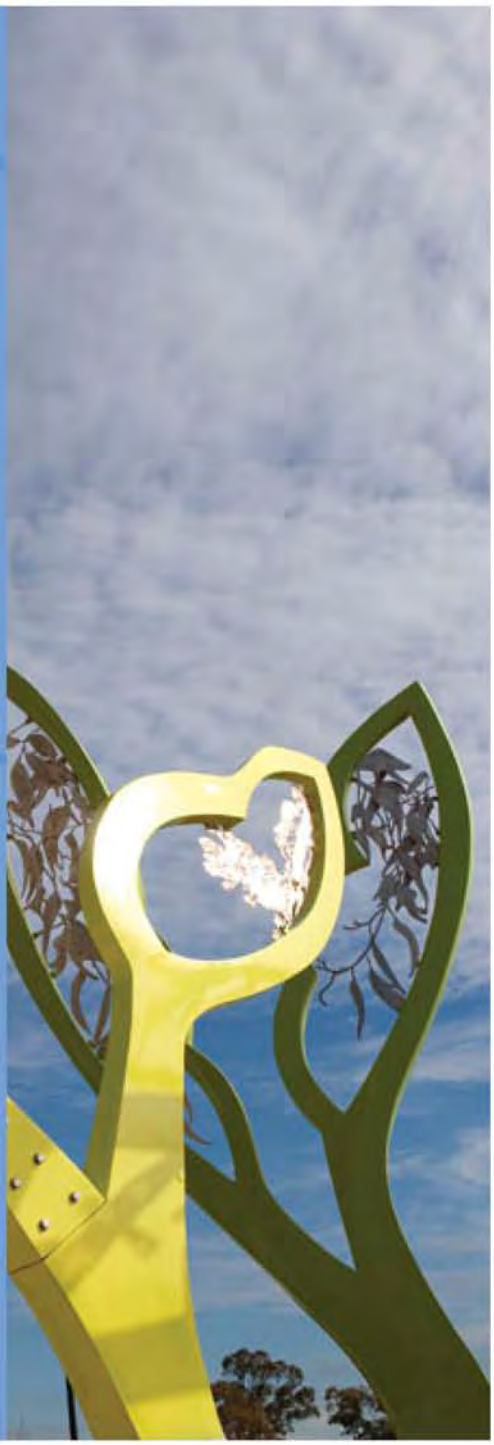
Lot 50 Cockram Street & Lot 119 Sparkman Road,
Mundijong (Mundijong-Whitby Sub-Precinct E2)

LOCAL STRUCTURE PLAN



Prepared for **Peet Limited**

April 2015

DOCUMENT STATUS

08/039		Revision	Reviewer	Date Issued
Prepared By:	**Taylor Burrell Barnett Town Planning and Design** 187 Roberts Road SUBIACO WA 6008 Phone: 9382 2911 Fax: 9382 4586 admin@tbbplanning.com.au	0	SD	15.10.12
		1	SD	29.10.12
		2	SD	06.11.12
		3	SD	03.05.13
		4	SD	27.08.13
		5	SD	03.09.13
		6	SD	24.04.14
		7	SD	28.04.15

ADOPTION OF AGREED STRUCTURE PLAN

CERTIFIED THAT AGREED LOT 50 COCKRAM STREET LOCAL STRUCTURE PLAN

WAS ADOPTED BY

RESOLUTION OF THE WESTERN AUSTRALIAN PLANNING COMMISSION ON

1 September 2015

Signed for and on behalf of the Western Australian Planning Commission

.....

an officer of the Commission duly authorised by the Commission pursuant to section 57 of the Western Australian Planning Commission Act 1985 for that purpose, in the presence of:

M. Wreclaw ..... Witness

11 September 2015 ..... Date

AND BY

RESOLUTION OF THE COUNCIL OF THE SHIRE OF SERPENTINE JARRAHDALE ON

25 May 2015

AND THE SEAL OF THE MUNICIPALITY WAS PURSUANT

TO THE COUNCIL'S RESOLUTION HEREUNTO AFFIXED IN THE

PRESENCE OF:

.....

PRESIDENT ~~Mayor~~, Shire of Serpentine Jarrahdale

.....

Chief Executive Officer, Shire of Serpentine Jarrahdale

29/07/15 ..... Date

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

This local structure plan applies to Lot 50 Cockram Street and Lot 119 Sparkman Road, Mundijong (the subject land). The subject land is located in the Perth Metropolitan South East Corridor, within the municipality of the Shire of Serpentine Jarrahdale. The site is approximately one kilometre west of the Mundijong town centre and 40 kilometres south east of the Perth Central Area, and is accessible via South Western Highway, Mundijong Road, and the Kwinana Freeway.

The Structure Plan proposes residential development of the land ranging in density from R20 to R60, associated public open space and a primary school.

The subject land forms the southern portion of Precinct E of the Mundijong-Whitby District Structure Plan (DSP). The proposed local structure plan is consistent with the Mundijong-Whitby DSP which identifies the site for residential development and one primary school. There has been no previous local structure plan over the subject land.

STRUCTURE PLAN SUMMARY TABLE

Item	Data	Section number referenced within the Structure Plan Report
Total area covered by the structure plan	56.6 hectares	1.1.2
Area of each land use proposed: • Residential • Primary School	 26.2951 hectares 3.50 hectares	3.2
Estimated lot yield	Approximately 557 lots	3.5
Estimated number of dwellings	Approximately 574 dwellings	3.5
Estimated residential site density	14.8 – 17.8 dwellings per gross hectare	3.5
Estimated population	1,549 people (assuming 2.7 people/dwelling as per DSP)	3.5
Number of high schools	0 high schools	N/A
Number of primary schools	1 primary school	3.8
Estimated commercial floor space (for activity centres if appropriate)	0 net lettable area	N/A
Employment self sufficiency targets	Opportunity for home based employment. Opportunity for employment at proposed primary school.	N/A
Estimated number and % of public open space: • Regional open space • District open space	 0 hectares 0% 0 hectares 0%	N/A
Estimated area and number: • neighbourhood parks • local parks	 4.3908 hectares 1 parks 1.9886 hectares 10 parks	3.3
Estimated number and area of natural area and biodiversity assets	0 hectares 0 sites	N/A

CONTENTS

FIGURES

APPENDICES

PART ONE
STATUTORY SECTION

1 STRUCTURE PLAN AREA

This Local Structure Plan (LSP) shall apply to Lot 50 Cockram Street and Lot 119 Sparkman Road, Mundijong, being land contained within the inner edge of the line denoting the Structure Plan boundary on the Structure Plan Map (**Plan 1**).

2 STRUCTURE PLAN CONTENT

This Structure Plan comprises:

Part 1 - Statutory Section
This section contains the Structure Plan map and statutory planning provisions and requirements.

Part 2 – Explanatory (non-statutory) Section
This section to be used as a reference guide to interpret and justify the implementation of Part 1.

Appendices – Technical reports and supporting plans and maps.

3 INTERPRETATION AND SCHEME RELATIONSHIP

Unless otherwise specified in this part, the words and expressions used in this Structure Plan shall have the respective meanings given to them in the Shire of Serpentine Jarrahdale Town Planning Scheme No. 2 (the Scheme) including any amendments gazetted thereto.

The Structure Plan Map (**Plan 1**) outlines land use, zones and reserves applicable within the Structure Plan area. The zones and reserves designated under this Structure Plan apply to the land within it as if the zones and reserves were incorporated into the Scheme. The road layout as shown on **Plan 1** is indicative only and is subject to detailed design at subdivision stage.

Pursuant to clause 5.18.6.5 of the Scheme:

a) The provisions, standards and requirements specified under Part 1 of this Structure Plan shall have the same force and effect as if it were a provision, standard or requirement of the Scheme. In the event of there being any variations or conflict between the provisions, standards or requirements of the Scheme and the provisions, standards or requirements of this Structure Plan, then the provisions, standards or requirements of the Scheme shall prevail;

b) Any other provision, standard or requirement of Part 1 of the Structure Plan that is not otherwise contained in the Scheme, shall apply to the Structure Plan area as though it is incorporated into the Scheme, and shall be binding and enforceable to the same extent as if part of the Scheme; and

c) Part 2 of this Structure Plan and all appendices are to be used as a reference only to clarify and guide interpretation and implementation of Part 1.

STRUCTURE PLAN

Lot 50 Cockram Street & Lot 119 Adams Street, Mundijong

A Peet Ltd Project

0m 20 40 60m

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d: 14/04/2015
p: 08/039/020B

plan 01

4 OPERATION

In accordance with sub-clause 5.18.6.1 of the Scheme, this Structure Plan shall come into operation when it is adopted by the Shire of Serpentine-Jarrahdale after receiving notice of the approval by the Western Australian Planning Commission (WAPC), pursuant to 5.18.3.15 of the Scheme.

5 LAND USE AND SUBDIVISION REQUIREMENTS

The Structure Plan Map (**Plan 1**) outlines land use, zones and reserves applicable within the Structure Plan area. The zones and reserves designated under this Structure Plan apply to the land within it as if the zones and reserves were incorporated into the Scheme.

5.1 LAND USE PERMISSIBILITY

Land use permissibility within the Structure Plan area shall be in accordance with the corresponding zone or reserve under the Scheme.

5.2 RESIDENTIAL

5.2.1 DWELLING TARGET

Objective: To provide for a minimum 15 dwellings per site hectare within the Structure Plan area.

b) Subdivisions are generally to achieve the following:

   i) 15 dwellings per site hectare.

5.2.2 DENSITY

a) Plan 1 (Structure Plan) defines the broad residential density ranges that apply to different areas within the Structure Plan. Lot-specific residential densities, generally in accordance with 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 application for subdivision approval to the WAPC, and shall indicate the Residential Density Code applicable to each lot within the proposed subdivision and shall be generally consistent with the residential density ranges identified in the Structure Plan and locational criteria identified in Clause 5.2.3.

c) The Residential Density Code Plan is to include a summary of the proposed dwelling yield of the proposed 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) Variations to the Residential Density Code Plan will require further approval of the WAPC, with a revised Residential Density Code Plan submitted generally consistent with the approved plan of subdivision issued by the WAPC. The revised Residential Density Code Plan shall be consistent with Residential Density ranges identified on Plan 1 and the locational criteria contained in clause 5.2.3.

f) A revised Residential Density Code Plan, consistent with clause 5.2.2 (e) will replace, wholly or partially, the previously approved Residential Density Code Plan, and shall then form part of the Structure Plan as outlined in clause 5.2.2 (d).

g) Residential Density Code Plan 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; or

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

5.2.3 LOCATIONAL CRITERIA

The allocation of residential densities on the Residential Density Code Plan shall be in accordance with the following criteria:

a) R30 – R60
Medium density of R30 – R60 shall apply in areas of high amenity including adjacent to public open space, the primary school and along neighbourhood connector roads.

b) R20 – R40
Low to medium density of R20 – R40 shall apply for the remainder of residential land in the structure plan area.

5.3 PUBLIC OPEN SPACE

The provision of a minimum of 10 per cent public open space will be provided in accordance with the WAPC's Liveable Neighbourhoods. The proposed largest parcel of public open space within the structure plan area is to be co-located with the primary school. Public open space is to be provided generally in accordance with **Plan 1.**

5.4 CONDITIONS OF SUBDIVISION APPROVAL

At the time of subdivision the following conditions may be recommended, as applicable, requiring the preparation and/or implementation of the following strategies:

i. Acid Sulphate Management (Department of Environment and Conservation)

ii. Noise Management Strategy (if deemed necessary) (Main Roads Western Australia/Shire of Serpentine Jarrahdale)

iii. Construction Management Plan (Shire of Serpentine Jarrahdale)

iv. Urban Water Management Plan (Department of Water)

v. Aboriginal Heritage Management Plan (Shire of Serpentine Jarrahdale)

vi. Landscape Management Plan (Shire of Serpentine Jarrahdale)

vii. Fire and Emergency Management Plan (Shire of Serpentine Jarrahdale)

Subdivision and development plans are required to provide adequate road and verge widths to accommodate the service alignments of a possible future third pipe system.

This is a non-exhaustive list of suggested conditions which may be imposed at the time of subdivision, subject to consideration by the Shire of Serpentine Jarrahdale and relevant authorities at the time of subdivision referral.

At the time of subdivision the Shire of Serpentine Jarrahdale shall recommend to the WAPC the implementation of the following strategies which have been prepared and approved as part of the Structure Plan as conditions of subdivision:

viii. Local Water Management Strategy

5.5 NOISE ATTENUATION TREATMENTS

Noise attenuation treatments as per the recommendations outlined in the Herring Storer Acoustic Assessment dated April 2014 including but not limited to the construction of a 3.0 metre high noise wall along Tonkin Highway, notifications on title, and quiet house design and height limit provisions within Local Development Plans, shall be implemented as conditions of subdivision approval for any lots affected by the presence of Tonkin Highway unless an updated and more accurate Acoustic Assessment is provided with, and approved for, any future subdivision application for the lots in closest proximity of Tonkin Highway.

6 DEVELOPMENT REQUIREMENTS

6.1 LOCAL DEVELOPMENT PLANS (FORMERLY DETAILED AREA PLANS)

Local Development Plans (LDP) are to be prepared in accordance with the Detailed Area Plan provisions established in clause 5.18.5 of the Scheme, prior to any subdivision and/or development of:

- Lots smaller than 260 m^2;
- Lots abutting POS areas;
- Lots abutting the Water Corporation service corridor; and
- Laneway lots.

Council may waive the requirement to advertise a LDP pursuant to Clause 5.18.5 where the land subject of the LDP is in single ownership and the adjoining land is in the same ownership.

6.2 RESIDENTIAL DESIGN CODE VARIATIONS

Table 2A, **2B** and **2C** sets out variations to the *Residential Design Codes* that are deemed to constitute 'deemed-to-comply' development within the Structure Plan area and which do not therefore, require neighbour consultation and planning approval.

TABLE 1A: VARIATIONS TO 'ACCEPTABLE DEVELOPMENT' REQUIREMENTS OF THE R-CODES FOR R25 SINGLE LOTS (EXCLUDES LOTS TO BE DEVELOPED FOR MORE THAN ONE DWELLING)

ITEM	R-CODE CLAUSE	VARIATION
Front Setback Requirements	5.1.2	Primary Street Setback – minimum 4m (can be averaged as per the R-Codes)
Rear Setback Requirements	5.2	A 0.5m minimum garage setback is required to the laneway boundary for rear loaded lots.
		A nil rear setback is permitted to the 1st floor of a dweling for rear loaded lots.
Side Setback Requirements	5.1.3	A nil side setback is permitted to the ground floor level of a dwelling to a maximum wall height of 3.6m (no average) for a maximum length determined by the requried front and rear setbacks, to one side boundary only.
		A second nil side setback is permitted for a maxiumum length of 9m for the purposes of a garage/store only.
Other - Streetscape	5.2.3	Dwellings must address the Primary and Secondary (where applicable) street by way of design and must contain at least one major opening to a habitable room facing the primary and secondary street.

TABLE 2B: VARIATIONS TO 'ACCEPTABLE DEVELOPMENT' REQUIREMENTS OF THE R-CODES FOR R30 SINGLE LOTS (EXCLUDES LOTS TO BE DEVELOPED FOR MORE THAN ONE DWELLING)

ITEM	R-CODE CLAUSE	VARIATION
Front Setback Requirements	5.2	Primary Street Setback – minimum 3m (can be averaged as per the R-Codes)
Rear Setback Requirements	5.2	A 0.5m minimum garage setback is required to the laneway boundary for rear loaded lots.
		A nil rear setback is permitted to the 1st floor of a dweling for rear loaded lots.
Side Setback Requirements	5.1.2	Side Setback (to Secondary Street) – minimum 1m.
	5.1.3	A nil side setback is permitted to the ground floor level of a dwelling to a maximum wall height of 3.6m (no average) for a maximum length determined by the requried front and rear setbacks, to one side boundary only.
		A second nil side setback is permitted for a maxiumum length of 9m for the purposes of a garage/store only.
Other - Streetscape	5.2.3	Dwellings must address the Primary and Secondary (where applicable) street by way of design and must contain at least one major opening to a habitable room facing the primary and secondary street.

TABLE 2C: VARIATIONS TO 'ACCEPTABLE DEVELOPMENT' REQUIREMENTS OF THE R-CODES FOR R40 SINGLE LOTS (EXCLUDES LOTS TO BE DEVELOPED FOR MORE THAN ONE DWELLING)

ITEM	R-CODE CLAUSE	VARIATION
Front Setback Requirements	5.1.2	Primary Street Setback – minimum 3m (can be averaged as per the R-Code).
Rear Setback Requirements	5.2	A 0.5m minimum garage setback is required to the laneway boundary for rear loaded lots.
		A nil rear setback is permitted to the 1st floor of a dweling for rear loaded lots.
Side Setback Requirements	5.1.2	Side Setback (to Secondary Street) – minimum 1m.
	5.1.3	A nil side setback is permitted to the ground floor level of a dwelling to a maximum wall height of 3.6m (no average) for a maximum length determined by the requried front and rear setbacks, to one side boundary only.
		A second nil side setback is permitted for a maxiumum length of 9m for the purposes of a garage/store only.
Other - Streetscape	5.2.3	Dwellings must address the Primary and Secondary (where applicable) street by way of design and must contain at least one major opening to a habitable room facing the primary and secondary street.

6.3 BUILT FORM DESIGN GUIDELINES

Design Guidelines are to be prepared as a Local Planning Policy to establish objectives for built form prior to applications for development.

6.4 LANDSCAPE DESIGN GUIDELINES

Landscape Design Guidelines are to be prepared to establish measures to be adopted to implement public and private landscaping, prior to applications for development.

PART TWO
EXPLANATORY INFORMATION

1 PLANNING BACKGROUND

1.1 INTRODUCTION AND PURPOSE

The purpose of this LSP is to guide and facilitate the urbanisation of Lot 50 Cockram Street and Lot 119 Sparkman Road, Mundijong. This LSP has been prepared in accordance with:

- section 5.18.2 of the Shire of Serpentine Jarrahdale's Town Planning Scheme No. 2; and
- the Western Australian Planning Commission's newly released 'Structure Plan Preparation Guidelines' (August 2012)

This LSP proposes the development of the land for predominantly residential purposes generally to a density of between R10 to R40. The LSP provides for a primary school as designated in the Mundijong Whitby DSP.

1.1.1 LOCATION

The subject land is Lot 50 Cockram Street and Lot 119 Sparkman Road, Mundijong.

The subject land is located within the Perth Metropolitan South East corridor, within the municipality of the Shire of Serpentine Jarrahdale (the Shire). The land is situated approximately one kilometre west of the Mundijong townsite and 40 kilometres south east of the Perth Central Area and is accessible via the South Western Highway, Mundijong Road, and the Kwinana Freeway (refer **Figure 1** – Regional Context Plan). The subject land is bounded by Sparkman Road to the north, Adams Street to the east, Mundijong Road to the south, and the road reserve for the future extension of Tonkin Highway to the west. Refer **Figure 2** – Location Plan.

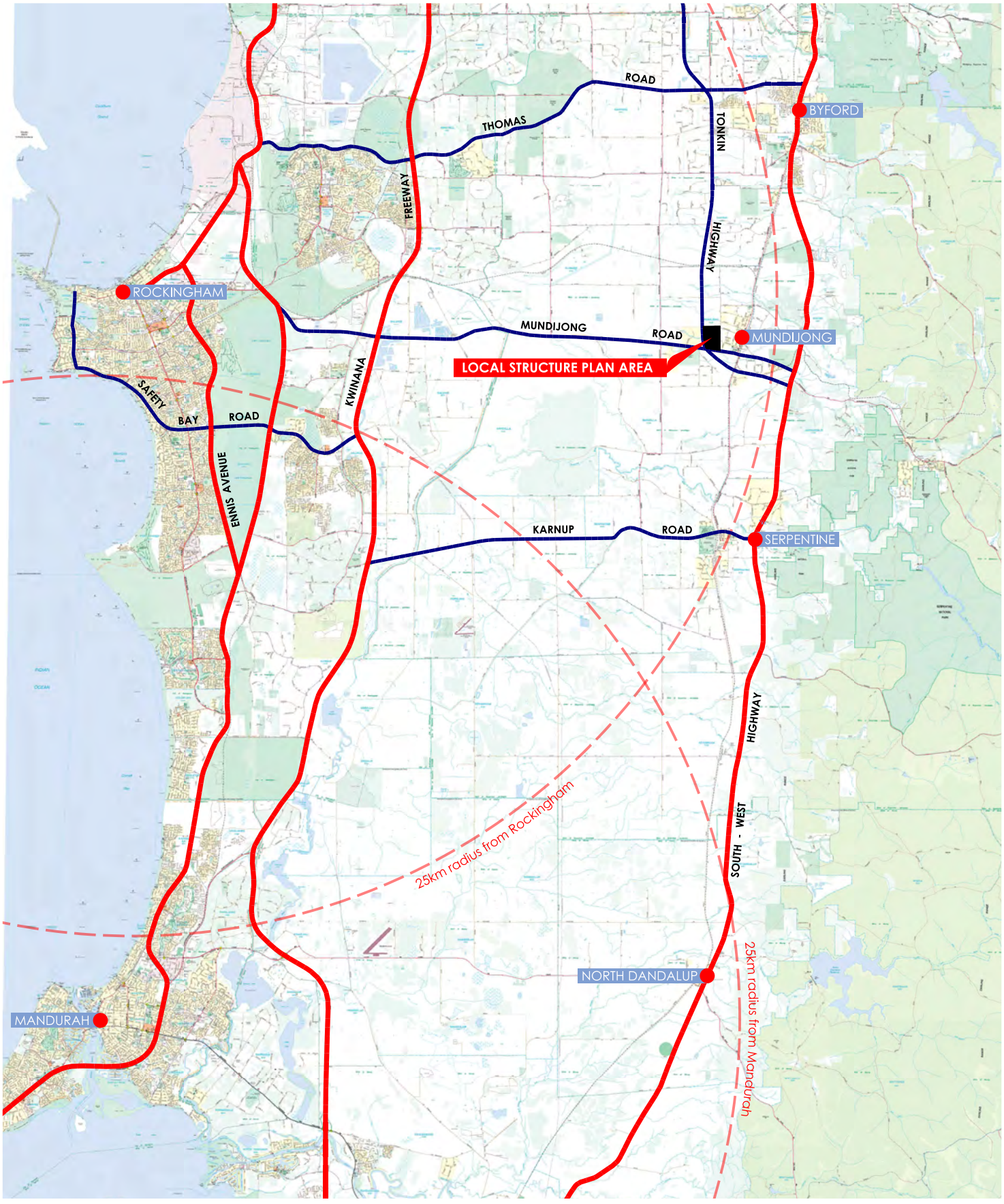
1.1.2 AREA AND LAND USE

The subject land comprises an area of approximately 56.6 hectares. The land is currently used for grazing and similar agricultural activities. There are some existing sheds and a house on Lot 119. The land is mostly cleared, with an existing stand of trees in the north-west of Lot 50 planted by the previous owner. Advice from PGV environmental consultants indicates that these trees are not native to this locality and are therefore not significant and do not require retention. Refer **Figure 3** – Aerial Photograph.

Given the close proximity of the site to the Mundijong townsite and within the Mundijong-Whitby Urban area, the site is strategically placed to accommodate urban development.

1.1.3 LEGAL DESCRIPTION AND OWNERSHIP

The following is the legal title and ownership details for the land of the LSP. Certificates of Title are attached at **Appendix 2.**



LEGEND

- LOCAL STRUCTURE PLAN AREA
- MAJOR REGIONAL ROADS
- OTHER KEY REGIONAL ROADS

REGIONAL CONTEXT PLAN

Lot 50 Cockram Street &
Lot 119 Adams Street, Mundijong

A Peet Limited Project

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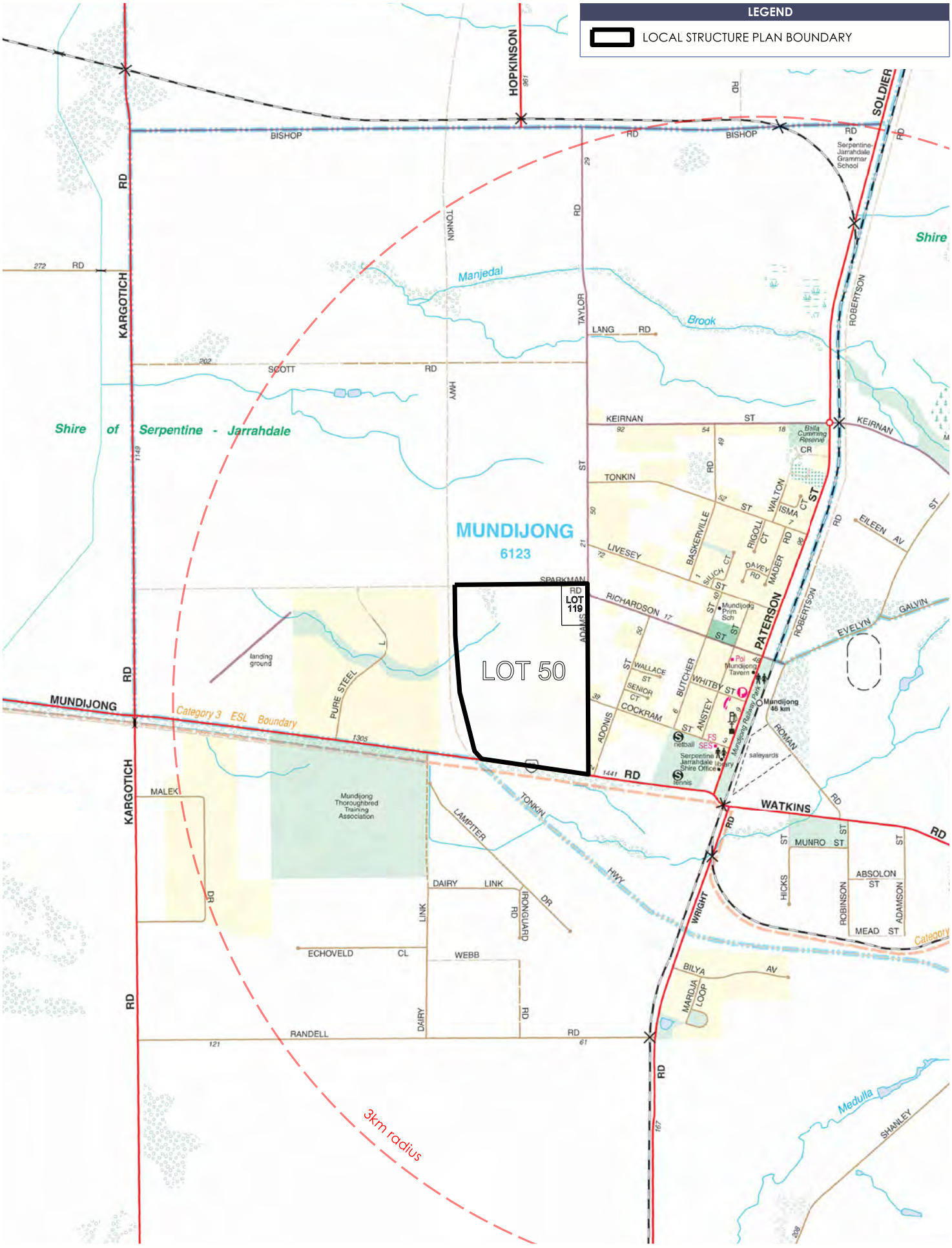
figure 01



LOCATION PLAN

Lot 50 Cockram Street &
Lot 119 Adams Street, Mundijong

A Peet Limited Project

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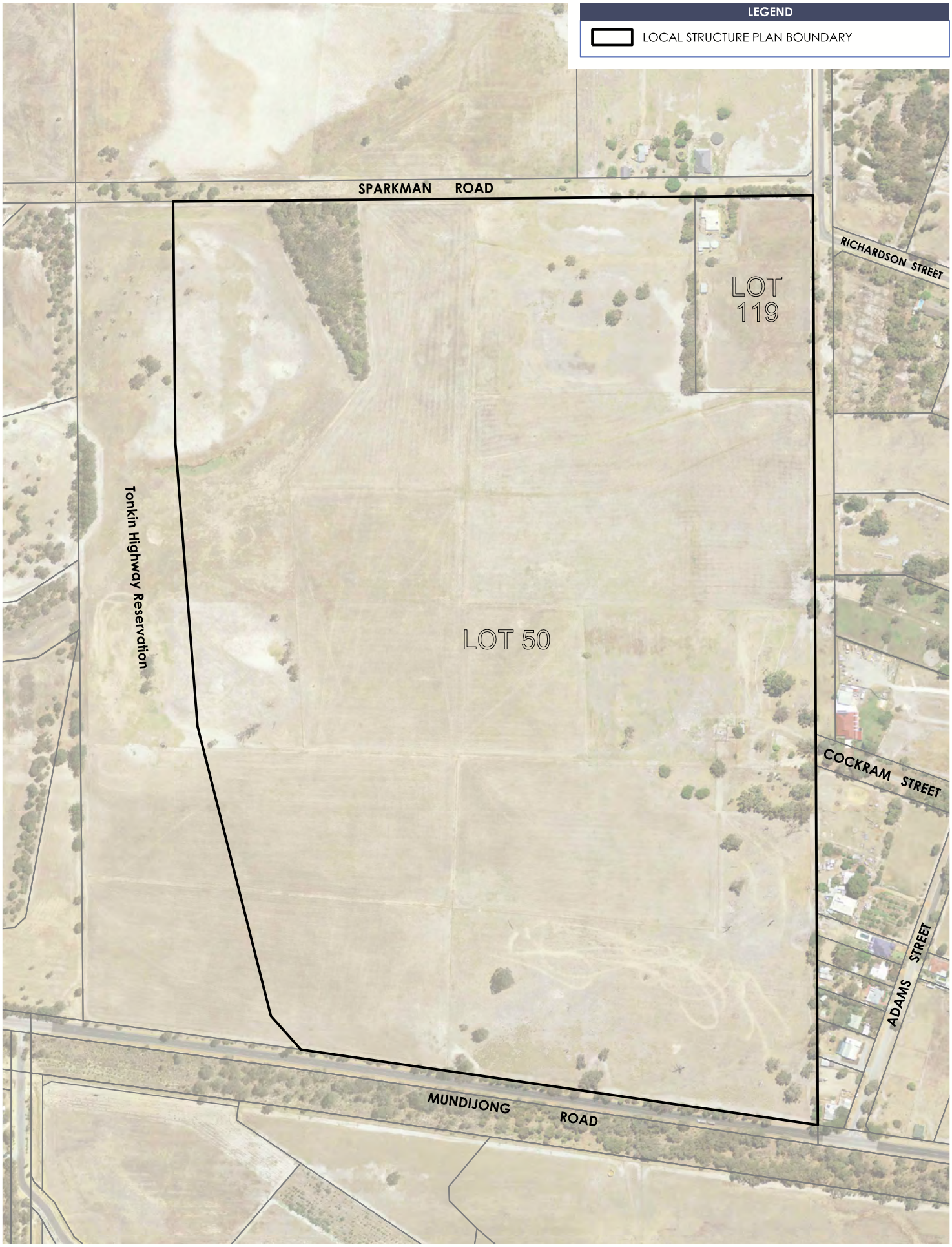
figure 02



AERIAL PHOTOGRAPH

Lot 50 Cockram Street &
Lot 119 Adams Street, Mundijong

A Peet Limited Project

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p: 08/039/024

figure 03

TABLE 2: LEGAL DESCRIPTION

Lot Address	Land Owner	Volume	Folio	Diagram/Plan	Area
Lot 50 Cockram Street, Mundijong	Peet No 88 Pty Ltd	2752	408	67194	54.2113 ha
Lot 119 Sparkman Road, Mundijong	Ramsay MacDonald Lightbody	723	99	226156	2.4283 ha

1.2 PLANNING FRAMEWORK

1.2.1 ZONING AND RESERVATIONS

METROPOLITAN REGION SCHEME

The subject land is zoned 'Urban' under the Metropolitan Region Scheme (MRS). The land to the north, east and southeast of the site is also zoned Urban. Abutting the site to the west is a 'Primary Regional Roads' reservation for the future Tonkin Highway extension. Refer **Figure 4 –** Metropolitan Region Scheme Zoning.

