed development, as per the documented assumptions



Legend

- Project area
- 100m assessment area
- 150m assessment area
- Cadastral boundary (LGATE-002)
- DBNGP easement
- Peel main drain
- High voltage powerline easement
- Topographic contours (mAHD)

Roads (LGATE-195)

- Minor road

Vegetation classification

- Class A Forest
- Class B Woodland
- Class C Shrubland
- Class D Scrub
- Class G Grassland
- Clause 2.2.3.2 (e) & (f)

JBS&G

0 100 metres

Apsley, Mandogalup Structure Plan Amendment, Mandogalup, WA

PRE-DEVELOPMENT VEGETATION CLASSIFICATION AND EFFECTIVE SLOPE

Job Number: 66636		Scale 1:3,500 at A3	
Client: QUBE		Coord. Sys. GDA2020 MGA Zone 50	
Drawn By: jcrute	Checked By: ZC	Version: Rev A	Date: 10-Jun-2025

FIGURE: 2

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Image Reference: www.nearmap.com© - Imagery Date: 02. April 2024.



Legend

- Project area
- 100m assessment area
- 150m assessment area
- Cadastral boundary (LGATE-002)
- DBNGP easement
- Peel main drain
- High voltage powerline easement
- Proposed POS
- 12m wide APZ
- 17m wide APZ
- 22m wide APZ
- 27m wide APZ
- Drainage basin
- Cell development layout
- Future indicative lot layout on adjacent stages
- Topographic contours (mAHD)

Roads (LGATE-195)

- Minor road

Vegetation classification

- Class B Woodland
- Class C Shrubland
- Class D Scrub
- Class G Grassland
- Clause 2.2.3.2 (d)
- Clause 2.2.3.2 (e) & (f)
- Area to be modified to non-vegetated and low threat state

JBS&G

0 100 metres

Apsley, Mandogalup Structure Plan Amendment, Mandogalup, WA

POST-DEVELOPMENT VEGETATION CLASSIFICATION AND EFFECTIVE SLOPE

Job Number: 66636		Scale 1:3,500 at A3	
Client: QUBE		Coord. Sys. GDA2020 MGA Zone 50	
Drawn By: jcrute	Checked By: ZC	Version: Rev A	Date: 17-Jun-2025

FIGURE: 3

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Image Reference: www.nearmap.com© - Imagery Date: 02. April 2024.

2.2 Assessment outputs

2.2.1 Pre-development BHL assessment

The pre-development classified vegetation extent has been assigned various BHLs in accordance with methodology detailed in Appendix 2 of the Guidelines, as outlined in **Table 3**.

Table 3: BHL assessment results

Bushfire Hazard Level	Characteristics*
Extreme	• Class A Forest • Class B Woodland (05) • Class D Scrub • Any classified vegetation with a greater than 10° slope.
Moderate	• Class B Low Woodland (07) • Class C Shrubland • Class E Mallee/Mulga • Class G Grassland, including sown pasture and crops • Class G Grassland: Open woodland (06), Low open woodland (08), Open shrubland (09) • Vegetation that has a low hazard level but is within 100 metres of vegetation classified as a moderate or extreme hazard, is to adopt a moderate hazard level.
Low	• Low threat vegetation may include areas of maintained lawns, golf courses, public recreation reserves and parklands, vineyards, orchards, cultivated gardens, commercial nurseries, nature strips and windbreaks • Managed grassland in a minimal fuel condition (insufficient fuel is available to significantly increase the severity of the bushfire attack). For example, short-cropped grass to a nominal height of 100 millimetre • Non-vegetated areas including waterways, roads, footpaths, buildings and rock outcrops.
*Vegetation classifications from AS 3959-2018 Table 2.3.	

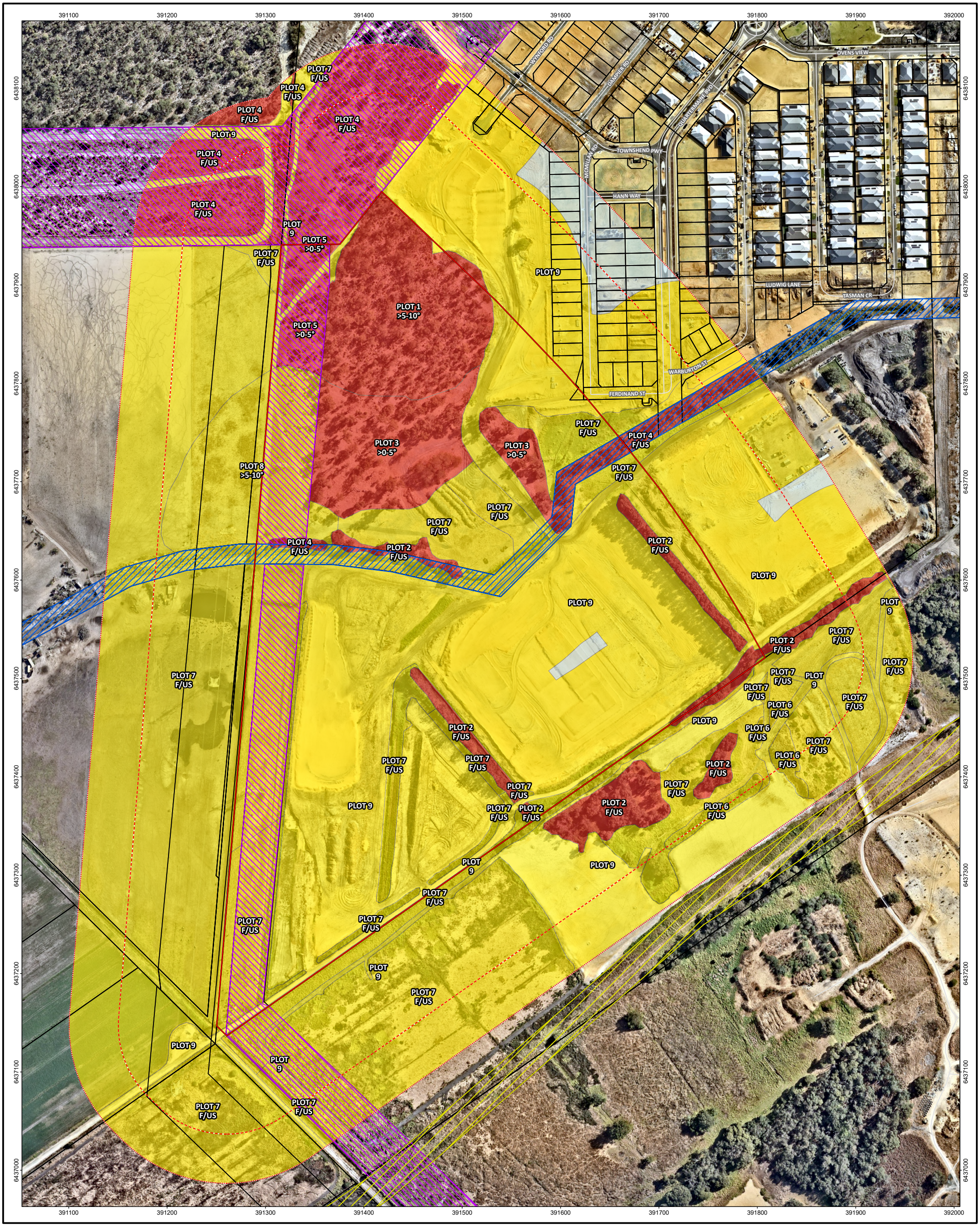
JBS&G has mapped the pre-development BHLs within the project area and surrounding 150 m. The BHLs have been assessed on the basis of the vegetation summarised in Section 2.1.3 (i.e. the current pre-development extent of classified vegetation within and surrounding the project area).

The pre-development BHL assessment (refer to **Figure 4**) indicates that based on the existing vegetation extent, the project area contains land predominantly with Moderate and Extreme BHLs. Whilst some of the project area is rated with a pre-development Extreme BHL, the on-site vegetation is temporary and subject to modification to a non-vegetated/low threat managed state as part of proposed development. Therefore, the post-development BHL will be significantly reduced following proposed development.

2.2.2 Post-development BHL assessment

The post-development BHLs have been mapped within the assessment area on the basis of the anticipated post-development vegetation summarised in Section 2.1.4.

The post-development BHL assessment map (**Figure 5**) demonstrates that all proposed development areas will be located on land with either a Low or Moderate BHL. This achieves compliance with Element 1 of the bushfire protection criteria of the Guidelines, as discussed in Section 3.



Legend

- Project area
- 100m assessment area
- 150m assessment area
- Cadastral boundary (LGATE-002)
- DBNGP easement
- Peel main drain
- High voltage powerline easement

Roads (LGATE-195)

- Minor road

Bushfire hazard level

- Extreme
- Moderate
- Low

JBS&G

0 100 metres

Job Number: 66636		Scale 1:3,500 at A3	
Client: QUBE		Coord. Sys. GDA2020 MGA Zone 50	
Drawn By: jcrute	Checked By: ZC	Version: Rev A	Date: 10-Jun-2025

Apsley, Mandogalup Structure Plan Amendment, Mandogalup, WA

PRE-DEVELOPMENT BUSHFIRE HAZARD LEVELS

FIGURE: 4

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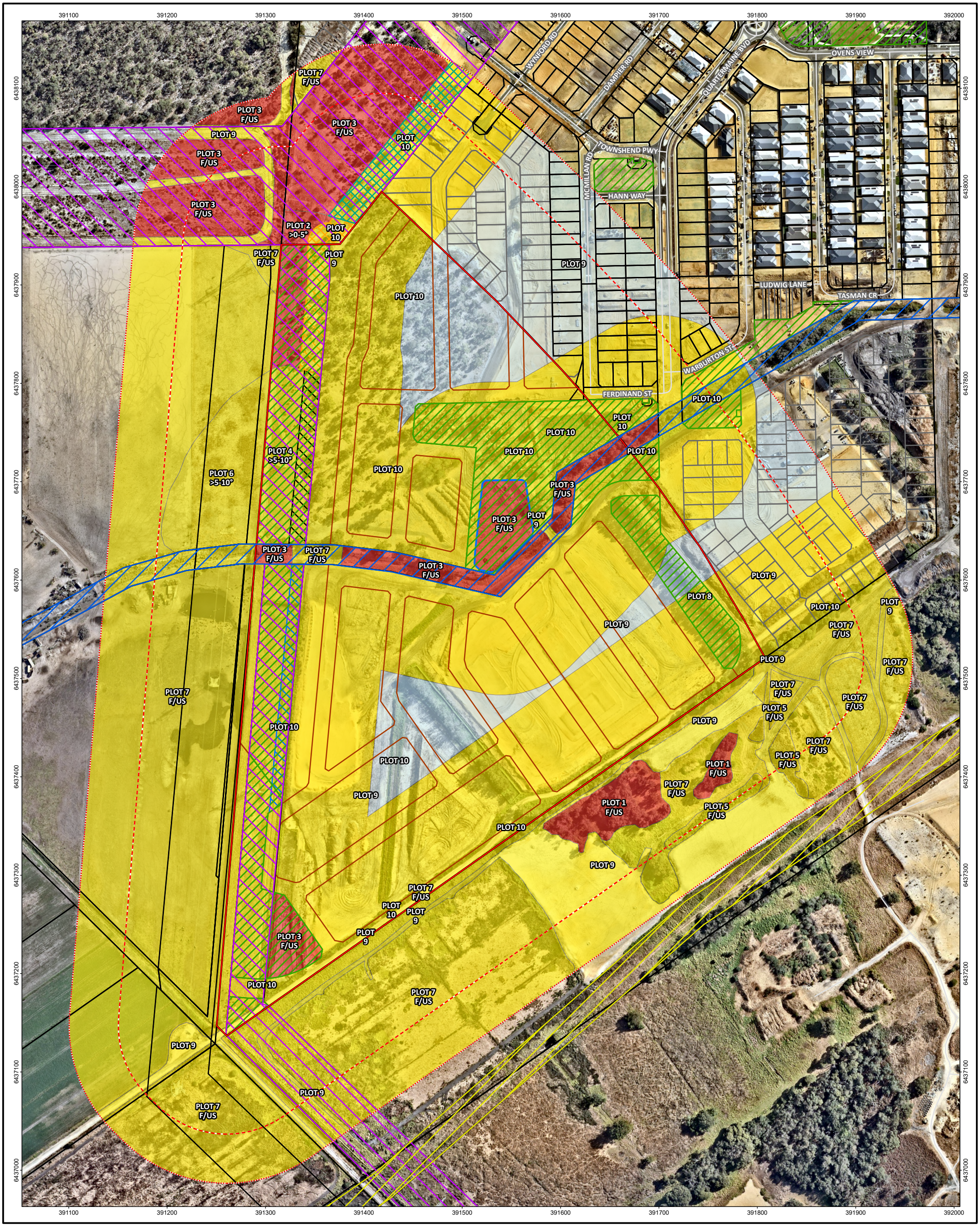
Image Reference: www.nearmap.com© - Imagery Date: 02. April 2024.



Legend

- Project area
- 100m assessment area
- 150m assessment area
- Cadastral boundary (LGATE-002)
- DBNGP easement
- Peel main drain
- High voltage powerline easement
- Proposed POS
- 12m wide APZ
- 17m wide APZ
- 22m wide APZ
- 27m wide APZ
- Drainage basin
- Cell development layout
- Future indicative lot layout on adjacent stages

Bushfire hazard level

- Extreme
- Moderate
- Low

Roads (LGATE-195)

- Minor road

JBS&G

0 100 metres

Apsley, Mandogalup Structure Plan Amendment, Mandogalup, WA

POST-DEVELOPMENT BUSHFIRE HAZARD LEVELS

Job Number: 66636		Scale 1:3,500 at A3	
Client: QUBE		Coord. Sys. GDA2020 MGA Zone 50	
Drawn By: jcrute	Checked By: ZC	Version: Rev A	Date: 17-Jun-2025

FIGURE: 5

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Image Reference: www.nearmap.com© - Imagery Date: 02. April 2024.

2.2.3 Post-development Bushfire Attack Level (BAL) contour assessment

A post-development Bushfire Attack Level (BAL) contour assessment has been undertaken for the project area in accordance with Method 1 of AS3959. The Method 1 procedure incorporates the following factors:

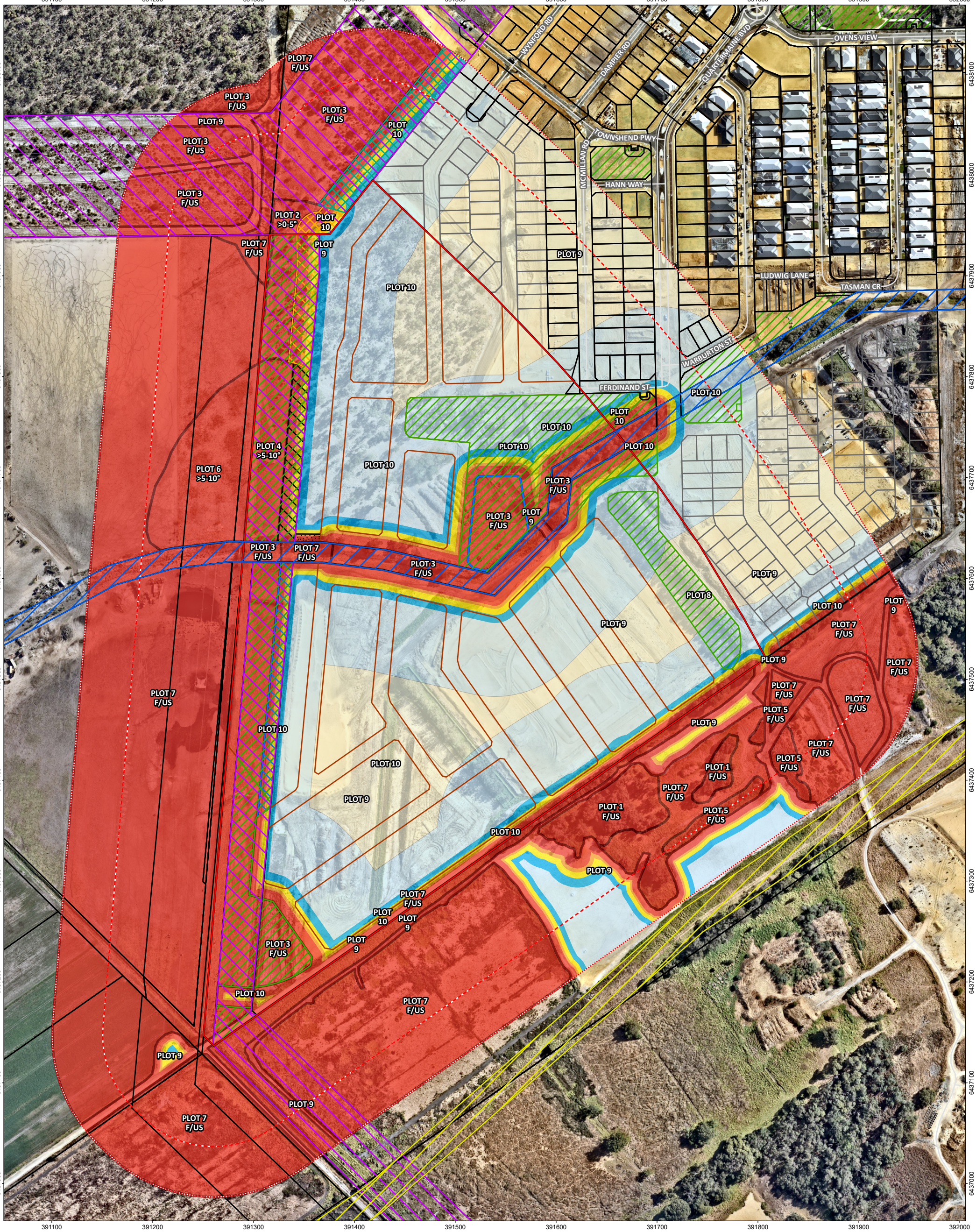
- state-adopted Fire Danger Index (FDI) rating of 80
- vegetation classification
- effective slope
- distance maintained between proposed development areas and the classified vegetation.

The BAL rating gives an indication of the level of bushfire attack (i.e. the radiant heat flux) that may be received by future development and subsequently informs the standard of building construction and/or setbacks required for proposed habitable development to potentially withstand such impacts and/or deliver compliance with the bushfire protection criteria of the Guidelines.

The BAL contours are based on the anticipated post-development vegetation classifications, exclusions and effective slope mapped in **Figure 3**. Results of the BAL contour assessment are detailed in **Table 4** and illustrated in **Figure 6**. The anticipated worst case BAL impact to future habitable development within the project area is BAL–FZ as a result of a section of direct development interface with abutting Class G grassland within the PMD. However, following provision of an 8 m APZ setback into the affected development cell, BAL–29 is achieved. This impact can be managed at the subdivision stage through the conditioning of a restrictive covenant on title enforcing implementation of the APZ setback. All other areas of proposed habitable development achieve a rating of BAL-29 or lower, as detailed in **Table 4**.

Table 4: BAL contour assessment results

Method 1 BAL determination					
Vegetation plot	**Vegetation classification**	**Effective slope**	**Separation distance to nearest lot boundary**	**Highest BAL to nearest lot boundary**	**Modified BAL with APZ setback (see Figure 6)**
1	Class B Woodland	Flat/upslope (0°)	19 m	BAL–29	N/A
2	Class D Scrub	Downslope >0–5°	22 m	BAL–19	N/A
3	Class D Scrub	Flat/upslope (0°)	13 m	BAL–29	N/A
4	Class C Shrubland	Downslope >5–10°	17 m	BAL–19	N/A
5	Class C Shrubland	Flat/upslope (0°)	60 m	BAL–12.5	N/A
6	Class G Grassland	Downslope >5–10°	>50 m	BAL–Low	N/A
7	Class G Grassland	Flat/upslope (0°)	0 m	BAL–FZ	BAL–29 with 8 m APZ setback
8	Excluded – Clause 2.2.3.2 [d]	N/A	N/A	N/A	N/A
9	Excluded – Non-vegetated and Low threat (Clause 2.2.3.2 [e] and [f])	N/A	N/A	N/A	N/A
10	Excluded – Non-vegetated and Low threat (Clause 2.2.3.2 [e] and [f])	N/A	N/A	N/A	N/A



Legend

- Project area
- 100m assessment area
- 150m assessment area
- Cadastral boundary (LGATE-002)
- DBNGP easement
- Peel main drain
- High voltage powerline easement
- Proposed POS
- 12m wide APZ
- 17m wide APZ
- 22m wide APZ
- 27m wide APZ
- Drainage basin
- Cell development layout
- Future indicative lot layout on adjacent stages

Roads (LGATE-195)

- Minor road

- 8m wide APZ setback
- Classified vegetation

BAL contours

- BAL FZ
- BAL 40
- BAL 29
- BAL 19
- BAL 12.5
- BAL Low

JBS&G

0 100 metres

Job Number: 66636

Scale 1:3,500 at A3

Client: QUBE

Coord. Sys. GDA2020 MGA Zone 50

Drawn By: jcrute | Checked By: ZC | Version: Rev A | Date: 17-Jun-2025

Apsley, Mandogalup Structure Plan Amendment, Mandogalup, WA

POST-DEVELOPMENT BAL CONTOUR MAP

FIGURE: 6

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Image Reference: www.nearmap.com© - Imagery Date: 02. April 2024.

3. Assessment against bushfire protection criteria

3.1 Compliance with Elements 1–4

Demonstration that the proposed development can comply with relevant acceptable solutions of Elements 1–4 of the bushfire protection criteria of the Guidelines (Version 1.4) is outlined in **Table 5**.

Table 5: Compliance with the bushfire protection criteria of the Guidelines (Elements 1–4)

Bushfire protection criteria	Performance Principle	Method of compliance Acceptable solutions	Proposed bushfire management strategies	Compliance achievable at future planning stages
Element 1: Location	**Performance Principle P1** The strategic planning proposal, subdivision and development application is located in an area where the bushfire hazard assessment is or will, on completion, be moderate or low, or a BAL–29 or below, and the risk can be managed. For unavoidable development in areas where BAL–40 or BAL–FZ applies, demonstrating that the risk can be managed to the satisfaction of the decision-maker.	**A1.1 Development location** The strategic planning proposal, subdivision and development application is located in an area that is or will, on completion, be subject to either a moderate or low bushfire hazard level, or BAL–29 or below.	The pre-development BHL assessment (**Figure 4**) identifies that the project area currently contains land with Moderate and Extreme BHLs. On completion of development however, it is expected that the majority of vegetation within the project area will be cleared and/or managed in a low threat state with the only remaining classified vegetation potentially being present within the PMD, powerline easement and POS drainage areas, noting this is subject to change as part of detailed landscape design. Therefore, post-development BHLs were assessed to be Low or Moderate in locations of proposed habitable development (see **Figure 5**). Furthermore, the post-development BAL contour assessment (see **Figure 6** and **Table 4**) demonstrates that all proposed habitable development can achieve BAL-29 or lower subject to an 8 m APZ setback within a small section of a development cell that directly abuts the PMD. This impact can be managed at the subdivision stage through the conditioning of a restrictive covenant on title enforcing implementation of the APZ setback.	✓

Bushfire protection criteria	Performance Principle	Method of compliance Acceptable solutions	Proposed bushfire management strategies	Compliance achievable at future planning stages
Element 2: Siting and design	**Performance Principle P2** The siting and design of the strategic planning proposal, subdivision or development application, including roads, paths and landscaping, is appropriate to the level of bushfire threat that applies to the site. The proposal incorporates a defendable space and significantly reduces the heat intensities at the building surface thereby minimising the bushfire risk to people, property and infrastructure, including compliance with AS 3959 if appropriate.	**A2.1 Asset Protection Zone** Every habitable building is surrounded by, and every proposed lot can achieve, an APZ depicted on submitted plans, which meets the requirements set out in Schedule 1.	Low threat separation for future habitable development to achieve BAL—29 or lower is to be implemented for all relevant lots where required. This will be predominantly achieved through appropriate subdivision design and the use of perimeter roads/low threat staging buffers at interfaces with on-site and external classified vegetation. In addition, APZs ranging from 12–22 m wide are proposed to be established into abutting areas of the powerline easement, which aim to deliver a BAL-19 rating for proposed development areas, as per the Landscape Masterplan in **Appendix A**. This is a moderated continuation of the approach adopted under existing planning approvals for Apsley Estate to the northeast of the project area and will be implemented at future planning stages as part of landscaping design within the powerline easement. As previously mentioned, an 8 m wide APZ setback will be required within a small section of a development cell that directly abuts the PMD. This impact can be managed at the subdivision stage through the conditioning of a restrictive covenant on title enforcing implementation of the APZ setback. APZs are to be implemented and maintained in accordance with Schedule 1 of the Guidelines **(Appendix C**).	✓
Element 3: Vehicular access	**Performance Principle P3i** The design and capacity of vehicular access and egress is to provide for the community to evacuate to a suitable destination before a bushfire arrives at the site, allowing emergency services personnel to attend the site and/or hazard vegetation.	**A3.1 Public roads** *The minimum requirements under this acceptable solution are applicable to all proposed and existing public roads.* Public roads are to meet the minimum technical requirements in Table 6, Column 1. The trafficable (carriageway/pavement) width is to be in accordance with the relevant class of road in the Local	All proposed public roads will be designed and constructed to comply with the technical requirements of the Guidelines (refer to A3.1 and **Appendix D**). This will be demonstrated at the subdivision stage of planning.	✓

Bushfire protection criteria	Performance Principle	Method of compliance Acceptable solutions	Proposed bushfire management strategies	Compliance achievable at future planning stages
		Government Guidelines for Subdivisional Development (IPWEA Subdivision Guidelines), Liveable Neighbourhoods, Austroad standards and/or any applicable standards for the local government area.		
		A3.2a Multiple access routes Public road access is to be provided in two different directions to at least two different suitable destinations with an all-weather surface (two-way access). If the public road access to the subject site is via a no-through road which cannot be avoided due to demonstrated site constraints, the road access is to be a maximum of 200 metres from the subject lot(s) boundary to an intersection where two-way access is provided. The no-through road may exceed 200 metres if it is demonstrated that an alternative access, including an emergency access way, cannot be provided due to site constraints and the following requirements are met: • the no-through road travels towards a suitable destination; and • the balance of the no-through road, that is greater than 200 metres from the subject site, is wholly within BAL-LOW, or is within a residential built-out area – Figure 23.	On completion of the development, the existing and future public road network will provide all occupants with the option of travelling to multiple suitable destinations as detailed below: • access north through existing stages of Apsley Estate to Rowley Road • access east through existing stages of Apsley and Florence Estates and south via the existing Emergency Access Way (EAW) to Hoffman Road • for proposed development areas south of PMD, access east via the proposed subdivision EAWs linking with Hoffman Road in the south (refer to Plate 2 extract below from the JBS&G [2024] subdivision renewal BMP) • it should also be noted that multiple connections south to the adjacent Florence Estate will ultimately be provided, as per the subdivision stage BMP addendum for Florence Mandogalup Stages 11–18 (JBS&G 2025). A minimum of two access routes to two suitable destinations will also need to be provided during staging of subdivision, which will be demonstrated at the subdivision stage. JBS&G can confirm that compliant secondary vehicular access south to Hoffman Road can be achieved through existing temporary emergency access arrangements, as given effect through the subdivision process for both Apsley and Florence Estates, and are adequate for the intended subdivision and development.	✓

Bushfire protection criteria	Performance Principle	Method of compliance Acceptable solutions	Proposed bushfire management strategies	Compliance achievable at future planning stages
			 **Plate 2: Proposed EAW connections south of Peel Main Drain**	
		A3.2b Emergency access way *Where it is demonstrated that A3.2a cannot be achieved due to site constraints, or where an alternative design option does not exist, an emergency access way can be considered as an acceptable solution.* An emergency access way is to meet all the following requirements: • requirements in Table 6, Column 2; • provides a through connection to a public road; • be no more than 500 metres in length; and • must be signposted and if gated, gates must open the whole trafficable width and remain unlocked.	No permanent EAWs are proposed or required as part of the development. However, as depicted in Plate 2, temporary compliant subdivision EAWs are proposed for development areas south of PMD, which navigate east and south to Hoffman Road and provide a secondary access route for these development areas. These EAWs will remain in place until such time that a formal secondary access route is in place, such as proposed extension of public roads south through Florence Estate to Hoffman Road, as identified in the subdivision stage BMP addendum for Florence Mandogalup Stages 11–18 (JBS&G 2025). Any temporary EAWs required as part of staged development are to be constructed to the technical requirements of the Guidelines (see A3.2b and Appendix D), which will be confirmed at the subdivision stage.	✓

Bushfire protection criteria	Performance Principle	Method of compliance Acceptable solutions	Proposed bushfire management strategies	Compliance achievable at future planning stages
		A3.3 Through-roads All public roads should be through-roads. No-through roads should be avoided and should only be considered as an acceptable solution where: • it is demonstrated that no alternative road layout exists due to site constraints; and • the no-through road is a maximum length of 200 metres to an intersection providing two-way access, unless it satisfies the exemption provisions in A3.2a of this table. A no-through road is to meet all the following requirements: • requirements of a public road (Table 6, Column 1); and • turn-around area as shown in Figure 24.	All proposed public roads will be through-roads. Whilst the extension of Quartermaine Boulevard south of PMD creates a temporary single access route for proposed development areas south of PMD, this will be resolved through provision of the temporary subdivision EAWs depicted in Plate 2 and discussed in JBS&G (2024), which navigate east and south to Hoffman Road. These will remain in place until such time that a formal secondary access route is in place, such as proposed extension of public roads south through Florence Estate to Hoffman Road as identified in the subdivision stage BMP addendum for Florence Mandogalup Stages 11–18 (JBS&G 2025). Temporary no-through roads may also be required during development staging and will need to comply with relevant technical requirements under the Guidelines (refer A3.3 and **Appendix D**).	✓
	Performance Principle P3ii The design of vehicular access and egress provides: • access and egress for emergency service vehicles while allowing the community to evacuate; • a defendable space for emergency services personnel on the interface • between classified vegetation and development site; and • hazard separation between classified vegetation and the subject site to reduce the potential radiant heat that may impact a lot(s).	**A3.4a Perimeter roads** A perimeter road is a public road and should be provided for greenfield or infill development where 10 or more lots are being proposed (including as part of a staged subdivision) with the aim of: • separating areas of classified vegetation under AS3959, which adjoin the subject site, from the proposed lot(s); and • removing the need for battle-axe lots that back onto areas of classified vegetation.	The proposed public road network provides perimeter access to the surrounding bushfire hazards, where required. Where perimeter roads have not been provided, the interfacing hazard is Class G grassland and/or an APZ treatment is proposed to remove the direct vegetation interface, which is acceptable under A3.4a.	✓

Bushfire protection criteria	Performance Principle	Method of compliance Acceptable solutions	Proposed bushfire management strategies	Compliance achievable at future planning stages
		A perimeter road is to meet the requirements contained in Table 6, Column 1. A perimeter road may not be required where: • the adjoining classified vegetation is Class G Grassland; • lots are zoned for rural living or equivalent; • it is demonstrated that it cannot be provided due to site constraints; or • all lots have frontage to an existing public road.		
	Performance Principle P3iii Vehicular access is provided which allows: • access and egress for emergency service vehicles; • defendable space for emergency services • personnel on the interface between classified vegetation and development; and • hazard separation between classified vegetation and the site to reduce the potential radiant heat that may impact a lot(s).	**A3.4b Fire service access route** *Where proposed lots adjoin classified vegetation under AS3959, and a perimeter road is not required in accordance with A3.4a, a fire service access route can be considered as an acceptable solution to provide firefighter access, where access is not available, to the classified vegetation.* A fire service access route is to meet all the following requirements: • requirements in Table 6, Column 3; • be through-routes with no dead-ends; • linked to the internal road system at regular intervals, every 500 metres; • must be signposted; • no further than 500 metres from a public road; • if gated, gates must open the required horizontal clearance and can be locked	As previously discussed, the proposed public road network provides perimeter access to the surrounding bushfire hazards, where required. On this basis, no permanent FSARs will be required. However, temporary FSARs may be required during staging of development to ensure firefighters are able to gain access to stage perimeters prior to future subdivision roads being constructed. Any FSARs will need to comply with relevant technical requirements of the Guidelines (refer to A3.4b and Appendix D).	✓

Bushfire protection criteria	Performance Principle	Method of compliance Acceptable solutions	Proposed bushfire management strategies	Compliance achievable at future planning stages
		by the local government and/or emergency services, if keys are provided for each gate; and • turn-around areas designed to accommodate type 3.4 fire appliances and to enable them to turn around safely every 500 metres.		
	Performance Principle P3iv Vehicular access is provided which allows emergency service vehicles to directly access all habitable buildings and water supplies and exit the lot without entrapment.	**A3.5 Battle-axe access legs** *Where it is demonstrated that a battle-axe cannot be avoided due to site constraints, it can be considered as an acceptable solution.* There are no battle-axe technical requirements where the point the battle-axe access leg joins the effective area of the lot, is less than 50 metres from a public road in a reticulated area. In circumstances where the above condition is not met, or the battle-axe is in a non-reticulated water area, the battle-axe is to meet all the following requirements: • requirements in Table 6, Column 4; and • passing bays every 200 metres with a minimum length of 20 metres and a minimum additional trafficable width of two metres (i.e. the combined trafficable width of the passing bay and constructed private driveway to be a minimum six metres).	A3.5 is applicable to subdivision stage only.	N/A
		A3.6 Private driveways There are no private driveway technical requirements where the private driveway is:	A3.6 is applicable to the DA stage only.	N/A

Bushfire protection criteria	Performance Principle	Method of compliance Acceptable solutions	Proposed bushfire management strategies	Compliance achievable at future planning stages
		• within a lot serviced by reticulated water; • no greater than 70 metres in length between the most distant external part of the development site and the public road measured as a hose lay; and • accessed by a public road where the road speed limit is not greater than 70 km/h. In circumstances where all of the above conditions are not met, or the private driveway is in a non-reticulated water area, the private driveway is to meet all the following requirements: • requirements in Table 6, Column 4; • passing bays every 200 metres with a minimum length of 20 metres and a minimum • additional trafficable width of two metres (i.e. the combined trafficable width of the passing bay and constructed private driveway to be a minimum six metres); and • turn-around area as shown in Figure 28 and within 30 metres of the habitable building.		
Element 4: Water	No performance principle applies	**A4.1 Identification of future water supply** Evidence that a reticulated or sufficient non-reticulated water supply for bushfire fighting can be provided at the subdivision and/or development application stage, in accordance with the specifications of the relevant water supply authority or the requirements of Schedule 2.	Reticulated water supply services will be extended throughout the project area from services currently present within surrounding areas of development, which will result in provision of a reticulated mains water supply for future habitable development to Water Corporation Design Standard 63 requirements.	✓

Bushfire protection criteria	Performance Principle	Method of compliance Acceptable solutions	Proposed bushfire management strategies	Compliance achievable at future planning stages
		Where the provision of a strategic water tank(s) is required a suitable area within a road reserve or a dedicated lot the location should be identified, should be identified on the structure plan, to the satisfaction of the local government.		
	Performance Principle P4 Provide a permanent water supply that is: • sufficient and available for firefighting purposes; • constructed from non-combustible materials (e.g. steel), or able to maintain its integrity throughout a bushfire; and • accessible, with legal access for maintenance and re-filling by tankers and emergency service vehicles.	**A4.2 Provision of water for firefighting purposes** Where a reticulated water supply is existing or proposed, hydrant connection(s) should be provided in accordance with the specifications of the relevant water supply authority. Where these specifications cannot be met, then the following applies: • The provision of a water tank(s), in accordance with the requirements of Schedule 2; and • Where the provision of a strategic water tank(s) is applicable, then the following requirements apply: – land to be ceded free of cost to the local government for the placement of the tank(s); – the lot or road reserve where the tank is to be located is identified on the plan of subdivision; – tank capacity, construction, and fittings, provided in accordance with the requirements of Schedule 2; and – a strategic water tank is to be located no more than 10	A4.2 is applicable to the subdivision and DA stages only.	N/A

Bushfire protection criteria	Performance Principle	Method of compliance Acceptable solutions	Proposed bushfire management strategies	Compliance achievable at future planning stages
		minutes from the subject site (at legal road speeds). Where a subdivision includes an existing habitable building(s) that is to be retained, a water supply should be provided to this existing habitable building(s), in accordance with the requirements listed above.		

4. Responsibilities for implementation and management of the bushfire measures

This BMP addendum has been prepared as a strategic guide to demonstrate how development compliance will be delivered at future planning stages in accordance with the Guidelines. Aside from the preparation of future BMPs/addendums to accompany future subdivision/development applications where appropriate, there are no further items to implement, enforce or review at this strategic stage of the planning process.

Future BMPs/addendums prepared to accompany future subdivision/development applications are to meet the relevant commitments outlined in this strategic level BMP addendum, address the relevant requirements of SPP 3.7 (i.e. Policy Measures 6.4 and 6.5 respectively) and demonstrate in detail how the proposed development will comply with the relevant acceptable solutions of the Guidelines. Future BMPs/addendums prepared to accompany future subdivision/development applications are to include the following detailed information:

- proposed lot layout, including any public open space (POS) and drainage areas
- detailed landscaping design in regard to POS and drainage to delineate low threat exclusions from classified vegetation
- confirmation of any retained vegetation or revegetation areas, particularly throughout drainage POS
- confirmation of the post-development classified vegetation extent, effective slope and separation distances
- BAL contour mapping demonstrating that proposed development areas will achieve a rating of BAL–29 or lower
- width and alignment of compliant low threat separation or APZs, including any APZ setback requirements into proposed lots
- confirmation of how bushfire management will be addressed regarding temporary bushfire hazards on adjacent future development stages, including low threat staging buffers
- vehicular access provisions, including demonstration that a minimum of two access routes will be achieved for each stage of development (may require consideration of temporary compliant access provisions such as no-through roads and EAWs)
- confirmation of a compliant reticulated water supply
- provisions for notification on Title for any future lots with a rating of BAL-12.5 or greater as a condition of subdivision
- compliance requirements with the annual City of Kwinana firebreak notice (see Appendix E)
- assessment against the bushfire protection criteria of the Guidelines
- proposed implementation and audit program outlining all measures requiring implementation and the appropriate timing and responsibilities for implementation.

Based on the information contained in this BMP, JBS&G considers the bushfire hazards within and adjacent to the project area and the associated bushfire risks are readily manageable through adoption of standard acceptable solutions outlined in the Guidelines, which will be implemented as required throughout future planning stages. JBS&G considers that on implementation of the proposed management measures, the site will be able to be developed with a manageable level of bushfire risk whilst maintaining full compliance with the Guidelines.

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5. References

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Appendix A Landscape Masterplan

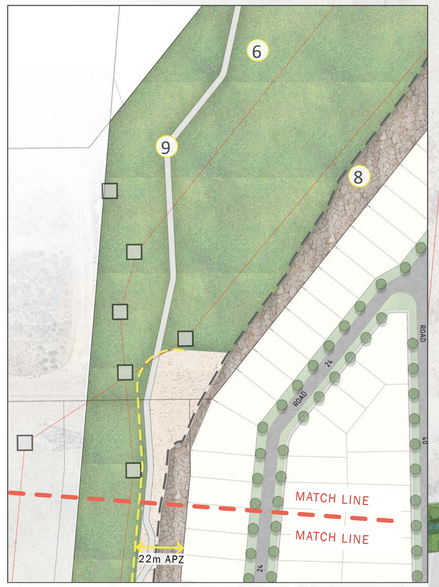


APSLEY ESTATE

1403302 apsley south - landscape concept plan [G]

PLAN E

02 | APSLEY SOUTH
LANDSCAPE MASTER PLAN



INSET PLAN
WESTER POWER EASEMENT

MATCH LINE
MATCH LINE
22m APZ
17m APZ
12m APZ
FERDINAND STR
FERDINAND STREET
WALKER RD
MCMILLAN RD
QUARTERMAINE BLVD
QUARTERMAINE BOULEVARD
LUDWIG LANE
TASMAN CRESCENT
WARBURTON
WARBURTON STREET
HARTOG CRESCENT
GREGORY STREET
ROAD
POWER DISTRIBUTION
BATTER
APZ LINE

LEGEND

01 POS H- REFER DRAWING M1.103

02 POS J - REFER DRAWING M1.105

03 POS F&G - REFER DRAWING M1.107

04 PEEL MAIN DRAIN - REFER DRAWING M1.103 & M1.107 :
20m WIDE EASEMENT WITH REALIGNED PEEL MAIN DRAIN WHERE THERE ARE NO EXISTING TREES

05 POS I - NATIVE SHRUB AND TREE PLANTING:
PLANTED WITH NATIVE LOW SHRUBS AND TREES AS BUFFER TO PEEL MAIN DRAIN

06 WESTERN POWER EASEMENT :
PLANTED WITH NATIVE VEGETATION (<1M MATURE HEIGHT) OUTSIDE APZ AREAS

07 WESTERN POWER EASEMENT DRAINAGE BASIN :
PLANTED WITH NATIVE RUSHES AND SEDGES TOLERANT OF WINTER WET AND SUMMER DRY CONDITIONS

08 WESTERN POWER EASEMENT APZ :
PLANTED WITH LOW FUEL LOAD NATIVE VEGETATION (<0.5M MATURE HEIGHT) WITHIN APZ AREAS

09 DUAL USE PATH

10 POS K DRAINAGE BASIN:
PLANTED WITH NATIVE RUSHES AND SEDGES TOLERANT OF WINTER WET AND SUMMER DRY CONDITIONS

ASSET PROTECTION ZONE (APZ)

PEEL MAIN DRAIN EASEMENT (20.0M WIDE)

APSLEY ESTATE

PREPARED FOR QUBE PROPERTY GROUP

APSLEY SOUTH - LANDSCAPE MASTER PLAN
JUNE 2025

JOB NO. 1403302
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M1.102

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03 | POS H & PEEL MAIN DRAIN

LANDSCAPE CONCEPT PLAN



LEGEND

01 INSITU CONCRETE PEDESTRIAN PATH NETWORK

02 3.0M WIDE CONCRETE PEDESTRIAN PATH AND MAINTENANCE VEHICLE ACCESS

03 NATIVE LOW SHRUB AND GROUNDCOVER PLANTING

04 OPEN TURF AREA

05 20% AEP DRAINAGE BASIN FOR STORMWATER CATCHMENT TO BE FULLY PLANTED WITH SUITABLE INDIGENOUS NATIVE TREE AND SHRUB SPECIES

06 SHELTER WITH SEATING AND BBQ FACILITIES

07 TODDLER (1-3 YRS) NATURE PLAYGROUND UNDER EXISTING TREE CANOPY

08 JUNIOR (3-8 YRS) NATURE PLAYGROUND

09 SEATING NODE

10 FOOTBRIDGE ACROSS PEEL MAIN DRAIN

11 PEEL MAIN DRAIN CHANNEL - RETAIN EXISTING TREES AND FULLY VEGETATED

12 EXISTING TREES TO BE RETAINED

13 PROPOSED NEW STREET TREES

14 PROPOSED POS TREE PLANTING

15 LOW RETAINING WALL (500MM HIGH)

16 TRANSFORMER

PEEL MAIN DRAIN EASEMENT (20.0M WIDE)

LOCATION MAP

APSLEY ESTATE

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LANDSCAPE CONCEPT PLAN

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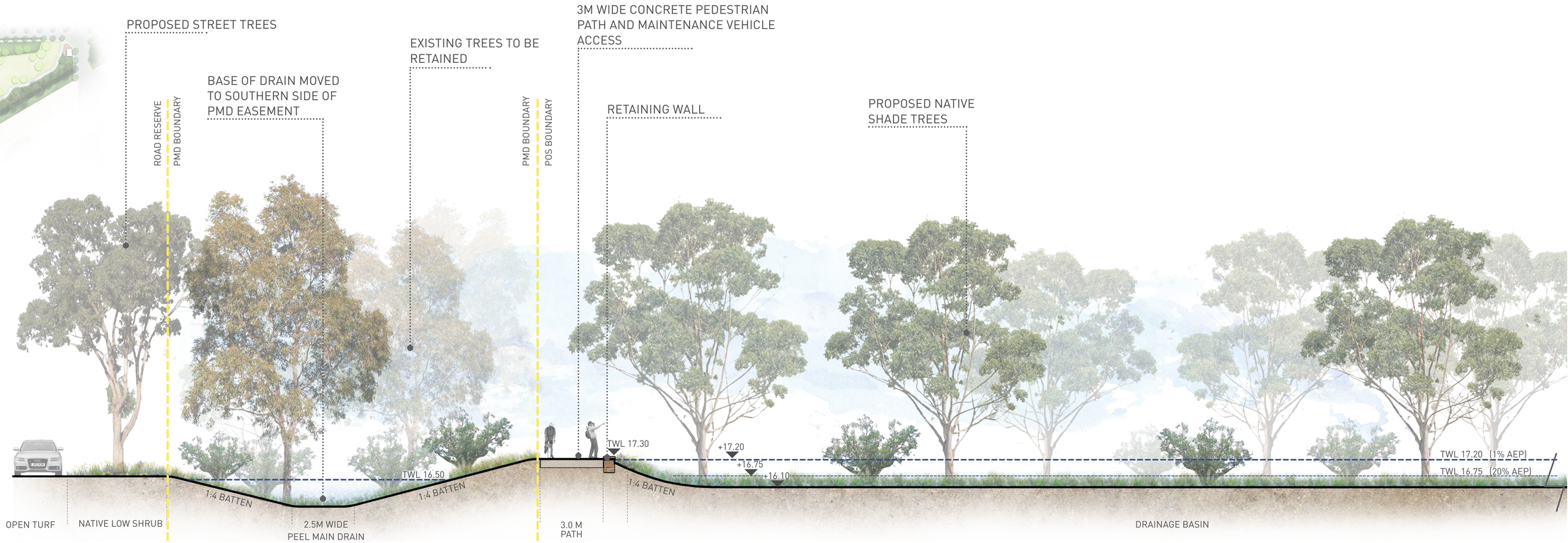
04 | POS H & PEEL MAIN DRAIN

SECTION A



LOCATION MAP



SECTION A-A'



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05 | POS J

LANDSCAPE CONCEPT PLAN



LEGEND

01 INSITU CONCRETE PEDESTRIAN PATH NETWORK TO ACCOMMODATE PEDESTRIAN AND MAINTENANCE ACCESS

02 GRAVEL PATH WITH ROCK BOULDERS

03 NATIVE LOW SHRUB AND GROUNDCOVER PLANTING

04 OPEN TURF AREA

05 DRAINAGE BASIN FOR STORMWATER CATCHMENT TO BE FULLY VEGETATED WITH SUITABLE INDIGENOUS TREE AND SHRUB SPECIES

06 SEATING NODE

07 LARGE BOULDER STEPPERS ACROSS SWALE

08 STEP ACCESS TO POS

09 SMALL PLAYGROUND

10 SHELTER WITH SEATING FACILITIES

11 SMALL NATURE PLAYGROUND

12 RETAINING WALL

13 PEDESTRIAN FOOTPATH CONNECTING INTO ESTATE NETWORK

14 DRAINAGE SWALE WITHIN MEDIAN ISLAND

15 OPEN IRRIGATED TURF TO CORNER TO PROMOTE VIEW INTO POS

16 DUAL USE PATH CONNECTING INTO ESTATE NETWORK

17 EXISTING TREES TO BE RETAINED

18 PROPOSED NEW STREET TREES

19 PROPOSED POS TREE PLANTING

20 BOARDWALK CONNECTION ACROSS SWALE



LOCATION MAP

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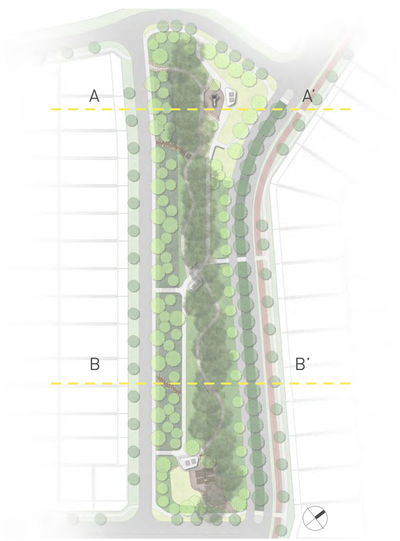
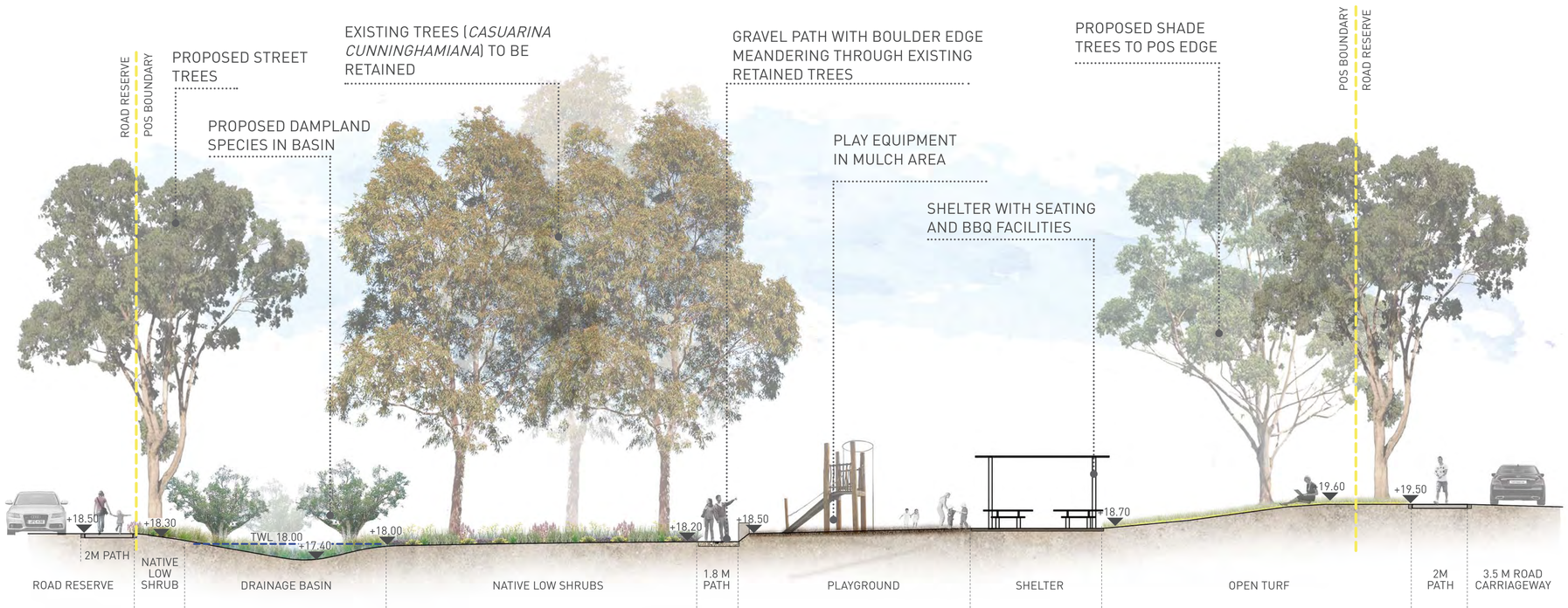
06 | POS J

SECTION A & B



LOCATION MAP



SECTION A-A'



SECTION B-B'

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07 | POS F & POS G & PEEL MAIN DRAIN

LANDSCAPE CONCEPT PLAN



LEGEND

01 INSITU CONCRETE PEDESTRIAN PATH NETWORK TO ACCOMMODATE PEDESTRIAN AND MAINTENANCE ACCESS

02 DUAL USE PATH CONNECTING INTO ESTATE NETWORK

03 OPEN TURF AREA

04 NATIVE LOW SHRUB AND GROUNDCOVER PLANTING

05 EXISTING PEEL MAIN DRAIN CHANNEL - RETAIN EXISTING TREES AND FULLY VEGETATED

06 SHELTER WITH SEATING FACILITIES

07 NATURE PLAYGROUND

08 SEATING NODE

09 EXISTING TREES TO BE RETAINED

PEEL MAIN DRAIN EASEMENT (20.0M WIDE)



LOCATION MAP

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08 | POS F & POS G & PEEL MAIN DRAIN

SECTION A



LOCATION MAP



SECTION A-A'
1:75 @ A1

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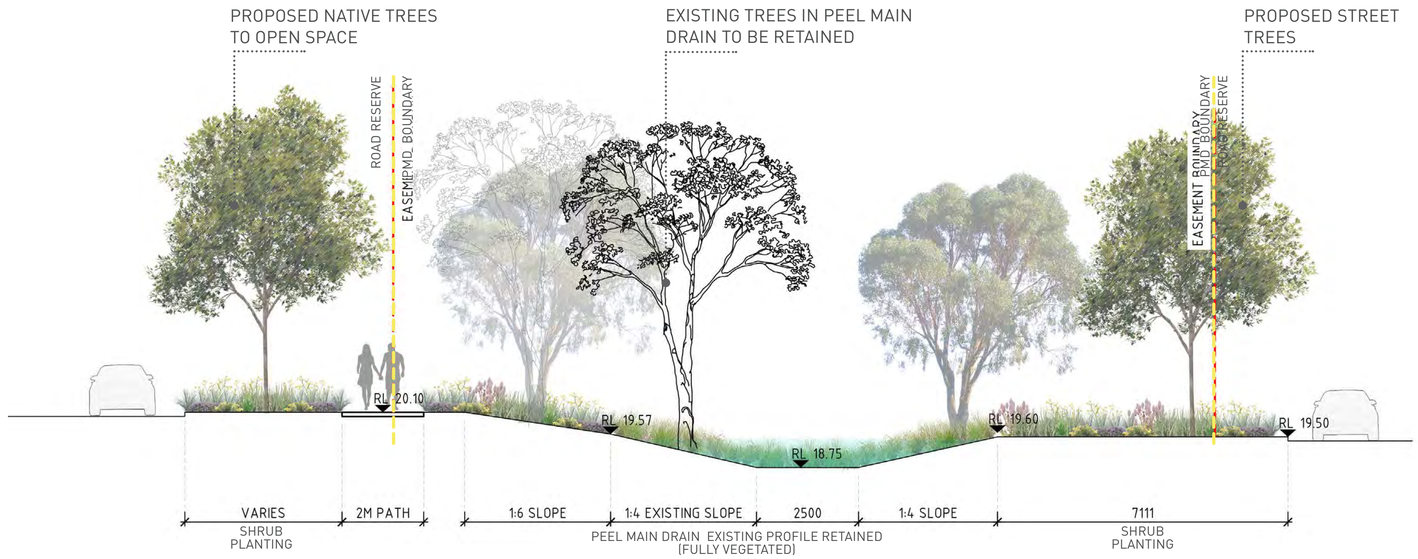
09 | POS F & POS G & PEEL MAIN DRAIN

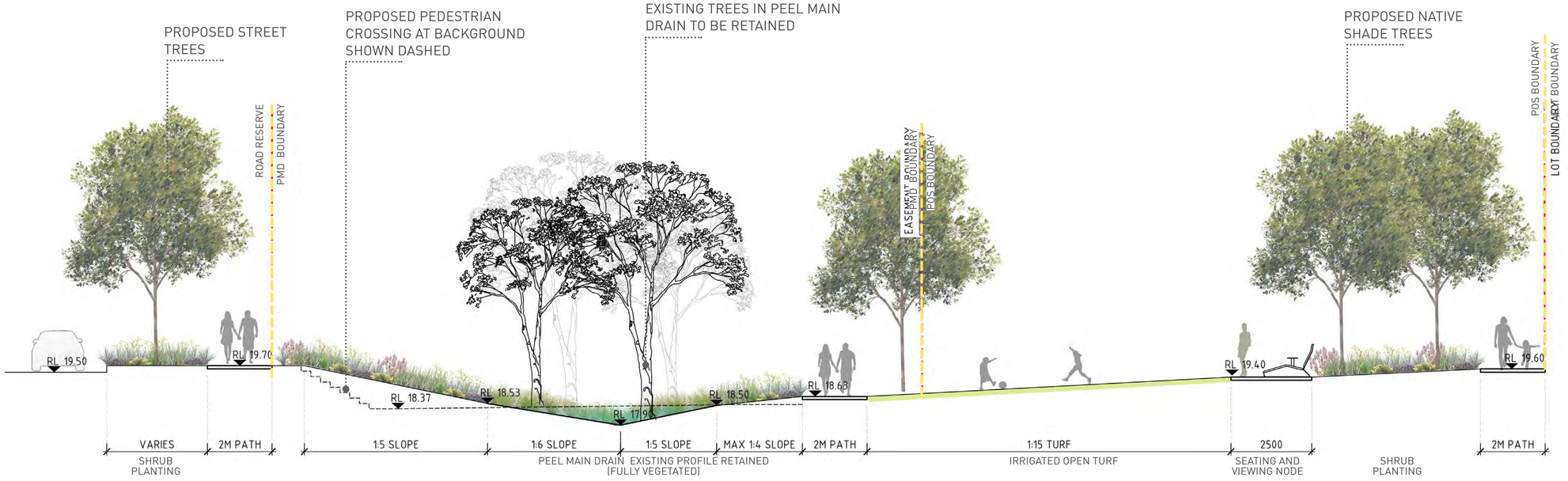
SECTION B & C



LOCATION MAP



SECTION B-B'
1:75 @ A1



SECTION C-C'
1:75 @ A1

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LANDSCAPE CONCEPT PLAN
JUNE 2025

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POS K & WESTERN POWER EASEMENT SOUTH

PROPOSED TREATMENT CONCEPT PLAN





LEGEND

01 PROPOSED SHRUBLAND PLANTING (<1M MATURE HEIGHT TO COMPLY WITH WP CRITERIA, NOTING THE 17M APZ ALLOWS FOR SHRUBS UP TO 2.0M HEIGHT).