SHIRE OF SERPENTINE JARRAHDALE TOWN PLANNING SCHEME NO 2

The land is zoned 'Urban Development' under the Shire of Serpentine Jarrahdale Town Planning Scheme No. 2 (TPS 2); refer **Figure 5** – Shire of Serpentine-Jarrahdale Town Planning Scheme No. 2 Zoning. It is located within Development Area 1 – Mundijong (DA 1), and development must adhere to the DA 1 Provisions within the Scheme Text. As stated in the Scheme, the purpose of the Urban Development zone is:

> *"to provide for the orderly planning of large areas of land in a locally integrated manner and within a regional context, whilst retaining flexibility to review planning with changing circumstances."*

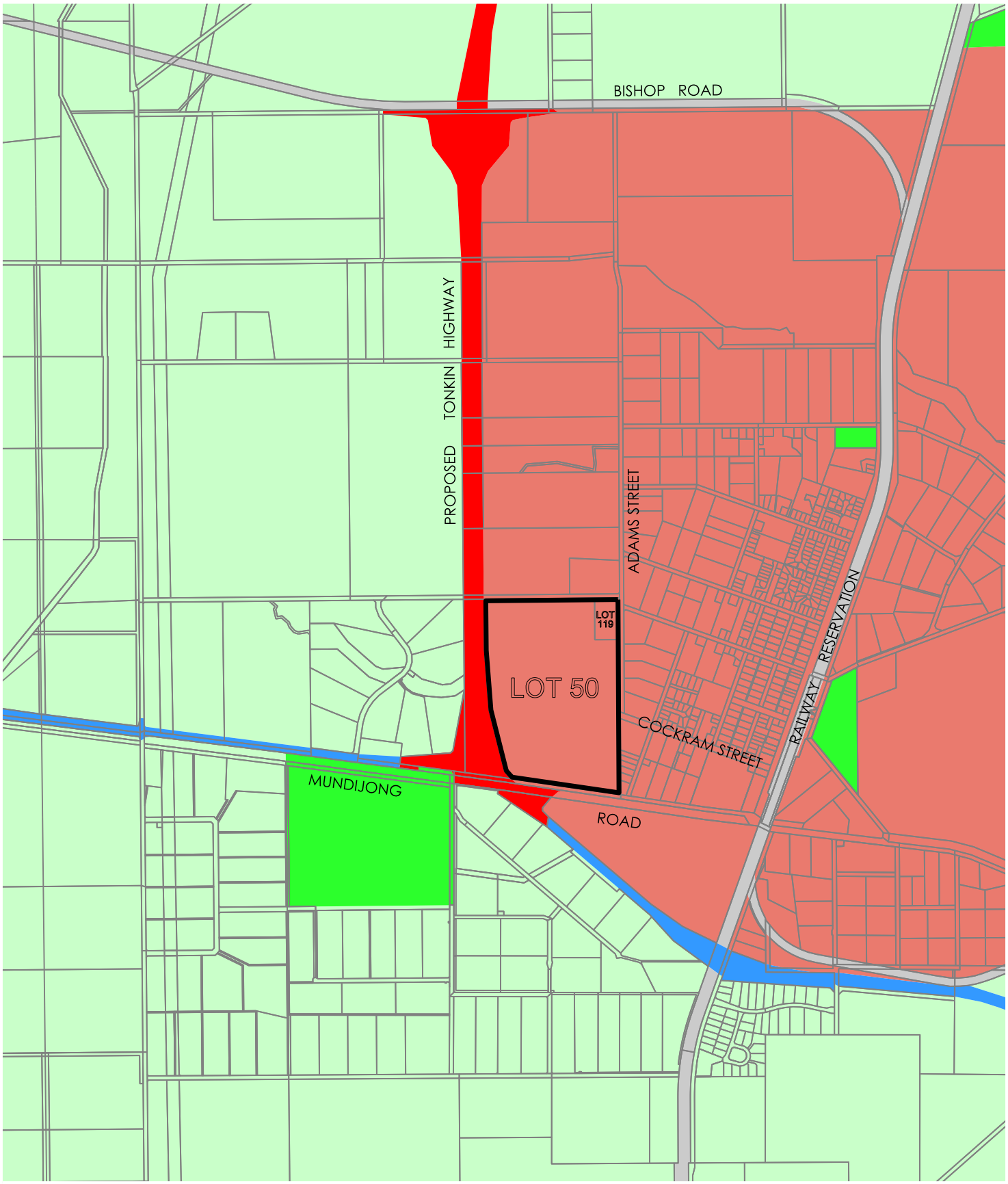
TPS 2 requires any Local Structure Plans over DA1 to be consistent with the provisions of the District Structure Plan. This LSP proposes to designate land for residential use with accompanying public open space, a primary school and roads consistent with the purpose and intent of the 'Development' zone, as well as the Mundijong-Whitby District Structure Plan.

1.2.2 REGIONAL AND SUB-REGIONAL STRUCTURE PLAN

In August 2011 the Shire adopted the Mundijong-Whitby District Structure Plan (DSP) (refer **Figure 6** – Mundijong-Whitby District Structure Plan. This document aims to provide guidance to the structure, vision and objectives identified for the planning and development of the Mundijong-Whitby area, as well as guiding the preparation of more detailed Local Structure Plans.

There are a number of district level issues dealt with by the DSP, including:

- Biodiversity;
- Landscape Protection;
- Water Resources;
- Urban Form;



LEGEND

RESERVED LANDS
- PARKS AND RECREATION
- RAILWAY

ROADS
- PRIMARY REGIONAL ROAD
- OTHER REGIONAL ROAD

ZONES
- URBAN
- RURAL
- LOCAL STRUCTURE PLAN BOUNDARY

METROPOLITAN REGION SCHEME ZONING

Lot 50 Cockram Street & Lot 119 Adams Street, Mundijong

A Peet Limited Project

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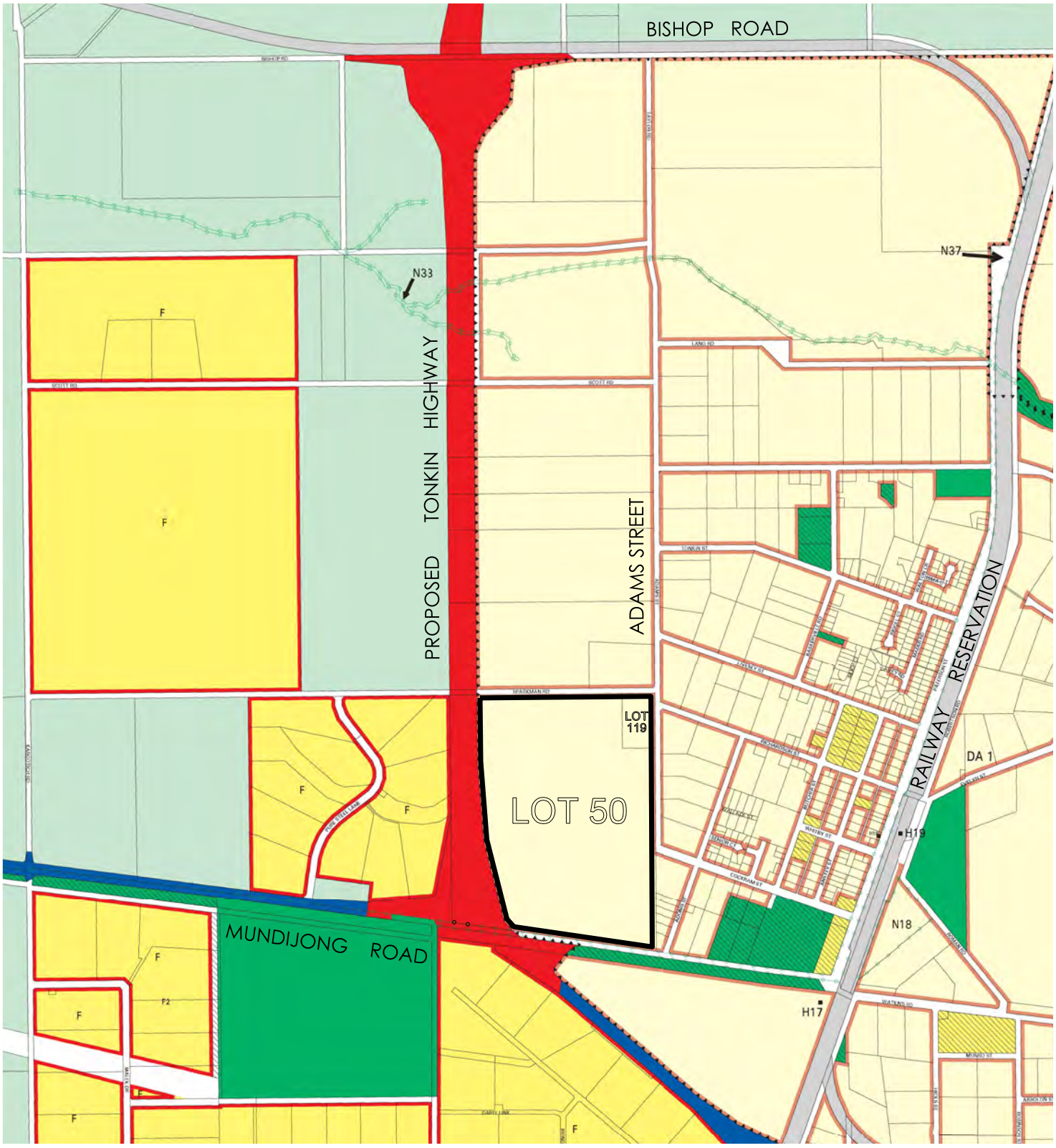
p: 08/039/012

figure 04



LEGEND

METROPOLITAN REGION SCHEME RESERVES
- PARKS AND RECREATION
- RAILWAY
- PRIMARY REGIONAL ROAD
- OTHER REGIONAL ROAD

LOCAL SCHEME RESERVES
- DRAINAGE PURPOSES
- LOCAL ROAD
- PUBLIC OPEN SPACE

ZONES
- URBAN DEVELOPMENT
- CONSERVATION
- FARMLET
- RURAL

OTHER
- DEVELOPMENT AREA (SEE SCHEME TEXT)
- AREA OF NATURAL BEAUTY (SEE SCHEME TEXT)

LEGEND
- LOCAL STRUCTURE PLAN BOUNDARY

SHIRE OF SERPENTINE-JARRAHDALE TOWN PLANNING SCHEME No.2 ZONING

Lot 50 Cockram Street &
Lot 119 Adams Street, Mundijong
A Peet Limited Project

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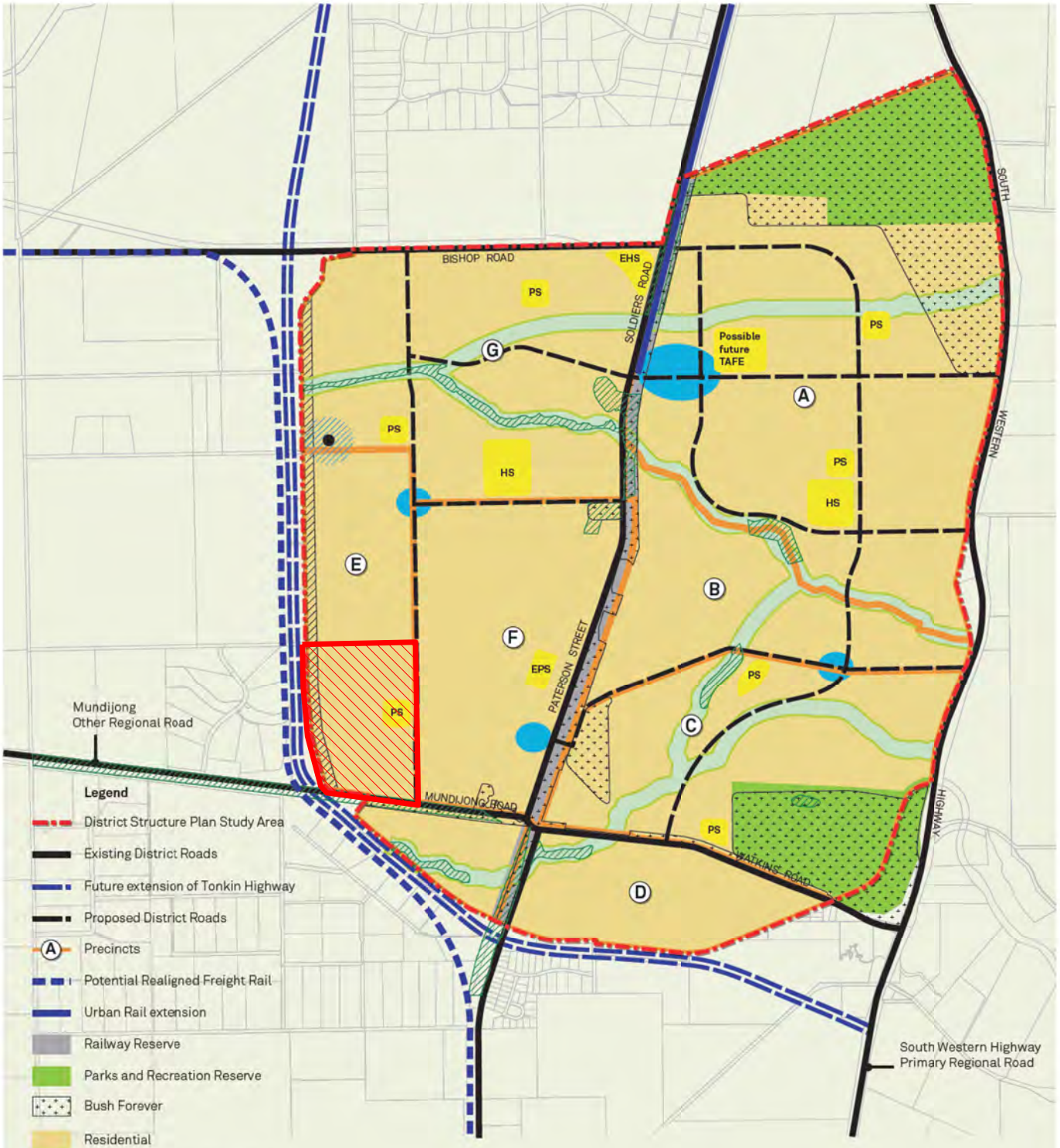
figure 05



Legend

- District Structure Plan Study Area
- Existing District Roads
- Future extension of Tonkin Highway
- Proposed District Roads
- (A) Precincts
- Potential Realigned Freight Rail
- Urban Rail extension
- Railway Reserve
- Parks and Recreation Reserve
- Bush Forever
- Residential
- Conservation Category Wetland
- Possible Wastewater Pump Station location and associated 150m radius odour buffer
- Multiple Use Corridor - location, size and dimension to be determined at LSP stage
- Possible Service Corridor
- Centre
- Schools EPS - Existing Primary School, EHS - Existing High School, HS - High School, PS - Primary School, TAFE - Possible Future Tafe

Lot 50 & 119 Local Structure Plan Area

'The District Structure plan has been prepared to provide overall guidance to the structure, vision and objectives identified for the planning and development of Mundijong/Whitby. It is designed to establish the overall development theme and address major district-wide issues in order to facilitate efficient and coordinated development in a manner that delivers the objectives and vision identified.

The District Structure Plan by its nature is not intended to address detailed planning and design matters but to provide the context for which these matters can be appropriately dealt with as part of further more detailed planning and design.'

MUNDIJONG-WHITBY DISTRICT STRUCTURE PLAN

Lot 50 Cockram Street & Lot 119 Adams Street, Mundijong

A Peet Limited Project

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figure 06

- Movement Networks;
- Climate-responsive Design and Energy;
- Economic Prosperity; and
- Community Wellbeing.

Local Structure Plans are to be prepared in accordance with the precincts defined in the DSP. As stated in the Shire's Local Planning Policy No 29 – Mundijong-Whitby Planning Framework (LPP 29), local structure plans prepared for any area geographically smaller than the sub-precincts defined in the DSP will not be supported by Council unless specifically resolved otherwise.

The DSP originally comprised seven precincts selected based on various criteria intended to enable efficient and coordinated development to be progressed. Following the adoption of the Shire's LPP 29, a proposal to modify the DSP precinct boundaries was submitted to the Shire to separate Precinct E (within which the subject site is located) and Precinct G into two sub-precincts each based on land ownership, existing roads and land use for the purposes of LSP preparation. At the Shire's Ordinary Council Meeting on 27 August 2012, Council adopted the updated LPP 29, incorporating the new sub-precincts, thus allowing for the preparation of a structure plan over only Precinct E2, being the subject land.

Clause 7.5 of the Mundijong-Whitby DSP considers 11 matters to be addressed within a Local Structure Plan for Precinct E. **Table 4** demonstrates how the LSP addresses these statutory requirements.

TABLE 4: LSP COMPLIANCE WITH STATUTORY REQUIREMENTS FOR PRECINCT E OF THE MUNDIJONG-WHITBY DSP

Matters to be addressed in LSP	LSP section/comment
Matters outlined in the Shire of Serpentine-Jarrahdale Town Planning Scheme Number 2, Clause 5.18.2.4.	The LSP has been prepared in accordance with Clause 5.18.2.4 of the Scheme (Details to be included in a Structure Plan).
Matters outlined in the Shire of Serpentine-Jarrahdale Town Planning Scheme Number 2, Schedule 15.	The LSP area is contained with DA1 and is prepared in accordance with the relevant provisions listed in Schedule 15 of the Scheme.
Matters outlined in the Shire of Serpentine-Jarrahdale Local Planning Policy No. 29 (LPP 29 Mundijong-Whitby Planning Framework).	Detailed in section 1.2.2 of the LSP report continued below.
The identification of two sites for the purposes of public primary schools generally in the location indicated in the DSP. The final location of the primary school sites within a LSP shall be determined in accordance with Liveable Neighbourhoods Element 8.	Precinct E2 of the DSP contains one of the two public primary schools required for the entire Precinct E. Its location as depicted on **Plan 1** on the eastern boundary of the precinct is in accordance with the location identified in the DSP.
POS shall be provided in accordance with clause 6.3 of the DSP and relevant policy.	POS is provided in accordance with clause 6.3 of the DSP and relevant policy including Element 4 of Liveable Neighbourhoods.
LSPs should establish objectives for built form and any design guidelines that are required to be established, typically as Local Planning Policies or Centre Plans that are required prior to applications for subdivision and/or subdivision. These should be cognisant of sections 8.8 and 8.9 of the Enquire by Design Report and should reflect the structure described in Explanatory Part 2, chapter 6, clause 6.2.2 (5) of the Mundijong-Whitby DSP.	Section 6.2 of Part 1 includes Residential Design Codes variations intended to guide the acceptable built form outcome.

Matters to be addressed in LSP	LSP section/comment
Landscape design guidelines shall be provided as part of any LSP. These shall address matters to be adopted to implement both public and private landscaping that reflects the historic landscape character of Mundijong/Whitby and should reflect the structure described in Explanatory Part 2, chapter 6, clause 6.2.2 (5) of the Mundijong-Whitby DSP.	Section 3.4 of the LSP details landscaping design guidelines for the structure plan area.
LSPs should confirm the extent of the proposed service corridor to the east of Tonkin Highway and pump station site. The pump station site will need to be set aside for future acquisition by WaterCorp.	**Plan 1** identifies the proposed service corridor at 60m wide.
Noise mitigation measures are required under appropriate policy requirements including SPP 5.4 are to be addressed at LSP stage.	Detailed in section 2.6.1.
The LSPs are to acknowledge and allow for appropriate interface to Bush Forever sites.	The southern entrance road is located within Bush Forever Site No. 360 (Mundijong and Watkins Roads Bushland, Mundijong/Peel Estate). The road is located through an area of Completely Degraded vegetation.
Such other information as may reasonably be required by the Council or the WAPC.	The LSP has been prepared and information has been provided in accordance with the WAPC Structure Plan Guidelines. Any additional information as may reasonably be required by the Council or WAPC may be provided at request.

1.2.3 SURROUNDING LOCAL STRUCTURE PLANNING

Local Structure Plans for adjoining land to the north and further to the east of the subject land have provided further context for the LSP design.

The Local Structure Plans for nearby land respect the development framework established in the DSP. The Whitby Local Structure Plan for land north-east of the subject land and east of the railway line was adopted by the Shire at the Ordinary Council Meeting held on 9 July 2012. Refer **Figure 7** – Whitby Structure Plan.

The Shire has recently considered a proposed local structure plan for the adjoining land to the north owned by Qube and Investa JV. Refer **Figure 8** – Proposed Mundijong Structure Plan. The proposed Mundijong Structure Plan of the subject land shows one neighbourhood connector road extending south towards Lot 50, as well as two other local access streets. The current proposed LSP shows neighbourhood connector road continuing through the subject site, bringing traffic from the northern site through to the primary school to be located within the subject site.

The Shire of Serpentine Jarrahdale has recently released a draft District Structure Plan for the West Mundijong Industrial Area located to the west of the subject land on the opposite side of Tonkin Highway. The West Mundijong Industrial Area is bounded by Mundijong Road to the south, Tonkin Highway Road reserve to the east, Railway Reserve (freight rail) to the north and Kargotich Road to the west. The draft District Structure Plan proposes predominantly light industrial land use along the Tonkin Highway.

source | Roberts Day Group

WHITBY LOCAL STRUCTURE PLAN

Lot 50 Cockram Street & Lot 119 Adams Street, Mundijong

A Peet Limited Project

N

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figure 07

1. Reserve for the future Tonkin Highway extension. Appropriate noise attenuation measures may apply, such as an estate wall or earthen bund. Further investigations are required to determine.

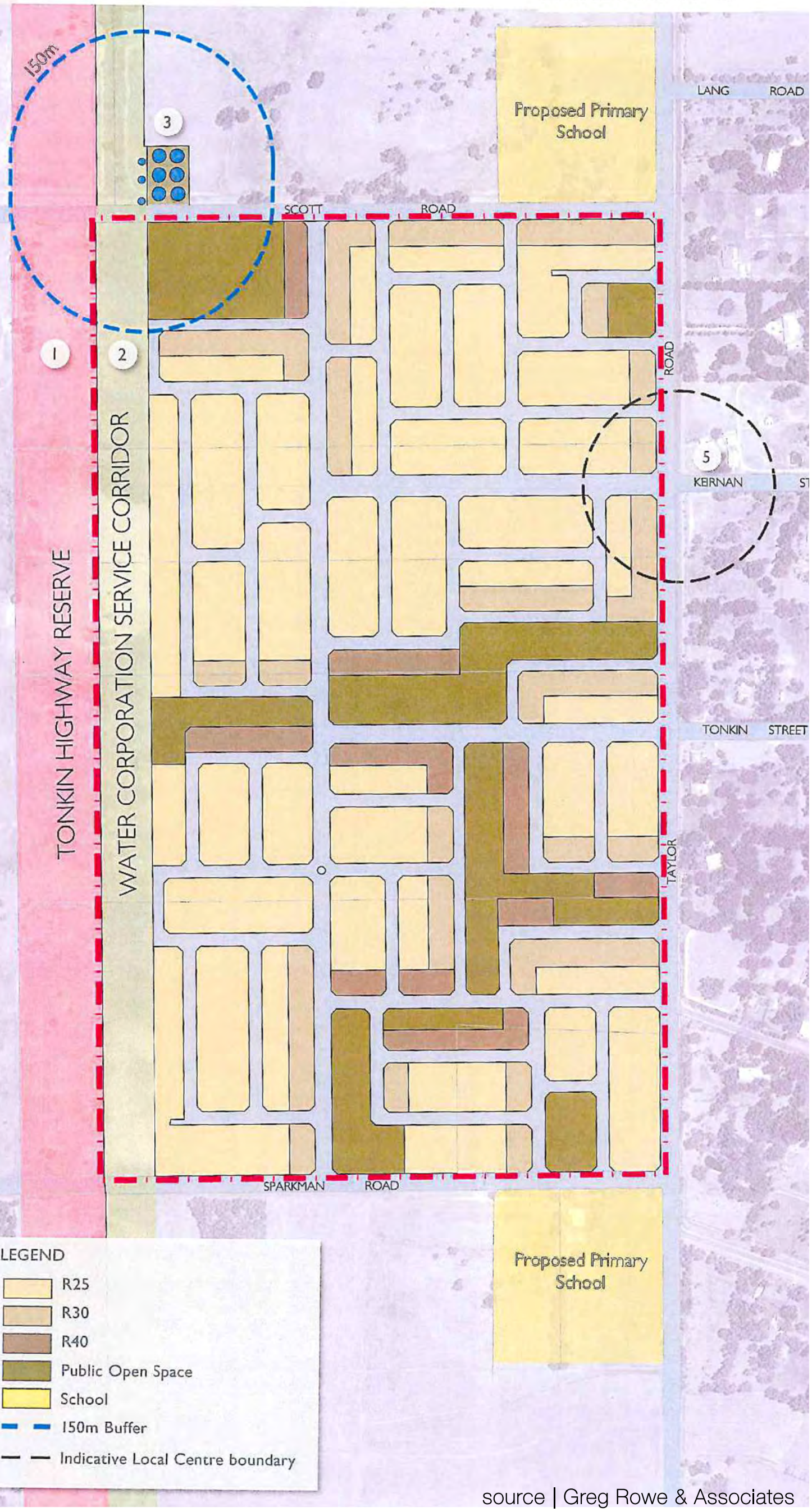
2. An appropriate interface is to be provided between the residential development and the Water Corporation Service Corridor. Further discussions and negotiation between the Water Corporation and the Shire is required to determine an appropriate treatment of the Corridor. Appropriate interface treatment options will be dealt with in the Built Form and Landscape Design Guidelines, to be prepared for the site.

3. A Waste Water Pump Station site is to be situated within Precinct E north of Scott Road, as identified under the Mundijong/Whitby District Structure Plan. A 150 metre odour buffer applies to the Waste Water Pump Station. Sensitive land uses, such as residential development, are not permitted within this buffer.

4. Development is to be in accordance with the Built Form and Landscape Design Guidelines to be prepared for the site. The Guidelines will be prepared by the landowner prior to approval of LSP. The Guidelines are to be prepared in consultation with the Shire.

5. Indicative Local Centre location, subject to further investigations and detailed area planning.

6. The road hierarchy identified on the LSP is fixed as per the traffic impact assessment undertaken for the site. The road connections and network shown on the LSP however, are indicative and may be subject to change during detailed subdivision design.



source | Greg Rowe & Associates

PROPOSED MUNDIJONG LOCAL STRUCTURE PLAN

Lot 50 Cockram Street &
Lot 119 Adams Street, Mundijong

A Peet Limited Project

N 0m 50 100m

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d: 09/08/2012
p: 08/039/018

figure 08

1.3 PLANNING STRATEGIES

1.3.1 DIRECTIONS 2031 AND BEYOND

Directions 2031 and Beyond is Western Australia's high level spatial framework and strategic plan. The document provides a vision for future growth of the metropolitan Perth and Peel region. The aim of the plan is to achieve a connected city pattern of growth by promoting a better balance between greenfields and infill development. Infill and consolidation is promoted in existing 'Urban' zoned land, and the plan sets a density target of 15 dwellings per gross 'Urban' zoned hectare of land in new development areas and encourages more intensive development closer to Activity Centres.

The subject land is located within the Directions 2031 south-east sub-region. It is identified by Directions 2031 that 35,000 additional dwellings are required in the south-east sub-region in order to accommodate the projected population of 228,000 in this region by 2031. This growth is to be achieved through a combination of infill and greenfields development. The residential development proposed within the LSP will contribute to reaching the dwelling target for the wider south-east sub-region.

1.3.2 OUTER METROPOLITAN PERTH AND PEEL SUB-REGIONAL STRATEGY

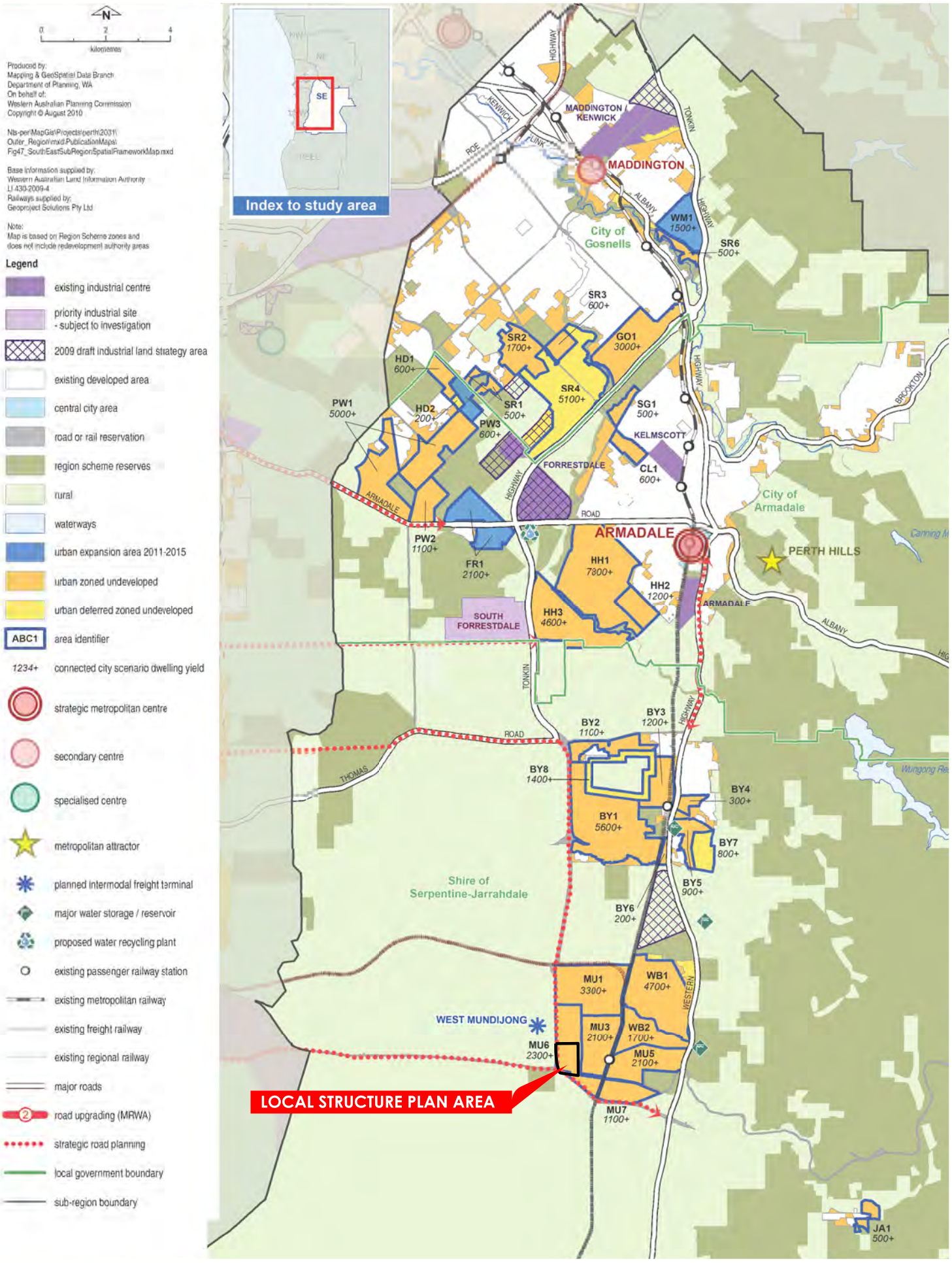
The subject land is included in the draft Outer Metropolitan Perth and Peel Sub-Regional Strategy (OMPPSRS). Located in the south-east sub-region, the sub-regional strategy has been prepared to assist State and local government authorities in delivering the objectives of Directions 2031. The document will also aid in linking State and local government strategic planning to guide the preparation and review of structure plans and local planning strategies. The OMPPSRS classifies the subject land 'Urban Zone Undeveloped'.

Potential dwelling yields provided in this document have been calculated using a range between the 'business as usual' scenario of achieving 10 dwellings per gross urban zoned hectare, and the 'connected city' scenario of achieving 15 dwellings per gross urban hectare in greenfields development. Using this method an estimated dwelling yield of 62,400 under the 'business as usual' scenario, and 86,700 under the 'connected city' scenario have been calculated for the south-east sub-region.

The planned urban growth areas listed in the OMPPSRS have been identified in Byford, Southern River/Forrestdale, Mundijong and the Armadale Redevelopment Authority Area (refer **Figure 9** – Outer Metropolitan Perth and Peel Sub-Regional Strategy). In relation to Mundijong, the OMPPSRS states the following:

> *"The town of Mundijong is experiencing significant development pressure. Structure planning for the area is underway and has identified capacity to accommodate 30,000 residents over the long term. It is expected that development in Mundijong will follow Byford and is therefore, considered a medium and long term growth opportunity for beyond 2031."*

Additional to this, development of the Mundijong Urban Village is underway, facilitated through the District Structure Plan and subsequent local structure planning.



OUTER METROPOLITAN PERTH AND PEEL SUB REGIONAL STRATEGY

Lot 50 Cockram Street &
Lot 119 Adams Street, Mundijong

A Peet Limited Project

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figure 09

1.4 POLICIES

1.4.1 SPP 5.4 ROAD AND RAIL TRANSPORT NOISE AND FREIGHT CONSIDERATIONS IN LAND USE PLANNING

The land to the west of the subject site is reserved under the MRS for the future extension of Tonkin Highway. SPP 5.4 – Road and Rail Transport Noise and Freight Considerations in Land Use will require consideration in context with the proposed development abutting the reserve. The Policy addresses transport noise from major transport corridors, including primary freight routes, and its impact on nearby noise-sensitive land uses, such as residential.

SPP 5.4 identifies Mundijong Road as a Primary Freight route, however it is anticipated that the future Tonkin Highway connection to South West Highway will carry the majority of freight traffic, thus lessening the noise impact resultant from traffic travelling along Mundijong Road. Currently the Tonkin Highway only extends as far south as Thomas Road in Byford.

It is also expected that noise will be somewhat mitigated by the proposed 60 metre wide service corridor (Water Corporation) on the western boundary of the subject land which will provide a buffer for noise and vibrations occurring from the traffic expected on Tonkin Highway. An acoustic assessment will be undertaken by the proponent or others if required as part of the future planning process for subdivision.

1.4.2 STATE PLANNING POLICY 3.6 - DEVELOPMENT CONTRIBUTIONS FOR INFRASTRUCTURE

Development contributions for the provision of public infrastructure and facilities within the site will be as per SPP 3.6, which sets out the principles and considerations that apply to development contributions for the provision of infrastructure in new and established urban areas.

PROPOSED SCHEME AMENDMENT 167 – REVISED SCHEME PROVISIONS FOR DEVELOPMENT CONTRIBUTION PLANS

The Shire's proposed Amendment 167 – Revised Scheme Provisions for Development Contribution Plans intends to update the Scheme to include new provisions based on the model provisions contained within SPP 3.6. The Scheme applies to developer contributions for the standard infrastructure items set out in Appendix 1 of SPP 3.6. Development Contribution Plans are to be prepared in accordance with the provisions of SPP 3.6 and the provisions of clause 10 of the Scheme, and are to be prepared for each development contribution area.

The following items are examples of infrastructure that may be included in the DCP:

- Adams Street upgrade
- Mundijong Road upgrade
- The extension of trunk services that will service the wider DSP area (e.g. HV power, wastewater pump stations and pressure mains, water mains, gas and telecommunications infrastructure), where these are not funded by the service provider's capital works budget
- District-scale post-development water quality monitoring
- Any infrastructure and associated land that is identified in accordance with SPP 3.6

The above list is not exhaustive and items to be included within any DCP will be subject to a separate planning, assessment and approvals process. The above shall have no binding effect and is indicative only.

1.4.3 LOCAL PLANNING POLICIES

A collection of Local Planning Policies (LPPs) have been prepared by the Shire of Serpentine Jarrahdale, and many of these have influenced the preparation of this LSP. The following LPPs have been considered and where relevant will be implemented through further detailed design at subdivision and detailed area planning stages:

- LPP 4 Revegetation Policy
- LPP 6 Water Sensitive Design
- LPP 8 Landscape Protection
- LPP 22 Water Sensitive Urban Design
- LPP 24 Designing Out Crime (Draft)
  - A completed Schedule 1 (Designing Out Crime Toolbox) of LPP24 is included at **Appendix 3**.
- LPP 26 Biodiversity Planning
- LPP 27 Stakeholder Engagement in Land Use Planning
- LPP 29 Mundijong-Whitby Planning Framework
- LPP 43 Hazards and Natural Disasters
- LPP 57 Housing Diversity
- LPP 60 Public Open Space
- LPP 61 Local Structure Plan
- LPP 62 Urban Water Management (Draft)
- LPP 63 Integrated Transport and Land Use Planning (Draft)
- LPP 68 Sustainability Assessment

2 SITE CONDITIONS AND ENVIRONMENT

2.1 BIODIVERSITY AND NATURAL AREA ASSETS

The site contains limited environmental assets due to the historical clearing for agricultural purposes and the current use of pasture crops and grazing. All native vegetation has been cleared from the site with the exception of isolated trees over pasture. The isolated native trees provide environmental value and vision amenity to the otherwise flat landscape. The isolated exotic tree species have limited environmental value but do provide some visual amenity.

The soils and groundwater characteristics within the site pose some limitations however these limitations can be mitigated and/or managed and are not considered being serious constraints to the future development of the site.

- Drainage and stormwater management will be required to control run-off from roads, car parking areas, roofs of buildings and lawn/landscape areas.
- The Bassendean soil units B2 and B6 have a high occurrence of phosphorous export (70% and 90% respectively) and the Pinjarra P1b has a low risk of occurrence (5%).
- The Bassendean Dune System is subject to a high risk (35% occurrence) of wind erosion, due to lack of structure of the deep, grey, non-vegetated sands which provide little resistance to wind when stripped of vegetation. In comparison, the Pinjarra land unit has a low risk (5% occurrence) wind erosion.

2.1.1 VEGETATION AND FLORA

A Level 2 Flora and Vegetation survey was conducted by PGV Environmental across the site in October 2011 and findings are detailed in the PGV Environmental Report (see **Appendix 4**).

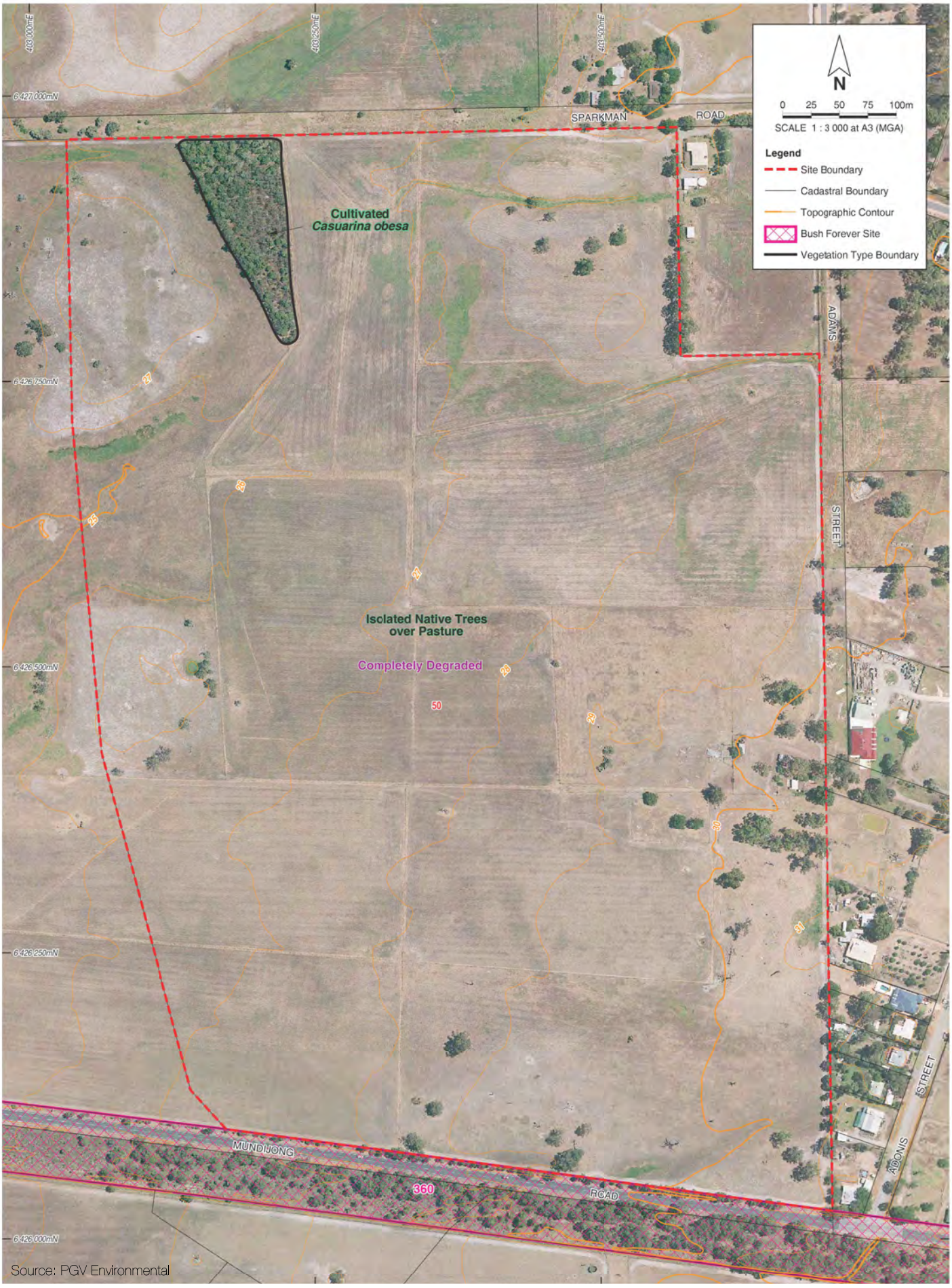
The site has been historically cleared for agricultural uses and is in a Completely Degraded condition. The site does not contain any remnant intact vegetation, significant flora species, Threatened Ecological Communities or Priority Ecological Communities (refer **Figure 10** – Vegetation Types and Condition).

There are some mature native trees across the site of the following species that have some environmental value:

- *Corymbia calophylla* (Marri);
- *Kingia australis*; and
- *Eucalyptus rudis* (Flooded Gum).

The location of these trees is identified by a red cross in **Figure 10** - Vegetation Types and Condition.

The majority of the site is covered by annual pasture and weed species. There are a number of cultivated Eucalyptus species including *Eucalyptus camaldulensis* (River Red Gum) and *Eucalyptus sideroxylon* (Ironbark) located around the boundary of the site. A small stand of *Casuarina obesa* with limited environmental value has been planted in the northern part of the site.



VEGETATION TYPES AND CONDITION

Lot 50 Cockram Street &
Lot 119 Adams Street, Mundijong

A Peet Limited Project

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figure 10

Mature trees to be retained or transplanted will be identified and marked appropriately prior to commencement of any pre-construction activities.

Five mature *Kingia australis* over pasture are located in the northern and southern end of the site. Where possible these will be retained or salvaged and replanted in POS.

No management practises are required for significant flora or TECs/PECs as there were none found on the site.

2.1.2 FAUNA

A Level 1 Fauna survey was conducted by Terrestrial Ecosystems across the site in September 2011 (see Appendix 2 of **Appendix 4**)

Two fauna habitat types were identified on the site of limited environmental value to avifauna:

- Isolated native trees; and
- *Casuarina obesa* stand in the northern part of the site.

The conservation significant species that could potentially be seen on the site are the Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*), Baudin's Black Cockatoo (*Calyptorhynchus baudinii*) and the Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*). The three species of Black Cockatoo may infrequently forage and roost on the isolated mature Marri trees in the paddock. There is no evidence of the Black Cockatoo's nesting on the site.

The isolated trees that should be retained where possible for fauna habitat are identified in yellow on **Figure 10** – Vegetation Types and Condition.

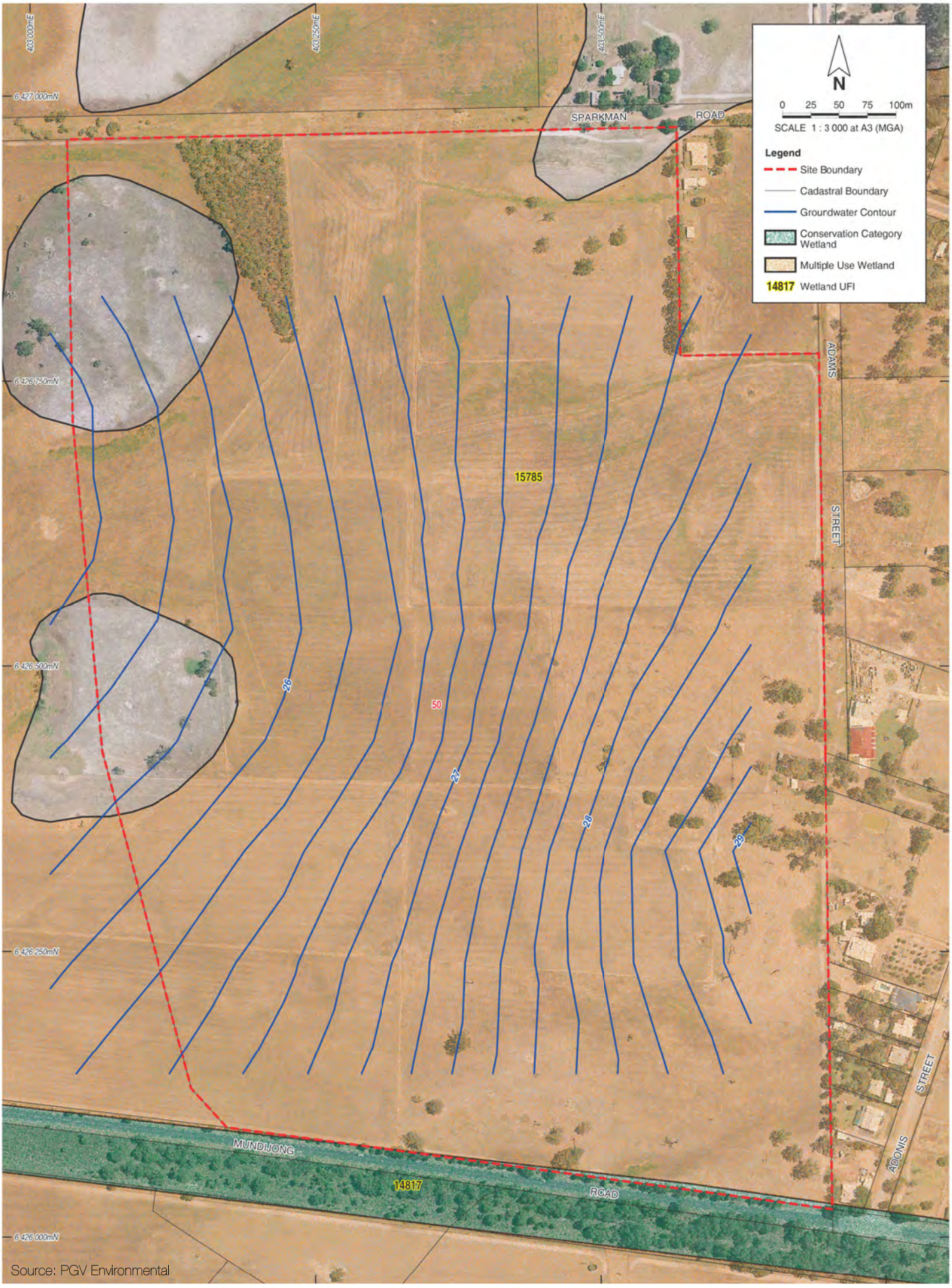
2.1.3 WETLANDS

A significant portion of the site is shown in the DEC *Geomorphic Wetlands of the Swan Coastal Plain* dataset as being a Multiple Use wetland. Multiple Use wetlands are described as having few environmental attributes and have no statutory and limited policy protection. The wetland on the site fits this definition as a cleared paddock (refer **Figure 11** – Hydrology).

The *Geomorphic Wetlands of the Swan Coastal Plain* dataset shows a Conservation Category wetland in the Mundijong Road reserve. The road reserve north of Mundijong Road adjacent to the site is very narrow and contains scattered trees over a weedy understorey. As such this part of the road reserve does not exhibit any significant wetland values. The vegetation in the road reserve south of Mundijong Road is wider and in better condition and exhibits wetland values representative of a Conservation Category wetland.

2.1.4 STRUCTURE PLAN RESPONSE TO ENVIRONMENTAL ASSETS AND CONSTRAINTS

Within the LSP, the environmental values of the subject site have been considered as a part of the design process through a variety of mechanisms. These include the retention of the environmental values, provision of public open space locations and road alignments to accommodate specific values and/or provide for the protection and management of these values. The most significant spatial considerations within the LSP used to address the different environmental values include:



HYDROLOGY

Lot 50 Cockram Street & Lot 119 Adams Street, Mundijong

A Peet Limited Project

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figure 11

- Location of the southern entrance road in Bush Forever No. 360 through an area of Completely Degraded vegetation;
- Location of public open space to accommodate stands of paddock trees wherever possible, to provide post development opportunities for Black Cockatoos to roost and forage and to enhance the view amenity of a largely flat landscape;
- Translocation of mature trees where possible into POS; and
- Provision of larger lots along the western boundary adjacent to the future Tonkin Highway reserve.

Refer **Figure 12** – Environmental Assets.

2.2 LANDFORM AND SOILS

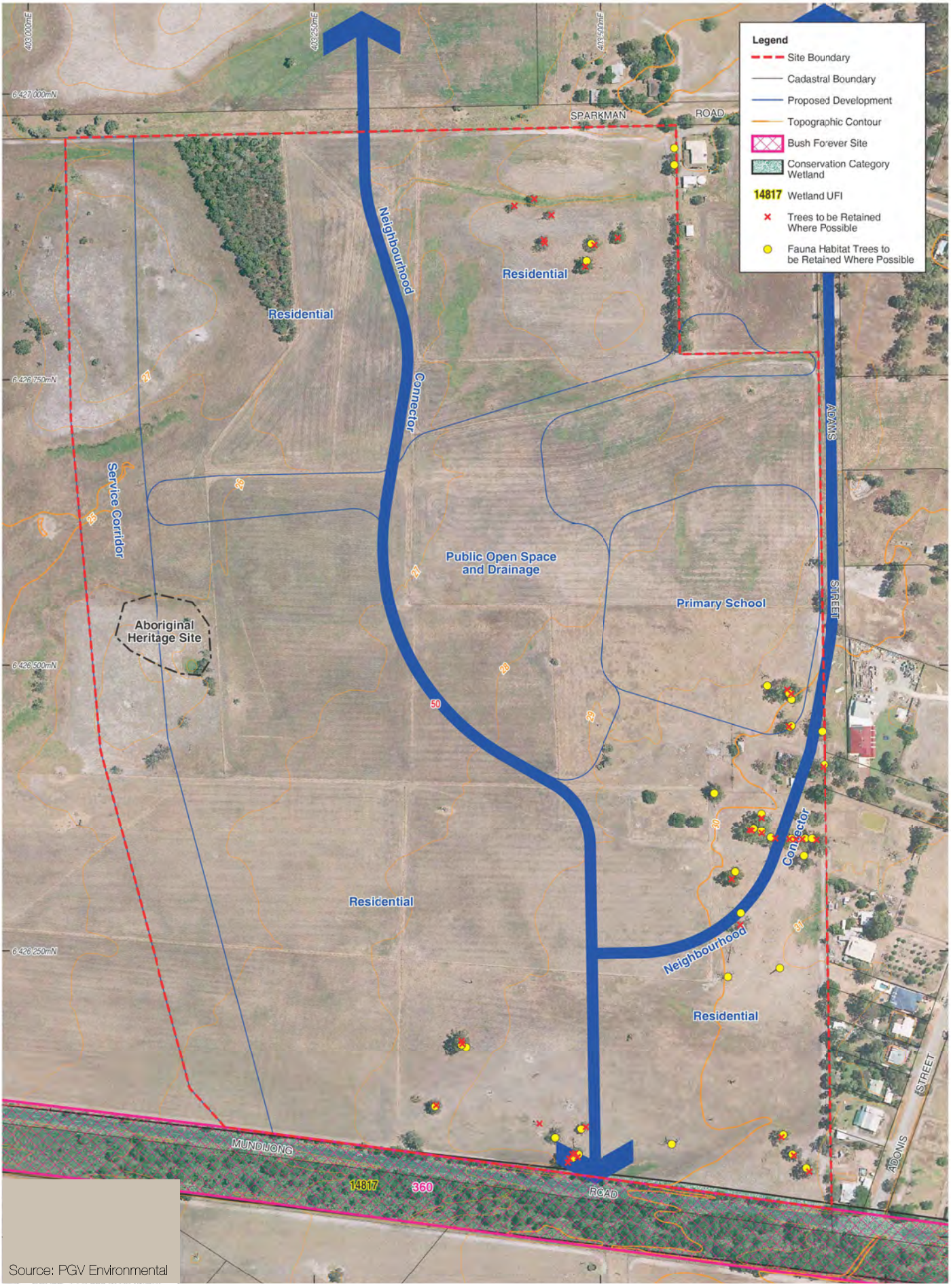
The site is located on the Swan Coastal Plain largely within the Bassendean Dune with the south east corner within the Pinjarra Plain. The site gently slopes from east to west with elevations ranging from approximately 31m AHD to 26m AHD. Refer **Figure 13** – Current Land Use and Topography.

The Bassendean soils within the site are very low relief and range from deep bleach grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at depths greater than 2m have tendency to become waterlogged during the winter months. The Pinjarra Plain soils are low in relief with deep acidic mottled yellow duplex (or "effective duplex") soils comprising moderately deep pale sand to sandy loam over clay. These soils often become waterlogged during the winter season. Refer **Figure 14** – Geology and Soils.

A preliminary ASS investigation will be undertaken as part of the subdivision planning process to determine if ASS is present within the site.

To minimise potential for soil erosion to occur the following management measures are proposed:

- Ground disturbing activities will be kept to a minimum and carried out 'as required' (in stages) immediately prior to lots being released for sale as part of a 'staged' development of the site;
- Landscaping/stabilising/dust suppression of areas where ground disturbance has occurred will be scheduled to occur immediately after clearing/and or infrastructure construction has been completed; and
- Clearing activities have the potential to add clay 'fines' into the drainage channel creating turbid water downstream (drainage channel) and the installation of temporary drop-out basins to capture and aid in the settling of clay fines will be considered.



Source: PGV Environmental

ENVIRONMENTAL ASSETS

Lot 50 Cockram Street & Lot 119 Adams Street, Mundijong

A Peet Limited Project

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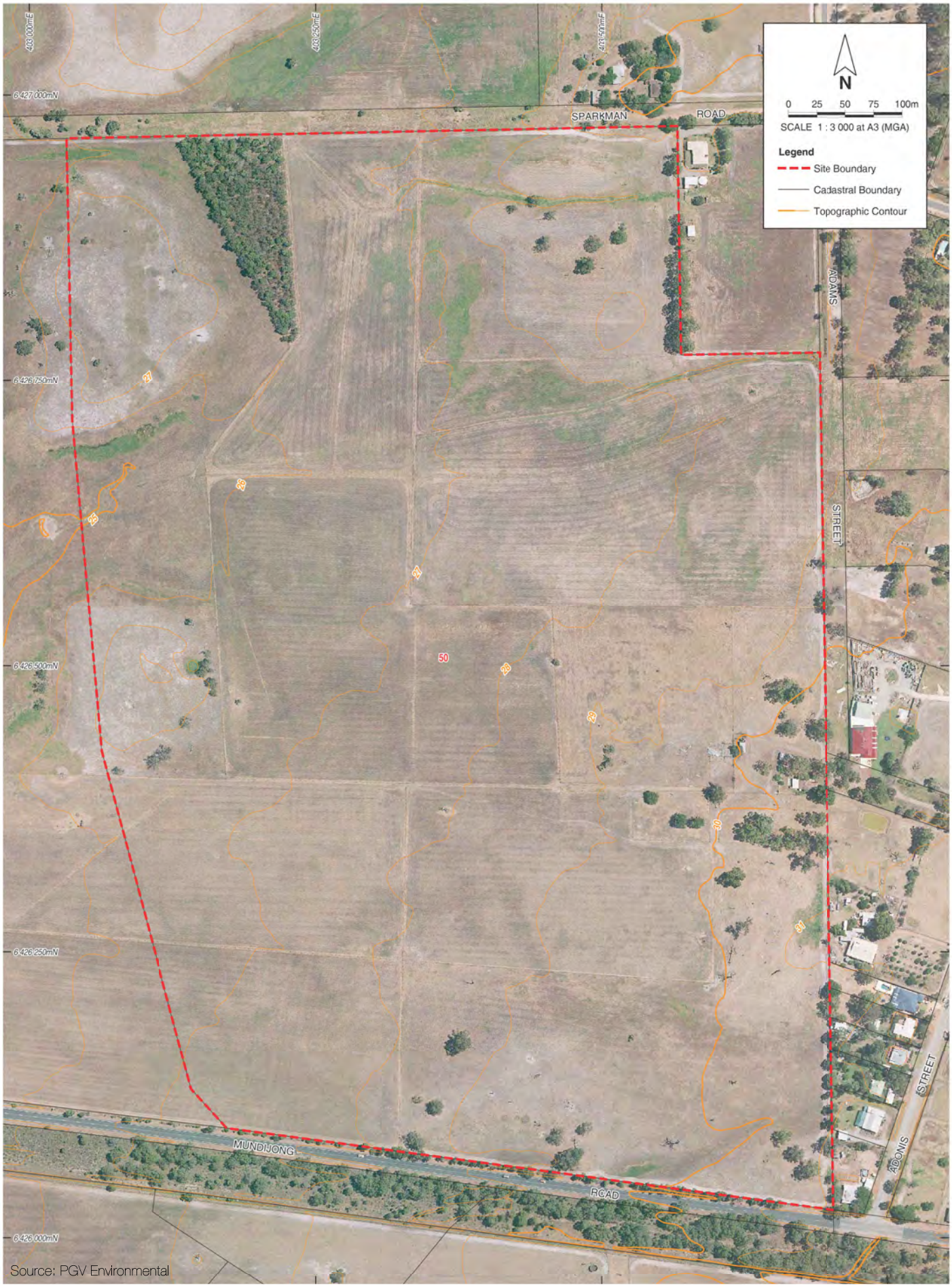
figure 12



CURRENT LAND USE AND TOPOGRAPHY

Lot 50 Cockram Street &
Lot 119 Adams Street, Mundijong

A Peet Limited Project

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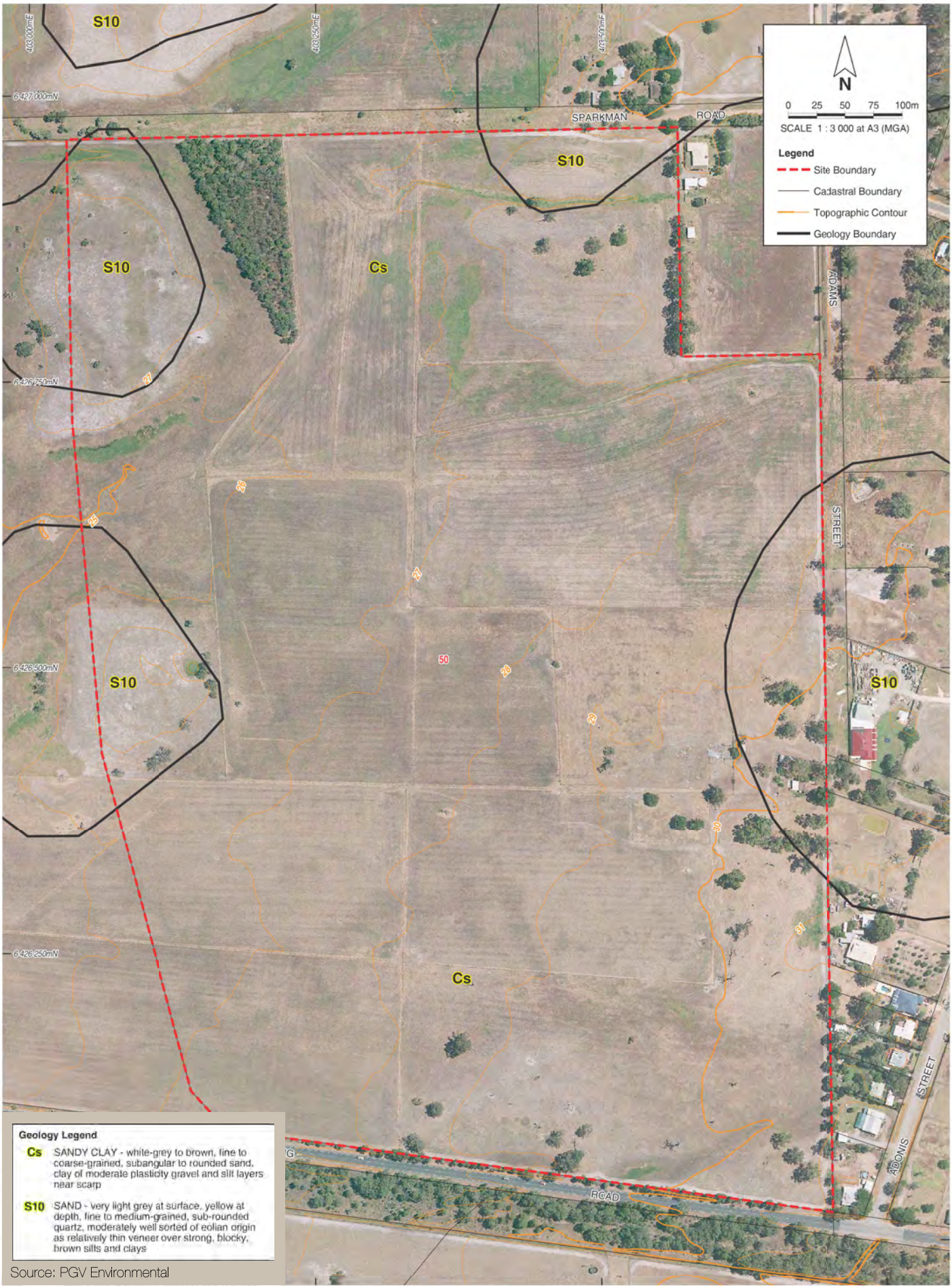
figure 13



Source: PGV Environmental

GEOLOGY AND SOILS

Lot 50 Cockram Street & Lot 119 Adams Street, Mundijong

A Peet Limited Project

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d: 29 Oct 2012
p: 08/039/033

figure 14

2.3 GROUNDWATER AND SURFACE WATER

Site-specific groundwater monitoring was carried out by Brown Geotechnical & Environmental and Emerson Stewart between September 2008 and August 2011 to obtain information on pre-development groundwater levels and water quality across the LSP area. The monitoring showed that groundwater levels were at their highest in September 2009, when depth to groundwater ranged from at-surface to 700mm below natural surface. Groundwater across this area tends to perch on the underlying clayey soils, causing large fluctuations of up to 2.5m between high and low groundwater levels. In areas of the site where the depth to the underlying clay materials is low, typical peak groundwater levels are very shallow (within 100mm of existing surface). Parts of the site with greater depth of sand over the underlying clays have a slightly larger natural separation between existing surface and peak groundwater levels (up to 800mm).

Surface runoff from the site is via overland flow from east to west, following the natural topography. There are some very shallow farm drains (approx 0.2 - 0.5m deep) across the site, which direct stormwater runoff towards the western side of the site. The main flow path through the site becomes more pronounced near the site's western border, and the existing waterway discharges to a Water Corporation main drain at Kargotich Road, approximately 1.5km west of the site. The Mundijong-Whitby DWMS (GHD, 2010) identified two flow paths which take runoff from upstream catchments east of Adams Street through the site. The DWMS estimated the combined flow through the Precinct E2 site from upstream catchments to be approximately 12m^3/s under pre-development conditions (for the critical 100yr ARI event).

A Local Water Management Strategy (LWMS) has been prepared by Wave International to support the LSP. Groundwater quality will be protected by the use of Water Sensitive Urban Design principles as outlined in the LWMS.