02 SHARED USE PATH

03 CRUSHED COMPACTED LIMESTONE SURFACE WITH SCATTERED POCKETS OF LOW PLANTING TO COMPLY WITH APZ CRITERIA

04 DRAINAGE BASIN

05 LIMESTONE PITCHING ON BATTERS

06 POWER LINE PYLONS

07 PROPOSED POS H, REFER TO M1.102

08 PROPOSED POS K

09 PROPOSED SHRUBLAND PLANTING (<1M MATURE HEIGHT TO COMPLY WITH WP CRITERIA, NOTING 22M APZ ALLOWS FOR SHRUBS UP TO 6.0M HEIGHT)

10 PROPOSED GRASSLAND SEDGES AND RUSHES OUTSIDE 12M APZ (<1M MATURE HEIGHT TO COMPLY WITH WP CRITERIA)

11 PROPOSED GRASSLAND SEDGES AND RUSHES IN THIS SECTION OF PEEL MAIN DRAIN, TO EXTEND 13M BEYOND THE CORNERS OF THE RESIDENTIAL LOT BOUNDARIES ON EITHER SIDE OF PMD

BATTER BOUNDARY

APZ LINE

PEEL MAIN DRAIN

D D SECTIONS



LOCATION MAP

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LANDSCAPE CONCEPT PLAN
JUNE 2025

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M1.110
REV G

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11 | POS K & WESTERN POWER EASEMENT SOUTH

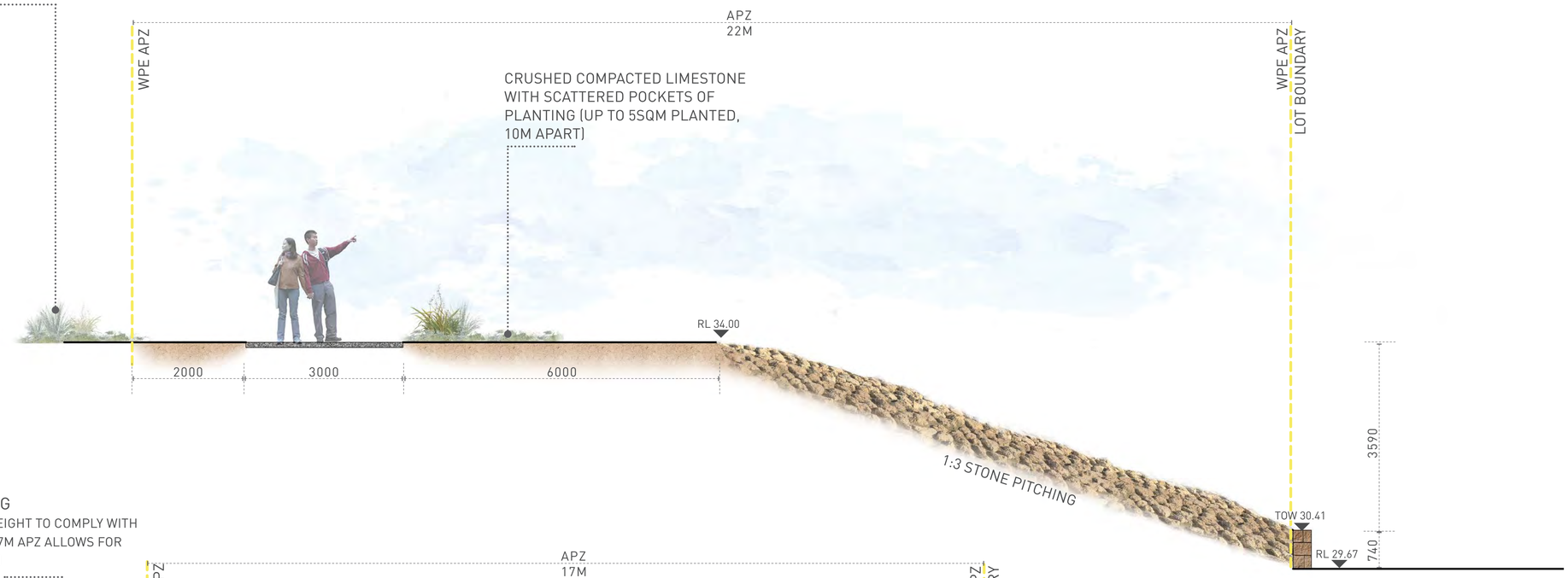
SECTION A & B



LOCATION MAP

SHRUBLAND PLANTING
(LESS THAN 1.0M HEIGHT TO COMPLY WITH WP CRITERUA, NOTING THE 22M APZ ALLOWS FOR SHRUBS UP TO 6M HEIGHT)

SECTION A-A'



SHRUBLAND PLANTING
(LESS THAN 1.0M MATURE HEIGHT TO COMPLY WITH WP CRITERIA, NOTING THE 17M APZ ALLOWS FOR SHRUBS UP TO 2.0M HEIGHT)

SECTION B-B'



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SECTIONS
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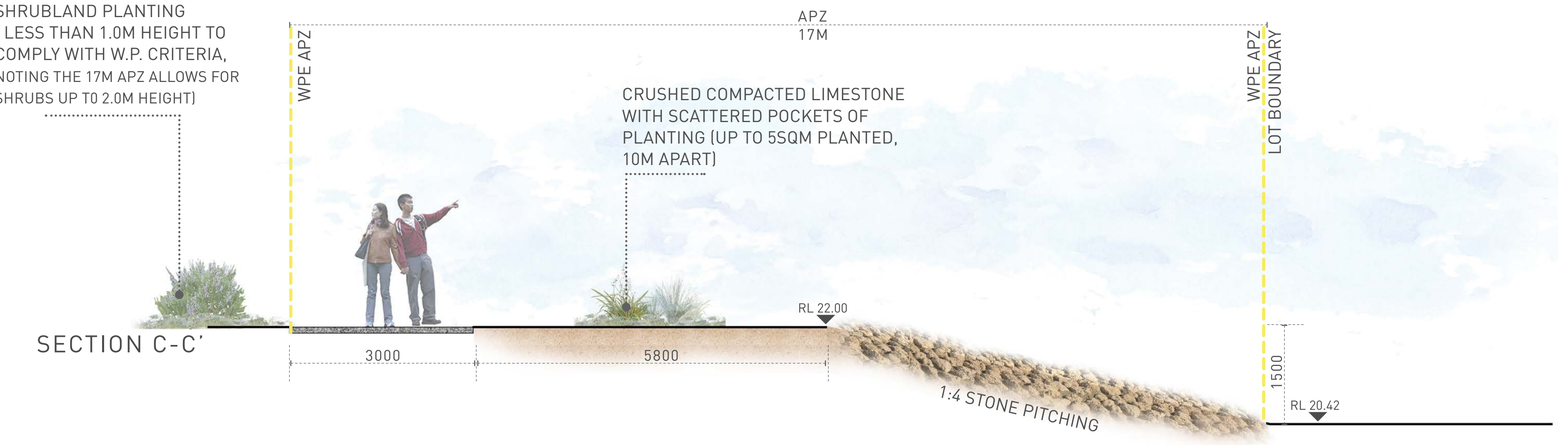
POS K & WESTERN POWER EASEMENT SOUTH

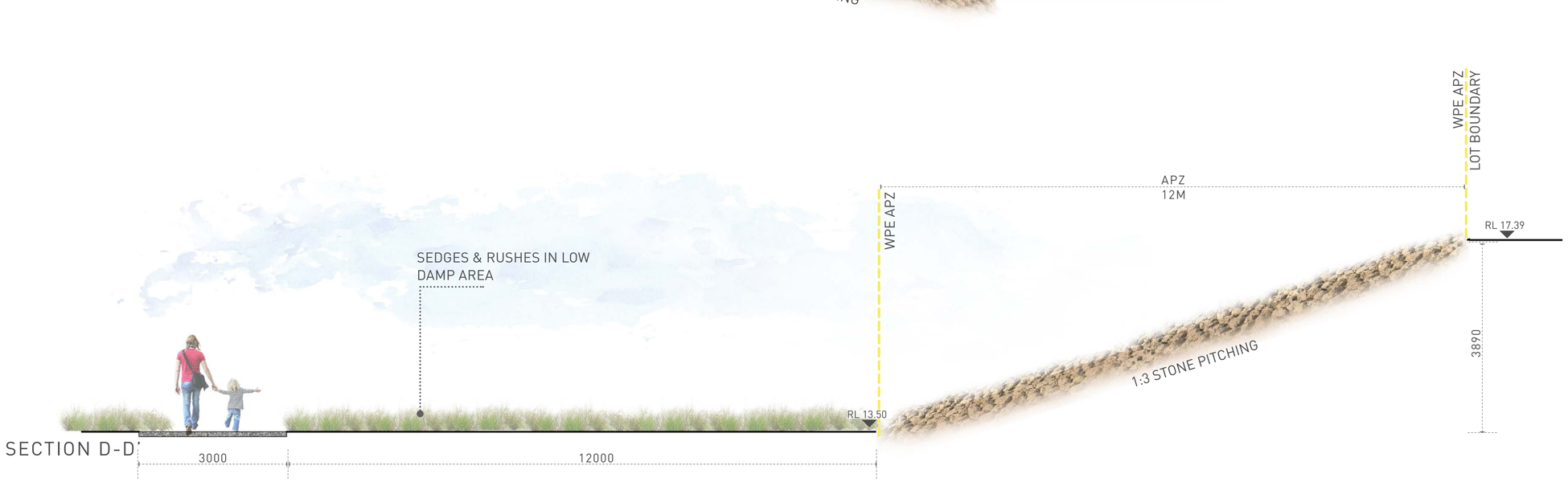
SECTION C, D & E



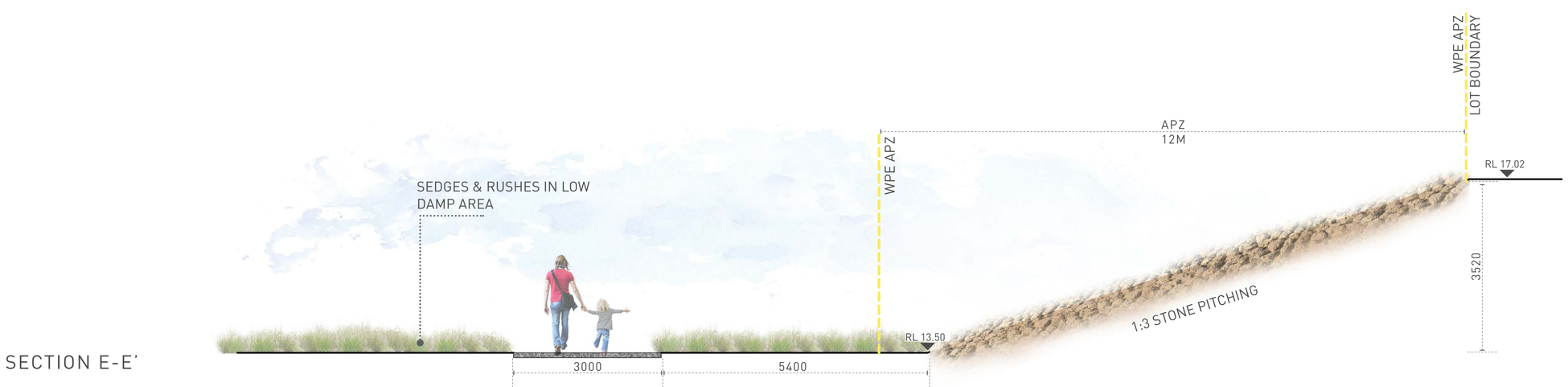
LOCATION MAP



SECTION C-C'



SECTION D-D'



SECTION E-E'

APSLEY ESTATE

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SECTIONS
JUNE 2025

JOB NO. 1403302
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PLAN E

LANDSCAPE ARCHITECTS

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Appendix B Pre-development vegetation plot photos and descriptions

Plot 1	
Vegetation classification	Class A Forest
Description / justification	Trees 10-30 m high at maturity, dominated by Eucalypts, multi-tiered structure comprising tall canopy layer, shrubby middle layer and grass/herb/sedge understorey



Photo ID: 1a



Photo ID: 1b

Plot 2	
Vegetation classification	Class B Woodland (Flat/upslope)
Description / justification	Trees 2-30 m at maturity, dominated by trees with a grassy understorey (lacks shrubby middle layer and deep surface litter)



Photo ID: 2a



Photo ID: 2b



Photo ID: 2c



Photo ID: 2d



Photo ID: 2e



Photo ID: 2f

Plot 3	
Vegetation classification	Class B Woodland (Downslope >0–5°)
Description / justification	Trees 2-30 m at maturity, dominated by trees with a grassy understorey (lacks shrubby middle layer and deep surface litter)



Photo ID: 3a



Photo ID: 3b



Photo ID: 3c

Plot 4	
Vegetation classification	Class D Scrub (Flat/upslope)
Description / justification	Vegetation with a continuous horizontal and vertical structure, greater than 2 m high at maturity



Photo ID: 4a



Photo ID: 4b



Photo ID: 4c



Photo ID: 4e



Photo ID: 4f

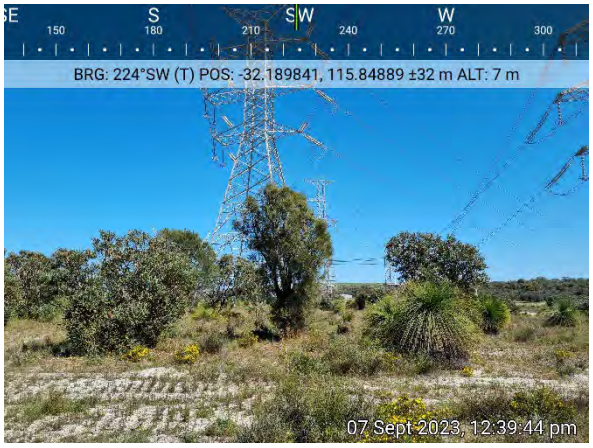


Photo ID: 4g

Plot 4	
 **Photo ID:** 4h	

Plot 5	
Vegetation classification	Class D Scrub (Downslope >0–5°)
Description / justification	Vegetation with a continuous horizontal and vertical structure, greater than 2 m high at maturity



Photo ID: 5a

Plot 6	
Vegetation classification	Class C Shrubland
Description / justification	Shrub vegetation less than 2 m high at maturity



Photo ID: 6a (in foreground)

Plot 7	
Vegetation classification	Class G Grassland (Flat/upslope)
Description / justification	Grassland greater than 100 mm in height



Photo ID: 7a



Photo ID: 7b



Photo ID: 7c



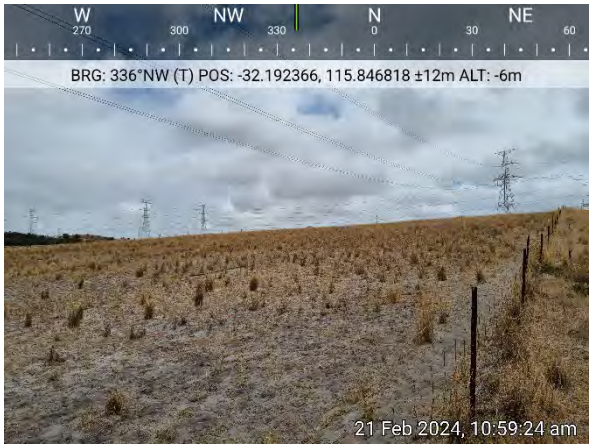
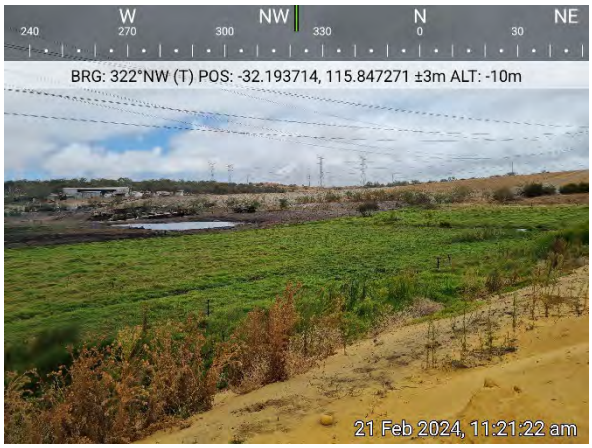
Photo ID: 7d



Photo ID: 7e



Photo ID: 7f

Plot 7	
 **Photo ID:** 7g	 **Photo ID:** 7i
 **Photo ID:** 7j	 **Photo ID:** 7k
 **Photo ID:** 7l	 **Photo ID:** 7m

Plot 8	
Vegetation classification	Class G Grassland (Downslope >5–10°)
Description / justification	Grassland greater than 100 mm in height



Photo ID: 8a

Plot 9	
Vegetation classification	Excluded – Non-vegetated and Low threat (Clause 2.2.3.2 [e] and [f])
Description / justification	Existing non-vegetated land/low threat managed areas including buildings, infrastructure, roads, access tracks, low threat staging buffers, earthworked land, urban street verges, etc



Photo ID: 9a



Photo ID: 9b



Photo ID: 9c



Photo ID: 9d



Photo ID: 9e

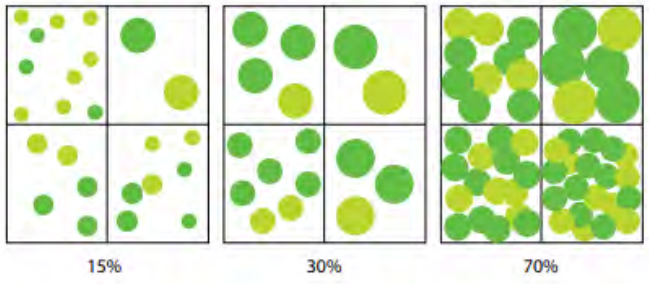


Photo ID: 9f

Plot 9	
 **Photo ID:** 9g	 **Photo ID:** 9h
 **Photo ID:** 9i	 **Photo ID:** 9j
 **Photo ID:** 9k	 **Photo ID:** 9l

Plot 9	
 **Photo ID:** 9m	 **Photo ID:** 9n
 **Photo ID:** 9o	

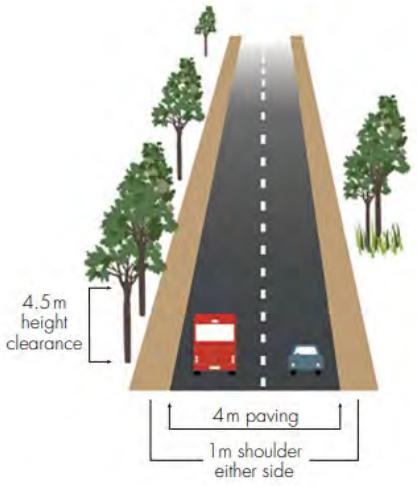
Appendix C APZ Standards (Schedule 1 of the Guidelines)

Schedule 1: Standards for Asset Protection Zones	
Object	**Requirement**
Fences within the APZ	Should be constructed from non-combustible materials (for example, iron, brick, limestone, metal post and wire, or bushfire-resisting timber referenced in Appendix F of AS 3959).
Fine fuel load (Combustible, dead vegetation matter <6 millimetres in thickness)	Should be managed and removed on a regular basis to maintain a low threat state. Should be maintained at <2 tonnes per hectare (on average). Mulches should be non-combustible such as stone, gravel or crushed mineral earth or wood mulch >6 millimetres in thickness.
Trees* (>6 metres in height)	Trunks at maturity should be a minimum distance of six metres from all elevations of the building. Branches at maturity should not touch or overhang a building or powerline. Lower branches and loose bark should be removed to a height of two metres above the ground and/or surface vegetation. Canopy cover within the APZ should be <15 per cent of the total APZ area. Tree canopies at maturity should be at least five metres apart to avoid forming a continuous canopy. Stands of existing mature trees with interlocking canopies may be treated as an individual canopy provided that the total canopy cover within the APZ will not exceed 15 per cent and are not connected to the tree canopy outside the APZ. **Figure 19:** Tree canopy cover – ranging from 15 to 70 per cent at maturity 
Shrub* and scrub* (0.5 metres to six metres in height). Shrub and scrub >6 metres in height are to be treated as trees.	Should not be located under trees or within three metres of buildings. Should not be planted in clumps >5 square metres in area. Clumps should be separated from each other and any exposed window or door by at least 10 metres.
Ground covers* (<0.5 metres in height. Ground covers >0.5 metres in height are to be treated as shrubs)	Can be planted under trees but must be maintained to remove dead plant material, as prescribed in 'Fine fuel load' above. Can be located within two metres of a structure, but three metres from windows or doors if >100 millimetres in height.
Grass	Grass should be maintained at a height of 100 millimetres or less, at all times. Wherever possible, perennial grasses should be used and well-hydrated with regular application of wetting agents and efficient irrigation.

Schedule 1: Standards for Asset Protection Zones	
Defendable space	Within three metres of each wall or supporting post of a habitable building, the area is kept free from vegetation, but can include ground covers, grass and non-combustible mulches as prescribed above.
LP Gas Cylinders	Should be located on the side of a building furthest from the likely direction of a bushfire or on the side of a building where surrounding classified vegetation is upslope, at least one metre from vulnerable parts of a building. The pressure relief valve should point away from the house. No flammable material within six metres from the front of the valve. Must sit on a firm, level and non-combustible base and be secured to a solid structure.

Source: *Guidelines for Planning in Bushfire Prone Areas (WAPC 2021)*

Appendix D Vehicular access technical standards of the Guidelines

Acceptable Solution A3.1 – Public Roads
Explanatory Note E3.1
These Guidelines do not prescribe values for the trafficable (carriageway/pavement) width of public roads as they should be in accordance with the class of road as specified in the IPWEA Subdivision Guidelines, Liveable Neighbourhoods, Austroad Standards and/or any applicable standard in the local government area. The IPWEA Subdivision Guidelines, Liveable Neighbourhoods, Austroad Standards do not prescribe a horizontal clearance. However, it is recommended that a traversable verge is provided to allow for emergency services vehicles to stop and operate on the side of the public road, specifically where the public road may traverse large areas of classified vegetation. Where local government roads are proposed to be widened by the proponent, they must obtain approval from the local government.  Figure 20: Example of a public road
Source: *Guidelines for Planning in Bushfire Prone Areas (WAPC 2021)*

Acceptable Solution A3.2a – Multiple access routes

Explanatory Note E3.2a

Two-way public road access is public road access from a lot in at least two different directions to two suitable destinations, and provides residents and the community, as well as emergency services, with access and egress from both the subdivision and individual habitable buildings/development in the event of a bushfire emergency. A single road provides no alternative route if the access becomes congested or is unable to be traversed due to smoke and/or fallen trees during a bushfire.

Two-way public road access applies to access/egress routes leading into a subdivision, as well as those within a subdivision. A road that loops back onto itself does not constitute the option of two different directions.

Two-way public road access should always be the first option. Where the site is not able to achieve two-way access within 200 metres of the lot boundary, due to demonstrated site or environmental constraints, the proponent should identify options for an emergency access way from the subject site to a suitable destination. Where an emergency access way cannot be provided, the proponent should demonstrate compliance with the performance principle.

Subject sites or proposed lots greater than 200 metres from an intersection, which provides two-way access, do not satisfy the requirement for two-way access unless they meet the provisions which allow for no-through roads greater than 200 metres in A3.2a.

To demonstrate compliance with the performance principle for two-way access, the bushfire planning practitioner may have regard to:

a. the extent of the bushfire hazard, location and vegetation classification, the likelihood, potential severity and impact of bushfire to the subject site and the road network;
b. time between fire detection and the onset of conditions in comparison to travel time for the community to evacuate to a suitable destination;
c. available access route(s) travelling towards a suitable destination; and
d. turn-around area for a fire appliance for no-through roads.



Figure 21: Example of compliant and non-compliant two-way

Source: *Guidelines for Planning in Bushfire Prone Areas (WAPC 2021)*

Acceptable Solution A3.2b – Emergency access way

Explanatory Note E3.2b

An emergency access way is not a preferred alternative to through public road access and should only be considered acceptable where it has been demonstrated that it will provide the safety and performance needs of emergency services and the community, including consideration for future needs, and that public road access to satisfy A3.2a cannot be achieved due to site constraints, such as an established road network with no opportunity to provide a public road for secondary access. Acceptance of an emergency access way should also consider the ability to accommodate reasonable worst-case vehicle volumes.

The principle function of the emergency access way is to provide a contingency (second) community evacuation route and simultaneously provide access for emergency services, in the event of a bushfire emergency. Where an emergency access way traverses classified vegetation, which has the potential to create a bushfire hazard, an emergency access way performs the secondary function of providing access by emergency services to this vegetation.

Emergency access ways should connect to a public road to allow alternative two-way through access. An emergency access way should not exceed 500 metres in length as they may not be as safe for road-use due to not being designed or constructed to the full requirements of a public road and may present uncertainties to emergency service personnel and the public as they are not part of the daily road network and not identified on Maps.

Permanent public emergency access way

An emergency access way can be provided as either a public easement in gross or a right-of-way. In both approaches, the management of the emergency access way is by the local government as the grantee of the easement or management body of the right-of-way. The proponent must obtain written consent from the local government that the local government will accept care, control and management of the easement or right-of-way; this must be provided to the decision-maker prior to granting planning approval. The approach taken is at the discretion of the decision-maker and/ or the local government and is also dependent on whether the land is to remain in private ownership or be ceded to the Crown. Consultation with Land Use Management at the Department of Planning, Lands and Heritage should also be considered if the land is to be ceded to the Crown or if the local government is uncertain of which approach to take.

If the emergency access way is provided as an easement, it should be provided as a public easement in gross under sections 195 and 196 of the Land Administration Act 1997 in favour of the local government and/or public authority, to ensure accessibility for emergency services and the public at all times. To be provided as a right-of-way the emergency access way should be vested in the Crown under section 152 of the Planning and Development Act 2005 as a right-of-way and such land to be ceded free of cost and without any payment or compensation by the Crown. If gates are used to control traffic flow during non-emergency periods, these will be managed by the local government and must not be locked. Gates should be double gates wide enough to access the full pavement width and accommodate Type 3.4 fire appliances with the design and construction to be approved by the relevant local government.

Temporary public emergency access way

A temporary emergency access way may be proposed to facilitate the staging arrangements of a subdivision. The provision of two public roads may not be possible in the first stage of the subdivision and an emergency access way can be provided as an interim access route until the second public road is developed and gazetted in a subsequent stage of the subdivision (see figure 22). The emergency access way should be provided in the same manner as a permanent emergency access way, but it should be removed from the certificate of title once the public road is developed and gazetted. Where an emergency access way is proposed as an alternative to a public road, the Bushfire Management Plan should provide thorough justification for its use.

Restricted public emergency access way

There may be some instances where a restricted emergency access way is proposed as a performance principle based solution where access is only available to the public in the event of a bushfire emergency. This option can only be considered where the local government or Main Roads WA have advised that vehicular access on the emergency access way is not allowed during non-emergency periods, as it provides an additional thoroughfare and entry point on a local or State road. In this scenario, the emergency access way can be

provided as an easement under section 195 of the Land Administration Act 1997, as public access in the event of a bushfire emergency or vested in the Crown as a reserve under section 152 of the Planning and Development Act 2005. Such land is to be ceded free of cost without any payment or compensation by the Crown. The proponent must obtain written consent from the local government that the local government will accept care, control and management of the proposed reserve and agree to the terms of the Management Order Conditions (if applicable); this must be provided to the decision-maker prior to granting planning approval.

The purpose of the reserve should be for a public purpose specified in the condition related to the subdivision, for example for emergency access only, or for emergency access and recreation. A reserve for emergency access and recreation can optimise the land-use as a dual purpose where it provides vehicular access in the event of a bushfire emergency, but can be accessed by the public (on foot) on a day-to-day basis as a recreation link. Appropriate signage can ensure the general public is aware of the purpose of the reserve. The approach taken is at the discretion of the decision-maker and/or local government.

Right-of-carriageway emergency access way

There may be some instances where a right-of-carriageway easement is proposed as a performance principle-based solution. This may be where particular landowner(s) and emergency services, but not the public, require access over a neighbouring lot(s). A right-of-carriageway easement should be provided under section 195 of the Land Administration Act 1997. The easement is to provide alternative access for the particular landowner(s) in the event of a bushfire emergency and not for use by the public. In this scenario, support will be necessary from the adjoining lot owner(s). The easement is to be granted to the local government and it is to agree with the landowner on the arrangements of the management of the easement area by deed. These management arrangements will be at the discretion of the local government. If gated, the easement area can be locked to restrict day-to-day vehicular access.

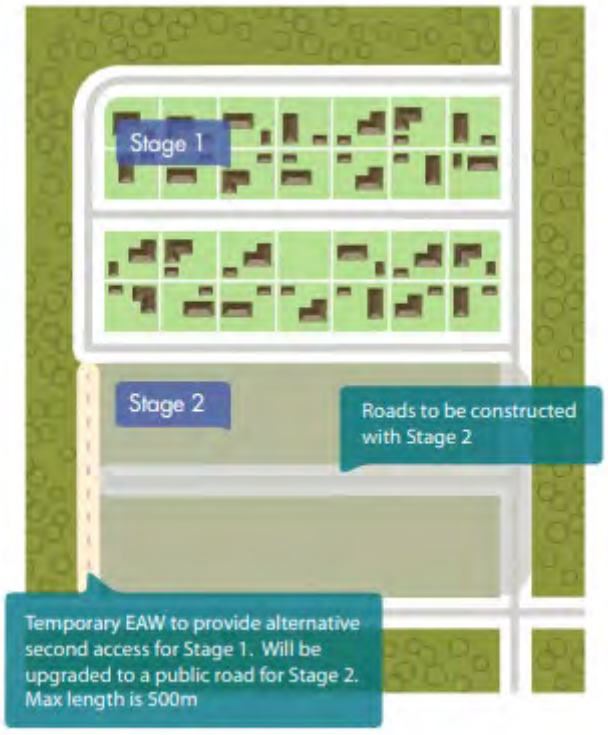


Figure 22: Example of an emergency access way

Source: *Guidelines for Planning in Bushfire Prone Areas (WAPC 2021)*

Acceptable Solution A3.3 – Through roads

Explanatory Note E3.3

In bushfire prone areas, a proposed structure plan or subdivision that incorporates no-through roads should be avoided because they do not provide a connected and legible design that allows for easy access and egress by the community, residents and emergency services in the event of a bushfire. No-through roads also reduce the options available for access and egress in the event of a bushfire emergency.

There will however be situations where a subject site is accessed via an existing or proposed no-through road and alternative access cannot be provided. In these situations, the proponent should demonstrate to the decision-maker, that all efforts have been made with the local government and/or adjoining landowners to secure alternative public road access or an emergency access way and that a redesign has been explored. The bushfire planning practitioner may need to develop a performance principle-based solution or address the non-compliance and demonstrate to the decisionmaker why discretion should be exercised in accordance with section 2.6 of these Guidelines.

No-through roads will only be considered an acceptable solution where it is demonstrated by the proponent, to the satisfaction of the decision maker, that a no through-road cannot be avoided due to site constraints. For example, the internal road design of a structure plan or subdivision where site constraints, such as a water body or Bush Forever, prevent the ability to create a through-road and a no through road may be a more appropriate road layout.

No-through roads should be a maximum of 200 metres from the lot(s) boundary to an intersection where two-way access is provided and may only exceed 200 metres if it meets the provisions which allow for no-through roads greater than 200 metres in A3.2a.

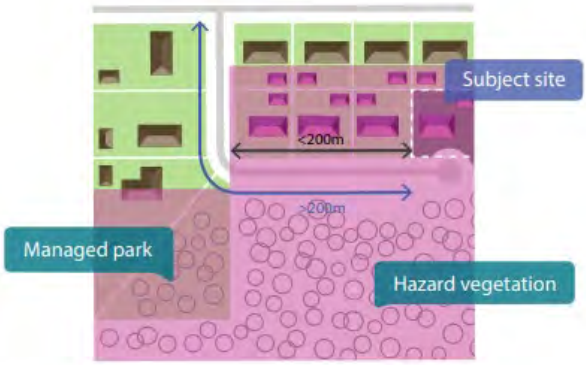


Figure 23: Example of a site on a no-through road greater than 200 metres from the intersection, but within 200 metres of BAL-LOW

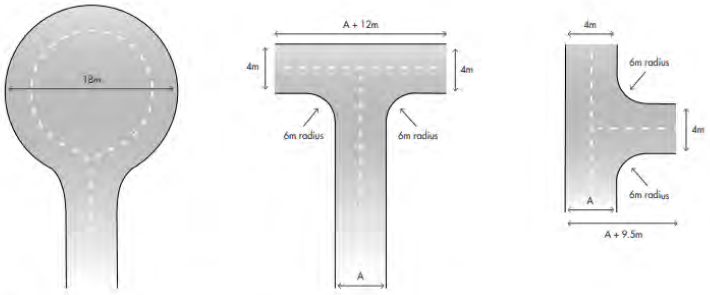


Figure 24: Turn-around area dimensions for a no-through road

Source: *Guidelines for Planning in Bushfire Prone Areas (WAPC 2021)*

Acceptable Solution A3.4a – Perimeter roads

Explanatory Note E3.4a

Where a planning proposal includes the creation of 10 or more lots adjacent to each other, which adjoin classified vegetation under AS 3959 with the exception of Class G Grassland, as part of a greenfield development or large urban infill site, hazard separation and defendable space should be provided in the form of a perimeter road. Greenfield is 'undeveloped or minimally developed areas that have been identified for urban development'; and urban infill is 'the redevelopment of existing urban areas at a higher density than currently exists'. The creation of 10 or more lots includes cumulative subdivision applications where the subdivision application may be part of a staged subdivision.

A perimeter road should be in accordance with the class of road as specified in the IPWEA Subdivision Guidelines, Liveable Neighbourhoods, Austroad Standards and/or any applicable standard in the local government area as per the requirements of a public road in Table 6, Column 1.

As the road is likely to function as a key neighbourhood distributor, or similar, consideration should be given to the provision of additional width to allow for emergency services vehicles to stop and operate on the side of the perimeter road, whilst simultaneously proving for the evacuation of the community (Figure 20).

When designing a strategic planning proposal and/or subdivision, creating a large setback between classified vegetation and proposed lots with a perimeter road, and orientating habitable buildings to front onto (rather than back onto) areas of vegetation has many benefits, including:

- passive surveillance;
- defendable space for firefighting and emergency management purposes;
- reducing the potential radiant heat that may impact a habitable building in a bushfire event;
- reducing the need for battle-axe lots; and
- unconstrained public access/egress for the community in the event of a bushfire.

In developments where no perimeter road exists, property defence in a bushfire event is difficult and can be impossible. Where proposed lots have frontage to an existing public road and abut the hazard at the rear or side, it may be an undesirable planning outcome to create lots which front the existing public road and back onto a perimeter road. In this instance, consideration should be given to a fire service access route. Refer to E3.4b below.



Figure 25: Example of a perimeter road

Source: *Guidelines for Planning in Bushfire Prone Areas (WAPC 2021)*

Acceptable Solution A3.4b – Fire service access route

Explanatory Note E3.4b

Where a subdivision adjoins classified vegetation and where A3.2a has been satisfied, hazard separation and defendable space across multiple lots may be required in the form of a fire service access route.

A fire service access route is not intended to provide residents and the general public with emergency egress and therefore is not a suitable second access or substitute for a public road. A fire service access route is to provide access for emergency services to classified vegetation for firefighting and fire management purposes.

A fire service access route can be provided as either an easement in gross over private or Crown land, or ceded to the Crown as a reserve. In both approaches, the management of the fire service access route is by the local government as the grantee of the easement or management body of the reserve. Determining which approach to take is dependent on what the intended tenure of the fire service access route is, which is explained further below. The proponent must obtain written consent from the local government that the local government will accept care, control and management of the easement or reserve and agree to the terms of the Management Order Conditions (if applicable); this must be provided to the decision-maker prior to granting planning approval. The approach taken is at the discretion of the decision-maker and/or the local government. Consultation with Land Use Management at the Department of Planning, Lands and Heritage should also be considered if the land is to be ceded to the Crown or if the local government is uncertain of which approach to take.



Figure 26: Example of a fire service access route

Where gates are used, these should be double gates wide enough to access the full required horizontal clearance and accommodate type 3.4 fire appliances with the design and construction to be approved by the relevant local government. Gates on fire service access routes may be locked to restrict access, provided a common key system is used, and such keys are made available for emergency services and designated fire officers within the local government area and/or surrounding district. Gates should be installed where fences cross fire service access routes. If an easement in gross is proposed, such arrangements for gates should be included in the deed of easement and be agreed to by the local government.

Fire service access route to remain in private ownership of multiple landowners

Where a fire service access route is proposed to traverse multiple private lots and they are intended to remain in the private ownership of the multiple landowners, it should be provided as an easement in gross under section 196 of the Land Administration Act 1997, to ensure accessibility for fire emergency services and not for use by the public. The easement is to be granted to the local government and/or public authority for firefighting and emergency management purposes.

Fire service access route to be created under State ownership

Where a fire service access route is proposed to traverse multiple private lots, but the decision-maker and/or local government prefer for the fire service access route to remain in one ownership under the State for management purposes, the fire service access route can be vested in the Crown under section 152 of the Planning and Development

Acceptable Solution A3.4b – Fire service access route
Explanatory Note E3.4b
Act 2005 as a reserve, such land to be ceded free of cost without any payment or compensation by the Crown. The purpose of the reserve should be for a public purpose specified in the condition related to the subdivision, for example for vehicular access for emergency services and the local government only, or for vehicular access for emergency services and the local government and recreation. A reserve for emergency services access and recreation can optimise the land-use as a dual purpose, where it provides vehicular access for emergency services, but can be accessed by the public (on foot) on a day-to-day basis as a recreation link. Appropriate signage will ensure the general public is aware of the purpose of the reserve. The approach taken is at the discretion of the decision-maker and/or local government.

Source: *Guidelines for Planning in Bushfire Prone Areas (WAPC 2021)*

Technical requirement	1	2	3	4
	Public road	Emergency access way[1]	Fire service access route[1]	Battle-axe and private driveways[2]
Minimum trafficable surface (m)	In accordance with A3.1	6	6	4
Minimum horizontal clearance (m)	N/A	6	6	6
Minimum vertical clearance (m)	4.5	4.5	4.5	4.5
Minimum weight capacity (t)	15	15	15	15
Maximum grade unsealed road[3]	As outlined in the IPWEA Subdivision Guidelines	1:10 (10%, 6°)	1:10 (10%, 6°)	1:10 (10%, 6°)
Maximum grade sealed road[3]		1:7 (14.3%, 8°)	1:7 (14.3%, 8°)	1:7 (14.3%, 8°)
Maximum average grade sealed road		1:10 (10%, 6°)	1:10 (10%, 6°)	1:10 (10%, 6°)
Minimum inner radius of road curves (m)		8.5	8.5	8.5

[1] To have crossfalls between 3 and 6%

[2] Where driveways and battle-axe legs are not required to comply with the widths in A3.5 or A3.6, they are to comply with the Residential Design Codes and Development Control Policy 2.2 Residential Subdivision

[3] Dips must have no more than a 1 in 8 (12.5% -7.1 degree) entry and exit angle.

Appendix E City of Kwinana annual firebreak notice

FIRST AND FINAL NOTICE

FIRE HAZARD COMPLIANCE NOTICE 2024/2025

COMPLIANCE DUE BY

1 December 2024

INSPECTIONS COMMENCE FROM

1 December 2024

Important The works outlined below **must** be completed by 1 December 2024 and maintained up to and including 31 May 2025, unless otherwise stated in this notice.

Notice to all landowners within the City of Kwinana

This Fire-Break/Hazard Compliance Notice is issued by the City of Kwinana pursuant to *Section 33 of the* ***Bush Fires Act 1954*** to assist with the prevention, control and extinguishment of bush fires or to prevent the spread or extension of a bush fire to any adjoining land.

All property owners and/or occupiers of land within the City of Kwinana are hereby served with a first and final Fire-Break/ Hazard Compliance Notice (the Notice) and are required to comply with the requirements in full.

Failure or neglect to comply with this notice is an offence and may result in a penalty of up to $5,000.

The table below outlines the requirements of landowners and/or occupiers in the City of Kwinana. Please refer to the column that best describes your land size to view your legal responsibilities.

Land with a total area of:	3,501m² (0.35ha) or greater	1,501m² (0.15ha) up to 3,500m² (0.35ha)	Less than 1,500m² (0.15ha)
Fire Breaks Install and maintain mineral earth fire breaks as per the specifications defined below.	✓		
Asset Protection Zone Maintain a reduced fuel zone around all habitable buildings which extends twenty (20) metres as per the specifications below.	✓		
Defendable Space Within three (3) metres of all walls or supporting posts of a habitable building, the area is kept free from vegetation including overhanging branches within three (3) metres of any habitable building.		✓	
Flammable Ground Fuel • Reduce and/or maintain all Dead Flammable Material (DFM) on the ground across the entire property to a "fuel load" of below eight (8) tonnes per hectare. See definition below. • Ensure that all long grass and weeds are slashed, mowed or trimmed down to a height no greater than 50mm across your entire property. (Compliance required year-round)		✓	✓
Driveways Ensure driveways and access ways to all buildings are maintained at a minimum of three (3) metres in width and a vertical clearance height of four (4) metres to allow emergency vehicle access.	✓	✓	✓
Flammable Material Gutters, roofs, and walls of all buildings to be free of flammable matter and maintained.	✓	✓	✓

Variations to Notice

If it is impractical for you to install a firebreak as specified in this Notice, you may apply to vary the location of your firebreak within your property by completing and submitting an 'Application to Vary Location and Type of Firebreaks' form available on the City's Fire Permits and Burn Offs page.

Submit completed forms to customer@kwinana.wa.gov.au marked for the attention of the Chief Bush Fire Control Officer – no later than 31 October 2024.

Additional Works

Regardless of land size and location, the City or its Bush Fire Control Officers may require additional work to be undertaken on a property to improve access, and/or undertake further works to reduce a hazard that may be conducive to preventing an outbreak and/or the spread or extension of a bush fire.

'**Industrial Zoned**' areas may require additional works as identified by the Bush Fire Control Officer during fire hazard inspections.

Bushfire Management Plan

Where a property is affected by an approved bushfire management plan, the property owner and/or occupier must still comply with all requirements in this notice and with ALL additional requirements outlined within that plan.

Engagement of contractors by owner and/or occupier to carry out works

Any owner and/or occupier who engages a contractor to undertake works on their behalf is responsible for ensuring that such works when completed meet the requirements of this Notice.

Firebreak/fire hazard compliance inspections

To promote community safety and education, property inspections will be carried out by the City's Bush Fire Control Officers to identify non-compliant properties from 1 December 2024.

No burning in areas defined as Urban

Pursuant to section, *24G (2) of the **Bush Fires Act 1954***, no burning of garden refuse is to be undertaken in areas defined as "Urban" without written approval by the City of Kwinana.

Environmental and Heritage Conditions

Any property subject to environmental and heritage value such as, but not limited to, Threatened Ecological Communities (TEC), Bush Forever sites, Declared Rare Flora, and Fauna (DRF) sites and Aboriginal Heritage sites, etc should seek further information about what can or cannot be carried out prior to complying with the requirements under this Notice.

If you do not meet your fire prevention responsibilities as a property owner, you could be liable for a maximum penalty of $5,000 plus costs. The City may also access a property and undertake the required work at the expense of the owner.

For further information, please contact the City of Kwinana, view the included brochure or the City of Kwinana website kwinana.wa.gov.au/fires

Definitions

Firebreak:
A strip of mineral earth land free of all flammable material with the intention of minimising the spread or extension of a bushfire and provide safe access on the property for emergency vehicles and other firefighting operations.

- Clearance must be 3 metres wide and 4 metres in height as close as practically possible, inside and along all boundaries of the perimeter of the land.
- Living green lawn is acceptable in lieu of mineral earth firebreaks, provided that the same width and height requirements for a firebreak are maintained.
- Must have a corner turning radius of up to 10 metres.
- Must be a continuous trafficable surface for a 4WD vehicle and be clear of any obstructions and must not terminate in a dead end.

Asset Protection Zone: Maintain a fuel-reduced zone around all habitable buildings which extends 20 metres (m) from the outermost point of the building.

- Fuel load within the 10m inner zone is reduced and maintained to no more than 2 tonne per hectare. Fuel load within the 10-20m outer zone is reduced and maintained to below 8 tonne per hectare.
- Trees over 5m in height within the 20m zone to be under pruned up to 2m.
- Trees or shrubs within 3m of the asset shall be pruned to a maximum height of 2m and/or pruned to ensure a 2m wide vertical clearance from the asset.

Fuel Load: Can be live and dead vegetation that accumulates over time. This Notice refers only to dead vegetation.

- A fuel load depth of 15mm (fine fuels) to the mineral earth is indicative of approximately 8 tonne per hectare. The more fuel load, the higher the flame height and increased fire intensity.
- Mulch piles, stored firewood and burn piles can contribute to fuel loading on land and must be stored safely away from assets, removed from the property, or actioned as directed by a Fire Control Officer.
- Fine fuels include Leaf litter, grasses, twigs (up to 6mm diameter), bark etc.

Flammable Material: Any bush, plant, tree, grass, vegetation, object, or material that may or is likely to catch fire and burn.

Wayne Jack,
Chief Executive Officer

Administration
Cnr Gilmore Ave & Sulphur Rd, Kwinana WA 6167 | PO Box 21, Kwinana WA 6966
Hours Mon-Fri 8:30am-4:30pm | **Telephone** Mon-Fri 8:00am-5:00pm 08 9439 0200
customer@kwinana.wa.gov.au | **www.kwinana.wa.gov.au**

City of Kwinana

FPA AUSTRALIA | Fire Protection Association Australia | Life. Property. Environment.

BPAD Bushfire Planning & Design

Bushfire Management Plan Coversheet

This Coversheet and accompanying Bushfire Management Plan has been prepared and issued by a person accredited by Fire Protection Association Australia under the Bushfire Planning and Design (BPAD) Accreditation Scheme.

Bushfire Management Plan and Site Details

Site Address / Plan Reference: Lot 682 Rowley Road

Suburb: Mandogalup **State:** WA **P/code:** 6167

Local government area: City of Kwinana

Description of the planning proposal: Local Structure Plan

BMP Plan / Reference Number: QPG13247.01 **Version:** R002 Rev 2 **Date of Issue:** 10/08/2017

Client / Business Name: QUBE Property Group Pty Ltd

Reason for referral to DFES	Yes	No
Has the BAL been calculated by a method other than method 1 as outlined in AS3959 (tick no if AS3959 method 1 has been used to calculate the BAL)?	☐	☒
Have any of the bushfire protection criteria elements been addressed through the use of a performance principle (tick no if only acceptable solutions have been used to address all of the BPC elements)?	☐	☒
Is the proposal any of the following special development types (see SPP 3.7 for definitions)?		
Unavoidable development (in BAL-40 or BAL-FZ)	☐	☒
Strategic planning proposal (including rezoning applications)	☒	☐
Minor development (in BAL-40 or BAL-FZ)	☐	☒
High risk land-use	☐	☒
Vulnerable land-use	☐	☒

If the development is a special development type as listed above, explain why the proposal is considered to be one of the above listed classifications (E.g. considered vulnerable land-use as the development is for accommodation of the elderly, etc.)?

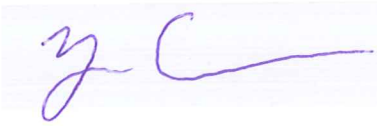
The proposal is a strategic planning proposal (Local Structure Plan)

Note: The decision maker (e.g. local government or the WAPC) should only refer the proposal to DFES for comment if one (or more) of the above answers are ticked "Yes".

BPAD Accredited Practitioner Details and Declaration

Name	Accreditation Level	Accreditation No.	Accreditation Expiry
Zac Cockerill	Level 2	BPAD37803	31/08/2017
Company		**Contact No.**	
Strategen Environmental		9792 4797	

I declare that the information provided within this bushfire management plan is to the best of my knowledge true and correct

Signature of Practitioner  **Date** 10/08/2017



intelligent outcomes | respected experience

Bushfire Management Plan

Lot 682 Rowley Road, Mandogalup

Prepared for
QUBE Property Group Pty Ltd
by Strategen

August 2017

BPAD Bushfire Planning & Design Accredited Practitioner Level 2

strategen ENVIRONMENTAL

Bushfire Management Plan

Lot 682 Rowley Road, Mandogalup

Strategen is a trading name of
Strategen Environmental Consultants Pty Ltd
Level 1, 50 Subiaco Square Road Subiaco WA 6008
ACN: 056 190 419

August 2017

Limitations

Scope of services

This report ("the report") has been prepared by Strategen Environmental Consultants Pty Ltd (Strategen) in accordance with the scope of services set out in the contract, or as otherwise agreed, between the Client and Strategen. In some circumstances, a range of factors such as time, budget, access and/or site disturbance constraints may have limited the scope of services. This report is strictly limited to the matters stated in it and is not to be read as extending, by implication, to any other matter in connection with the matters addressed in it.

Reliance on data

In preparing the report, Strategen has relied upon data and other information provided by the Client and other individuals and organisations, most of which are referred to in the report ("the data"). Except as otherwise expressly stated in the report, Strategen has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report ("conclusions") are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. Strategen has also not attempted to determine whether any material matter has been omitted from the data. Strategen will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to Strategen. The making of any assumption does not imply that Strategen has made any enquiry to verify the correctness of that assumption.

The report is based on conditions encountered and information received at the time of preparation of this report or the time that site investigations were carried out. Strategen disclaims responsibility for any changes that may have occurred after this time. This report and any legal issues arising from it are governed by and construed in accordance with the law of Western Australia as at the date of this report.

Environmental conclusions

Within the limitations imposed by the scope of services, the preparation of this report has been undertaken and performed in a professional manner, in accordance with generally accepted environmental consulting practices. No other warranty, whether express or implied, is made.

Client: QUBE Property Group Pty Ltd

Report Version	Revision No.	Purpose	Strategen author/reviewer	Submitted to Client	
				Form	Date
Draft Report	Rev A	For review by client	Z Cockerill / R Banks	Electronic (email)	29/05/2014
Draft Report	Rev 0	For agency comment	Z Cockerill	Electronic (email)	30/05/2014
Final Draft Report	Rev B	For final review by client	Z Cockerill / R Banks	Electronic (email)	29/09/2016
Final Report	Rev 1	Issued for use: to accompany Structure Plan submission	Z Cockerill (BPAD No. 37803)	Electronic (email)	10/11/2016
Final Report	**Rev 2**	**Issued for use: to accompany Structure Plan submission**	**A Ennis / Z Cockerill (BPAD37803)**	**Electronic (email)**	**10/08/2017**

Filename: QPG13247_01 R002 Rev 2 - 10 August 2017

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1. Introduction

1.1 Background

QUBE Property Group (QPG) is proposing to develop Lot 682 Rowley Road, Mandogalup in the City of Kwinana (heron referred to as the project area). Strategen has prepared a Bushfire Management Plan (BMP) in support of the Mandogalup West Local Structure Plan (MWLSP) prior to subsequent subdivision and development to demonstrate bushfire risk is not a limiting factor to development approval. The MWLSP concept plan is depicted in Figure 1. It should be noted that a Western Power easement (Lot 52) is also included within the MWLSP area.

The majority of the project area is designated as bushfire prone on the WA *Map of Bush Fire Prone Areas* (DFES 2017) due to the extent of on-site and adjacent vegetation. As a result, Strategen has prepared this Bushfire Management Plan (BMP) to inform strategic planning and fulfil the following key objective:

1. Accompany the proposed LSP submission Western Australian Planning Commission (WAPC) in order to meet planning requirements triggered under *State Planning Policy 3.7 Planning in Bushfire-Prone Areas* (SPP 3.7; WAPC 2015).

The following information is required as part of this BMP to address SPP 3.7 Policy Measure 6.3:

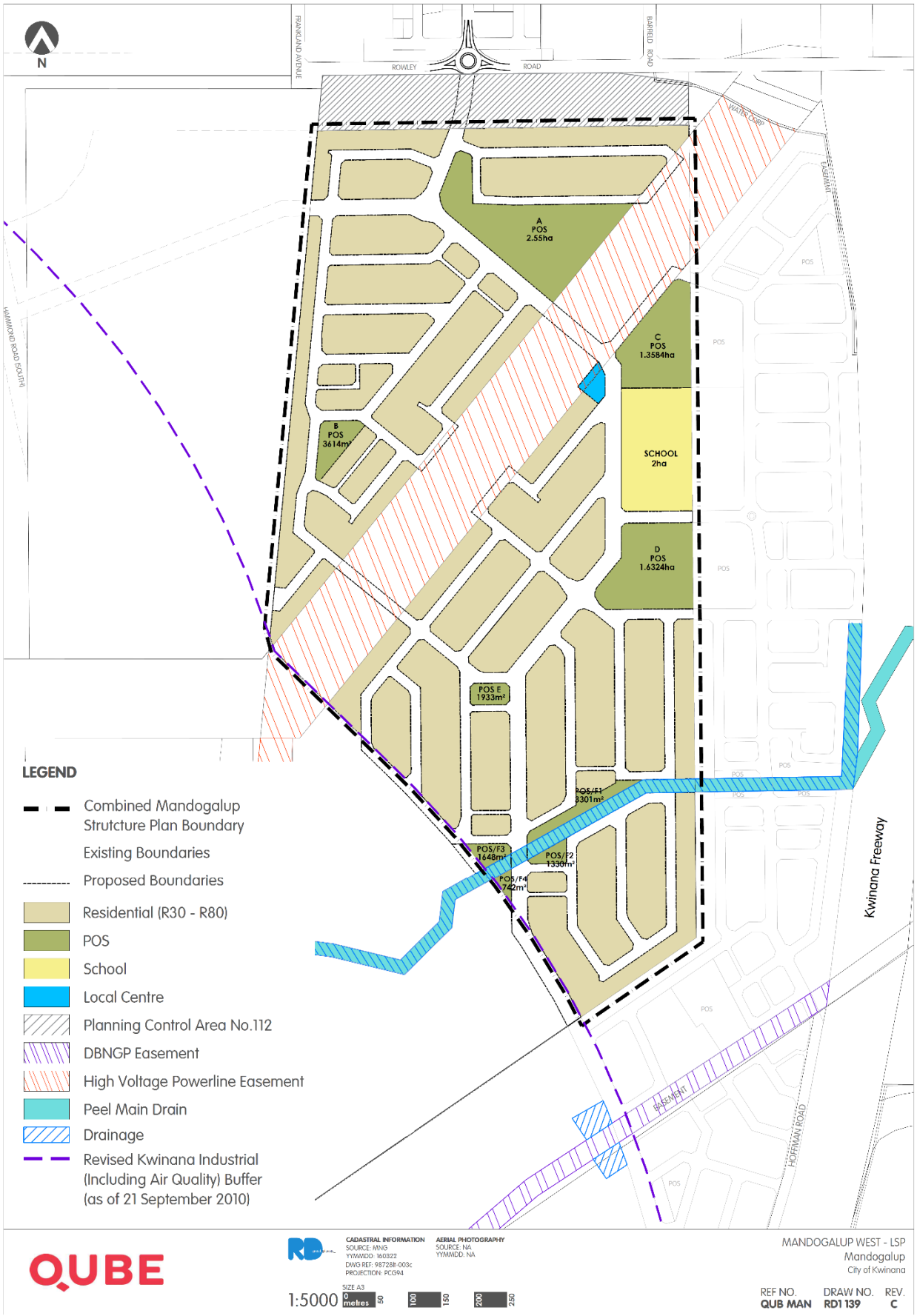
- results of a Bushfire Hazard Level (BHL) assessment determining the applicable hazard level(s) across the subject land in accordance with methodology set out in *Guidelines for Planning in Bushfire-Prone Areas* (the Guidelines; WAPC 2017) – refer to Section 2.3 and Figure 4
- identification of any bushfire hazard issues arising from the relevant assessment – refer to Section 2.4
- clear demonstration that compliance with the bushfire protection criteria in the Guidelines can be achieved in subsequent planning stages – refer to Section 4 and Table 3.

This BMP has been prepared in accordance with the Guidelines and addresses all of the above information requirements to satisfy SPP 3.7 specific to the strategic planning stage for this project.

The project area forms part of the overall Mandogalup LSP area (Appendix 1), which also includes the adjacent Mandogalup East Local Structure Plan (MELSP). Strategen also acts on behalf of Satterley Property Group (SPG) in regard to BMP prepared for the adjacent MELSP area. The assessment and outcomes of the BMP's for both the MWLSP and MELSP are consistent and compatible.

1.2 Purpose and application of the plan

The purpose of this BMP is to provide strategic level guidance on how to plan for and manage the bushfire risk to future assets of the project area through a commitment to implement a range of bushfire management measures at future planning stages. The BMP outlines how future on-site assets can be protected during the summer months when the threat from bushfire is at its peak. This is particularly relevant when existing fire appliances in the area may be unable to offer an immediate emergency suppression response; therefore, development planning and design should aim to provide mitigation strategies that protect future life and property from bushfire as a priority.



Source: Roberts Day 2017

Figure 1: Structure Plan concept

2. Spatial consideration of bushfire threat

2.1 Existing site characteristics

2.1.1 Location

The project area comprises the majority of Lot 682 Rowley Road, Mandogalup in the City of Kwinana (Figure 2). This includes approximately 72.89 ha of land but excludes a small balance portion of Lot 682 to the southwest. The project area also includes the following infrastructure corridors:

- Planning Control Area No. 112 (November 2015) orientated east-west in the northern portion of the project area to account for future road widening of Rowley Road
- Western Power overhead power line easement (Lot 52) orientated northeast-southwest in the northern half of the project area
- Peel Main Drain easement orientated east-west in the southern portion of the project area.

The project area is bound by the following (Figure 2):

- Lot 9033 (proposed SPG MELSP area) and Kwinana Freeway to the east
- Lot 9006 (proposed SPG MELSP area) to the south
- balance portion of Lot 682 to the southwest
- Lot 2 Rowley Road and Lot 4 Norkett Road to the west
- Rowley Road and Vivente/Hammond Park residential development to the north.

2.1.2 Zoning and land use

The project area is zoned 'Urban' under the Metropolitan Region Scheme (MRS) and 'Development' under the City of Kwinana Town Planning Scheme No. 2 (TPS No. 2), except for the Planning Control Area to the north, which is zoned 'Urban Deferred' under the MRS and 'Rural A' under TPS No. 2. These zoning classifications are suitable to progress proposed development as per the LSP.

The project area currently consists of the following land uses:

- undeveloped and fully vegetated land to the north of the Western Power easement
- predominantly cleared agricultural land with partial retention of vegetation between the Western Power Easement and Peel Main Drain
- fully cleared agricultural land to the south of the Peel Main Drain.

Adjacent land to the east and west is predominantly undeveloped and vegetated. Adjacent land to the south is predominantly cleared for agricultural use with retention of some small vegetation remnants. Adjacent land to the north is predominantly cleared and in the process of being developed, or due to be cleared as part of ongoing development within the Hammond Park locality.

Clearing and development within the project area and adjacent landholdings in all directions will eventually result in a densely populated urban area accompanied by gradual removal of the vegetation extent and associated bushfire risk. However, this means that bushfire management measures will need to be implemented to manage the bushfire risk from temporary vegetation during development staging within the project area and adjacent development sites.

2.1.3 Assets

The project area and adjacent land to the west, south and east do not contain any significant life or infrastructure assets by virtue of the undeveloped nature of these sites. Adjacent land to the north is in the process of being developed (Vivente residential development) and contains early stage dwelling construction. Generally, undeveloped land within the project area and adjacent landholdings that has not been cleared for agricultural use contains native vegetation with environmental value.

2.1.4 Access

The project area is currently accessed from Rowley Road to the north via an extensive network of tracks and firebreaks. The project area does not contain any formal access routes or public roads by virtue of the undeveloped nature of the site.

2.1.5 Water and power supply

The project area is not currently connected to reticulated mains water or power supplies by virtue of the undeveloped nature of the site. Irrigated agriculture is currently in operation in the southern portion of the site.

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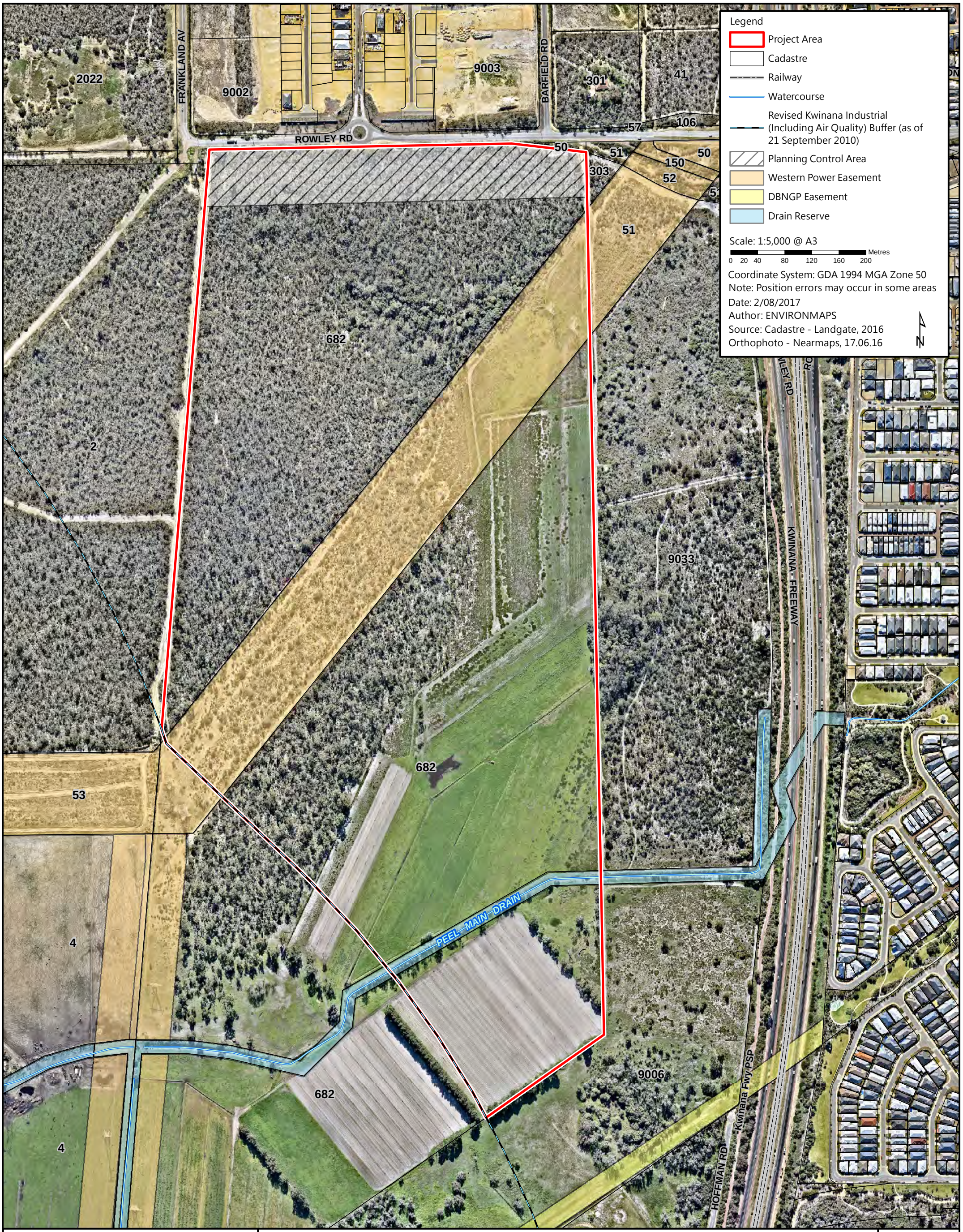

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Bushfire Management Plan: Lot 682 Rowley Road, Mandogalup

Site Overview

Figure 2

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2.2 Existing fire environment

2.2.1 Vegetation class

Pre-development vegetation class has been assessed for this site in accordance with methodology contained within *AS 3959–2009 Construction of Buildings in Bushfire-Prone Areas* (AS 3959; SA 2009). Strategen assessed vegetation class within the project area and adjacent 100 m through on-ground site investigation on 23 September 2016. Strategen has ensured consistency with vegetation classification outlined in the BMP for MELSP.

A summary of results is provided below and depicted in Figure 3:

1. Class A forest occurs within two small low-lying wetland pockets on the adjacent east and south landholdings where the fuel profile transitions to a three-tiered fuel ladder including an overstorey of eucalypts (predominantly Flooded gum).
2. Class B woodland is the predominant on-site vegetation and occurs in areas that are yet to be cleared, mainly in the northern half of the site. The vegetation consists of a predominant Banksia/Sheoak overstorey with Grass trees over low shrubs and grasses. This vegetation class also dominates Lot 2 to the west and occurs in smaller remnants to the north and south. Class B woodland also occurs in the form of isolated strips of individual overstorey trees amongst a predominant cleared grassland understorey in the southern portion of the site and adjacent south/southwest landholdings.
3. Class C shrubland occurs within two small remnants, one to the north of the project area within the verge of Rowley Road consisting of low acacia scrub and Grass trees; and one to the south of the project area within Lot 9006 consisting of Bracken fern.
4. Class D scrub dominates the Western Power easement (Lot 52) and adjacent east Lot 9033. This vegetation consists of a sparse assembly of low Banksia amongst a predominant coverage of acacia scrub, Grass trees, Spearwood, Woolley bush and grasses/weeds.
5. Class G grassland occurs in areas where native vegetation has been cleared for agricultural use within the eastern and southern portions of the project area, as well as adjacent land to the southeast, south and southwest. The north-eastern section of the Western Power easement (Lot 52) also contains a predominant coverage of grassland species and weeds.
6. Non-vegetated areas where vegetation has been removed for the construction of roads, tracks, firebreaks and buildings are excluded from classification under Clause 2.2.3.2 (e) of AS 3959.
7. Areas where the vegetation is managed in a low threat, minimal fuel condition such as road verges and managed landscaping (such as within the Vivente development site to the north of Rowley Road) are excluded from classification under Clause 2.2.3.2 (f) of AS 3959.

Strategen has compiled a comprehensive array of georeferenced photographs taken during on-ground site investigation, which are contained in Appendix 2 and demonstrate the location, direction and class of vegetation observed.

Strategen emphasises that the vegetation extent discussed above and mapped in Figure 3 demonstrates pre-development (current) site conditions and does not take into account any vegetation clearing that will occur as part of proposed development or development on adjacent landholdings.

2.2.2 Effective slope

Effective slope has been assessed for this site in accordance with methodology contained within AS 3959. Strategen assessed effective slope within 100 m of the project area through on-ground site investigation on 23 September 2016 and this information is depicted in Figure 3.

The project area and adjacent land is subject to undulating topography in the north and low-lying (flat) topography in the south. This presents some variation in the slope under classified vegetation, which ranges from flat land in the south, southeast and southwest, to >0–5 degrees up-slope in the east, northeast, north, northwest and southwest, to >0–5 degrees down-slope in the west, to >5–10 degrees up-slope in the southwest. These results are supported by topographic contours and elevation depicted in Figure 3.

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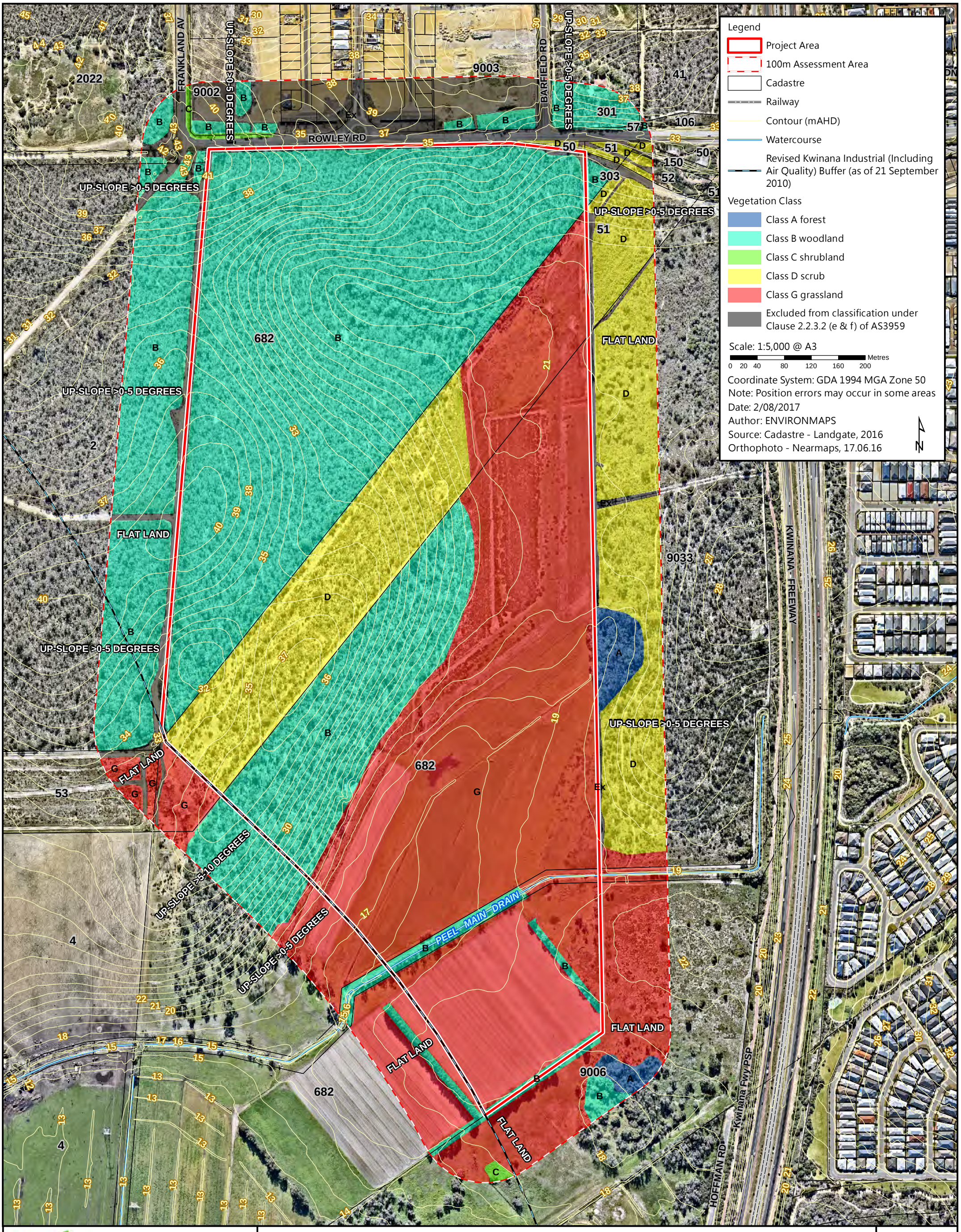

Bushfire Management Plan: Lot 682 Rowley Road, Mandogalup

Vegetation Class and Effective Slope

Figure 3

2.3 Bushfire hazard level assessment

2.3.1 Pre-development hazard levels

Bushfire hazard levels have been assessed for this site in accordance with methodology contained within the Guidelines. Strategen has mapped the bushfire hazard levels within the project area and adjacent 100 m as per current pre-development conditions as depicted in Figure 3. Strategen has ensured consistency with the bushfire hazard level assessment outlined in the BMP for the adjacent MELSP area.

A summary of results is provided below and depicted in Figure 4:

- all areas of Class A forest represent an extreme bushfire hazard level
- all areas of Class B woodland represent an extreme bushfire hazard level
- all areas of Class C shrubland represent a moderate bushfire hazard level
- all areas of Class D scrub represent an extreme bushfire hazard level
- all areas of Class G grassland represent a moderate bushfire hazard level
- all areas located within 100 m of moderate or extreme bushfire hazards areas represent a moderate bushfire hazard level by default (WAPC 2017).

Proposed residential development will result in clearing or management of the majority of existing vegetation within the MWLSP (see Figure 1). The post development vegetation extent will therefore result in lower hazard levels than those currently depicted in Figure 4.

2.3.2 Post development hazard levels

The existing vegetation extent within and surrounding the project area will be substantially cleared, due to the cleared/low fuel outcome of proposed urban development. The post development vegetation extent will therefore result in lower hazard levels than those currently existing within the project area.

Strategen has mapped the post-development bushfire hazard levels on and within 100 m of the project area to indicate those areas of the site where vegetation and bushfire hazards will be removed through vegetation clearing and modification. All current vegetation extent within the project area will be cleared and/or managed in a low fuel state, apart from portions of retained vegetation within POS A and POS D, which is supported by the MWLSP layout (see Figure 1) and Landscape Principles Plan (Appendix 3).

A summary of post-development bushfire hazard level results is provided below and depicted in Figure 5:

- all areas of Class A forest represent an extreme bushfire hazard level
- all areas of Class B woodland represent an extreme bushfire hazard level
- all areas of Class C shrubland represent a moderate bushfire hazard level
- all areas of Class D scrub represent an extreme bushfire hazard level
- all areas of Class G grassland represent a moderate bushfire hazard level
- all areas located within 100 m of moderate or extreme bushfire hazards areas represent a moderate bushfire hazard level by default (WAPC 2017)
- all remaining areas represent a low bushfire hazard level.

2.4 Identification of bushfire hazard issues

Under worst case fire weather conditions, the bushfire risk from the northern quadrant is limited due to the clearing extent within the Vivente/Hammond Park residential development areas. Potential fire behaviour from the northwest and northeast will be moderated due to the fragmented bushland remnants in these directions and potential for direct fire suppression at the Rowley Road, Barfield Road and Frankland Avenue interfaces.

Strategen considers that the worst-case bushfire scenario that could affect future assets of the project area is from the temporary vegetation retained within Lot 2 to the west. A head fire approaching the project area from the west under standard afternoon summer conditions is expected to exhibit elevated levels of radiant heat and ember attack by virtue of the relatively long fire run through intact banksia woodland vegetation on undulating terrain. Lot 2 is proposed to be developed at some future stage; however, the bushfire risk to the project area from this vegetation will need to be adequately managed until such time that this vegetation is removed. This will be achieved through delayed development of adjacent lots and application of AS 3959 and Asset Protection Zones (APZs) along the interfacing boundary of Lot 2.

A similar issue occurs to the east and south adjacent to Lots 9033 and 9006 respectively. This land is proposed to be cleared for development as part of the MELSP; however, in its current uncleared state, this site presents a bushfire risk to future assets of the project area. As mentioned above, the bushfire risk to the project area from this vegetation will need to be adequately managed until such time that this vegetation is removed. This will be achieved through delayed development and application of AS 3959 and APZs.

The bushfire risk posed by the current vegetation extent within the Western Power easement (Lot 52), Planning Control Area to the north and Peel Main Drain to the south is proposed to be managed through regular vegetation management and fuel reduction undertaken by the developer. Being the landowner of these easements, QPG has the authority to manage or clear the vegetation and reduce bushfire risk to internal development areas of the site provided the formal agency approvals are in place.

Aside from small patches of remnant vegetation retained within POS A and POS D, the on-site vegetation extent is proposed to be cleared to enable development of a significant urban built footprint amongst areas of landscaped/managed POS and various easements. Areas of retained vegetation within POS A and POS D will be surrounded by areas of low fuel managed POS and perimeter roads, providing adequate separation distances at the vegetation-development interface. The proposed school site, which is located across the MWLSP–MELSP boundary, will be surrounded by perimeter roads to the east, west and south and low fuel playing fields to the north. In addition, following clearing to the east as part of the adjacent MELSP development, retained vegetation within POS D will likely be excluded from classification under Clause 2.2.3.2 (b) of AS 3959.

Therefore, Strategen does not consider the proposed post development vegetation extent to be a bushfire hazard issue since these hazards will be managed through a staged clearing and development process and ongoing fuel management that will be undertaken in and around individual development stages.

On the basis of the above information, Strategen considers that the bushfire hazards within and adjacent to the project area and the associated bushfire risk is readily manageable through standard management responses and compliance with acceptable solutions outlined in the Guidelines and AS 3959. These management measures will need to be factored in to subdivision design as early as possible to ensure a suitable, compliant and effective bushfire management outcome is achieved to ensure protection of future life and property assets.