To ensure nutrient rich runoff (and other potential sources of contamination) does not directly enter the drainage channel the following management measures are proposed:

- In the vicinity of watercourses construct purpose built 'detention' basins that have the ability to trap sediments and nutrients. These basins will not be allowed to discharge directly to watercourses;
- Lawn areas (that require fertiliser, pesticide and/or herbicide application) will be minimised in areas of POS adjacent to watercourses; and
- During the subdivision of the site, the local community/new landowners will be provided with informative literature describing preventative methods they can implement themselves (i.e. reducing nutrient run-off) to reduce adverse impacts on the environment.

2.4 BUSHFIRE HAZARD

The site is predominantly cleared and is not situated within close proximity to any bushland with the exception of the narrow reserve to the south of the site and Mundijong Road. Mundijong Road acts as a separation zone between the site and the reserve. A fire break will be maintained around the boundary of the landholding and around each stage of subdivision as the development progresses.

2.5 HERITAGE

A search of the Department of Indigenous Affairs Register of Aboriginal Sites revealed that there are no previously recorded ethnographic sites on the site.

Ethnosciences undertook an Aboriginal Heritage Assessment of the site in 2011/2012 (refer **Appendix 5**). The assessment included a desktop search and ethnographic and archaeological field surveys. A separate report has been prepared to detail the findings of the assessment.

In summary, no ethnographic sites were reported on the land during the ethnographic survey which involved representatives of Bilya and Winjan Aboriginal Corporation who have long-standing associations with the region.

A recently recorded artefact scatter (MJ-06) is partially located on Lot 50 and partially within the adjacent service corridor. MJ-06 is a small, medium-density, open quartz artefact scatter situated on a Bassendean sand dune above seasonally inundated wetlands. The site represents either the by-products of task specific activities or a short term or infrequently used occupation site. However, MJ-06 is assessed as currently being of low archaeological significance.

The consultants from the Bilya and Winjan Aboriginal Corporation groups were of the view that Site MJ-06 — the artefact scatter identified on Lot 50 during the archaeological survey — was of low cultural significance and did not oppose Peet Limited applying for Section 18 consent for the site.

Following discussions with the Department of indigenous Affairs (DIA) it was decided that before the site's scientific, cultural and heritage significance could be fully assessed and management strategies determined further investigation was required. Specifically, the DIA was keen to determine the nature and importance of any artefactual material that might be located in the subsurface of MJ-06. Such information would play a significant part in determining MJ-06's significance, particularly if any stratified and dateable deposits were located. In order to address the questions raised by the DIA, test excavations of MJ-06 are being undertaken within the conditions layout in the excavation licence obtained by the archaeological team.

This work still in progress with the assistance of members from two regionally based Aboriginal organisations, the Bilya Noongar Organisation and the Winjan Aboriginal Corporation.

A fair amount of subsurface archaeological material was recovered from MJ-06 in spits between 50cm-80cm deep and further bulk excavation was undertaken in early 2013. However, the assessment of the significance of the material recovered and therefore of the site, will be only be determined following its detailed analysis.

Once this is done, appropriate management strategies can be devised following further consultation with the Aboriginal community, Peet Mundijong Syndicate Limited, the DIA and the determination of the Aboriginal Cultural Material Community. Based on what is currently known, it is probable that the Community will determine that MJ-06 is an Aboriginal site as defined by Section 5(a) of the Act. However, it is also possible that Peet could obtain Ministerial consent, with or without the conditions (e.g., further archaeological investigations), under Section 18 to use the land or a portion of it on which the site is located. It is unlikely that MJ-06 and its management will have anything other than a localised impact on the LSP and therefore planning processes ought to continue as normal.

2.6 CONTEXT AND OTHER LAND USE CONSTRAINTS

The existing site is best described as flat to gently undulating and exhibits minimal change in ground elevation with the low point being at approximately 26m AHD in the north western corner, rising evenly to approximately 31m AHD in the south eastern corner.

The existing site's former land use as a grazing/pastoral property has resulted in all but a very small percentage of the existing vegetation being cleared. The occasional remnant tree remains, which have been supplemented with occasional introduced tree plantings which could have been acting as windbreaks to paddocks and/or for spatial definition around sheds and other farming infrastructure. Fruit trees indicate a possible small orchard previously existed on part of the site. No understorey vegetation exists at all with the exception of pasture grasses.

2.6.1 NOISE

The proposed Tonkin Highway extension and possible re-alignment of the Kwinana Freight Rail Line (west of Tonkin Highway) are adjacent to the western boundary of the LSP area. Noise emissions from the highway and rail line may have some impacts on those lots adjacent to the Tonkin Highway road reserve.

Noise emissions from any railway line and road would need comply with the requirements of State Planning Policy 5.4 *"Road and Rail Transport Noise and Freight Considerations In Land Use Planning".* Under SPP 5.4, noise received at any residence would need to comply with the "Noise Limits", these being:

- EXTERNAL
  - LAeq(day) of 60 dB(A); and
  - LAeq(night) of 55 dB(A).

As this is a new rail infrastructure in the vicinity of a future extension to Tonkin Highway and proposed noise-sensitive land uses, it is noted that under the policy "in these instances, the infrastructure provider and developer are both responsible for ensuring that the objectives of this policy are achieved, and a mutually beneficial noise management plan, including individual responsibilities, should be negotiated between the parties." Thus under SPP 5.4 all parties should enter into discussions/negotiations to obtain the optimum outcome. The final civil designs for the development and the transport infrastructure are required inputs for acoustic models to determine the level of impact. Consideration will be given at further detailed stages of planning to explore the merits and potential construction of a noise amelioration barrier to mitigate emissions.

2.6.2 DUST, NOISE AND VIBRATION (CONSTRUCTION) MANAGEMENT

A Construction Environmental Management Plan will be prepared as part of the subdivision process. The CEMP will address the preconstruction and construction phases of the project and will provide guidance to the Proponent/Contractors on the following issues:

- Vegetation Clearing Protocols;
- Vegetation Management;
- Weed Management;
- Dust Management;
- Noise and Vibration Management;
- Fuel Storage;
- Waste Management;
- Hours of Operation; and
- Implementation and Monitoring.

3 LAND USE AND SUBDIVISION REQUIREMENTS

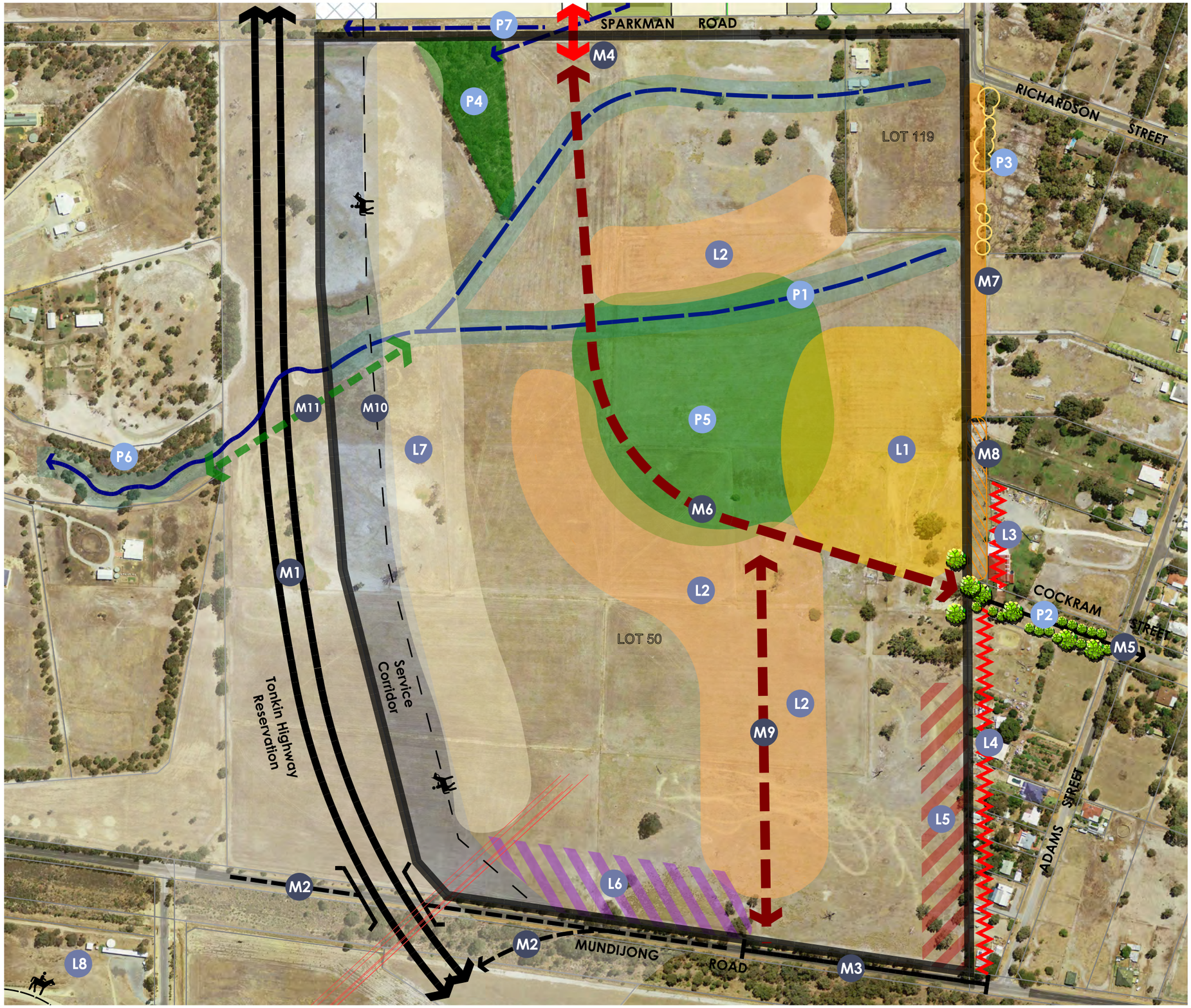
3.1 DESIGN OBJECTIVES

There are a number of fundamental design principles that underpin the proposed LSP, as summarised below:

- Respect for the inherent features/attributes of the land and its location.
- A sound rationale for the development, including its context within the wider Mundijong locality, to ensure that the future development is fully integrated with the existing and proposed surrounding development. Particular consideration has been given to the existing residential area south of Mundijong Road, existing residential area and Town Centre east of Taylor Road, proposed Qube and Investor JV LSP to the north and future Tonkin Highway to the west.
- A sensitive and innovative stormwater management approach to conveyance, treatment and storage in an urban context.
- To achieve a distinct identity and sense of place for future residents of the area.
- To facilitate a diversity of built form in terms of housing typologies, affordability and sustainability.
- To optimise passive solar orientation of lots as far as practicable, taking into account constraints such as existing road alignments, drainage patterns, topography and trees.
- Configuration of street blocks to develop an efficient and legible layout that promotes walkability and reduces private motor vehicle journeys.
- To ensure that the Estate completes and builds upon the arterial road network identified in the Mundijong Whitby DSP.
- Creation of a network of attractive and well-utilised public open space areas with a prominent focus on a central Public Open Space.
- Creation of a dynamic Community/Public Open Space hub at the heart of the estate, incorporating a viable combination of uses that include recreation and education.
- To establish an environment that provides a variety of active and passive recreational facilities that specifically seek to promote the mental and physical health and well-being of future residents.

3.1.1 OPPORTUNITIES AND CONSTRAINTS

Site analysis opportunities and constraints are provided diagrammatically in **Figure 15** – Opportunities and Constraints.



MOVEMENT

- M1 Future Tonkin Highway Alignment.
- M2 Connection of Mundijong Road to Tonkin Highway to be determined.
- M3 Connection to Mundijong Road may be limited to long-term available interface.
- M4 Location of proposed Neighbourhood Connector road.
- M5 Cockram Street to:
  - Town Centre
  - Recreation Centre and Town Oval.
- M6 Connection of Cockram Street with northern Neighbourhood Connector to be considered.
- M7 Unmade road reserve.
- M8 Consider relocating road reserve to control estate equally on both sides of road.
- M9 Control the quality of key entry road by relocating it away form the edge of site.
- M10 Possible bridal path in Service Corridor.
- M11 Possible short-medium term opportunity to connect with existing linear park.

LANDUSE

- L1 Location of Primary School adjacent to Adams Street.
- L2 Medium-density housing adjacent to open space and main entrance.
- L3 Poor interface with existing building.
- L4 Rear lot boundary-interface issue.
- L5 New development should back-on to existing properties.
- L6 Interface between landuse and road will change if Mundijong Road realigned.
- L7 Consideration for 'horse lots' along service corridor, with access to a bridal trail.
- L8 Horse training track in close proximity to estate.

PUBLIC OPEN SPACE

- P1 Existing drainage line (following east to west). Possible inclusion of drainage lines into linear park elements.
- P2 Existing large trees provide attractive public realm transition to development area.
- P3 Minimal existing tree amenity in Adams Road reserve; barren landscape to be addressed.
- P4 Investigate integration of tree copse into a feature parkland.
- P5 Consider major park central to residents.
- P6 Linear park through rural residential estate; existing drainage channel.
- P7 Nothern landowner considering putting drainage through Peet land or piped in Sparkman Road.

OPPORTUNITIES AND CONSTRAINTS

Lot 50 Cockram Street & Lot 119 Adams Street, Mundijong

A Peet Limited Project

0m 20 40 60m

s: 1:4000@A3
d: 15 Oct 2012
p: 08/039/014B

figure 15

3.2 LAND USE

Development proposed within the LSP is primarily residential, and provides a range of housing choices through the provision and low and medium density single lots, as well as potential for grouped housing sites. Lots situated in close proximity to high amenity areas such as public open space are identified as being suitable for medium density residential development and have been provided for accordingly.

The provision of Public Open Space (POS) is distributed throughout the site to provide accessibility to residents and responds to the existing drainage lines present in the area. The layout of POS comprises a mixture of linear parks, smaller areas of POS, and a large park central to residents. The major park is to be co-located with the primary school site.

The proposed primary school is to be located on a 3.5022 hectare site, bounded by three roads. The co-location of this site with the shared POS will provide sporting and recreational facilities to the school as well as the surrounding community.

Refer **Figure 16** – Draft Masterplan.

NOTES

1. INTEGRATION WITH FUTURE RESIDENTIAL AREA
2. CONSIDERATION FOR LARGER 'SPECIAL RESIDENTIAL' LOTS ADJACENT TO SERVICE CORRIDOR
3. DIVERSITY OF MEDIUM DENSITY LOCATED NEAR LANDSCAPED AMENITY
4. LINEAR OPEN SPACE NETWORK WITH INTEGRATED DRAINAGE
5. CENTRALLY LOCATED PRIMARY SCHOOL CO-LOCATED WITH SHARED OVAL
6. LARGE, CENTRAL PARK CREATED AS A FOCUS FOR COMMUNITY LIFE
7. SPECIAL WIDE STREET LINKING COCKRAM STREET TO PRIMARY SCHOOL AND CENTRAL PARK
8. EXISTING TREES TO BE RETAINED IN PARKS AND STREETS WHERE POSSIBLE
9. WIDE MEANDERING ENTRANCE ROAD LEADING TO CENTRAL PARK
10. LONG-TERM REALIGNMENT OF MUNDIJONG ROAD

LEGEND

- LOCAL STRUCTURE PLAN BOUNDARY
- RESIDENTIAL R10
- RESIDENTIAL R25
- RESIDENTIAL R30
- RESIDENTIAL R40
- PRIMARY SCHOOL
- PUBLIC OPEN SPACE

DRAFT MASTERPLAN

Lot 50 Cockram Street & Lot 119 Adams Street, Mundijong

A Peet Ltd Project

0m 20 40 60m

s: 1:4000@A3
d: 22/10/2012
p: 08/039/021B

figure 16

3.3 OPEN SPACE

3.3.1 PUBLIC OPEN SPACE

The provisions of Liveable Neighbourhoods require a range of site responsive urban parkland in order to address the district, neighbourhood and local needs of residents, and should be a mixture of unrestricted and restricted open space. The POS provided throughout the subject land is a mix of a number of smaller POS areas, drainage corridors and a major centrally located park adjacent to the primary school site. The POS layout allows access for all residents in the area, encouraging the usage of these spaces by the community. The central POS co-located with the primary school will provide a shared sized oval, providing active recreational facilities for students of the school and the wider community and provide a central focal point for the community. Refer **Figure 17** – Public Open Space Plan.

The POS is made up of restricted and unrestricted open space, providing drainage basins based on the 1 year, 5 year and 100 year storm event, combined with the provision of drainage channels. Drainage channels through the site will be developed as natural swales, or 'living streams', through the use of planting and grasses, and walled or contoured banks. Native sedges and rushes are proposed to assist with nutrient stripping and midge and mosquito control. Boulders or low walls will act as minor barriers to control the flow of storm water through the living stream. The proposed drainage swales will be unfenced and landscaped in accordance with Liveable Neighbourhoods to allow for informal active and passive recreational uses.

An indicative calculation of the POS intended in the current LSP is provided in the Public Open Space Schedule overleaf (refer **Table 5**).

It is estimated the current LSP will provide a total of 10.9% POS, exceeding the 10% POS required by Liveable Neighbourhoods. This will be subject to detailed design at subdivision stage, which will meet the 10% requirement. The Landscape Strategy (refer **Appendix 6**) identifies various facilities and treatments of the POS areas. This design is provided as a guide and will be further informed by detailed site planning, engineering design and discussions with the Shire at subdivision stage. The calculated POS provision does not include any POS that may potentially be provided within adjoining Lot 119, as it is recognised that the landowner is not required to develop the land. All POS and drainage indicated on this lot is indicative only, based on the assumption of this lot being self sufficient. Likewise, Lot 50 is completely self sufficient in terms of POS provision and accommodating all necessary drainage functions.

PUBLIC OPEN SPACE TABLE	
PUBLIC OPEN SPACE SITE	SIZE (ha)
1	0.0733
2	0.0672
3	0.0490
4	0.7154
5	0.0486
6	0.0887
7	0.1264
8	4.3908
9	0.1437
10	0.4663
11	0.2100

LEGEND

- LOCAL STRUCTURE PLAN BOUNDARY
- PUBLIC OPEN SPACE

SPARKMAN ROAD
ADAMS STREET
RICHARDSON STREET
COCKRAM STREET
ADONIS STREET
MUNDIJONG ROAD
106
107
119
121
120
122
123
124
125
126
84
86
50
0724

PUBLIC OPEN SPACE PLAN

Lot 50 Cockram Street & Lot 119 Adams Street, Mundijong

A Peet Ltd Project

0m 20 40 60m

s: 1:4000@A3 | 1:5500@A4
d: 16/10/2012
p: 08/039/028

figure 17

TABLE 5: PUBLIC OPEN SPACE SCHEDULE

PUBLIC OPEN SPACE SCHEDULE		
Gross Site Area - Excluding Existing Roads (ha)		**54.2113**
Deductions		
Service Corridor	5.2422	
Primary School	3.5022	
Drainage Basins (1:1)	0.5900	
Surplus Restricted Public Open Space	0.7855	
Total Deductions	**10.1199**	
Gross Subdivisible Area		44.0914
Required Public Open Space (10%)		**4.4091**
Public Open Space Requirements		
Unrestricted public open space – minimum 80%	3.5273	
Restricted public open space – maximum 20%	0.8818	
Total		**4.4091**
PUBLIC OPEN SPACE PROVISION		
Unrestricted Public Open Space		
Formalised POS	3.8964	
Total Unrestricted Public Open Space		**3.8964**
Restricted Public Open Space		
Drainage Basins (Between 1:1 & 1:5)	0.8600	
Linear Swales (1:5)	0.8230	
Total Credited Restricted Public Open Space		**0.8975**
Total Credited Public Open Space		**4.7939**
Percentage of Public Open Space Provided (Unrestricted and Restricted POS Contribution)		**10.9%**
POS Oversupply		**0.3848**

- All areas are in hectares.

3.4 LANDSCAPING

3.4.1 FOCAL POINTS AND VIEWS

Given the site's gentle undulation as outlined previously, there are no strong views or vistas from vantage points located within the site.

The important focal points and views to be considered, retained and reinforced through the urban and landscape design process relate to the dominant landform features surrounding the site, of which there are two distinctive features, being:

1. The Darling Scarp; and

2. Swan Coastal Plain.

The entire subject land is located on the low lying, gently undulating Swan Coastal Plain. The nature of the landscape of the Swan Coastal Plain in the immediate vicinity is largely unvegetated, with a predominant rural character. Views are dominated by the Darling Scarp to the east.

The Darling Scarp is the most dominant physical feature and the retention of views from the subject site onto the Scarp will be critical in ensuring a rural character with green values can be promoted to enhance the built environment.

The views and vistas to the Scarp will typically occur through the creation and reinforcement of long vistas along east west aligned roads and public open space links within the proposed development. These views and vistas should be reinforced and/or framed through the consideration of tree placement.

3.4.2 RECREATION CONNECTIONS

There are no existing recreation connections around the existing site. The site is located at the end of Cockram Street and therefore is within 500m walking distance to the existing Mundijong Sporting Oval.

The installation of a dual use path along Cockram Street to the existing town centre and sporting oval would create a strong recreation connection to the proposed open space areas within the Development Plan.

3.4.3 SIGNIFICANT TREES

The extensive pasture/grazing activity during the site's previous land uses has resulted in little to no remnant vegetation remaining on the site and as such significant trees that could be retained within the development are few and far between. There are the occasional examples of endemic and exotic trees which could be incorporated into the urban design and/or public open space to provide instant amenity as follows:

Towards to southern boundary of the site, a group of approximately six (6) *Corymbia calophylla* (Marri) exist which could be incorporated into an entry statement of Mundijong Road. It is planned that these trees be retained in a widened verge on the major boulevard running north south in the Development Plan. Also within close proximity to this stand of Marri trees are three (3) *Kingia australis* (Bullanock) which if unable to be incorporated in the urban design are able to be relocated to POS.

At the current Cockram Street cul-de-sac end of the site on the eastern boundary a number of introduced trees exist which appear to have been related to the previous farming operations of the site. A group of *Eucalyptus camaldulensis* (Northern River Red Gum) are the main species in this location which are suitable for retention in POS only due to the propensity of this species to unpredictably drop large limbs. If retained in POS, these it should be ensured that these trees are retained in garden beds away from POS infrastructure such as playgrounds or bench seats.

In addition to the Northern River Red Gum's a variety of exotic trees exist which could possibly be relocated into POS areas, including the following species:

- One (1) *Citrus limon* (Lemon Tree)
- One (1) *Liquidambar styraciflua* (American Sweetgum)
- One (1) *Caesalpinia ferrea* (Leopard Tree)
- Two (2) *Erythrina indica* (Coral Tree)
- One (1) *Pinus radiata* (Monterey Pine)

Towards the northern boundary of the site, adjacent to Sparkman Road, another group of approximately five (5) *Corymbia calophylla* exist which could be incorporated into the urban design if possible. A further four (4) *Kingia australis* are also present in this location and are suitable for transplant into POS areas.

In the north western corner of the site, a large triangular grove of Casuarina obesa (Swamp She-Oak) have been planted in regularly defined rows. The density of planting and the locally wet depression that these trees are located in results in no opportunity or value for incorporation of these specimens in a worthwhile urban design or POS outcome and their removal is recommended.

In the north eastern corner of the site, a north south oriented row of Eucalyptus plantings exist as a windbreak, which sit just in the adjacent landowners property, but are planned to be retained in the development as part of the road layout in this area.

3.4.4 LANDSCAPE DESIGN

LANDSCAPING VISION

The landscape strategy behind public open space development is to provide a readily useable, aesthetic and liveable environment to potential residents. Landscaped open space areas shall incorporate features and facilities to both encourage residential growth and to provide public, aesthetic and site character building amenities to residents. Landscape works shall contain and maximise both aesthetic and functional uses where possible.

Part of the successful delivery of aesthetic and functional POS areas will be the retention of the site's existing significant trees where possible in accordance with proposed Civil Engineering design levels. The retention of existing significant trees will assist in establishing the site's Sense of Place, which will be reinforced through the landscape materials palette.

LANDSCAPING THEME

It is proposed that close attention to detail will be provided in the landscape detailing and materials selection to ensure the development comprises a palette that is relevant to its locality while creating a quality open space environment.

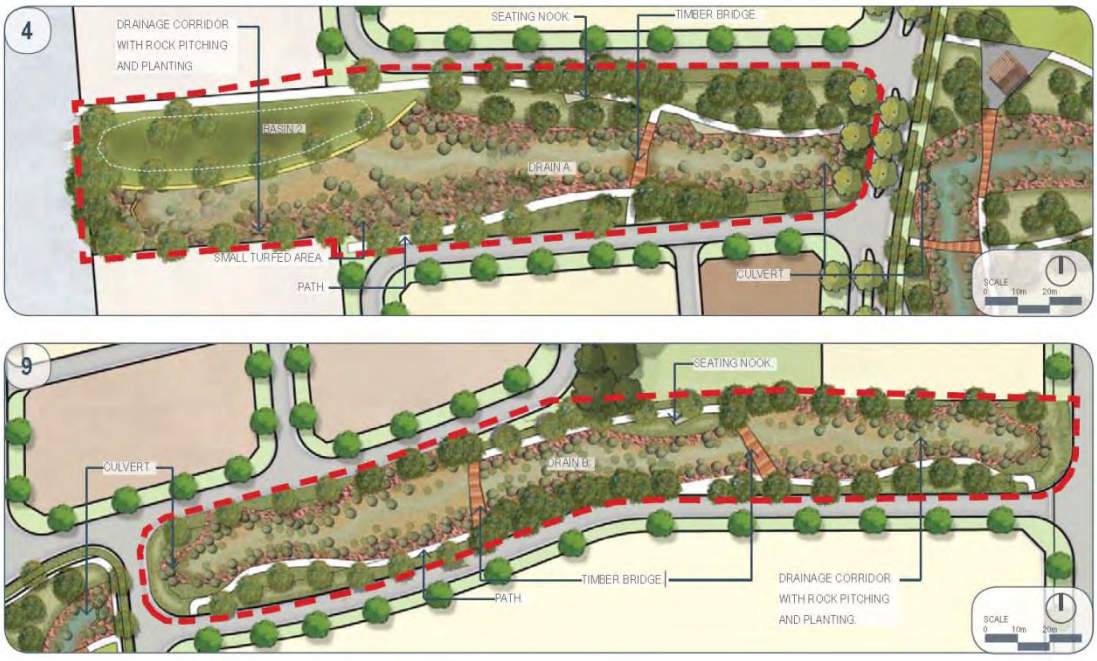
The inclusion and use of some the following detailing is proposed to achieve this outcome within the project area:

- Paving styles and colours will be chosen to create visual interest, assist in differentiation between area uses and provide hard-wearing surfaces of varying textures.
- Wall detailing through the use of local stone features and laterite coloured limestone retaining where required.
- Durable street furniture of a style and colour palette to co-ordinate with the overall POS design.
- Tree and shrub planting palettes that are aesthetically pleasing while responding to the surrounding natural environment, incorporating water sensitive design species while creating view shafts to develop community value.

LANDSCAPE MASTERPLAN

MULTIPLE USE CORRIDORS

Three major Public Open Space [POS 4, 8 & 9] areas have been designated to include the site's overland drainage paths whilst also designed to accept major and minor stormwater drainage events in an attractive landscape setting. Ranging in size between 6,769 square metres and 4.3 hectares, these open space areas will contain the swales and overland flow path that will be created, contoured and stabilised where necessary to provide a multiple use - drainage / landscaped response. This will be critical to establishing an immediate informal active and passive recreation opportunity as the centrepiece to the development area. Indicative concepts for POS 4 and POS 9 are shown below.



To facilitate multiple uses, it is proposed 1:1 year and 1:10 year stormwater events will be contained within landscaped drainage channels within the POS and the 1:100 year stormwater event contained within the adjacent drainage basins. The drainage channels will typically be planted with side slopes no greater than 1:3 or grassed areas with maximum side slopes of 1:6 grade to allow for ongoing maintenance activities and safe egress in the event of a large stormwater event. Occasional small walls no greater than 900mm in height could exist to provide definition to the drainage channels.

All outlet structures into POS areas will incorporate stabilised water entry points, smooth and even grading of contours and mass planting of suitable native water tolerant tree and shrub species for maintenance minimisation.

All associated landscape infrastructure such as picnic shelters, playgrounds, footpaths and the like will be constructed above the 1:10 year stormwater flood levels. The 1:10 year stormwater levels will not exceed 900mm deep in POS areas and similarly the 1:100 year stormwater flood levels will not exceed 1100mm deep when full.

Pedestrian crossings over the drainage channels will be incorporated into the overall footpath network which will be constructed of all metal subframe with timber or composite decking products as agreed with the Shire. Balustrading will be provided where the fall heights exceed the requirements of the Building Code of Australia (typically 900mm in height).

There is currently limited to no remnant native vegetation on a large portion of the multiple use POS area proposed within the development area. The existing vegetation over the site has been highly modified through previous farming and land use practices. Several large existing trees are to be retained adjacent to the north-eastern MUC and will remain elevated above any drainage basins to ensure their long term health and viability. These trees (and any other retained vegetation through the site) will have remedial pruning undertaken to ensure accordance with the requirements of fire management techniques.

Edge treatment to the swales will include planted garden beds with mowing kerbs and / or hard edge treatments as a maintenance edge between adjoining turf areas within the open space. Hard edge interfaces will include either one of the following:

- Limestone retaining wall
- Concrete mowing kerb
- Informal granite rockwork

The MUC areas shall incorporate dual use and pedestrian path systems with built in vehicular crossing and access points for maintenance purposes. Dual use and pedestrian paths shall provide smooth and easy access to all features of the open space and link accordingly into residential and other areas adjacent as part of a greenbelt system across the development. Disability access will be given a high priority and will be designed in accordance with relevant Australian Standards.

LARGE PARKS

One large Public Open Space will be developed as part of the development plan. It will be positioned central to the development and co-located to a proposed Primary School incorporating a shared playing field. This POS will be approximately 4.3 hectares in size and shall incorporate dual use and pedestrian path systems with built in vehicular crossing and access points for landscape maintenance purposes. Dual use and pedestrian systems shall provide smooth and easy access to all features of the open space and link accordingly into residential and other areas adjacent. Disability access will be given a high priority in all large parks and will be designed in accordance with relevant Australian Standards where practicable.

The large park will be a parkland area which will offer a range of recreation and community facilities. This area will provide both informal active and passive recreation functions. The parkland shall consist of open grassed spaces bounded and defined by both feature avenue trees and native tree groupings. The western boundary will be defined by a swale with drifts of native plantings and a three row avenue of street trees running up the central boulevard.

Shrub plantings are planned to strategic areas to provide spatial definition and colour where required. Shrub planting shall primarily consist of lower growing species to enable clear vision and security through passive surveillance. It is proposed that the shrubs will consist of native species, with consideration and adherence to Waterwise principles.

Access to the large central POS shall be via the path system running along the east-west tending MUC as well as four additional pathways leading from the central boulevard spine across the swale. These entrances will incorporate gateway features principally situated along the axes of side streets. Through the development of manicured landscaped areas and its associated facilities will be the provision for picnic settings and informal gathering spaces. One of these gathering spaces will be located adjacent to the formal playing field. A shelter will allow surveillance over both the playing field and the informal recreation area to the other side. Play equipment and BBQ facilities will be considered to enable a variety of use.

A main playground with feature shelter is intended to be located adjacent to the north south aligned boulevard road through the development but with strong views and vistas across the open space and from the proposed road network to draw users into the space. Shelters, seating, BBQ's and shade trees will position this as the predominant passive and community activation space within the POS. Positioning of all facilities within the large park will maximise available views towards the Darling Range wherever possible.