Demonstration of compliance with the relevant requirements of SPP 3.7, the Guidelines and AS 3959 at future planning stages will predominantly depend on QPG's ability to coordinate the timing and staging of clearing and development works within the project area with those developments proposed on adjacent landholdings in the aim of avoiding unnecessary bushfire impacts from temporary vegetation.

2.5 BAL contour assessment

A BAL contour assessment has not been undertaken as part of this BMP on the basis that lot layout over the project area is not yet known. A BAL contour map prepared at this early strategic stage of the planning process would be too indicative to add any significant value to inform planning decisions.

In light of the above, a BAL contour assessment will need to be undertaken at future planning stages (i.e. to accompany a subdivision application) and an updated BMP prepared to reflect the outcomes of the assessment, including requirements that any proposed development consisting of dwellings located within 100 m of classified post development vegetation will require application of AS 3959 and increased building construction standards in response to the assessed BALs.

Proposed development areas consisting of habitable buildings will need to achieve minimum hazard separation distances necessary to achieve a BAL–29 rating or lower (Table 1).

Table 1: Minimum hazard separation distances based on effective slope

Vegetation class	Effective slope	Minimum APZ width to achieve BAL–29 or lower
Class A forest	Up-slope and flat land	21 m
Class B woodland	Up-slope and flat land	14 m
	Down-slope >0 to 5 degrees	17 m
Class C shrubland	Up-slope and flat land	9 m
Class D scrub	Up-slope and flat land	13 m
Class G grassland	Class G grassland	8 m

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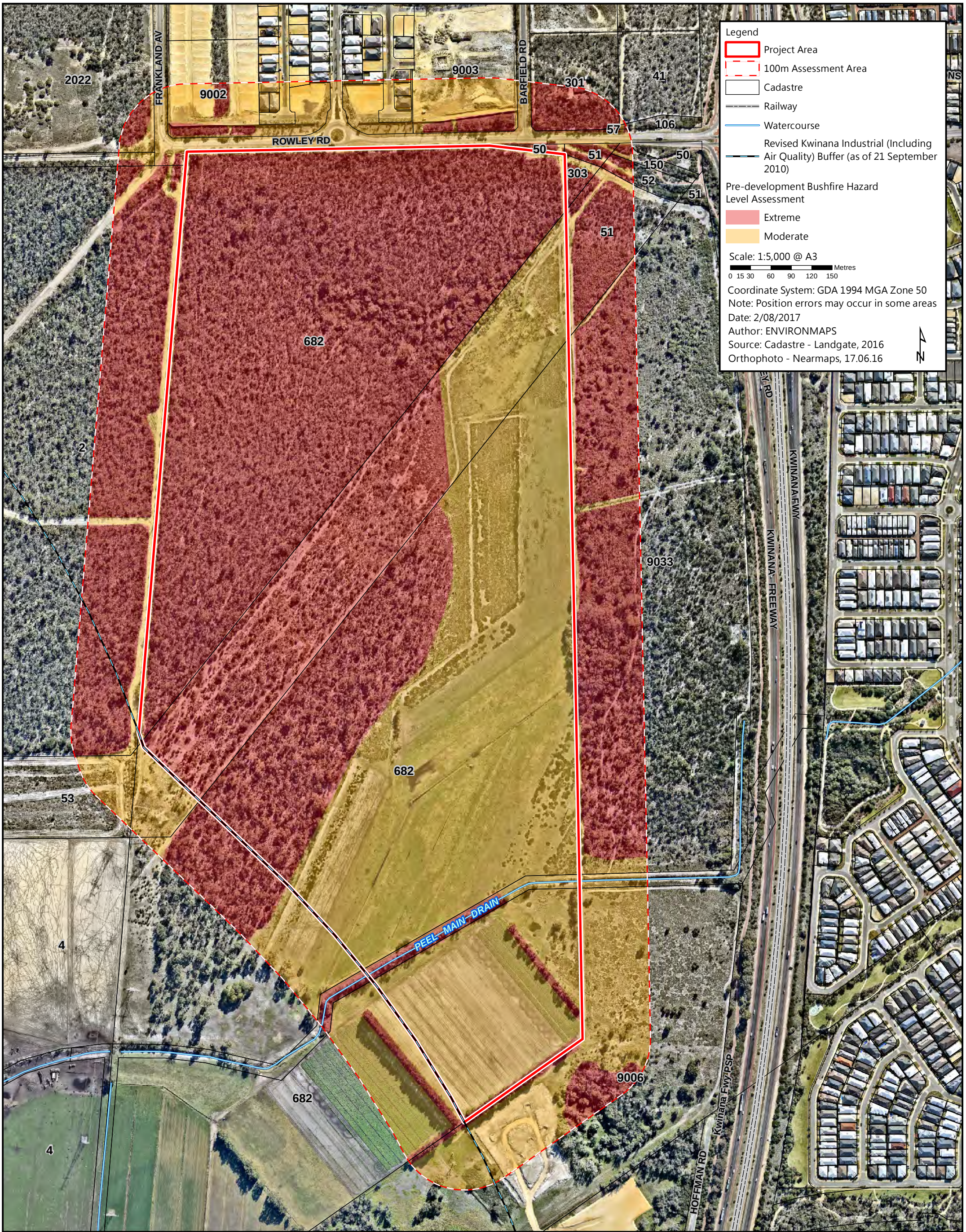

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Bushfire Management Plan: Lot 682 Rowley Road, Mandogalup

Pre-development Bushfire Hazard Level Assessment

Figure 4

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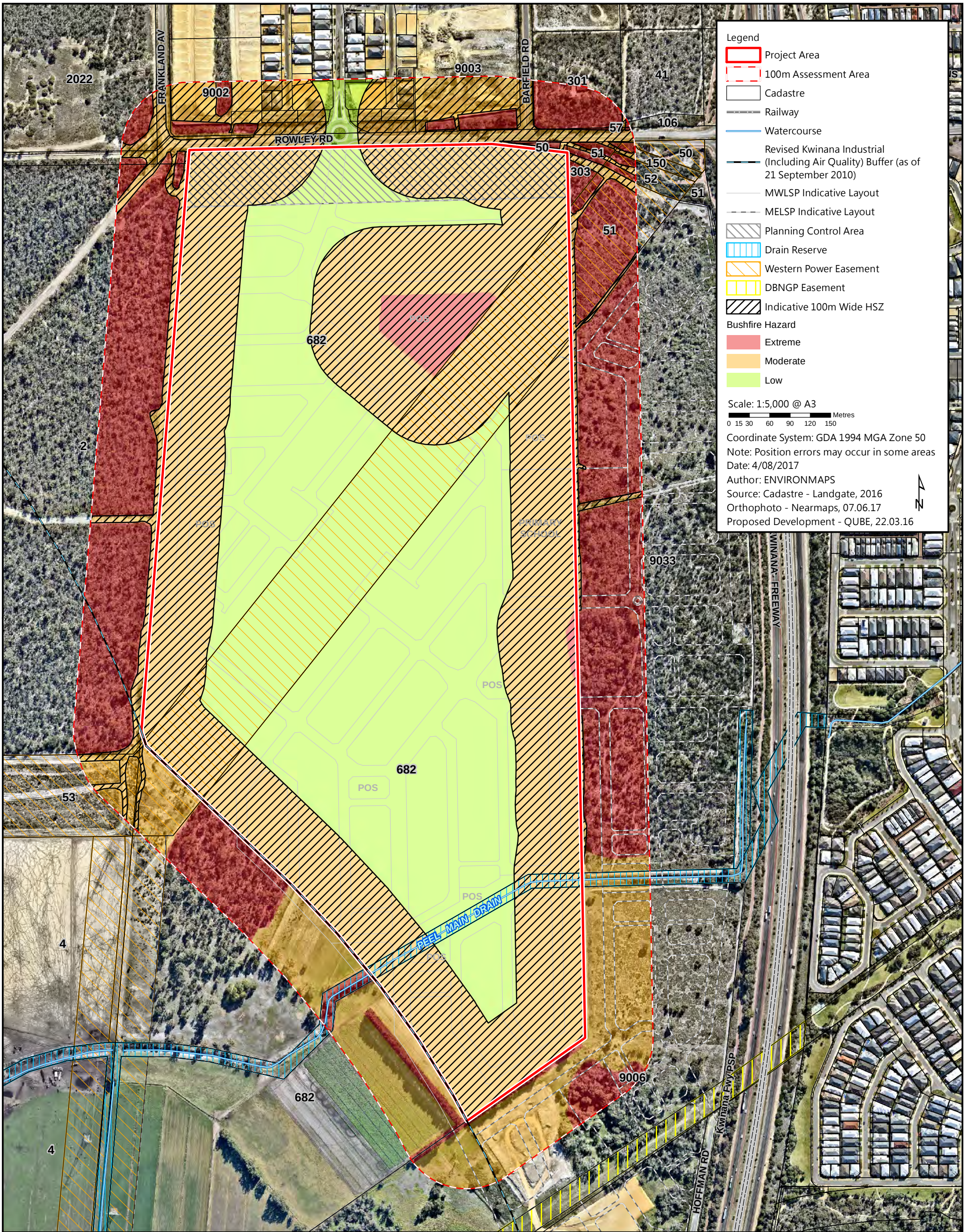

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Bushfire Management Plan: Lot 682 Rowley Road, Mandogalup

Post Development Bushfire Hazard Level Assessment

Figure 5

3. Bushfire management measures

This BMP has been prepared as a strategic guide to demonstrate how development compliance will be delivered at future planning stages in accordance with the Guidelines. In this respect, Strategen has outlined a range of bushfire management measures that QPG will need to commit to implementing at future planning stages once an adequate level of detail is available to confirm the location and design of such measures.

Strategen considers that on implementation of the proposed management measures outlined in the following subsections, the project area will be able to be developed with a manageable level of bushfire risk whilst maintaining full compliance with the Guidelines and AS 3959.

3.1 Separation distances and fuel management

3.1.1 Asset Protection Zones (APZs)

APZs will be implemented at all interfaces where proposed development abuts classified vegetation to ensure future assets are afforded an appropriate level of low fuel defendable space and to prevent development in high risk areas such as BAL–FZ and BAL–40.

The minimum width of the APZs is required to be sufficient enough for proposed development areas to achieve a rating of BAL–29 or lower, which will meet compliance with acceptable solutions A1.1 and A2.1. The potential range of minimum APZ widths relevant to the project area are provided in Table 1 and the final alignment and width of APZs will depend on the class and effective slope of the interfacing vegetation.

Any lots along the western, eastern and southern boundaries that may be temporarily impacted by BAL-40 or BAL-FZ will be subject to staged building exclusion (i.e. will be temporarily quarantined) and cannot be developed until vegetation clearing occurs on Lot 2 to the west, Lot 9033 to the east and Lot 9006 to the south of the project area as part of future residential development on adjacent lands. Management measures for implementing staged development in any areas subject to BAL–FZ and BAL–40 will be addressed as part of a future BMP or BMP addendum to be prepared at the subdivision stage.

The fuel load throughout the APZ is required to be maintained at less than 2 tonnes per hectare on a regular and ongoing basis (e.g. through regular slashing and weed control). Individual trees can be retained within the APZ; however, a minimum of 5 m separation between tree canopies is generally required. APZs are required to meet the criteria for low threat vegetation managed in a minimal fuel condition in accordance with Clause 2.2.3.2 (f) of AS 3959 and this can be achieved most effectively through the use of one or a combination of the following:

- existing/proposed sealed roads and managed road verges (roads can be most effective for use within an APZ as they also provide public and emergency access at the vegetation interface)
- regularly managed/landscaped lawns, gardens or POS
- other sealed areas including driveways and car parks
- temporarily quarantined lots
- minor building setbacks.

No buildings are permitted within the APZ. Indicative alignment and width of APZs for the project area will be determined once proposed lot layout is confirmed. This is to be documented in an addendum to this BMP to accompany future subdivision applications where appropriate.

3.1.2 On-site staging buffers

Vegetation clearing will occur throughout the project area on a staged basis and in advance where necessary to ensure building construction is not inhibited by a temporary vegetation extent located on a future development stage that is yet to be cleared. This can be achieved by ensuring each approved stage subject to construction is surrounded by a 100 m wide, on-site cleared or low threat vegetation buffer prior to building construction (excluding any on-site vegetation proposed to be retained). Once the buffers are created, they will need to be maintained on a regular and ongoing basis at a fuel load less than 2 t/ha to achieve a low threat minimal fuel condition all year round until such time that the buffer area is developed as part of the next development stage. This will manage the bushfire risk from on-site temporary vegetation during development staging. This measure will be confirmed following confirmation of proposed lot layout and development staging provisions and will be documented in an addendum to this BMP to accompany future subdivision applications where appropriate.

3.1.3 Temporary buffers to adjacent landholdings

Should development stages be constructed prior to removal of bushfire hazards on adjoining landholdings (i.e. within Lot 2 to the west, Lot 9033 to the east, Lot 9006 to the south and the balance of Lot 682 to the southwest), then one or a combination of the following options will need to be implemented prior to construction to ensure development is not situated within BAL–FZ or BAL–40 areas and a sufficient APZ can be established:

- delay development in those areas subject to BAL–FZ and BAL–40 until such time that the adjacent hazard is removed and a rating of BAL–29 or lower can be achieved for all proposed lots
- establish a temporary APZ within and along the boundary of the project area at the vegetation interface to enable development to occur in areas of BAL–29 or lower and ensure development is excluded within areas of BAL–FZ and BAL–40 (the APZ is to be managed on a regular basis until such time that the adjacent hazard is removed [this measure is intrinsically linked to the above point]).

These measures will be confirmed following confirmation of proposed lot layout and development staging provisions and will be documented in a brief addendum to this BMP to accompany future subdivision applications where appropriate.

3.1.4 Fuel management within on-site POS

As per the Landscape Principles Plan (Appendix 3), apart from portions of POS A and POS D, existing vegetation within all POS areas will be cleared and/or subject to low fuel landscaping and management. Existing vegetation to be retained in POS A and POS D is depicted in Figure 5.

Areas of retained vegetation within POS A and POS D are surrounded by areas of low fuel managed POS and perimeter roads, providing adequate separation distances at the vegetation-development interface. The proposed school site, which is located across the MWLSP–MELSP boundary, will be surrounded by perimeter roads to the east, west and south and low fuel playing fields to the north

3.1.5 Fuel management within easements and Planning Control Area

The Western Power, Peel Main Drain easements and Planning Control Area, located within the project area, are owned by the developer and existing vegetation within the easements will also be subject to clearing and/or management to achieve a minimal low fuel state on an ongoing basis.

Clearing and fuel management will be undertaken to ensure these areas do not result in the introduction of bushfire hazards. The required works may include slashing of understorey grasses and weed control on a regular and ongoing basis to maintain fuel loads at less than 2 t/ha and achieve a low threat minimal fuel condition all year round.

Individual trees throughout the easements and Planning Control Area can be retained for visual/aesthetic/screening purposes. Management of easements and Planning Control Area will be the responsibility of the developer until such time that these management responsibilities are transferred to the relevant agencies.

3.2 BAL assessment and increased building construction standards

The on-site vegetation extent is proposed to be cleared to enable development of a significant urban built footprint amongst areas of landscaped/managed POS and various easements. Therefore, the predominant BAL impact on future assets will be around the perimeter of the project area in response to the adjacent temporary vegetation extent. Measures will need to be put in place (such as those outlined in Section 3.1) to ensure all areas of BAL–FZ and BAL–40 are avoided so that a rating of BAL–29 or lower can be achieved with provision of a suitable APZ where required.

Once proposed lot layout is confirmed at the subdivision stage, as well as a suitable approach to manage the risk from adjacent bushfire hazard areas, BAL contours will need to be assessed to inform the indicative BAL impact over the site, as well as the necessary APZ separation requirements for proposed development areas. This process will inform those lots that require increased building construction standards.

The development design process will ensure a rating of BAL-29 or lower is achieved by incorporating the necessary APZs discussed in Section 3.1.1, which will meet the necessary performance criteria of Element 1 and Element 2 of the Guidelines. BAL contours and APZs will be depicted in an addendum to this BMP to accompany future subdivision applications where appropriate.

3.3 Vehicular access

3.3.1 Public roads

The indicative public road network outlined in the LSP (Figure 1) is appropriate for the purposes of satisfying the intent of Element 3 of the Guidelines at this strategic planning stage in that there are no significant dead ends located in areas of extreme bushfire hazard and suitable linkages are proposed with future development on adjacent landholdings.

The ultimate proposed vehicular access network will provide through access to the existing and proposed surrounding public road network, including Rowley Road to the north and future road linkages on adjacent landholdings to the west, east and south, ensuring egress and access is available to at least two different destinations.

Lots situated near proposed public road connections to adjacent landholdings to the west, east and south will be subject to staged building exclusions that are tied to future development progressing within these adjacent lands. Therefore, development will not occur on these lots until the proposed internal public access links to adjacent lands are in place, thereby ensuring that lots will have two access routes at all times.

A proposed temporary emergency access way, highlighted in red in Appendix 4, will provide a secondary connection to Rowley Road in the north and will ensure that any development occurring within the project area prior to future development within adjacent lands (particularly with regards to the early development stages) will have suitable access and egress to two different routes at all times, which eliminates the one-road-in/one-road-out scenario. The temporary emergency access way can achieve compliance with acceptable solutions under the Guidelines, in that it will be less than 600 m from a public road at any point, be provided as a public access easement in gross to ensure accessibility, would be signposted and would meet other technical requirements outlined in Table 2.

The abovementioned emergency access way is likely to link with the emergency access way proposed for MELSP along a proposed service corridor extending from Stage 1 MWLSP to Stage 1 MELSP. This will ultimately provide connection to Hoffman Road in the southeast. Reciprocal arrangements between both QPG and SPG will be in place to ensure both MWLSP and MELSP sites have access to these emergency access ways to ensure two access routes are available for both development sites at all times.

Should any cul-de-sacs be proposed, acceptable solution A3.3 will be met to ensure the cul-de-sac/s are restricted to a maximum length of 200 m and the cul-de-sac head/s meet a minimum 17.5 m diameter. Should any battle-axe lots be proposed, acceptable solution A3.4 will be met to ensure battle-axe legs are a maximum length of 600 m and a minimum width of 6 m. Should any private driveways longer than 50 m be proposed, acceptable solution A3.5 will be met to ensure requirements of the Guidelines are complied with.

Firebreaks will not be required throughout the residential lot component of proposed development since these lots will be of a size that will not trigger firebreak requirements; however, firebreaks may be required for larger lots (such as staged balance lots, the school site, POS or easements) in accordance with acceptable solution A3.8 and the City of Kwinana annual firebreak notice (Appendix 5).

Technical requirements for vehicular access components that may form part of proposed development will be met in accordance with Table 2. Vehicular access components of proposed development will be confirmed as part of subdivision design and demonstration of compliance with the relevant acceptable solutions for Element 3 of the Guidelines will be documented in a brief addendum to this BMP to accompany future subdivision applications where appropriate.

Table 2: Vehicular access technical requirements

Technical requirement	Public road	Cul-de-sac	Battle-axe legs and private driveways longer than 50 m	Emergency access ways	Fire service access routes
Minimum trafficable surface (m)	6*	6	4	6*	6*
Horizontal distance (m)	6	6	6	6	6
Vertical clearance (m)	4.5	N/A	4.5	4.5	4.5
Maximum grade <50 m	1 in 10	1 in 10	1 in 10	1 in 10	1 in 10
Minimum weight capacity (t)	15	15	15	15	15
Maximum crossfall	1 in 33	1 in 33	1 in 33	1 in 33	1 in 33
Curves minimum inner radius	8.5	8.5	8.5	8.5	8.5

* Refer to E3.2 Public roads: Trafficable surface

Source: WAPC 2017

3.4 Reticulated water supply

All proposed development areas will be provided a reticulated water supply through extension of adjacent services. The reticulated system will ensure an all year round supply of water is provided for each lot to meet minimum domestic and emergency water supply requirements. This will thereby meet the intent of Element 4 of the Guidelines through compliance with acceptable solution A4.1.

A network of hydrants will also be provided along the internal road network at locations which meet relevant water supply authority and DFES requirements, in particular the Water Corporation Design Standard DS 63 'Water Reticulation Standard Design and Construction Requirements for Water Reticulation Systems up to DN250'. This standard will guide construction of the internal reticulated water supply system and fire hydrant network, including spacing and positioning of fire hydrants so that the maximum distance between a hydrant and the rear of a building envelope (or in the absence of a building envelope, the rear of the lot) shall be 120 m and the hydrants shall be no more than 200 m apart.

3.5 Additional measures

Strategen makes the following additional recommendations to inform ongoing development stages:

1. Notification on Title: where relevant, a notification pursuant to Section 165 of the *Planning and Development Act 2005* is to be placed on the certificates of title of proposed lots with a BAL rating of 12.5 or above, advising of the existence of a hazard or other factor (relevant authority). The notification is to state as follows:

   This land is subject to a Bushfire Management Plan. Additional planning and building requirements may apply to development on this land.

2. BMP addendum: this BMP is a strategic level guide to demonstrate how development compliance will be met at future planning stages. Once an appropriate level of detail is available to demonstrate development compliance, which is expected to be at the subdivision application stage, a brief addendum to this BMP or updated BMP containing the necessary development and bushfire planning detail will need to be lodged with the subdivision application/s (where appropriate) to the City of Kwinana and WAPC.
3. Compliance with current City Kwinana annual firebreak notice: the developer/land manager and prospective land purchasers are to comply with the current City of Kwinana annual firebreak notice as outlined in Appendix 5.
4. Vulnerable land uses: Bushfire Emergency Evacuation Plans will need to be prepared for any vulnerable land uses (such as schools or aged care facilities) that are located in areas subject to BAL–12.5 to BAL–29 to address requirements of SPP 3.7 Policy Measure 6.6. This is to be completed at the DA or building permit stage once an adequate level of detail is available to inform such plan. As outlined in Section 2.4, the school site will be surrounded by perimeter roads to the east, west and south and low fuel playing fields to the north, meaning vehicular access to this site will be suitable. In addition, following vegetation clearing to the east of the project area within MELSP, any retained vegetation within POS D is likely to be excluded from classification under Clause 2.2.3.2 (b) of AS 3959. On this basis, Strategen considers post development bushfire hazards adjacent to the school site to be limited and manageable to enable compliant development of this Vulnerable Land Use.

4. Proposal compliance and justification

Proposed development within the project area is required to comply with SPP 3.7 under the following policy measures:

6.2 Strategic planning proposals, subdivision and development applications

a) Strategic planning proposals, subdivision and development applications within designated bushfire prone areas relating to land that has or will have a Bushfire Hazard Level (BHL) above low and/or where a Bushfire Attack Level (BAL) rating above BAL-LOW apply, are to comply with these policy measures.

b) Any strategic planning proposal, subdivision or development application in an area to which policy measure 6.2 a) applies, that has or will, on completion, have a moderate BHL and/or where BAL-12.5 to BAL-29 applies, may be considered for approval where it can be undertaken in accordance with policy measures 6.3, 6.4 or 6.5.

c) This policy also applies where an area is not yet designated as a bushfire prone area but is proposed to be developed in a way that introduces a bushfire hazard, as outlined in the Guidelines.

6.3 Information to accompany strategic planning proposals

Any strategic planning proposal to which policy measure 6.2 applies is to be accompanied by the following information prepared in accordance with the Guidelines:

a) (i) the results of a BHL assessment determining the applicable hazard level(s) across the subject land, in accordance with the methodology set out in the Guidelines. BHL assessments should be prepared by an accredited Bushfire Planning Practitioner; or

a) (ii) where the lot layout of the proposal is known, a BAL Contour Map to determine the indicative acceptable BAL ratings across the subject site, in accordance with the Guidelines. The BAL Contour Map should be prepared by an accredited Bushfire Planning Practitioner; and

b) the identification of any bushfire hazard issues arising from the relevant assessment; and

c) clear demonstration that compliance with the bushfire protection criteria in the Guidelines can be achieved in subsequent planning stages.

This information can be provided in the form of a Bushfire Management Plan or an amended Bushfire Management Plan where one has been previously endorsed.

Implementation of this BMP is expected to meet the following objectives of SPP 3.7:

5.1 Avoid any increase in the threat of bushfire to people, property and infrastructure. The preservation of life and the management of bushfire impact are paramount.

5.2 Reduce vulnerability to bushfire through the identification and consideration of bushfire risks in decision-making at all stages of the planning and development process.

5.3 Ensure that higher order strategic planning documents, strategic planning proposals, subdivision and development applications take into account bushfire protection requirements and include specified bushfire protection measures.

5.4 Achieve an appropriate balance between bushfire risk management measures and, biodiversity conservation values, environmental protection and biodiversity management and landscape amenity, with consideration of the potential impacts of climate change.

In response to the above requirements of SPP 3.7, the bushfire management measures, as outlined in Section 3, have been devised for the proposed development in accordance with acceptable solutions of the Guidelines to meet compliance with bushfire protection criteria. An ‘acceptable solutions’ assessment is provided in Table 3 to assess the proposed bushfire management measures against each bushfire protection criteria in accordance with the Guidelines and demonstrate that the measures proposed meet the intent of each element of the bushfire protection criteria.

Table 3: Acceptable solutions assessment against bushfire protection criteria

Bushfire protection criteria	Intent	Acceptable solutions	Proposed bushfire management measures	Compliance statement
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 The strategic planning proposal, subdivision and development application is located in an area that is or will, on completion, be subject to either a moderate or low bushfire hazard level, or BAL–29 or below.	Refer to Section 3.1 and 3.2, which demonstrate that development will only occur in areas of BAL–29 or lower. No development will occur in BAL–FZ or BAL–40 areas. This will be confirmed as part of a BMP addendum to accompany future subdivision applications where appropriate.	The measures proposed are considered to comply and meet the intent of Element 1 Location.
Element 2: Siting and design of development	To ensure that the siting and design of development minimises the level of bushfire impact	A2.1 Asset Protection Zone Every building is surrounded by an APZ, depicted on submitted plans, which meets detailed requirements (refer to the Guidelines for detailed APZ requirements).	Refer to Section 3.1, which demonstrates that an APZ will be provided at all development-vegetation interfaces based on either post-development vegetation extent within the project area or staged building exclusions tied to vegetation clearing occurring on Lot 2 to the west, Lot 9033 to the east and Lot 9006 to the south of the project area. This will be confirmed as part of the revised BMP or an addendum to this BMP to accompany the subdivision application.	The measures proposed are considered to comply and meet the intent of Element 2 Siting and design of development
Element 3: Vehicular access	To ensure that the vehicular access serving a subdivision/development is available and safe during a bushfire event	A3.1 Two access routes Two different vehicular access routes are provided, both of which connect to the public road network, provide safe access and egress to two different destinations and are available to all residents/the public at all times and under all weather conditions.	Refer to Section 3.3, which demonstrates that a minimum of two different vehicular access routes will be provided for the proposed development at all times, including during staging, via the internal and external road network and temporary emergency access way.	The measures proposed are considered to comply and meet the intent of Element 3 Vehicular access
		A3.2 Public road A public road is to meet the requirements in Table 4 Column 1 of the Guidelines.	Refer to Section 3.3, which demonstrates that all proposed public roads will meet requirements of the Guidelines (refer to Table 2). This will be confirmed as part of a BMP addendum to accompany future subdivision applications where appropriate.	
		A3.3 Cul-de-sac (including a dead-end-road) A cul-de-sac and/or a dead end road should be avoided in bushfire prone areas. Where no alternative exists (i.e. the lot layout already exists and/or will need to be demonstrated by the proponent), detailed requirements will need to be achieved as per Table 4 Column 2 of the Guidelines.	Refer to Section 3.3, which demonstrates that any cul-de-sacs (if proposed) will meet requirements of the Guidelines (refer to Table 2). This will be confirmed as part of a BMP addendum to accompany future subdivision applications where appropriate.	

		A3.4 Battle-axe Battle-axe access legs should be avoided in bushfire prone areas. Where no alternative exists, (this will need to be demonstrated by the proponent) detailed requirements will need to be achieved as per Table 4 Column 3 of the Guidelines.	Refer to Section 3.3, which demonstrates that any battle-axe lots (if proposed) will meet requirements of the Guidelines (refer to Table 2). This will be confirmed as part of a BMP addendum to accompany future subdivision applications where appropriate.	
		A3.5 Private driveway longer than 50 m A private driveway is to meet detailed requirements as per Table 4 Column 3 of the Guidelines.	Refer to Section 3.3, which demonstrates that any private driveways longer than 50 m (if proposed) will meet requirements of the Guidelines (refer to Table 2). This will be confirmed as part of a BMP addendum to accompany future subdivision applications where appropriate.	
		A3.6 Emergency access way An access way that does not provide through access to a public road is to be avoided in bushfire prone areas. Where no alternative exists (this will need to be demonstrated by the proponent), an emergency access way is to be provided as an alternative link to a public road during emergencies. An emergency access way is to meet detailed requirements as per Table 4 Column 4 of the Guidelines.	Refer to Section 3.3, which demonstrates that the temporary emergency access way will meet requirements of the Guidelines (refer to Table 2). This will be confirmed as part of a BMP addendum to accompany future subdivision applications where appropriate.	
		A3.7 Fire service access routes (perimeter roads) Fire service access routes are to be established to provide access within and around the edge of the subdivision and related development to provide direct access to bushfire prone areas for fire fighters and link between public road networks for fire fighting purposes. Fire service access routes are to meet detailed requirements as per Table 4 Column 5 of the Guidelines.	Refer to Section 3.3, which demonstrates that any FSARs (if proposed) will meet requirements of the Guidelines (refer to Table 2). This will be confirmed as part of a BMP addendum to accompany future subdivision applications where appropriate.	
		A3.8 Firebreak width Lots greater than 0.5 hectares must have an internal perimeter firebreak of a minimum width of three metres or to the level as prescribed in the local firebreak notice issued by the local government	Refer to Section 3.3, which demonstrates that no firebreaks will be required for individual residential lots. However, should any firebreaks be required for larger lots (such as POS or easements) these will meet requirements of the Guidelines and the City of Kwinana annual firebreak notice. This will be confirmed as part of a BMP addendum to accompany future subdivision applications where appropriate.	
Element 4: Water	To ensure that 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 The subdivision, development or land use is provided with a reticulated water supply in accordance with the specifications of the relevant water supply authority and Department of Fire and Emergency Services.	Refer to Section 3.4, which demonstrates that all proposed lots will be provided a reticulated water supply and network of hydrants in accordance with local water authority, City and DFES requirements.	The measures proposed are considered to comply and meet the intent of Element 4 Water

		A4.2 Non-reticulated areas Water tanks for fire fighting purposes with a hydrant or standpipe are provided and meet detailed requirements (refer to the Guidelines for detailed requirements for non-reticulated areas)	N/A The proposed development will not occur within a non-reticulated area.	
		A4.3 Individual lots within non-reticulated areas (only for use if creating 1 additional lot and cannot be applied cumulatively) Single lots above 500 square metres need a dedicated static water supply on the lot that has the effective capacity of 10 000 litres.	N/A The proposed development will not occur within a non-reticulated area.	

5. Implementation, enforcement and review

This BMP has been prepared as a strategic guide to demonstrate how development compliance will be delivered at future planning stages in accordance with the Guidelines. In this respect, the management measures documented in Section 3, where applicable, will be incorporated into development design as early as possible and confirmed at the subdivision stage. Therefore, aside from preparation of a BMP addendum to accompany future subdivision applications where appropriate, there are no further items to implement, enforce or review at this stage of the planning process.

The revised BMP or addendum to this BMP will meet the relevant commitments outlined in this strategic level BMP, address the relevant requirements of SPP 3.7 (i.e. Policy Measure 6.4) and demonstrate in detail how the proposed development will incorporate the relevant acceptable solutions to meet the performance requirements of the Guidelines. The revised BMP or BMP addendum will include the following detailed information:

- proposed lot layout and detailed POS design
- post development vegetation class extent, effective slope and separation distances
- post development 100 m wide BAL application requirements
- BAL contour map demonstrating that proposed development areas will achieve a rating of BAL–29 or lower
- width and alignment of compliant APZs
- confirmation of how bushfire management will be addressed during development staging
- confirmation of how bushfire management will be addressed with regards to bushfire hazards on adjacent landholdings, including temporary quarantining of lots where required
- fuel management or AS 3959 application in response to on-site POS or easements (if and where required)
- vehicular access provisions, including demonstration that a minimum of two access routes will be achieved in accordance with acceptable solution A3.1
- water supply provisions with regards to reticulated water
- future requirements for any identified vulnerable land uses, such as provision of a Bushfire Emergency Evacuation Plan at the DA or building permit stage
- provisions for notification on Title as a subdivision condition
- compliance requirements with the current City of Kwinana annual firebreak notice
- acceptable solutions assessment against the bushfire protection criteria
- proposed works program outlining all measures requiring implementation and the appropriate timing and responsibilities for implementation
- document review protocol
- summary of stakeholder consultation (if applicable).

On the basis of the information contained in this BMP, Strategen considers the bushfire hazards within and adjacent to the project area and the associated bushfire risk is readily manageable through standard management responses outlined in the Guidelines and AS 3959. Strategen considers that on implementation of the proposed management measures, the project area will be able to be developed with a manageable level of bushfire risk whilst maintaining full compliance with the Guidelines and AS 3959.

6. References

Department of Fire and Emergency Services (DFES) 2017, *Map of Bush Fire Prone Areas*, [Online], Government of Western Australia, available from: *http://www.dfes.wa.gov.au/regulationandcompliance/bushfireproneareas/Pages/default.aspx*, [27/09/2016].

Roberts Day 2017, *Plan Series Base – LSP: Mandogalup City of Kwinana*, plan prepared for QUBE Property Group Pty Ltd, 2017.

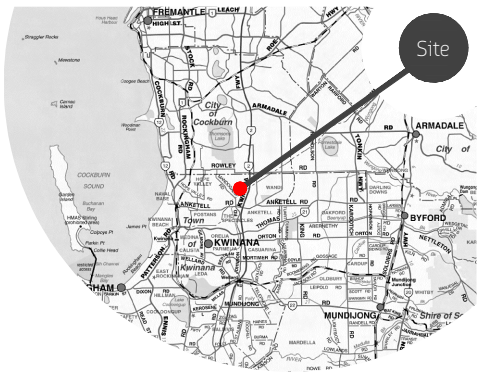
Standards Australia (SA) 2009, *Australian Standard AS 3959–2009 Construction of Buildings in Bushfire-prone Areas*, Standards Australia, Sydney.

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

Western Australian Planning Commission (WAPC) 2017, *Guidelines for Planning in Bushfire-Prone Areas*, Western Australian Planning Commission, Perth.

Appendix 1
Mandogalup Local Structure Plan

Planning Design Delivery



RESIDENTIAL

Residential (R30-R80)

PUBLIC PURPOSE

PS Educational/Institutional

PS Primary School

PARKS,RECREATION & CONSERVATION

Parks, Recreation and Drainage

Drainage

TRANSPORT

Access Street - Local Road

Primary Distributor Road

Regional Distributor

Neighbourhood Connector A

Temporary Neighbourhood Connector A

Neighbourhood Connector B

Temporary Neighbourhood Connector B

Indicative Cycleway Access

OTHER

Local Structure Plan Boundary

ADDITIONAL INFORMATION

Existing Lot Boundaries

Planning Control Area No.112

Indicative Neighbourhood Centre

Revised Kwinana Industrial (including Air Quality) Buffer (as of 21 September 2010)

DBNGP Easement

Western Power Easement

0 200 400 Metres

REVISIONS

Rev	Date	Drawn
H	2016.11.08	M. Sullivan
I	2017.04.12	M. Sullivan
J	2017.07.03	M. Sullivan
K	2017.07.26	M. Sullivan

ROWEGROUP
PLANNING DESIGN DELIVERY

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p: 08 9221 1991

Date Drawn:	2016-03-17
Job Ref:	7282A
Scale:	1:7500 @ A3
Client:	Satterley Property Group
Designer:	R. Cumming
Drawn:	M. Sullivan
Projection:	PCG 94
Plan ID:	7282A-STR-05-K

Mandogalup Local Structure Plan

N:\TOWN PLANNING\7000-7999\7282\7282A\DRAFTING\A-CAD\7282A_STR05K_20170726 MANDOGALUP (WAPC - PROPOSED).DWG
Matt Sullivan 26 July 2017

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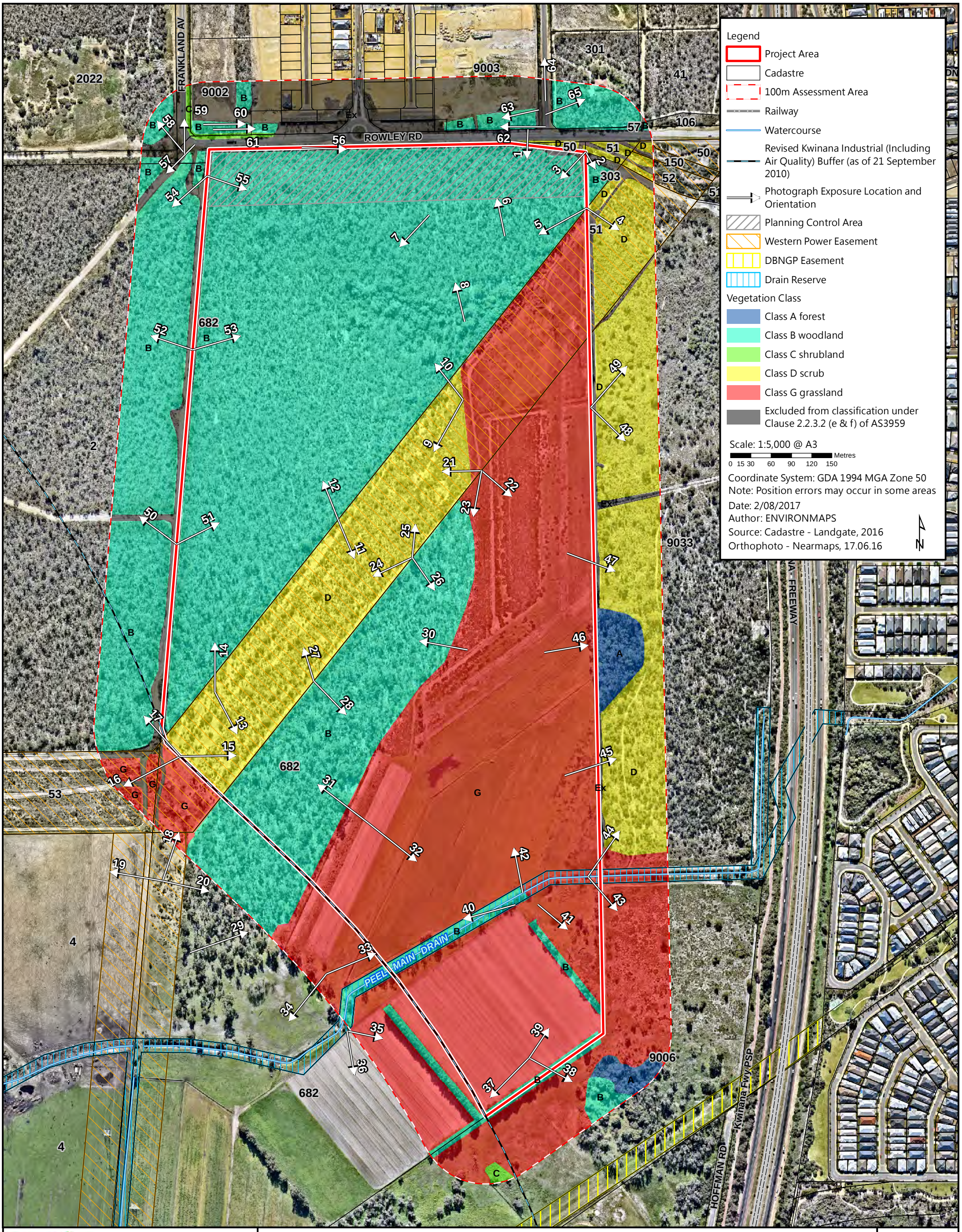
Appendix 2
Site photographs

Created by ENVIRONMAPS | e: simoncrofts@environmaps.com.au p: 0406 590 006



strategen ENVIRONMENTAL

Bushfire Management Plan: Lot 682 Rowley Road, Mandogalup

Site Photographs

Appendix 2



Photo Point 1: Class B woodland within project area to the northeast



Photo Point 2: Class B woodland adjacent northeast of project area within Lot 303



Photo Point 3: Class B woodland within project area to the northeast



Photo Point 4: Class D scrub adjacent east of project area within Western Power easement (Lot 52)



Photo Point 5: Class B woodland within project area to the northeast



Photo Point 6: Class B woodland within project area to the northeast



Photo Point 7: Class B woodland within project area to the north



Photo Point 8: Class B woodland within project area to the north



Photo Point 9: Class D scrub within project area (Western Power easement)



Photo Point 10: Class B woodland within project area to the north

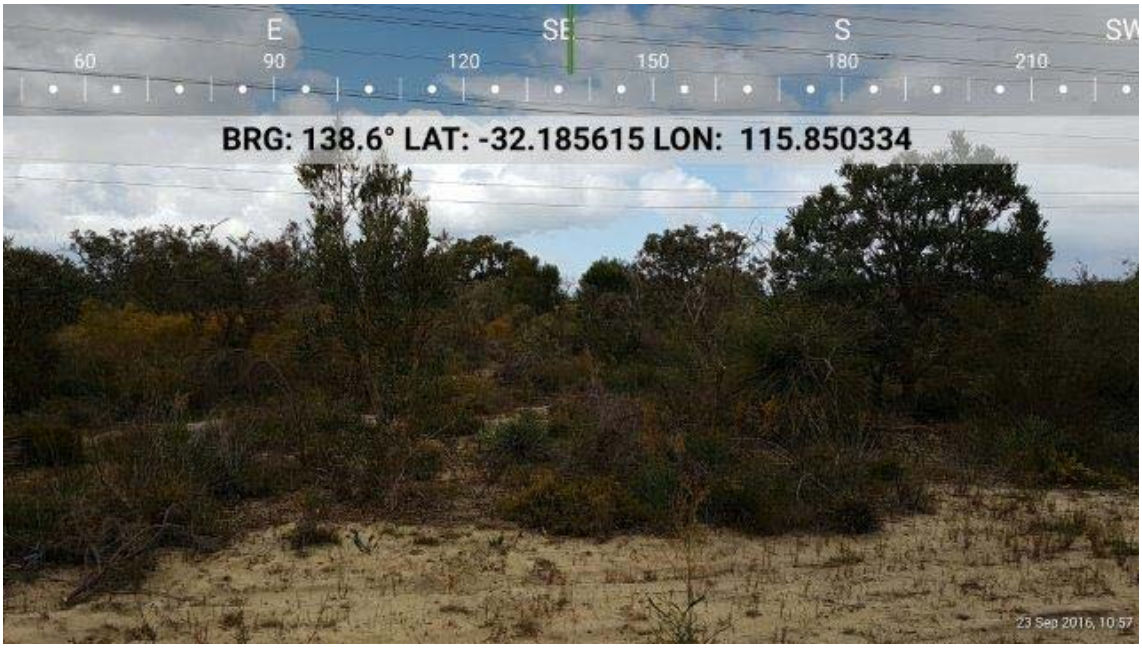


Photo Point 11: Class D scrub within project area (Western Power easement)



Photo Point 12: Class B woodland within project area central to site (north of Western Power easement)

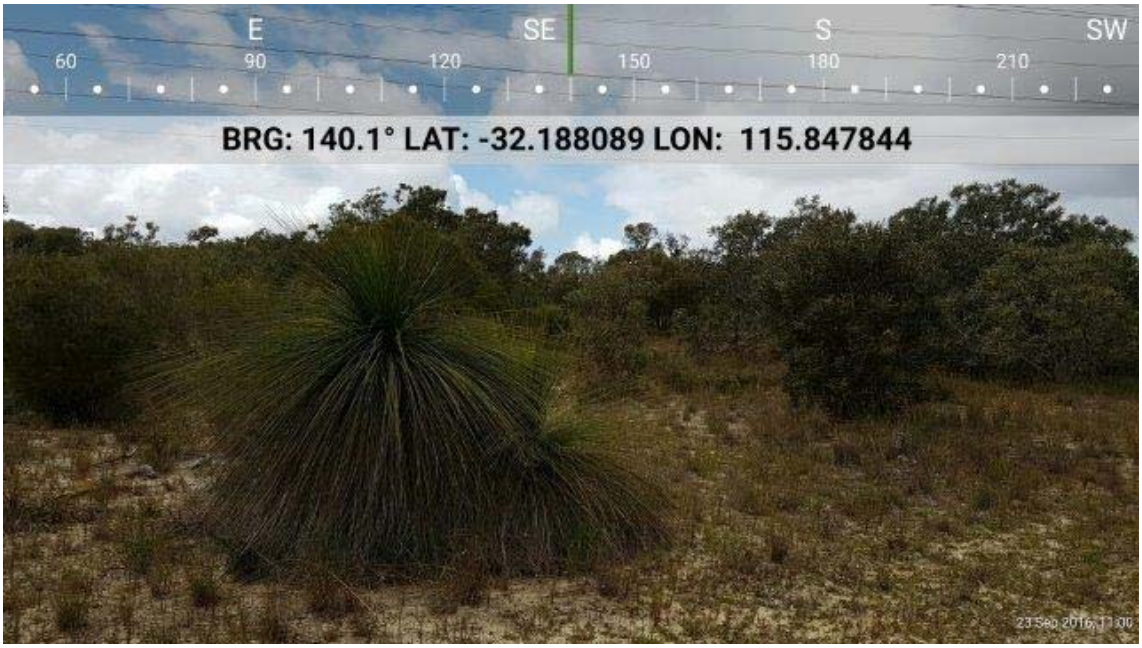


Photo Point 13: Class D scrub within project area (Western Power easement)



Photo Point 14: Class B woodland within project area to the west

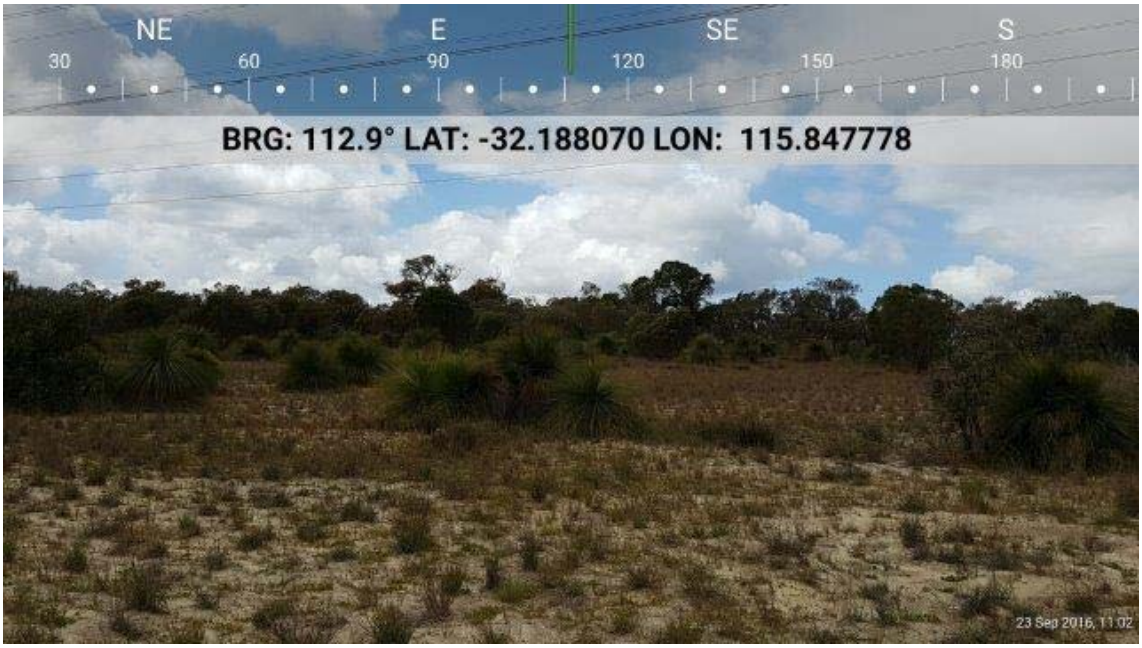


Photo Point 15: Class D scrub within project area (Western Power easement)



Photo Point 16: Class G grassland adjacent west of project area within Western Power easement



Photo Point 17: Class B woodland adjacent west of project area within Lot 2

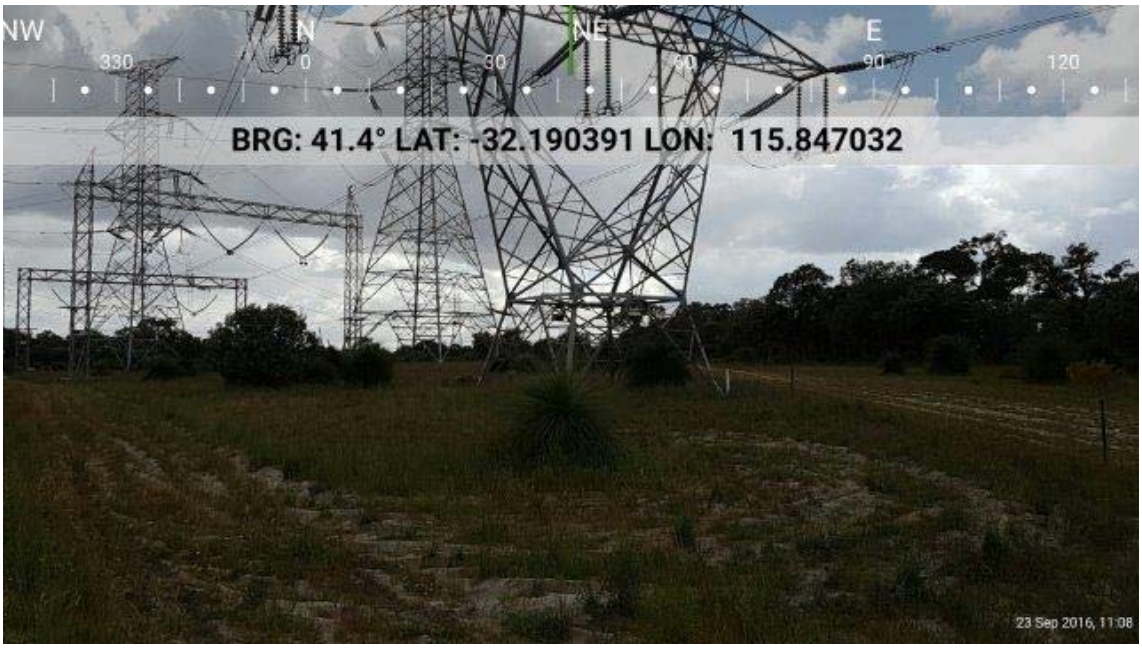


Photo Point 18: Class G grassland adjacent west of project area within Western Power easement



Photo Point 19: Non-vegetated area (Clause 2.2.3.2 e) adjacent west of project area within Lot 4

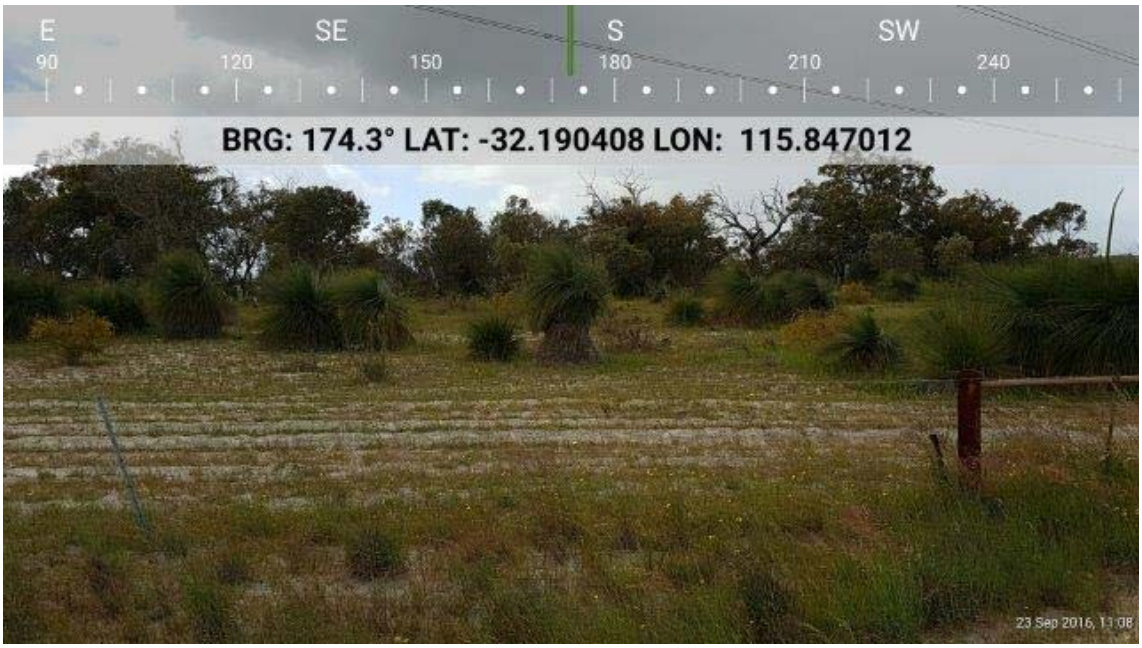


Photo Point 20: Class B woodland adjacent southwest of project area within Lot 682



Photo Point 21: Class D scrub within project area (Western Power easement)



Photo Point 22: Class G grassland within project area to the east



Photo Point 23: Interface between Class G grassland (left), Class D scrub (right) and Class B woodland (background) within project area to the east



Photo Point 24: Class D scrub within project area (Western Power easement)

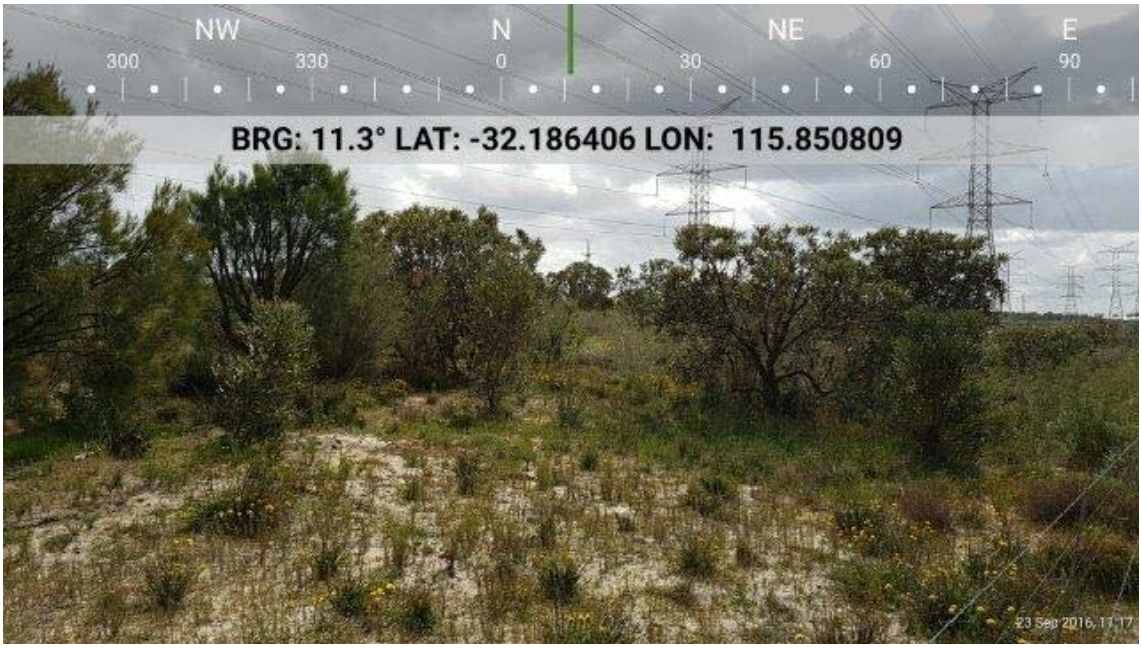


Photo Point 25: Class D scrub within project area (Western Power easement)



Photo Point 26: Class B woodland within project area central to site (south of Western Power easement)



Photo Point 27: Class D scrub within project area (Western Power easement)

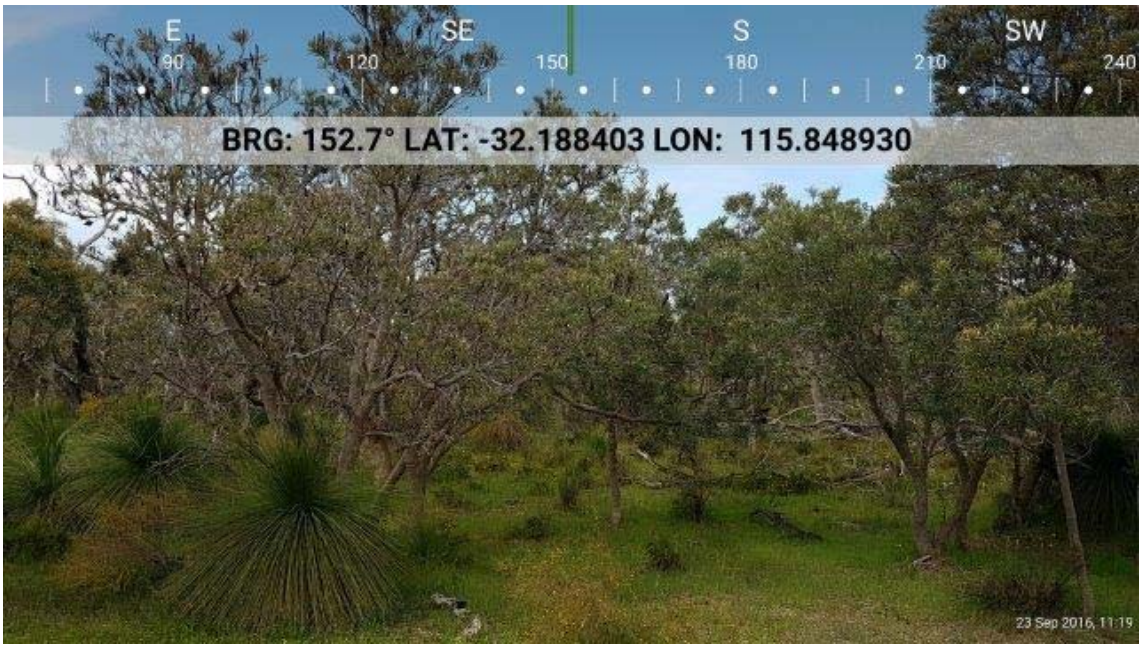


Photo Point 28: Class B woodland within project area central to site (south of Western Power easement)



Photo Point 29: Class G grassland (foreground) and Class B woodland (background) adjacent southwest of project area within Lot 682



Photo Point 30: Class G grassland (foreground) and Class B woodland (background) within project area central to site (south of Western Power easement)



Photo Point 31: Class G grassland (foreground) and Class B woodland (background) within project area to the southwest



Photo Point 32: Class G grassland within project area to the southwest



Photo Point 33: Class G grassland adjacent southwest of project area within Lot 682

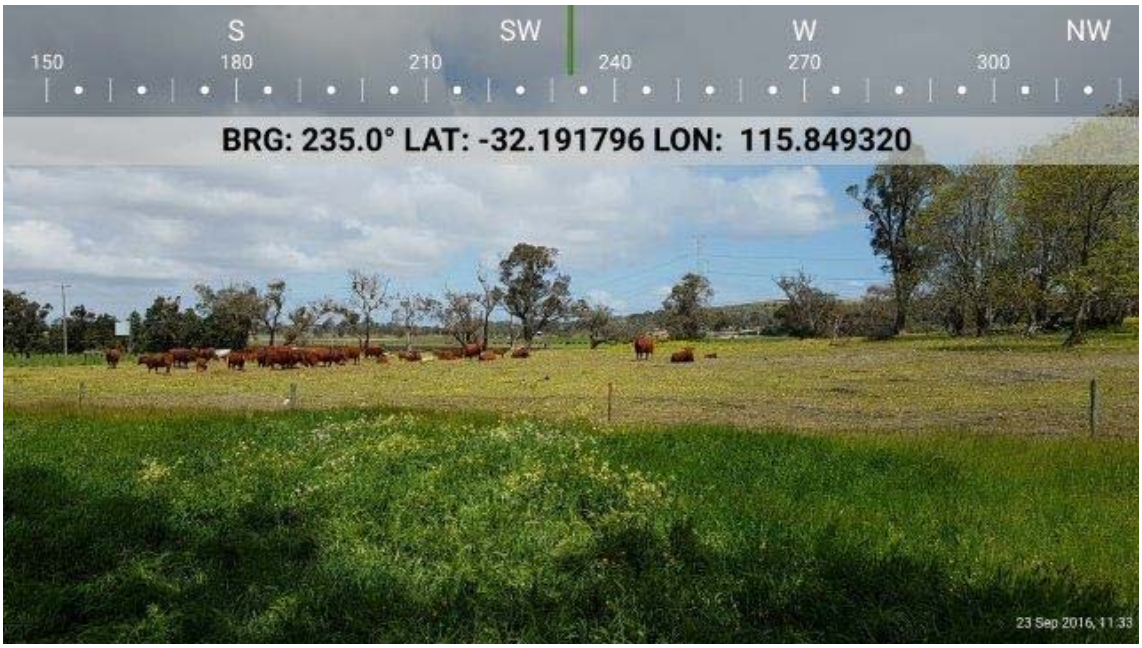


Photo Point 34: Class G grassland adjacent southwest of project area within Lot 682



Photo Point 35: Class G grassland (foreground) and Class B woodland strip (background) adjacent southwest of project area within Lot 682



Photo Point 36: Class G grassland adjacent southwest of project area within Lot 682



Photo Point 37: Class G grassland (left and right) and Class B woodland strip (centre) within project area to the south



Photo Point 38: Class G grassland (foreground) and Class A forest/Class B woodland combination (background) adjacent south of project area within Lot 9006



Photo Point 39: Class G grassland within project area to the south



Photo Point 40: Class G grassland (foreground) and Class B woodland strip (background) within project area to the south



Photo Point 41: Class G grassland within project area to the south



Photo Point 42: Class G grassland within project area to the south



Photo Point 43: Class G grassland within project area to the southeast and adjacent southeast within Lot 9006



Photo Point 44: Class G grassland (foreground) and Class D scrub (background) adjacent east of project area within Lot 9006



Photo Point 45: Class G grassland (foreground) and Class D scrub (background) adjacent east of project area within Lot 9006



Photo Point 46: Class G grassland (foreground) and Class A forest (background) adjacent east of project area within Lot 9006



Photo Point 47: Class G grassland (foreground) and Class D scrub (background) adjacent east of project area within Lot 9006



Photo Point 48: Class G grassland (foreground) and Class D scrub (background) adjacent east of project area within Lot 9006

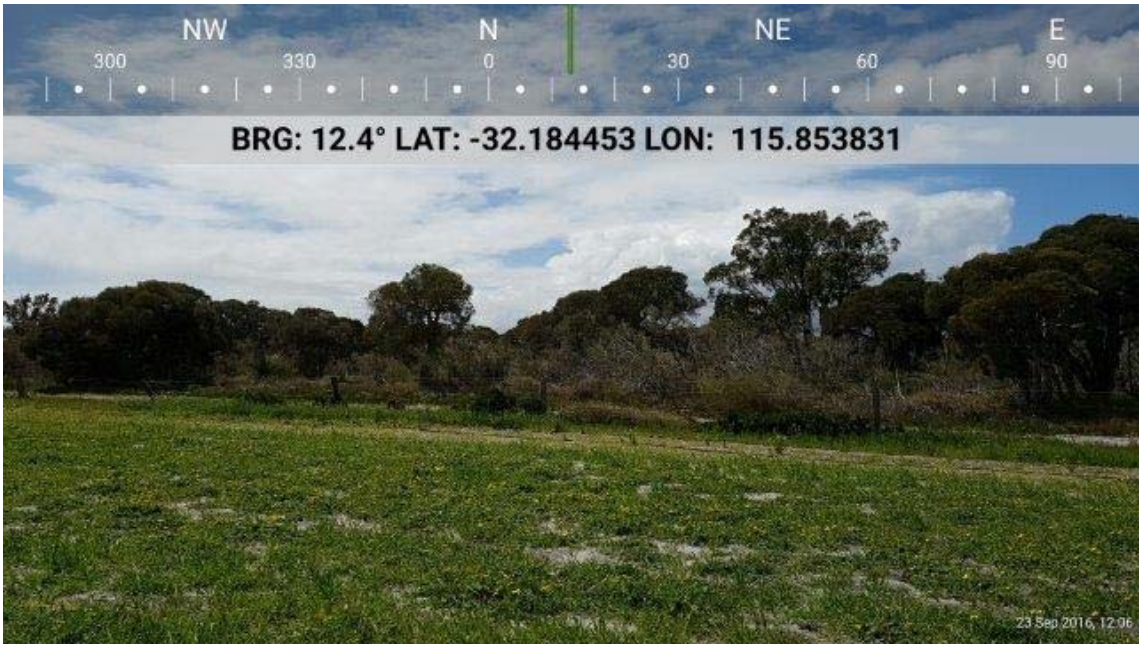


Photo Point 49: Class G grassland (foreground) and Class D scrub (background) adjacent east of project area within Lot 9006

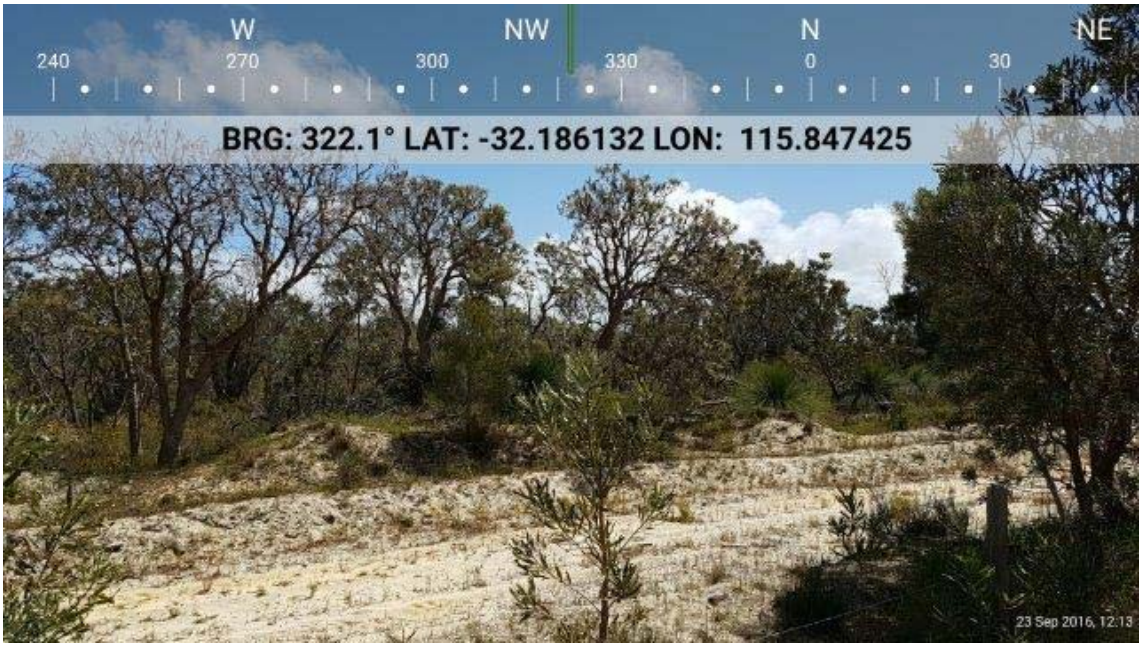


Photo Point 50: Class B woodland adjacent west of project area within Lot 2



Photo Point 51: Class B woodland within project area to the west



Photo Point 52: Class B woodland adjacent west of project area within Lot 2



Photo Point 53: Class B woodland within project area to the west



Photo Point 54: Class B woodland adjacent northwest of project area within Lot 2



Photo Point 55: Class B woodland within project area to the northwest



Photo Point 56: Class B woodland within project area to the north



Photo Point 57: Non-vegetated area (Clause 2.2.3.2 e) adjacent northwest of project area within Lot 2



Photo Point 58: Class G grassland (foreground) and Class B woodland (background) adjacent northwest of project area within Lot 2022



Photo Point 59: Non-vegetated area (Clause 2.2.3.2 e) adjacent northwest of project area within Frankland Avenue road reserve



Photo Point 60: Class B woodland strip adjacent north of project area within Lot 9002

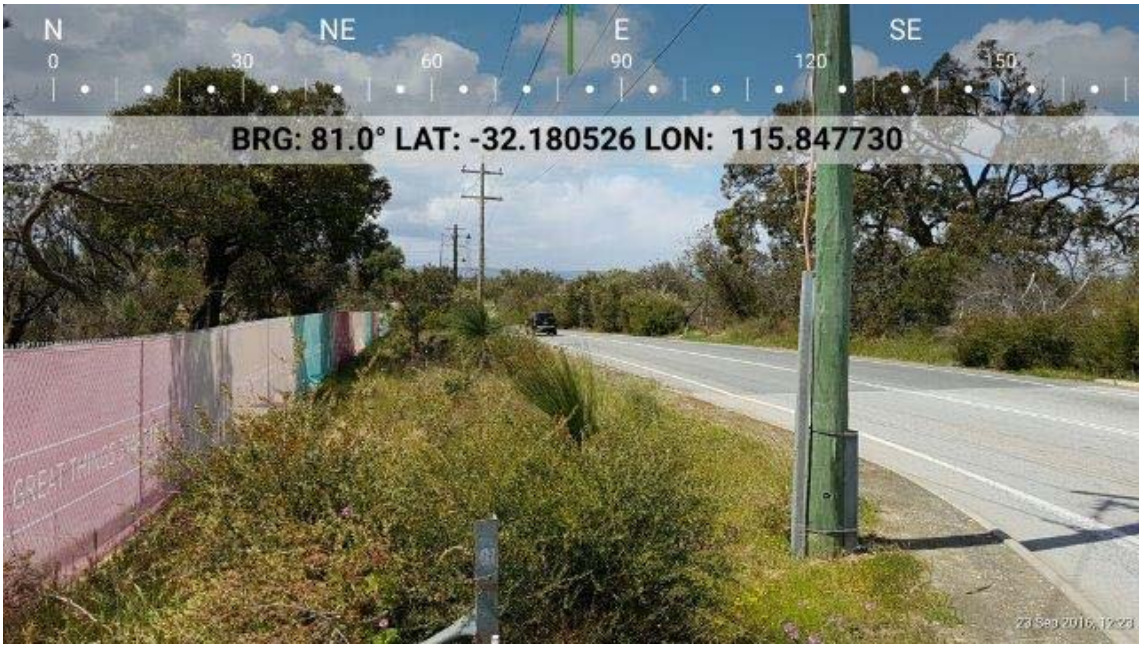


Photo Point 61: Class C shrubland strip adjacent north of project area within Rowley Road reserve



Photo Point 62: Non-vegetated area (Clause 2.2.3.2 e) adjacent northeast of project area within Rowley/Barfield Road reserves

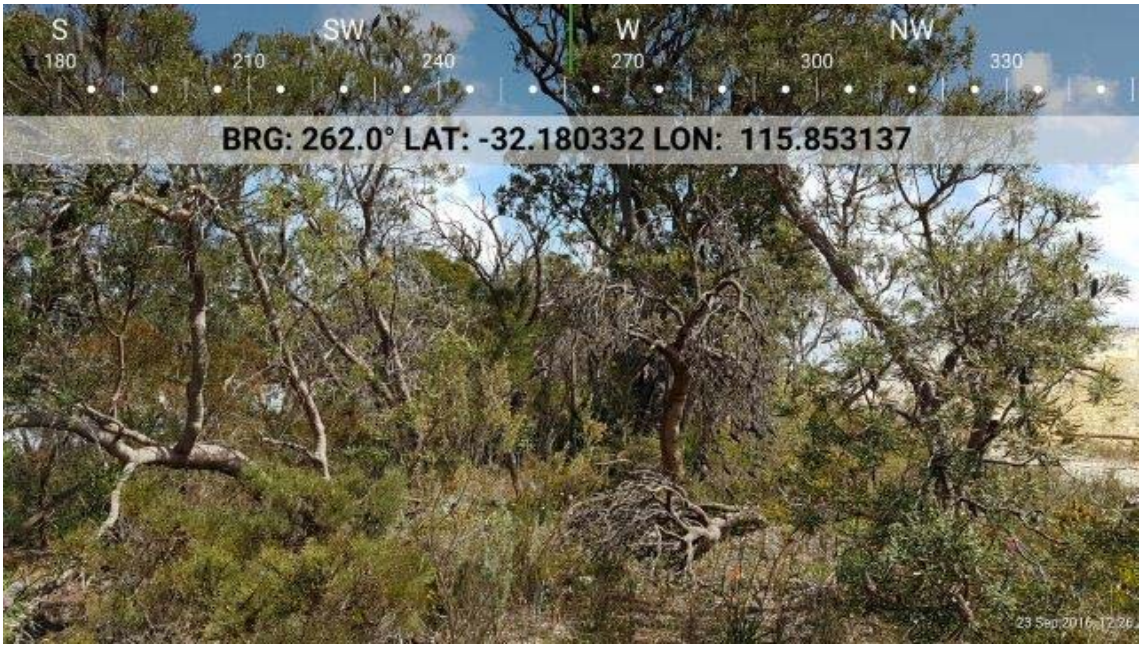


Photo Point 63: Class B woodland strip adjacent north of project area within Lot 9003



Photo Point 64: Non-vegetated area (Clause 2.2.3.2 e) adjacent northeast of project area within Barfield Road reserve



Photo Point 65: Class B woodland adjacent northeast of project area within Lot 301

Appendix 3
Landscape Principles Plan

LANDSCAPE PHILOSOPHY

THE EXISTING SITE CONDITIONS OF THE MANDOGALUP DEVELOPMENT WILL BE USED TO INFORM THE GUIDING URBAN AND LANDSCAPE DESIGN PRINCIPLES FOR THE DEVELOPMENT. THE RUSTIC AGRICULTURAL AND UNTOUCHED NATURAL QUALITIES OF THE SITE INSPIRE A LANDSCAPE PHILOSOPHY THAT COMBINES TWO MAIN PRINCIPLES: A PRODUCTIVE LANDSCAPE CONTRASTED AGAINST A NATURAL LANDSCAPE.

PRODUCTIVE LANDSCAPE

THE PRODUCTIVE AGRICULTURAL LANDSCAPES ARE FOUND ON THE SOUTHERN PORTION OF THE SITE. THEY FEATURE PROLIFIC CROP PLANTING AND OPEN PASTURE LANDS THAT SUPPORT A MIX OF LIVESTOCK (MOSTLY CATTLE). WITH THE REGIONAL MAIN DRAIN RUNNING THROUGH THE SITE, AN EMPHASIS IS PUT ON THE IMPORTANT ROLE WATER PLAYS IN MAINTAINING THESE LAND USES. IT IS AN ESSENTIAL ELEMENT TO THE SITE AND WILL BE REFERENCED ACCORDINGLY AS A GUIDING LANDSCAPE PRINCIPLE. THE PRODUCTIVE LANDSCAPE THEME ALSO REFERENCES THE CULTURAL HERITAGE OF THE SITE AS A FOOD BOWL FOR EARLY NEARBY SETTLEMENT.

NATURAL LANDSCAPE

THE NORTHERN HALF OF THE SITE IS COMPRISED PREDOMINANTLY OF BUSHLAND DOMINATED BY BANKSIA WOODLAND, BUT ALSO FEATURING LARGE JARRAH, MELALEUCA AND FLOODED GUM TREES. RETAINING MATURE TREES, WHERE POSSIBLE, WILL HELP IN REFERENCING THE NATURAL HISTORY OF THE SITE. PLANTING PALETTES FOR STREETSCAPES AND POS AREAS WILL REFERENCE NATIVE SPECIES FOUND ON SITE, IN LINE WITH THE PRINCIPLES OF WATER SENSITIVE URBAN DESIGN.

POS LEGEND

Ⓐ POS A - LARGE NEIGHBORHOOD PARK. PREDOMINANTLY LAWN WITH TREES AND NATIVE GARDEN BED AREAS. FEATURE (ARTWORK, STRUCTURE, ETC) TO TERMINATE VIEW OF MAIN BOULEVARD. LANDSCAPE CHARACTER TO REFERENCE NATURAL BUSHLAND QUALITIES WITH EXTENSIVE RETENTION OF EXISTING MELALEUCAS AND EUCALYPTS. PLAYS AN IMPORTANT VISUAL ROLE TERMINATING THE VIEW FROM THE ROWLEY ROAD ENTRY. INCORPORATE PLAY & PICNIC FACILITES.

Ⓑ POS B - SMALL NEIGHORHOOD PARK FOR INFORMAL PASSIVE & ACTIVE RECREATION COMPRISING PREDOMINANTLY OPEN TURF, GARDEN BED AREAS AND TREES, INCLUDING SHADE STRUCTURE, BENCH SEATS, AND PATH NETWORK.

Ⓒ POS C - MEDIUM SIZED NEIGHBORHOOD POS FOR PASSIVE RECREATION FEATURING LAWN, TREES AND GARDEN BED, INCLUDING PATHS, BENCH SEATS, SHADE STRUCTURE AND ARTWORK. PLAYS AN IMPORTANT VISUAL ROLE TERMINATING THE VIEW ALONG THE MAIN BOULEVARD AS IT CROSSES THE POWER EASEMENT, AND CREATES AN ATTRACTIVE 'GREEN' ENTRY INTO THE SOUTHERN SECTOR.

Ⓓ POS D - A LARGE, FOCAL, CENTRAL OPEN SPACE THAT PLAYS AN IMPORTANT VISUAL ROLE TERMINATING THE VIEW ALONG THE MAIN BOULEVARD. PARK WILL INCORPORATE REINSTATED BUSHLAND (FLANKING & REINFORCING ADJACENT SATTERLEY BUSHLAND PARK). TRAIL/BOARDWALK NETWORK WITH FULLY LANDSCAPED DRAINAGE BASIN. PARK TO INCLUDE SHADE STRUCTURE, BENCH SEATING AND NATURE BASED PLAY AREA.

POS E - SMALL NEIGHORHOOD PARK FOR INFORMAL PASSIVE & ACTIVE RECREATION COMPRISING PREDOMINANTLY OPEN TURF, GARDEN BED AREAS AND TREES, INCLUDING SHADE STRUCTURE, BENCH SEATS, AND PATH NETWORK.

GREEN LINKS

MAIN BOULEVARD:

THE MAIN ENTRY BOULEVARD WILL PROVIDE AN IMPORTANT NORTH-SOUTH GREEN LINK THROUGH THE DEVELOPMENT, LINKING NUMEROUS PARKS & INTERSECTING WITH THE REGIONAL MAIN DRAIN, WHICH FORMS AN IMPORTANT EAST-WEST GREEN LINK. IT WILL INCORPORATE A DEDICATED CYCLEWAY & FOOTPATHS IN AN ATTRACTIVELY LANDSCAPED CORRIDOR, ENCOURAGING PEDESTRIAN & CYCLIST USE.

REGIONAL MAIN DRAIN:

THE REGIONAL MAIN DRAIN IS AN IMPORTANT REFERENCE TO THE RURAL/AGRICULTURAL HERITAGE OF THE SITE AND SHOULD BE CELEBRATED IN THE LANDSCAPE. IT FORMS A SIGNIFICANT EAST/WEST GREEN LINK AND RECREATION CORRIDOR, CONNECTING MAJOR OPEN SPACES AND INTERSECTING WITH THE MAIN BOULEVARD WHICH FORMS THE NORTH-SOUTH GREEN LINK.



POS PRINCIPLES PLAN

SYMBOL KEY

- ALL AGES NATUREPLAY
- JUNIOR NATUREPLAY
- INTERMEDIATE PLAY
- WATER FOUNTAIN
- SHELTER
- PASSIVE RECREATION
- ACTIVE SPORTS FIELD
- SEATING NODE
- ENTRY SIGNAGE
- PICNIC TABLE & BIN
- REVEGETATION
- PATH NETWORK
- BBQ
- DRAINAGE SWALE
- ACCESS POINT
- CONSERVATION
- FENCING
- BRIDGE

MANDOGALUP DEVELOPMENT

PREPARED FOR QUBE PROPERTY GROUP PTY LTD

LANDSCAPE PRINCIPLES PLAN

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JOB NO. 14033-01 M1.101 REV D MAY 2017

1:5000 @ A3

0 25 50 100 150 250m

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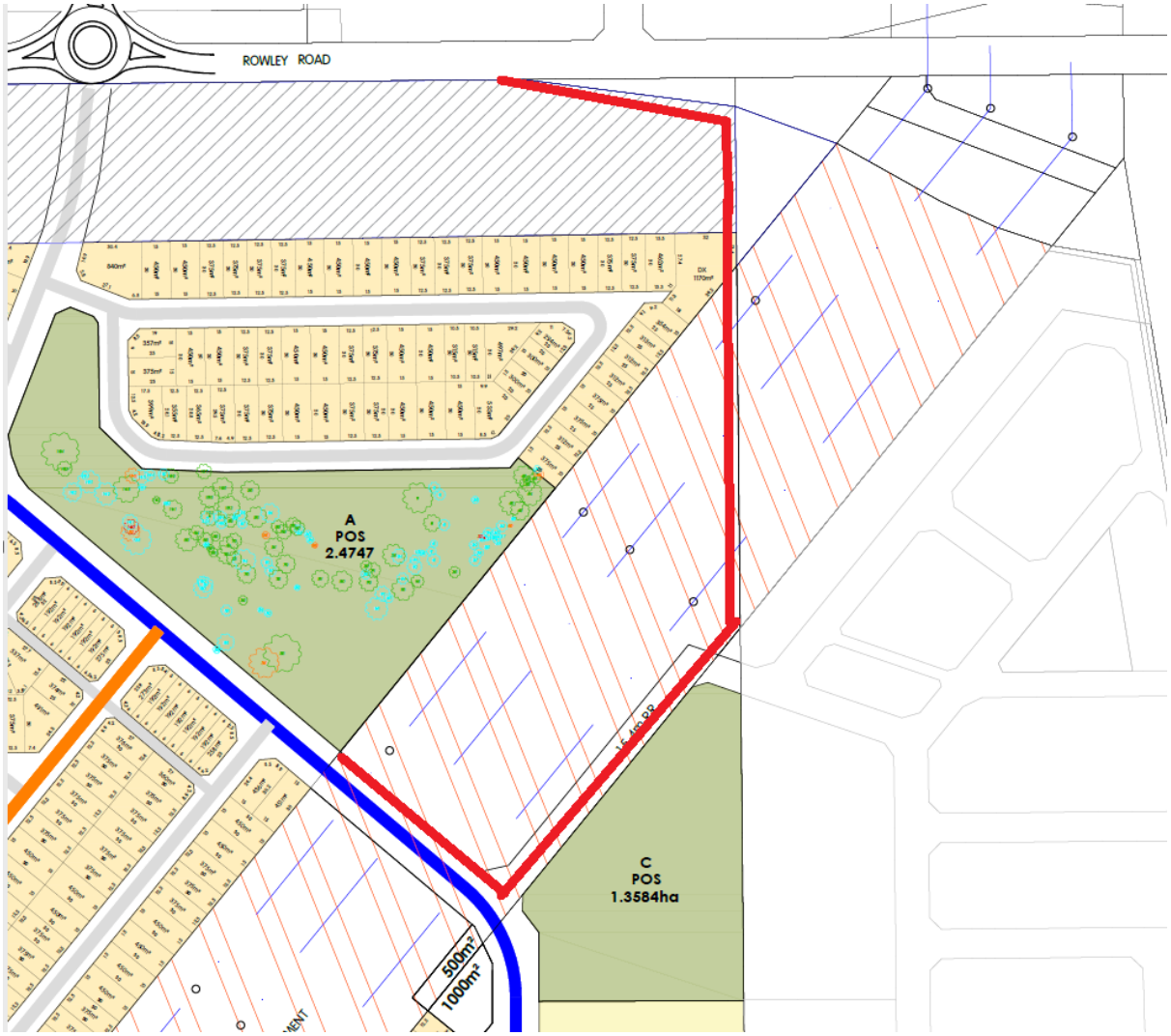
T: (08) 9388 9566 E: mail@plane.com.au
LANDSCAPE PTY LTD ACN 056 538 679

PLAN E

Appendix 4
Temporary emergency access way


ROWLEY ROAD
A
POS
2.4747
C
POS
1.3584ha
500m²
1000m²

Appendix 5
City of Kwinana annual firebreak notice

City of Kwinana

Bush Fires Act 1954

Fire Breaks Notice 2016/17

Pursuant to the powers contained in Section 33 of the Bushfires Act 1954 (as amended), as the property owner or occupier of land within the City of Kwinana, you are hereby required to comply with the requirements set out in this notice.

The applicable works outlined below must be completed before 1 December 2016 and maintained up to and including 31 March 2017.

Land area – 3,001m² or greater

You are required to:

- construct bare earth firebreaks three (3) metres wide inside and along all boundaries of land in a continuous form, including on boundaries adjacent to roads, rail and drain reserves and all public open space reserves, with all overhanging branches, trees, limbs etc. to be trimmed back from over the firebreak area to a minimum height of four (4) metres;



- remove all flammable matter except living trees, shrubs, plants under cultivation and lawns, three (3) metres wide and minimum height of four (4) metres immediately surrounding all buildings situated on the land;
- firebreaks three (3) metres in width and minimum height of four (4) metres are to be cleared immediately surrounding any place where wood or timber piles, hay stacks, tyres, vehicles, flammable liquids, chemicals and gas products are kept on the land; and
- maintained and living lawns are acceptable in conjunction with or in lieu of mineral earth firebreaks, provided that the same minimum width and height requirements for a firebreak are maintained.

Land area – 3,000m² or less

You are required to:

- have all flammable material such as long dry grass, weeds, etc. slashed, mowed or trimmed down by other means to a height no greater than 50mm across the entire property.

Bare earth fire breaks are not necessary on properties that are 3,000m² or less in areas where slashing, mowing or living and maintained garden beds or lawn is established.

Fire break variations

If it is impractical to install a firebreak immediately inside a property boundary, for environmental or any other reasons, you are required to apply to the City of Kwinana in writing by 1 October 2016 to obtain approval to install fire breaks in an alternative position.

Previously approved fire break variations do not need to be reapplied for unless circumstances have changed.

Joanne Abbiss

CHIEF EXECUTIVE OFFICER

www.kwinana.wa.gov.au

Appendix F

Landscape Concept

(Plan E)

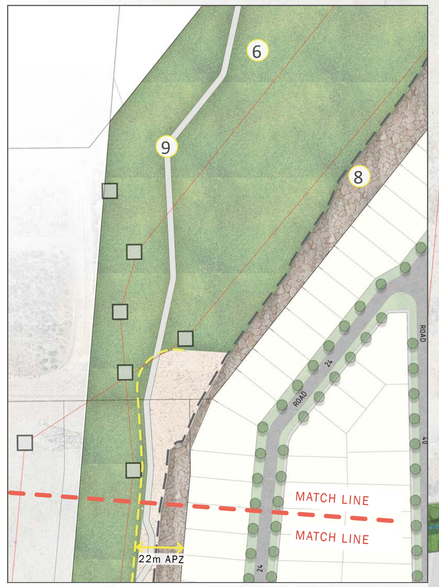


APSLEY ESTATE

1403302 apsley south - landscape concept plan [G]

PLAN E

02 | APSLEY SOUTH
LANDSCAPE MASTER PLAN



INSET PLAN
WESTER POWER EASEMENT

MATCH LINE
MATCH LINE
22m APZ
17m APZ
12m APZ
FERDINAND STR
FERDINAND STREET
WALKER RD
MCMILLAN RD
QUARTERMAINE BLVD
QUARTERMAINE BOULEVARD
LUDWIG LANE
TASMAN CRESCENT
WARBURTON
WARBURTON STREET
HARTOG CRESCENT
GREGORY STREET
ROAD
POWER DISTRIBUTION
BATTER
APZ LINE

LEGEND

01 POS H- REFER DRAWING M1.103

02 POS J - REFER DRAWING M1.105

03 POS F&G - REFER DRAWING M1.107

04 PEEL MAIN DRAIN - REFER DRAWING M1.103 & M1.107 :
20m WIDE EASEMENT WITH REALIGNED PEEL MAIN DRAIN WHERE THERE ARE NO EXISTING TREES

05 POS I - NATIVE SHRUB AND TREE PLANTING:
PLANTED WITH NATIVE LOW SHRUBS AND TREES AS BUFFER TO PEEL MAIN DRAIN

06 WESTERN POWER EASEMENT :
PLANTED WITH NATIVE VEGETATION (<1M MATURE HEIGHT) OUTSIDE APZ AREAS

07 WESTERN POWER EASEMENT DRAINAGE BASIN :
PLANTED WITH NATIVE RUSHES AND SEDGES TOLERANT OF WINTER WET AND SUMMER DRY CONDITIONS

08 WESTERN POWER EASEMENT APZ :
PLANTED WITH LOW FUEL LOAD NATIVE VEGETATION (<0.5M MATURE HEIGHT) WITHIN APZ AREAS

09 DUAL USE PATH

10 POS K DRAINAGE BASIN:
PLANTED WITH NATIVE RUSHES AND SEDGES TOLERANT OF WINTER WET AND SUMMER DRY CONDITIONS

ASSET PROTECTION ZONE (APZ)

PEEL MAIN DRAIN EASEMENT (20.0M WIDE)

APSLEY ESTATE

PREPARED FOR QUBE PROPERTY GROUP

APSLEY SOUTH - LANDSCAPE MASTER PLAN
JUNE 2025

JOB NO. 1403302
1:1250 @ A1

M1.102

0 25 50 72 125m

REV G

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PLAN E
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03 | POS H & PEEL MAIN DRAIN

LANDSCAPE CONCEPT PLAN



LEGEND

01 INSITU CONCRETE PEDESTRIAN PATH NETWORK

02 3.0M WIDE CONCRETE PEDESTRIAN PATH AND MAINTENANCE VEHICLE ACCESS

03 NATIVE LOW SHRUB AND GROUNDCOVER PLANTING

04 OPEN TURF AREA

05 20% AEP DRAINAGE BASIN FOR STORMWATER CATCHMENT TO BE FULLY PLANTED WITH SUITABLE INDIGENOUS NATIVE TREE AND SHRUB SPECIES

06 SHELTER WITH SEATING AND BBQ FACILITIES

07 TODDLER (1-3 YRS) NATURE PLAYGROUND UNDER EXISTING TREE CANOPY

08 JUNIOR (3-8 YRS) NATURE PLAYGROUND

09 SEATING NODE

10 FOOTBRIDGE ACROSS PEEL MAIN DRAIN

11 PEEL MAIN DRAIN CHANNEL - RETAIN EXISTING TREES AND FULLY VEGETATED

12 EXISTING TREES TO BE RETAINED

13 PROPOSED NEW STREET TREES

14 PROPOSED POS TREE PLANTING

15 LOW RETAINING WALL (500MM HIGH)

16 TRANSFORMER

PEEL MAIN DRAIN EASEMENT (20.0M WIDE)

LOCATION MAP

APSLEY ESTATE

PREPARED FOR QUBE PROPERTY GROUP

LANDSCAPE CONCEPT PLAN

JUNE 2025

JOB NO. 1403302

1:400 @ A1

M1.103

REV G

0 8 16 24 40m

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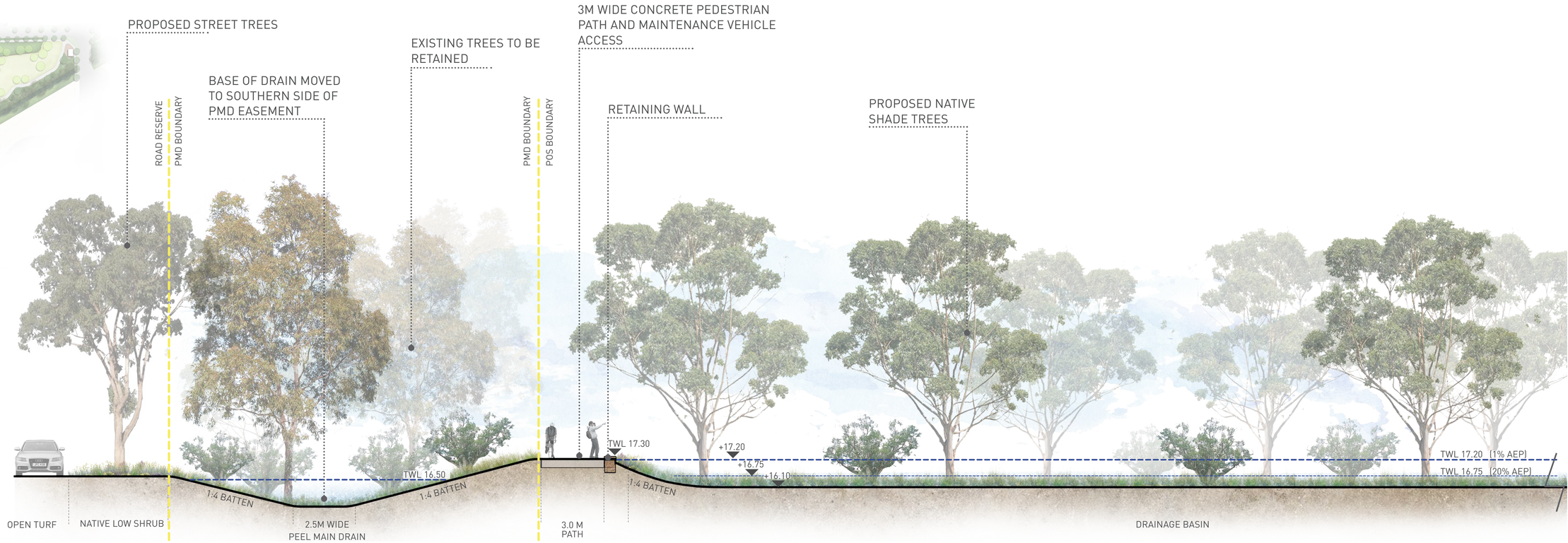
04 | POS H & PEEL MAIN DRAIN

SECTION A



LOCATION MAP



SECTION A-A'



APSLEY ESTATE

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LANDSCAPE CONCEPT PLAN

JUNE 2025

JOB NO. 1403302

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M1.104

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05 | POS J

LANDSCAPE CONCEPT PLAN



LEGEND

01 INSITU CONCRETE PEDESTRIAN PATH NETWORK TO ACCOMMODATE PEDESTRIAN AND MAINTENANCE ACCESS

02 GRAVEL PATH WITH ROCK BOULDERS

03 NATIVE LOW SHRUB AND GROUNDCOVER PLANTING

04 OPEN TURF AREA

05 DRAINAGE BASIN FOR STORMWATER CATCHMENT TO BE FULLY VEGETATED WITH SUITABLE INDIGENOUS TREE AND SHRUB SPECIES

06 SEATING NODE

07 LARGE BOULDER STEPPERS ACROSS SWALE

08 STEP ACCESS TO POS

09 SMALL PLAYGROUND

10 SHELTER WITH SEATING FACILITIES

11 SMALL NATURE PLAYGROUND

12 RETAINING WALL

13 PEDESTRIAN FOOTPATH CONNECTING INTO ESTATE NETWORK

14 DRAINAGE SWALE WITHIN MEDIAN ISLAND

15 OPEN IRRIGATED TURF TO CORNER TO PROMOTE VIEW INTO POS

16 DUAL USE PATH CONNECTING INTO ESTATE NETWORK

17 EXISTING TREES TO BE RETAINED

18 PROPOSED NEW STREET TREES

19 PROPOSED POS TREE PLANTING

20 BOARDWALK CONNECTION ACROSS SWALE



LOCATION MAP

APSLEY ESTATE

PREPARED FOR QUBE PROPERTY GROUP

LANDSCAPE CONCEPT PLAN
JUNE 2025

JOB NO. 1403302
1:400 @ A1

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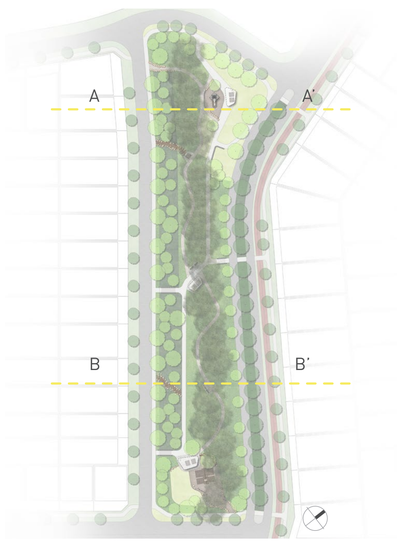
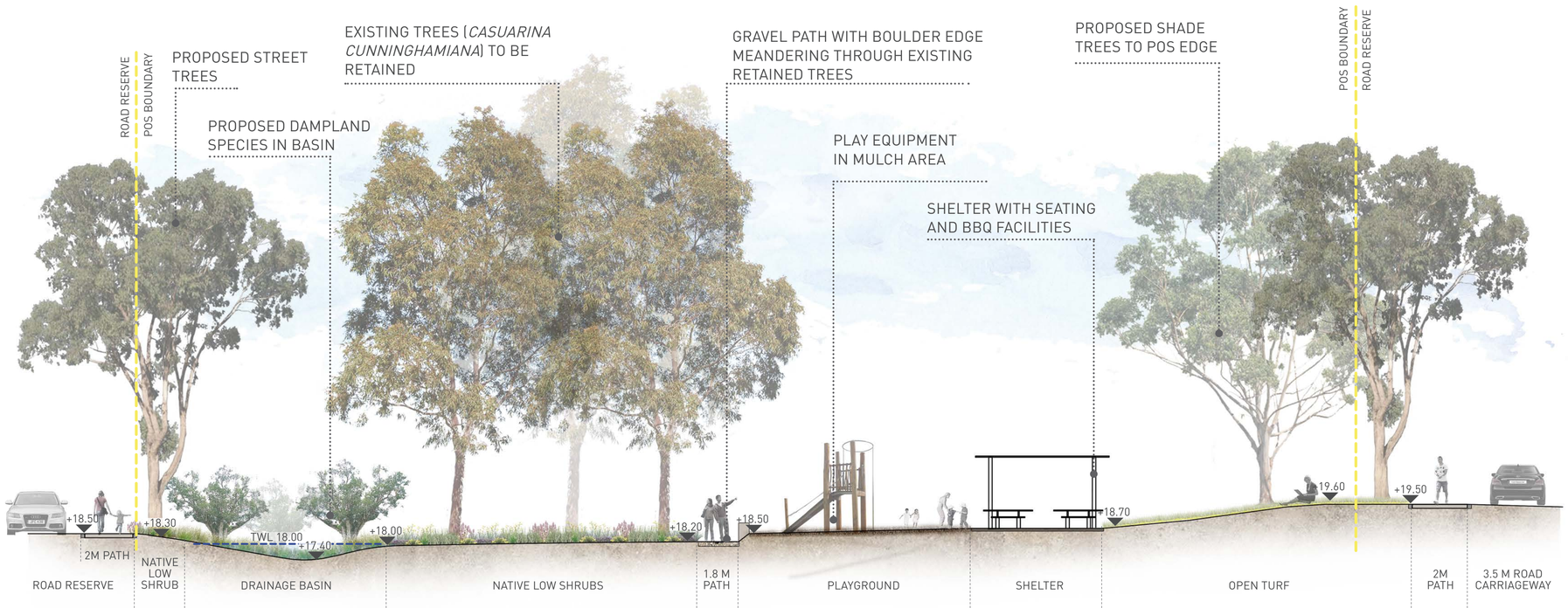
06 | POS J

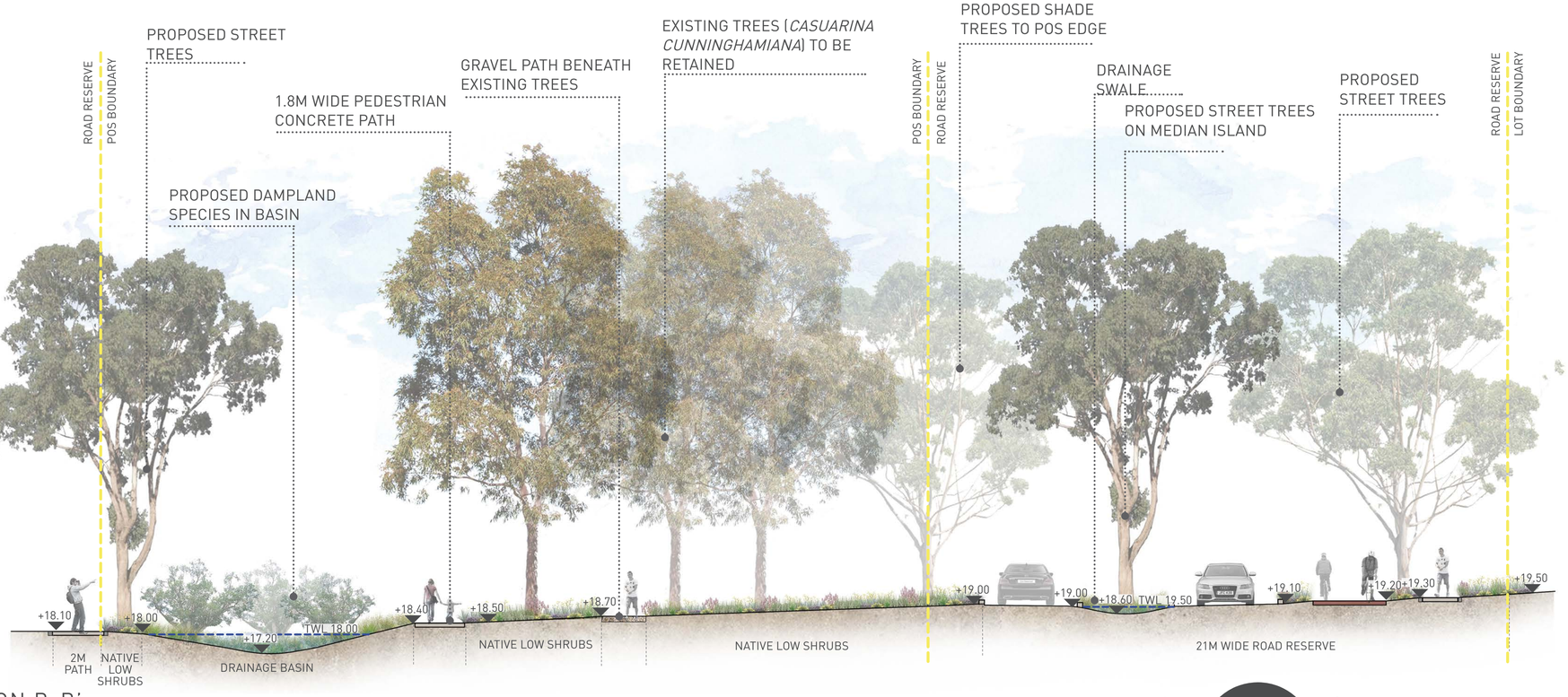
SECTION A & B



LOCATION MAP



SECTION A-A'



SECTION B-B'

APSLEY ESTATE

PREPARED FOR QUBE PROPERTY GROUP

LANDSCAPE CONCEPT PLAN

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1: 100 @ A1

M1.106

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07 | POS F & POS G & PEEL MAIN DRAIN

LANDSCAPE CONCEPT PLAN



LEGEND

01 INSITU CONCRETE PEDESTRIAN PATH NETWORK TO ACCOMMODATE PEDESTRIAN AND MAINTENANCE ACCESS

02 DUAL USE PATH CONNECTING INTO ESTATE NETWORK

03 OPEN TURF AREA

04 NATIVE LOW SHRUB AND GROUNDCOVER PLANTING

05 EXISTING PEEL MAIN DRAIN CHANNEL - RETAIN EXISTING TREES AND FULLY VEGETATED

06 SHELTER WITH SEATING FACILITIES

07 NATURE PLAYGROUND

08 SEATING NODE

09 EXISTING TREES TO BE RETAINED

PEEL MAIN DRAIN EASEMENT (20.0M WIDE)



LOCATION MAP

APSLEY ESTATE

PREPARED FOR QUBE PROPERTY GROUP

LANDSCAPE CONCEPT PLAN
JUNE 2025

JOB NO. 1403302
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M1.107 REV E

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08 | POS F & POS G & PEEL MAIN DRAIN

SECTION A



LOCATION MAP



SECTION A-A'
1:75 @ A1

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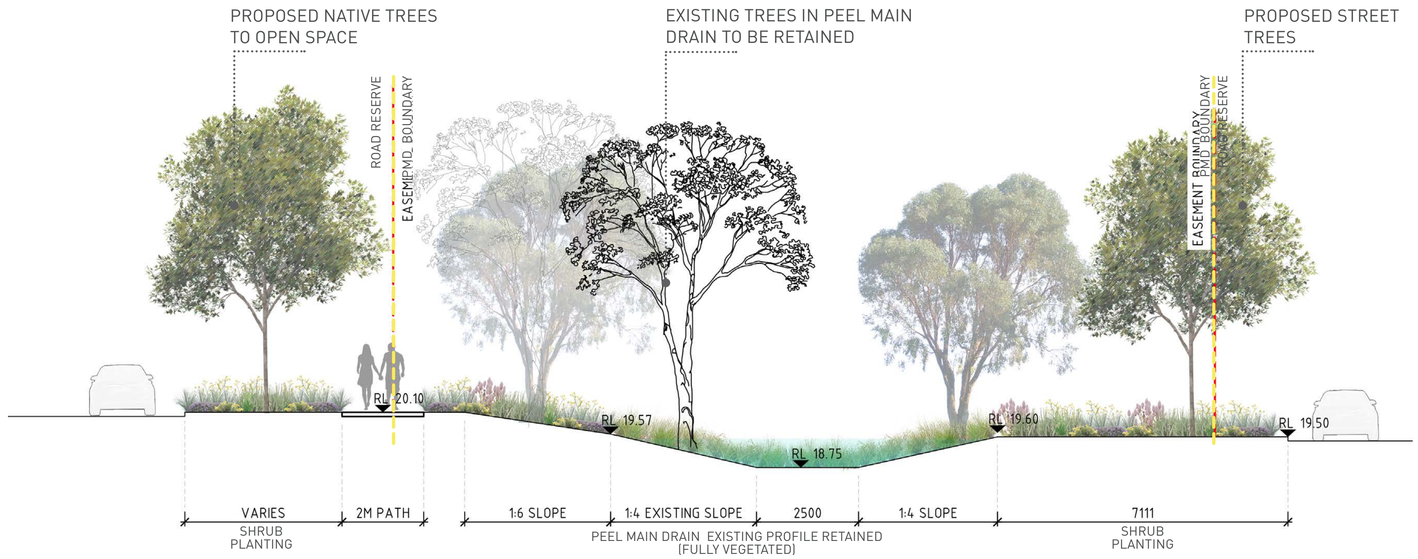
09 | POS F & POS G & PEEL MAIN DRAIN

SECTION B & C



LOCATION MAP



SECTION B-B'
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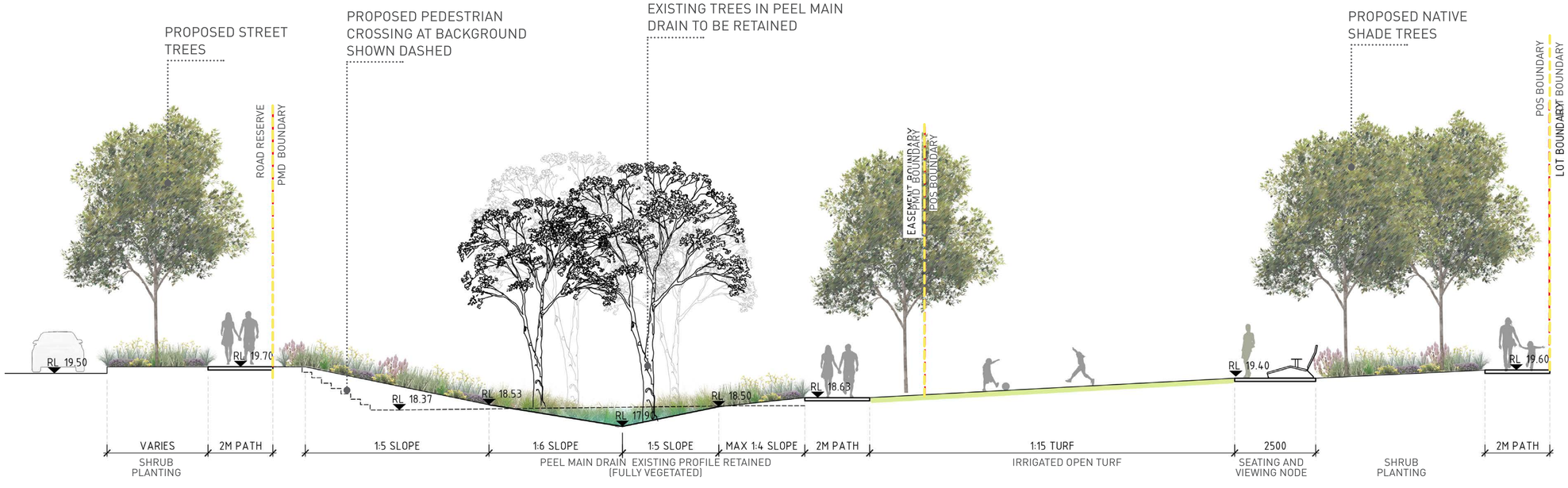

SECTION C-C'
1:75 @ A1

APSLEY ESTATE

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LANDSCAPE CONCEPT PLAN
JUNE 2025

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POS K & WESTERN POWER EASEMENT SOUTH

PROPOSED TREATMENT CONCEPT PLAN





LEGEND

01 PROPOSED SHRUBLAND PLANTING (<1M MATURE HEIGHT TO COMPLY WITH WP CRITERIA, NOTING THE 17M APZ ALLOWS FOR SHRUBS UP TO 2.0M HEIGHT).

02 SHARED USE PATH

03 CRUSHED COMPACTED LIMESTONE SURFACE WITH SCATTERED POCKETS OF LOW PLANTING TO COMPLY WITH APZ CRITERIA

04 DRAINAGE BASIN

05 LIMESTONE PITCHING ON BATTERS

06 POWER LINE PYLONS

07 PROPOSED POS H, REFER TO M1.102

08 PROPOSED POS K

09 PROPOSED SHRUBLAND PLANTING (<1M MATURE HEIGHT TO COMPLY WITH WP CRITERIA, NOTING 22M APZ ALLOWS FOR SHRUBS UP TO 6.0M HEIGHT)

10 PROPOSED GRASSLAND SEDGES AND RUSHES OUTSIDE 12M APZ (<1M MATURE HEIGHT TO COMPLY WITH WP CRITERIA)

11 PROPOSED GRASSLAND SEDGES AND RUSHES IN THIS SECTION OF PEEL MAIN DRAIN, TO EXTEND 13M BEYOND THE CORNERS OF THE RESIDENTIAL LOT BOUNDARIES ON EITHER SIDE OF PMD

BATTER BOUNDARY

APZ LINE

PEEL MAIN DRAIN

D D SECTIONS



LOCATION MAP

APSLEY ESTATE

PREPARED FOR QUBE PROPERTY GROUP

LANDSCAPE CONCEPT PLAN
JUNE 2025

JOB NO. 1403302
1:1000 @ A1

M1.110
REV G

0 20 40 60 100m

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PLAN E

LANDSCAPE ARCHITECTS

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11 | POS K & WESTERN POWER EASEMENT SOUTH

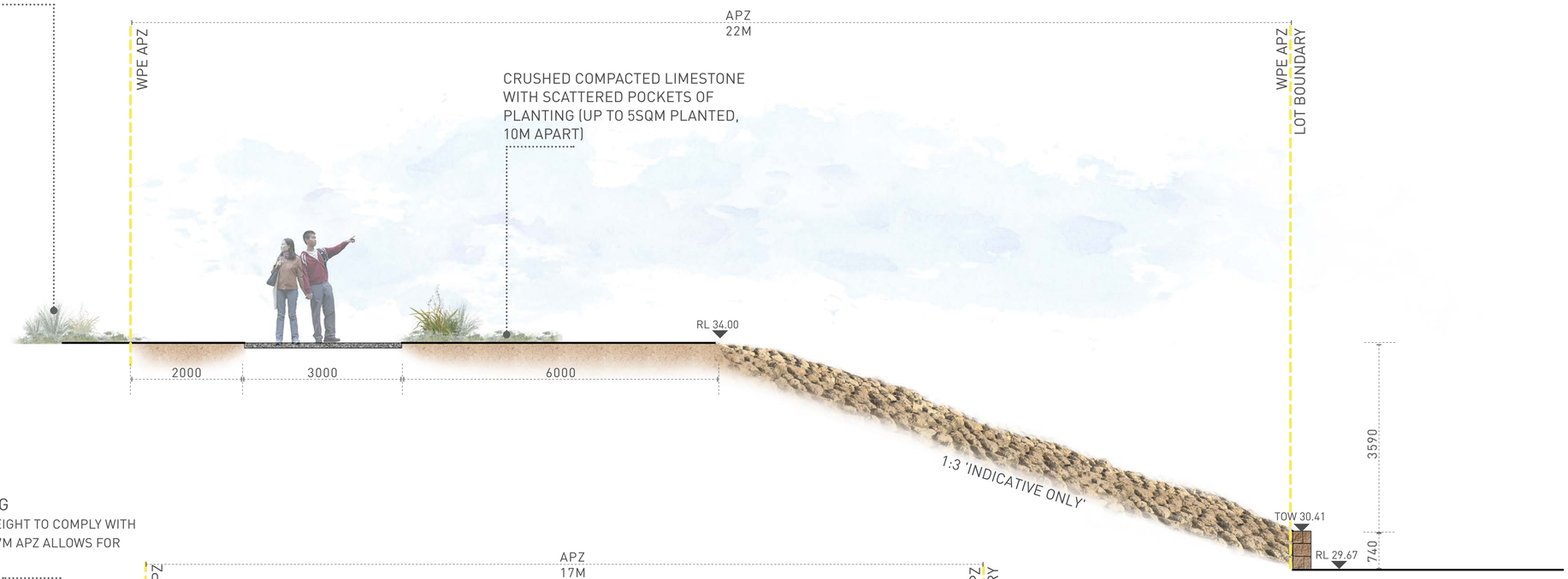
SECTION A & B



LOCATION MAP

SHRUBLAND PLANTING
(LESS THAN 1.0M HEIGHT TO COMPLY WITH WP CRITERUA, NOTING THE 22M APZ ALLOWS FOR SHRUBS UP TO 6M HEIGHT)

SECTION A-A'



SHRUBLAND PLANTING
(LESS THAN 1.0M MATURE HEIGHT TO COMPLY WITH WP CRITERIA, NOTING THE 17M APZ ALLOWS FOR SHRUBS UP TO 2.0M HEIGHT)

SECTION B-B'



'Indicative Only' – detailed design response subject to consultation with the City of Kwinana through the subdivision process. This includes the consideration of materials and treatments such as terraced retaining and stabilised earth battering.

APSLEY ESTATE

PREPARED FOR QUBE PROPERTY GROUP

SECTIONS
JUNE 2025

JOB NO. 1403302
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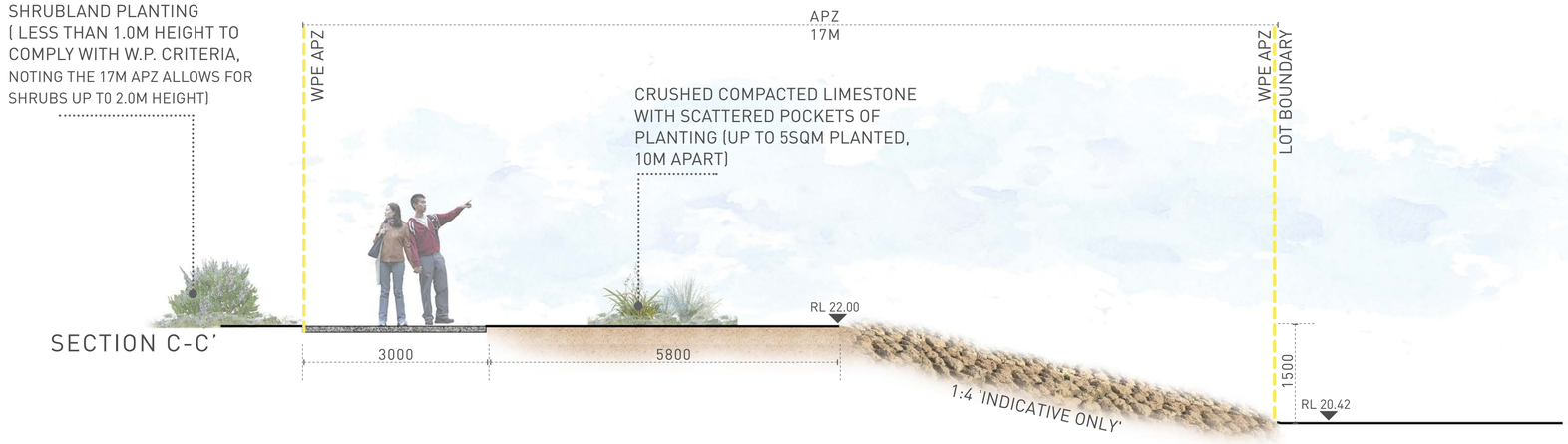
POS K & WESTERN POWER EASEMENT SOUTH

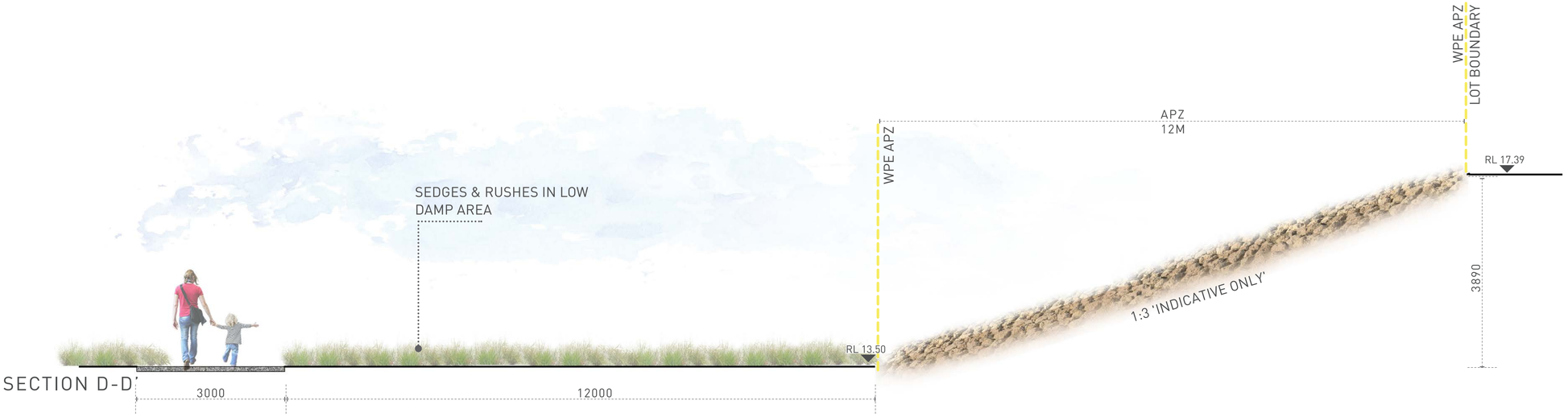
SECTION C, D & E



LOCATION MAP

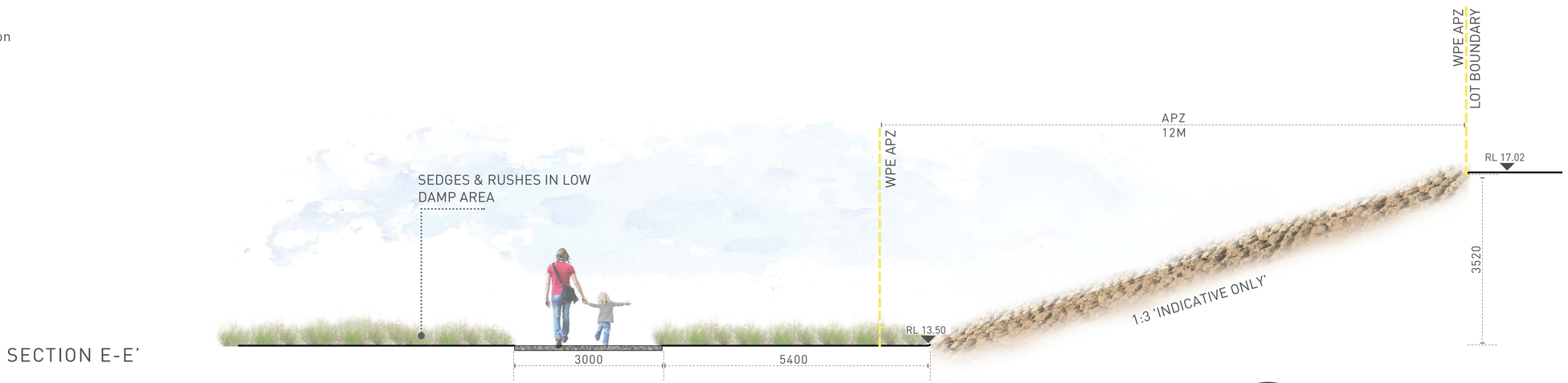


SECTION C-C'



SECTION D-D'

'Indicative Only' – detailed design response subject to consultation with the City of Kwinana through the subdivision process. This includes the consideration of materials and treatments such as terraced retaining and stabilised earth battering.



SECTION E-E'

APSLEY ESTATE

PREPARED FOR QUBE PROPERTY GROUP

SECTIONS

JUNE 2025

JOB NO. 1403302

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M1.112

REV G

0 1 2 3 5m

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PLAN E

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LANDSCAPE PHILOSOPHY

THE EXISTING SITE CONDITIONS OF THE MANDOGALUP DEVELOPMENT WILL BE USED TO INFORM THE GUIDING URBAN AND LANDSCAPE DESIGN PRINCIPLES FOR THE DEVELOPMENT. THE RUSTIC AGRICULTURAL AND UNTOUCHED NATURAL QUALITIES OF THE SITE INSPIRE A LANDSCAPE PHILOSOPHY THAT COMBINES TWO MAIN PRINCIPLES: A PRODUCTIVE LANDSCAPE CONTRASTED AGAINST A NATURAL LANDSCAPE.

PRODUCTIVE LANDSCAPE

THE PRODUCTIVE AGRICULTURAL LANDSCAPES ARE FOUND ON THE SOUTHERN PORTION OF THE SITE. THEY FEATURE PROLIFIC CROP PLANTING AND OPEN PASTURE LANDS THAT SUPPORT A MIX OF LIVESTOCK (MOSTLY CATTLE). WITH THE REGIONAL MAIN DRAIN RUNNING THROUGH THE SITE, AN EMPHASIS IS PUT ON THE IMPORTANT ROLE WATER PLAYS IN MAINTAINING THESE LAND USES. IT IS AN ESSENTIAL ELEMENT TO THE SITE AND WILL BE REFERENCED ACCORDINGLY AS A GUIDING LANDSCAPE PRINCIPLE. THE PRODUCTIVE LANDSCAPE THEME ALSO REFERENCES THE CULTURAL HERITAGE OF THE SITE AS A FOOD BOWL FOR EARLY NEARBY SETTLEMENT.

NATURAL LANDSCAPE

THE NORTHERN HALF OF THE SITE IS COMPRISED PREDOMINANTLY OF BUSHLAND DOMINATED BY BANKSIA WOODLAND, BUT ALSO FEATURING LARGE JARRAH, MELALEUCA AND FLOODED GUM TREES. RETAINING MATURE TREES, WHERE POSSIBLE, WILL HELP IN REFERENCING THE NATURAL HISTORY OF THE SITE. PLANTING PALETTES FOR STREETSCAPES AND POS AREAS WILL REFERENCE NATIVE SPECIES FOUND ON SITE, IN LINE WITH THE PRINCIPLES OF WATER SENSITIVE URBAN DESIGN.

POS LEGEND

Ⓐ POS A - LARGE NEIGHBOURHOOD PARK PLAYS AN IMPORTANT ROLE IN TERMINATING THE VIEW FROM THE ROWLEY ROAD ENTRY. EXTENSIVE RETENTION OF EXISTING BUSHLAND AS FENCED CONSERVATION AREA, WITH CONTROLLED ACCESS THROUGH GATES TO A PATH NETWORK PROVIDING AN ATTRACTIVE WALKING CIRCUIT AND OFFERING SEVERAL SEATING AND VIEWING NODES. THE DEVELOPED PART OF THIS PARK WILL INCORPORATE A LARGE MULTI-AGE NATUREPLAY AREA AND ASSOCIATED PICNIC FACILITIES WITH SHADE STRUCTURE, CONNECTED TO THE REST OF THE PARK BY A PATH NETWORK.

Ⓑ POS B - SMALL NEIGHORHOOD PARK FOR INFORMAL PASSIVE & ACTIVE RECREATION COMPRISING PREDOMINANTLY OPEN TURF, GARDEN BED AREAS AND TREES, INCLUDING SHADE STRUCTURE, BENCH SEATS, AND PATH NETWORK.

Ⓒ POS C - MEDIUM SIZED NEIGHBORHOOD POS FOR PASSIVE RECREATION FEATURING LAWN, TREES AND GARDEN BED, INCLUDING PATHS, BENCH SEATS, SHADE STRUCTURE AND ARTWORK. PLAYS AN IMPORTANT VISUAL ROLE TERMINATING THE VIEW ALONG THE MAIN BOULEVARD AS IT CROSSES THE POWER EASEMENT, AND CREATES AN ATTRACTIVE 'GREEN' ENTRY INTO THE SOUTHERN SECTOR.

Ⓓ POS D - A LARGE, FOCAL, CENTRAL OPEN SPACE THAT PLAYS AN IMPORTANT VISUAL ROLE TERMINATING THE VIEW ALONG THE MAIN BOULEVARD. PARK WILL INCORPORATE A SMALL AREA OF RETAINED BUSHLAND (FLANKING & REINFORCING ADJACENT SATTERLEY BUSHLAND PARK). TRAIL/BOARDWALK NETWORK WITH FULLY LANDSCAPED DRAINAGE BASIN. PARK TO INCLUDE SHADE STRUCTURE, BENCH SEATING AND NATURE BASED, JUNIOR & INTERMEDIATE, PLAY AREA.

Ⓔ POS E - SMALL NEIGHORHOOD PARK FOR INFORMAL PASSIVE & ACTIVE RECREATION COMPRISING PREDOMINANTLY OPEN TURF, GARDEN BED AREAS AND TREES, INCLUDING SHADE STRUCTURE, BENCH SEATS, AND PATH NETWORK.

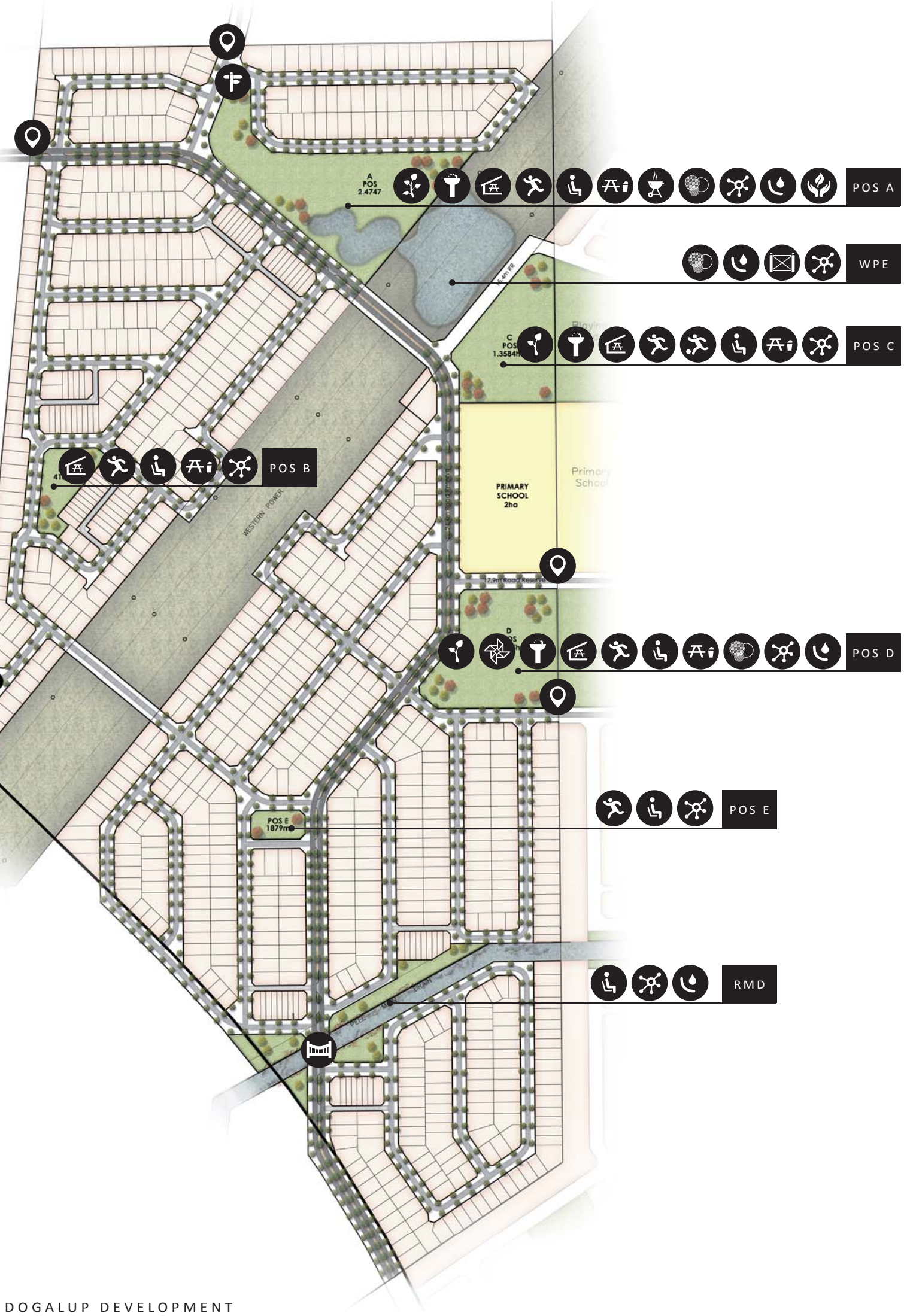
GREEN LINKS

MAIN BOULEVARD:

THE MAIN ENTRY BOULEVARD WILL PROVIDE AN IMPORTANT NORTH-SOUTH GREEN LINK THROUGH THE DEVELOPMENT, LINKING NUMEROUS PARKS & INTERSECTING WITH THE REGIONAL MAIN DRAIN, WHICH FORMS AN IMPORTANT EAST-WEST GREEN LINK. IT WILL INCORPORATE A DEDICATED CYCLEWAY & FOOTPATHS IN AN ATTRACTIVELY LANDSCAPED CORRIDOR, ENCOURAGING PEDESTRIAN & CYCLIST USE.

REGIONAL MAIN DRAIN:

THE REGIONAL MAIN DRAIN IS AN IMPORTANT REFERENCE TO THE RURAL/AGRICULTURAL HERITAGE OF THE SITE AND SHOULD BE CELEBRATED IN THE LANDSCAPE. IT FORMS A SIGNIFICANT EAST/ WEST GREEN LINK AND RECREATION CORRIDOR, CONNECTING MAJOR OPEN SPACES AND INTERSECTING WITH THE MAIN BOULEVARD WHICH FORMS THE NORTH-SOUTH GREEN LINK.



POS PRINCIPLES PLAN

SYMBOL KEY

- ALL AGES NATUREPLAY
- JUNIOR NATUREPLAY
- INTERMEDIATE PLAY
- WATER FOUNTAIN
- SHELTER
- PASSIVE RECREATION/ KICK ABOUT
- ACTIVE SPORTS FIELD
- SEATING NODE
- ENTRY STATEMENT
- PICNIC TABLE & BIN
- REVEGETATION
- PATH NETWORK
- BBQ
- DRAINAGE SWALE
- ACCESS POINT
- CONSERVATION
- FENCING
- BRIDGE

MANDOGALUP DEVELOPMENT

PREPARED FOR QUBE PROPERTY GROUP PTY LTD

LANDSCAPE PRINCIPLES PLAN

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PLAN E

MANDOGALUP DEVELOPMENT – LANDSCAPE PHILOSOPHY

The existing site conditions of the Mandogalup development will be used to inform the guiding urban and landscape design principles for the development. While much of the site has been cleared, there are remnant pockets of bushland as well as references to the agricultural heritage of the area, which inspire a landscape philosophy that combines 2 main principles; a productive agricultural landscape contrasted against a natural bush landscape.

The productive agricultural landscapes are found on the southern portion of the site. They feature crop planting and open pasture lands that support a mix of livestock (mostly cattle, but also some sheep). With the regional main drain running through the site, an emphasis is put on the important role water plays in maintaining these land uses. It is an essential element to the site and will be referenced accordingly as a guiding landscape principle. The productive landscape theme also references the cultural heritage of the Mandogalup area as a food bowl, established in the 1920's as part of the Group Settlement Scheme to encourage the development of agricultural land and thereby reduce reliance on food imports from interstate. The area contained many farms in the arable land amongst the wetlands.