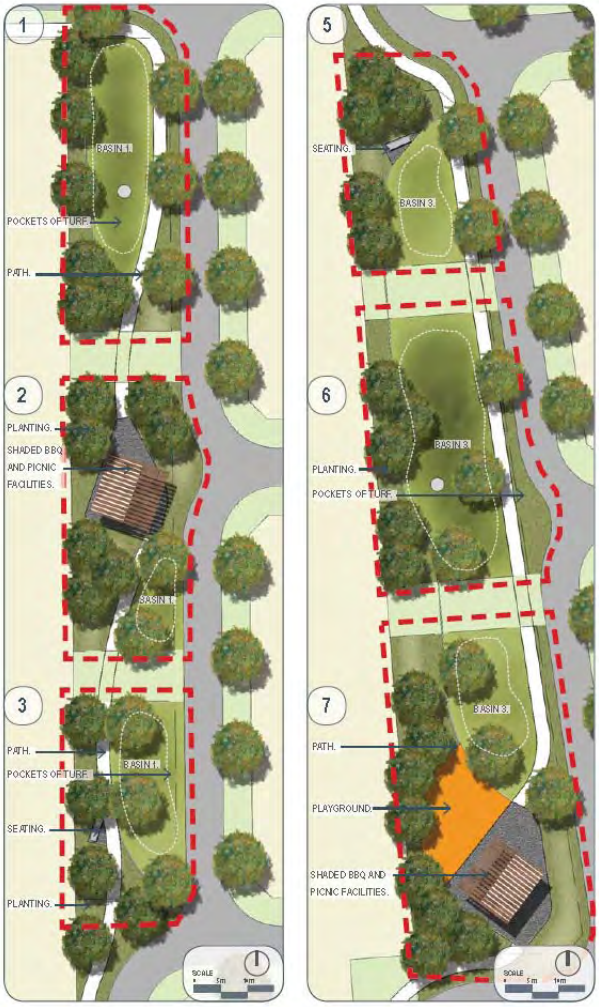
The large park will be required to accept some stormwater runoff from the surrounding development area in a multi-use drainage channel as outlined in the Multiple Use Corridor section of **Appendix 6**. An indicative concept for the large central park is shown above.

POCKET PARKS

A series of eight (8) smaller to medium sized POS areas, ranging in size from approximately 486sqm up to 2106sqm will also be provided within the development. (POS areas 1-3, 5-7 and 10. These parks will incorporate elements of the items outlined previously, with the exception of larger informal recreation / kickabout areas and communal features such as BBQ's. The five (5) smallest POS areas will act as a transition from the smaller lot densities to large lifestyle sized lots and consist of feature paths, turf with tree and amenity shrub planting. These Pocket Parks are not designed to accept any stormwater drainage. Their path systems will link to the adjoining residential streets to provide access as necessary. Avenues of trees and minimal shrub planting are preferred. Species will be a mix of native and exotic tree species and native groundcovers that are Waterwise.

The three (3) largest of these parks will typically consist of a central built feature such as a picnic shelter or playground only. The Pocket Park adjacent to the end of Cockram Street will retain a group of existing trees. The elements proposed for this POS will be positioned around these plantings to maximise shade and amenity values whilst considering the tree species habit outlined previously in this report.

An indicative concept for the pocket parks is shown opposite.



STREETSCAPES

Streetscapes throughout the development shall incorporate a variety of treatments in response to the road hierarchy system. In all cases landscape works shall incorporate tree planting in accordance with accepted traffic standards on the standard street tree alignment in relation to the service utility corridor. Treatments may include soft works such as street trees, hedge planting and groundcovers.

Final tree species are yet to be decided; however an indicative street tree plan has been included in **Appendix 6** to this report and primarily consist of Australian native and West Australian native species. Following discussion with the Shire, the indicative species list will be reviewed and updated at the detailed landscape design stage to include locally native shrubs and groundcovers and a majority of native tree species.

The timing of installation will be to occur at the completion of civil engineering works, prior to the construction of homes. It is envisioned street trees will be allocated at one per lot for standard lots and three per lot for corner blocks. Trees will be placed typically centre of lot and / or a minimum of 8m from any boundary to allow for driveway crossovers and in accordance with the corridor provided by utility service providers, being 2.7m from lot boundary.

The retention of existing significant trees to the Mundijong Road boundary and the main boulevard running from that road will enhance the project's landscape theme. The trees will serve an important visual buffer and amenity function in reinforcing the rural character of Mundijong. Within the entrance from Mundijong Road the road reserve has been increased to allow for the proposed retained trees to be accommodated within a wide verge to allow suitable width for long term tree health and maintenance minimisation.

IRRIGATION STRATEGY

In general terms the project is committed to undertaking water sensitive design with minimal impact on good quality groundwater sources and preserving water quality.

It is anticipated that irrigation water will be provided through a series of deep aquifer groundwater bores constructed across the open space areas. The flow rate of the production bores will determine the number of bores required, however, it is envisaged that up to three deep aquifer bores will be required for this development. The use of large droplet format sprinklers within turf areas and subsurface drip line irrigation within garden beds will assist in reducing evaporation and aid water conservation.

All irrigation shall be installed to the local authorities' standard specifications and industry best practice. Maintenance minimisation processes will apply in all circumstances. Controllers shall be keyed and accessed in accordance with the local authorities standards. Irrigation shall be designed to incorporate stations that can be terminated as agreed upon planting establishment and maintenance handover to the Council in accordance with relevant policies.

LANDSCAPE MAINTENANCE

The industry accepted standard Developer funded and managed landscape and irrigation maintenance period is typically two (2) summers as outlined in Liveable Neighbourhoods. Following this period, the landscape and irrigation maintenance will be handed over to the Serpentine Jarrahdale Shire to manage, unless otherwise negotiated.

Typically the first year is an establishment period, followed by a second year of consolidation. Irrigation requirements are to be scheduled to be wound back during this period to a point of almost self sufficiency at the time of handover to the Council.

As part of the ongoing approval process, every public open space landscape and irrigation design will be submitted to and approved by the Serpentine Jarrahdale Shire for Development Application prior to construction commencing.

The Landscape Design will incorporate recreation and environmental requirements, whilst focusing on maintenance minimisation principles and techniques. The developer is committed to working with the local authority to deliver outcomes in this process to reflect best practice throughout the development.

3.5 RESIDENTIAL

Low and medium density residential development is proposed for the LSP land, ranging from R20 to R60. Higher densities are located within close proximity to high amenity areas including public open space and adjacent the primary school site and neighbourhood connectors (proximity to transport connections).

Early assessment of the LSP suggests an indicative lot yield in the range of 670 to 810 lots, equating to approximately 14.8 to 17.8 dwellings per gross hectare across the site. Actual yields will be determined at subdivision design stage.

The proposed densities will facilitate subdivision to create lots with a range of sizes. Based on the Indicative Masterplan, an indicative only breakup of the lot range is shown below.

Density Coding	Number of lots as %age of total lots	Average lot size
R20	3.5%	1620m^2
R25	65.3%	550m^2
R30	14.9%	340m^2
R40	15.57%	270m^2

Grouped Housing sites	Lot Size (approximate)
Site 1	2100m^2
Site 2	1900m^2

3.6 MOVEMENT NETWORK

The traffic and transport impacts of developing Lot 50 and Lot 119 have been considered by Riley Consulting, and are detailed in the Structure Plan Traffic Report attached as **Appendix 7**.

3.6.1 PROPOSED ROAD NETWORK AND STAGING

The development of Lots 50 and 119 is anticipated to generate a total of 4,256 trips per day. Assuming that direct access is taken to Mundijong Road and developments to the north are not connected, **Figure 18** – Forecast Traffic Flows shows the forecast traffic movements. **Table 6** shows the anticipated road network impacts.

Figure 18 – Forecast Traffic Flows

TABLE 6: LOTS 50 & 119 TRAFFIC VOLUMES AND LEVELS OF SERVICE (LOS)

Road	Type	Lot 50	Forecast	LoS
Mundijong Road west of Paterson Street	1	2,181	5,461	C
Mundijong Road east of Tonkin	1	2,075	4,865	C
Mundijong Road east of Baldivis Road	1	1,343	4,133	B
Watkins Road	1	593	2,993	B
South Western Highway north	1	360	9,470	D
Paterson Street	1	1,588	3,788	B
Soldiers Road	1	1,588	3,788	B
Lot 50 Access Road	1	4,256	4,256	B
Taylor Road	1	0	500	A
Adams Street	1	0	500	A

ACCESS

The subject land is presently accessed from Mundijong Road. It has a frontage to the unmade roads of Adams Street and Sparkman Road to the north. It is possible to develop the subject land in isolation with access taken purely from Mundijong Road to the south. In the longer term, the development would become part of Mundijong and will accommodate the neighbourhood connector of Adams Street/Taylor Road.

Access to streets other than Mundijong Road will be created as new streets are planned in accordance with *Liveable Neighbourhoods.*

As discussed, access to the subject land will be taken directly to Mundijong Road and in the first years of development would operate as a priority controlled intersection. In the longer term, traffic associated with developments to the north will pass through the LSP area and affect the operation of the proposed intersection with Mundijong Road.

Figure 19 shows the suggested road hierarchy for the LSP, involving a combination of laneways, access streets and neighbourhood connectors.

NEIGHBOURHOOD CONNECTORS

Roads shown as neighbourhood connectors in **Figure 19** provide the primary access to the structure plan area. Daily traffic flows on these roads are well within the 7,000vpd recommended. These streets can be provided with a standard 7.2m carriageway, which is suited to bus movements. A footpath on both sides of the street is required, although one side may be designated as a shared use path. At intersections, median islands of 2.0m width would be desirable to provide safer pedestrian crossing points and to highlight the intersection. A residual verge width of 4.1m will occur where such medians are provided.

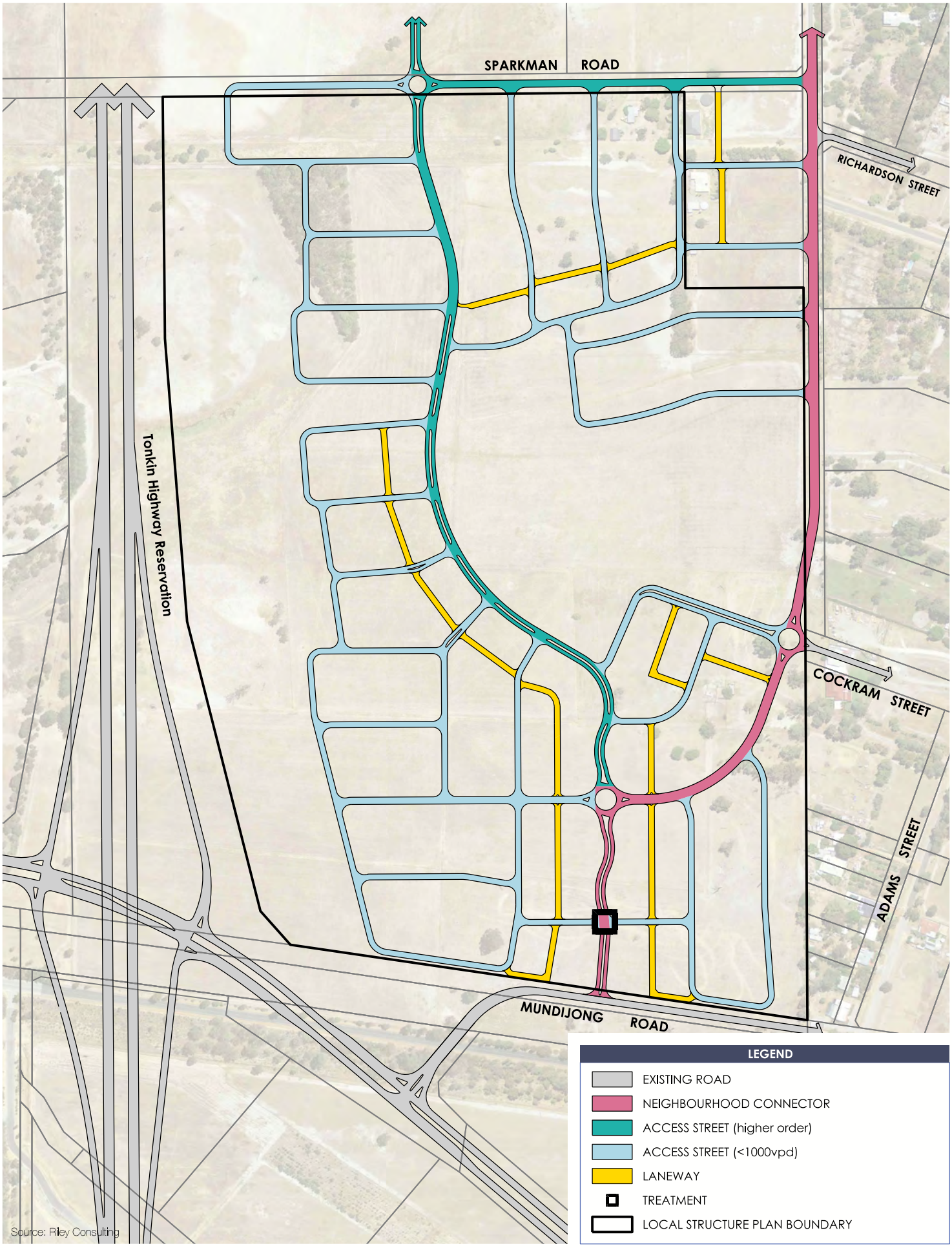
ACCESS STREETS

Access streets are the main residential streets within the development and provide direct lot access. A typical access street would be provided with a 6.0m to 7.0m carriageway depending on the bus routes and Local Government requirements. It is recommended however, that the minimum carriageway width be provided to encourage a slower speed environment. Unfortunately, many streets with 7.0m+ carriageways and low density lots frequently experience traffic speeds well in excess of the posted 50kph limit. A reduced carriageway width with assist in achieving a more appropriate 40kph typical travel speed.

HIGH ORDER ACCESS STREETS

Access streets carrying between 1,000vpd to 3,000vpd are considered to be higher order access streets and a slightly wider road reservation is suitable. *Liveable Neighbourhoods* suggests that these streets would be considered as “typical residential streets” and a carriageway width of 7.0m within a 15.4m to 16.0m road reservation is appropriate. However, the 7.0m wide carriageway is not supported in residential areas as it will tend to encourage a higher traffic speed. A 6.0m carriageway is preferred to encourage a 40kph target speed. A wide carriageway is only recommended where buses or large vehicles are expected.

In higher density areas, the provision of parking embayment’s is a preferred treatment rather than an increased carriageway width.



ROAD HIERARCHY

Lot 50 Cockram Street &
Lot 119 Adams Street, Mundijong

A Peet Limited Project

N 0m 20 40 60m

s: 1:5000@A4
d: 15 Oct 2012
p: 08/039/027

figure 19

It should be noted that from a road network capacity basis, a 6.0m wide carriageway could accommodate two-way traffic flows up to 1,100 vehicles per hour (indicatively 11,000vpd), but as a residential street should be restricted to less than 3,000vpd to maintain appropriate residential amenity. A wider carriageway is not required from a traffic movement perspective.

LOT 50 ACCESS ROAD

Primary access to the LSP area and development to the north will be taken via the Lot 50 access road. Daily traffic volumes on this link are shown to be in the order of 8,000 to 9,000vpd approaching Mundijong Road will determine if four lanes would actually be required. It should also be noted that the higher volume using the Lot 50 access road could be reduced by traffic redistributing to Adonis Street. Modelling indicates that this is not a desirable route for LSP traffic accessing Mundijong Road, but would be attractive to development further north. To date, the planning team has not sought raise the capacity of Adonis Street for access to Mundijong Road.

ADAMS STREET/TAYLOR ROAD

Adams Street is currently provided with a 20 metre road reservation. In isolation, the LSP is highly unlikely to increase traffic movements on Adams Street/Taylor Road until the development connects to Adams Street. This connection will be progressively upgraded as adjacent land is developed.

The current sealed width of Taylor Road/Adams Street is about 6 metres (approximately) and may require additional width to cater for significant increases in traffic demand.

3.6.2 WALKING AND CYCLING NETWORK

The structure plan provides for a primary school which is within a pleasant walking distance for the majority of households. Adjacent to the school and on identified walking routes, it is desirable to provide a footpath to both sides of the street. Current planning guidelines suggest that all streets should be provided with a footpath where ever possible. Where traffic flows exceed 1,000 vehicles per day, a footpath to both sides of the road should be provided.

The Shire has recently made revisions to its *Local Area Bicycle and Shared Path Plan (July 2012),* which focuses on providing linkages to services such as schools and business centres, whilst ensuring the safety of pedestrians. This is reflected in the proposed walking and cycling network for Precinct E2, as cycling would be safe on the majority of local streets where traffic flows are less than 1,000vpd. On the neighbourhood connector shared paths should be provided to provide a safe alternative to on-road cycling. A principle shared path is indicated in the district structure plan adjacent to the future Tonkin Highway. It is desirable to provide linkages to this path, although the future service corridor may preclude such access.

3.6.3 PUBLIC TRANSPORT AND STAGING

Armadale is about 21 kilometres to the north of Mundijong, where the metro rail line service to the CBD currently terminates. There is discussion of the service being extended to Byford, however this is a very long term proposal. The Perth – Mandurah line can be accessed at Wellard, Rockingham and Safety Bay. These stations are probably closer than Armadale to the north and have been developed as park and ride stations. It can be expected that commuters to Perth will be split 60/40 to the Perth – Mandurah line.

There are two bus services passing through the locality, routes 252 and 253. The services connect to Armadale railway station. The district station plan sets out to provide a bus route along Taylor Road/Adams Street that would terminate to the north side of Mundijong Road.

3.7 WATER MANAGEMENT

3.7.1 DISTRICT WATER MANAGEMENT STRATEGY

The subject land falls within the area covered by the Mundijong Whitby District Structure Plan District Water Management Strategy, which was prepared by GHD (2010).The DWMS addresses broad-scale stormwater management measures over an 1800ha area which extends from the future Tonkin Highway reserve to South Western Highway.

3.7.2 LOCAL WATER MANAGEMENT STRATEGY

A Local Water Management Strategy has been prepared by Wave International to further define surface water and groundwater management design concepts at Lot 50 Cockram Street & Lot 119 Sparkman Road (refer **Appendix 8**). The LWMS outlines the design criteria and objectives for stormwater management, groundwater management, water quality management, water conservation & sustainability measures and requirements for additional work as planning and design for the site progresses.

3.7.3 DISTRICT STORMWATER MANAGEMENT

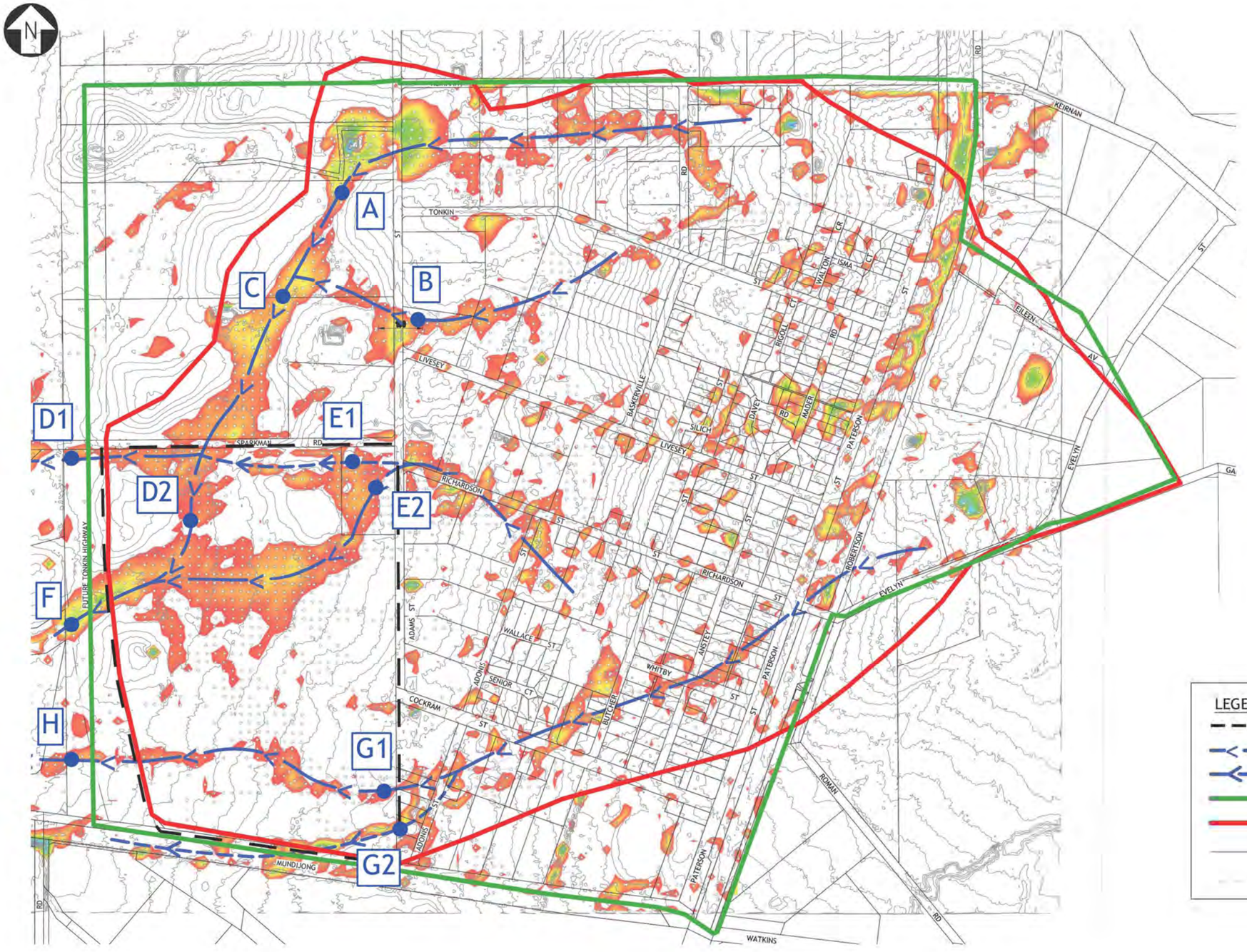
Surface runoff from a 390ha catchment discharges through Lot 50 Cockram Street and Lot 7 Adams Street. Due to the relatively flat nature of the site and very shallow existing drains, there is significant interaction between flow paths throughout the catchment which makes the calculation of pre-development flow rates particularly complex.

A 2-dimensional surface water model was developed using XP Storm's 2D module, which has the ability to model floodplains and areas with poorly-defined flow paths with greater accuracy than a traditional 1-dimensional model. The model was developed to clarify pre-development flow rates from the overall catchment and to better delineate the flow paths through the catchment, as the existing drains are very shallow and not well defined.

The modelling showed that a total flow rate of 7.9m^3/s enters Lot 50 & Lot 119 from catchments to the east in the critical 100yr ARI storm event, and the design of the open drains through the multiple use corridors will be designed to accommodate this inflow. The pre-development modelling also showed that a peak flow rates of 2.3m^3/s is generated by surface runoff from Lot 50 & Lot 119 in a 100yr ARI storm event.

Figure 20 shows the pre-development surface contours (taken from the Department of Water's LiDAR dataset), the extent of the upstream surface water catchment, and also shows the main flow paths and overflow locations between adjacent flow paths.

To ensure that downstream landholdings are not adversely impacted by development in upstream catchments, each development must ensure that peak post-development flow rates generated by runoff from the development area do not exceed pre-development levels. This is achieved through the use of detention storage areas spread throughout the development. Off-line storage areas will be provided within public open space to attenuate peak flows, and will discharge to open swale drains through the multiple use corridors. **Figure 21** shows the approximate locations and sizes of the detention basins required to attenuate post-development flows.



100YR ARI DEPTH OF INUNDATION

- 1.000m
- 0.900m
- 0.800m
- 0.700m
- 0.600m
- 0.500m
- 0.400m
- 0.300m
- 0.200m
- 0.100m

LOCATION	5yr Q (m^3)	100yr Q (m^3)
A	1.2	2.9
B	0.8	1.9
C	1.8	4.6
D1	1.2	2.1
D2	1.1	3.3
E1	0.5	1.4
E2	1.5	3.2
F	3.6	7.2
G1	1.0	2.5
G2	0.4	0.9
H	0.5	1.8

LEGEND

- DEVELOPMENT BOUNDARY
- PRE-DEVELOPMENT FLOW PATH
- OVERLAND FLOW PATH FOR MAJOR STORM EVENTS
- CATCHMENT BOUNDARY (GHD DWMS)
- CATCHMENT BOUNDARY (2D MODELLING)
- PREDEVELOPMENT GROUND CONTOUR (0.5m INTERVAL)
- DIRECTION OF FLOW

Source: WAVE International

PRE-DEVELOPMENT FLOW PATHS

Lot 50 Cockram Street & Lot 119 Adams Street, Mundijong

A Peet Limited Project

0m 50 100 150m

s: 1:10000@A3
d: 22 Mar 2013
p: 08/039/025A

figure 20

BASIN INFORMATION

BASIN NUMBER	BASIN OUTLET SIZE (mm)	INVERT LEVEL (mAHD)	1YR AREA (m²)	5YR AREA (m²)	5YR TWL (mAHD)	100YR AREA (m²)	100YR TWL (mAHD)
1	300	26.0	370	1000	26.8	1300	26.9
2	225	25.9	540	1000	26.8	1300	26.8
3	525	26.0	1050	1800	26.8	2300	26.9
4	225	26.8	480	1600	27.7	1900	27.7
5	225	27.1	930	2600	28.0	3100	28.0
6	225	26.8	820	3100	27.7	3900	27.8
7	375	28.0	1710	3400	28.8	3900	28.8
8	225	27.3	550	1000	28.3	2100	28.3

Source: WAVE International

POST DEVELOPMENT DRAINAGE MANAGEMENT
Lot 50 Cockram Street &
Lot 119 Adams Street, Mundijong
A Peet Limited Project

N 0m 30 60 90m
s: 1:6000@A4
d: 22 Mar 2013
p: 08/039/026A

figure 21

3.7.4 LOCAL STORMWATER MANAGEMENT

Road runoff from events up to 1yr ARI will be directed into the bioretention swales in POS areas for on-site retention. Residential lots are expected to retain runoff from roof and hardstand areas in soakwells within the lot.

Inflows from the upstream catchment to the east of Precinct E2 have been allowed for in the design of the open drainage swales through Precinct E2.

JDA Consultant Hydrologists has prepared an LWMS to address water management for Precinct E1 (immediately north of Precinct E2), which proposes to discharge flow from the Precinct E1 LSP area along the Sparkman Road reserve, without discharging into Precinct E2. This flow would be piped for up to the 5yr ARI event, and conveyed by overland flow for major storm events.

Runoff within Precinct E2 will be managed by collecting road runoff in a piped drainage network, which will discharge to flood storage basins in the POS areas. These basins will act to attenuate the runoff to predevelopment levels and will discharge to the open drains which replicate, as closely as practicable, the predevelopment flow paths through POS corridors.

3.7.5 GROUNDWATER MANAGEMENT

Groundwater flows from east to west across the region, generally following the topography. The Perth Groundwater Atlas (DoW, online) shows a snapshot of groundwater levels as measured in May 2003 (which are an indication of low groundwater levels); showing groundwater levels at the site ranging from 27mAHD in the east to 23mAHD in the west.

Groundwater across this area tends to perch on the underlying clayey soils, causing large fluctuations of up to 2.5m between high and low groundwater levels. In areas of the site where the depth to the underlying clay materials is low, typical peak groundwater levels are very shallow (within 100mm of existing surface). Parts of the site with a greater depth of sand over the underlying clays have a slightly larger natural separation between existing surface and peak groundwater levels (up to 800mm). A comparison of the pre-development monitoring data to nearby long-term DoW monitoring bores showed that the maximum measured water levels measured in September 2009 were close to the long-term (25 year) average maximum levels. Using the long-term DoW data, the site groundwater levels have been calibrated to estimate a typical winter perched water level (refer **Appendix 8**). A combination of imported sand fill and subsoil drainage will be used in the design of the development to ensure adequate separation between finished lot levels and perched water levels, and to alleviate the perching of infiltrated rainwater on the impermeable clay soils and ferricrete across the site. Finished lot levels are to be a minimum of 1.5m above subsoil drainage inverts, or 1.8m above the underlying clay surface – whichever is higher. Minimum subsoil drainage levels will be dictated by several factors – the level of the clay and ferricrete material present across the site; the invert level of the open drainage swales and subsoil outfall locations; and in the upstream reaches of the subsoil drainage network the invert levels will be governed by minimum pipe grades.

The perched groundwater that is intercepted by suboil drains during winter months will be treated in bioretention swales at the drainage outfalls, which will be located in POS areas and will be designed with appropriate soil media and plant species to retain and treat the discharge from subsoil drains.

3.7.6 NON-POTABLE WATER SUPPLY

An important part of water sustainability is fit-for-purpose water use, or the use of alternative water sources for applications where drinking-quality water is not necessary (e.g. toilet flushing, garden watering).

The State Water Plan (Government of Western Australia, 2007) identified a potable water consumption target of 40-60 kL/person/year. This target can only by achieved if all outdoor water use is supplied by non-potable sources, and the widespread implementation of non-potable water schemes is most successful when installed with the construction of subdivision works. A non-potable water supply (third pipe) system would allow the use of alternative water sources throughout the development and would greatly reduce consumption of potable water.

The widespread implementation of non-potable water schemes is most successful when installed with the construction of subdivision works. A reticulated non-potable water supply (third pipe) system would allow the use of alternative water sources throughout the development and would greatly reduce consumption of potable water.

The Shire of Serpentine Jarrahdale is investigating potential alternative water sources that could be used for a third-pipe scheme throughout the greater Mundijong area. The developer will continue to liaise with the Shire as the development process continues, with a view to implementing a reticulated third-pipe system should an alternative water source be available at the time of development.

Public open space is expected to be irrigated using groundwater from the superficial aquifer. The site falls within the Serpentine Groundwater Area, and the Byford 3 Groundwater Subarea. According to the Department of Water (September 2012), there is water available in the superficial aquifer, and a groundwater licence application is currently being assessed by the DoW with the licence expected to be issued in March 2013.

The groundwater licence application is for approximately 44 kL/yr, to irrigate 5.6 ha of POS and streetscapes. The primary school site has not been included in the application, and DET will be responsible to secure a groundwater allocation for the primary school area. When the groundwater licence is approved, exploratory drilling will be undertaken to determine the possible yield in the proposed bore locations.

3.8 EDUCATION FACILITIES

3.8.1 PRIMARY SCHOOL SITE

Education requirements have been guided by relevant policy and the requirements of the Department of Education (DoE). The provision of primary school sites in urban areas provides a vital social value to the area, with primary schools being recognised for their role as place making elements. There is one Primary School Site proposed within the LSP area, representing one of the eight primary school sites identified as necessary within the Mundijong-Whitby DSP area. This primary school site is 3.5022 hectares in size and will service Precinct E of the DSP area, which includes the LSP area to the north of the subject LSP. The primary school site is to be co-located with the major park in the centre of the LSP, hosting active recreational and sporting facilities for the community and school students.

Development Control Policy 2.4 – School Sites states that one primary school site is required for between 1,500 and 1,800 housing units. It is also stated in the policy the importance of primary school sites being located close to a local distributor road to ensure ease of access by vehicles and proximity to public transport routes. The co-location of the primary school site with public open space allows for facility sharing.

Element 8 of Liveable Neighbourhoods (LN) provides a guide to facilitate the responsive design of school sites in new subdivision areas. It is noted that it is important to consider the provision of school sites during the sub-regional and district structure planning stages and in consultation with both government and non-government education providers. It is reiterated in LN that primary schools be located on a neighbourhood connector with good accessibility for walking, cycling and public transport together with vehicular access. LN states that one primary school is required per 1,500 housing units. Shared ovals with local government and school sites are encouraged to improve land efficiency, and allow the provision of smaller school sites, as is the case with the proposed primary school site within the subject area. There is a requirement of a minimum 3.5 hectare site for a primary school in cases of co-location with adjoining public open space.

A meeting was held with Richard Bloor at the Department of Education on 26 July 2012 to discuss the proposed primary school site. Mr Bloor confirmed that the location and configuration of the primary school and the co-located oval were suitable. It was also indicated during this meeting that as the expected lot yield of approximately 557 does not meet the housing unit requirement for a primary school, compensation will be received for the development of the primary school site from surrounding landowners and the DoE. The expected lot yield of 557 contributes to development of approximately one third of the 1,500 dwelling units required for the development of a primary school, and Lot 50 is therefore required to contribute one third of the school site, being approximately 1.1 hectares. The remaining 2.4 hectares shall be contributed by surrounding landowners via the Department of Education.