Two avenues of mature existing trees are also proposed to be retained; these would have been planted as part of the agricultural development of the site, providing windrows. One is an avenue of pine trees and the other is an avenue of Casuarinas and Eucalypts. Their retention provides reference to the cultural heritage of the site, and will assist in providing visual and environmental amenity.

Natural bushland dominated by Banksia woodland but also featuring Jarrah and Melaleuca occupies the northern portion of the site. A substantial portion of Banksia woodland incorporating some mature Jarrah and Melaleuca has been identified for retention within future POS and will be fenced. Controlled access will be provided into the retained bushland through gates, with a path network providing an attractive walking circuit and offering several seating and viewing nodes. The developed part of this POS will incorporate a multi-age natureplay area and associated picnic facilities, connected to the rest of the park by a path network.

An existing bush reserve containing high quality Flooded Gum woodland on the adjoining Mandogalup East landholding will be retained as open space, abutting the eastern boundary of the site; the Mandogalup West development plan proposes an extension of this POS to capture the western extremity of this retained bushland, and forming a large central POS within the development, which will benefit from the visual and environmental amenity afforded by this retained bush. This POS will incorporate open grassed areas for informal passive and active recreation, junior and intermediate play facilities and picnic facilities connected by a path network, and will also accommodate stormwater drainage.

Existing mature trees (predominantly Flooded Gum) will be retained along the main drain, and scattered specimens of Eucalypts and Casuarinas will be retained in future open space adjoining the main drain, forming an attractive east-west green spine incorporating seating nodes and a path network.

Landscape theming will draw inspiration from the existing site conditions of a productive agricultural landscape contrasted against a natural bush landscape. Predominantly native vegetation is proposed for streetscapes and POS, however exotic trees typically associated with rural properties and farms will be used selectively in POS areas; this will include species such as Jacarandas and Coral Trees, and also ornamental pears and other species which reference orchard plantings. Laterite stone, already used for drop weirs in the main drain, will be used for feature walls and structures in POS areas, and also as a feature element in lot retaining walls and fences. In some locations drainage channels may be formalised to reference the constructed drains associated with agricultural landscapes. Other features such as water standpipes, tanks and windmills may be referenced in the landscape as objects of interest or public art to reflect the historical significance of water to this site. Earthy tones are proposed for paths and lot walls to reflect the agricultural soils, and road treatments will be kept simple, with black asphalt throughout. The main north-south boulevard may be in red asphalt to reflect the importance of this road as a pedestrian green spine.

Appendix G

Transport Assessment Report

(Transcore)

Engineering a better future for over 20 years!

Mandogalup West

Proposed Amended Local Structure Plan

Transport Impact Assessment

PREPARED FOR:
Qube

April 2024

Document history and status

Author	Revision	Approved by	Date approved	Revision type
Mohammad Rasouli	r01	Behnam Bordbar	03/04/2024	Draft
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Mohammad Rasouli	r01b	Behnam Bordbar	25/06/2025	Revised Final

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Author: Mohammad Rasouli

Project manager: Mohammad Rasouli

Client: Qube

Project: Mandogalup West

Document revision: r01b

Project number: t24.076

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1 Introduction and Background

Transcore prepared a revised TIA report for the Mandogalup West Local Structure Plan (MWLSP) in November 2017. At the time of preparation of the MWLSP TIA report the area to the south west of the MWLSP was zoned as urban differed and was not included in the MWLSP.

The Metropolitan Region Scheme (MRS) has since been amended to rezone land to the south west of the MWLSP from the Urban Deferred to the Urban zone, as shown in **Figure 1**. Hatch consulting has prepared an amended LSP for the Qube Mandogalup including the urban zone to the south west which is the subject of this TIA.

Transcore prepared a TIA in April 2024 for the amended LSP. The Western Australian Planning Commission (WAPC) recently endorsed the Amendment No. 1 to the Mandogalup West Structure Plan, subject to modifications. The traffic related modifications are listed below:

- Identify the width of road reserves (access streets) according to the City of Kwinana specifications.
- Identify road reserves adjacent to Parks, Recreation, and Drainage areas that are wide enough for sufficient on-street parking without encroaching into these areas, as per City of Kwinana specifications.
- Confirm the alignment of, the width of, and the likely intersection treatments for the east-west neighbourhood connector and any other roads connecting to the Mandogalup Improvement Scheme area, to the southwest, to the specifications of the Department of Planning, Lands and Heritage (DPLH).

This Revised TIA is prepared to address the above traffic matters and reflect the updated LSP prepared by Hatch consulting.

Transcore was the traffic engineer for Mandogalup East Local Structure Plan (MELSP) and prepared a TIA in November 2017 on behalf of Satterley Property Group for the proposed MELSP.

Both MELSP (referred to as Florence) and MWLSP (referred to as Apsley) depicted in **Figure 2**, received endorsement from the Western Australian Planning Commission (WAPC) in March 2018. The approved MELSP and MWLSP aim to deliver a total of 607 and 911 residential lots respectively. Collectively, the approved LSPs are expected to generate a combined total of 1,518 new residential lots. Subdivision for the Florence (MELSP) and Apsley (MWLSP) estates is currently progressing in accordance with the approved structure plans.

Since the preparation of the LSPs, The Western Australian Planning Commission (WAPC) prepared an Improvement Plan (IP47) for the land to the west and south of the LSPs. The IP47 came into effect on 12 April 2019 and following Gazettal of the

draft Improvement Scheme, it will provide a framework for future planning and development.

In January 2024, Taylor Burrell Barnett prepared the Improvement Scheme Report for Department of Planning, Lands and Heritage (DPLH) in support of the Mandogalup Improvement Scheme No. 1. A copy of the Mandogalup Improvement Scheme concept plan is provided in **Appendix A**.

Transcore also prepared a Technical Note (Technical Note 1a dated 02 June 2023) to assess the impact of the proposed IP47 to traffic pattern of the MWLSP and MELSP.

The suggested access strategy to Hammond Road in Transcore Technical Note is generally in line with the access strategy documented in the Improvement Scheme Report as shown in Appendix A.

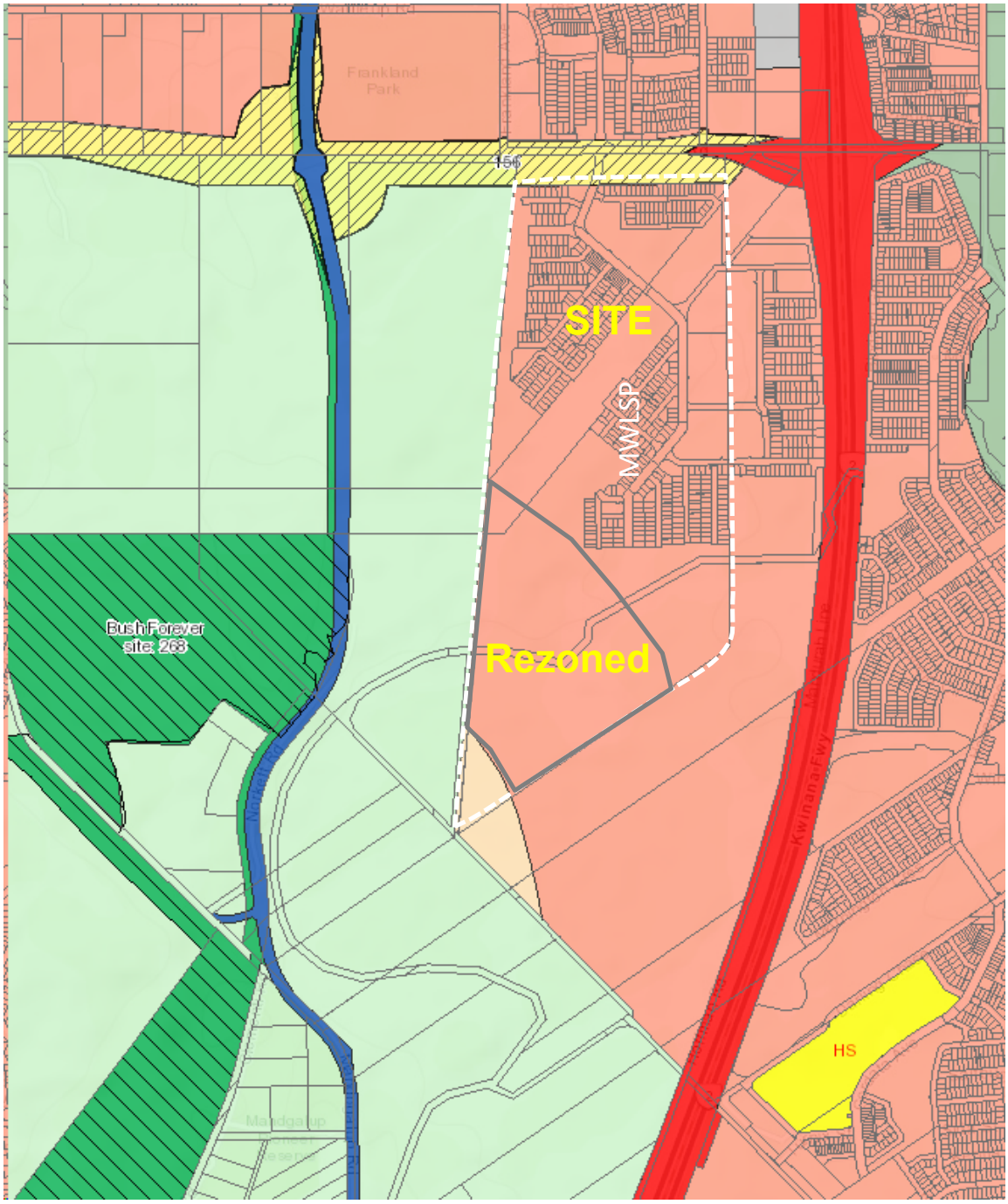


Figure 1: Site location including the land rezoned from Urban Deferred to Urban in the MRS

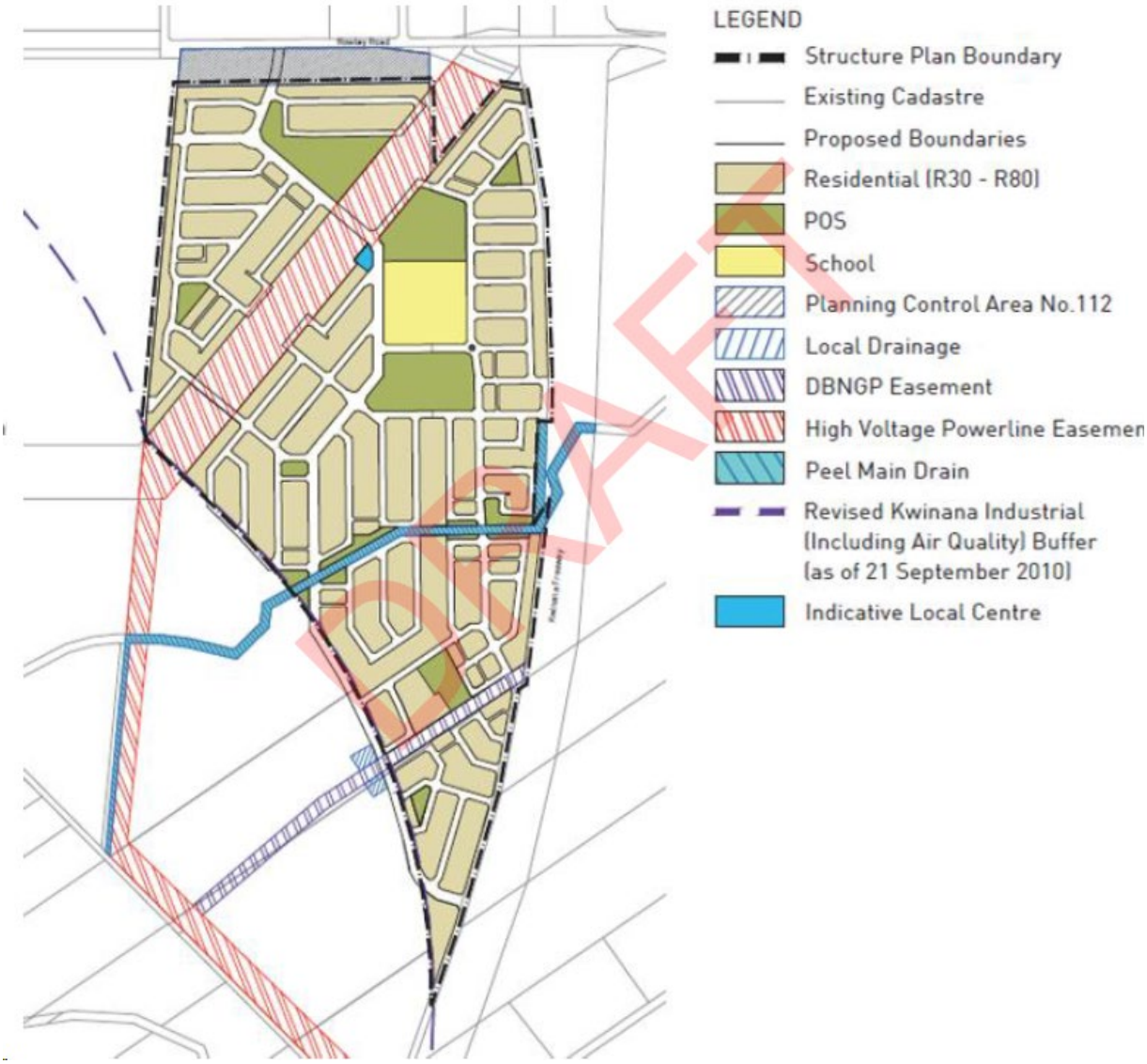


Figure 2: Combined approved Mandogalup East and West Concept Plan

The proposed MWLSP and MELSP areas are located on the western side of the Kwinana Freeway and south of Rowley Road, as shown in **Figure 3**. The subject of this TIA is MWLSP. However, the traffic modelling and analysis undertaken in this TIA include the traffic generation of both MWLSP and MELSP.



Figure 3: Location of the Subject Site

2 Proposed Amended Local Structure Plan

The revised amended Local Structure Plan is shown in **Figure 4**.

Currently, there is an ongoing subdivision development in the northern part of the amended LSP area. The amended LSP is currently linked to Rowley Road through a roundabout intersection at Rowley Road/Quartermain Blvd/Irvine Pde.

According to the Vivente Master Plan in Hammond Park, Irvine Pde (the northern leg of the roundabout intersection on Rowley Road) would be closed after completion of Vivente subdivision or earlier subject to council or Main Roads WA approval. Therefore, the existing roundabout intersection on Rowley Road would be converted to a 3-leg roundabout with additional spare capacity in near future.

Quartermain Blvd serves as the primary north-south spine road within the amended LSP area, and there are plans to extend it southward to connect with Mandogalup Road at the southern end. In addition to the southern connection, two additional connections are proposed for future development. One connection is planned at the southern boundary of the amended LSP area, and another connection is planned through continuation of Goldwyer Drive. These additional connections will provide further access and connectivity within the amended LSP area.

According to the information provided to Transcore, there may be a potential delay in establishing the northern connection to Hammond Road (via Goldwyer Drive) due to uncertainty around the development of Lot 2 which is located between MWLSP and future Hammond Road.

To address the concern regarding the availability of the northern connection to Hammond Road, an investigation has been conducted for a connection further south along the Western Power corridor. This alternative connection aims to ensure that an alternate route would be available in case the northern connection is delayed.

The proposed alternative connection would intersect with Access Street C, which crosses the Western Power corridor and provides connectivity to both sides of the amended LSP area as shown in **Figure 4**. The transport modelling and analysis undertaken in this TIA have confirmed that the projected traffic volumes on Access Street C would not exceed the threshold of 3,000vpd for Access Street C, and the allocated road reserve for this street, is sufficient to accommodate the additional traffic from the proposed alternative connection.

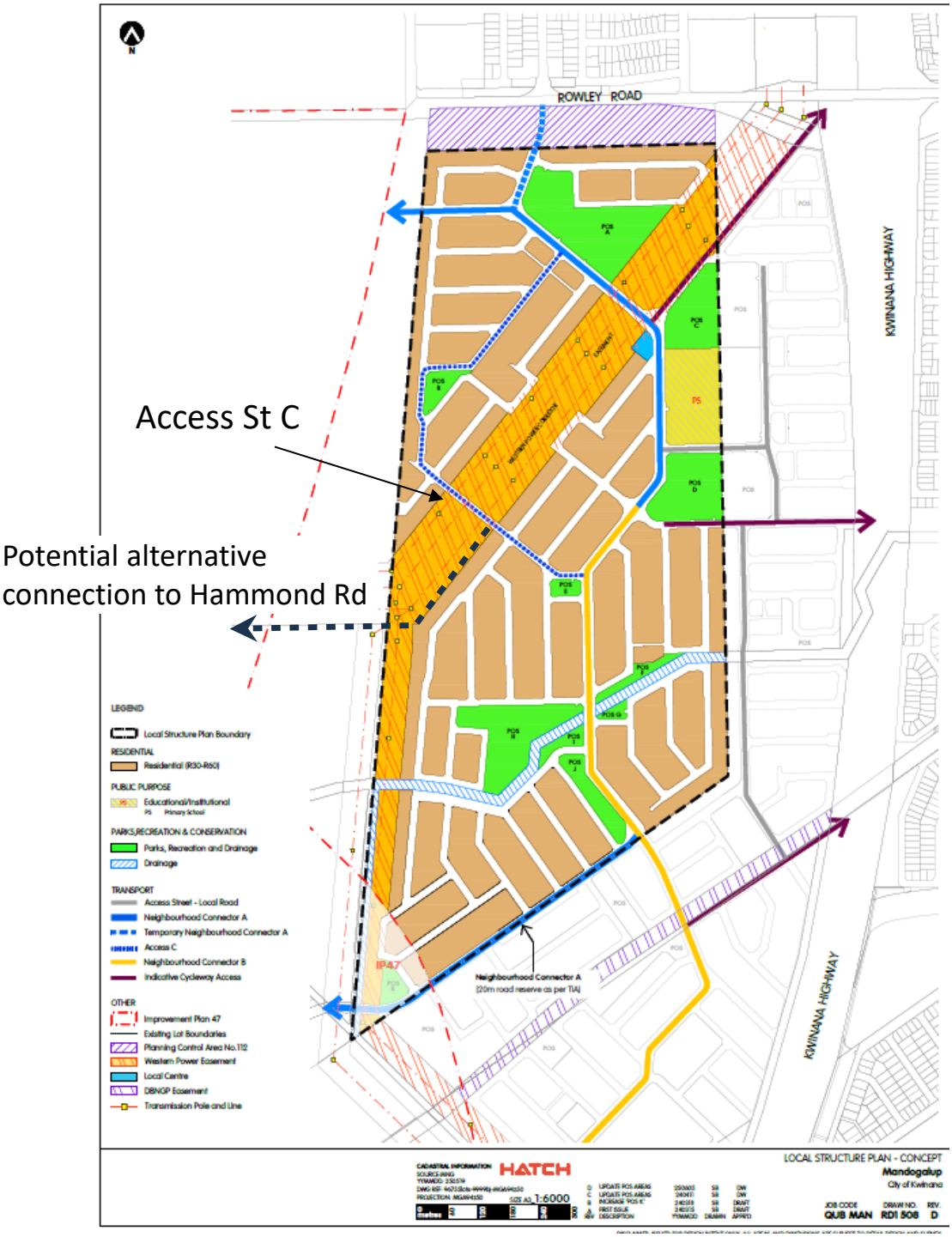


Figure 4: Proposed Amended Local Structure Plan

3 Existing Situation

3.1 Existing Land Use

Currently, there is an ongoing subdivision development in the northern part of the site.

3.2 Existing Road Network

The existing road network and its classification in the Main Roads WA functional road hierarchy is illustrated in **Figure 5**.

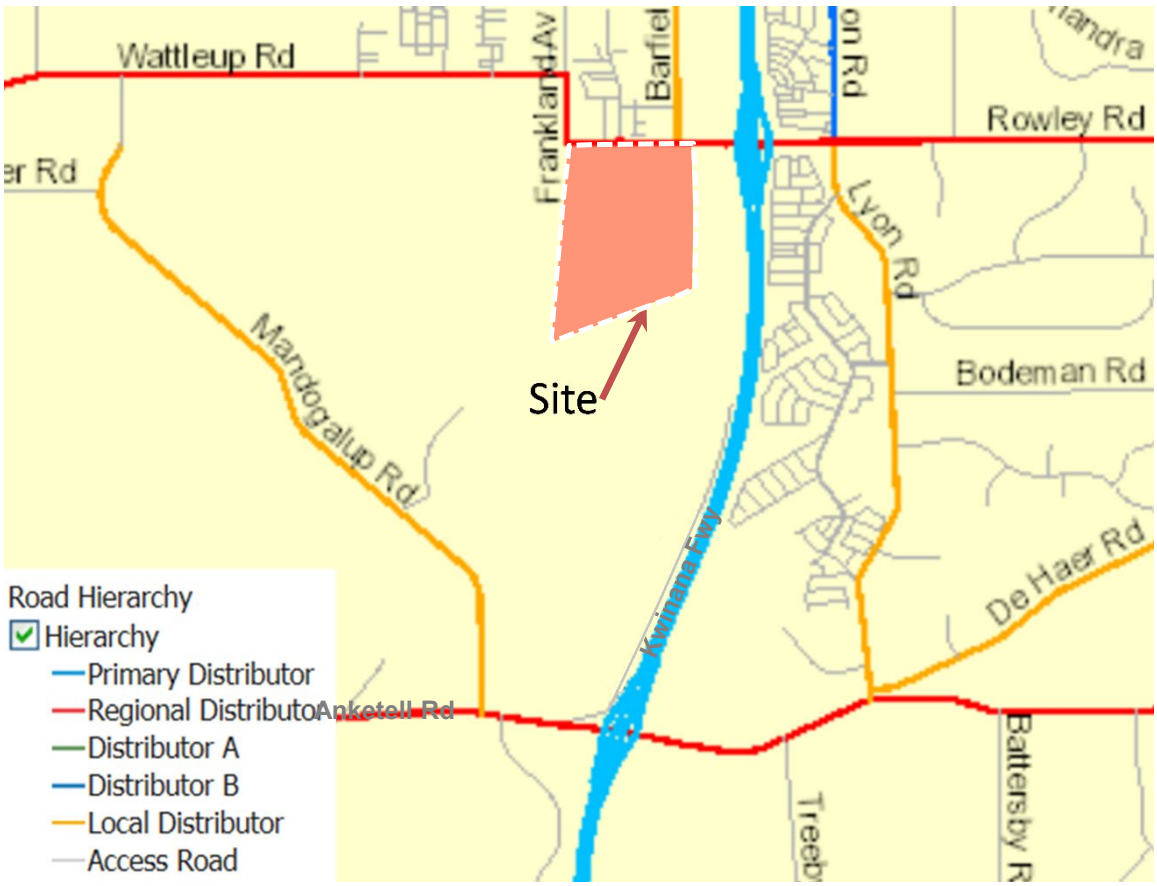


Figure 5: Existing road hierarchy

Rowley Road is classified as a Regional Distributor in the Main Roads WA Functional Road Hierarchy and is currently constructed as a rural standard single carriageway road. Rowley Road provides an east-west connection between South Western Highway (via Eleventh Road in Armadale), Tonkin Highway, Kwinana Freeway and Rockingham Road in Wattleup (via Wattleup Road).

Anketell Road is classified as a Regional Distributor in the Main Roads WA Functional Road Hierarchy and is constructed as a single carriageway road. The existing posted speed limit on Anketell Road (about 150m west of the Hoffman Road intersection) is 80km/h for westbound and 70km/h for eastbound directions.

Anketell Road has been identified as an alternative freight route to the Naval Base / Kwinana Beach industrial areas. Liaison with Department of Planning, Lands & Heritage and Main Roads WA indicates that ultimately a dual divided carriageway standard is planned for Anketell Road.

Mandogalup Road is classed as a Local Distributor primarily running in a north-south direction from Wattleup Road in the north to Anketell Road in the south. The posted speed limit along this road typically varies between 70 and 80 km/h.

Mandogalup Road is constructed as a single carriageway with rural standards, and it occupies a road reserve width of approximately 20 meters. Currently, there is no dedicated infrastructure available for pedestrians or cyclists along this road.

3.3 Existing Traffic Volumes

Existing average weekday traffic (AWT) volumes on surrounding roads have been obtained from Main Roads WA and are illustrated in Figure 6.

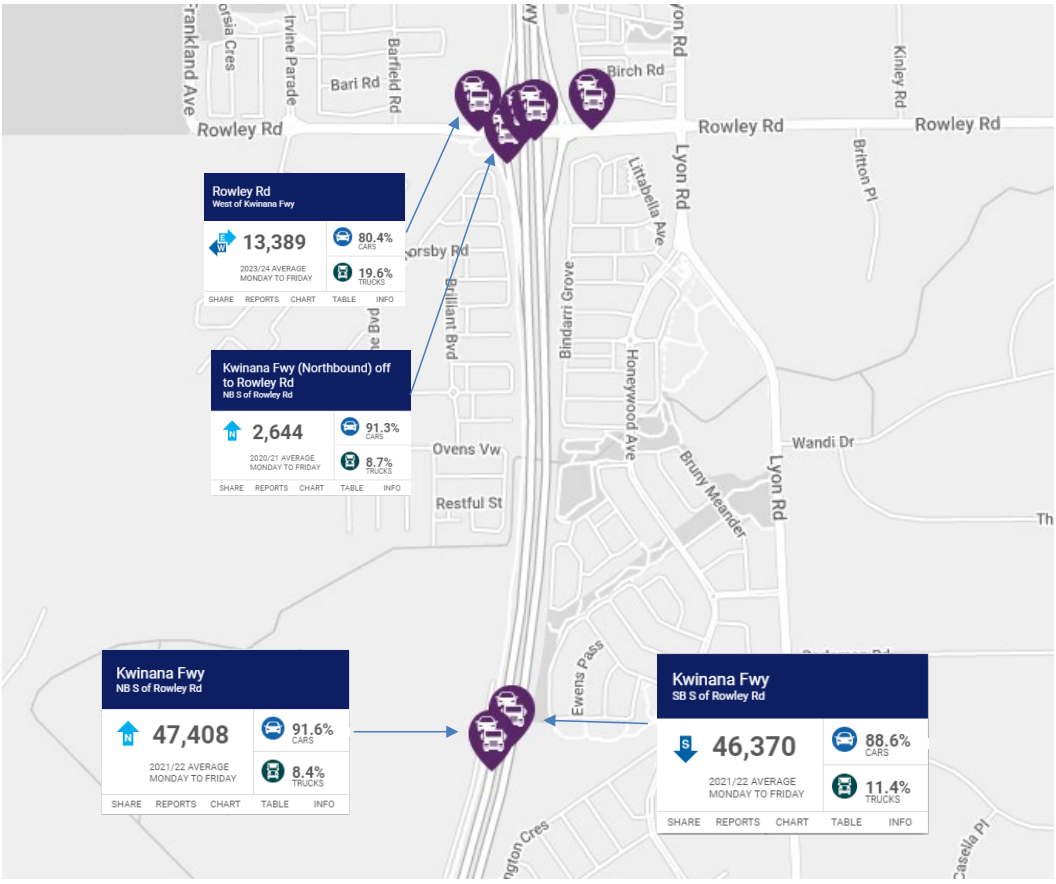


Figure 6: Existing traffic volumes

Anketell Road carried about 22,122vpd in 2023/2024 immediately west of Kwinana Freeway. The existing turning counts at the intersection of Anketell Road/ Mandogalup Road were also sourced from Main Roads WA traffic map (dated Tuesday 27th October 2020). **Figure 7** illustrates the existing traffic counts at the intersection.

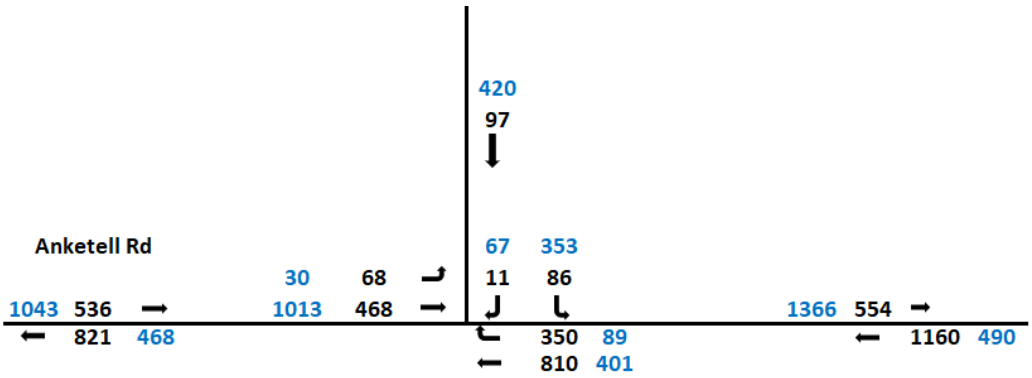


Figure 7: Existing traffic counts at Mandogalup Rd/ Anketell Road intersection AM and PM peak hours

3.4 Public Transport

Currently, there are no bus routes servicing the subject site. The closest existing bus route to the amended LSP is Bus Route No. 527 which traverses through the new developments to the east of the Kwinana Freeway.

Bus routes 525 and 526 are located about 2km to the north of the amended LSP area and terminate north of Gaebler Road, as shown in **Figure 8**. Both of these bus routes are located outside the 400m walking distance to the subject site.

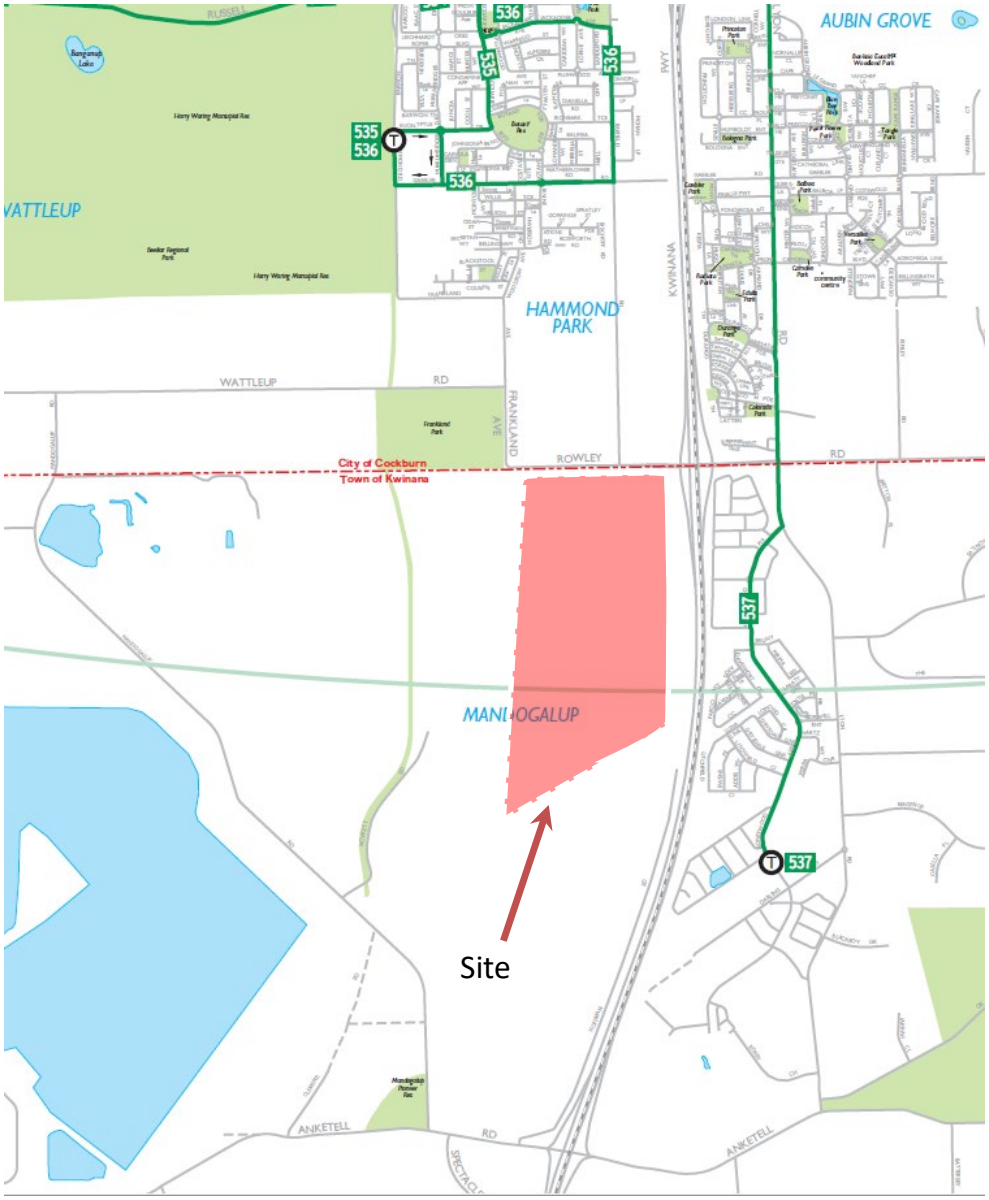


Figure 8: Existing Bus Routes

3.5 Pedestrian and Cyclist Facilities

Currently, there is a 3m Principal Shared Path (PSP) along Kwinana Freeway. The PSP continues north and south along Kwinana Freeway through existing underpasses (under Rowley Road and Anketell Road) immediately west of the Freeway. There is an existing shared path along the south side of Rowley Road which connects to the existing PSP. This shared path terminates immediately east of Barfield Road.

The Department of Transport's Perth Bike Map series (see **Figure 9**) also shows the existing PSP along Kwinana Freeway in the vicinity of the amended LSP area. According to this plan Rowley Road and Barfield Road are considered to be part of the Perth Bicycle Network (PBN) and are nominated as continuous signed routes.

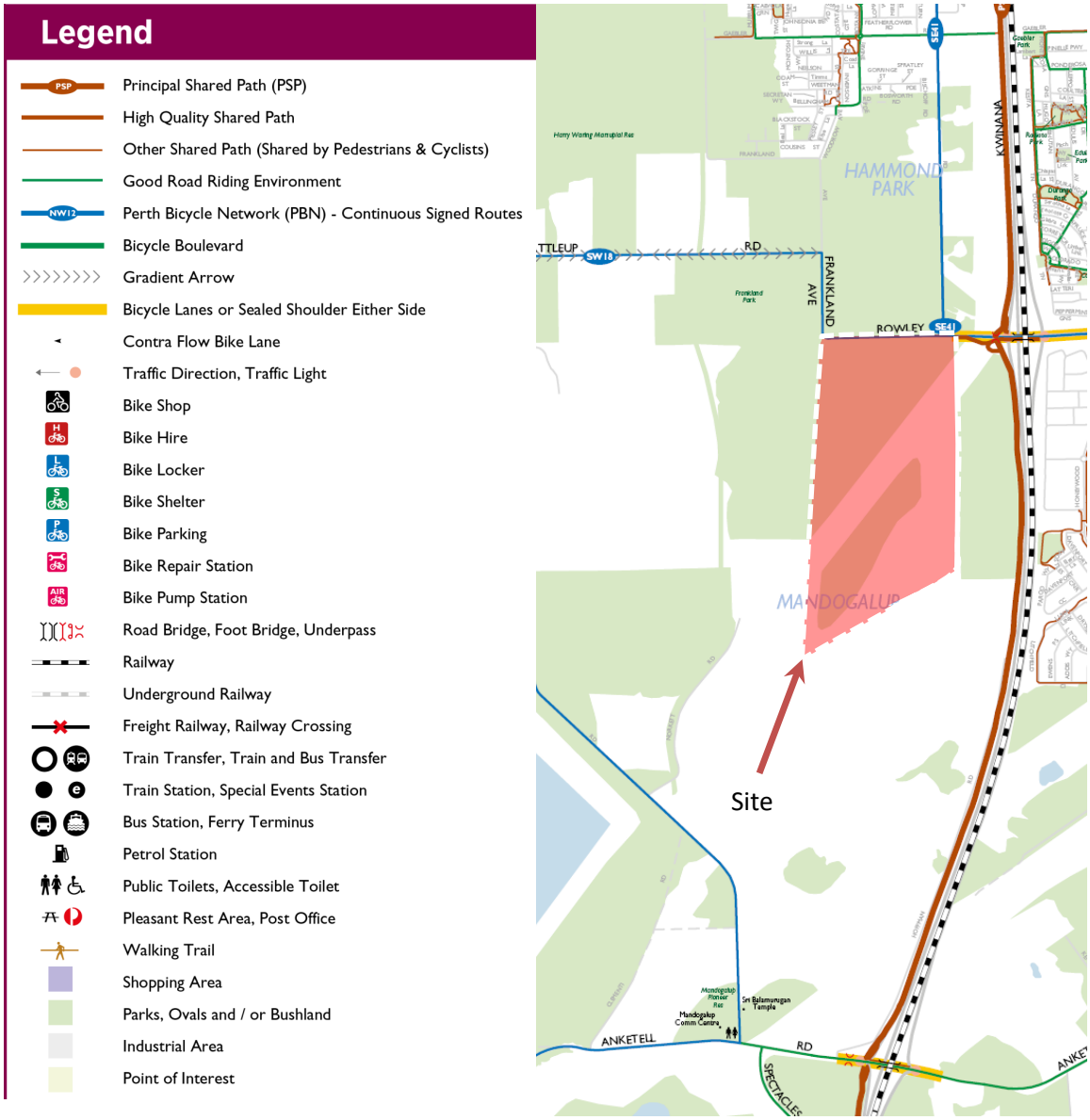


Figure 9: Bike Map

3.6 Changes to the surrounding road network

In June 2015 the Minister for Planning approved the declaration of two Planning Control Areas (PCA) over Rowley Road and Anketell Road west of the Kwinana Freeway.

- PCA 111 is for the protection of the proposed road freight transport access corridor along Anketell Road between the Kwinana Freeway and Rockingham Road.
- PCA 112 is for the protection of the proposed road and rail freight transport access corridor of Rowley Road, between Kwinana Freeway and the coast.

Future road network planning for this part of the Metropolitan area includes the extension of Rowley Road to Rockingham Road. According to the information obtained from Main Roads WA, ultimately Rowley Road is planned to be constructed to four lanes divided standard.

The planned intersection arrangements along Rowley Road to the west of the Kwinana Freeway for the ultimate situation are as follows:

- Barfield Road to be terminated to the north of Rowley Road with no connection on Rowley Road;
- The existing roundabout intersection on Rowley Road would be converted to a 3-leg roundabout intersection by removing the northern leg in the short term. Eventually, the northern leg will be completely removed, and the southern connection will operate as a left-in/left-out access.
- The Frankland Avenue intersection would be downgraded to a left in/ left out intersection;
- Hammond Road would be extended towards the south forming a four-way, grade-separated intersection with Rowley Road and a T-intersection with Anketell Road and Mandogalup LSPs would connect to Hammond Road as per the Draft Mandogalup Improvement Scheme Map shown in **Figure 10**.

According to Main Roads WA, planning is now underway to upgrade Anketell Road between Leath Road and Kwinana Freeway as part of the future Anketell Thomas Road Freight Corridor.

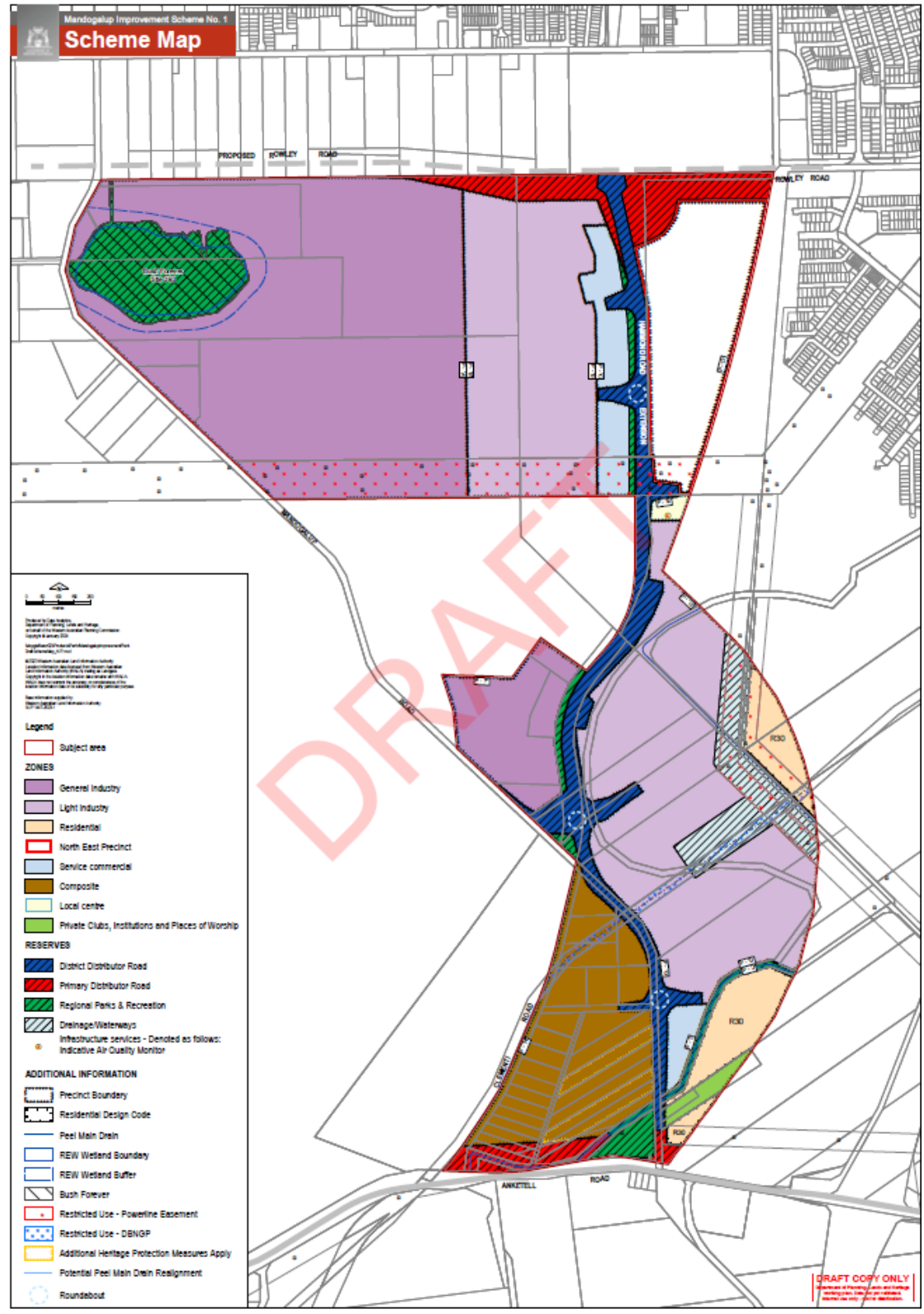


Figure 10: Draft Mandogalup Improvement Scheme Map

3.7 Public Transport Network Planning

According to the information obtained from the Public Transport Authority (PTA), it is anticipated that the area to the west of the Kwinana Freeway would be served by future Bus Routes 535 and 536. These new routes are likely to commence in the near future (subject to the progress of developments and availability of funding) and operate out of Aubin Grove Station. These routes would eventually connect Hammond Park to Mandogalup. **Figure 11** illustrates the proposed bus routes 535 and 536 in this area.



Figure 11: Future Bus Routes in the Vicinity of the subject site

4 Proposed Internal Transport Network

4.1 Road Hierarchy

The proposed hierarchy of roads within the amended LSP area is in line with original approved MWLSP and is illustrated in **Figure 12**. The proposed road hierarchy was based on traffic projections and the road classification of the WAPC Liveable Neighbourhoods guidelines (2007).

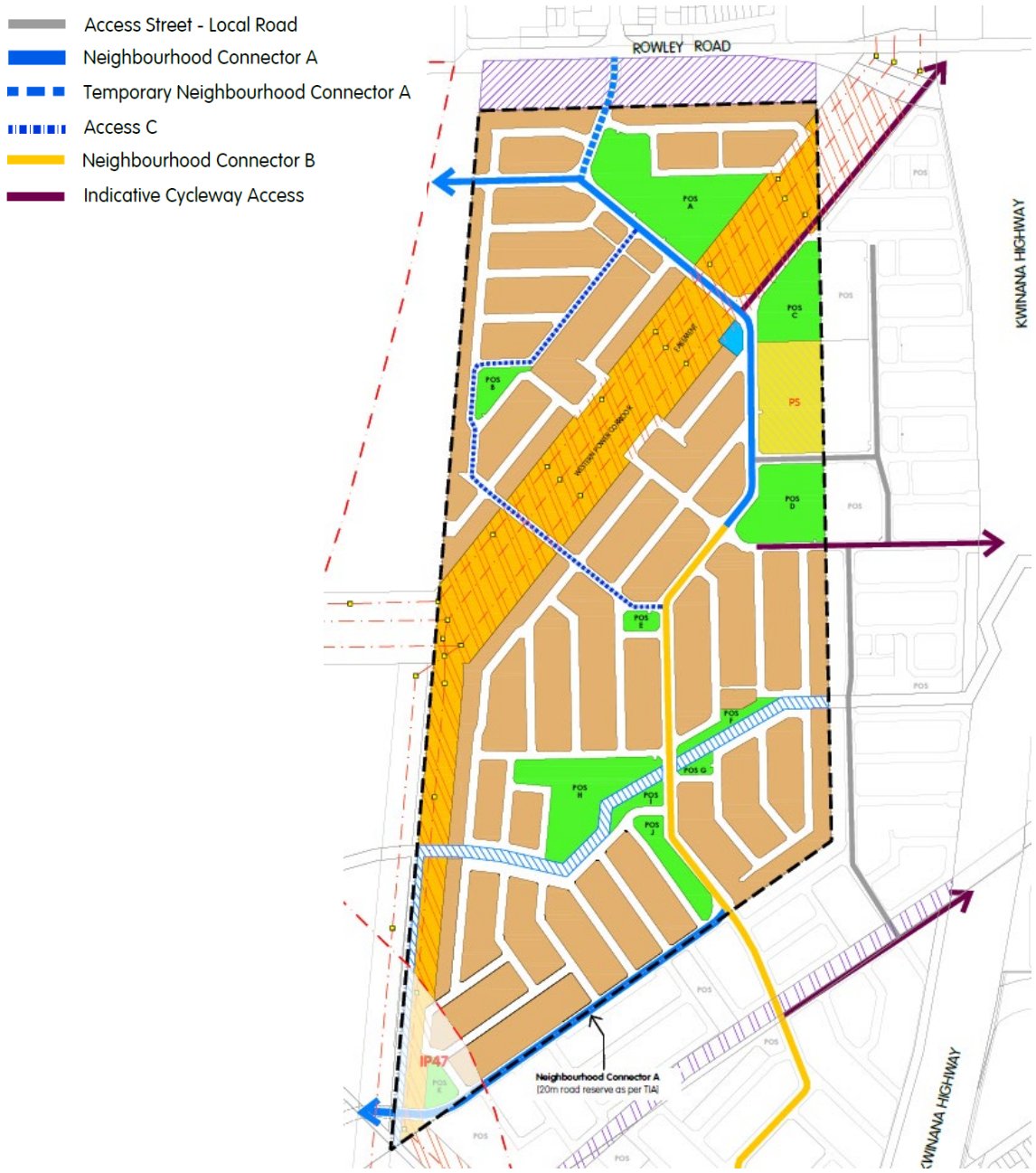


Figure 12: Proposed Road Hierarchy

The road network of the northern part of the proposed amended LSP has already been constructed as per the approved LSP for Apsley.

The proposed amended LSP shows a Neighbourhood Connector A (to the north of the amended LSP area) which would eventually connect to Hammond Road. As explained before, there may be a potential delay in establishing this connection due to uncertainty around the development of Lot 2 which is located between MWLSP and future Hammond Road.

To address the concern, an investigation has been conducted for a connection further south along the Western Power corridor. This alternative connection aims ensure that an alternate route would be available in case the northern connection is delayed.

The proposed alternative connection would intersect with Access Street C, which crosses the Western Power corridor and provides connectivity to both sides of the amended LSP area as shown in **Figure 4**. The transport modelling and analysis undertaken in this TIA have confirmed that the projected traffic volumes on Access Street C, would remain below the threshold of 3,000vpd for Access Street C and therefore the allocated road reserve for this street, is sufficient to accommodate the additional traffic from the proposed alternative connection.

The updated traffic modelling and analysis undertaken indicates that the projected traffic volumes on most of the amended LSP internal roads would be less than 1,000vpd and therefore most of the internal roads of the amended LSP would be classified as Access Street D in line with Liveable Neighbourhood Guidelines.

The proposed cross section for the roads within the amended LSP area is shown in **Figure 13**.

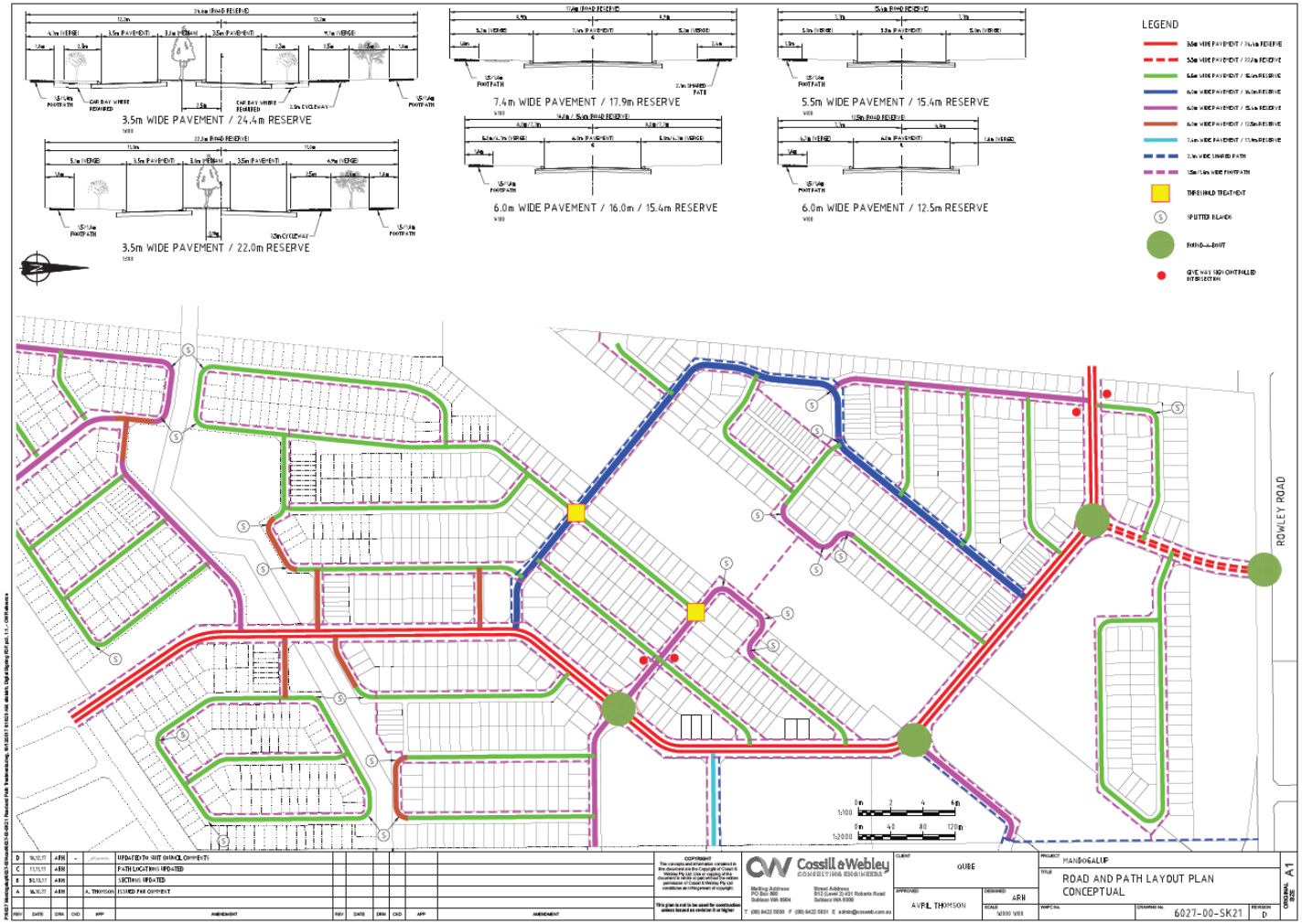


Figure 13: proposed cross sections for the amended LSP road network

The amended LSP also shows a neighbourhood connector road at the boundary of the Florence and Apsley Estates. This neighbourhood connector road is planned to extend further west through future industrial areas, crossing the existing Peel Main Drain, and ultimately connecting to the future Hammond Road. Cossill and Webley (C&W) Consulting Engineers have prepared a design concept plan for the neighbourhood connector road which is shown in **Figure 14**.

This plan depicts the section of the road on both sides of the existing Peel Main Drain. On the east side of the drain, the road traverses residential subdivisions and connects to the continuation of Quartermain Blvd via a roundabout. The assessments undertaken in this Revised TIA indicates that traffic projections for the proposed neighbourhood connector road would be approximately 5,800 vpd. According to the Liveable Neighbourhoods Guidelines, this road would be classified as a Neighbourhood Connector A road. A typical Neighbourhood Connector A road requires a 24.4m road reserve, which includes 2.1m on-street parking bays indented in the verge and 1.5m on-road cycle lanes.

However, since the proposed neighbourhood connector road will pass through an industrial area to the west, the need for on-road cycle lanes is not warranted. Effective on-road cycling depends on integrated network that connects various routes, and the western section of the road, characterized by industrial zones, poses safety risks for on road cyclists. The presence of heavy vehicle traffic and industrial operations makes it challenging to ensure a safe environment for on-road cycling in this area. Instead, it is recommended that a shared path be provided within the verge of the neighbourhood connector road. This design allows cyclists to travel safely along the verge rather than on the road itself. Therefore, the following cross-section within a 20m road reserve is suggested:

- 2 x 3.5m carriageway, 2m flush median, 2 x 5.5m verge

This configuration allows for lot frontage along the neighbourhood connector road. With respect to the direct lot frontage, the LN Guideline suggests that "*Developments along neighbourhood connector roads with ultimate vehicle volumes over 5000 vehicles per day should be designed either so vehicles entering the street can do so travelling forward, or are provided with alternative forms of vehicle access. Wider lots with paired driveways and protected reversing areas in the parking lane may be used on streets with up to 7000 vehicles per day.*"

For those lots that will have direct frontage to the neighbourhood connector road, either wider lots should be designed to facilitate the safe exit of vehicles in a forward direction or a cap road should be provided to facilitate the access/ egress of the residential dwellings through the cap road rather than directly onto the proposed neighbourhood connector road.

The western section of the neighbourhood connector road, located to the west of the Peel Main Drain, will also pass through the industrial area. Therefore, the 20m road reserve will extend through this area, featuring a different cross-section that includes a 9m carriageway suitable for industrial development.

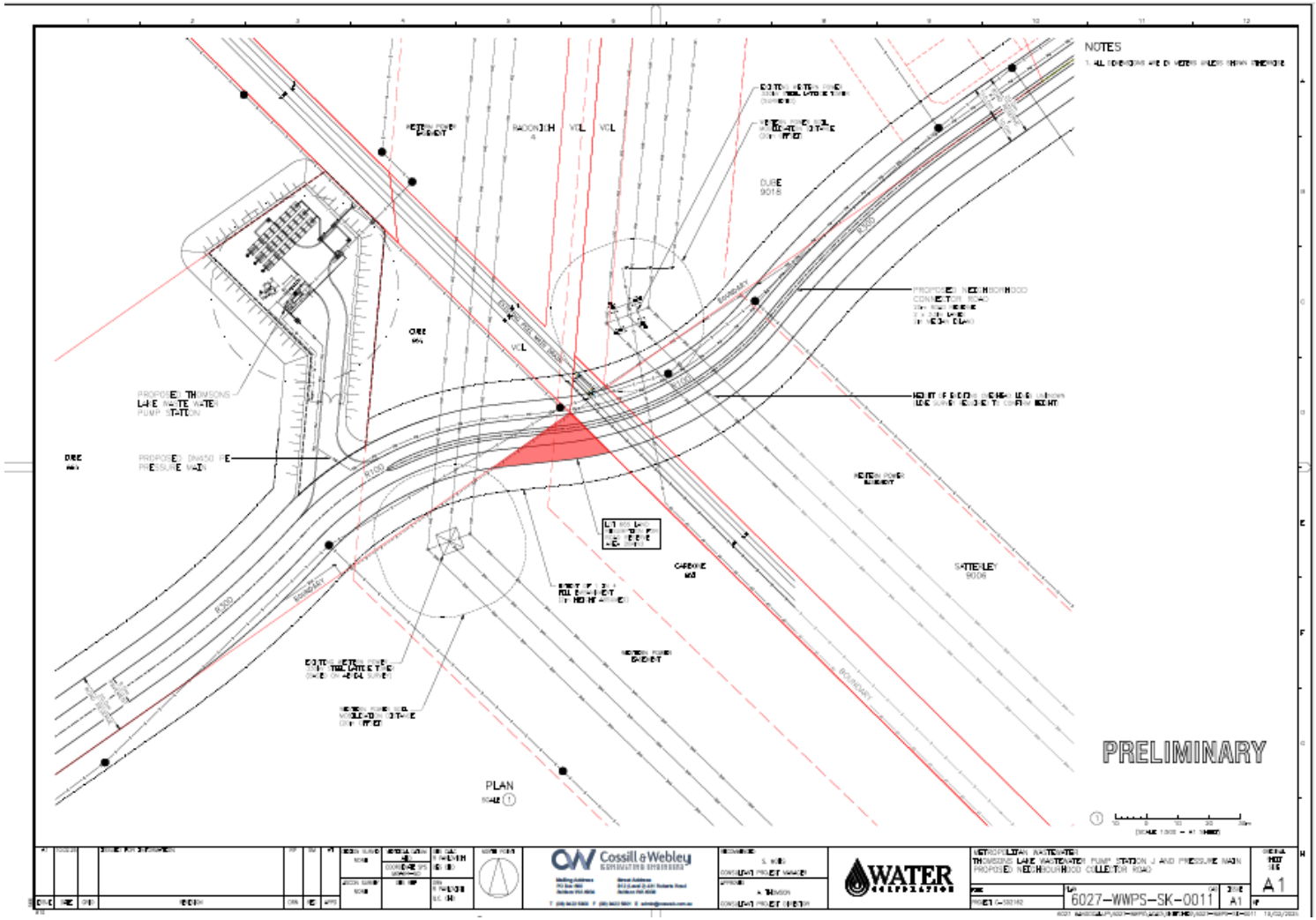


Figure 14: Proposed profile of the neighbourhood connector road at the boundary of the Florence and Apsley Estates

4.2 Public Transport

According to the information obtained from the Public Transport Authority (PTA), it is anticipated that the area to the west of Kwinana Freeway would be served by future bus routes 535 and 536 as outlined in Section 3.7 of this report.

It is most likely that route 536 would serve the Mandogalup LSP areas including the proposed amended LSP in future as it operates closest to the Kwinana Freeway on the western side. PTA intention is to run bus route 536 along the north-south spine road within the Mandogalup LSP areas to the south of Rowley Road while maintaining a distance of approximately 500-600m away from the Kwinana Freeway alignment.

The proposed bus route is most likely to traverse southbound on Barfield Road from Hammond Park and then across Rowley Road traversing along the north-south spine road. When Barfield Road intersection is terminated, then this bus route is likely to be rerouted to other north-south links such as Hammond Road.

4.3 Pedestrian and Cyclist Facilities

The neighbourhood connector roads within the amended LSP are planned with 2.5m designated cycleways in the verge on one side of the road.

The proposed LSP also shows three indicative cycle access to the existing PSP along Kwinana Freeway.

4.4 Integration with Surrounding Area

The proposed land uses within the southern part of the amended LSP are residential and are in line with the approved MWLSP. The road network of the amended LSP area is proposed to connect to the neighbouring landholdings at a number of locations to improve permeability and facilitate connection to surrounding regional roads.

5 Analysis of the Transport Network

5.1 Assessment Period

The assessment year that has been adopted for this analysis is for:

Short term Scenario (Say 2031): With the assumption of full development of the approved MWLSP and MELSP areas and the recently rezoned land to the south of both LSPs.

Long term Scenario (say 2041 and 2051): Reference is made to Main Roads WA ROM 24 traffic projections for 2041 daily traffic projections and the transport report prepared by Flyt for the proposed Mandogalup Improvement Scheme which entails long term assessment (2051) after full development of the IP47.

5.2 Traffic generation and distribution

The daily traffic generation rate used for this transport assessment is 8 vehicle trips per day (vpd) per dwelling, which corresponds to peak hour trip generation rates of 0.8vph per dwelling recommended in the Western Australian Planning Commission (WAPC) *Transport Impact Assessment Guidelines* (2016).

The proposed amended MWLSP is expected to accommodate approximately 1304 residential dwellings which would generate approximately 10,432vpd.

The overall Mandogalup LSPs are anticipated to accommodate approximately 2,236 dwellings including 932 dwellings for MELSP (including the recently rezoned land to the south) and 1304 dwellings for MWLSP. Therefore, the total trip generation of the residential dwellings of the LSPs are approximately 17,888vpd.

The approved MWLSP and MELSP planed a primary school site, another potential school is also anticipated within the amended MELSP area.

For the proposed primary schools, the trip rate used is 1.0 vph (vehicle per hour) per student during before and after school peak periods (typically 8-9am and 3-4pm) and 2vpd (vehicle per day) per student overall. For this assessment the Education Department's standard 540 student primary school design has been assumed, so the two primary schools are assumed to attract traffic flows of 2,160vpd or 1,080vph.

The proposed 750m2 NLA Local Centre within the MWLSP area would also attract approximately 900vpd.

Therefore, total traffic generation of the amended MWLSP and MELSP areas would be approximately 20,948vpd.

Due to the land use mix within the proposed amended MWLSP and MELSP incidences of multi-purpose trips are anticipated. Accordingly, it is expected that about 20% of the total residential trips would be internal to the LSP area and about 80% of the trips (16,758vpd) would be distributed to the external road network.

The potential external road network connections before Hammond Road extension are expected to be the existing roundabout intersection on Rowley Road, and the southern connection to Mandogalup Road via MELSP.

The transport modelling and analysis undertaken indicates that about 8,000vpd of the total 16,758vpd external trips would be distributed to the roundabout intersection on Rowley Road and the balance of traffic (8,758vpd) would be distributed to the southern connection/s to Mandogalup Road.

5.3 traffic flow forecast on Surrounding roads

5.3.1 Short term Scenario:

Figure 15 illustrates the total traffic projections after full development of the amended LSPs before Hammond Road extension (shoer term scenario). The external connections at this stage are expected to be the 3-leg roundabout intersection on Rowley Road and a secondary connection further south to Mandogalup Road. The location and layout of the proposed secondary connection to Mandogalup Road will need to be investigated further in the subsequent stages of the development of the MWLSP and MELSP.

The Draft Mandogalup Improvement Scheme Map shown in **Figure 10**, shows potential connections to Mandogalup Road further south via two roundabout intersections. One of these connections combined with the future 3-leg roundabout intersection of Rowley Road is expected to be sufficient to accommodate the amended LSPs traffic in 2031.

8,000 : Future traffic projections after full development of the LSPs



Figure 15: Total interim traffic – Weekday AM and PM peak hours

In order to establish the peak hour traffic volumes at the future 3-leg roundabout intersection on Rowley Road, it was assumed that the peak hour traffic would be 10% of the daily traffic and in/ out split would be 30%/ 70% for AM and reverse for PM on LSPs external connections. The total post development traffic for the interim scenario includes the existing background traffic plus the development traffic. A 2% annual traffic growth was applied to the background traffic on Rowley Road. **Figure 15** illustrates the interim peak hour traffic volumes at the intersection.

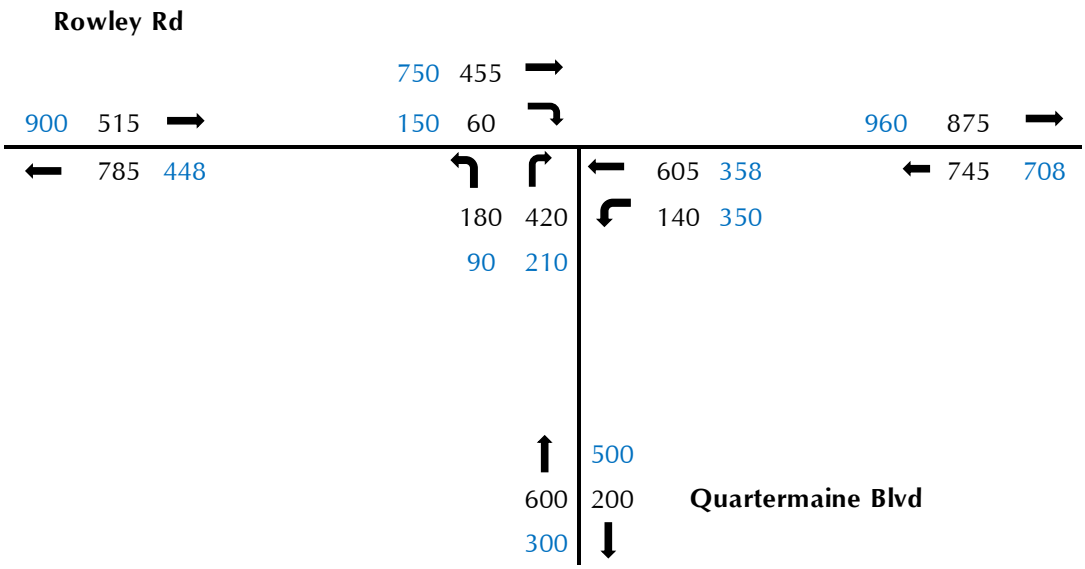


Figure 16: Interim peak hour traffic volumes AM/ PM peak hour

5.3.2 Long term (2041 and 2051) daily traffic projections:

The transport report for the proposed Mandogalup Improvement Scheme prepared by Flyt (revision 3 dated 16/08/2023) provides ROM24 daily traffic projections for year 2041 which was sourced from Main Roads WA (refer **Appendix B**) and 2051 daily traffic projections based on Flyt assessments (refer **Appendix C**).

The 2041 and 2051 daily traffic projections sourced from Flyt report for the surrounding roads are summarised in **Table 1**. In this table the existing (2021) counts and interim traffic projections (by Transcore) are also added for comparison purposes.