It is of note that there is an existing Mundijong primary school to the east of the subject site, with a student enrolment of 175 students. The Mundijong Primary School is currently at capacity in terms of student accommodation, thus confirming the timely requirement for an additional primary school in Mundijong. It has been advised by the DoE that transportables may be added to the Mundijong Primary School to meet excess demand in the interim, depending on the size and accessibility of the space available. There is an existing Serpentine Jarrahdale Grammar School private K-Yr12 school located north-east of the subject site servicing a large portion of the Mundijong existing community.

3.9 ACTIVITY CENTRES AND EMPLOYMENT

3.9.1 NEIGHBOURHOOD CENTRE

Precinct E of the Mundijong-Whitby DSP contains portion of a local neighbourhood centre which will provide for the convenience needs of the local community. The location of this neighbourhood centre is within Sub-Precinct E1 to the north of the LSP area, and is outside the responsibility of the subject LSP. Future residents within the LSP area (Sub-Precinct E2) will be able to access the neighbourhood centre via Adams Street on the eastern boundary of the LSP land, which provides a direct connection through to Sub-Precinct E1 to the north.

3.10 INFRASTRUCTURE COORDINATION, SERVICING AND STAGING

3.10.1 STORMWATER MANAGEMENT

Lot runoff will be managed through the use of soakwell systems to retain and infiltrate roof runoff within individual lots. Subsoil drainage will be installed within road reserves to promote infiltration and improve the efficiency of soakwells. Future lot owners may also opt to install rainwater tanks, which will also act to retain lot runoff on-site.

A conventional piped network will be designed to manage road runoff, with 'leaky' side entry/gully pits located to suit appropriate spread rates and pit spacings. The level of service for the side entry/gully pits and the pipe network will be dependent on the road hierarchy. Road runoff from minor storm events (up to 1 year ARI) will be retained and treated within bioretention systems in public open space areas to ensure water quality objectives are met.

To ensure that downstream landholdings are not adversely impacted by development in upstream catchments, each development must ensure that peak post-development flow rates generated by runoff from the development area do not exceed pre-development levels. This is achieved through the use of detention storage areas spread throughout the development. Off-line storage areas will be provided within public open space to attenuate peak flows, and will discharge to open swale drains through the multiple use corridors.

3.10.2 WATER SUPPLY

The main water supply to Mundijong is currently supplied off the Serpentine Trunk Main on Summerfield Road 5.5km to the south of Mundijong Road. This water main consists of pipes of 150mm and 300mm diameter and Water Corporation is in the process of upgrading the 150mm diameter pipes to 400mm diameter pipes.

The long term water supply proposed for Mundijong would be a supply from the north along Soldier Road from the Byford gravity tank. This proposed water distribution pipeline would vary in size from 500 to 900mm diameter. Sections of the mains will be installed to allow for staging as development occurs to the north of Mundijong, but this would need to be supplied off the current network and works will be developer funded.

Water Corporation is currently undertaking a review of the water planning in Mundijong and it is expected that the review will be completed by November 2012.

However in the interim, the water supply for Lot 50 Cockram Street can be obtained from the water main at the corner of Paterson Street and Mundijong Road. It is expected that a 250mm diameter main will be laid from Paterson Street to the site.

The proposed water infrastructure requirements for Lot 50 Cockram Street are shown on drawing 2681-01-SK-01 of the Infrastructure Servicing Report (refer **Appendix 9)**.

3.10.3 WASTEWATER

The Water Corporation has a long term plan to construct a permanent Type 1000 sewer pump station (Mundijong A) at Scott Road to service the whole of Mundijong. The discharge from Mundijong A will be at East Rockingham Waste Water Treatment Plan via a pressure main along the service corridor and Mundijong Road. Initially a temporary pump station will be built in Scott Road and pump northwards to an existing pump station in Byford with an approximately 20 l/s capacity available.

The availability of this 20 l/s capacity for Mundijong will be subject to ongoing monitoring and will only be available on a staged basis and will be dependent on the progressive upgrades of Byford pump station.

Water Corporation is currently undertaking a review of the sewer planning in Mundijong and it is expected that the review will be completed by November 2012.

To service Lot 50 Cockram Street, a temporary Type 40 sewer pump station can be constructed near Sparkman Road and discharge via a pressure main to the proposed temporary pump station at Scott Road.

The proposed sewer infrastructure requirements for Lot 50 Cockram Street are shown on drawing 2681-01-SK-01 of the Infrastructure Servicing Report (refer **Appendix 9)**.

3.10.4 POWER SUPPLY AND TELECOMMUNICATIONS

The existing Western Power distribution infrastructure in the vicinity of Lot 50 Cockram Street comprises of several three phase 22kV high voltage (HV) aerial feeder lines (BYF 524) from Byford Zone Substation along Taylor Road and Adams Street.

There is currently some spare capacity on the BYF 524 feeder but the actual spare capacity is not known and confirmation from Western Power will be required. This capacity is available on a first-come first-served basis.

Western Power has plans to construct a major Zone Substation along Gossage Road in Oldbury in 2025. If the supply capacity is required before 2025 Western Power will charge the developer for the full capital costs.

Western Power's Feasibility Study for Mundijong estimates that the Headworks charges will amount to approximately $2,500 to $3,000 per lot for the initial phase of development. Headworks refer to distribution network reinforcements outside the subdivision that are necessary in order to provide power capacity to the subdivision. All headworks extensions, removal, moving or upgrades to the network will be fully funded by the developer.

The WAPC and Western Power will most likely stipulate that the existing HV and LV aerials adjacent to the subdivision are to be undergrounded and any existing consumers affected must have their consumer mains reconnected to the underground network.

It is envisaged that the Lot 50 Cockram Street development will fall under the ambit of the National Broadband Network (NBN) which requires developers to install an approved pipe and pit system as part of the development.

Network infrastructure will be installed subsequently by NBN appointed contractors at no cost to the developers.

3.10.5 GAS SUPPLY

As there are currently no ATCO gas headworks infrastructure in the vicinity of the subject site, the provision of natural gas will require the construction of a headworks high pressure gas main from Nettleton Road, Byford.

3.11 DEVELOPER CONTRIBUTIONS AND ARRANGEMENTS

The Shire is currently preparing a Development Contribution Arrangement for the Mundijong-Whitby Development Contribution Area, inclusive of the LSP area. The timing for the completion of this Plan is not known at this stage. In the interim, it is understood a Developer Contribution Agreement, similar to that prepared for Byford, will be negotiated between the developer and the Shire.

Developer Contribution arrangements will include both 'traditional' infrastructure and 'community' infrastructure, through statutory processes and in accordance with State Planning Policy 3.6 Development Contributions for Infrastructure.

4 CONCLUSION

This structure plan has been prepared following a detailed and considered analysis of the opportunities and constraints within the subject site.

The LSP provides a guiding framework for subdivision and development. It serves to coordinate the provision of land use, services and infrastructure. The proposed land uses and subdivision design are compliant with the MRS, the Shire's TPS 2, the Mundijong-Whitby DSP, and have been prepared in accordance with the principles of Liveable Neighbourhoods.

From the research and analysis undertaken on the land use capabilities of the subject site, it is evident that the site is suitable for development for urban purposes, with the provision of sufficient POS. The site is accessible from the existing road network and servicing requirements within the site such as roads, drainage and utilities have been adequately addressed.

APPENDIX 1
PRE-LODGEMENT CONSULTATION

Appendix 1: Pre-lodgement consultation

Agency	Date of Consultation	Method of Consultation	Summary of Outcome
Land owners within and adjacent to the structure plan area			
Relevant community groups in the area			
Local government			
Department of Planning			
Department of Water			
Department of Environment and Conservation			
Department of Education	26 July 2012	Discussion at DoE offices.	DoE approve of preliminary primary school site design and location.
Department of Indigenous Affairs			
Main Roads Western Australia			
Heritage Council			
Department of Transport			
Department of Health			
Public Transport Authority			
Environmental Protection Authority			
Western Power			
Alinta Gas			
Water Corporation			
Telstra			
Non-government school providers			
Department for Community Development			
Department of Sports and Recreation			
Department of Agriculture and Food Western Australia			
Fire and Emergency Services Authority			
Any other relevant government agency as Required			

APPENDIX 2
CERTIFICATE OF TITLE

REGISTER NUMBER	
50/DP67194	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
2	**25/1/2011**

WESTERN AUSTRALIA

RECORD OF CERTIFICATE OF TITLE

VOLUME **2752** FOLIO **408**

UNDER THE TRANSFER OF LAND ACT 1893

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

REGISTRAR OF TITLES

REGISTRAR OF TITLES WESTERN AUSTRALIA

LAND DESCRIPTION:

LOT 50 ON DEPOSITED PLAN 67194

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

PEET NO 88 PTY LTD OF LEVEL 7, 200 ST GEORGES TERRACE, PERTH
(AF L407053) REGISTERED 20 AUGUST 2010

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

1. L527839 MORTGAGE TO ANZ FIDUCIARY SERVICES PTY LTD REGISTERED 11.1.2011.

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

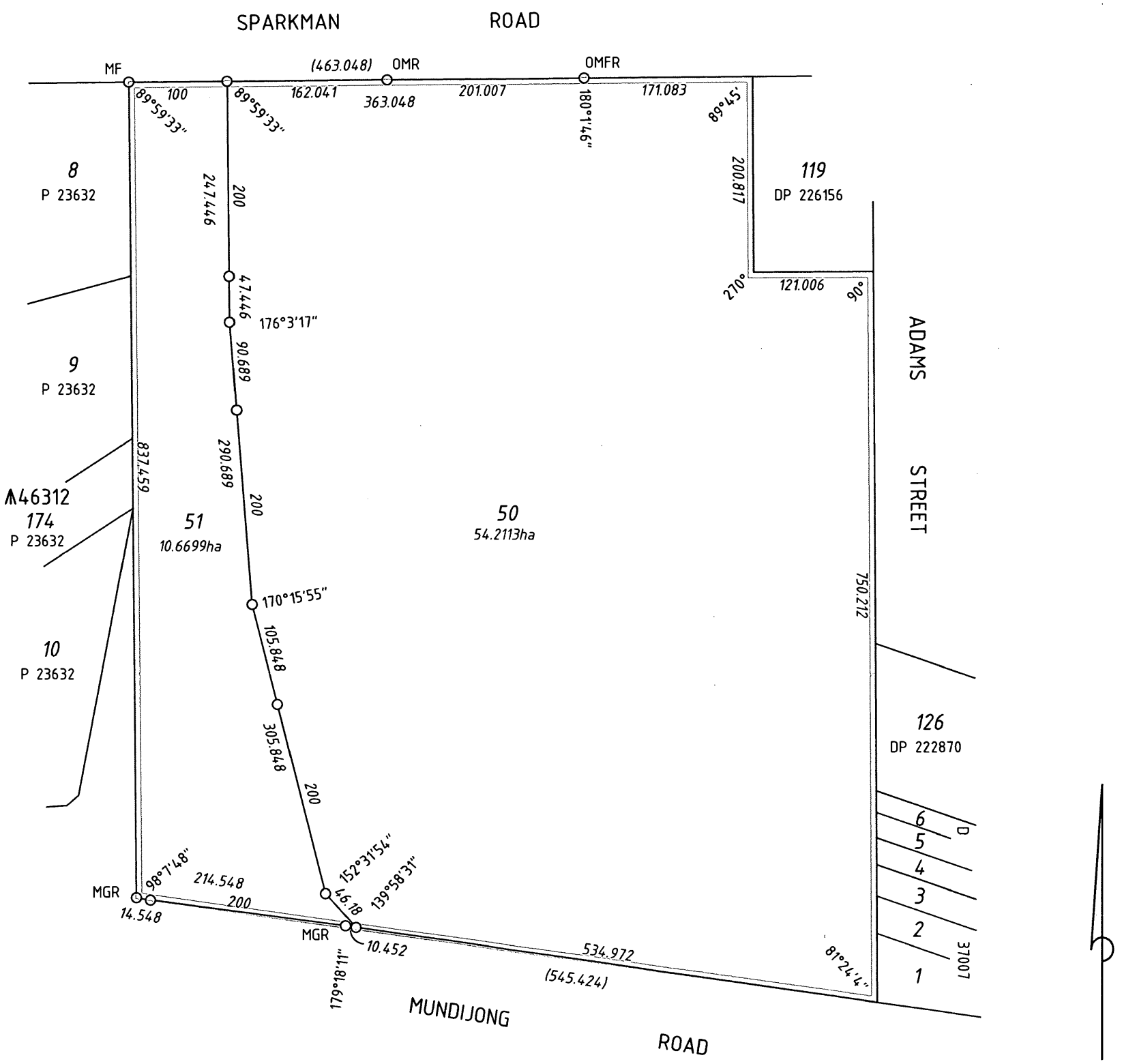
----------END OF CERTIFICATE OF TITLE----------

STATEMENTS:

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

SKETCH OF LAND: DP67194 [SHEET 1].
PREVIOUS TITLE: 723-98.
PROPERTY STREET ADDRESS: 75 COCKRAM ST, MUNDIJONG.
LOCAL GOVERNMENT AREA: SHIRE OF SERPENTINE-JARRAHDALE.

VER	AMENDMENT	AUTHORISED BY	DATE
2	DP REPLACED, ADDED ACQUISITION NOTE	P.J. READ	28.4.2010
3	DP REPLACED, REMOVED ACQUISITION NOTE	P.J. READ	17.5.2010



SEE SHEET 2 FOR SURVEY INFORMATION

SURVEY CARRIED OUT UNDER REG 26A
SPECIAL SURVEY AREA GUIDELINES

SPECIAL SURVEY AREA SUBDIVISION

whelans

s:/projects/11/11395/carto/11395/11395dp2.dgn
ssa combined-dp2.acs FP-11395-003-VER 3.0

DP 67194 (01)

TYPE FREEHOLD

PURPOSE SUBDIVISION

PLAN OF

LOTS 50 & 51

SSA YES/~~NO~~

DISTRICT COCKBURN SOUND DPI FILE

TOWNSITE

LOCAL AUTHORITY SHIRE OF SERPENTINE-JARRAHDALE
LOCALITY MUNDIJONG

FORMER TENURE	ON	FIELD BOOK
LOT 46 DP 226156 C/T 723/98	INDEX BG33 (2) 20.26,20.27	113513 (SAM 4500)

100 0 100 200 300

SCALE: 1:5000 AT A3 SIZE ALL DISTANCES ARE IN METRES

SURVEYOR'S CERTIFICATE - Reg 54

I PETER JAMES READ

hereby certify that this is accurate and is a correct representation of the
(a) *survey; and /or (b) *calculations from measurements
(*delete if inapplicable)
undertaken for the purposes of this plan and that it complies with the relevant written law(s) in relation to which it is lodged

✓ Peter James Read 2010.05.17 06:23:03.2

Licensed Surveyor Date

SURVEYOR'S CERTIFICATE - Compiled

I .....

hereby certify that this compiled plan
(a) is a correct and accurate representation of the survey(s) of the subject land ; and
(b) is in accordance with the relevant law in relation to which it is lodged.

Licensed Surveyor Date

SURVEYING & DRAFTING BY:
WHELANS (WA) PTY. LTD.
(08) 9443 1511 www.whelans.com.au

LODGED
DATE 20-May-10
FEE PAID $316.00
ASSESS No. 6809804

TYPE OF VALIDATION
FULL AUDIT
LEGAL COMPONENT MJR
DOCKET PLAN/DIAG 00420-2010
CERTIFIED CORRECT M Read 20/5/10
I.S.C.
F.S.C.

APPROVED BY
WESTERN AUSTRALIAN PLANNING COMMISSION
FILE 807-2-29-44PV
~~Delegated Under S.16 P & D ACT 2005~~
DATE 25/5/2010

IN ORDER FOR DEALINGS
SUBJECT TO

FOR INSPECTOR OF PLANS & SURVEYS AUTHORIZED LAND OFFICER 26.5.10 DATE

APPROVED REG 26A (4)
INSPECTOR OF PLANS & SURVEYS AUTHORIZED LAND OFFICER 20.8.10 DATE

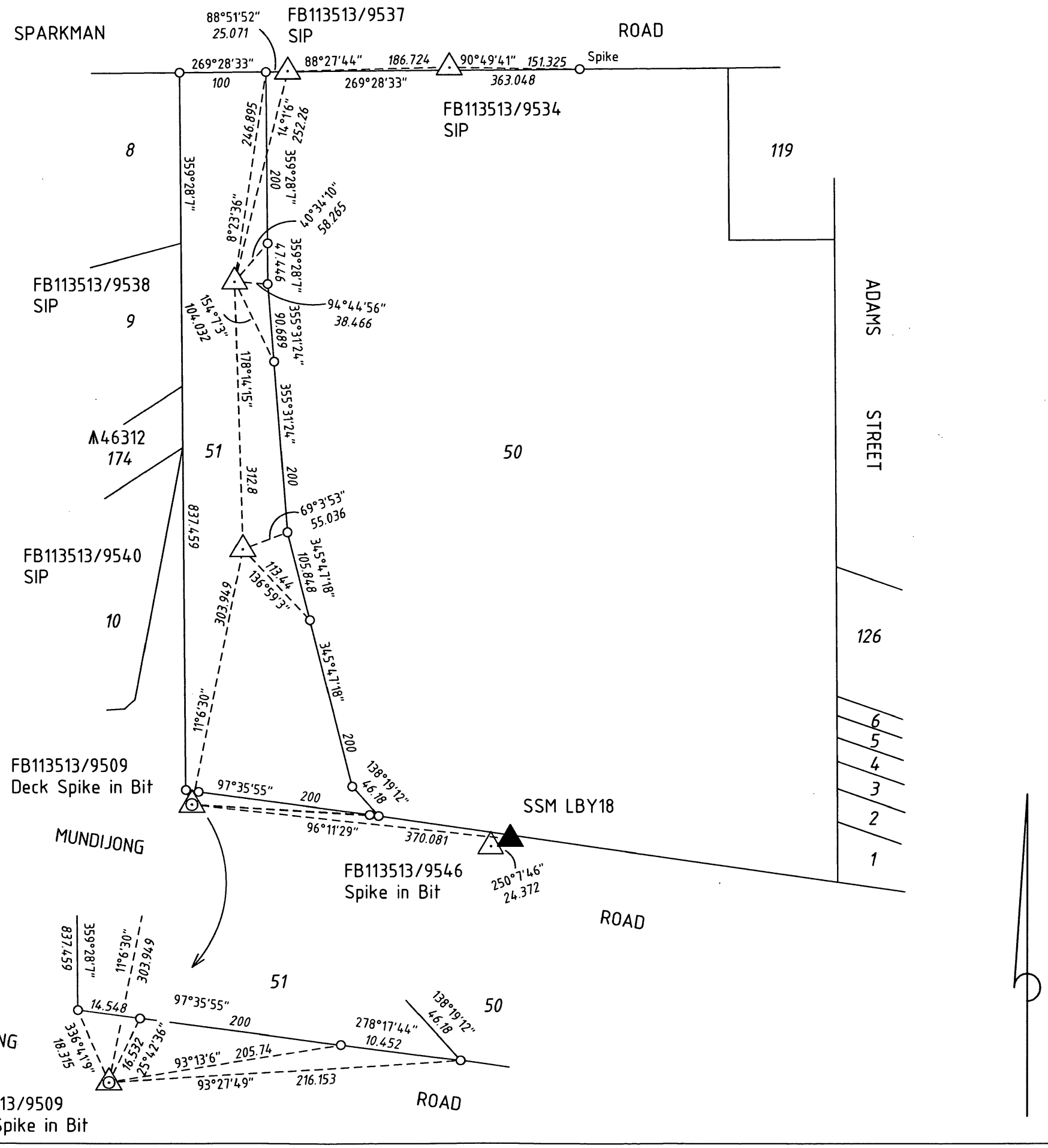
Landgate
Western Australian Land Information Authority

DEPOSITED PLAN
67194
ORIGINAL

SHEET 1 OF 2
VERSION 3

FOR HEADING SEE SHEET 1

DP 67194 (02)



SURVEY INFORMATION ONLY

FINAL SURVEY SHEET
SURVEY CARRIED OUT UNDER REG26A
SPECIAL SURVEY AREA GUIDELINES

- ▲ Denotes Standard Survey Mark
- ◉ Denotes Permanent Survey Mark
- ◎ Denotes Permanent Control Mark
- △ Denotes Temporary Control Mark
- o Denotes Peg
- × Spike

THIS SUBDIVISION CONTAINS RETAINING WALLS WHICH ARE ALL LOCATED WITHIN THE HIGH (OR LOW) LOT/S

PRIJECT GRID IS PCG 94

whelans

s:/projects/11/11395/carto/11395/11395dp2(sht2).dgn
ssa-dp2.acs FP-11395-003-VER 3.0

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SCALE: 1:5000 AT A3 SIZE

ALL DISTANCES ARE IN METRES

SURVEYOR'S CERTIFICATE - Reg 54

I PETER JAMES READ

hereby certify that this is accurate and is a correct representation of the

(a) *survey; and /or

(b) *calculations from measurements

[*delete if inapplicable]

undertaken for the purposes of this plan and that it complies with the relevant written law(s) in relation to which it is lodged

✓ Peter James Read 2010.05.17 06:23:03 Z

Licensed Surveyor Date

Landgate
Western Australian Land Information Authority

DEPOSITED PLAN

67194

ORIGINAL

SHEET 2 OF 2

VERSION 3

REGISTER NUMBER	
119/DP226156	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
N/A	**N/A**

WESTERN AUSTRALIA

RECORD OF CERTIFICATE OF TITLE

UNDER THE TRANSFER OF LAND ACT 1893

VOLUME **723** FOLIO **99**

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

REGISTRAR OF TITLES

REGISTRAR OF TITLES WESTERN AUSTRALIA

LAND DESCRIPTION:

LOT 119 ON DEPOSITED PLAN 226156

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

RAMSAY MACDONALD LIGHTBODY OF MUNDIJONG

(T T5200/1952) REGISTERED 27 MARCH 1952

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

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

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

STATEMENTS:

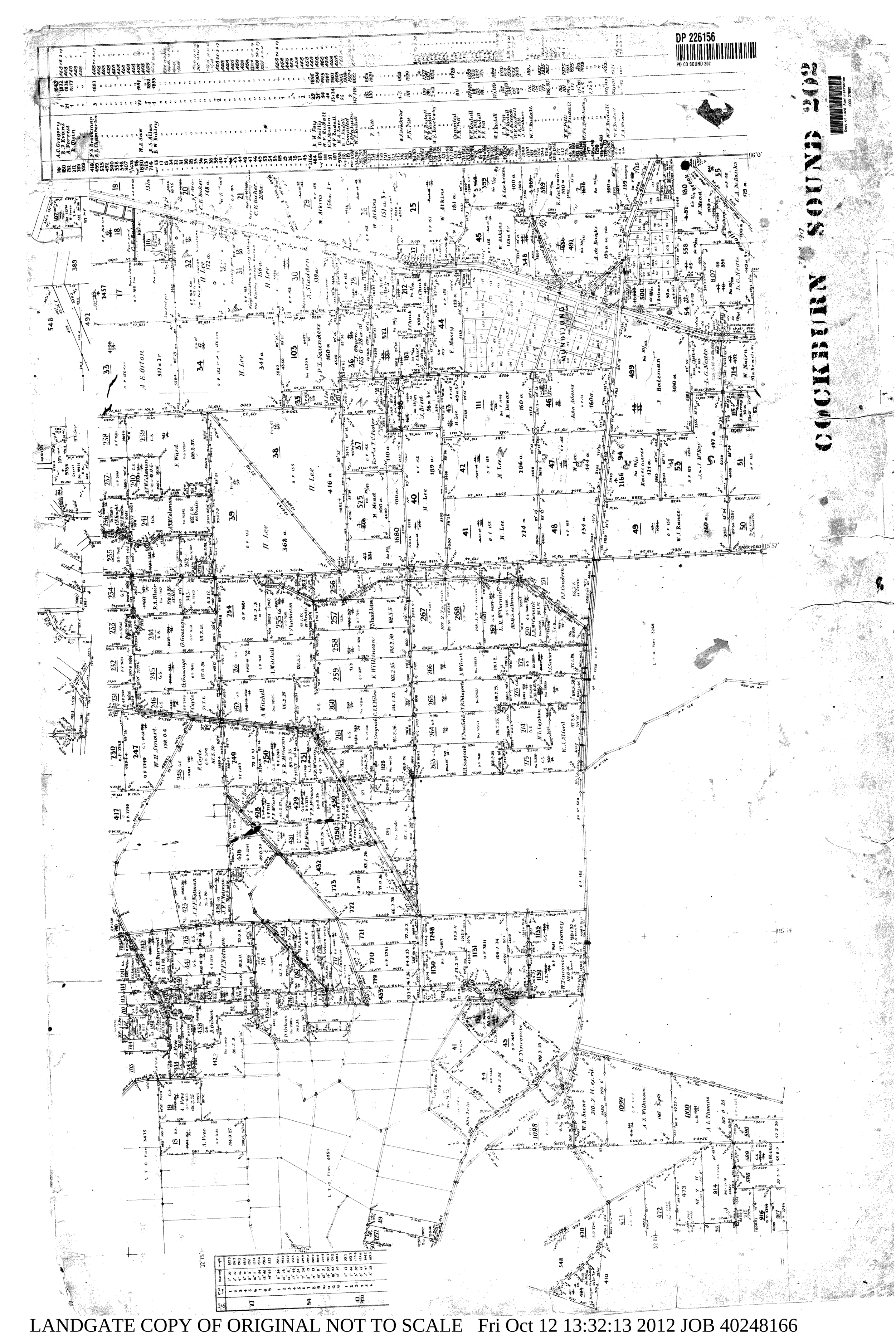
The statements set out below are not intended to be nor should they be relied on as substitutes for inspection of the land and the relevant documents or for local government, legal, surveying or other professional advice.

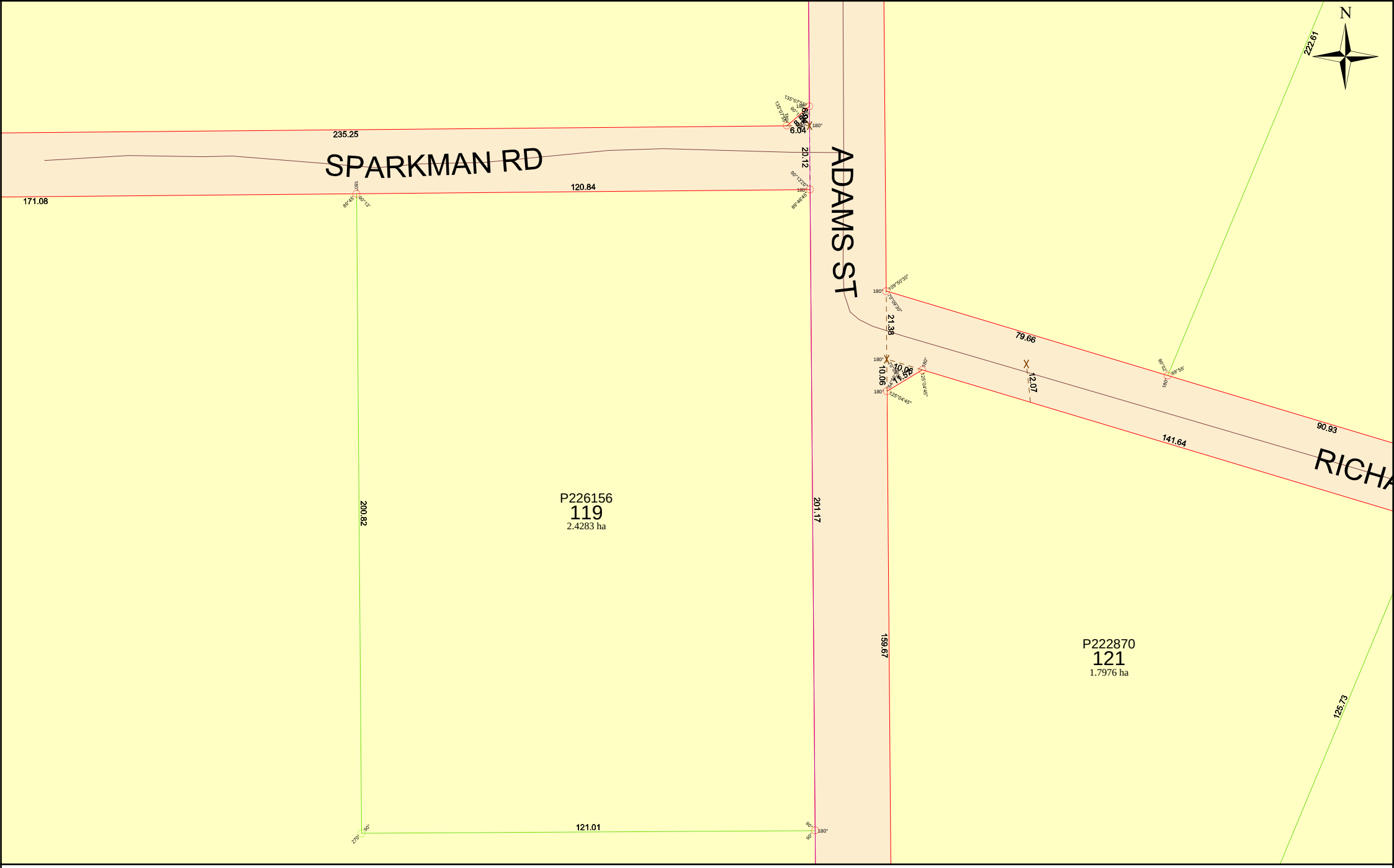
SKETCH OF LAND:	723-99 (119/DP226156).
PREVIOUS TITLE:	This Title.
PROPERTY STREET ADDRESS:	LOT 119 SPARKMAN RD, MUNDIJONG.
LOCAL GOVERNMENT AREA:	SHIRE OF SERPENTINE-JARRAHDALE.

NOTE 1:	A000001A	LAND PARCEL IDENTIFIER OF SERPENTINE AGRICULTURAL AREA LOT 119 (OR THE PART THEREOF) ON SUPERSEDED PAPER CERTIFICATE OF TITLE CHANGED TO LOT 119 ON DEPOSITED PLAN 226156 ON 01-JUN-02 TO ENABLE ISSUE OF A DIGITAL CERTIFICATE OF TITLE.
NOTE 2:		THE ABOVE NOTE MAY NOT BE SHOWN ON THE SUPERSEDED PAPER CERTIFICATE OF TITLE OR ON THE CURRENT EDITION OF DUPLICATE CERTIFICATE OF TITLE.