Table 1: Traffic projections on surrounding roads

Daily traffic projections				
year	Source	Rowley Rd west of Kwinana Freeway	Anketell Rd west of Kwinana Freeway	Mandogalup Rd north of Anketell Rd
2024	MRWA	13,389	22,122	4,829
2031(interim)	Transcore	16,729	27,155	10,804
2041	MRWA ROM 24	19,300	36,200	10,000
2051	Flyt	41,800	48,500	37,800

5.4 Roads and Intersections

Figure 16 illustrates the existing and proposed intersection controls for key intersections within the amended LSP area. As explained before subdivision development is under progress from the northern part of LSP towards south. The internal roundabout intersections shown in Figure 16 are all constructed as per the approved 2020 LSP.

Existing roundabout

Threshold treatment



Figure 17: Proposed intersection treatments

There are three four-way intersections shown on the amended LSP on low-traffic-volume access streets. These intersections are recommended to be constructed as priority-controlled intersections with Give-Way control on the minor road approaches as suggested in Liveable Neighbourhoods document. Appropriate entry treatments are recommended on the side roads to help to alert drivers to the presence of the intersections and that traffic on the major road has priority.

The existing roundabout intersection at Rowley Road currently serves both MWLSP and MELSP areas. However, in a longer term when Rowley Road is upgraded to four lanes and Hammond Road is extended south, this roundabout intersection will be downgraded to left in/ left out intersection.

In short term, Irvine Pde (the northern leg of the roundabout intersection on Rowley Road) would be closed after completion of Vivente subdivision or earlier subject to council or Main Roads WA approval.

The closure of the Irvine Pde would provide extra capacity at the roundabout intersection on Rowley Road to support subdivision progress on MELSP and MWLSP. However, at some point in time the secondary connection to Mandogalup Road would be required to facilitate the full development of the amended LSPs.

The location and layout of the proposed secondary connection to Mandogalup Road will need to be investigated further in the subsequent stages of the development of the MWLSP and MELSP.

The intersection of Mandogalup Road/ Anketell Road would ultimately operate as a full movement T-intersection in the form of a roundabout or traffic lights.

5.5 Intersection Analysis

The operation of the future 3-leg roundabout intersection on Rowley Road was analysed in SIDRA for the weekday AM and PM peak hours in 2031.

SIDRA outputs are presented in the form of Degree of Saturation, Level of Service, Average Delay and 95% Queue. These characteristics are defined as follows:

- **Degree of Saturation (DoS)**: is the ratio of the arrival traffic flow to the capacity of the approach during the same period. The Degree of Saturation ranges from close to zero for varied traffic flow up to one for saturated flow or capacity.
- **Level of Service (LoS)**: is the qualitative measure describing operational conditions within a traffic stream and the perception by motorists and/or passengers. In general, there are 6 levels of service, designated from A to F, with Level of Service A representing the best operating condition (i.e. free flow) and Level of Service F the worst (i.e. forced or breakdown flow).
- **Average Delay**: is the average of all travel time delays for vehicles through the intersection.
- **95% Queue**: is the queue length below which 95% of all observed queue lengths fall.

The results of the SIDRA analysis are attached in **Appendix C** and briefly discussed in the following paragraphs.

Roundabout intersection on Rowley Road

The existing roundabout intersection would be downgraded to 3-leg roundabout intersection in near future. The removal of the northern leg (Irvine Pde) would provide extra capacity at the roundabout intersection on Rowley Road to support subdivision progress on MELSP and MWLSP. **Figure 17** Illustrates the layout of the roundabout intersection modelled in SIDRA.

The SIDRA analysis results indicate that the 3-leg roundabout intersection on Rowley Road would operate satisfactorily during the short term (2031) AM and PM peak hours and with minimal queues and delays on all approaches of the intersection.

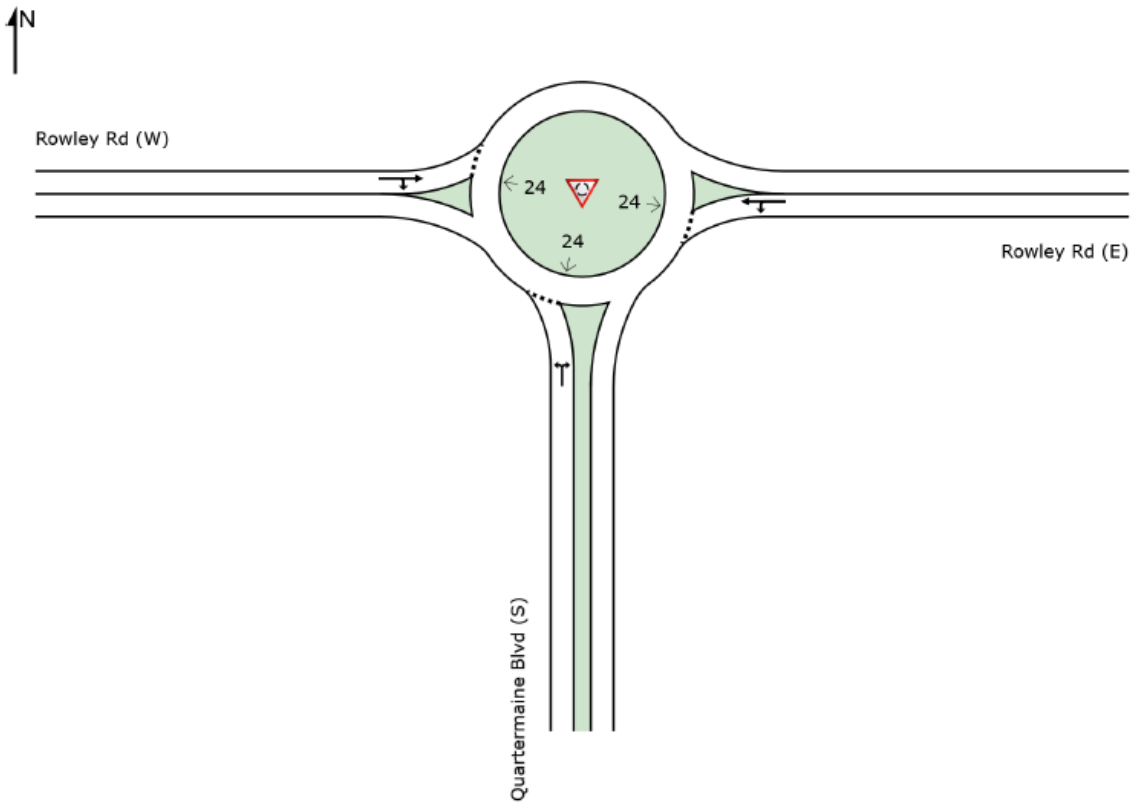


Figure 18: The roundabout intersection on Rowley Road modelled in SIDRA

5.6 Access to Frontage Properties

The WAPC *Liveable Neighbourhoods* policy requires that "Development along integrator B and neighbourhood connector streets with ultimate vehicle volumes over 5000 vehicles per day should be designed either so vehicles entering the street can do so travelling forward, or are provided with alternative forms of vehicle access. Wider lots with paired driveways and protected reversing areas in the parking lane may be used on streets with up to 7000 vehicles per day."

All of the roads within the proposed amended LSP area are expected to carry less than 5,000vpd, so no restriction on vehicular access is required. The northern section of Quartermaine Blvd (north of Goldwyer Dr) is expected to carry more than 5,000vpd in the interim and therefore, no direct lot frontage is provided along this section of Quartermaine Blvd.

For those lots that will have direct frontage to the neighbourhood connector road at the boundary of Florence and Apsley Estates, either wider lots should be designed to facilitate the safe exit of vehicles in a forward direction or a cap road should be provided to facilitate the access/ egress of the residential dwellings through the cap road rather than directly onto the proposed neighbourhood connector road.

5.7 Pedestrian/ Cycle Network

The proposed network of pedestrian and cycle is detailed in the amended LSP which includes shared paths within the amended LSP area that connects to the existing Principal Shared Paths along Kwinana Freeway. This network of cycleways and paths will provide an excellent level of accessibility and permeability for pedestrians and cyclists within the proposed amended LSP area.

5.8 Access to Public Transport

At this stage of the planning process the details of the bus route planning and the location of bus stops are not known. However, in these circumstances the WAPC *Transport Assessment Guidelines for Developments* (2006) suggest that it is desirable for at least 90 per cent of dwellings to be within 400m straight line distance of a bus route. The potential future bus route proposed along the main north-south road would service the majority of the lots within the proposed amended LSP area.

6 Conclusion

The WAPC has endorsed Amendment No. 1 to the Mandogalup West Structure Plan, subject to some modifications. The traffic related modifications include identifying the width of road reserves according to City of Kwinana specifications and confirming the alignment, width, and likely intersection treatments for the east-west neighbourhood connector and other roads connecting to the Mandogalup Improvement Scheme area, as per the specifications of the DPLH.

Both MELSP and MWLSP received endorsement from the Western Australian Planning Commission (WAPC) in March 2018. Since the preparation of the LSPs, The WAPC prepared an Improvement Plan (IP47) for the land to the west and south of the LSPs. The IP47 came into effect April 2019 and following Gazettal of the draft Improvement Scheme, it will provide a framework for future planning and development.

The proposed amended LSP would eventually connect to future Hammond Road via three different connections. According to the information provided to Transcore, there may be a potential delay in establishing the northern connection to Hammond Road (via Goldwyer Drive) due to uncertainty around the development of Lot 2 which is located between MWLSP and future Hammond Road.

To address the concern regarding the availability of the northern connection to Hammond Road, an investigation has been conducted for a connection further south along the Western Power corridor. This alternative connection aims to ensure that an alternate route would be available in case the northern connection is delayed.

The proposed alternative connection would intersect with Access Street C, which crosses the Western Power corridor and provides connectivity to both sides of the amended LSP area. The transport modelling and analysis undertaken in this TIA have confirmed that the projected traffic volumes on Access Street C would not exceed the threshold of 3,000vpd for Access Street C, and the allocated road reserve for this street, is sufficient to accommodate the additional traffic from the proposed alternative connection.

The neighbourhood connector road between Florence and Apsley Estates is suggested to include a 20m road reserve with the following cross sections:

- Residential area: 2x 3.5m carriageway + 2m flush median + 2x 5.5m verges; and
- Industrial area: 9m carriageway + 2 x 5.5m verges.

According to the Vivente Master Plan in Hammond Park, Irvine Pde (the northern leg of the roundabout intersection on Rowley Road) would be closed after completion of Vivente subdivision or earlier subject to council or Main Roads WA approval.

The transport report prepared by Flyt for the proposed Mandogalup Improvement Scheme entails long term assessment (2051) after full development of the IP47 and

identifies the long-term traffic projections and potential connections to Hammond Road.

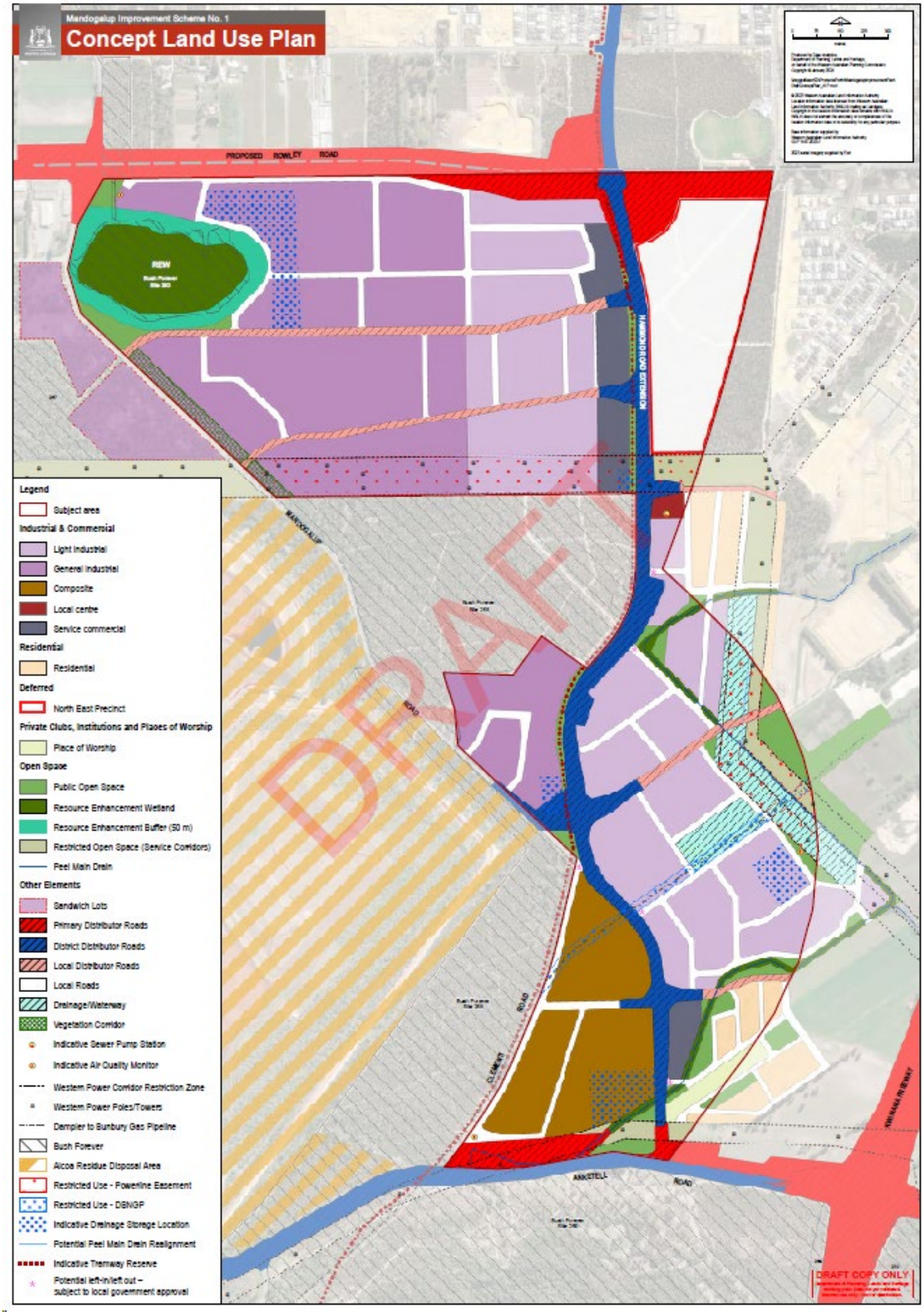
The assessments undertaken for the short-term scenario (say 2031 and before Hammond Road extension) indicates that in 2031 the combination of the roundabout intersection on Rowley Road (after conversion to 3-leg) and the secondary connection to Mandogalup Road as per the Mandogalup Improvement Scheme would be able to accommodate the traffic generation of the amended MWLSP and MELSP.

Appendix A

MANDOGALUP IMPROVEMENT SCHEME CONCEPT PLAN

transcore

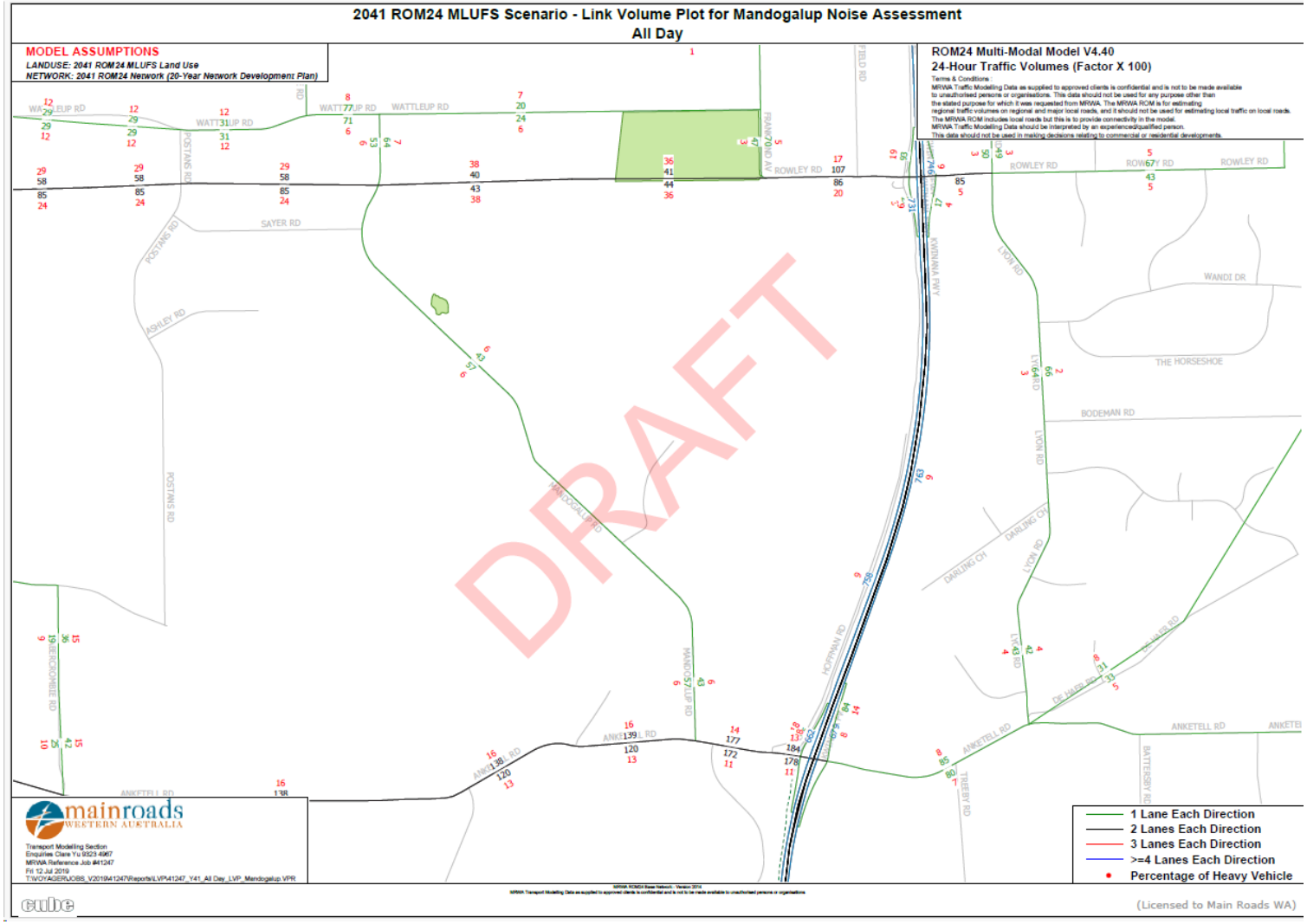
Engineering a better future for over 20 years!


Mandogalup Improvement Scheme No. 1
Concept Land Use Plan
PROPOSED ROWLEY ROAD
RDW
HAMMONDROAD EXTENSION
ROAD
CLEMENT
ANKETELL
ROAD
Legend
Subject area
Industrial & Commercial
Light Industrial
General Industrial
Composite
Local centre
Service commercial
Residential
Residential
Deferred
North East Precinct
Private Clubs, Institutions and Places of Worship
Place of Worship
Open Space
Public Open Space
Resource Enhancement Wetland
Resource Enhancement Buffer (50 m)
Restricted Open Space (Service Corridors)
Peel Main Drain
Other Elements
Sandwich Lots
Primary Distributor Roads
District Distributor Roads
Local Distributor Roads
Local Roads
Drainage/Waterway
Vegetation Corridor
Indicative Sewer Pump Station
Indicative Air Quality Monitor
Western Power Corridor Restriction Zone
Western Power Poles/Towers
Dampier to Bunbury Gas Pipeline
Bush Forever
Alcoa Residue Disposal Area
Restricted Use - Powerline Easement
Restricted Use - DBNGP
Indicative Drainage Storage Location
Potential Peel Main Drain Realignment
Indicative Tramway Reserve
Potential left-in/left out – subject to local government approval
DRAFT
DRAFT COPY ONLY

Appendix B

2041 ROM24 PROJECTIONS

Engineering a better future for over 20 years!


2041 ROM24 MLUFS Scenario - Link Volume Plot for Mandogalup Noise Assessment
All Day
MODEL ASSUMPTIONS
LANDUSE: 2041 ROM24 MLUFS Land Use
NETWORK: 2041 ROM24 Network (20-Year Network Development Plan)
ROM24 Multi-Modal Model V4.40
24-Hour Traffic Volumes (Factor X 100)
DRAFT
1 Lane Each Direction
2 Lanes Each Direction
3 Lanes Each Direction
>=4 Lanes Each Direction
Percentage of Heavy Vehicle
mainroads
WESTERN AUSTRALIA
cube
(Licensed to Main Roads WA)

Appendix C

2051 DAILY TRAFFIC PROJECTIONS (SOURCE: FLYT)

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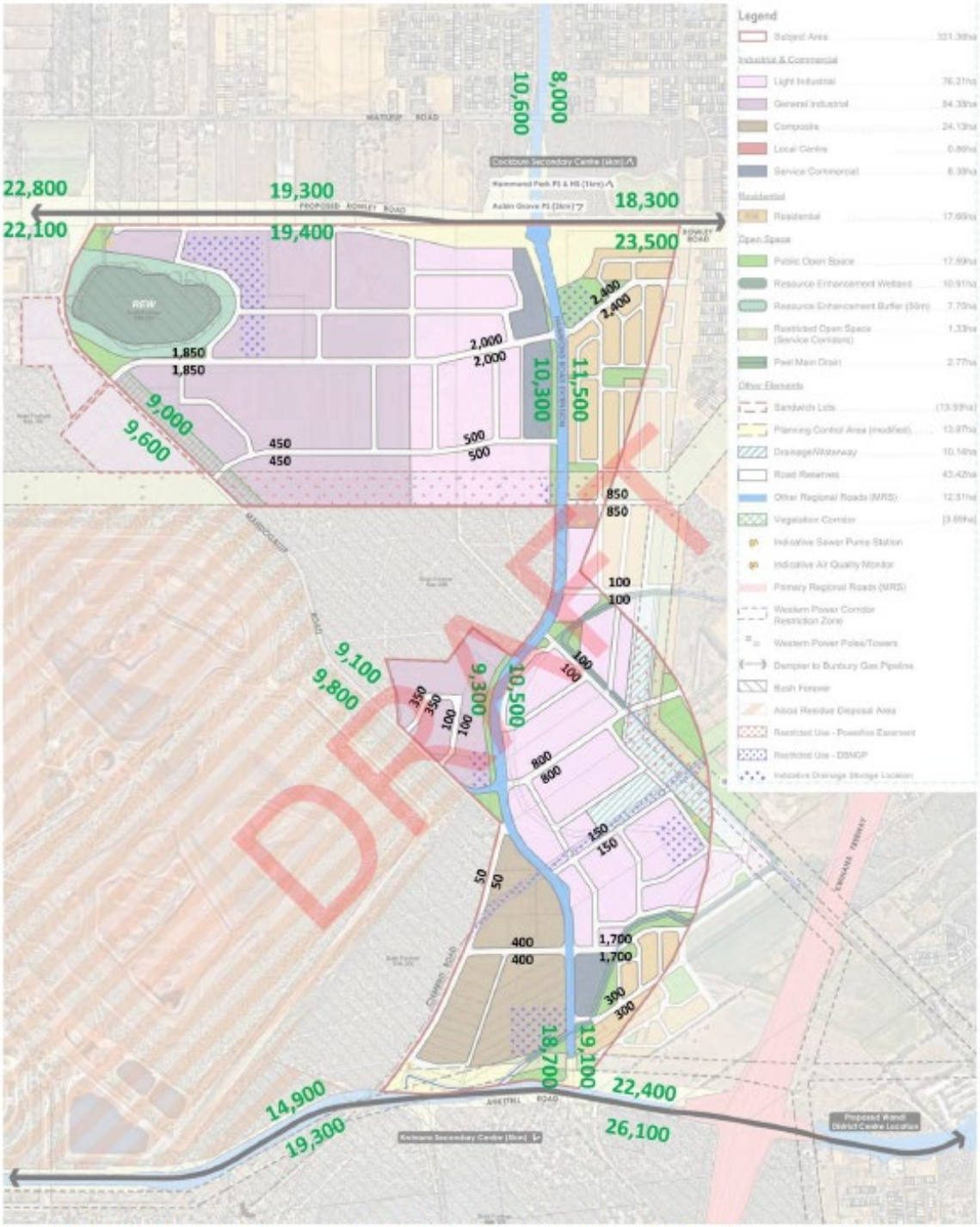

Figure 47 Total 2051 Daily Traffic Volumes Including Final Preferred Scenario Land Uses and Traffic Volumes on Internal Roads (base plan source: TBB)

Appendix C

SIDRA ANALYSIS

transcore

Engineering a better future for over 20 years!

MOVEMENT SUMMARY

Site: [Rowley Rd - AM - 2031 (Site Folder: 2031 - 8000 Veh/ Day)]

Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Quartermaine Blvd (S)														
1	L2	180	2.0	189	2.0	0.874	37.4	LOS D	23.5	178.3	1.00	1.58	2.31	35.7
3	R2	420	2.0	442	2.0	0.874	41.1	LOS D	23.5	178.3	1.00	1.58	2.31	36.2
Approach		600	2.0	632	2.0	0.874	40.0	LOS D	23.5	178.3	1.00	1.58	2.31	36.1
East: Rowley Rd (E)														
4	L2	140	2.0	147	2.0	0.599	5.2	LOS A	7.1	65.2	0.41	0.46	0.41	52.8
5	T1	605	19.9	637	19.9	0.599	6.0	LOS A	7.1	65.2	0.41	0.46	0.41	55.9
Approach		745	16.5	784	16.5	0.599	5.9	LOS A	7.1	65.2	0.41	0.46	0.41	55.3
West: Rowley Rd (W)														
11	T1	455	19.0	479	19.0	0.742	16.3	LOS B	10.3	94.8	1.00	1.08	1.38	49.2
12	R2	60	2.0	63	2.0	0.742	20.2	LOS C	10.3	94.8	1.00	1.08	1.38	48.1
Approach		515	17.0	542	17.0	0.742	16.7	LOS B	10.3	94.8	1.00	1.08	1.38	49.1
All Vehicles		1860	12.0	1958	12.0	0.874	19.9	LOS B	23.5	178.3	0.76	0.99	1.29	45.8

MOVEMENT SUMMARY

Site: [Rowley Rd - PM - 2031 (Site Folder: 2031 - 8000 Veh/ Day)]

Site Category: (None)
Roundabout

Vehicle Movement Performance

Mov ID	Turn	INPUT VOLUMES [Total veh/h	HV] %	DEMAND FLOWS [Total veh/h	HV] %	Deg. Satn v/c	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh. veh	Dist] m	Prop. Que	Effective Stop Rate	Aver. No. Cycles	Aver. Speed km/h
South: Quartermaine Blvd (S)														
1	L2	90	2.0	95	2.0	0.346	6.9	LOS A	2.7	20.7	0.74	0.73	0.74	50.3
3	R2	210	2.0	221	2.0	0.346	10.7	LOS B	2.7	20.7	0.74	0.73	0.74	51.2
Approach		300	2.0	316	2.0	0.346	9.5	LOS A	2.7	20.7	0.74	0.73	0.74	50.9
East: Rowley Rd (E)														
4	L2	350	2.0	368	2.0	0.649	6.3	LOS A	7.0	60.5	0.62	0.58	0.62	52.2
5	T1	358	19.9	377	19.9	0.649	7.4	LOS A	7.0	60.5	0.62	0.58	0.62	55.2
Approach		708	11.1	745	11.1	0.649	6.8	LOS A	7.0	60.5	0.62	0.58	0.62	53.6
West: Rowley Rd (W)														
11	T1	750	19.0	789	19.0	0.913	19.2	LOS B	26.1	238.3	1.00	1.01	1.48	47.2
12	R2	150	2.0	158	2.0	0.913	23.3	LOS C	26.1	238.3	1.00	1.01	1.48	46.2
Approach		900	16.2	947	16.2	0.913	19.9	LOS B	26.1	238.3	1.00	1.01	1.48	47.1
All Vehicles		1908	12.0	2008	12.0	0.913	13.4	LOS B	26.1	238.3	0.82	0.81	1.04	49.9

Mandogalup West Local Structure Plan
Revised Transport Impact Assessment

PREPARED FOR:
Qube Property Group

August 2017

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Project manager: Mohammad Rasouli

Client: Qube Property Group

Project: Mandogalup West Local Structure Plan, Transport Impact Assessment

Document revision: r01b

Project number: t16.239

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1.0 Executive Summary

This revised Traffic Impact Assessment (TIA) report has been prepared in accordance with the Transport Impact Assessment Guidelines (WAPC, Vol 2 – Planning Schemes, Structure Plans and Activity Centre Plans, August 2016).

During the course of preparation of this TIA report, liaison was undertaken with Main Roads WA, the City of Kwinana and adjoining landowner (Satterley).

The transport modelling and analysis documented in this TIA report is undertaken for Mandogalup West Local Structure Plan (MWLSP) and Mandogalup East Local Structure Plan (MELSP) and the report findings/ recommendations are compatible.

The outcome of the study indicates that initially, it is anticipated that Rowley Road extension would be constructed as a two lane standard road with the existing roundabout intersection on Rowley Road between Barfield Road and Frankland Avenue. This roundabout intersection provides access and connectivity to future developments on both sides of Rowley Road.

The existing roundabout is expected to be removed or downgraded to left in/ left out intersection in the ultimate scenario when Rowley Road is duplicated and Hammond Road is extended. At this point MWLSP would connect to Hammond Road from west.

Modelling and analysis undertaken for the potential vehicular/ pedestrian underpass on Rowley Road at Barfield Road location indicate that this proposal has little benefit on the vehicular and pedestrian/ cyclist movements of the MWLSP.

Current discussion with MRWA indicated that it is no longer intended to pursue concepts for a vehicle underpass linking Barfield Road with Mandogalup (Qube) land.

2.0 Introduction and Background

Transcore prepared a Transport Impact Assessment (TIA) report (t14.039.mr.r01b) in June 2014 on behalf of Qube Property Group for the proposed original Mandogalup West Local Structure Plan (MWLSP).

This revised TIA report is prepared for the recently updated MWLSP prepared by RobertsDay. The updates include the relocation of the proposed primary school and local playing fields towards the north of the MWLSP area and removal of the potential lots within the Kwinana Industrial Buffer which was shown in the original MWLSP.

This revised TIA report aims to provide an update on the traffic modelling and analysis to reflect the proposed modifications to the MWLSP area and update the report figures to reflect the current Mandogalup West Local Structure Plan.

Transcore is the traffic engineer for the Mandogalup East Local Structure Plan (MELSP) and has reviewed both LSPs for consistency in terms of access points, connectivity, road hierarchy and road reserves. A Consolidated Plan including both LSPs is also prepared which is used for the preparation of the report figures for both LSPs.

During the course of preparation of this report, Transcore has liaised with Main Road WA with respect to the proposed Rowley Road access intersection to serve both LSPs during the interim and ultimate stages. The timeframe associated with the ultimate stage is determined by the status and timing of Hammond Road extension and duplication of Rowley Road.

The proposed MWLSP area is located on the western side of the Kwinana Freeway and south of Rowley Road, as shown in **Figure 1.** A Satterley landholding, which is subject to a separate LSP, is located to the east of the subject site (MELSP). The areas to the west and south of the subject site are vacant land at present.

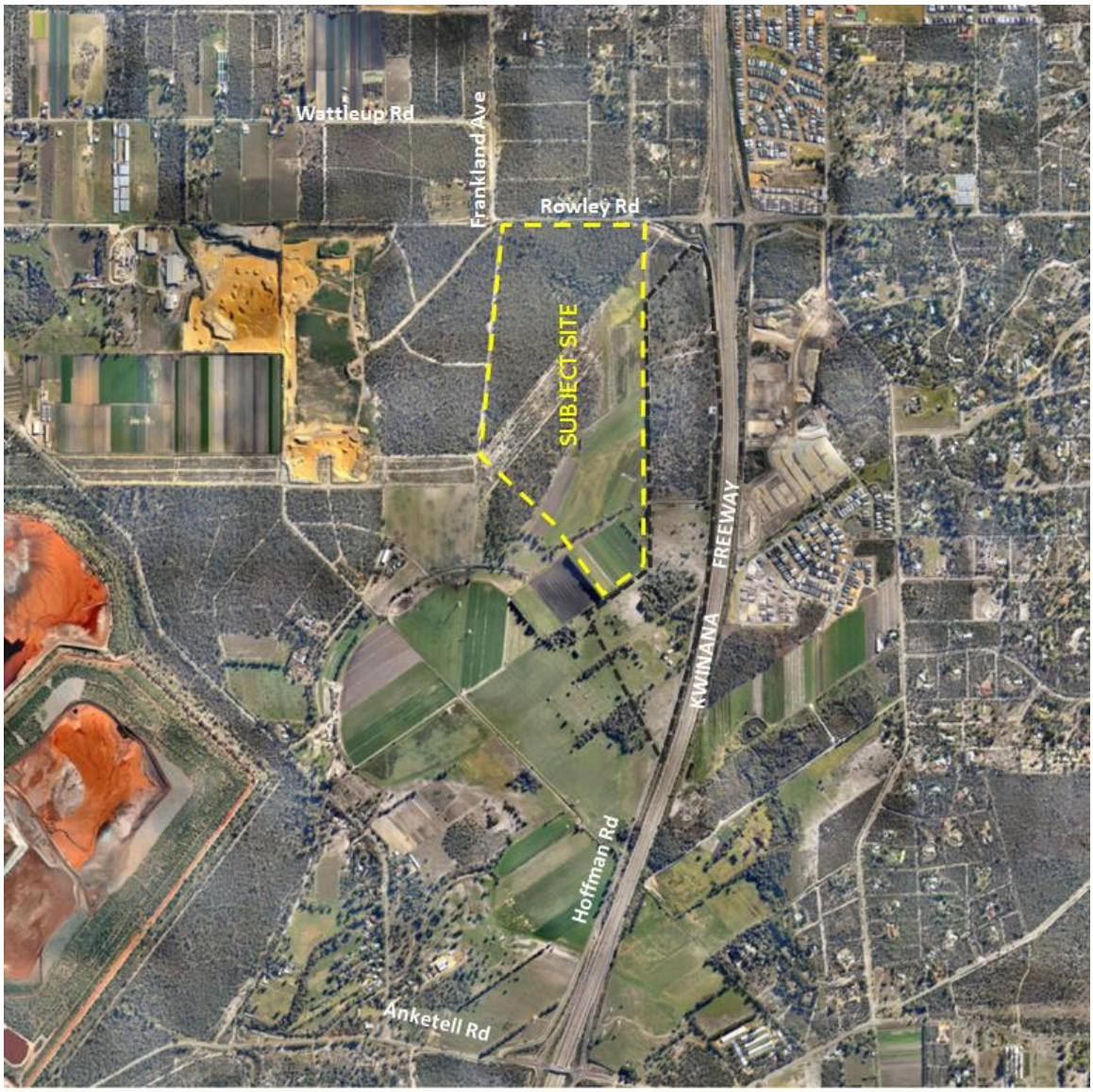


Figure 1: Location of the Subject Site

3.0 Proposed Local Structure Plan

The proposed Mandogalup West Local Structure Plan is shown in **Figure 2**. A total of approximately 911 residential lots with a local centre is planned for the MWLSP area.

There is a proposed Primary School site within the northern part of the MWLSP area, with about half of the school site within the MWLSP area. The other half of the primary school is located within the MELSP.

The proposed MWLSP does not show any residential dwellings within the Kwinana Industrial Buffer.

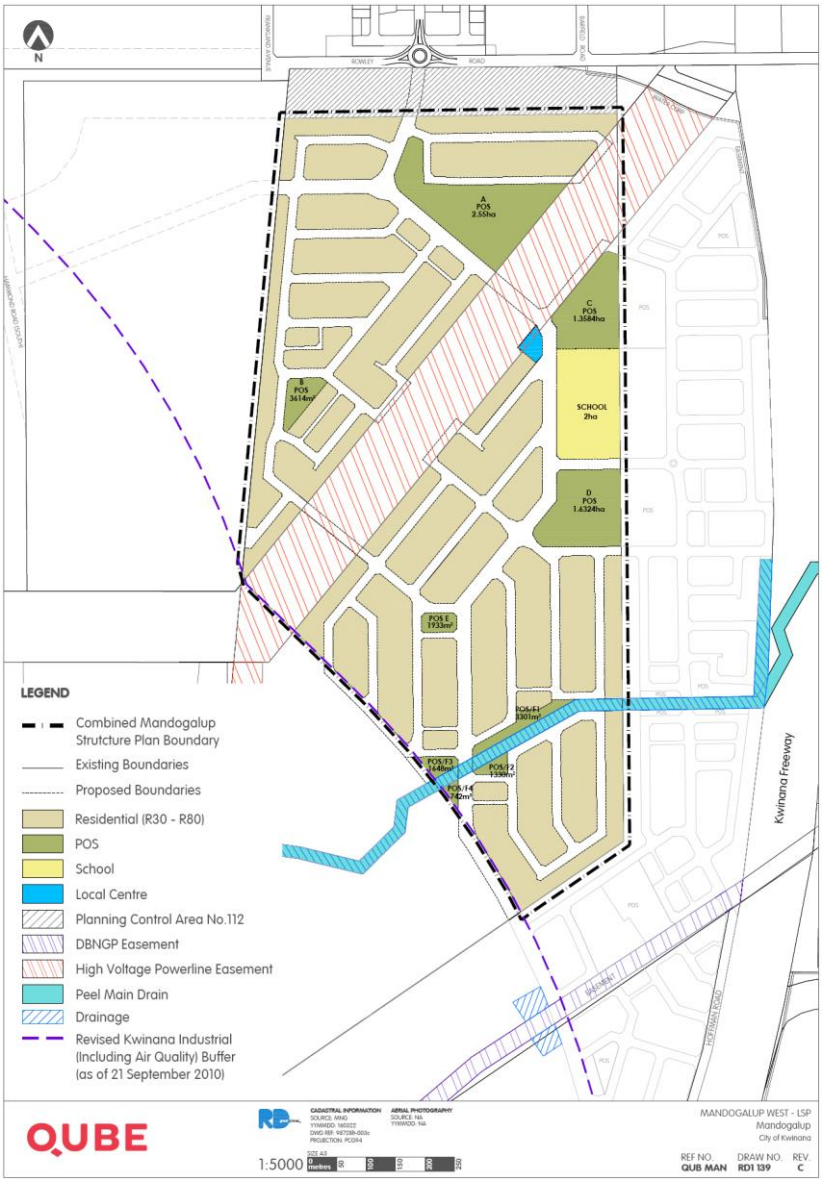


Figure 2: Proposed Mandogalup West Local Structure Plan

4.0 Existing Situation

4.1 Existing Land Use

The site currently is rural vacant land. Adjacent land uses to the east, west and south are also vacant lands. Rowley Road forms the northern boundary of the site.

4.2 Existing Road Network

Rowley Road is classified as a District Distributor A Road in the Main Roads WA Functional Road Hierarchy document and is currently constructed as a rural standard single carriageway road. Traffic data provided by the City of Kwinana indicates 4,870vpd on Rowley Road east of Barfield Road (June 2013) and about 3,280vpd between Frankland Avenue and Barfield Road (May 2012).

Rowley Road provides an east-west connection between South Western Highway (via Eleventh Avenue in Armadale), Tonkin Highway, Kwinana Freeway and Rockingham Road in Wattleup (via Wattleup Road). Rowley Road has been identified as a primary freight route to the Naval Base / Kwinana Beach industrial areas.

Currently, there is no connection into Rowley Road (to the west of the Freeway) from the south. Barfield Road connects to Rowley Road from the north at a priority-controlled T-intersection.

The existing shared path along Kwinana Freeway extends to the west about 100m along the south side of Rowley Road and terminates immediately west of Barfield Road. There is a pedestrian and cyclist underpass (under the Rowley Road) immediately west of the Kwinana Freeway.

Anketell Road is classified as a District Distributor A Road in the Main Roads WA Functional Road Hierarchy document and is constructed as a single carriageway road. The existing traffic counts on Anketell Road sourced from the City of Kwinana indicate that Anketell Road east of Mandogalup Road carried an average weekly traffic volume of about 9,400vpd in February 2016. The AM and PM peak volumes are reported to be about 470vph (11:00-12:00) and 900vph (16:00-17:00) respectively. The existing posted speed limit on Anketell Road (about 150m west of the Hoffman Road) is 80km/hr for westbound and 70km/hr for eastbound directions.

Anketell Road has been identified as an alternative freight route to the Naval Base / Kwinana Beach industrial areas. Liaison with Department of Planning and Main Roads WA indicates that ultimately a dual divided carriageway standard is planned for Anketell Road.

Hoffman Road is a local access road constructed as a 6.2m wide sealed rural road which runs parallel to the Kwinana Freeway. Hoffman Road connects to Anketell Road from the south and extends north to the southern portion of the MELSP area and terminates there. The intersection of Hoffman Road and Anketell Road is in the form of a basic T-intersection without any widening on Anketell Road. There are no traffic counts available on Hoffman Road, but the traffic volumes are expected to be very low.

Kwinana Freeway is classified as a Primary Distributor and is reserved as a Primary Regional Road in the MRS. It is currently constructed as four- lanes divided carriageway in this area and has a posted speed limit of 100km/h. The closest freeway interchanges are at Rowley Road, just to the north of the MELSP area and at Anketell Road, 2km south of the MELSP area. The most recent available Main Roads WA traffic count for the Freeway in this area was approximately 97,200vpd (average weekday traffic, south of Rowley Road) in 2013/2014.

4.3 Public Transport

Currently, there are no bus routes servicing the subject site. The closest existing bus route to the MWLSP area is Bus Route No. 527 which traverses through the new developments to the east of the Kwinana Freeway. Bus routes 525 and 526 are located about 2km to the north of the MWLSP area and are terminating north of Gaebler Road, as shown in Figure 3. Both of these bus routes are located outside the 400m walking distance to the subject site.

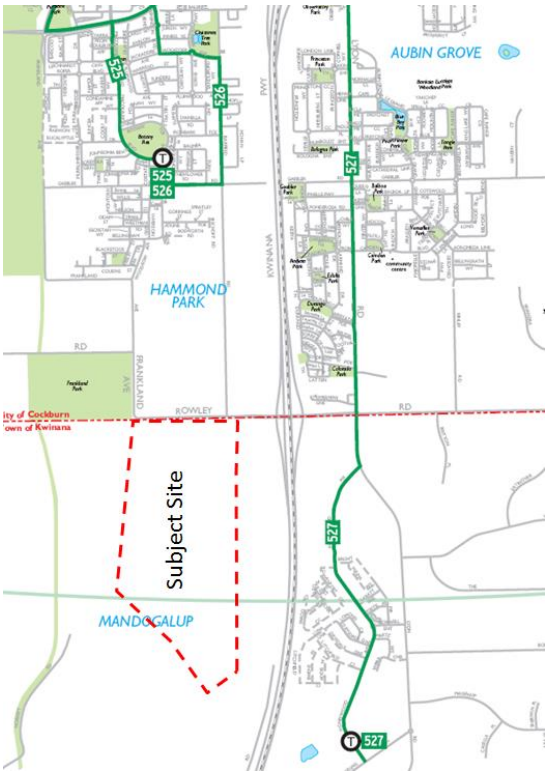


Figure 3: Existing Bus Routes

4.4 Pedestrian and Cyclist Facilities

Currently, there is a 2.5m Principal Shared Path (PSP) along Kwinana Freeway. The PSP continues towards north along Kwinana Freeway through an existing underpass (under the Rowley Road) immediately west of the Freeway. There is an existing shared path along the south side of Rowley Road which connects to the existing PSP. This shared path terminates immediately east of Barfield Road.

The Department of Transport's Perth Bike Map series (see **Figure 4**) also shows the existing PSP along Kwinana Freeway in the vicinity of the MWLSP area. According to this plan Rowley Road and Barfield Road are considered to be part of the Perth Bicycle Network (PBN) and are nominated as continuous signed routes.

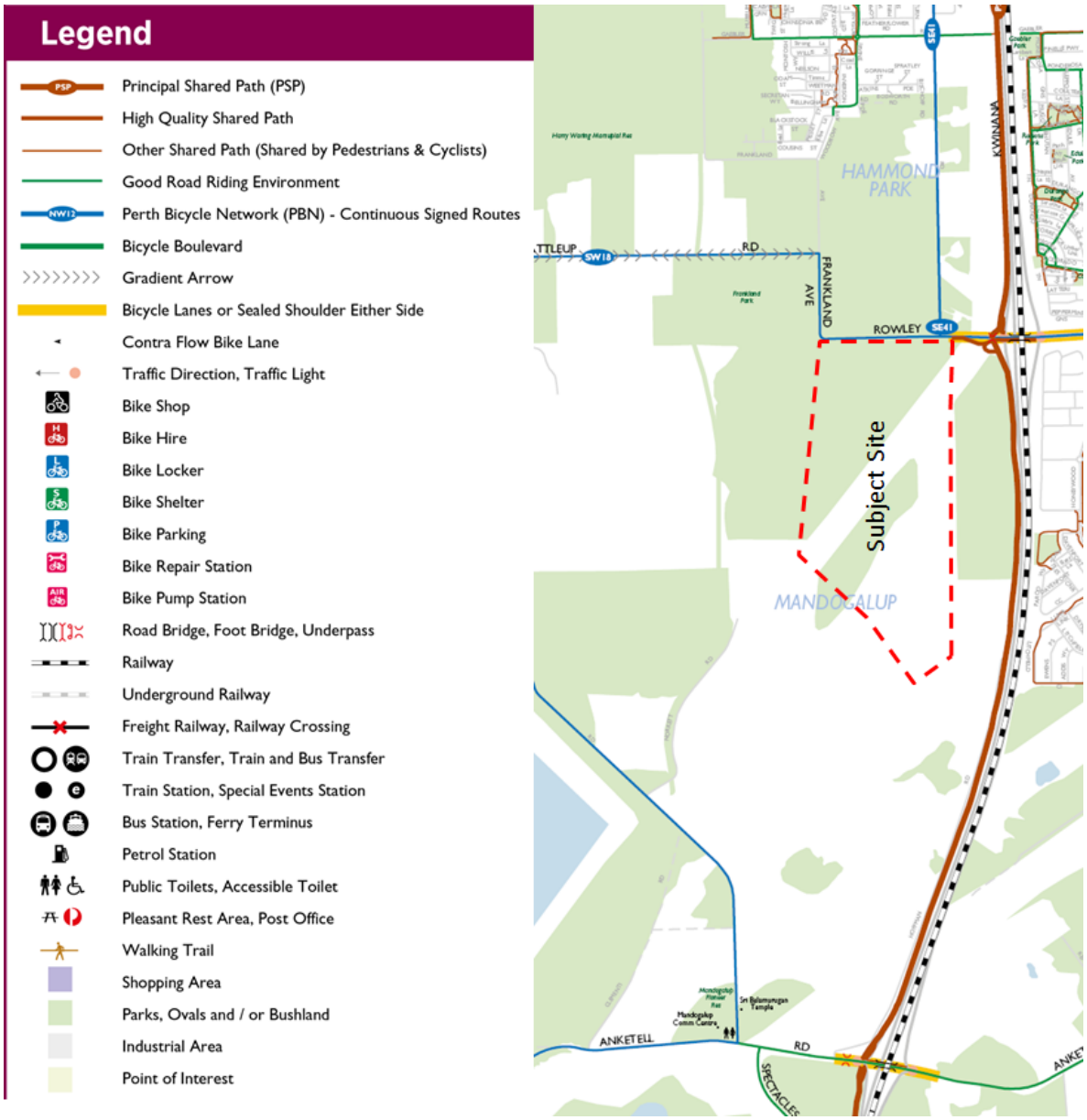


Figure 4: Bike Map

4.5 Changes to the Surrounding Road Network

There are proposed interim and ultimate road network changes in the locality as shown in **Figure 5.** Future road network planning for this part of the Metropolitan area includes the extension of Rowley Road to Rockingham Road. Rowley Road has been identified as a primary freight route to the Naval Base / Kwinana Beach industrial areas. According to the information obtained from Main Roads WA, ultimately Rowley Road is planned to be constructed to four lanes divided standard. The planned intersection arrangements along Rowley Road to the west of the Kwinana Freeway for the ultimate situation are discussed and agreed with Main Roads WA and are as follows (relevant Main Roads WA drawings are also provided in **Appendix A**):

- Barfield Road to be terminated to the north of Rowley Road with no connection on Rowley Road;
- The existing roundabout intersection between Barfield Road and Frankland Avenue in the interim stage would be removed, and the connection from the north would be closed off. The connection from the south would operate as left in/left out or cul-de-sac.
- The Frankland Avenue intersection would be downgraded to left in/ left out intersection;
- Hammond Road would be extended towards south forming a four-way, grade-separated intersection with Rowley Road and a T-intersection with Anketell Road;
- Mandogalup LSPs would connect to Hammond Road from west;
- Existing Hoffman Road intersection with Anketell Road will be converted to left in/left out or cul-de-sac;
- Hoffman Road south of the LSPs would be realigned towards west to connect to Hammond Road extension; and,
- Wattleup Road would be realigned further north with a signalised intersection on Hammond Road.

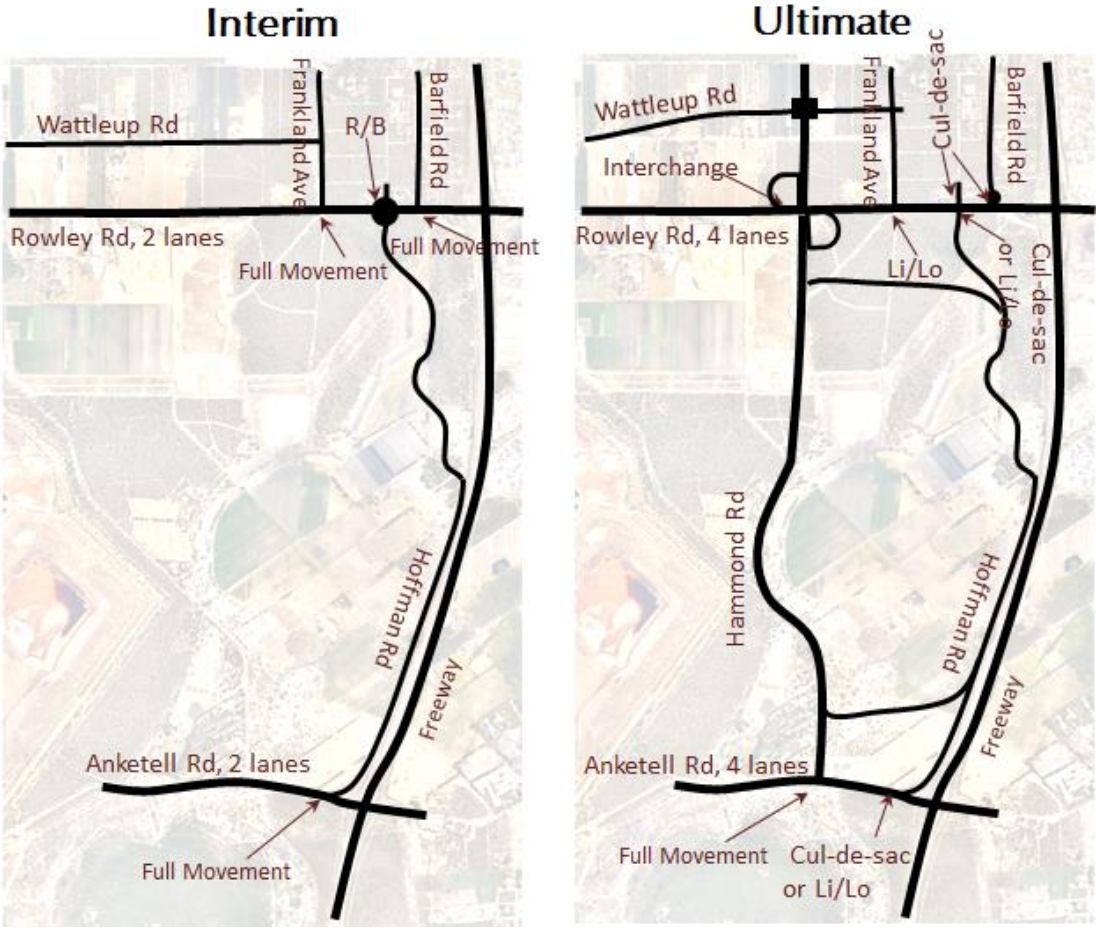


Figure 5: Interim and Ultimate changes to the road network

In the interim, it is anticipated that Rowley Road extension would be constructed as two lanes standard. The existing roundabout intersection between Barfield Road and Frankland Avenue provides connectivity for the proposed developments to the north and south of Rowley Road. This roundabout is expected to be removed or downgraded to left in/ left out intersection in the ultimate scenario and when Rowley Road is duplicated and Hammond Road is extended.

4.6 Public Transport Network Planning

According to the information obtained from Public Transport Authority (PTA), it is anticipated that the area to the west of the Kwinana Freeway would be served by future Bus Routes 535 and 536. These new routes are likely to commence in near future (subject to the progress of developments and availability of funding) and operate out of Aubin Grove Station. These routes would eventually connect Hammond Park to Mandogalup. **Figure 6** illustrates the proposed bus routes 535 and 536 in this area.



Figure 6: Future Bus Routes in the Vicinity of the MWLSP Area

5.0 Proposed Transport Network

5.1 Road Hierarchy

The proposed hierarchy of roads within the MWLSP and MELSP area was established through transport modelling undertaken for both LSPs and is illustrated in **Figure 7.** The proposed road hierarchy was based on traffic projections and the classification of Liveable Neighbourhoods document (2007).



Figure 7: Proposed Road Hierarchy

The proposed road classification reflects future planning for the surrounding district including the proposed future neighbourhood centre adjacent to the extension of Hammond Road.

Some key characteristics of the relevant road classifications have been summarised in Table 1. These are generally based on Liveable Neighbourhoods (LN) Guidelines.

Table 1: Key Characteristics for the Proposed LSP Road Classifications

Road Classification	Indicative upper volume (vpd)	Indicative road reserve width (m)
Neighbourhood Connector A	7,000	25.2m
Neighbourhood Connector B	3,000	19.4m
Access Street B	3,000	17.9m
Access Street C	1,000	15.4m

It should be noted that the outlined reservation widths are indicative only and are subject to further adjustment in consultation with the Department of Planning Lands and Heritage (DoPLH) and City of Kwinana during detailed subdivision design process.

Neighbourhood Connectors

The current Mandogalup LSP indicates a north-south spine road through both LSP areas. This north-south spine road connects to Anketell Road at its southern end and continues north along the proposed Primary School and connects to Rowley Road. Ultimately, when Hammond Road is extended towards the south, this road would connect to Hammond Road.

Transport Modelling and analysis undertaken indicate that the projected traffic volumes for the southern part of the north-south spine road are less than the estimated volumes from the original modelling and analysis. This is due to:

- Removal of the potential residential dwellings within the Revised Kwinana Industrial (including air quality) Buffer (as of 21 September 2010) as requested by DoPLH; and,
- Relocation of the proposed primary school towards the northern part of the LSP area.

Accordingly, the projected traffic volumes for the interim and ultimate scenarios are estimated to be less than 3,000vpd for the southern part of the north-south spine road and therefore this section of spine road can be classified as Neighbourhood Connector B road. The projected traffic volumes for north-south spine road fronting the proposed Primary School and to the north/ north-west of the Primary School is estimated to be between 3,000vpd to 7,000vpd and therefore this section of spine road is classified as Neighbourhood Connector A road.

It must be noted that the proposed road hierarchy and road reserve for the north-south spine road are only determined by the projected traffic volumes in

accordance with LN Guidelines. The proposed road hierachy and road reserve do not consider the servicing and drainage requirements or provision of a consistent road cross section for the entire length of the main north-south spine road within both LSP areas.

Access Streets

The majority of both LSP internal roads are classified as Access Street C roads. The Access Street C typical cross section entails 4.7m verges on both sides, with embayed parking provided in the verges as appropriate, such as for visitor parking for rear loading lots. Access Street C classification is proposed for the LSP local roads with less than 1,000vpd.

The access streets to the east and south of the primary school are recommended to be constructed to the 17.9-metre Access Street B cross-section standard, which allows for on-street parking on both sides of the street. The continuation of the proposed Access Street B road towards the south of the Primary School within the MELSP is also estimated to carry more than 1,000vpd and therefore is classified as Access Street B road.

5.2 Public Transport

According to the information obtained from Public Transport Authority (PTA), it is anticipated that the area to the west of Kwinana Freeway would be served by future bus routes 535 and 536 as outlined in Section 3.6 of this report.

It is most likely that route 536 would serve the LSP areas in future as it operates closest to the Kwinana Freeway on the western side. PTA intention is to run bus route 536 along the north-south spine road within the LSP areas to the south of the Rowley Road while maintaining a distance of approximately 500-600m away from the Kwinana Freeway alignment.

The proposed bus route is most likely to traverse southbound on Barfield Road from Hammond Park and then across Rowley Road traversing along the north-south spine road. When Barfield Road intersection is terminated, then this bus route is likely to be rerouted to other north-south links such as Hammond Road.

5.3 Pedestrian and Cyclist Facilities

Figure 8 outlines the proposed pedestrian and cyclist network for both LSP areas. In accordance with the LN Guidelines, shared paths are proposed on one side of the main north-south spine road with a footpath on the other side. Figure 8 also shows the location of the proposed shared path connections to the existing Principal Shared Path along Kwinana Freeway. These connections would improve the utilisation of the existing PSP along the Freeway.



Figure 8: Proposed Pedestrian and Cyclist Road Network

5.4 Integration with Surrounding Area

The proposed land uses for the MWLSP area are predominantly residential which are in line with the proposed land uses within the surrounding area. The road network of the MWLSP area is proposed to connect to the neighbouring landholding to the east at a number of locations to improve permeability and facilitate connection to Rowley Road. Section 6.3 of the report provides the projected traffic volumes on the MWLSP road network and the road connection to the MELSP.

6.0 Analysis of the Transport Network

6.1 Assessment Period

The assessment year that has been adopted for this analysis is 2031, with the assumption of full development of MWLSP, MELSP, Hammond Park and the other potential developments to the north of Rowley Road as per the Southern Suburbs District Structure Plan (SSDSP) prepared by City of Cockburn. A copy of the SSDSP is provided in **Appendix B** of this report.

The assessment of the operation of the proposed roundabout on Rowley Road for the interim scenario has been undertaken for single carriageway Rowley Road standard but with the full development of the SSDSP area.

6.2 Traffic generation and distribution

Transcore has developed a subregional strategic transport model for year 2031based on weekday traffic flows for this area using the EMME transport modelling software package. Overall, the land uses modelled in this area reflects the land use aspirations of *Directions 2031* document.

The daily traffic generation rate used for this transport assessment is 8 vehicle trips per day (vpd) per dwelling, which corresponds to peak hour trip generation rates recommended in the Western Australian Planning Commission (WAPC) *Transport Assessment Guidelines for Development* (2016).

The anticipated 581 and 911 dwellings of the proposed MELSP and MWLSP areas will, therefore, generate approximately 12,000vpd.

For the proposed primary school the trip rate used is 1.0 vph per student during the school peak periods (typically 8-9am and 3-4pm) and 2vpd per student overall. For this assessment, the Education Department's standard 430 student primary school design has been assumed, so this primary school is assumed to attract traffic flows of 860vpd.

The proposed 500m^2 NLA Local Centre within the MWLSP area would also attract approximately 600vpd. The future 7,000m^2 Neighbourhood Centre adjacent to the extension of Hammond Road would attract about 8,480vpd.

The distribution of the LSPs traffic is determined by the transport model in proportion to the location of trip productions and attractors for work trips, education trips and other trips (shopping, social, recreational, etc.) among all the land uses in the traffic model.

6.3 Traffic Flow Forecasts

Transport modelling and analysis were undertaken for both interim and ultimate scenarios. The road network modelled for the interim and ultimate scenarios are as reflected in **Figure 5** in section 4.5 of this report. For the ultimate scenario, additional modelling and analysis were undertaken to reflect the potential termination of the proposed access intersections on Rowley Road and Anketell Road.

Figure 9 illustrates the projected traffic volumes for interim scenario with full movement intersections on Rowley Road and Anketell Road.

Figure 10 shows the projected traffic volumes for the ultimate scenario for two options:

- With no connection on Rowley Road and Anketell Road; and,
- With Li/ Lo connections on Rowley Road and Anketell Road.



Figure 9: Projected Daily Traffic Volumes (Interim Scenario)

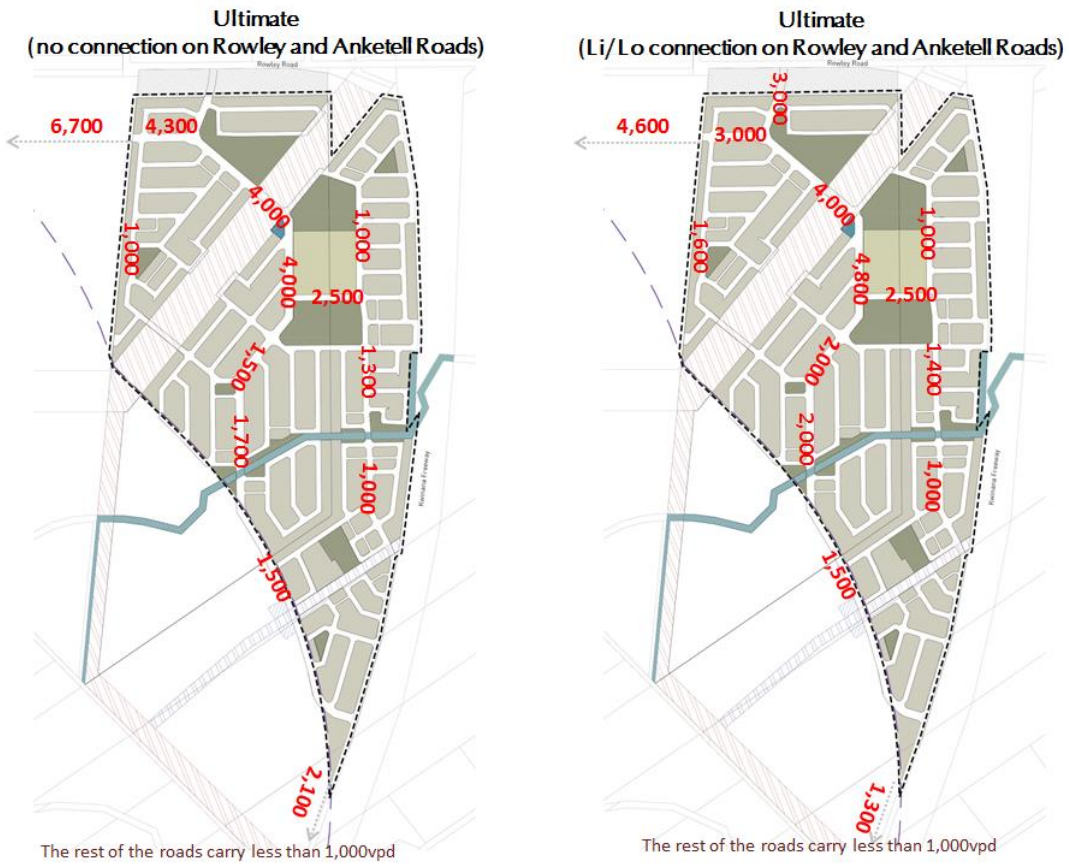


Figure 10: Projected daily traffic volumes for ultimate scenario

Additional modelling and analysis was undertaken to assess the impact of the potential vehicular/ pedestrian underpass on Rowley Road at Barfield location. The assessments were undertaken separately for the vehicles, Pedestrian and Cyclists.

Vehicle Assessment:

Figure 11 shows the link analysis for vehicles that would use the proposed underpass if it is constructed in the ultimate scenario. The transport modelling and analysis indicates that the proposed underpass would be mainly utilised by the vehicles who wish to turn right from Mandogalup to Rowley Road and travel north on Kwinana Freeway and only a few vehicles would use the proposed underpass to travel north to the proposed high school or local centres to the north of Rowley Road.

Given ultimately the existing roundabout intersection on Rowley Road would be downgraded to Li/ Lo or removed then these vehicles would use the proposed underpass as a "rat run" to go north then turn left towards Frankland Avenue and again turn left into Rowley Road to travel towards the Freeway.

In the interim scenario the existing roundabout on Rowley Road would provide full movement access for developments on both sides of Rowley Road and therefore the proposed Barfield underpass would provide little additional benefit.

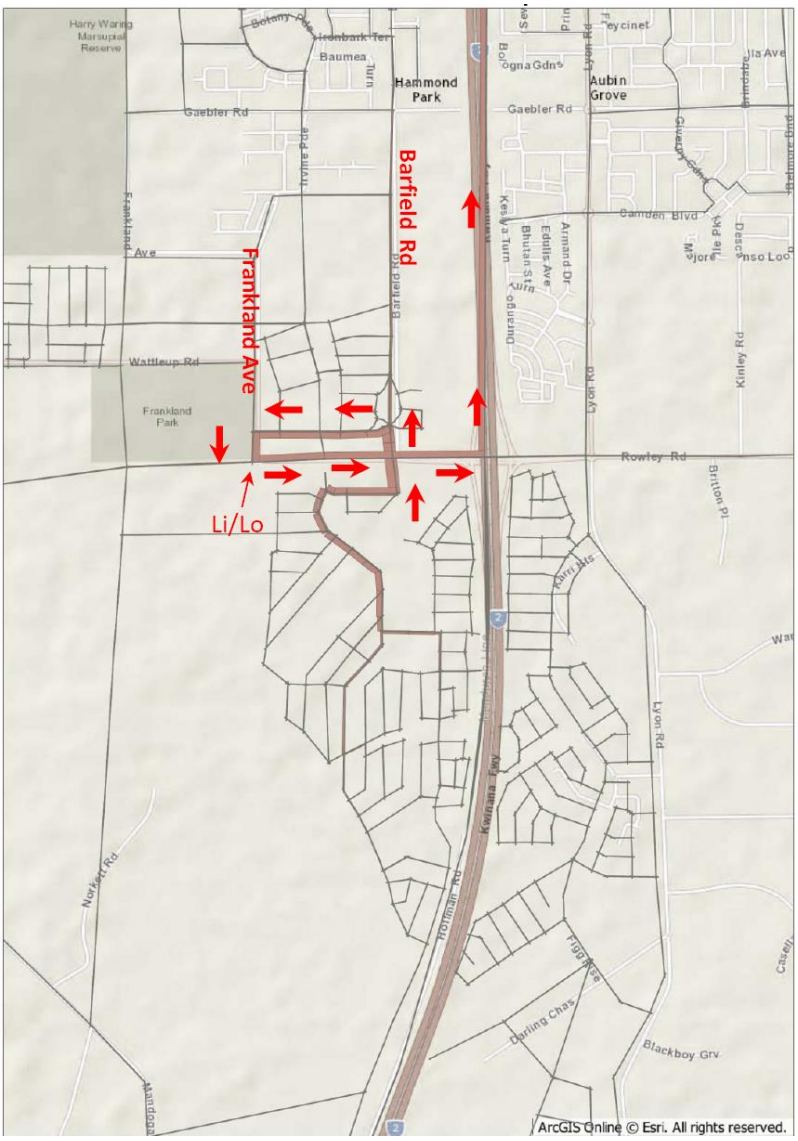


Figure 11: Link Analysis for the potential Barfield Road underpass

Pedestrian and Cyclist Assessment

The proposed Southern Suburbs District Structure Plan (refer Appendix B) shows the 400m walkable catchments on the plan. According to this plan the proposed high school to the north of Rowley Road is not within the 400m walking catchment of the Mandogalup LSPs and therefore, the proposed Barfield Road underpass is unlikely to be utilised by pedestrians going to the high school.

Cyclists would benefit the proposed Barfield underpass, as the cycling catchment circles are larger than the walking catchments. Currently, there is an existing underpass only a few hundred meters to the east of Barfield Road which can be utilised by cyclists who wish to cycle from Mandogalup towards the proposed developments to the north of Rowley Road. Main Roads WA has also confirmed that construction of the underpass at Barfield Road is not feasible given the existing and future levels.

Proposed pedestrian and cyclist road network shown in Figure 8 indicates three shared path connections to the existing Principal Shared Path along Kwinana Freeway. Provision of shard path connections to the existing Principal Shared Path (PSP) along the Freeway would improve the utilisation of the existing PSP and the existing Rowley Road underpass.

6.4 Roads and Intersections

The proposed road network to accommodate both LSP traffic volumes has been detailed in section 5 of this report, including the details of the proposed road hierarchy in section 5.1. **Figure 12** details the proposed intersection controls for key intersections within the LSP areas.

Two roundabouts are proposed at south-east corner of the proposed primary school and south west corner of the POS area. Two roundabouts are also proposed on the neighbourhood connector A road. These roundabouts will help manage the circulation of traffic flows and assist with speed management on major roads.



Figure 12: Intersection Treatments

There are a number of four-way intersections shown on both LSPs on low-traffic-volume access streets. These intersections are recommended to be constructed as priority-controlled intersections with Give-Way control on the minor road approaches as suggested in Liveable Neighbourhoods document. Appropriate entry treatments are recommended on the side roads to help to alert drivers to the presence of the intersections and that traffic on the major road has priority.

6.5 Intersection Analysis

There are two key intersections on the surrounding road network that are expected to be affected by the proposed MELSP and MWLSP traffic. These intersections are:

- Existing roundabout intersection on Rowley Road; and,
- Existing priority controlled T-intersection at Hoffman Road/ Anketell Road intersection.

Ultimately the existing roundabout intersection on Rowley Road will be downgraded to left in/ left out intersection or a cul-de-sac. However, for the interim scenario, this intersection is analysed as a single lane roundabout. In order to assess the operation of the roundabout for the interim stage, the projected daily traffic volumes through the roundabout were extracted from the transport model for the interim scenario and converted to typical peak hour traffic.

The existing intersection of Hoffman Road/ Anketell Road is located in close proximity of the Kwinana Freeway/Anketell Road interchange. Ultimately when Anketell Road is duplicated, this intersection is expected to be terminated or downgraded to left in/ left out standard.

Intersection analysis undertaken for this intersection indicates that it would operate satisfactorily and well within capacity during the interim scenario and would be able to accommodate the full MELSP development traffic with sufficient spare capacity to accommodate the future traffic growth on Anketell Road and traffic from other local developments. Details of the intersection analysis and the proposed layout of this intersection are documented in the MELSP TIA report.

Accordingly, capacity analysis is undertaken only for the existing roundabout intersection on Rowley Road during the interim stage using the SIDRA computer software package. SIDRA is an intersection modelling tool commonly used by traffic engineers for all types of intersections. SIDRA outputs are presented in the form of Degree of Saturation, Level of Service, Average Delay and 95% Queue. These characteristics are defined as follows:

- Degree of Saturation is the ratio of the arrival traffic flow to the capacity of the approach during the same period. The Degree of Saturation ranges from close to zero for infrequent traffic flow up to one for saturated flow or capacity.
- Level of Service is the qualitative measure describing operational conditions within a traffic stream and the perception by motorists and/or passengers. In general, there are 6 levels of service, designated from A to F, with Level of

Service A representing the best operating condition (i.e. free flow) and Level of Service F the worst (i.e. forced or breakdown flow).

- Average Delay is the average of all travel time delays for vehicles through the intersection.
- 95% Queue is the queue length below which 95% of all observed queue lengths fall.

The results of the SIDRA analysis are summarised in Appendix C. The proposed layout for the Rowley Road roundabout is also shown in Figure C1.

The SIDRA analysis indicates that the existing roundabout will operate satisfactorily with an overall Level of Service B. All movements will be at level of service A or B or C (good operation). The longest traffic queues will occur on Rowley Road with 95% back of queue of about 100m to the east and west of the existing roundabout. Queue lengths on the side roads are anticipated to be much shorter (generally about 6 vehicles at a time).

6.6 Access to Frontage Properties

The WAPC *Liveable Neighbourhoods* policy requires that "Development along integrator B and neighbourhood connector streets with ultimate vehicle volumes over 5000 vehicles per day should be designed either so vehicles entering the street can do so travelling forward, or are provided with alternative forms of vehicle access. Wider lots with paired driveways and protected reversing areas in the parking lane may be used on streets with up to 7000 vehicles per day."

All of the roads within the MWLSP and MELSP are expected to carry less than 7,000vpd, so no restriction on vehicular access is required.

6.7 Pedestrian / Cycle Networks

The proposed network of shared paths for pedestrians and cyclists is described in section 5.3 of this transport assessment. This network of paths will provide an excellent level of accessibility and permeability for pedestrians and cyclists within the MWLSP and MELSP, and connections to existing PSP along the Kwinana Freeway and neighbouring precincts.

6.8 Access to Public Transport

At this stage of the planning process the details of the bus route planning and the location of bus stops are not known. However, in these circumstances the WAPC *Transport Assessment Guidelines for Developments* (2006) suggest that it is desirable for at least 90 per cent of dwellings to be within 400m straight line distance of a bus route. The potential future bus route proposed along the main north-south road would service the majority of the lots within both LSP areas.

7.0 Conclusions

The transport modelling and analysis documented in this revised TIA report is undertaken for both MWLSP and MELSP, and the report findings/ recommendations are compatible.

The MWLSP area is anticipated to accommodate approximately 911 dwellings with a local centre and a Primary School, with a traffic generation of approximately 7,288vpd.

Initially, it is anticipated that Rowley Road extension would be constructed as a two lane standard. The existing roundabout intersection between Barfield Road and Frankland Avenue provides connectivity for the proposed developments to the north and south of Rowley Road.

The existing roundabout is expected to be removed or downgraded to left in/ left out intersection in the ultimate scenario when Rowley Road is duplicated and Hammond Road is extended.

SIDRA analysis undertaken for the existing roundabout on Rowley Road during the interim stage indicates that this roundabout will work satisfactorily with the full development of the MELSP and MWLSP areas.

Additional modelling and analysis undertaken for the potential vehicular/ pedestrian underpass on Rowley Road at Barfield Road location indicate that this proposal has little benefit on the vehicular and pedestrian/ cyclist movements of the Mandogalup LSPs.

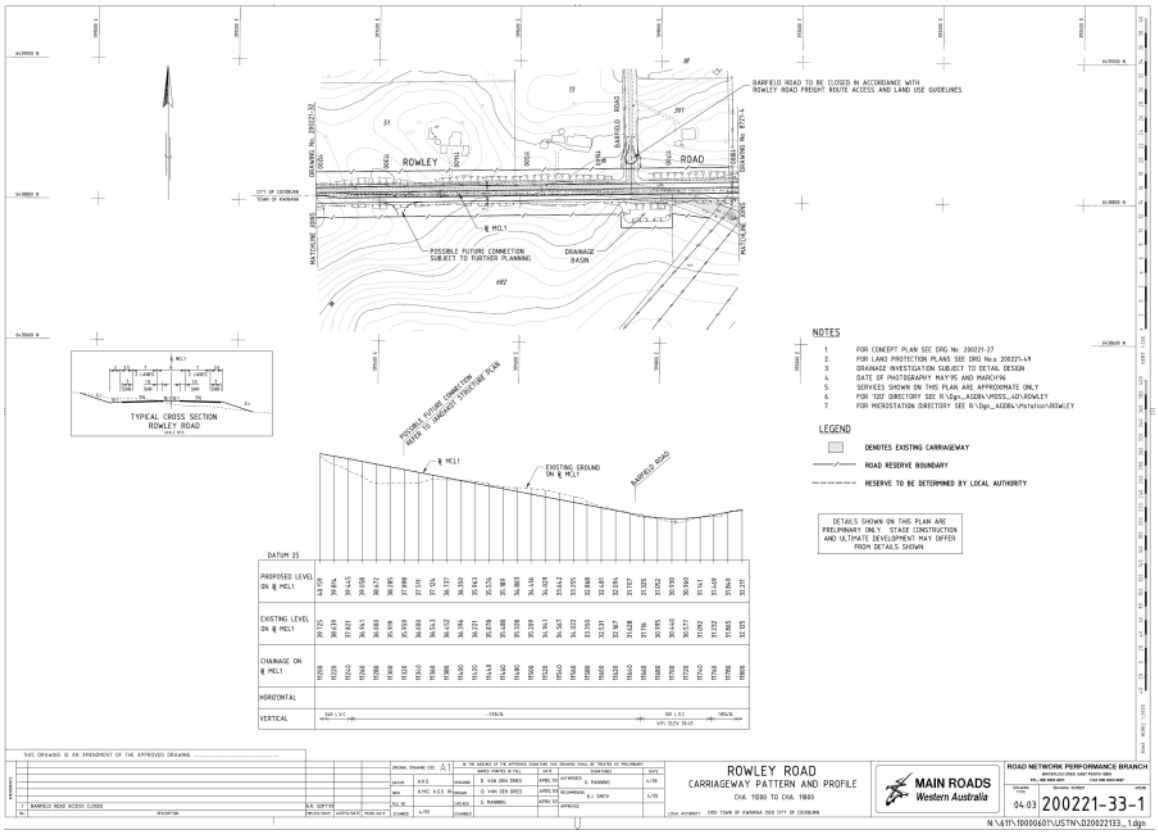
Main Roads WA has also confirmed that construction of the underpass at Barfield Road is not feasible given the existing and future levels. Current discussion with MRWA indicated that it is no longer intended to pursue concepts for a vehicle underpass linking Barfield Road with Mandogalup (Qube) land.

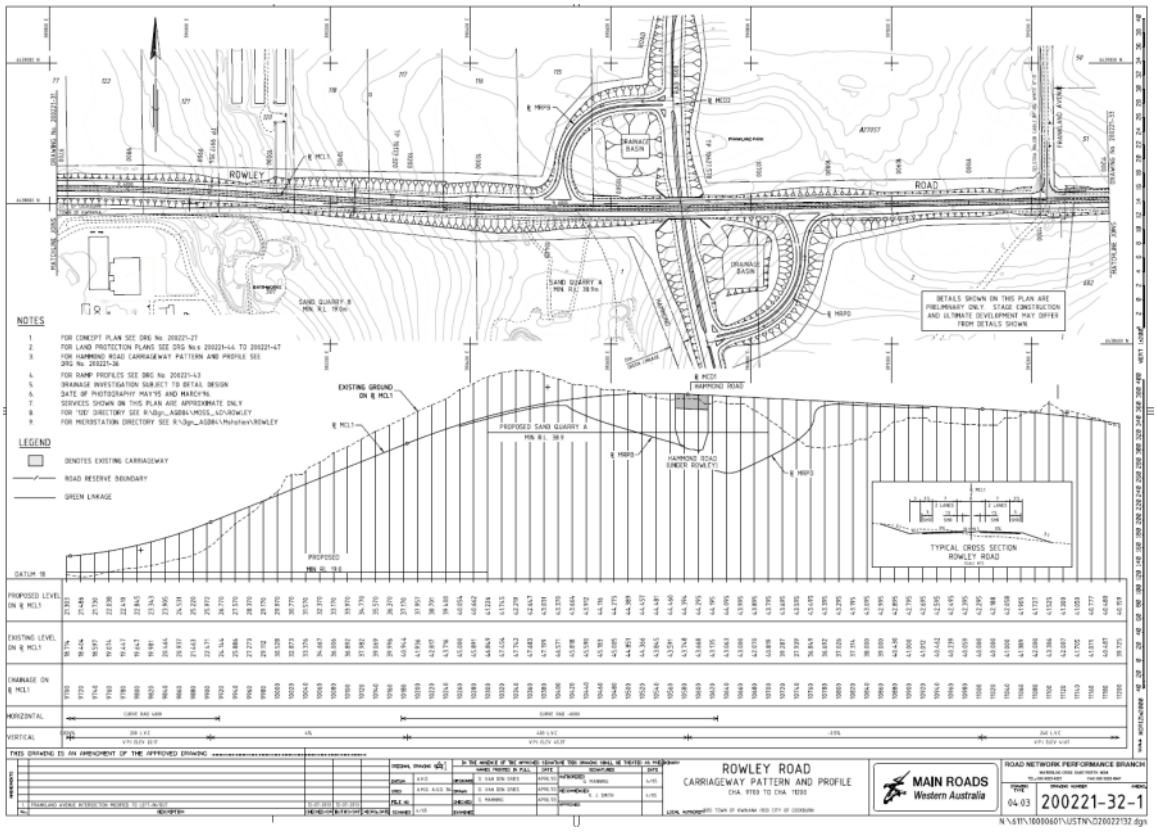
Currently, there is an existing underpass only a few hundred meters to the east of Barfield Road which can be utilised by pedestrian/ cyclists who wish to travel from Mandogalup area towards the proposed developments to the north of Rowley Road.

The road network of the MWLSP area has been planned based on WAPC Liveable Neighbourhoods guidelines to accommodate the future traffic flows that will be generated within this area.

Appendix A

ROWLEY ROAD ACCESS ARRANGEMENTS
(MAIN ROADS WA DESIGNS)


ROWLEY ROAD
CARRIAGEWAY PATTERN AND PROFILE
CHA 7090 TO CHA 7880
MAIN ROADS Western Australia
ROAD NETWORK PERFORMANCE BRANCH
04-03
200221-33-1
NOTES
LEGEND
DENOTES EXISTING CARRIAGEWAY
ROAD RESERVE BOUNDARY
RESERVE TO BE DETERMINED BY LOCAL AUTHORITY
DETAILS SHOWN ON THIS PLAN ARE PRELIMINARY ONLY. STAGE CONSTRUCTION AND ULTIMATE DEVELOPMENT MAY DIFFER FROM DETAILS SHOWN
BARFIELD ROAD TO BE CLOSED IN ACCORDANCE WITH ROWLEY ROAD FREIGHT ROUTE ACCESS AND LAND USE GUIDELINES
POSSIBLE FUTURE CONNECTION SUBJECT TO FURTHER PLANNING
DRAINAGE BASIN
TYPICAL CROSS SECTION ROWLEY ROAD
EXISTING GROUND ON ℄ MC1
BARFIELD ROAD
DATUM 25
PROPOSED LEVEL ON ℄ MC1
EXISTING LEVEL ON ℄ MC1
CHAINAGE ON ℄ MC1
HORIZONTAL
VERTICAL


ROWLEY ROAD
CARRIAGEWAY PATTERN AND PROFILE
CHA 9780 TO CHA 10130
MAIN ROADS Western Australia
ROAD NETWORK PERFORMANCE BRANCH
04-03
200221-32-1
NOTES
LEGEND
DENOTES EXISTING CARRIAGEWAY
ROAD RESERVE BOUNDARY
GREEN LINKAGE
DETAILS SHOWN ON THIS PLAN ARE PRELIMINARY ONLY. STAGE CONSTRUCTION AND ULTIMATE DEVELOPMENT MAY DIFFER FROM DETAILS SHOWN
SAND QUARRY A MIN R.L. 38.5m
SAND QUARRY B MIN R.L. 39.0m
DRAINAGE BASIN
EXISTING GROUND ON ℄ MC1
PROPOSED SAND QUARRY A MIN R.L. 39.5
HAMMOND ROAD
TYPICAL CROSS SECTION ROWLEY ROAD
DATUM 18
PROPOSED LEVEL ON ℄ MC1
EXISTING LEVEL ON ℄ MC1
CHAINAGE ON ℄ MC1
HORIZONTAL
VERTICAL

Appendix B

SOUTHERN SUBURBS DISTRICT STRUCTURE PLAN

1. THE PROPOSED LOCAL CENTRES TO BE 'MAIN STREET' BASED CENTRES. ALL LOCAL STRUCTURE PLANS MUST INCORPORATE CONCEPT PLANS THAT DEMONSTRATE THE MANNER IN WHICH THE CENTRES MAY DEVELOP AND THESE WILL BE USED TO DETERMINE THE CONFIGURATION AND EXTENT OF THE LOCAL CENTRE ZONES SHOWN ON THE LOCAL STRUCTURE PLANS. LOCAL CENTRES WILL BE SUBJECT TO A DETAILED AREA PLAN TO BE PREPARED AT SUBDIVISION STAGE.
2. MEDIUM DENSITY DEVELOPMENT WILL BE ENCOURAGED AROUND AREAS OF HIGH AMENITY SUCH AS PUBLIC OPEN SPACE.
3. IN AREAS ADJACENT TO BUSH LAND, LOCAL STRUCTURE PLANS NEED TO ADDRESS BUSH FIRE MANAGEMENT ISSUES IN ACCORDANCE WITH STANDARD REQUIREMENTS.
4. LAND WITHIN CLOSE PROXIMITY TO ROWLEY ROAD AND THE KWINANA FREEWAY WILL NEED TO ADDRESS NOISE AND VIBRATION ISSUES IN ACCORDANCE WITH STANDARD REQUIREMENTS.
5. ALL LOCAL STRUCTURE PLANS MUST INCORPORATE A LOCAL WATER MANAGEMENT STRATEGY TO DEMONSTRATE THE MANNER IN WHICH DRAINAGE CAN BE SELF CONTAINED WHILST TAKING INTO CONSIDERATION THE REGIONAL DRAINAGE OBJECTIVES.
6. ALL LOCAL STRUCTURE PLANS TO BE ACCOMPANIED BY A DETAILED LOCAL TRAFFIC ASSESSMENT WHICH IN ADDITION TO DETERMINING LOCAL TRAFFIC IMPACT MUST ALSO TAKE INTO CONSIDERATION THE LIKELY TRAFFIC GENERATED FROM THE DISTRICT STRUCTURE PLAN AREA.
7. THE BARFIELD - ROWLEY ROAD INTERSECTION IS A TEMPORARY ACCESS AND SHALL BE CLOSED ONCE ROWLEY ROAD IS UPGRADED AND CONSTRUCTED TO A REGIONAL ROAD.
8. GRADE SEPERATED ACCESS LINKING HAMMOND PARK AND FUTURE DEVELOPMENT SOUTH OF ROWLEY ROAD SHOULD BE INVESTIGATED AS PART OF THE LSP.



FIGURE

City of Cockburn

GNA 2/05

0 250m

SCALE 1:12,500

Residential - Target Urban Density:
- 20 DU's / ha
- 15 DU's / ha
- 10 DU's / ha

- Local Centre (Pedestrian Based Retail)
- Mixed Business / Commercial / Home Based Business
- Community Facilities / Schools etc
- Western Power Easement

Key Local Open Space Areas:
- POS
- Conservation
- Regional Open Space

- Major Shared Path
- Historic Baldivis Tramway Trail
- 400m Walkable Catchment

SOUTHERN SUBURBS DISTRICT STRUCTURE PLAN

- STAGE 3, HAMMOND PARK / WATTLEUP

Appendix C

INTERSECTION ANALYSIS

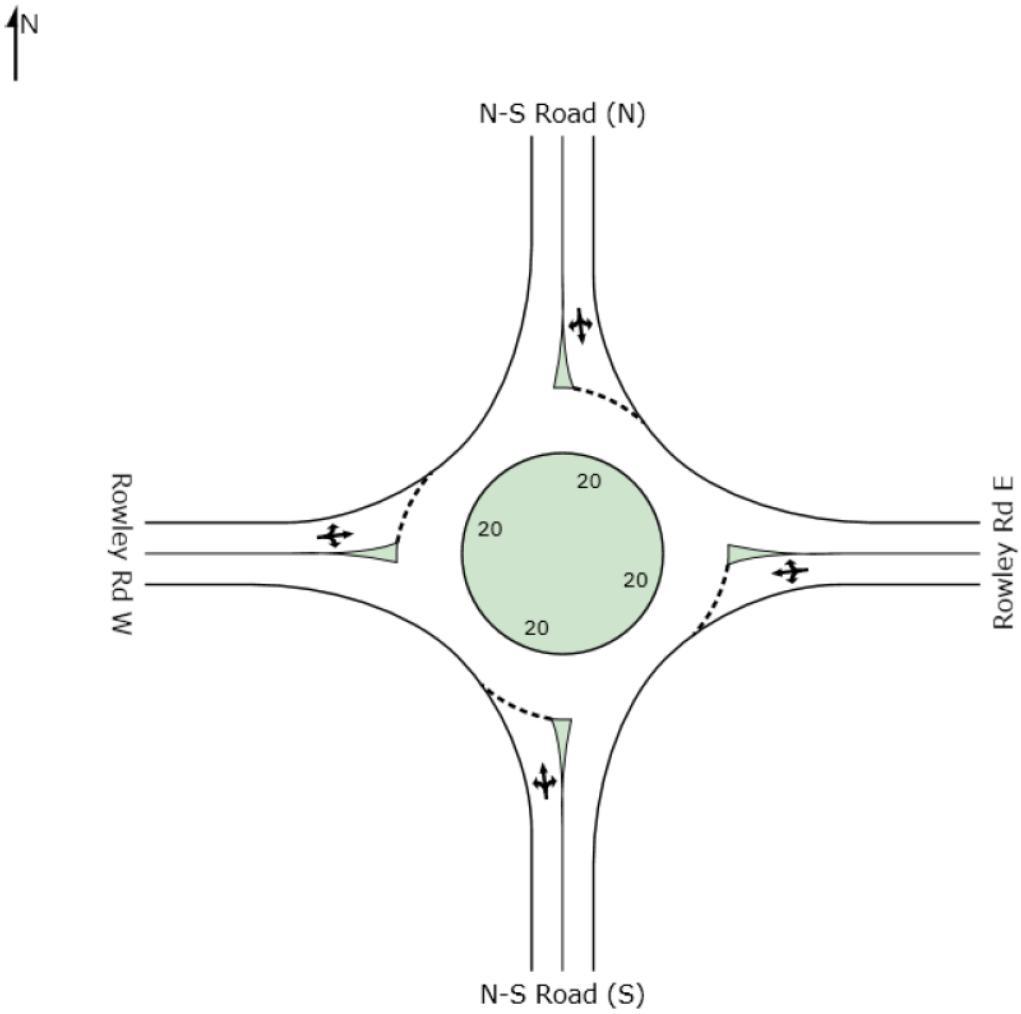


Figure C1: Proposed Roundabout at Rowley Road

Movement Performance - Vehicles											
Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: N-S Road (S)											
1	L	110	0.0	0.591	21.7	LOS C	5.9	41.0	1.00	1.13	37.2
2	T	10	0.0	0.591	20.8	LOS C	5.9	41.0	1.00	1.13	37.3
3	R	143	0.0	0.591	26.6	LOS C	5.9	41.0	1.00	1.13	35.7
Approach		263	0.0	0.591	24.3	LOS C	5.9	41.0	1.00	1.13	36.4
East: Rowley Rd E											
4	L	140	0.0	0.829	8.1	LOS A	13.2	98.6	0.84	0.58	46.5
5	T	684	12.0	0.829	7.5	LOS A	13.2	98.6	0.84	0.58	46.2
6	R	258	0.0	0.829	13.0	LOS B	13.2	98.6	0.84	0.63	45.3
Approach		1082	7.6	0.829	8.9	LOS A	13.2	98.6	0.84	0.59	46.0
North: N-S Road (N)											
7	L	256	0.0	0.599	20.4	LOS C	6.0	42.0	1.00	1.13	38.4
8	T	20	0.0	0.599	19.5	LOS B	6.0	42.0	1.00	1.13	38.5
9	R	10	0.0	0.599	25.2	LOS C	6.0	42.0	1.00	1.13	36.8
Approach		286	0.0	0.599	20.5	LOS C	6.0	42.0	1.00	1.13	38.4
West: Rowley Rd W											
10	L	10	0.0	0.832	17.3	LOS B	14.3	109.2	1.00	1.11	41.1
11	T	664	12.0	0.832	16.8	LOS B	14.3	109.2	1.00	1.12	41.2
12	R	96	0.0	0.832	22.2	LOS C	14.3	109.2	1.00	1.11	39.1
Approach		770	10.3	0.832	17.5	LOS B	14.3	109.2	1.00	1.12	40.9
All Vehicles		2401	6.7	0.832	14.7	LOS B	14.3	109.2	0.93	0.88	42.1

Table C1: SIDRA results – Proposed Roundabout on Rowley Road, Interim Stage

Appendix H

Power Easement Document

INSTRUCTIONS

1. This form may be used only when a "Box Type" Form is not provided or is unsuitable. It may be completed in narrative style.
2. If insufficient space hereon Additional Sheet, Form B1, should be used.
3. Additional Sheets shall be numbered consecutively and bound to this document by staples along the left margin prior to execution by the parties.
4. No alteration should be made by erasure. The words rejected should be scored through and those substituted typed or written above them, the alteration being initialled by the persons signing this document and their witnesses.

NOTES

1. Insert document type.
2. A separate attestation is required for every person signing this document. Each signature should be separately witnessed by an Adult person. The address and occupation of the witness must be stated.

G 402223 E
20 Feb, 1997 11:30:42 Perth

REG. $ 60.00

LODGED BY WESTERN POWER

ADDRESS 363-365 WELLINGTON ST, PERTH

PHONE No. 326 4096

FAX No. 326 6880 (S:R\902.kjy)

REFERENCE No. KWI-ST 42

ISSUING BOX No. BOX 184

PREPARED BY

AS ABOVE

ADDRESS

PHONE No. FAX No.

INSTRUCT IF ANY DOCUMENTS ARE TO ISSUE TO OTHER THAN LODGING PARTY.

Please issue to Box 184 Perth

(2) - 2

TITLES, LEASES, DECLARATIONS ETC. LODGED HEREWITH

1.
2.
3.
4.
5.
6.

Received Items

Nos.

Receiving Clerk

ENDORSING INSTRUCTION

NE38

EXAMINED

Registered pursuant to the provisions of the TRANSFER OF LAND ACT 1893 as amended on the day and time shown above and particulars entered in the Register Book.

INITIALS OF SIGNING OFFICER

REGISTRAR OF TITLES WESTERN AUSTRALIA

REGISTRAR OF TITLES

16748/6/92-3M-L/5696

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SIGNED

MAURICE FRANK WHITE

in the presence of:

D W Little

20 KING ST KENSINGTON

PROPERTY OFFICER

SIGNED

ROBERT ALFRED WHITE

in the presence of:

D W Little

20 KING ST KENSINGTON

PROPERTY OFFICER.

THE COMMON SEAL of ELECTRICITY CORPORATION was affixed in the presence of:

Director:

Director/Executive Officer:

ELECTRICITY CORPORATION Western Power COMMON SEAL

ENCUMBRANCES REFERRED TO

NIL

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ADDITIONAL PAGE TO **EASEMENT IN GROSS** Dated

(c) subject to the express provisions of this Grant, Electricity Corporation shall do as little damage as is reasonably possible and shall make good or otherwise pay adequate compensation for all physical damage done to the Land and any premises or thing, by Electricity Corporation in the course and at the time of the exercise of any power of entry onto that land premises or thing;

(d) in this Grant, unless the context otherwise requires:

(i) a covenant or agreement entered into by more than one person shall be deemed entered into and to bind all parties jointly and each party severally;

(ii) a reference to the Grantor (where there is more than one) shall mean and include each of them and any two or more of them; and

(iii) all words and phrases which are defined in the Act, shall have the same meanings whenever they appear in this Grant;

(e) this Grant is made and received upon and subject to all of the rights, powers and authority of Electricity Corporation contained in the Act and any other Act or Acts which now or subsequently confer any rights, powers or authorities on Electricity Corporation.

THE SCHEDULE

KWINANA TO SOUTHERN TERMINAL 330KV TRANSMISSION LINE

DATED this 31 day of January 1997.

ENDORSER: On the back of C/T 533/188A (Orig. + Dup.)

TRANSFER G402223. The right to enter upon the within land for the purpose of constructing, maintaining and using electrical transmission works in, upon and across the said land as set out in the said Transfer is granted to Electricity Corporation.

Registered 20.2.1997 at 11:30:42 hrs.

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(I) a fence or trellis not exceeding two (2) metres in height from the natural surface of the Land, earthed to the satisfaction of Electricity Corporation in the case of a metallic fence or trellis; and

(ii) those structures and improvements specified in and to the extent permitted by subclause 1(c)

(c) construct, erect, set up, improve, enlarge or alter any:

(I) contour bank;

(ii) fenced stormwater drain or compensating basin; or

(iii) fenced artificial lake;

within the Easement without the prior written consent of Electricity Corporation, which Electricity Corporation shall be under no obligation to grant and then upon those terms and conditions, if any, which Electricity Corporation may determine;

(d) grow, cultivate or maintain any vegetation exceeding one (1) metre in height from the natural surface of the land, within the Easement;

(e) stack, place or store any plant or material within the Easement;

(f) bring within the easement any vehicle or machinery which together with any attachment, aerial or accessory exceeds 5 metres in height from the natural surface of the land;

(g) park or leave stationary within the easement any vehicle or machinery exceeding 2.5 metres in height from the natural surface of the land;

(h) bring onto or permit to be brought onto the Easement any explosive, flammable or unstable substance or material other than agricultural crops;

(I) blast or permit any blasting within the Easement;

(j) carry on or permit to be carried on any activity or operation which endangers the safety of the Transmission Works or the safe, efficient and continuous operation of those Works.

2. MUTUAL COVENANTS

The Grantor and Electricity Corporation MUTUALLY AGREE AND DECLARE that:

(a) Electricity Corporation shall maintain all bridges, gates, culverts, access roads and improvements which it makes to the Land to the extent that they serve Electricity Corporation's Transmission Works;

(b) Electricity Corporation shall not be required to fence off all or any part of the Easement but may cut and remove part of any fence and construct and maintain a gate or gates as Electricity Corporation may require;

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FORM B2

WESTERN AUSTRALIA
TRANSFER OF LAND ACT 1893 AS AMENDED.

BLANK INSTRUMENT FORM

EASEMENT IN GROSS (Note 1)

WA STAMP DUTY PAID SECTION 112V	
273.5-58	$ 1-00
Signature	$ 5-00 Duty

I/WE **MAURICE FRANK WHITE AND ROBERT ALFRED WHITE BOTH of RMB 372, MANDOGALUP** in the State of Western Australia ("the Grantor", which expression includes the transferees, assigns, personal representatives and successors in title of the Grantor) being registered as the proprietor of an estate in fee simple in ALL THAT land being:

PORTION OF COCKBURN SOUND LOCATION 16 AND BEING PART OF THE LAND ON PLAN 9780 AND BEING THE WHOLE OF THE LAND CONTAINED IN CERTIFICATE OF TITLE VOLUME 533 FOLIO 188A

subject to the encumbrances notified hereunder ("the Land")

AGREE THAT IN CONSIDERATION of the sum of **ONE DOLLAR ($1.00)** paid to me/us on the execution of this GRANT by Electricity Corporation, a body corporate pursuant to the Electricity Corporation Act 1994 ("the Act") of 363-365 Wellington Street, Perth in the State of Western Australia (which expression includes the successors and assigns of Electricity Corporation) I/WE TRANSFER AND GRANT to Electricity Corporation full right and liberty for Electricity Corporation from time to time and at all times hereafter, to enter in, upon, under, over and across ALL OF THE SUBJECT LAND ("the Easement") and to remain on and occupy the Easement at all times for so long as is necessary for Electricity Corporation to:

(a) clear and keep the Easement clear of trees, shrubs, vegetation and other growth;

(b) break, excavate (to the depth necessary), remove timber, vegetation, soil, earth, gravel and stone upon the Easement; and

(c) set up, lay down, establish, maintain, utilise and operate and at any time, inspect, service, maintain, repair, replace, alter or remove the system of electricity Transmission Works named and described in the Schedule and all of the Works and Undertakings which now or in the future form any part of those Transmission Works.

1. GRANTORS COVENANTS

The Grantor COVENANTS with Electricity Corporation not to:

(a) alter or disturb the present grades and contours of the surface of the land within the Easement except:

(i) in the course of normal farming operations; or

(ii) otherwise with the prior written consent of Electricity Corporation on each occasion

(b) construct, erect or set up any building, structure or improvement within the Easement other than:

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Appendix I

Transportation Noise Assessment

(Lloyd George Acoustics)

Lloyd George Acoustics
PO Box 717
Hillarys WA 6923
T: 9401 7770
www.lgacoustics.com.au

Transportation Noise Assessment

Proposed Rezoning, Mandogalup (Apsley Estate) to Support Local Planning Scheme Amendment

Reference: 19075084-01b.docx

Prepared for:
Qube

Association of Australasian Acoustical Consultants

Report: 19075084-01b.docx

Lloyd George Acoustics Pty Ltd

ABN: 79 125 812 544

PO Box 717
Hillarys WA 6923

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M:	0439 032 844	0400 414 197	0412 611 330	0439 987 455	0457 095 555

This report has been prepared in accordance with the scope of services described in the contract or agreement between Lloyd George Acoustics Pty Ltd and the Client. The report relies upon data, surveys, measurements and results taken at or under the particular times and conditions specified herein. Any findings, conclusions or recommendations only apply to the aforementioned circumstances and no greater reliance should be assumed or drawn by the Client. Furthermore, the report has been prepared solely for use by the Client, and Lloyd George Acoustics Pty Ltd accepts no responsibility for its use by other parties.

Date:	Rev	Description	Prepared By	Verified
23-Jul-19	0	Issued to Client	Terry George	Matt Moyle
23-Jul-19	A	Update to Fig 1-2 & 1-3. No other changes	Terry George	-
1-Aug-19	B	Client comments	Terry George	-

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Appendices

A Terminology

1 INTRODUCTION

Apsley Estate by Qube Property is a future subdivision located in the suburb of Mandogalup, west of the Kwinana Freeway and south of Rowley Road - refer *Figure 1-1* for locality. Between the Qube site and Kwinana Freeway is land being developed by Satterley Property Group.



Figure 1-1 Apsley Estate Site Location

The approved Qube subdivision plan is shown in *Figure 1-2*. It can be seen that the subdivision plan circles an area to the southwest, which is currently zoned as Urban. This report considers the road traffic noise impacts to the recently zoned Urban area, shaded in *Figure 1-3*, to support the Local Planning Scheme Amendment from Rural to Development.

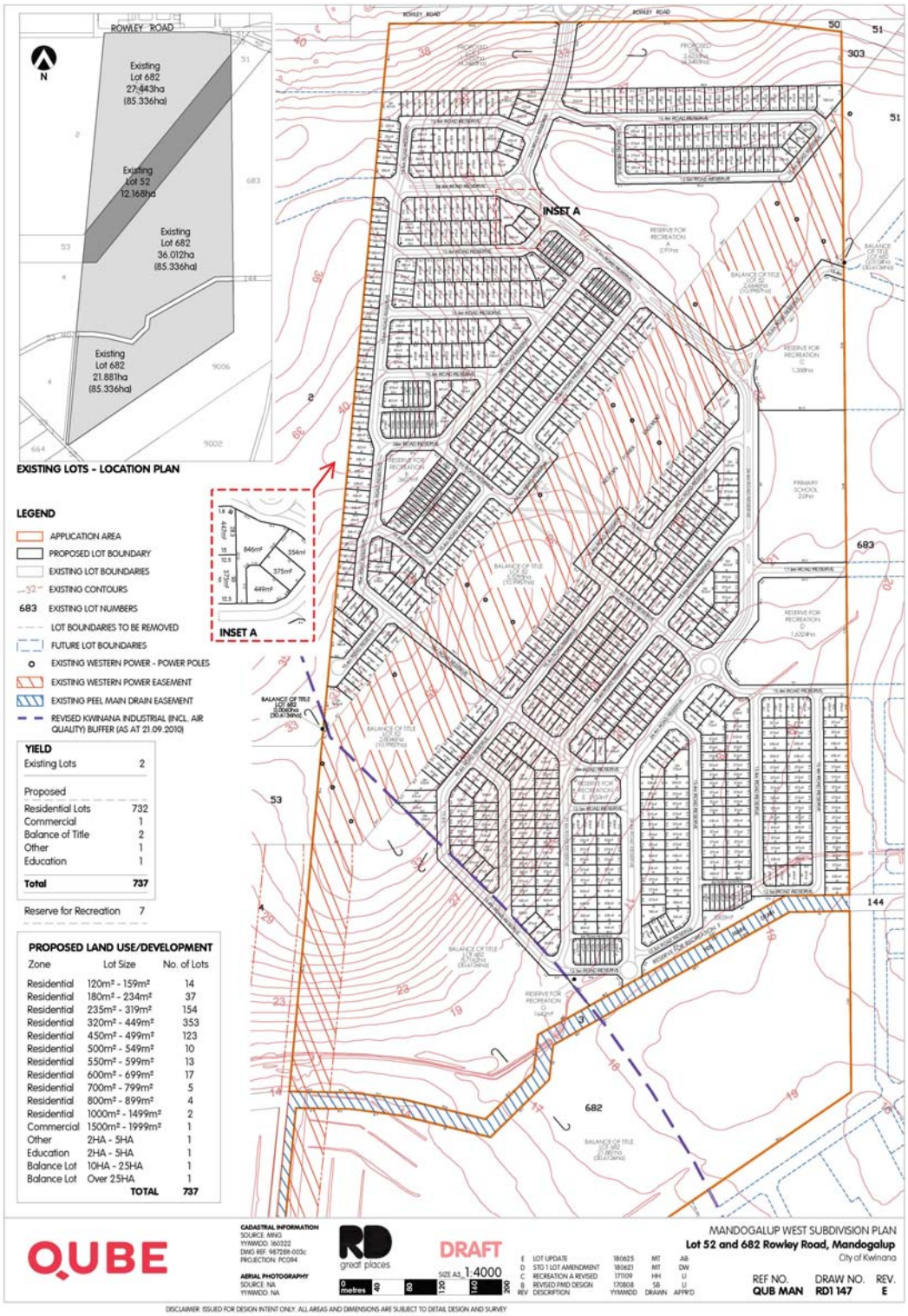


Figure 1-2 Apsley Estate Concept Plan

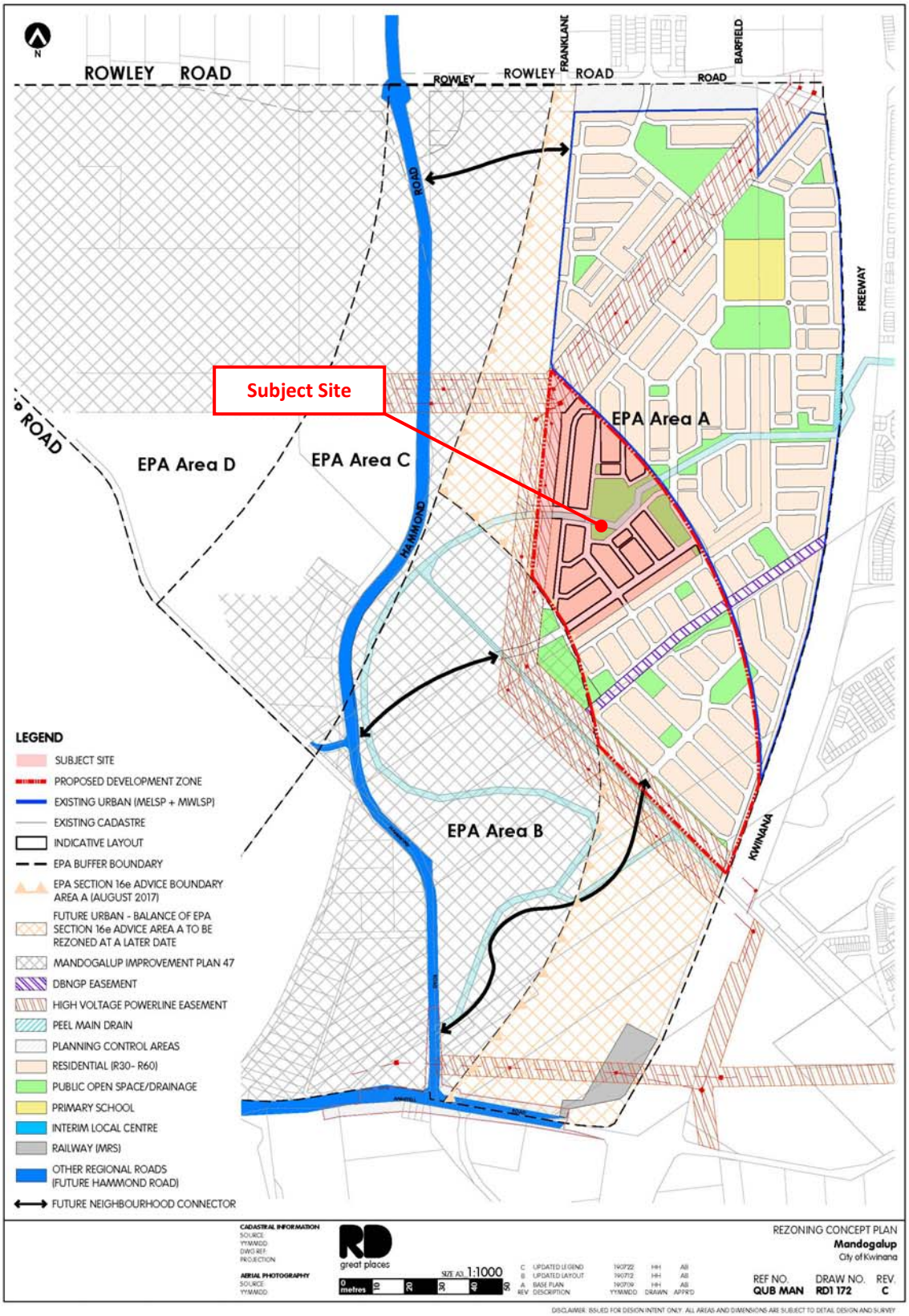


Figure 1-3 Apsley Estate Subject Area

Appendix A contains a description of some of the terminology used throughout this report.

2 CRITERIA

The criteria relevant to this assessment is the *State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning* (hereafter referred to as the Policy) produced by the Western Australian Planning Commission (WAPC). The objectives in the Policy are to:

- Protect people from unreasonable levels of transport noise by establishing a standardised set of criteria to be used in the assessment of proposals;
- Protect major transport corridors and freight operations from incompatible urban encroachment;
- Encourage best practice design and construction standards for new development proposals and new or redevelopment transport infrastructure proposals;
- Facilitate the development and operation of an efficient freight network; and
- Facilitate the strategic co-location of freight handling facilities.

The Policy's outdoor noise criteria are shown in *Table 2-1*. These criteria apply at any point 1-metre from a habitable façade of a noise sensitive premises and in one outdoor living area.

Table 2-1 Outdoor Noise Criteria

Period	Target	Limit
Day (6am to 10pm)	55 dB $L_{Aeq(Day)}$	60 dB $L_{Aeq(Day)}$
Night (10pm to 6am)	50 dB $L_{Aeq(Night)}$	55 dB $L_{Aeq(Night)}$

Note: The 5 dB difference between the target and limit is referred to as the margin.

In the application of these outdoor noise criteria to new noise sensitive developments, the objectives of this Policy is to achieve -

- acceptable indoor noise levels in noise-sensitive areas (e.g. bedrooms and living rooms of houses); and
- a 'reasonable' degree of acoustic amenity in at least one outdoor living area on each residential lot.

If a noise sensitive development takes place in an area where outdoor noise levels will meet the *target*, no further measures are required under this Policy.

In areas where the *target* is exceeded, customised noise mitigation measures should be implemented with a view to achieving the *target* in at least one outdoor living area on each residential lot, or if this is not practicable, within the *margin*. Where indoor spaces are planned to be facing outdoor areas that are above the *target*, mitigation measures should be implemented to achieve acceptable indoor noise levels in those spaces.

For residential buildings, "acceptable indoor noise levels" are taken to be 40 dB $L_{Aeq(Day)}$ in living areas and 35 dB $L_{Aeq(Night)}$ in bedrooms.

3 METHODOLOGY

In November 2017, Lloyd George Acoustics completed a road traffic noise impact assessment to the approved Apsley Estate subdivision (*Transportation Noise Assessment, Mandogalup Subdivision*; Reference: 14113004-01d). This current report therefore uses the same methodology, with any updated information discussed below.

3.1 Ground Topography

To ensure the latest information was used in the model, the finished levels for the Qube site were requested and obtained from Cossill and Webley (email dated 15 July 2019). The same was also requested from Peritas, being the Satterley engineers. The information provided is dated May 2016 and aligns with what was already in the previous noise model. It was confirmed by Satterley that this is the most recent data for their landholdings.

3.2 Traffic Data

The previous model for the approved subdivision, utilised 2031 forecast traffic volumes, as these were the latest available from Main Roads WA at that time. The model has now been updated to consider 2041 traffic volumes, as these are now the latest forecast year available from Main Roads WA. In addition to the 2041 volumes, a validation plot was also provided (Clare Yu, Traffic Modelling Analyst, Reference: #41247, dated 12 July 2019) allowing the modelled traffic volumes to be calibrated as shown in *Table 3-1*.

Table 3-1 2016 Traffic Volume Calibration – Kwinana Freeway

Section	MRWA Model		MRWA Observed		Difference	
	Northbound	Southbound	Northbound	Southbound	Northbound	Southbound
South of Rowley Road	37,600	39,200	47,500	49,700	9,900	10,500

It can be seen from *Table 3-1* that the Main Roads WA model is under-predicting traffic volumes. As such, the modelled 2041 traffic volumes have been adjusted by the identified difference as shown in *Table 3-2*.

Table 3-2 2041 Traffic Volumes – Kwinana Freeway

Section	MRWA Model		Difference from Validation Plot		2041 Calibrated	
	Northbound	Southbound	Northbound	Southbound	Northbound	Southbound
South of Rowley Road	75,800	76,300	9,900	10,500	85,700 (9%)	86,800 (9%)

Note: (9%) refers to the Main Roads WA percentage heavy vehicles used in the model.

3.3 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 spaces, which are set to 1.00 (100%).

3.4 Parameter Conversion

The CoRTN algorithms used in the *SoundPLAN* modelling package were originally developed to calculate the $L_{A10,18hour}$ noise level. However, the WAPC Policy uses the parameters $L_{Aeq(Day)}$ and $L_{Aeq(Night)}$ (refer *Table 2.1*). Therefore an adjustment needs to be made to the predicted $L_{A10,18hour}$ noise level to enable the noise modelling results to be compared to the allowable $L_{Aeq(Day)}$ and $L_{Aeq(Night)}$ traffic noise criteria. The relationship between these parameters varies depending on the composition of traffic on the road (the volumes during each time period and the percentage of heavy vehicles).

As part of the study for the Satterley land to the east, ATP Consulting Engineers undertook noise measurements on the site (*Road & Railway Noise Assessment, Mandogalup East Local Structure Plan, Mandogalup*; ATP140414-R-TNIA-04, November 2016). As part of the earlier work, the ATP study was shared between parties to ensure consistency. An extract from the ATP report is shown in *Figure 3-1*, resulting in the $L_{Aeq(Day)}$ being 1 dB less than the $L_{A10,18hour}$ and the $L_{Aeq(Night)}$ being 7 dB less than the $L_{Aeq(Day)}$. Therefore, these differences have been applied in this current study. Given the $L_{Aeq(Day)}$ is at least 5 dB more than the $L_{Aeq(Night)}$, the $L_{Aeq(Day)}$ parameter will determine compliance or otherwise.

Date	$L_{A10(18\text{-}hour)}$* dB(A)	$L_{Aeq(16\text{-}hour)}$* dB(A)	$L_{Aeq(8\text{-}hour)}$* dB(A)
8 July 2013 (Monday)	63	62	56
9 July 2013 (Tuesday)	64	63	55
10 July 2013 (Wednesday)	63	62	55
11 July 2013 (Thursday)	63	62	54
12 July 2013 (Friday)	63	61	55
Average	**63**	**62**	**55**

**Free-field*

Figure 3-1 Extract from ATP Report (Kwinana Freeway)

4 RESULTS

The results of the 2041 road traffic noise modelling are provided in *Figure 4-1* by way of a noise contour plot. Note that this includes a 4-metre high wall along the boundary of the Satterley subdivision, as recommended by ATP Consulting Engineers, as part of their noise study with Satterley Property Group. It also includes future residential dwellings as part of the Qube and Satterley subdivisions, since these also provide attenuation between the road and subject site.

5 ASSESSMENT

The objectives of the criteria are for noise at all houses to be no more than the *limit* and preferably no more than the *target*. Where the *target* is achieved, no further controls are required. Where the *target* is exceeded, further controls are necessary.

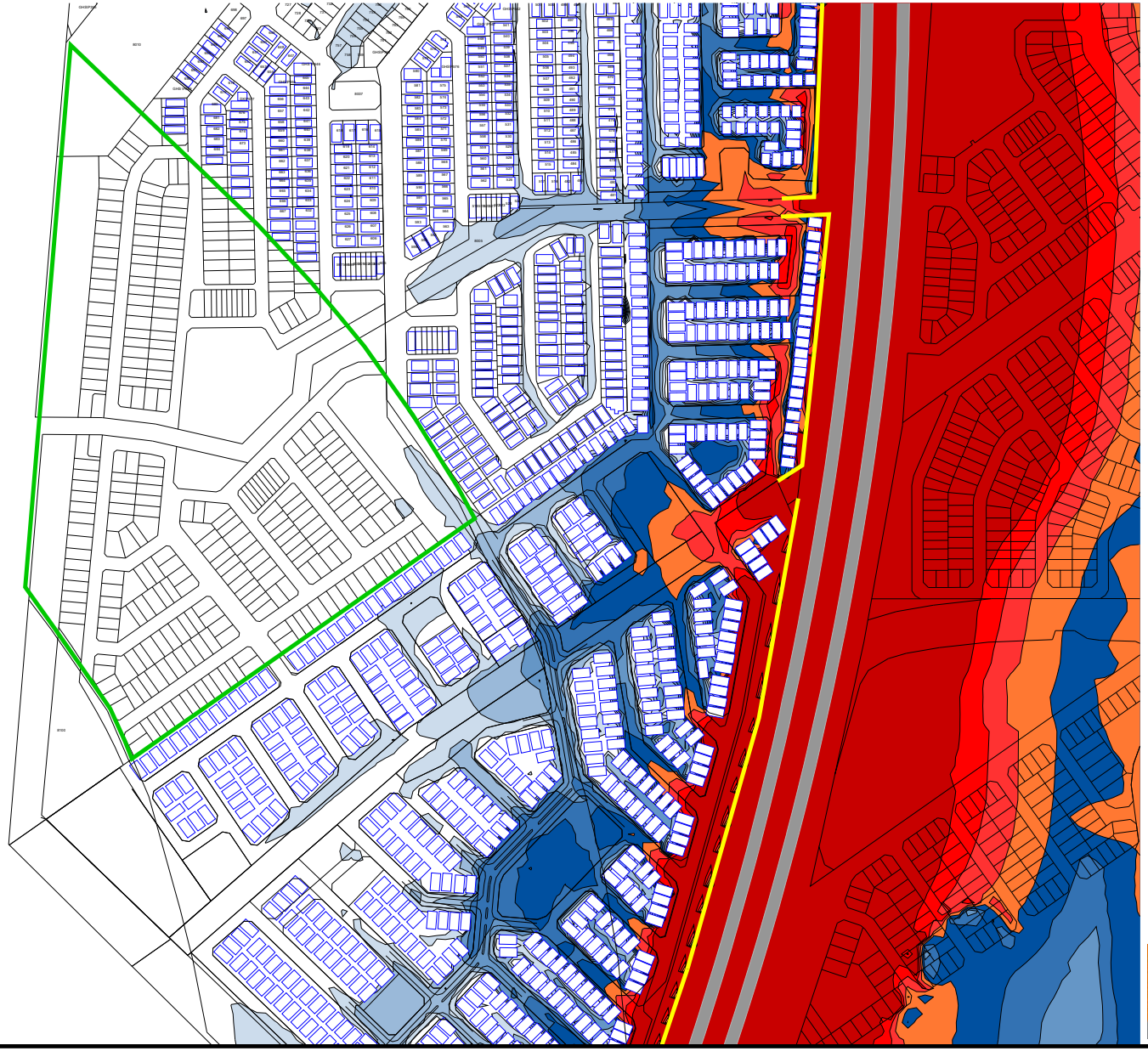
The results of *Figure 4-1* indicate that noise levels at the subject site (recently zoned Urban in April 2019) within the Qube site are below the *target*. As such, compliance is achieved with *State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning* and no further noise controls necessary to support the Local Planning Scheme Amendment from Rural to Development.

Figure 4-1

Mandogalup Residential Subdivision: Apsley Urban Deferred Zone

$L_{Aeq(Day)}$ Noise Level Contours - Future 2041

Includes 4m High Noise Wall Along Kwinana Freeway and Satterley Subdivision Buildings



Noise levels

$L_{Aeq,day}$ dB

55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

N

Signs and symbols

- Road Lanes
- Building
- Subject Site
- Wall by Satterley's

18 July 2019

Length Scale 1:7500

0 37.5 75 150 225 300 m

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Appendix A

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).

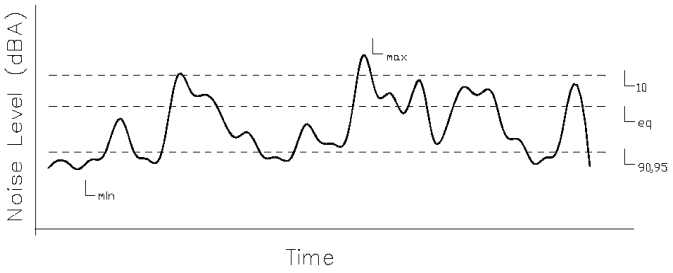
$L_{Aeq,8hour}$ / $L_{Aeq\ (Night)}$
The $L_{Aeq\ (Night)}$ level is the logarithmic average of the hourly L_{Aeq} levels from 10.00 pm to 6.00 am on the same day.

$L_{Aeq,16hour}$ / $L_{Aeq\ (Day)}$
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 $L_{A10,18hour}$.

Satisfactory Design Sound Level
The level of noise that has been found to be acceptable by most people for the environment in question and also to be not intrusive.

Maximum Design Sound Level
The level of noise above which most people occupying the space start to become dissatisfied with the level of noise.

Chart of Noise Level Descriptors



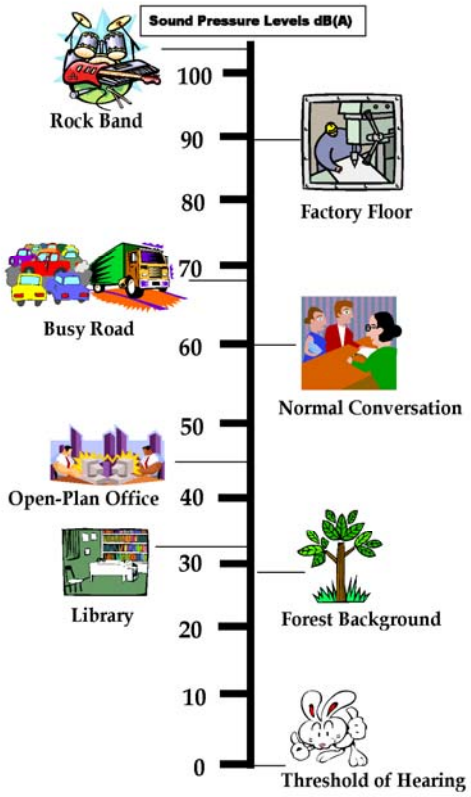
Austroads Vehicle Class

AUSTROADS Vehicle Classification System

Level 1 Length (indicative) Type	Level 2 Axles and Axle Groups Axles	Groups	Level 3 Vehicle Type Typical Description	AUSTROADS Classification Class	Parameters	Typical Configuration
			LIGHT VEHICLES			
Short up to 5.5m		1 or 2	Short Sedan, Wagon, 4WD, Utility, Light Van, Bicycle, Motorcycle, etc	1	d(1) ≤ 3.2m and axles = 2	
	3, 4 or 5	3	Short - Towing Trailer, Caravan, Boat, etc	2	groups = 3 d(1) > 2.1m, d(1) ≤ 3.2m, d(2) ≥ 2.1m and axles = 3, 4 or 5	
			HEAVY VEHICLES			
Medium 5.5m to 14.5m	2	2	Two Axle Truck or Bus	3	d(1) > 3.2m and axles = 2	
	3	2	Three Axle Truck or Bus	4	axles = 3 and groups = 2	
	> 3	2	Four Axle Truck	5	axles > 3 and groups = 2	
Long 11.5m to 19.0m	3	3	Three Axle Articulated Three axle articulated vehicle, or Rigid vehicle and trailer	6	d(1) > 3.2m, axles = 3 and groups = 3	
	4	> 2	Four Axle Articulated Four axle articulated vehicle, or Rigid vehicle and trailer	7	d(2) < 2.1m or d(1) < 2.1m or d(1) > 3.2m axles = 4 and groups > 2	
	5	> 2	Five Axle Articulated Five axle articulated vehicle, or Rigid vehicle and trailer	8	d(2) < 2.1m or d(1) < 2.1m or d(1) > 3.2m axles = 5 and groups > 2	
	> 6	> 2	Six Axle Articulated Six axle articulated vehicle, or Rigid vehicle and trailer	9	axles = 6 and groups > 2 or axles = 6 and groups = 3	
Medium Combination 17.5m to 36.5m	> 6	4	B Double B Double, or Heavy truck and trailer	10	groups = 4 and axles > 6	
	> 6	5 or 6	Double Road Train Double road train, or Medium articulated vehicle and one dog trailer (M.A.D.)	11	groups = 5 or 6 and axles > 6	
Large Combination Over 33.0m	> 6	> 6	Triple Road Train Triple road train, or Heavy truck and three trailers	12	groups > 6 and axles > 6	

Definitions: Group: Axle group, where adjacent axles are less than 2.1m apart. Groups: Number of axle groups. Axles: Number of axles (maximum axle spacing of 10.0m). d(1): Distance between first and second axle. d(2): Distance between second and third axle.

Typical Noise Levels



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Addendum to Transportation Noise Assessment

Mandogalup Subdivision

Reference: Addendum to 14113004-01d.docx

Prepared for:
Mandogalup Development Joint Venture

Report: Addendum to 14113004-01d.docx

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This report has been prepared in accordance with the scope of services described in the contract or agreement between Lloyd George Acoustics Pty Ltd and the Client. The report relies upon data, surveys, measurements and results taken at or under the particular times and conditions specified herein. Any findings, conclusions or recommendations only apply to the aforementioned circumstances and no greater reliance should be assumed or drawn by the Client. Furthermore, the report has been prepared solely for use by the Client, and Lloyd George Acoustics Pty Ltd accepts no responsibility for its use by other parties.

Prepared By:	Terry George 
Position:	Project Director
Date:	30 January 2019

ADDENDUM

In 2017, Lloyd George Acoustics completed a noise assessment in relation to road traffic to a proposed residential subdivision in Mandogalup (*Transportation Noise Assessment, Mandogalup Subdivision*; Reference: 14113004-01d, 23 November 2017). Since this time, the subdivision design has been modified and is provided below in *Figure 1*.



Figure 1 – Subdivision Plan

With the new lot design, the assumed houses were redrawn in the noise model and the noise model re-run, using all of the previous methodology and assumptions.

Figures 5-1 and 5-2 presented on the following pages show the noise contour plots with the new subdivision layout, representing a chip seal and dense graded asphalt road surface for Rowley Road respectively.

As before, these contour plots were combined to identify lots that were noise affected when assessed against *State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning* and the outcome of this is shown in *Figure 6-1*.

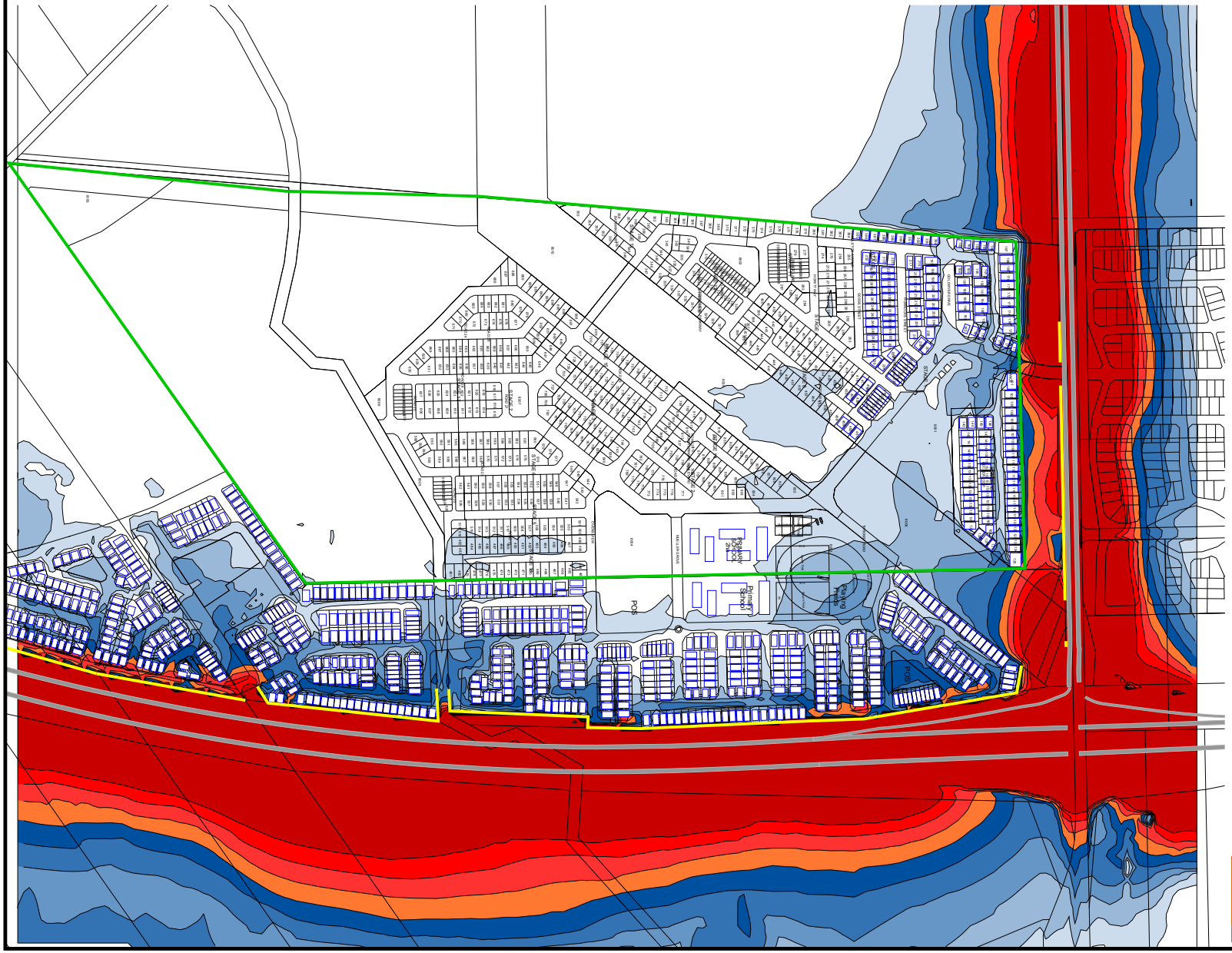
The figures within this Addendum therefore supersede those figures of the same number in the original report.