DP 226156

PD CO SOUND 202





Scale : 1:1250 (Geographical)
MGA : SW=403473.5E,6426761.3N Zone 50 / NE=403842.2E,6427036.2N Zone 50
Lat/Long : 115°58'29.410", -32°17'30.386" / 115°58'43.605", -32°17'21.573" H 184mm by W 297mm

Printed : 15:27 Fri 12/Oct/2012

APPENDIX 3
LPP24 SCHEDULE 1 (DESIGNING OUT CRIME TOOLBOX)

DESIGNING OUT CRIME TOOLBOX – SCHEDULE 1

Applicant: Taylor Burrell Barnett
Address: 187 Roberts Road, Subiaco
Proposed Development: LSP – Mundijong-Whitby Sub-Precinct E2
Contact: Sarah Davies
Email: sarah@tbbplanning.com.au
Telephone number: 08 9382 2911

Authorised Signature: 

Date: 22-08-2013

	Item	Submission Developer Comments	Assessment Compliance	Assessment Comment
1.0	**Natural Surveillance** Objectives: • To encourage surveillance of spaces from surrounding buildings and land uses; and • To improve surveillance of spaces through increased legitimate uses			
1.1	Blind corners and problem areas • Avoid blind corners in pathways, stairways, corridors, hallways, near toilets and car parks • Avoid sudden changes of grade on pathways • Ensure through visibility in tunnels and underpasses • Consider the use of hardware such as mirrors to improve • existing situations • Avoid or minimise the effect of barriers on pathways	Road network will be designed to avoid blind corners. There will be no barriers on future pathways. Greatest density housing overlooking POS to maximise eyes on the park. The concept Masterplan has been design to minimise blind corners and problem areas. The future Plan of Subdivision and Landscape Plan will be designed to avoid blind corners		

	Item	Submission Developer Comments	Assessment Compliance	Assessment Comment
		and other related issues within streets and POS.		
1.2	Communal or public areas • Provide natural surveillance from activity land uses and activity rooms for communal and public areas • Establish community focal points at locations where surveillance is essential • Ensure public shelters do not impede surveillance • Co-locate movement systems to encourage surveillance in public areas • Encourage mixed uses to extend hours of surveillance, ensuring compatible uses and avoiding conflicting uses	POS will generally be surrounded by roads to provide opportunity for passive surveillance. The main central POS has significant frontage to the main proposed north/south neighbourhood connector and to the extension of Cockram Street providing good opportunity for passive surveillance. Dwellings surrounding POS will be oriented to overlook the POS. Primary school and shared use oval in central location with surveillance from surrounding properties.		
1.3	Entrances • Provide entries which are clearly visible.	Future building entries will be clearly visible.		
1.4	Fencing • Fence design should maximise natural surveillance from the street to the building, building to the street, and minimise opportunities for intruders to hide.	Detailed design will have regard to safe fence design.		
1.5	Landscaping • Avoid landscaping which obstructs surveillance, serves as a barrier to unimpeded views and allows intruders to hide.	Detailed design will have regard to using plant species which do not obstruct surveillance or views.		
2.0	**Urban structure** • To promote definition of use and ownership; • To promote attractive, legible and well orientated	The concept Masterplan shows a well defined urban structure including a legible street layout and a connected Public Open Space		

	Item	Submission Developer Comments	Assessment Compliance	Assessment Comment
	development; • To facilitate safe and efficient movement of vehicles, • cyclists and pedestrians; and • To facilitate safe and convenient locations for recreation, work and home.	network overlooked by dwellings.		
2.1	Local context • Scale, sighting, orientation and connections should take into account the local context of local topography, other land uses, actual and perceived crime risk and specific project requirements	Site topography, scale and connections to existing and future development and facilities have been key influences on the concept Masterplan design. Future subdivisional roads will be designed to provide for legible movement throughout the LSP area and will be overlooked by dwellings to encourage passive surveillance. Roads will provide connection to adjoining existing and future developments and local and district facilities beyond. Site topography has informed the road layout which allows for long views/vistas which assist with legibility and the sense of safety. Housed will be oriented to overlook public spaces to provide passive surveillance.		
2.2	Street layout and land division • Consider crime reduction measures in the early stages of design • Define ownership and use of space • Avoid ambiguous space and connections • Promote legibility and orientation • Buildings should be oriented towards the main street frontage and other areas of public realm • Street furniture should facilitate surveillance and	See previous comments. POS areas provide a mix of recreation, passive use and drainage functions. No cul-de-sacs proposed and street network is legible and well connected.		

	Item	Submission Developer Comments	Assessment Compliance	Assessment Comment
	discourage inappropriate use • Cul-de-sacs should be short and straight, allow visibility from one end to the other and not be joined by networks of footpaths that are irregularly used and likely to foster criminal activity • Avoid the establishment of small, unusable pockets of land and open space as they are difficult to maintain and do not facilitate recreation			
2.3	Movement network • Maximise surveillance of entry and exit points • Base upon primary routes and shared spaces • Minimise confusion about priorities of use on shared paths and access ways • Minimise underused and unnecessarily segregated streets and footpaths • Avoid routes which can become entrapment spots • Provide direct and clearly signed pedestrian, cycle andvehicular links to nearby destinations • Pathways and cycleways to facilitate surveillance • Maximise legibility, sightlines and comfort to encourage use	See previous comments. Concept masterplan movement network is legible and well connected. Road hierarchy is clearly identifiable. Street layout provides clear sightlines throughout the estate. The future landscape management plan will further develop the detail design of the pedestrian and cycle routes.		
2.4	Location of land uses • Minimise opportunities for conflict, especially in mixed use development • Provide active frontages of overlooked streets • Minimise blank walls and sides of buildings onto public open space and public realm	Minimal opportunity for land use conflict given primarily residential land use. Street layout provides for dwellings to address and overlook POS and public realm. Primary school (whist overlooked by residential dwellings) is separated from dwellings by roads and POS.		

	Item	Submission Developer Comments	Assessment Compliance	Assessment Comment
		Dwellings and the primary school will be oriented to overlook public spaces. It is likely future design criteria will require buildings with more than one road frontage to appropriately address both the primary and secondary streets.		
2.5	Regeneration and remodelling • Minimise dereliction, under- utilised and under maintained spaces and places • All open space should be well defined and purposeful • Vulnerable public spaces should become more liveable or be removed from public ownership	Central POS will be highly utilised with co-location of primary school and oval. Central active POS area defined by road network and will be designed to cater for a number of recreation uses (passive and active) to attract different users.		
3.0	**Land use mix** • To create a mix of uses, which promote extended surveillance and which are compatible with adjacent uses.			
3.1	Land use layout • Encourage mixes that promote activity, surveillance and legitimate contact between people • Avoid strict separation of compatible land uses that may result in isolation of buildings or spaces • Encourage mixes which are compatible in scale and neighbouring uses, particularly in isolated areas	Large, central park created as a focus for community life. LSP proposes a mix of residential densities and centrally located primary school. Uses are compatible with surrounding residential development.		
3.2	Access • Encourage pedestrian passage through or activity at ground level to promote surveillance	Streets will be provided with footpaths and the linear POS system will provide a pleasant walking environment to encourage pedestrian movement. Ensuring streets and POS are overlooked by dwellings will assist		

	Item	Submission Developer Comments	Assessment Compliance	Assessment Comment
		with passive surveillance.		
4.0	**Activity generators** • To promote surveillance; • To promote a wide range of legitimate activities; and • To promote community ownership and increased use of public spaces.			
4.1	Land use Layout • Locate around active edges or fringes of space to create surveillance opportunities	Dwellings and primary school will be oriented towards public spaces.		
4.2	Activity mix • Balance activities which may be crime generators such as bars, night time uses, restaurants and entertainment venues in terms of scale, size and local context	The LSP contemplates uses in accordance with the “Residential” zone including a primary school.		
4.3	Access • Encourage movement networks which provide surveillance without creating barriers	Most of the future roads within the LSP area will be local access streets which will provide a legible street network without creating barriers. The neighbourhood connector will provide for important movement through the site as well as providing access to the central POS and primary school. This road will be designed to allow for safe crossing. The neighbourhood connector is adjoined by POS and overlooked by smaller lot product – it is integrated within the urban structure, rather than being a barrier through the site.		
5.0	**Building design, including boundary definition** • To integrate public buildings into the wider public realm;			

	Item	Submission Developer Comments	Assessment Compliance	Assessment Comment
	• To use buildings to support surveillance of the public realm and public spaces; • To use construction materials which reduce temptations to vandalise and graffiti; and • To reduce the risk of public buildings contributing to crime and safety problems.			
5.1	Building entrances • Ensure entrances are oriented to face open or active spaces • Ensure entrances are clearly defined, distinguishable form public walkways, secure and well lit • Design lobbies to be visible from the exterior so that entry and exits spaces can be seen • Avoid creating entrapment spots or places where intruders may loiter or be concealed • Avoid locating ramped and elevator entrances and lifts in isolated locations • Secure non pedestrian entrances from illegal entry • Ensure staff entrances are well lit and allow maximumsurveillance and sightlines	The primary school will be integrated into the wider public realm with co-location with central POS area. We understand the Department of Education will design the future primary school to its specifications, ensuring a safe design. Entrances will be visible from public spaces.		
5.2	Building design • Consider crime reduction measures in the early stages of • esign • Minimise blank walls overlooking parks, car parks and other public areas • Minimise features or structures that can be used as natural ladders to gain access to higher levels, windows or doors • Optimise the variety of building design to create interesting built environments	Future development will be required to avoid blank walls overlooking parks and other public spaces.		

	Item	Submission Developer Comments	Assessment Compliance	Assessment Comment
	• Provide windows to overlook public areas			
5.3	Materials and fixtures • Avoid materials and exterior fixtures which might encourage crime • Use transparent and materials in doors and walls at major entry points	Materials and fixtures to be determined at detailed design stage and will have regard to not encouraging crime.		
5.4	Storage areas • Ensure surveillance and illumination of loading and storage areas • Locate delivery hatches, bins and other service facilities in a manner which does not create natural ladders or entrapment spaces	Storage area be considered at detailed design stage at the time of a specific development proposal.		
5.5	Retail commercial frontages • Promote after hours uses in frontage locations where public buildings front public spaces	No retail/commercial uses proposed.		
5.6	Sightlines • Provide clear sightlines	The indicative Masterplan allows for clear sightlines along public roads and between buildings and public spaces.		
5.7	Lighting • Illuminate entries so that access and egress visibility is maximised • Facilitate good interior to exterior surveillance through Illumination	To be considered at detailed design stage. Lighting will be designed to provide appropriate visibility and illumination.		
5.8	Employee car parking • Ensure safe and secure parking for employees near the building entry	Primary school parking areas will be designed by the Department of Education to its safety standards.		

	Item	Submission Developer Comments	Assessment Compliance	Assessment Comment
	• Provide surveillance of car parking			
5.9	Landscaping • Ensure landscape design will not provide concealment or entrapment areas • Optimise the variety of landscape to create interesting built environments	The indicative landscape concept plan illustrates the intent to provide interesting public open spaces that provide for a variety of recreational activities and contribute to the amenity of the urban area in terms of its visual appeal and safety. Future detailed landscaping design will have regard to safety and amenity and will be determined at the detailed design stage.		
5.10	Building security • Secure all windows, particularly at street level but ensure that security devices do not create a “fortress like” appearance.	To be considered at the building design stage of development.		
6.0	**Lighting** • To promote legitimate activity by users of public spaces after dark; • To encourage the use of appropriate lighting fixtures; and • To ensure the appropriate placement of lighting.	To be determined at detailed design. Lighting will be provided in public open spaces.		
6.1	Situational lighting • Ensure lighting is an early consideration in site planning and design • Select lighting appropriate to local context • Ensure inset spaces, access, egress and signage are well lit • Provide adequate lighting for directional signage	To be determined at detailed design. Will have regard to situational lighting.		

	Item	Submission Developer Comments	Assessment Compliance	Assessment Comment
6.2	Consistency of lighting • Maximise opportunities for natural light penetration • Provide consistent levels of lighting to reduce contrast and shadow • Ensure lighting supports visibility • Consider energy use	To be determined at detailed design. Will have regard to consistency of lighting.		
6.3	Placement of lighting • Select and light safe routes and spaces • Avoid placement in areas shielded by vegetation, awnings and other physical barriers • Avoid unshielded lighting at eye level • Consider light pollution • Ensure lighting falls upon the subject matter • Avoid lighting areas not intended for night time use • Consider lighting in terms of vulnerable groups, elderly, people with disabilities, children, women, night staff • Avoid creating natural ladders with lighting fixtures	To be determined at detailed design. Will have regard to appropriate lighting placement.		
6.4	Types of lighting • Install vandal resistant lighting • Avoid dependence on bollard lighting as the only light source • Combine lighting along footpaths with entrance lighting wherever possible	To be determined at detailed design, Will have regard to types of lighting that discourages vandalism.		
6.5	Maintenance • Ensure light fixtures are routinely and rapidly maintained • Consider public notices regarding maintenance contact details	Maintenance requirements to be considered at the detailed design stage.		

	Item	Submission Developer Comments	Assessment Compliance	Assessment Comment
7.0	**Landscape** • To balance the needs of the environment with those of user groups; • To support ease of maintenance; and • To support and reinforce principles such as surveillance, sightlines, legibility and orientation through compatible selection and placement of appropriate species and materials			
7.1	Footpath planting • Should improve amenity • Ensure shrubbery and planting is of low to medium level and does not impede sightlines, surveillance, security and way finding • Non concealing trees for selected locations should not encourage climbing and should be placed to avoid clumping • Avoid planting screening signage and lighting	The indicative landscaping concept included in Part 2 of the LSP intends to provide a safe functional and attractive environment through planting and landscape design. Specific landscaping will be determined at the detailed design stage.		
7.2	Wall planting • Grade planting with taller plants next to walls.	See comment above.		
7.3	Entrance planting • Avoid planting screening doorways, entrances and windows	See comment above.		
7.4	Maintenance • Carefully locate climbing plants to deter graffiti and vandalism • Specify high quality plants for long, low maintenance life	See comment above.		

	Item	Submission Developer Comments	Assessment Compliance	Assessment Comment
7.5	Hard landscaping • Select low maintenance, long life materials appropriate to the local context, level and type of use • Use details to identify public and private space and access ways for pedestrian, cycle and vehicular movement.	See comment above.		
8.0	**Management and Maintenance** • To discourage graffiti and vandalism by reducing blank canvases. • To facilitate prompt reporting of any damage; • To ensure prompt maintenance and repairs; and • To promote the perception of a well cared for area.			
8.1	Maintenance • Identify emergency contacts for maintenance in public locations • Promptly repair damage • Consider preventative maintenance			
8.2	Materials • Use secure and enclosed service points • Specify materials that can withstand normal hard use and be easily replaced • Provide protective heavy duty coatings in public areas and vulnerable hot spots • Avoid the use of highly vulnerable and flimsy materials and fittings which can be easily vandalised or removed in open locations • Avoid extensive and prolonged use of problem materials such as heavy duty mesh, cyclone fencing and grilles which may encourage wilful damage • Avoid long expanses of non permeable walls unless there	Materials and maintenance to be determined at detailed design stage. Will have regard to quality and durability of materials.		

	Item	Submission Developer Comments	Assessment Compliance	Assessment Comment
	is extensive public surveillance			
8.3	Security education and coordination • Consider training programs and reporting systems in conjunction with the Police and Office of Crime Prevention			
9.0	**Sightlines and way finding** • To provide unimpeded sightlines, particularly along pedestrian pathways.			
9.1	Sightlines • Avoid the use of gradients or changes in direction which impede sightlines, especially on pathways, stairs or enclosed spaces • Avoid landscape materials acting as a screen or barrier to unimpeded views of pathways • Ensure that pedestrians have a clear view ahead • Improve the sightlines in established areas through a reconsideration of routes, times of access and additional hardware such as appropriate security mirrors	See previous comments. Pathways and road network layout will provide appropriate sightlines. Landscaping detail will have regard to view lines.		
9.2	Way finding • Signage should identify where assistance and key areas can be located such as taxi ranks, toilets, public transport and telephones • Signage should be visible, concise and easily maintained • Use environmental cues such as changes in footpath materials, levels of lighting and appropriate changes in grade or elevation	To be determined at detailed design. Directional signage will be provided as necessary and appropriately located.		

	Item	Submission Developer Comments	Assessment Compliance	Assessment Comment
	• Use appropriate physical barriers (permeable fences) and symbolic barriers (low vegetation) to define use and ownership			
10.0	**Signage** • To provide adequate, easily legible signage to assist all user groups, particularly young people, older people and people with disabilities to find their way safely; and to provide signage which indicates safe places and routes.	Signage to be determined at detailed design stage. Consideration will be given to sign legibility.		
10.1	Provision of signage • Prepare a signage plan focussing on safe routes, destinations, facilities and amenities en route • Ensure signage is easily legible at all hours • Locate signage strategically, at crossing points, junctions, activity places and other common areas • Indicate where to go for assistance • Provide maps in large public open spaces and orientate maps to be consistent with the viewers direction			
10.2	Maintenance • Ensure key public signage is not obscured by mature landscape, awnings, poor lighting, too many commercial signs and vandalism • Consider reporting contacts and the process for emergency maintenance	Detailed landscaping design will have regard to views of signage.		
11.0	**Predictable routes and spaces safe from entrapment** • To reduce the risk of attack by hidden persons; • To eliminate possible entrapment places; and • To ensure the location and design of facilities such as telephones and automatic teller machines do not create			

	Item	Submission Developer Comments	Assessment Compliance	Assessment Comment
	entrapment spaces.			
11.1	Entrapment spots adjacent to pedestrian and cycle routes • Avoid creating entrapment spots adjacent to a main pedestrian and or cycle route, a predictable and or unchangeable path or a private dead end alleyway In established areas consider additional facilities such as lighting, improved maintenance or uses such as a kiosk or vendors to make spaces safer • Consider appropriate target hardening of storage areas, loading docks or other potential entrapment spots after hours in order to limit access • Arrange for regular security or police patrols	Pedestrian and cycle routes will be legible and clearly defined. Paths will be part of an integrated network with no dead-ends or alley ways. Passive surveillance of paths will be facilitated through orientation of dwellings to overlook POS and location of roads along POS. Paths will travel through the central public open space.		
11.2	Location of facilities • Locate entrances to automatic teller machines and other facilities within direct view of pedestrian paths • Locate car parking away from potential entrapment spaces • Ensure signs do not create entrapment spots	Matter for consideration at detailed design stage.		
12.0	**Civic and Town Centres** • To ensure safe and easy movement between uses; • To balance the mix of uses with selective night time uses in safe and accessible locations; and • To encourage increased use and activity.	No civic or town centres proposed. See previous comments regarding activity, location and paths, public open spaces and design for safety.		
12.1	Street level activity • Encourage commercial uses with extended trading hours to open onto the street • Ensure outdoor public areas and parks are at street level,			

	Item	Submission Developer Comments	Assessment Compliance	Assessment Comment
	or encourage balconies			
12.2	Entrapment spaces • Ensure that alleyways and loading docks are well lit and secure after hours • Ensure that building set backs do not introduce dead zones and entrapment spaces			
12.3	Balancing land uses • Ensure pedestrian access between residential and activity precincts is well lit at all times • Encourage a range of activity times			
12.4	Safe access routes • Design safe access to activity zones, public transport and parking facilities • Provide direct pedestrian access to buildings from the front street rather than the side or rear			
12.5	Well located facilities • Locate public telephones, toilets, public transport and automatic teller machines in locations with good surveillance			
12.6	Maintenance • Ensure all outdoor public areas are well maintained			
13.0	**Shopping, commercial, health and education centres** • Provide a safe and attractive environment for staff and users; • Provide range of uses suitable for all members of the			

	Item	Submission Developer Comments	Assessment Compliance	Assessment Comment
	community; and • Ensure safe and easy access in and around the centre			
13.1	Design and use • Provide incentives to encourage footpath activities • Explore solutions which avoid the centre 'turning its back on the surrounding streets • Encourage spaces for young people to legitimately congregate • Encourage activities for diverse user groups • Provide secure storage spaces	Primary school centrally located with public open space with shared oval providing for primary school and wider community use. The POS will provide for diverse recreational activities for use by all age groups, including space for organised team sport, cycling, walking, kick around space as well as passive recreation (e.g. picnic space).		
13.2	Car parking • Design large car parks with good sightlines and clear signage • Avoid creating car parks that are too large to adequately manage and keep secure	Future detailed design of car parking will consider appropriate sightlines and security.		
13.4	Public transport • Locate bus and train stops at entrances of buildings rather than on edges of car parks	Future bus stop locations to be determined by PTA. Existing bus route travelling along eastern boundary of LSP area.		
13.5	Landscape • Consider using 'green screens' in areas with high potential for graffiti • Avoid creating entrapment spaces	For consideration at the detailed design stage.		
13.6	Maintenance • Remove obsolete and superfluous street furniture • Redevelop underused spaces	N/A site currently vacant.		

	Item	Submission Developer Comments	Assessment Compliance	Assessment Comment
13.7	Community participation • Involve the community in the design, construction, renewal and refurbishment of community facilities	Site vacant, no refurbishment proposed.		
14.0	**Parks and Public Open Space** • To encourage legitimate use by a wide range of users; • Ensure the design does not create unsafe or dead environments; and • Ensure appropriate plan selection, materials and lighting to reduce opportunities for crime			
14.1	Design and use • Locate where it can be surrounded by a mix of land use to generate activity over acceptable extended hours • Foster legibility, orientation and amenity • Consider water safety • Consider the relationship of users to adjacent private spaces for surveillance purposes and compatibility • Avoid over designing and limiting use and under designing and creating dead zones • Locate youth recreation areas so that they are visible and use access control measures as appropriate • Avoid below grade pathways • Ensure parks are visible from the street	Central public open space co-located with primary school and surrounding houses oriented towards POS.		
14.2	Lighting • Ensure adequate lighting of path ways, activity zones and signage	The future landscaping detailed design will provide for paths and POS to be adequately lighted.		
14.3	Maintenance • Ensure regular maintenance	Maintenance of parks and POS to be addressed at detailed design stage via the landscape management plan (or similar).		

	Item	Submission Developer Comments	Assessment Compliance	Assessment Comment
14.4	Community involvement • Promote community use and ownership	Community use of central park encouraged through co-location of primary school and oval.		
15.0	**Car parks, including grade and multi-storey** • To encourage car park design which assists all users to easily identify their vehicles; • To increase safety through optimising visibility and clear sightlines; • To encourage surveillance from surrounding land uses; and • To provide safe access to and from car parks.			
15.1	Car park size • Should be as small a size as possible or divided into smaller sections • Avoid large expanses of car parking which may act as barriers and create surveillance issues	Future car parking will be designed to be appropriately sized to meet safety requirements.		
15.2	Design • Integrate complementary and active land uses near car parks to prevent isolation • Clearly identify pedestrian routes in car parks	Future car parks will be related to the primary school use.		
15.3	Surveillance • Encourage surveillance of multi-storey or interior car parks through placement of windows and land uses to overlook • Exterior should be overlooked from the street	No interior or multi-storey car parks currently proposed.		
15.4	Access • Access points should be visible from every car parking space	Design of future car parks will ensure access points are clearly visible. Pedestrian accesses will be adequately		

	Item	Submission Developer Comments	Assessment Compliance	Assessment Comment
	• Ensure all paths to and from car parks have appropriate landscaping, lighting, signage and sightlines • Limit unauthorized entry points from the street • Ensure street level entry and exit points have maximum surveillance from adjacent uses during hours of operation • Where appropriate encourage on-street parking	lighted, landscaped and signed.		
15.5	Pedestrian routes • Pedestrian routes should be integrated into a walkway system • Safe routes make illegitimate use more obvious	Design of future car parks will include pedestrian pathways to provide access from car parks to building entrances and wider walkway network.		
15.6	Sightlines • Maximise sightlines • Limit support pillars which may obscure sightlines • Consider glazing and open design at access points, lifts and stairwells • Use vandal proof security mirrors as appropriate	Noted for future design of car parks.		
15.7	Lighting • Maximise consistent lighting for access, egress, orientation, surveillance and sightlines during all operational hours • Illuminate parking bays and circulation routes	Lighting to be determined at stage by detailed design. Access points will be adequately lighted during operational hours.		
15.8	Landscape • Consider landscape which provides the widest possible views from the street of access and egress points	Landscape detail to be determined during detailed design – will have regard to maintaining views from the street.		
15.9	Signage • Ensure adequate signage for orientation, emergency	Signage locations to be determined at detailed design stage.		

	Item	Submission Developer Comments	Assessment Compliance	Assessment Comment
	contacts and security			
15.10	Facilities • Locate facilities such as toilets, seating and telephones in safe locations where the opportunity to loiter is minimized	Location of facilities to be determined at stage of detailed design.		
15.11	Management • Consider regular security patrols or security personnel	Management of car parks to be considered at development stage.		
16.0	**Transit stations, including bus stops and taxi ranks** • To maximise the use of public transport by a wide range of people over extended operational hours; • To encourage all users to feel safe by increasing safety provisions; and • To promote surveillance.	To be determined at detailed design stage.		
16.1	Location • Avoid locating stations, interchanges and stops in isolated, derelict or underused locations including vacant land, car parks, alleys, wide set back zones and possible entrapment spots • Avoid locating entries and stops at different levels from the main activity zone to avoid isolation and reduced surveillance • Ensure short, safe routes to and from stations, interchanges and stops, especially near night time venues	To be determined at detailed design stage		
16.2	Access • Ensure access to and from public transport and other	To be determined at detailed design stage		

	Item	Submission Developer Comments	Assessment Compliance	Assessment Comment
	modes of transport and destinations is as direct, safe and universally accessible as possible			
16.3	Surveillance • Maximise surveillance opportunities • Consider risk assessment in established problem areas • Consider congestion as well as isolation factors	To be determined at detailed design stage		
16.4	Sightlines and visibility • Remove or ameliorate hard and soft structures which block sightlines or provide hiding places • Design attractive landscape at stations, interchanges and stops of an appropriate scale and robust, low maintenance quality	To be determined at detailed design stage		
16.5	Entrapment • Design and redevelop structures to reduce the risk of entrapment and to improve sightlines	To be determined at detailed design stage		
16.6	Signage • Provide adequate, easy to find, vandal proof signage for all user groups to assist orientation • Ensure signage provides up to date information including emergency contact details	To be determined at detailed design stage		
16.7	Design and maintenance • Ensure private, public and transition zones and uses are clearly understood • Design with graffiti resistant, vandal resistant materials wherever possible • Ensure well maintained public realm and facilities	To be determined at detailed design stage		

	Item	Submission Developer Comments	Assessment Compliance	Assessment Comment
16.8	Lighting • Ensure areas adjacent are appropriately illuminated (limit shadow and contrast) and protected from weather	To be determined at detailed design stage		
16.9	Other facilities • Ensure associated telephones, automatic teller machines, toilets and ticket machines are located near active frontages	To be determined at detailed design stage		
17.0	**Public toilets** • To ensure safety for all people using public toilets; • To maximise surveillance opportunities in the location of public facilities; and • To ensure prompt and effective maintenance.	To be determined at detailed design stage		
17.1	Location • Locate adjacent to high traffic and legitimate activity areas, rather than in isolation • Avoid designing in loitering opportunities such as seating, telephones, automatic teller machines which are too close or entrapment spaces such as storage, utility recesses or underused access ways • Consider relocating public toilets which are in established unsafe locations	To be determined at detailed design stage		
17.2	Surveillance • Ensure approaches and entrances to all toilets in all locations are highly visible so that people cannot loiter or enter without being seen • Ensure adequate lighting	To be determined at detailed design stage		

	Item	Submission Developer Comments	Assessment Compliance	Assessment Comment
17.3	Access • Ensure adequate signage • Ensure doors/windows can be secured only by legitimate key holder to reduce the danger of entrapment	To be determined at detailed design stage		
17.4	Maintenance • Ensure facilities are as vandal proof as possible, well maintained and promptly repaired	To be determined at detailed design stage		
18.0	**Pedestrian routes, laneways, alleyways and access ways** • Design to maximise safe pedestrian and cyclist linkages, especially at night; and • Design to encourage legitimate activity.			
18.1	Location • Locate to enhance other designing out crime initiatives • Locate as part of a collector system • Locate for views of activity as well as safety and security	Pedestrian and cycle linkages will be provided throughout the LSP area including POS areas.		
18.2	Design • Provide an attractive, convenient variety of options for diverse user groups • Avoid designing in areas where little pedestrian traffic is expected • Consider appropriate closure techniques and alternative uses to remove unsafe parts of an existing network • Avoid dead ends • Consider the needs of user groups sharing the movement network	Shared paths will be provided through the area as part of an integrated pathway network. The network will be designed to cater for recreational users as well as providing routes between destinations. There will be no paths leading to dead ends.		
18.3	Surveillance • Ensure routes do not violate privacy whilst providing	Pedestrian routes will be provided within roads overlooks by houses, paths through		

	Item	Submission Developer Comments	Assessment Compliance	Assessment Comment
	surveillance • Encourage appropriate surveillance especially in open space areas	POS will be adequately surveilled.		
18.4	Sightlines • Identify priorities for lighting	Location of lighting to be determined at stage of detailed design.		
18.5	Lighting • Align lighting and pathways • Align lighting and landscape	Location of lighting to be determined at stage of detailed design.		
18.6	Access • Provide direct access routes to and from destinations • Avoid designing in opportunities for short cuts • Provide a visible exit point • Provide secure cycle parking where appropriate • Ensure barrier free access • Provide clear edge definition	Paths will be designed to provide an integrated network for recreational users as well as providing routes between destinations, e.g. paths will provide direct routes between the surrounding residential area and the central park and primary school. All paths will be linked and without barriers. Bicycle parking will be considered at the detailed design stage in appropriate locations.		
18.7	Orientation • Design to enhance recognition of movement network during hours of use • Provide appropriate and vandal proof directional signage, maps and materials	Pedestrian paths will be provided along the road network. Directional signage to be determined at stage of detailed design.		
18.8	Maintenance • Ensure private, public and transition zones and uses are clearly understood • Design with graffiti resistant, vandal resistant materials wherever possible • Ensure well maintained public areas and facilities	Private and public zones to be clearly identified. Maintenance of public area and facilities to be determined at detailed design stage.		

	Item	Submission Developer Comments	Assessment Compliance	Assessment Comment
19.0	**Pedestrian overpasses and underpasses** • Balance the needs of road safety with community safety needs; and • Ensure design of underpasses and overpasses reduce opportunities for crime.	No overpasses or underpasses proposed		
19.1	Design • Avoid predictable or unchangeable routes • Avoid designing in claustrophobic spaces • Reduce opportunities for inappropriate activity • Design for easy and affordable maintenance • Maximise natural light and ventilation • Ensure direct sightlines • Avoid recesses • Maximise width and passing spaces	No overpasses or underpasses proposed		
19.2	Access • Avoid access to places closed at night	No overpasses or underpasses proposed		
19.3	Lighting • Ensure adequate, vandal proof lighting	No overpasses or underpasses proposed		
19.4	Maintenance • Ensure adequate drainage for maintenance • Maintain a safe and clean environment	No overpasses or underpasses proposed		

APPENDIX 4
ENVIRONMENTAL ASSESSMENT REPORT

LOT 50 MUNDIJONG ROAD MUNDIJONG

ENVIRONMENTAL ASSESSMENT REPORT

Prepared for:	Peet Mundijong Syndicate
Report Date:	16 October 2012
Version:	1
Report No.	2012-48

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CONTENTS

LIST OF ATTACHMENTS

Tables

Plates

Figures

Appendices

1 INTRODUCTION

1.1 Background

Peet Limited is proposing to develop Lot 50 Mundijong Road, Mundijong (the site) for urban purposes in accordance with its zoning. The Site is located in the Shire of Serpentine - Jarrahdale (the Shire) located 45km south east of the Perth Central Business District (Figure 1).

The Site is approximately 42ha in size and is bound by Mundijong Road to the south, the future Tonkin Highway to the west, Sparkman Road to the north and Adams Street to the east (Figure 2). The Bush Forever Site No. 360 occurs in the Mundijong Road reserve and abuts the southern boundary of Lot 50.

The Site is zoned “Urban” under the Metropolitan Region Scheme and “Urban Development” in the Shire Town Planning Scheme No. 2 (TPS 2).

1.2 Mundijong Whitby District Structure Plan

The Mundijong Whitby District Structure Plan (DSP) which guides the future development of the Mundijong – Whitby area including the site was approved by the Western Australian Planning Commission (WAPC) in April 2011. The Mundijong Whitby DSP was adopted by the Shire in August 2011 and to provide overall guidance to the structure, vision and objectives for the planning and development of Mundijong Whitby. The DSP contains a number of Precincts and defines a framework by which urban development can occur in a coordinated manner. The LSP is situated within Precinct E of the DSP

The DSP has been used as a guide in the preparation of the more detailed LSP. The DSP predominantly dealt with district level issues such as:

- Biodiversity;
- Landscape Protection;
- Appropriate management of water quality and maintenance of hydrology;
- Efficient use and re-use of water;
- Responsive built form outcomes, sense of place, and community identity and character;
- Providing for alternative modes of transport;
- Climate responsive design and energy efficiency;
- Economic prosperity ; and
- Community well-being.

SMEC (2009) prepared on behalf of the Shire an Environmental Study for the Mundijong Whitby DSP. The environmental study of the Mundijong Whitby area identified a series of potential environmental impacts associated with the proposed development of the area, as well as a series of broad management recommendations.

1.3 Scope of Work

A Local Structure Plan (LSP) is being prepared by Peet Limited to further guide the development of the site. This Environmental Assessment Report has been prepared to assist in the preparation of an environmentally responsible LSP in keeping with the owner's vision for the Site and the requirements of the DSP.