Figure 5-1

Mandogalup Residential Subdivision: Rowley Road Surface Assumed 14mm Chip Seal

LAeq(Day) Noise Level Contours - Future

Includes 4m High Noise Wall Along Rowley Road



Noise levels
LAeq,day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols

- Road Lanes
- Building
- Subject Site
- Wall

17 Jan 2019

Length Scale 1:10000

0 50 100 200 300 400 m

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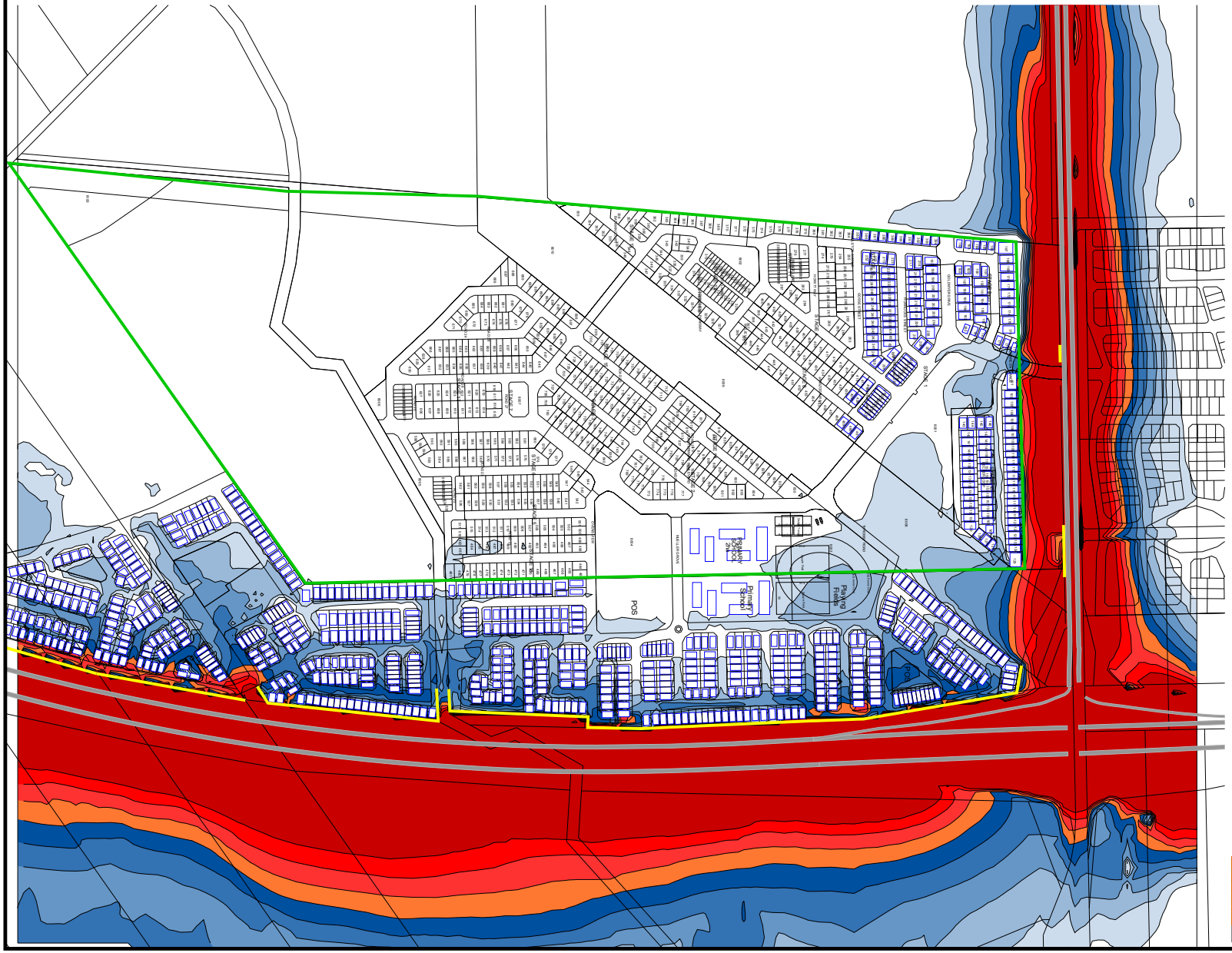
Figure 5-2

Mandogalup Residential Subdivision: Rowley Road Surface Assumed Dense Graded Asphalt

LAeq(Day) Noise Level Contours - Future

Includes 2m High Noise Walls Along Rowley Road



Noise levels
LAeq,day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols

- Road Lanes
- Building
- Subject Site
- Wall

16 January 2019

Length Scale 1:10000

0 50 100 200 300 400 m

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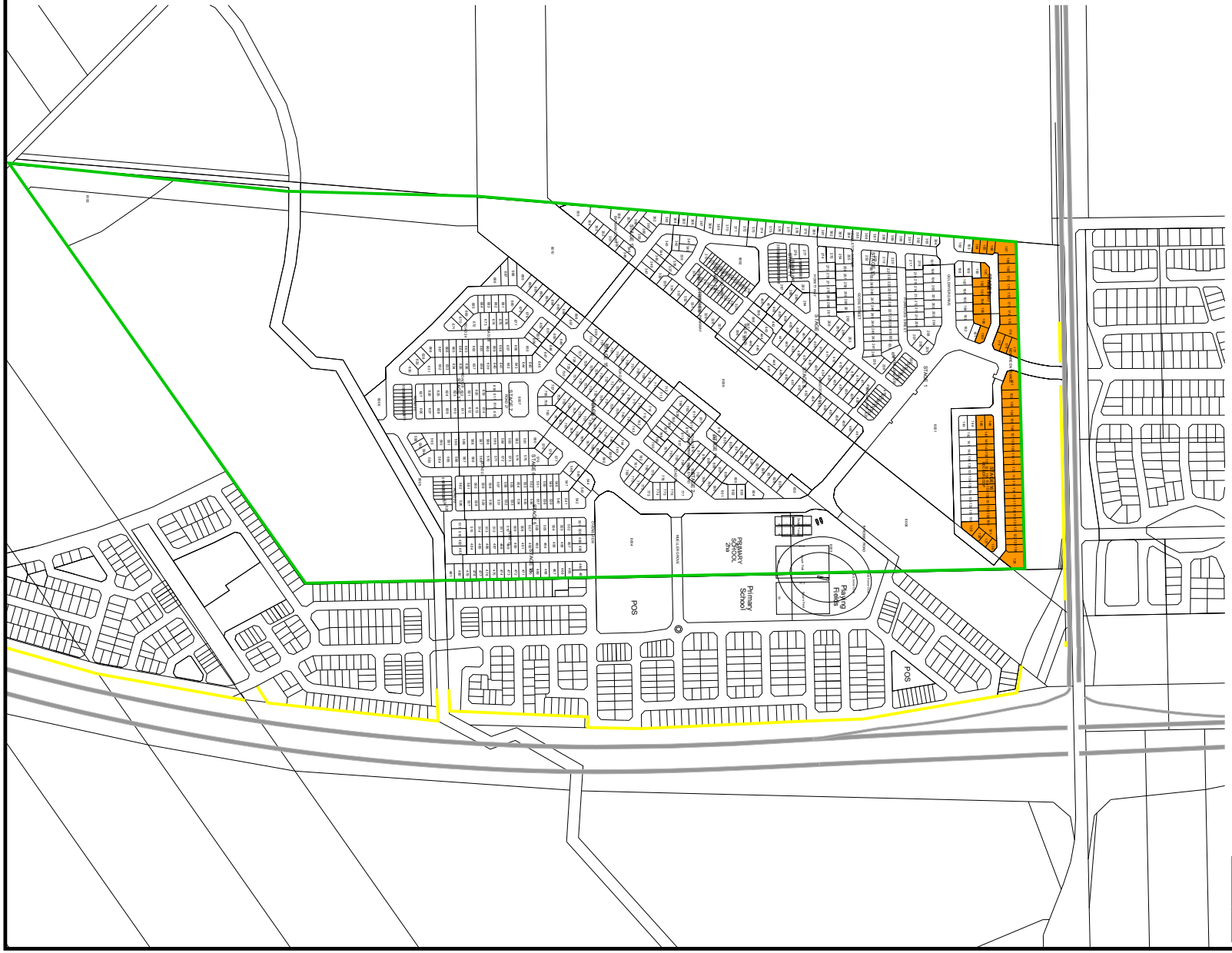
Figure 6-1

Mandogalup Residential Subdivision:
Lots Requiring Notifications and Package A Architectural Treatments



Signs and symbols

- Road Lanes
- Subject Site
- Wall Determined By Others
- Package A & Notification

17 January 2019

Length Scale 1:10000

0 50 100 200 300 400 m

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Transportation Noise Assessment

Mandogalup Subdivision

Reference: 14113004-01d.docx

Prepared for:
Mandogalup Development Joint Venture

Report: 14113004-01d.docx

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Prepared By:	Terry George 
Position:	Project Director
Date:	23 November 2017

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B Terminology

1 INTRODUCTION

This report considers future transportation noise impacts to a proposed residential subdivision, being developed by Mandogalup Development Joint Venture with the general locale shown in *Figure 1-1* and the local structure plan as *Figure 1-2* over page. Also provided is the current concept plan in *Figure 1-3.*



Figure 1-1 Site Location

The site is located within the City of Kwinana and is zoned as 'Development'. The land to the east, located between the subject site and Kwinana Freeway is also understood to be proposed to be developed for residential purposes.

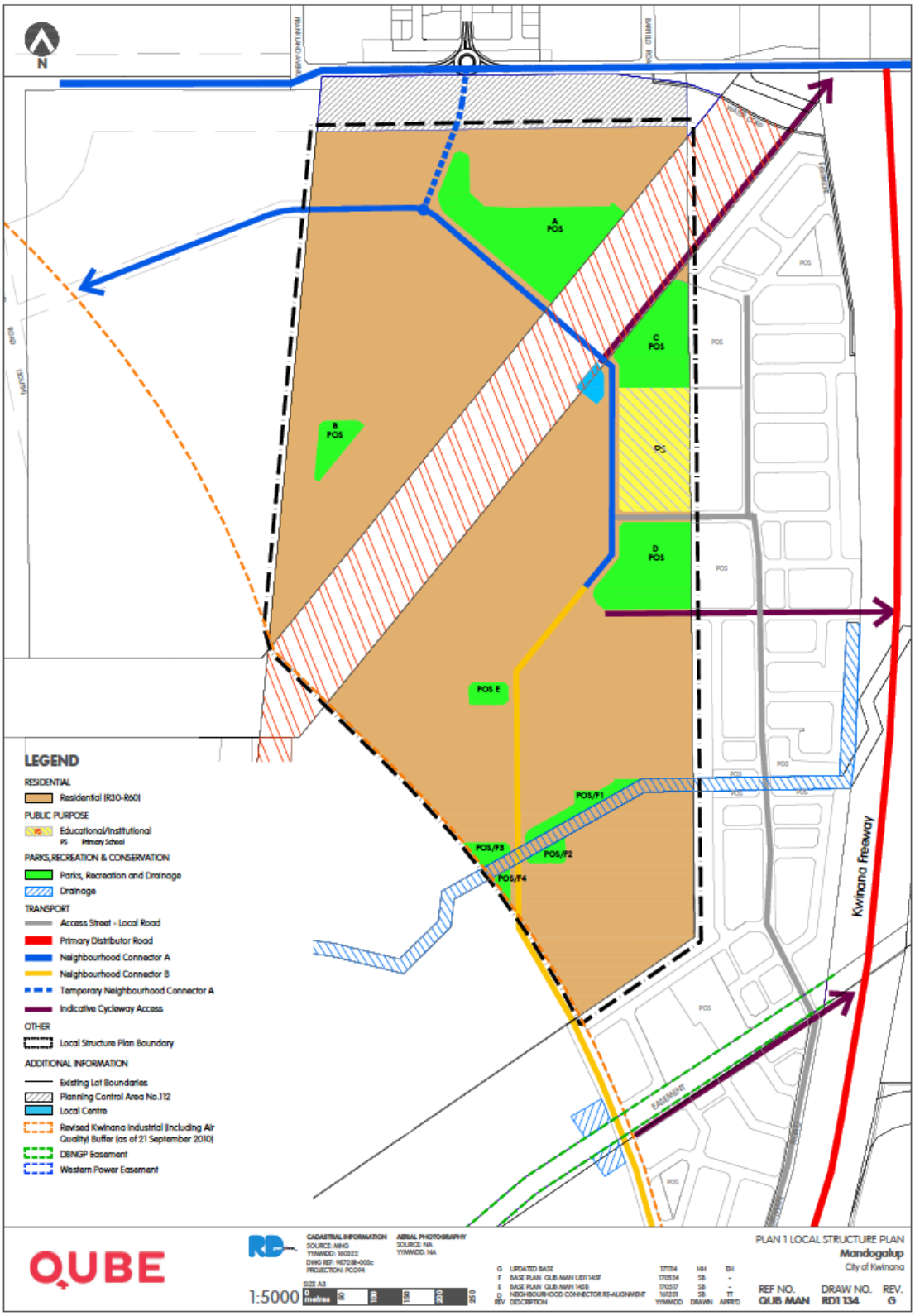


Figure 1-2 Local Structure Plan

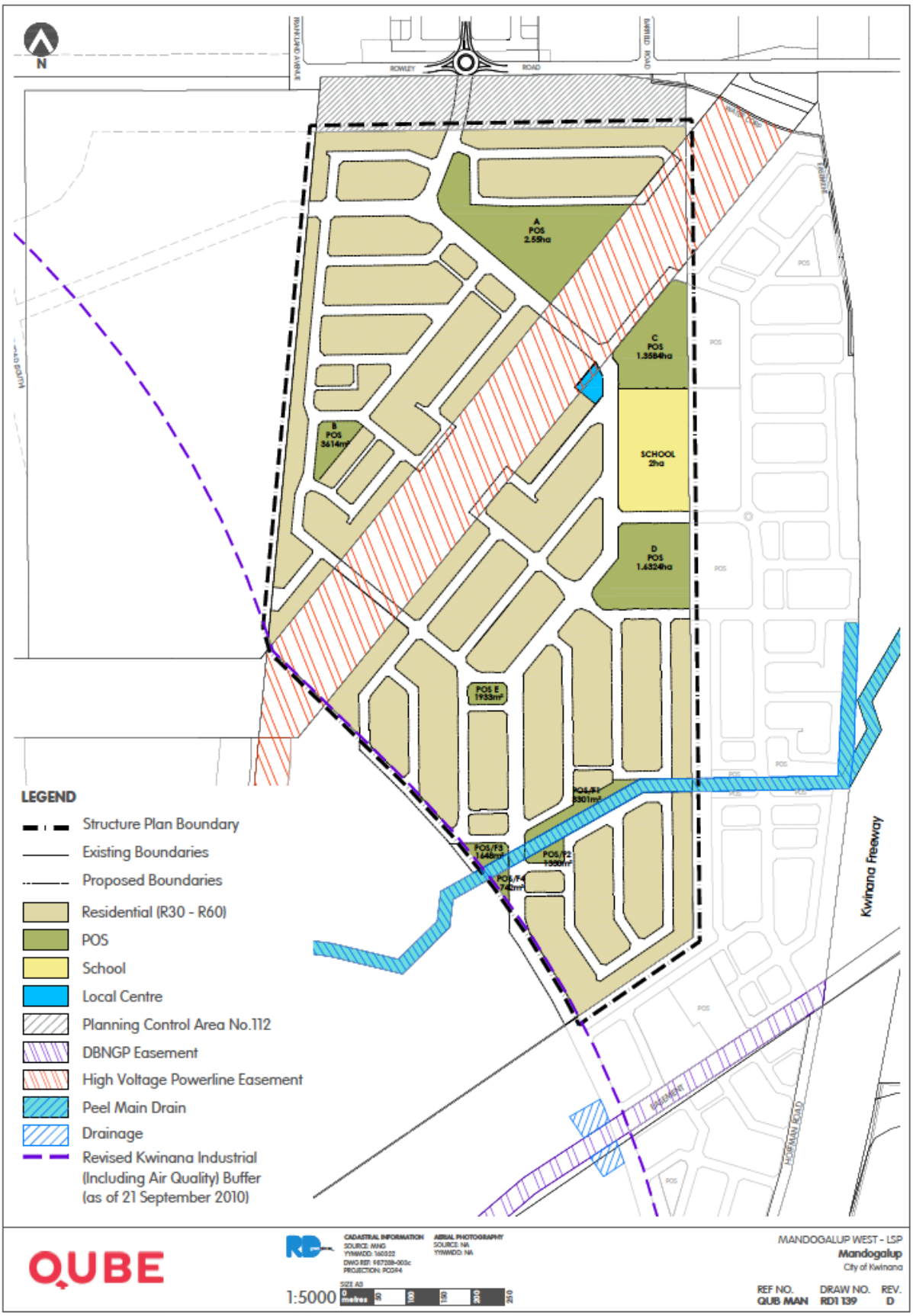


Figure 1-3 Mandogalup West Concept Plan

The future dwellings to the east will provide acoustic separation between the Kwinana Freeway road traffic noise and the subject site. To the north is Rowley Road, which currently carries relatively low traffic volumes (8,000 in 2016/7). The Western Australian Planning Commission (WAPC) has established a Planning Control Area (PCA 112) for the future upgrade of Rowley Road, west of the Kwinana Freeway. Rowley Road is intended to provide a strategic freight connection between the Kwinana Freeway and the Kwinana Industrial Area and for this purpose is in the future to be constructed (upgraded) to four lanes divided standard.

Appendix B contains a description of some of the terminology used throughout this report.

2 CRITERIA

The criteria relevant to this assessment is the *State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning* (hereafter referred to as the Policy) produced by the Western Australian Planning Commission (WAPC). The objectives in the Policy are to:

- Protect people from unreasonable levels of transport noise by establishing a standardised set of criteria to be used in the assessment of proposals;
- Protect major transport corridors and freight operations from incompatible urban encroachment;
- Encourage best practice design and construction standards for new development proposals and new or redevelopment transport infrastructure proposals;
- Facilitate the development and operation of an efficient freight network; and
- Facilitate the strategic co-location of freight handling facilities.

The Policy's outdoor noise criteria are shown below in *Table 2-1*. These criteria applying at any point 1-metre from a habitable façade of a noise sensitive premises and in one outdoor living area.

Table 2-1 Outdoor Noise Criteria

Period	Target	Limit
Day (6am to 10pm)	55 dB $L_{Aeq(Day)}$	60 dB $L_{Aeq(Day)}$
Night (10pm to 6am)	50 dB $L_{Aeq(Night)}$	55 dB $L_{Aeq(Night)}$

Note: The 5 dB difference between the target and limit is referred to as the margin.

In the application of these outdoor noise criteria to new noise sensitive developments, the objectives of this Policy is to achieve -

- acceptable indoor noise levels in noise-sensitive areas (e.g. bedrooms and living rooms of houses); and
- a 'reasonable' degree of acoustic amenity in at least one outdoor living area on each residential lot.

If a noise sensitive development takes place in an area where outdoor noise levels will meet the *target*, no further measures are required under this policy.

In areas where the *target* is exceeded, customised noise mitigation measures should be implemented with a view to achieving the *target* in at least one outdoor living area on each residential lot, or if this is not practicable, within the *margin*. Where indoor spaces are planned to be facing outdoor areas that are above the *target*, mitigation measures should be implemented to achieve acceptable indoor noise levels in those spaces.

For residential buildings, "acceptable indoor noise levels" are taken to be 40 dB $L_{Aeq(Day)}$ in living areas and 35 dB $L_{Aeq(Night)}$ in bedrooms. These levels fall within the range of the "Recommended Design Sound Levels" for houses and apartments near major roads, as given in Australian Standard AS 2107:2000 *Acoustics – Recommended design sound levels and reverberation times for building interiors*.[1]

3 METHODOLOGY

Noise modelling has been undertaken in accordance with the requirements of the Policy and associated Guidelines that accompany the Policy.

The computer programme *SoundPLAN 7.2* 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 corrections are applied to the exhaust of –8.0 dB (based on Transportation Noise Reference Book, Paul Nelson, 1987) and to the engine source of –0.8 dB, so as to provide consistent results with the CoRTN algorithms for the no barrier scenario;
- An adjustment of –1.7 dB has been applied to the predicted levels 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 1982.

Predictions are made at heights of 1.4 metres above ground floor level and at 1.0 metre from an assumed building façade (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 on the following page.

[1] The "acceptable indoor noise levels" for residential buildings are exactly midway between the "satisfactory" and "maximum" recommended design sound levels for houses and apartments near major roads.

3.1 Ground Topography, Road Design & Cadastral Data

Lloyd George Acoustics was previously involved in modelling the proposed Rowley Road upgrade in 2005, with the (then) Department of Planning and Infrastructure. The noise model included the existing surrounding topography, which was originally supplied by Maunsell (now AECOM). The ground contours were at 1-metre intervals. Where possible this ground contour information has been supplemented by additional survey data supplied by landowners. Cossill & Webley has provided their latest earthworks plan in 3D digital format via email (27 March 2017) for the subject site. Cossill & Webley also sourced the design surface levels for the Satterley site immediately east from Peritas Group (email dated 21 April 2017).

The road design information from the original noise model has been revised based on the latest information provided by the Department of Planning. The road design relates to both the proposed Rowley and Hammond Roads. The noise modelling also includes the existing Kwinana Freeway, and the interchange with Rowley Road, at the eastern extent.

Proposed buildings as part of this development and the adjoining site to the east have 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 at a height of 3.5 metres above lot level. The Satterley development is also understood to incorporate a 4 metre high wall along the eastern boundary so that this has also ben included in the model for completeness.

3.2 Traffic Data

Traffic data includes:

- Road Surface – The noise relationship between different road surface types is shown below in *Table 3-1*.

Table 3-1 Noise Relationship Between Different Road Surfaces

Road Surfaces						
Chip Seal			Asphalt			
14mm	10mm	5mm	Dense Graded	Novachip	Stone Mastic	Open Graded
+3.5 dB	+2.5 dB	+1.5 dB	0.0 dB	-0.2 dB	-1.0 dB	-2.5 dB

Noise modelling for Rowley Road considers the implications of 14mm chip seal, dense graded asphalt and open graded asphalt. Kwinana Freeway is and will remain open graded asphalt.

A transition will occur along on/off ramps where the road surface will be dense graded asphalt.

- Vehicle Speed

  It is assumed that the future posted speed through this section of the Rowley Road upgrade will be 80km/hr.

  Existing and future posted speeds for the Kwinana Freeway were assumed to be 100 km/hr and 80 km/hr for the ramps.

- Traffic Volumes

  To source the existing traffic volumes, these were obtained via a request to MRWA and using the MRWA Reporting Centre. In terms of the request for existing and forecast volumes, these were obtained from Clare Yu (Traffic Modelling Analyst) on 18 April 2017 (Job No. 40486). The information obtained included a 2016 calibration plot (showing the difference between observed counts and modelled counts). No existing count was shown on Rowley Road so this was obtained through the Reporting Centre. This data is used to assess the accuracy of the MRWA traffic model, with the differences between the observed and modelled then applied to the forecast volumes. The differences between the two are shown in *Tables 3-2 & 3-3*.

Table 3-2 2016 Traffic Volume Calibration – Kwinana Freeway

Road	MRWA Model		MRWA Observed		Difference	
	Northbound	Southbound	Northbound	Southbound	Northbound	Southbound
South of Rowley Road	39,200	41,200	47,500	49,700	-8,300	-8,500
Through Interchange	37,400	39,600	44,100	43,800	-6,700	-4,200
Off Ramp	4,100	-	2,300	-	+1,800	-
On Ramp	1,700	-	3,400	-	-1,700	-

Table 3-3 2016 Traffic Volume Calibration – Rowley Road

Section	MRWA Model		MRWA Observed		Difference	
	Eastbound	Westbound	Eastbound	Westbound	Eastbound	Westbound
West of Kwinana Freeway	5,800	3,300	3,865	4,143	+1,935	-843

In the above tables, a positive value indicates the model is over-predicting and a negative value the model is under-predicting.

Generally the model appears to be under-predicting. The determined differences have been applied to the 2031 volumes provided as shown in *Tables 3-4 & 3-5*. Also shown in brackets are the percentage heavy vehicles.

Table 3-4 2031 Traffic Volume Calibration – Kwinana Freeway

Road	MRWA Model		Difference		2031 Calibrated	
	Northbound	Southbound	Northbound	Southbound	Northbound	Southbound
South of Rowley Road	65,400	63,000	-8,300	-8,500	73,700 (9%)	71,500 (9%)
Through Interchange	62,700	60,900	-6,700	-4,200	69,400 (10%)	65,100 (10%)
Off Ramp	2,700		+1,800	-	900 (3%)	-
On Ramp	10,300		-1,700	-	12,000 (21%)	-

Table 3-5 2031 Traffic Volume Calibration – Rowley Road

Section	MRWA Model		Difference		2031 Calibrated	
	Eastbound	Westbound	Eastbound	Westbound	Eastbound	Westbound
West of Kwinana Freeway	14,500	12,100	+1,935	-843	12,565 (19%)	12,943 (22%)
West of Frankland Avenue[1]	5,300	6,200	+1,935	-843	3,365 (35%)	7,043 (30%)

1. The same difference has been applied to this section of road.

The CoRTN algorithms calculate an $L_{A10,\ 18hour}$ noise level and therefore require the input of 18-hour traffic volumes. The 18-hour traffic volumes (6:00am to midnight) were assumed to be 90% of the 24-hour volumes for Rowley Road and 94% for the Kwinana Freeway.

3.3 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%).

3.4 Parameter Conversion

The CoRTN algorithms used in the *SoundPLAN* modelling package were originally developed to calculate the $L_{A10,18hour}$ noise level. However, the WAPC Policy uses the parameters $L_{Aeq(Day)}$ and $L_{Aeq(Night)}$ (refer *Table 2.1*). Therefore an adjustment needs to be made to the predicted $L_{A10,18hour}$ noise level to enable the noise modelling results to be compared to the allowable $L_{Aeq(Day)}$ and $L_{Aeq(Night)}$ traffic noise criteria. The relationship between these parameters varies depending on the composition of traffic on the road (the volumes during each time period and the percentage of heavy vehicles).

For this assessment, the parameter conversion for Rowley Road was based on the results of actual noise measurements taken along Great Northern Highway between Reid/Roe Highway and West Swan Road, deemed to be a road similar in composition to the future Rowley Road. Note that the existing Rowley Road traffic is not considered representative of that in the future and therefore site noise measurements were not undertaken. An extract from the Great Northern Highway study is shown below, showing the $L_{Aeq(Day)}$ level is likely to be 2.8 dB less than the $L_{A10,18hour}$ value and the $L_{Aeq(Night)}$ level is likely to be 8.2 dB less than the $L_{A10,18hour}$ value. This results in the $L_{Aeq(Night)}$ being 5.4 dB less than the $L_{Aeq(Day)}$, so that the day parameter is slightly more critical, but only marginally.

Location	$L_{A10,18hour} - L_{Aeq,16hour}$	$L_{A10,18hour} - L_{Aeq,8hour}$	$L_{Aeq,16hour} - L_{Aeq,8hour}$
Lennard Road to Padbury Avenue			
706 GNH	3.1	9.1	6.0
758 GNH	2.6	8.2	5.6
822 GNH	3.3	9.2	5.9
899 GNH	1.9	7.3	5.4
Average	**2.7**	**8.5**	**5.7**
Padbury Avenue to Maisie Street			
934 GNH	2.9	8.1	5.2
998 GNH	2.5	8.1	5.5
1011 GNH	2.7	8.0	5.5
Average	**2.7**	**8.2**	**5.4**
Maisie Street to Haddrill Road			
1085 GNH	3.0	7.7	4.7
Average	**3.0**	**7.7**	**4.7**
Haddrill Road to West Swan Road			
1118 GNH	3.2	8.8	5.4
1247 GNH	2.7	7.2	4.5
Average	**3.0**	**8.0**	**5.0**

Figure 3-1 Extract from Great Northern Highway Study

As part of the study for the Satterley land to the east, ATP Consulting Engineers undertook noise measurements on the site (*Road & Railway Noise Assessment, Mandogalup East Local Structure Plan, Mandogalup*; ATP140414-R-TNIA-04, November 2016). An extract from this report is shown on the following page, resulting in the $L_{Aeq(Day)}$ being 1 dB less than the $L_{A10,18hour}$ and the $L_{Aeq(Night)}$ being 7 dB less than the $L_{Aeq(Day)}$. Hence, the $L_{Aeq(Day)}$ will again be the critical parameter to determine compliance.

Date	$L_{A10(18\text{-}hour)}$* dB(A)	$L_{Aeq(16\text{-}hour)}$* dB(A)	$L_{Aeq(8\text{-}hour)}$* dB(A)
8 July 2013 (Monday)	63	62	56
9 July 2013 (Tuesday)	64	63	55
10 July 2013 (Wednesday)	63	62	55
11 July 2013 (Thursday)	63	62	54
12 July 2013 (Friday)	63	61	55
Average	**63**	**62**	**55**

**Free-field*

Figure 3-2 Extract from ATP Report (Kwinana Freeway)

The measured differences have been applied to each road, with only the $L_{Aeq(Day)}$ parameter reported throughout, given this is expected to be more critical for compliance.

4 RESULTS

Initially the noise model was run with Kwinana Freeway traffic only and with an adjustment for existing (2013) traffic volumes obtained from the MRWA website to coincide with the ATP measurements (47,495 vpd northbound & 49,700 vpd southbound). The model was then run and showed that the model was over-predicting at the ATP noise logger by 2.3 dB, so that this calibration factor was incorporated into the noise model for Kwinana Freeway. As no monitoring exists (or is relevant) for the Rowley Road upgrade, this traffic does not have a calibration factor, which is considered conservative.

Earlier studies for Rowley Road upgrade had assumed an open graded asphalt road surface would be used in order to assist in noise mitigation, due to the urban zoning of the adjoining sites. This assumption has been used for approved subdivisions on the north side of Rowley Road. Recent advice from MRWA indicates this may not be the case so this study has considered the implications of Rowley Road as 14mm chip seal, dense graded asphalt and open graded asphalt road surfaces. The results of the modelling are presented as follows:

- *Figure 4-1*: Future Noise Contours Assuming Rowley Road is 14mm Chip Seal
- *Figure 4-2*: Future Noise Contours Assuming Rowley Road is Dense Graded Asphalt
- *Figure 4-3*: Future Noise Contours Assuming Rowley Road is Open Graded Asphalt

Where the road surface is chip seal, the predicted noise levels are above the *limit* at some residences, with noise levels up to 64 dB $L_{Aeq(Day)}$. Assuming a maximum wall height of 4 metres, it is not practicable to achieve the *target* at these residences.

Where the road surface is dense graded asphalt, the predicted noise levels are marginally above the *limit* at some (six) residences with noise levels up to 61 dB $L_{Aeq(Day)}$. Assuming a maximum wall height of 4 metres, it is not practicable to achieve the *target* at these residences.

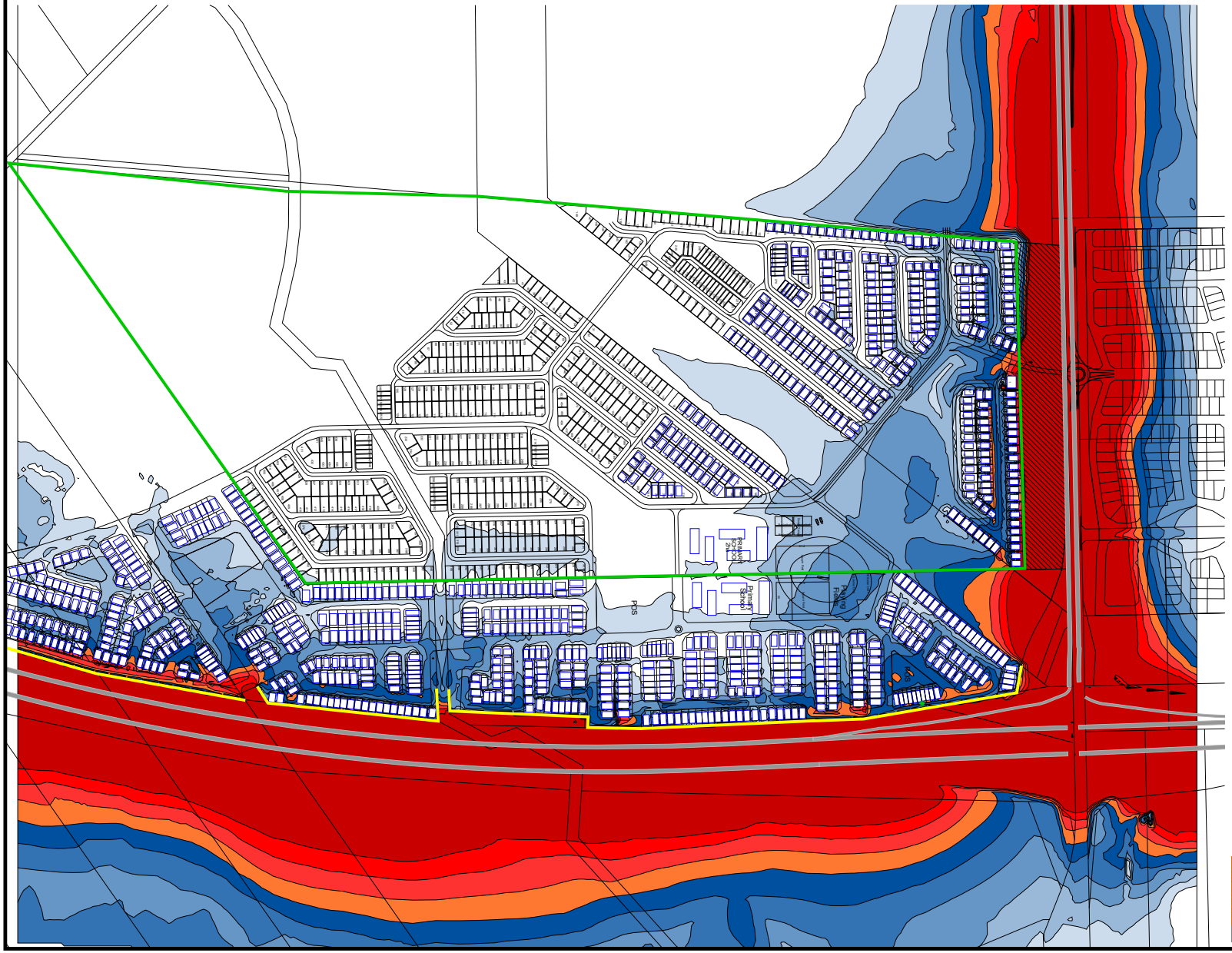
Where the road surface is open graded asphalt, the predicted noise levels are within the *margin*, with the highest noise level at 59 dB $L_{Aeq(Day)}$. Assuming a wall height of up to 4 metres, the *target* is achievable in this case.

Note in all cases, the assumed wall is to have a minimum surface mass of 15kg/m^2.

Figure 4-1

Mandogalup Residential Subdivision: Rowley Road Surface Assumed 14mm Chip Seal

LAeq(Day) Noise Level Contours - Future



Noise levels
LAeq,day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols

- Road Lanes
- Building
- Subject Site

5 May 2017

Length Scale 1:10000

0 50 100 200 300 400 m

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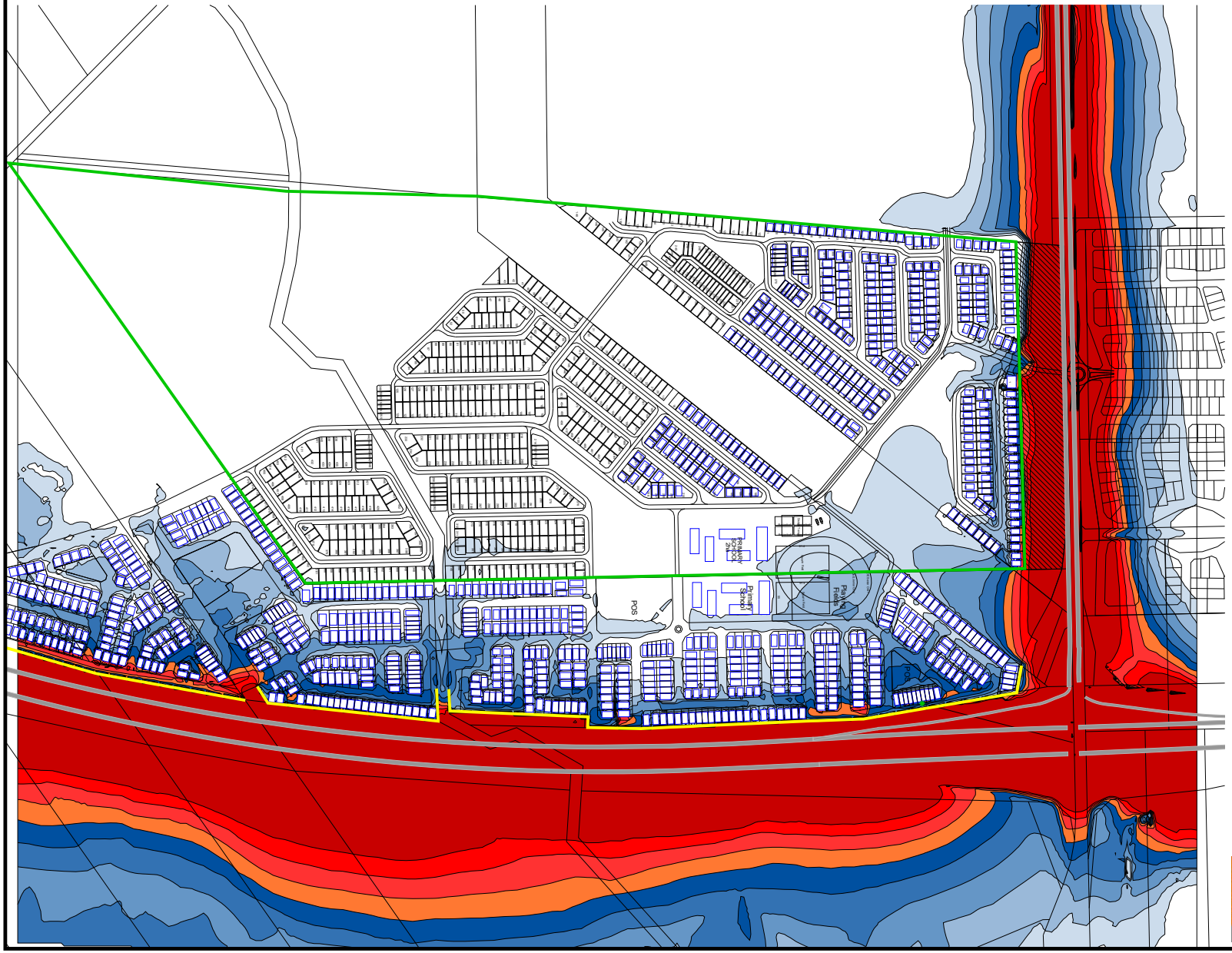
Figure 4-2

Mandogalup Residential Subdivision: Rowley Road Surface Assumed Dense Graded Asphalt

LAeq(Day) Noise Level Contours - Future



Noise levels
LAeq,day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols

- Road Lanes
- Building
- Subject Site

6 May 2017

Length Scale 1:10000

0 50 100 200 300 400 m

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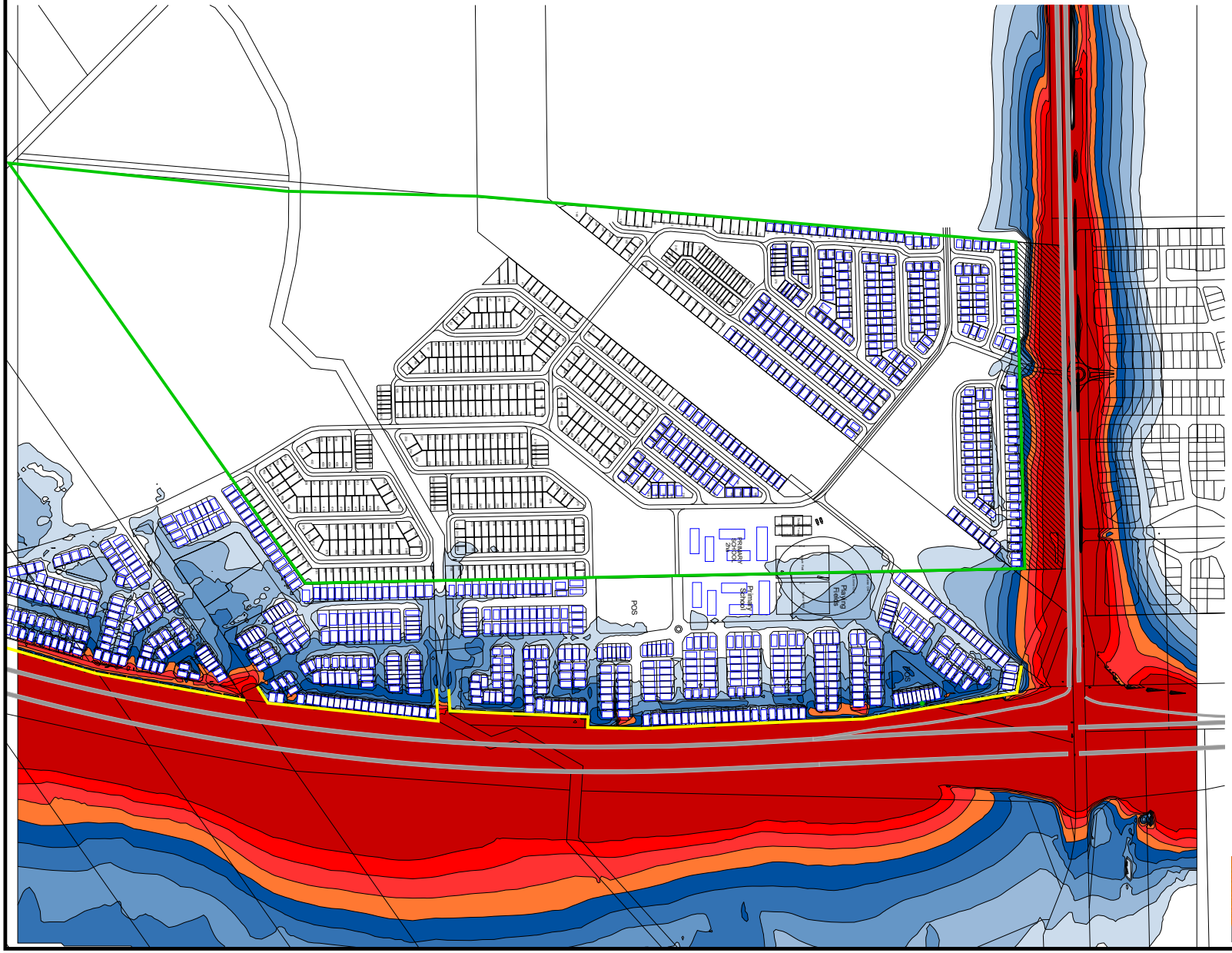
Mandogalup Residential Subdivision: Rowley Road Surface Assumed Open Graded Asphalt

LAeq(Day) Noise Level Contours - Future

Figure 4-3



Noise levels
LAeq,day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols

- Road Lanes
- Building
- Subject Site

6 May 2017

Length Scale 1:10000

0 50 100 200 300 400 m

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5 ASSESSMENT

The objectives of the criteria are for noise at all houses to be no more than the *limit* and preferably no more than the *target*. Where the *target* is achieved, no further controls are required. Where the *target* is exceeded, further controls are necessary.

Where the road surface of Rowley Road is 14mm chip seal (noisiest), noise levels at the nearest houses are above the *target* by up to 9 dB and therefore further noise control is to be considered. The road is elevated compared to the houses ranging from about 5 metres at the eastern end to 10 metres at the western end. Because of this, the most effective location for a noise barrier will be alongside the road, rather than the residences. When Rowley Road is upgraded, MRWA will undertake their own noise study and will be required to achieve the *limit* at the nearest houses. Assuming the 14mm chip seal road surface, a minimum 4 metre high, 440 metre long noise wall of minimum surface mass 15kg/m^2 would be required. The noise contours associated with the chip seal and noise wall scenario are provided in *Figure 5-1*. The noise wall is designed to achieve the *limit* and therefore some residences will be located above the *target*. These residences would require notifications on title and incorporation of Package A architectural treatments (refer *Appendix A*). Any affected residences that are to be double storey would require a specific assessment undertaken by a suitably qualified acoustical consultant.

Where the road surface of Rowley Road is dense graded asphalt, noise levels at the nearest houses are above the *target* by up to 6 dB and therefore further noise control is to be considered. As described above, the most effective location for a noise wall is alongside the road, which would then be constructed by MRWA as part of the road upgrade project. With the exceedance to the *limit* being only 1 dB, the minimum noise wall is 2 metres high, 120 metres long and with a minimum surface mass of 15kg/m^2. The noise contours associated with the dense graded asphalt and noise wall scenario are provided in *Figure 5-2*. Those residences above the *target* will require notifications on title and incorporation of Package A architectural treatments (refer *Appendix A*). Any affected residences that are to be double storey would require a specific assessment undertaken by a suitably qualified acoustical consultant.

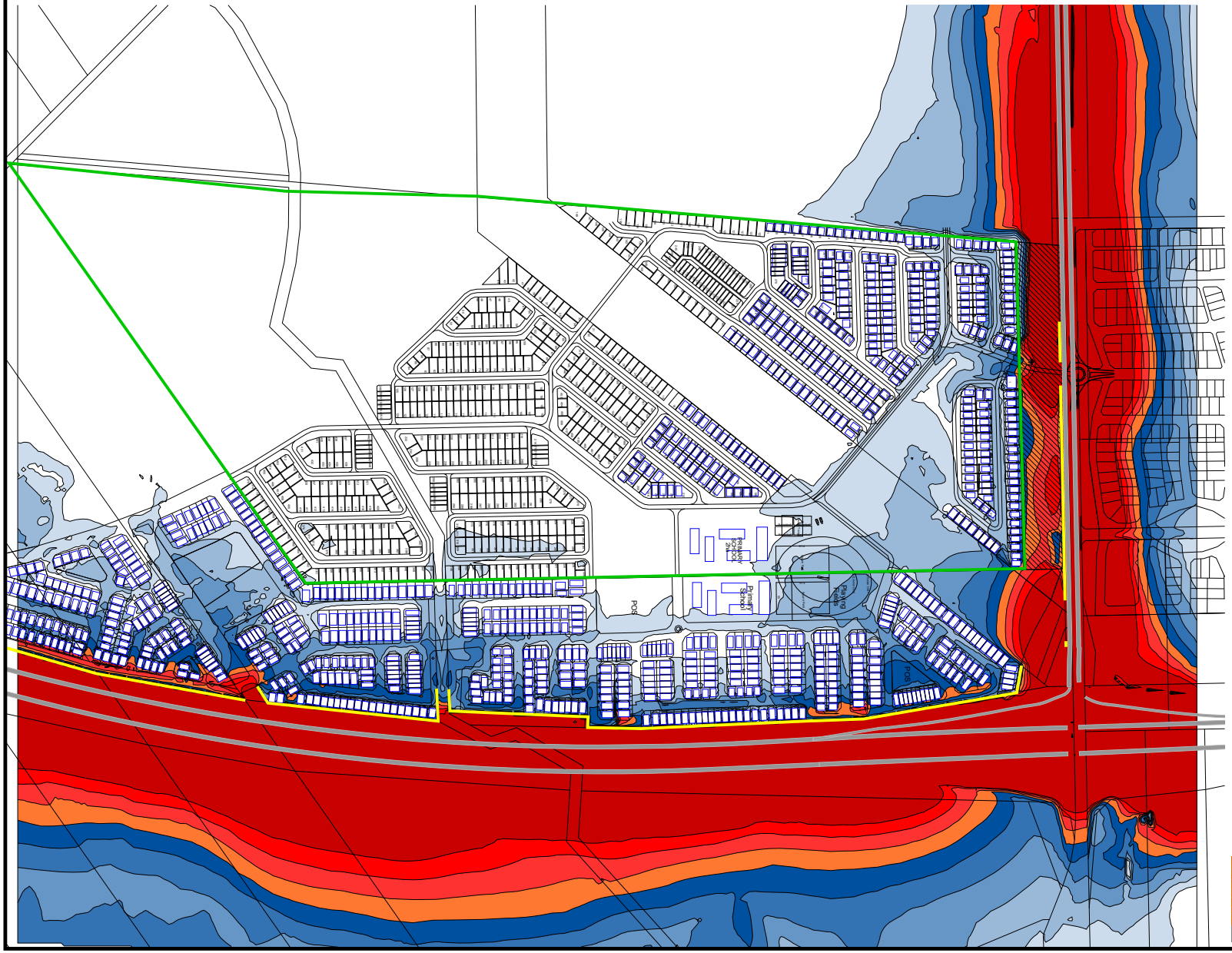
Where the road surface of Rowley Road is open graded asphalt, noise levels at the nearest houses are above the *target* by up to 4 dB and therefore within the *margin* (less than the *limit*). As such, it would not be mandatory for MRWA to construct a noise wall during the upgrade project, although they may choose to do so. Note that a wall similar to that shown on *Figure 5-1* would result in noise levels below the *target*. The noise contours associated with the open graded asphalt scenario are provided in *Figure 4-3*. Those residences above the *target* will require notifications on title and incorporation of Package A architectural treatments (refer *Appendix A*). Any affected residences that are to be double storey would require a specific assessment undertaken by a suitably qualified acoustical consultant.

Mandogalup Residential Subdivision: Rowley Road Surface Assumed 14mm Chip Seal

LAeq(Day) Noise Level Contours - Future

Includes 4m High Noise Wall Along Rowley Road

Figure 5-1



Noise levels
LAeq,day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols

- Road Lanes
- Building
- Subject Site
- Wall

7 May 2017

Length Scale 1:10000

0 50 100 200 300 400 m

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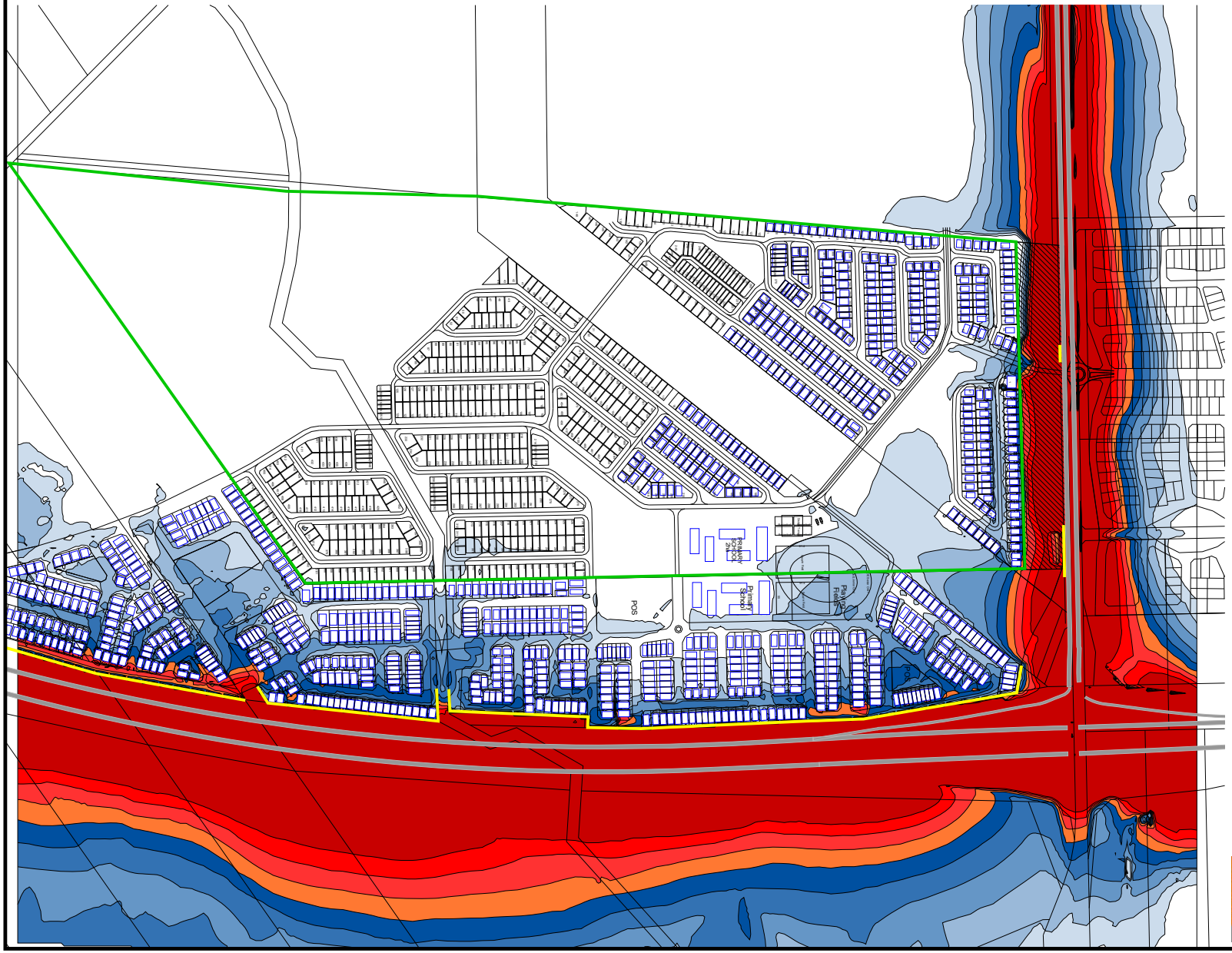
Mandogalup Residential Subdivision: Rowley Road Surface Assumed Dense Graded Asphalt

LAeq(Day) Noise Level Contours - Future

Includes 2m High Noise Walls Along Rowley Road

Figure 5-2



Noise levels
LAeq,day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols

- Road Lanes
- Building
- Subject Site
- Wall

7 May 2017

Length Scale 1:10000

0 50 100 200 300 400 m

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6 CONCLUSION

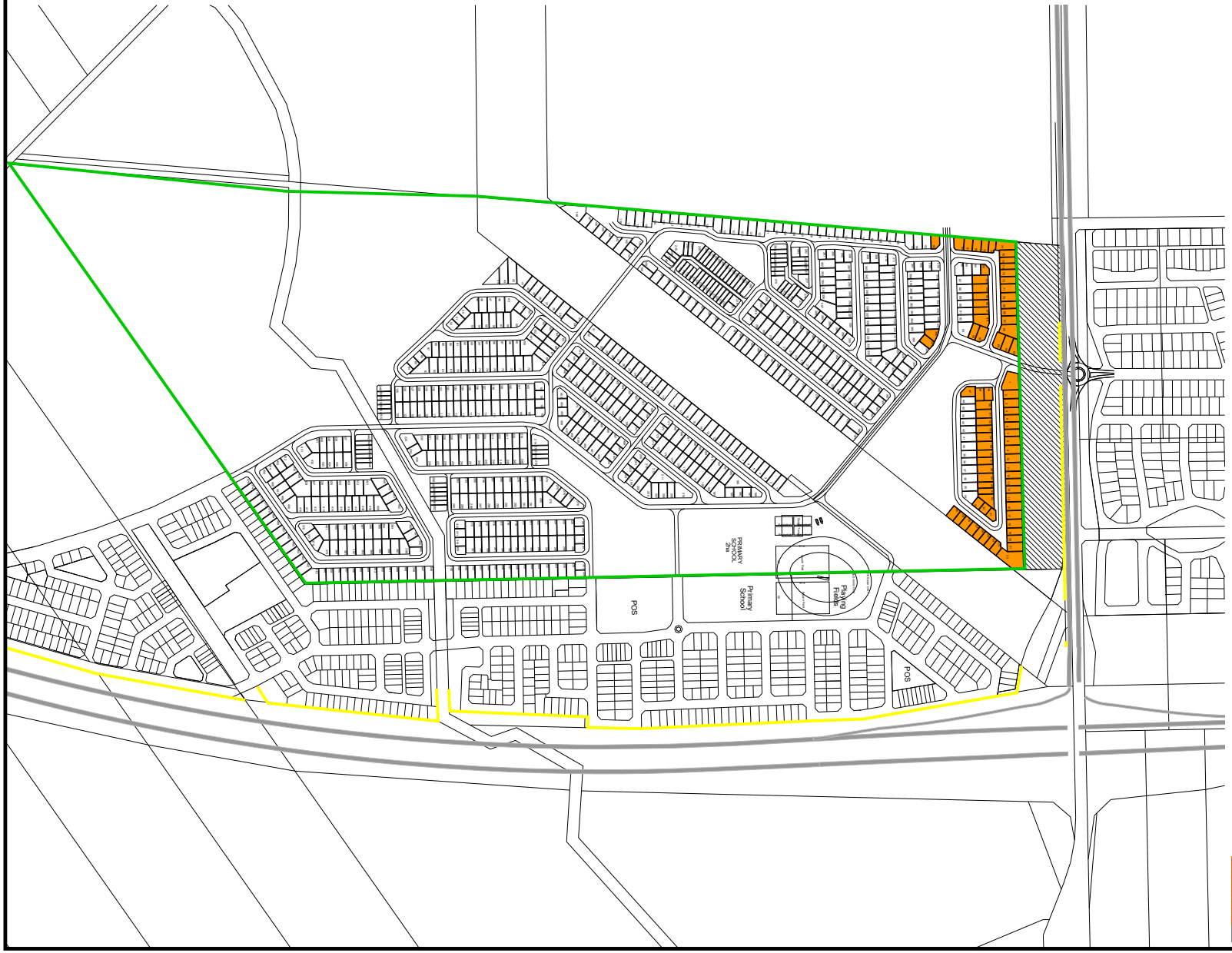
Compliance with *State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning*, will be dependent on road surface, noise barriers and architectural treatments. With the road being elevated and MRWA having an obligation to comply with the ***limit*** when Rowley Road is upgraded, the decision of the road surface and noise wall combination will be with them. For the developer, they will be responsible for notifications on titles and affected residences implementing Package A architectural treatments (refer *Appendix A*). *Figure 6-1* identifies the affected residences (those above the ***target***), which has combined the results of *Figures 5-1, 5-2 and 4-3*, since it is unknown which scenario will exist, although it should be noted that the worst case is governed by the chip seal with wall (*Figure 5-1*) scenario.

To summarise the developer's responsibilities are:

- Package A treatments for those lots identified in *Figure 6-1*;
- All affected lots in *Figure 6-1* are to have notifications on lot titles as per the Policy requirements – refer *Appendix A*.
- Where an affected lot shown on *Figure 6-1* is to be of double storey construction, specialist advice must be sort since the upper level will not receive the same level of attenuation as the ground floor, provided by the earthworks and/or noise barriers.

Mandogalup Residential Subdivision:
Lots Requiring Notifications and Package A Architectural Treatments

Figure 6-1



Signs and symbols

- Road Lanes
- Subject Site
- Wall Determined By Others
- Package A & Notification

9 May 2017

Length Scale 1:10000

0 50 100 200 300 400 m

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Appendix A

ACCEPTABLE TREATMENT PACKAGES

The packages and information provided on the following pages are taken from *Implementation Guidelines for State Planning Policy 5.4 Road and Rail Transport Noise and freight Considerations in Land Use Planning*; December 2014.

Where outdoor noise levels are above the ***target*** level, excluding the effect of any boundary fences, the Guidelines propose acceptable treatment packages that may be implemented without requiring detailed review. The packages are also intended for residential development only. At higher noise levels or for other building usages, specialist acoustic advice will be needed.

The acceptable treatment packages are intended to simplify compliance with the noise criteria, and the relevant package should be required as a condition of development in lieu of a detailed assessment.

Transition between each package should be made on the basis of the highest incident $L_{Aeq(Day)}$ or $L_{Aeq(Night)}$ value to the nearest whole number determined for the building development under assessment.

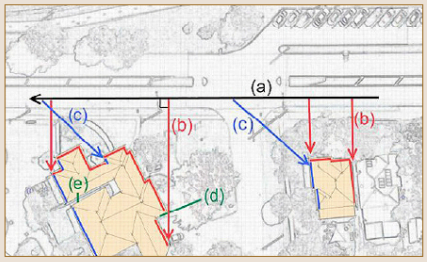
Any departures from the acceptable treatment specifications need to be supported by professional advice from a competent person that the proposal will achieve the requirements of the Policy.

With regards to the packages, the following definitions are provided:

- **Facing** the transport corridor: Any part of a building façade is 'facing' the transport corridor if any straight line drawn perpendicular to its nearest road lane or railway line intersects that part of the façade without obstruction (ignoring any fence).
- **Side-on** to transport corridor: Any part of a building façade that is not 'facing' is 'side-on' to the transport corridor if any straight line can be drawn from it to intersect the nearest road lane or railway line without obstruction (ignoring any fence).
- **Opposite** to transport corridor: Neither 'side on' nor 'facing', as defined above.

Determining building face orientation

The following sketch shows two residences in proximity to a road.



'Facing' façades are identified by drawing straight lines (b) perpendicular (at a 90 degree angle) to the road (a). Where these lines intersect a façade – without obstruction – the façades are shown in red as 'facing' the road.

Façades shown in blue are not 'facing' but have clear lines (c) that intersect the road at any angle, and are therefore classed as 'side on' to the road.

The remaining façades are 'opposite' to the road.

Package A

Area	Orientation to Road or Rail Corridor	Package A (up to 60 dB $L_{Aeq(Day)}$ and 55 dB $L_{Aeq(Night)}$)
Bedrooms	Facing	• Windows systems: Glazing up to 40% of floor area (minimum $R_w + C_{tr}$ 28) – 6mm thick glass (monolithic, toughened or laminated) in fixed sash, awning or casement opening with seals to openings.
	Side	• Windows systems: As above.
	Opposite	No requirements
Other Habitable Rooms Including Kitchens	Facing	• Windows and external door systems: Glazing up to 60% of floor area (minimum $R_w + C_{tr}$ 28) – 6mm thick glass (monolithic, toughened or laminated) in fixed sash, awning or casement opening with seals to openings. Doors to be either 35mm thick solid timber core door with full perimeter acoustic seals. Glazed inserts to match the above. Sliding glass doors to be same performance including brush seals.
	Side	• Windows and external door systems: As above.
	Opposite	No requirements
General	Any	• Walls (minimum $R_w + C_{tr}$ 45) – Two leaves of 90mm thick brick with minimum 50mm cavity • Roof and ceiling (minimum $R_w + C_{tr}$ 35) – Standard roof construction with 10mm plasterboard ceiling and minimum R2.5 insulation between ceiling joists. • Eaves to be closed using 4mm compressed fibre cement sheet. • Mechanical ventilation – Refer following pages.
Outdoor Living Area		• Locate on the side of the building that is opposite to the corridor if practicable; or • Locate within alcove area so that the house shields it from corridor if practicable.

Note: Any penetrations in a part of the building envelope must be acoustically treated so as to not downgrade the performance of the building elements affected. Most penetrations in external walls such as pipes, cables or ducts can be sealed through caulking gaps with non-hardening mastic or suitable mortar.

Mechanical Ventilation requirements

It is noted that natural ventilation must be provided in accordance with F4.6 and F4.7 of Volume One and 3.8.5.2 of Volume Two of the National Construction Code. Where the noise *limit* is likely to be exceeded, a mechanical ventilation system is usually required. Mechanical ventilation systems will need to comply with AS 1668.2 – *The use of mechanical ventilation and air-conditioning in buildings*.

In implementing the acceptable treatment packages, the following must be observed:

- Evaporative air conditioning systems will meet the requirements for Packages A and B provided attenuated air vents are provided in the ceiling space and designed so that windows do not need to be opened.
- Refrigerant based air conditioning systems need to be designed to achieve fresh air ventilation requirements.
- External openings (e.g. air inlets, vents) need to be positioned facing away from the transport corridor where practicable.
- Ductwork needs to be provided with adequate silencing to prevent noise intrusion.

Notification

Notifications on certificates of title and advice to prospective purchasers warning of the potential for noise impacts from major transport corridors help with managing expectations.

The area of land for which notification is required should be identified in the noise management plan and contain a description of major noise sources nearby (e.g. 24-hour freight rail).

Notification should be provided to prospective purchasers, and required as a condition of subdivision (including strata subdivision) for the purposes of noise sensitive development or planning approval involving noise sensitive development, where external noise levels are forecast or estimated to exceed the 'target' criteria as defined by the Policy.

In the case of subdivision and development, conditions of approval should include a requirement for registration of a notice on title, which is provided for under Section 165 of the Planning and Development Act 2005 and Section 70A of the Transfer of Land Act 1893. An example of a suitable notice is:

Notice: This lot is situated in the vicinity of a transport corridor and is currently affected, or may in the future be affected, by transport noise. Transportation noise controls and Quiet House design strategies at potential cost to the owner may be required to achieve an acceptable level of noise reduction. Further information is available on request from the relevant local government offices.

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).

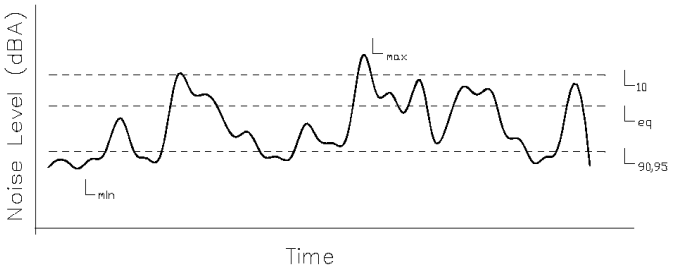
$L_{Aeq,8hour}$ / $L_{Aeq\ (Night)}$
The $L_{Aeq\ (Night)}$ level is the logarithmic average of the hourly L_{Aeq} levels from 10.00 pm to 6.00 am on the same day.

$L_{Aeq,16hour}$ / $L_{Aeq\ (Day)}$
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 $L_{A10,18hour}$.

Satisfactory Design Sound Level
The level of noise that has been found to be acceptable by most people for the environment in question and also to be not intrusive.

Maximum Design Sound Level
The level of noise above which most people occupying the space start to become dissatisfied with the level of noise.

Chart of Noise Level Descriptors



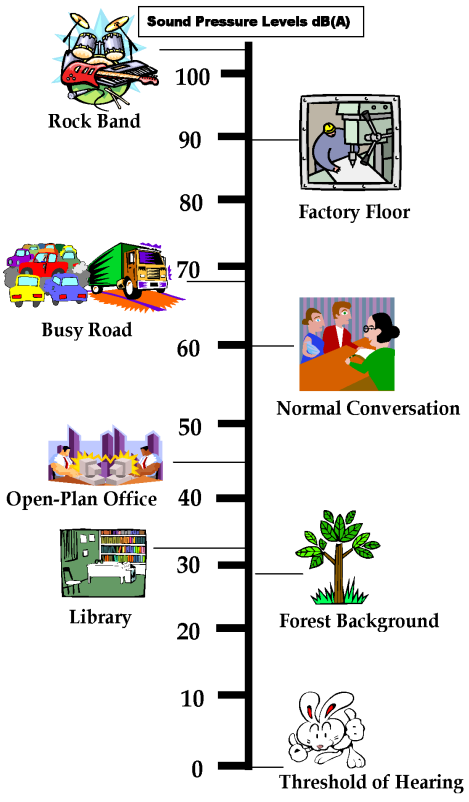
Austroads Vehicle Class

AUSTROADS Vehicle Classification System

Level 1 Length (indicative) Type	Level 2 Axles and Axle Groups Axles	Groups	Level 3 Vehicle Type Typical Description	AUSTROADS Classification Class	Parameters	Typical Configuration
			LIGHT VEHICLES			
Short up to 5.5m		1 or 2	**Short** Sedan, Wagon, 4WD, Utility, Light Van, Bicycle, Motorcycle, etc	1	d(1) ≤ 3.2m and axles = 2	
	3, 4 or 5	3	**Short - Towing** Trailer, Caravan, Boat, etc	2	groups = 3 d(1) > 2.1m, d(1) ≤ 3.2m, d(2) ≥ 2.1m and axles = 3, 4 or 5	
			HEAVY VEHICLES			
Medium 5.5m to 14.5m	2	2	**Two Axle Truck or Bus**	3	d(1) > 3.2m and axles = 2	
	3	2	**Three Axle Truck or Bus**	4	axles = 3 and groups = 2	
	> 3	2	**Four Axle Truck**	5	axles > 3 and groups = 2	
Long 11.5m to 19.0m	3	3	**Three Axle Articulated** Three axle articulated vehicle, or Rigid vehicle and trailer	6	d(1) > 3.2m, axles = 3 and groups = 3	
	4	> 2	**Four Axle Articulated** Four axle articulated vehicle, or Rigid vehicle and trailer	7	d(2) < 2.1m or d(1) < 2.1m or d(1) > 3.2m axles = 4 and groups > 2	
	5	> 2	**Five Axle Articulated** Five axle articulated vehicle, or Rigid vehicle and trailer	8	d(2) < 2.1m or d(1) < 2.1m or d(1) > 3.2m axles = 5 and groups > 2	
	≥ 6	> 2	**Six Axle Articulated** Six axle articulated vehicle, or Rigid vehicle and trailer	9	axles = 6 and groups > 2 or axles = 6 and groups = 3	
Medium Combination 17.5m to 36.5m	> 6	4	**B Double** B Double, or Heavy truck and trailer	10	groups = 4 and axles > 6	
	> 6	5 or 6	**Double Road Train** Double road train, or Medium articulated vehicle and one dog trailer (M.A.D.)	11	groups = 5 or 6 and axles > 6	
Large Combination Over 33.5m	> 6	> 6	**Triple Road Train** Triple road train, or Heavy truck and three trailers	12	groups > 6 and axles > 6	

Definitions: Group: Axle group, where adjacent axles are less than 2.1m apart
Groups: Number of axle groups
Axles: Number of axles (maximum axle spacing of 10.0m)
d(1): Distance between first and second axle
d(2): Distance between second and third axle

Typical Noise Levels



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