Much of the environmental work to date has been based on desktop assessment. The following more detailed work was undertaken to identify any site specific environmental issues to assist in the preparation of the LSP. The detailed work included the following:

- Level 2 Flora Survey;
    - Desktop search and review of DEC's Declared Rare and Priority Flora database;
    - Threatened Ecological Communities database;
    - Examination of recent aerial photography and contour maps to provisionally identify
    - vegetation types and condition;
    - Field survey in spring (September to October in this area) using plots or quadrats to record
    - native and introduced species as well as a thorough site walkover of any areas of native
    - vegetation;
    - Recording of any significant plant species using a hand-held GPS;
    - Description and mapping of vegetation types and vegetation condition;
    - Compilation of a flora list; and
    - Preparation of a stand-alone report,
- Level 1 Fauna Survey:
    - Desktop search and review of DEC's Threatened Fauna database and the Commonwealth;
    - EPBC Act Listed Fauna;
    - Field survey to identify fauna habitat types and quality;
    - Assessment of the potential habitat value for the three species of Black Cockatoo (Carnaby's,
    - Baudin's and Forest Red-tail). This will include searching for evidence of foraging, nesting
    - and measurement of individual large trees for their diameter;
    - Description and mapping of fauna habitat and potential Black Cockatoo habitat areas; and
    - Preparation of a report.

On completion of the field studies an Environmental Assessment Report (this Report) has been prepared to describe the environmental attributes, opportunities and constraints for the site and will assess the environmental impact of the LSP. Advice on the potential impact of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* is also included.

2 EXISTING ENVIRONMENT

2.1 Land Use

The Site has historically been cleared for agricultural purposes and does not contain any remnant native vegetation. There are a few isolated mature native trees over pasture and a pocket of cultivated C*asuarina obesa* on the northern boundary.

The Site is currently used for grazing with some farm infrastructure located on the central eastern boundary (Figure 4).

2.2 Topography

The Site gently slopes from east to west with elevations ranging from approximately 31m AHD to 26m AHD (Figure 4).

2.3 Landform and Soils

The site is located on the eastern side of the Swan Coastal Plain. The Swan Coastal Plain is generally flat and is approximately 20 to 30 kilometres wide, consisting of a series of geomorphic entities running parallel to the coastline.

The site is situated primarily in the Bassendean System, with the south east portion within the Pinjarra Plain System. The description of these systems and related sub-soil phases is provided in Table 1.

Table 1: Soil Landscape Systems Found Within the Site

Reference	Description
Bassendean Dune System	Very low relief, leached, grey siliceous Pleistocene sand dunes, intervening sandy and clayey swamps and gently undulating plains. These occur immediately west of, and partly overlie, the Pinjarra Plain. Topography becomes more subdued from west to east.
B1 Phase	Extremely low to very low relief dunes, undulating sandplain and discrete sand rises with deep bleached grey sands sometimes with a pale yellow B horizon or a weak iron-organic hardpan at depths generally greater than 2m; Banksia dominant.
B6 Phase	Imperfectly drained sandplain and broad extremely low rises. Deep or very deep grey siliceous sands.
Pinjarra Plain System	Broad low relief plain west of the foothills, comprising predominantly Pleistocene fluvial sediments and some Holocene alluvium associated with major current drainage systems. Major soils are naturally poorly drained and many swamps occur.

P1b Phase	Flat to very undulating plain with deep acidic mottled yellow duplex (or "effective duplex") soils comprising moderately deep pale sand to sandy loam over clay; imperfectly drained and moderately susceptible to salinity in limited areas.

2.4 Acid Sulphate Soils

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

The site is mapped in the DEC *Acid Sulphate Risk Map for the Swan Coastal Plain* as having a low to moderate risk of ASS (Landgate, 2012).

2.5 Hydrology

2.5.1 Groundwater

Groundwater flows from east to west across the region, generally following the topography. The Perth Groundwater Atlas (DoW, online) shows a snapshot of groundwater levels as measured in May 2003 (which are an indication of low groundwater levels); showing groundwater levels at the site ranging from 27mAHD in the east to 23mAHD in the west.

Pre-development groundwater levels

Site-specific groundwater monitoring was carried out by Brown Geotechnical & Environmental and Emerson Stewart between September 2008 and August 2011 to obtain information on pre-development groundwater levels and water quality across the LSP area. The monitoring showed that groundwater levels were at their highest in August 2011, and were within 400mm of existing surface levels.

The groundwater tends to perch on the underlying clayey soils, causing large fluctuations of up to 3m between high and low groundwater levels. Towards the western end of the site where the clay materials are within 1m of natural surface, peak groundwater levels are very shallow (within 100mm of existing surface). The eastern end of the site has a greater depth of sand over the underlying clays, which results in a slightly larger natural separation between existing surface and peak groundwater levels (0.5-0.6m).

A comparison of the pre-development monitoring data to nearby long-term DoW monitoring bores showed that the maximum groundwater levels measured in August 2011 were slightly higher than the long-term (25-year) average maximum levels.

2.5.2 Surface water

The site is within the Serpentine River Catchment and lower Serpentine Water allocation sub –area. Surface water in the Shire of Serpentine-Jarrahdale drains to the Serpentine River and ultimately the Peel Harvey Estuary.

Surface runoff from the site is via overland flow from east to west, following the natural topography. There are some very shallow farm drains (approx 0.2 - 0.5m deep) across the site, which help to drain the site.

The Mundijong-Whitby DWMS (GHD, 2010) identified two flow paths which take runoff from upstream catchments east of Adams St through the site. The DWMS estimated the combined flow through the Precinct E1 site from upstream catchments to be approximately 12m^3/s under pre-development conditions (for the critical 100yr ARI event).

Pre-development surface water modelling

Surface runoff from a 390ha catchment discharges through Lot 50 Cockram Street and Lot 7 Adams Street, and due to the relatively flat nature of the site and very shallow existing drains, there is significant interaction between flow paths throughout the catchment. This interaction between several flow paths makes the calculation of pre-development flow rates particularly complex. A 2-dimensional surface water model was developed using XP Storm's 2D module, which allows a more accurate calculation of runoff than a traditional 1-dimensional model. The model showed that there are two main inflow locations to Lot 50, with a total flow rate of 6.9m3/s entering Lot 50 from upstream catchments in the critical 100yr ARI storm event, and the design of the open drains through the multiple use corridors will be designed to accommodate this inflow. The pre-development modelling also showed that 2.0m3/s is generated within the Lot 50 site in a 100yr ARI storm event.

2.6 Wetlands

A significant portion of the site is shown in the DEC *Geomorphic Wetlands of the Swan Coastal Plain* dataset as being a Multiple Use wetland (Figure 6). PGV Environmental confirmed in their vegetation and flora assessment in September 2011 that the site was completely degraded and did not exhibit any significant wetland values and it was correctly classified as Multiple Use.

The *Geomorphic Wetlands of the Swan Coastal Plain* dataset shows a Conservation Category wetland in the Mundijong Road reserve. The road reserve north of Mundijong Road adjacent to the site is very narrow and contains scattered trees over a weedy understorey and does not exhibit any wetland values as shown in Plates 1 and 2. The road reserve on the southern side of Mundijong Road is wider and contains vegetation in better condition and contains some ecological and wetland values.

The DEC Conservation Category wetland boundary within the Mundijong Road reserve has been mapped at a very broad scale and it is most likely that the spatial representation of the wetland is not accurate when considered at a finer scale.

Plate 1: Mundijong Road Looking East

Plate 2: Mundijong Road Looking East

2.6.1 Peel Harvey Estuary

The site is located within the catchment of the Peel-Harvey Estuary. The Peel-Harvey Estuarine system is a valuable water resource under stress from nutrients, particularly phosphorus, draining from the catchment area. Phosphorus is considered the critical nutrient for eutrophication causing algal blooms in the Peel-Harvey Estuary. Current average nutrients for the Peel-Harvey Inlet are estimated at a rate of 15kg of phosphorus/ha per annum and 150kg of nitrogen/ha per annum (Peel-Harvey WSUD Local Planning Policy, 2006). The Estuary has a long history of nutrient enrichment and algal blooms which are a major environmental concern in the region.

2.7 Vegetation and Flora

PGV Environmental undertook a Level 2 Flora survey of the site in October 2011. The Level 2 Flora survey was undertaken in accordance with Guidance Statement 51: *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia.*

The Level 2 Flora Survey included:

- Desktop search and review of Department of Environment and Conservation's Declared Rare and Priority Flora database and Threatened Ecological Communities database;
- Examination of recent aerial photography and contour maps to provisionally identify vegetation types and condition;
- A site walkover to ground truth the results of the desktop study; and
- Advice on the potential for significant species identified in the desktop searched to be present on the site.

As there was no native vegetation in the site, a separate Flora and Vegetation Report has not been produced. The results are provided below.

The vegetation on the site has been historically cleared for rural purposes. The site contains some scattered trees over pasture and weed species. The remaining native species include *Corymbia calophylla* (Marri), *Kingia australis* and *Eucalyptus* rudis (Flooded Gum).

A small triangular stand of planted Sheoaks *(Casuarina obesa)* is located on the northern boundary of the site. Other exotic trees on the site include *Eucalyptus camaldulensis* (River Red Gum) and *Eucalyptus sideroxylon* (Ironbark).

Plate 3: Mature Marri Over Pasture

Plate 4: *Kingia australis* over Pasture

2.7.1 Vegetation Condition

The condition of the vegetation was assessed according to the system devised by Keighery and described in Bush Forever (Government of Western Australia, 2000a). Keighery's condition rating scale ranges from Pristine where the vegetation exhibits no visible signs of disturbance to Completely Degraded where the vegetation structure in no longer intact and without native plant species (Table 2).

Table 2: Vegetation Condition Rating Scale.

Condition	Description
Pristine	Pristine or nearly so, no obvious signs of disturbance.
Excellent	Vegetation structure intact, disturbance affecting individual species and weeds are non-aggressive species.
Very Good	Vegetation structure altered, obvious signs of disturbance. For example, disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
Good	Vegetation structure significantly altered by very obvious signs of multiple disturbance. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
Degraded	Basic vegetation structure severely impacted by disturbance. Scope for regeneration

	but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These are often described as 'parkland cleared' with the flora comprising weed or crop species with isolated native trees or shrubs.

Source: Government of Western Australia, 2000.

The site has been cleared of native vegetation and used for grazing purposes. The site is considered Completely Degraded based on the Bush Forever vegetation condition rating scale.

The remnant mature trees have been assessed and a number have been identified to be retained where possible (Appendix 1).

2.7.2 Conservation Significant Flora

A search of the DEC Threatened Flora Database (DEFL), the WA Herbarium database (WAHerb), the Declared Rare and Priority Flora Species List and the Environment Protection Biodiversity Conservation Act 1999 (EPBC Act) Protected Matters Report indicates that a number of species that are listed as Endangered, Threatened or priority have been located within a 5km radius of the site the results from these database searches are shown in Table 3.

The significant flora species listed in Table 2 are would not occur on the site due to the Completely Degraded condition of the vegetation.

Table 3: Conservation Significant Flora known to occur in the Mundijong Area

Family	Taxa	Status Under Wildlife Conservation Act 1950	Status Under EPBC Act 1999
Apiaceae	*Eryngium pinnatifidum subsp. palustre-*	3	
Apocynaceae	*Parsonsia diaphanophleba*	4	
Aponogetonaceae	*Aponogeton hexatepalus*	4	
Asteraceae	*Millotia tenuifolia*	2	
Asteraceae	*Pithocarpa corymbulosa*	3	
Asteraceae	*Pithocarpa corymbulosa*	3	
Asteraceae	*Trichocline sp. Treeton*	2	
Centrolepidaceae	*Centrolepis caespitosa*	4	E
Cyperaceae	*Cyathochaeta teretifolia*	3	
Cyperaceae	*Schoenus pennisetis*	1	
Cyperaceae	*Tetraria australiensis*	T	

Droseraceae	*Drosera occidentalis*	4	
Ericaceae	*Andersonia audax ms*	T	
Ericaceae	*Andersonia gracilis*		E
Ericaceae	*Andersonia saxatilis ms*	1	
Fabaceae	*Acacia lasiocarpa var. bracteolata*	3	
Fabaceae	*Acacia oncinophylla subsp. oncinophylla*	3	
Fabaceae	*Dillwynia dillwynioides*	3	
Fabaceae	*Jacksonia gracillima*	2	
Goodeniaceae	*Anthotium sp.*	1	
Hemerocallidaceae	*Johnsonia pubescens subsp. cygnorum*	2	
Myrtaceae	*Baeckea sp. Perth Region*	3	
Myrtaceae	*Darwinia foetida*		CE
Myrtaceae	*Eucalyptus balanites*		V
Myrtaceae	*Eucalyptus rudis subsp. cratyantha*	4	
Myrtaceae	*Verticordia lindleyi*	4	
Myrtaceae	*Verticordia plumosa*	T	E
Orchidaceae	*Caladenia huegelii*	T	
Orchidaceae	*Diuris purdiei*	T	
Orchidaceae	*Drakaea elastica*	T	E
Orchidaceae	*Paracaleana gracilicordata*	1	
Orchidaceae	*Paracaleana granitica*	1	
Poaceae	*Austrostipa jacobsiana*	1	
Proteaceae	*Grevillea crowleyae*	2	
Proteaceae	*Grevillea curviloba subsp. incurva*		E
Proteaceae	*Grevillea manglesii subsp. ornithopoda*	2	
Proteaceae	*Synaphea odocoileops*	1	
Proteaceae	*Synaphea sp. Fairbridge Farm*		CE
Proteaceae	*Synaphea sp. Pinjarra Plain*	1	
Proteaceae	*Synaphea sp. Serpentine*	3	
Restionaceae	*Meeboldina decipiens subsp. decipiens*	3	
Stylidiaceae	*Stylidium ireneae*	4	
Stylidiaceae	*Stylidium longitubum*	3	

2.7.3 Conservation Significant Vegetation

A search of the DEC's Threatened (TEC) and Priority Ecological Communities (PEC) database and EPBC Protected Matters conducted for the site indicated that 5 TEC and 5 PECs are present within a 5km radius of the site (Table 4).

Due to the Completely Degraded structure and condition of the vegetation on the site, the TECs and PECs do not occur on the site.

Table 4: Threatened and Priority Ecological Communities known to occur in the Mundijong Area

Ecological Community	Description	Status under the Wildlife Conservation Act	Status under the EPBC Act
SCP20b	*Banksia attenuata* and/or *Eucalyptus marginata* woodlands of the eastern side of the Swan Coastal Plain	Endangered	
SCP3b	*Eucalyptus calophylla - Eucalyptus marginata* woodlands on sandy clay soils of the southern Swan Coastal Plain	Vulnerable	
SCP3a	*Eucalyptus calophylla - Kingia australis* woodlands on heavy soils, Swan Coastal Plain	Critically Endangered	Endangered
SCP3c	*Eucalyptus calophylla - Xanthorrhoea preissii* woodlands and shrublands, Swan Coastal Plain	Critically Endangered	Endangered
SCP08	Herb rich shrublands in clay pans	Vulnerable	Critically Endangered
SCP1a	*Eucalyptus haematoxylon - E. marginata* woodlands on Whicher foothills	Priority 3	
Casuarina obesa association	*Casuarina obesa* Association	Priority 1	
SCP21c	Low lying *Banksia attenuata* woodlands or shrublands	Priority 3	
SCP22	*Banksia ilicifolia* woodlands	Priority 2	
SCP24	Northern Spearwood shrublands and woodlands	Priority 3	

The Bush Forever Site No 360 "Mundijong Road and Watkins Road Bushland" is mapped as occurring in the Mundijong Road reserve adjacent to the southern boundary of the site. Bush Forever Site No. 360 contains plant communities representative of the eastern side of the Swan Coastal Plain that are considered to be regionally significant (WAPC, 2000).

The southern portion of the Mundijong Road reserve exhibits conservation values described in Bush Forever Site No. 360. However, the reserve to the northern portion of Mundijong Road reserve does not exhibit any conservation values. The northern portion of the Mundijong Road reserve contains scattered trees largely over a weedy understorey.

2.8 Fauna

Terrestrial Ecosystems was commissioned by PGV Environmental to undertake a Level 1 fauna risk assessment of the site. The purpose of the Level 1 fauna risk assessment was to provide information to assess the potential impact of vegetation clearing on the fauna assemblages located on the site.

The methodology broadly followed that described in the Environmental Protection Authority (EPA) *Position Statement No. 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection* (EPA 2002), *Guidance Statement No. 56: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004) and the EPA/Department of Environment and Conservation (DEC) *Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment* (EPA/DEC 2010).

A Level 1 fauna risk assessment involves undertaking a desktop review and site inspection. The objectives of the fauna risk assessment were to:

- Provide an indication of the vertebrate fauna assemblage (reptiles, amphibians, small mammals and birds) on and in the vicinity of the project area;
- Identify the presence and/or potential risks of impacting on species of conservation significance that are present or likely to be present in the project area;
- Determine if any additional surveys are required to assess the potential impact on fauna assemblages in the project area, in particular, impacts on species of conservation significance; and
- Make recommendations that avoid, mitigate or minimise potential impacts on resident fauna.

The results of the Level 1 fauna risk assessment are summarised below and shown in full at Appendix 2.

2.8.1 Fauna Habitat

The site contains two habitat types (Plates 3 & 4):

- Fenced highly disturbed pasture with scattered mature native and planted trees: and
- Small patch of fenced densely planted *Allaocasuarina obesa* in the north west corner.

Plate 5: Tree over Pasture

Plate 6: *Casuarina obesa* Stand

2.8.2 Conservation Significant Fauna

Thirteen threatened species of fauna and 14 migratory species of birds identified under the *EPBC Act 1999* potentially occur in the vicinity of the site. There are 27 Schedule species listed under the WA *Wildlife Conservation Act 1950* and 10 species listed on the DEC's Priority Fauna List that potentially occur in the vicinity of the site. The following is an assessment of the likelihood of each of the species being found in the project area and Table 5 is a summary of this information.

Table 5: Conservation Significant Species that may occur in the Mundijong Area

Species	Status under the *Wildlife Conservation Act 1950*	Status under the *EPBC Act 1999*	Comment on potential impact that vegetation clearing will have on conservation significant species
Neopasiphae simplicior Native bee	Schedule 1	Critically Endangered	Unlikely to be found in the site. Low potential impact.
Phascogale calura Red-tailed Phascogale	Schedule 1	Endangered	Unlikely to be found in the site. Low potential impact.
Calyptorhynchus latirotris Carnaby's Black Cockatoo	Schedule 1	Endangered	Likely to be seen in the site. Low potential impact.
Botaurus poiciloptilus Australasian Bittern	Schedule 1	Endangered	Seen on the site. Low potential impact.
Calyptorhynchus banksii naso Forest Red-tailed Black Cockatoo	Schedule 1	Vulnerable	Likely to be seen in the site. Low potential impact.
Calyptorhynchus baudinii Baudin's Black Cockatoo	Schedule 1	Vulnerable	Likely to be seen in the site. Low potential impact.
Synemon gratiosa Graceful Sun-Moth	Schedule 1	Endangered	Unlikely to be found in the site. Low potential impact.
Sternula nereis nereis Fairy Term	Schedule 1	Endangered	Unlikely to be found in the site. Low potential impact.
Bettongia penicillata Woylie	Schedule 1	Endangered	Unlikely to be found in the site. Low potential impact.
Dasyurus geoffroii Chuditch	Schedule 1	Vulnerable	Unlikely to be found in the site. Low potential impact.
Myrmecobius fasciatus Numbat	Schedule 1	Vulnerable	Unlikely to be found in the site. Low potential impact.
Setonix brachyurus	Schedule 1	Vulnerable	Unlikely to be found in the

Quokka			site. Low potential impact.
Apus pacificus Fork-tailed Swift	Schedule 3	Migratory	May infrequently fly over the site. Low potential impact.
Haliaeetus leucogaster White-bellied Sea-eagle	Schedule 3	Migratory	May infrequently fly over the site. Low potential impact.
Merops ornatus Rainbow Bee-eater	Schedule 3	Migratory	May be found in the vicinity of the site. Low potential impact.
Calidris acuminata Sharp-tailed Sandpiper	Schedule 3	Migratory Wetland	Unlikely to be seen in the site. Low potential impact.
Calidris canutus Red Knot	Schedule 3	Migratory Wetland	Unlikely to be seen in the site. Low potential impact.
Calidris ferruginea Curlew Sandpiper	Schedule 3	Migratory Wetland	Unlikely to be seen in the site. Low potential impact.
Calidris ruficollis Red-necked Stint	Schedule 3	Migratory Wetland	Unlikely to be seen in the site. Low potential impact.
Ardea alba Great Egret	Schedule 3	Migratory Wetland	Unlikely to be seen in the site. Low potential impact.
Ardea ibis Cattle Egret	Schedule 3	Migratory Wetland	Unlikely to be seen in the site. Low potential impact.
Limosa lapponica Bar-tailed Godwit	Schedule 3	Migratory Wetland	Unlikely to be found in the site. Low potential impact.
Limosa limosa Black-tailed Godwit	Schedule 3	Migratory Wetland	Unlikely to be found in the site. Low potential impact.
Numenius minutus Little Curlew	Schedule 3	Migratory Wetland	Unlikely to be found in the site. Low potential impact.
Tringa glareola Wood Sandpiper	Schedule 3	Migratory Wetland	Unlikely to be seen in the site. Low potential impact.
Tringa stagnatilis Marsh Sandpiper	Schedule 3	Migratory Wetland	Unlikely to be seen in the site. Low potential impact.
Morelia spilota imbricata Carpet Python	Schedule 4		Unlikely to be found in the site. Low potential impact.
Falco peregrinus Peregrine Falcon	Schedule 4		May infrequently fly over the site. Low potential impact.

Acanthorhynchus superciliosus Western Spinebill	Priority 4		May infrequently visit over the site. Low potential impact.
Ctenotus gemmula	Priority 3		Unlikely to be found in the site. Low potential impact.

The conservation significant species likely to be seen on the site are the Carnaby's Black Cockatoo, Baudin's Black Cockatoo and Forest Red-tailed Black Cockatoo.

The Western Spinebill and the Migratory Rainbow Bee-eater and the White Bellied Sea-Eagle may infrequently be seen in the site (Terrestrial Ecosystems, 2011).

Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*) – Endangered under the *EPBC Act 1999* and Schedule 1 under the *Wildlife Conservation Act 1950*

Carnaby's Black Cockatoo inhabits the south-west of Western Australia (Garnett et al. 2011). Its preferred nesting trees include the smooth-barked Salmon Gum (*Eucalyptus salmonophloia*) and Wandoo (*E. wandoo*), which contain deep hollows. Nesting also occurs in Marri (*Corymbia calophylla*) and Tuart (*E. gomphocephala*). Its main foods are the seeds of Hakeas, Grevilleas, Banksias, Eucalypts and introduced pines.

The site contains some Marri (*Corymbia calophylla*) which are known feeding trees for Carnaby's Black Cockatoo (Higgins 1999). Carnaby's Black-Cockatoos were recorded during other fauna surveys in the general area. Carnaby's Black Cockatoo are likely to regularly feed in the native vegetation on the Mundijong Road verge on the southern boundary of the site (Terrestrial Ecosystems, 2011). There was no evidence of foraging or breeding seen on the site.

Baudin's Black Cockatoo (*Calyptorhynchus baudinii*) – Vulnerable under the *EPBC Act 1999* and Schedule 1 under the *Wildlife Conservation Act 1950*

This species is most common in the far south-west of Western Australia. It is known to breed from the southern forests north to Collie and east to near Kojonup. Baudin's Black Cockatoo is typically found in vagrant flocks and utilises the taller, more open Jarrah and Marri woodlands, where it feeds mainly on Marri seeds and various Proteaceous species. While they are seasonally present on the Swan Coastal Plain, Baudin's Black Cockatoo are potentially seen in the vicinity of the site (Garnett et al. 2011).

Baudin's Black Cockatoo may infrequently feed in the site, but would more frequently be seen foraging in the native vegetation on the south side of Mundijong Road, which is on the other side of the southern boundary of the site (Terrestrial Ecosystems, 2011).

Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*) – Vulnerable under the *EPBC Act 1999* and Schedule 1 under the *Wildlife Conservation Act 1950*

Forest Red-tailed Black Cockatoos frequent the humid to sub-humid south-west of Western Australia from Gingin in the north, to Albany in the south and west to Cape Leeuwin and Bunbury (Department of Sustainability Environment Water Population and Communities 2011). It nests in

tree hollows with a depth of 1-5m, that are predominately Marri (*C. calophylla*), Jarrah (*E. marginata*) and Karri (*E. diversicolor*) and it feeds primarily on the seeds of Marri.

Red-Tailed Black Cockatoos have been recorded during other fauna surveys in the general area and probably feed in the native trees on the south side of Mundijong Road outside of the site (Terrestrial Ecosystems, 2011). They may occasionally roost in the large trees on-site. There is no record to indicate that they breed in the vicinity of the site (Johnstone and Kirkby 2011).

Western Spinebill (*Acanthorhynchus superciliosus*) – Priority 4 with DEC

This species inhabits heath land, woodland, and open forest with healthy understorey and feed on banksias, eucalypts and numerous shrub species (Johnstone and Storr 2004). They also feed on insects. Their numbers have declined as a result of extensive habitat clearing and fires.

Western Spinebills have been recorded in other fauna surveys in the vicinity of the site. It may be seen occasionally in the Sheoak plantation area along the northern boundary (Terrestrial Ecosystems, 2011).

Rainbow Bee-eater (*Merops ornatus*) - Migratory under the *EPBC Act 1999* and Schedule 3 under the *Wildlife Conservation Act 1950*

Rainbow Bee-eaters are abundant in Australia, and found in many parts of Western Australia except the sandy deserts and dry arid interior. Johnstone and Storr (1998) described them as resident, breeding visitors and postnuptial nomads. They are generally migratory, moving south in late September and early October, having wintered from the Gascoyne to Indonesia.

Rainbow Bee-eaters are regularly seen across most of the wetter areas of Western Australia including around the site. Given their abundance and wide spread distribution, ground disturbance activities on a localised scale are unlikely to significantly impact on Rainbow Bee-eaters(Terrestrial Ecosystems, 2011) .

White-bellied Sea-Eagle (*Haliaeetus leucogaster*) – Migratory under the *EPBC Act 1999* and Schedule 3 under the *Wildlife Conservation Act 1950*

The White-bellied Sea-eagle is the second largest bird of prey found in Australia. This eagle has been seen in a variety of habitats and not always near the ocean, but they are more commonly seen in coastal areas. Birds form permanent pairs that inhabit territories throughout the year. These eagles are normally seen perched high in a tree, or soaring over waterways and adjacent land.

The White-bellied Sea-Eagle may infrequently be seen in the general area, but clearing the site is unlikely to significantly impact on this species (Terrestrial Ecosystems, 2011).

2.8.3 Biodiversity Value

The cleared pasture has almost no ecological value from a native fauna perspective. There are a few mature trees in the paddocks, some of which contain hollows which are currently providing nesting sites for Galahs and Australian Ringneck Parrots.

2.8.4 Ecological Linkages

There are four substantial areas set aside as Bush Forever sites nearby; Byford to Serpentine Rail/Road Reserves and adjacent bushland (BFS 350), Norman Road Bushland (BFS 354/361), Cardup Nature Reserve and adjacent bushland (BFE 352) and Roman Road Bushland (BFS 362). Avian fauna would regularly move through and between these areas.

The southern boundary of the site does not form part of an ecological linkage through the general area.

2.8.5 Conservation Significant Species

Conservation significant species that probably infrequently utilise the project area include Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*), Forest Red-tailed Black Cockatoo (*C. banksii naso*) and Baudin's Black Cockatoo (*C. baudinii*). The Western Spinebill (*A. superciliousus)* may infrequently be seen in the small triangular fenced area along the northern boundary. Migratory Rainbow Bee-eaters and the White-bellied Sea-eagle may infrequently be seen in the area, but will readily move when development commences and are unlikely to be significantly impacted.

All eucalypt trees on the site were inspected to determine whether any showed signs of use or had the potential to support a nesting hollow for a Black Cockatoo. Thirty five trees on the site had a trunk diameter of 50cm or greater at breast-height. The locations of these trees are shown on Figure 8. Three of these trees may have contained hollows.

Determining whether a tree contained a hollow can be difficult from the ground, as all you can see is the opening, but not inside the hollow. Three trees on the site may have contained hollows. Some of the trees that contained hollows contained nests of Australian Ringneck Parrots and Galahs. Johnstone and Kirkby (2011) indicated that there were no records of Carnaby's Black Cockatoos breeding in the vicinity of the site, and the closest nesting site was on the Darling Scarp to the east.

2.9 Heritage

2.9.1 Indigenous Heritage

A search of the Department of Indigenous Affairs Register of Aboriginal Sites revealed that there are no previously recorded ethnographic sites on the site (Landgate, 2012).

Ethnosciences undertook an Aboriginal Heritage Assessment of the site in 2011/2012. The assessment included a desktop search and ethnographic and archaeological field surveys. A separate report has been prepared to detail the findings of the assessment.

In summary, no ethnographic sites were reported on the land during the ethnographic survey which involved representatives of Bilya and Winjan Aboriginal Corporation who have long-standing associations with the region (Ethnosciences, 2012).

One archaeological site (MJ-06), an artefact scatter, was located on the site during the archaeological survey. MJ-06 is a small, medium-density, open quartz artefact scatter situated on a Bassendean sand dune above seasonally inundated wetlands. The site represents either the by-products of task specific activities or a short term or infrequently used occupation site. However, MJ-06 is assessed as currently being of low archaeological significance. No further recording of the surface assemblage of MJ-06 is required.

The consultants from the Bilya and Winjan Aboriginal Corporation groups were of the view that Site MJ-06 — the artefact scatter identified on Lot 50 during the archaeological survey — was of low cultural significance and did not oppose Peet Limited applying for Section 18 consent for the site. However, they differed in how the site should then be treated. The former wants the material left *in situ*; the latter wants the material salvaged and appropriately stored. At present, it is not possible to reconcile these opposing views.

2.9.2 Non Indigenous Heritage

A search of the following sources at federal, state and local government level was undertaken to determine the actual or potential presence of sites or features of non-indigenous heritage significance were within the site:

- World Heritage Sites.
- National Heritage Sites.
- Commonwealth Heritage Sites.
- Sites on the register of the National Estate.
- Sites listed in the Shire of Serpentine-Jarrahdale Municipal Heritage Inventory List.

This search revealed that there were no listed heritage sites occurring within the site.

2.10 Noise and Odour

The Mundijong Whitby DSP report identified a number of potential noise and odour emitting sources in the DSP area (Appendix 3).

2.10.1 Noise

There is one potential noise source that currently impacts on the southern boundary of the site, transport noise from Mundijong Road. The future Tonkin Highway alignment runs along the western boundary of the site and is likely to have transport noise impacts.

The final civil design for the development and proposed noise amelioration measures are required inputs for acoustic models to determine the level of impact. The final civil design will be completed as part of the future subdivision process. The Proponent will undertake an acoustic assessment as part of the planning process for subdivision.

2.10.2 Odour

The site is not impacted by any of the point odour sources or related buffers that were identified in the DSP.

3 LEGISLATION, POLICY AND GUIDELINES

The following legislation, policy and guidelines have been considered during this environmental assessment and will guide the required and expected management outcomes from Commonwealth, State and Local government agencies.

3.1 Environment Protection and Biodiversity Conservation Act 1999

The *Environment Protection and Biodiversity Conservation Act 1999* (the EPBC Act) is the Australian Government's central piece of environmental legislation.

The EPBC Act provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places — defined in the Act as matters of national environmental significance.

The seven matters of national environmental significance to which the EPBC Act applies are:

- world heritage sites
- national heritage places
- wetlands of international importance (often called 'Ramsar' wetlands after the international treaty under which such wetlands are listed)
- nationally threatened species and ecological communities
- migratory species
- Commonwealth marine areas
- nuclear actions.

Under the EPBC Act, a significant impact is determined by the sensitivity, value and quality of the environment which is to be impacted and the intensity, duration, magnitude and geographic extent of the impacts (DEWHA, 2008b). If a proposed action is deemed to have a significant impact, this action should be referred to the Minister.

The EPBC Act applies to 'actions' which:

- Have a 'significant impact' on 'matters of national environmental significance';
- Are undertaken by commonwealth government agencies and have a significant impact on the environment anywhere in the world; or
- Are undertaken by any person and have a significant impact on commonwealth land (even if the activity is not actually carried out on the commonwealth land).

The Matters of National Environmental Significance. Significant Impact Guidelines 1.1 Environment Protection and Biodiversity Conservation Act 1999 (DSEWPaC, 2009) provides a guide for determining the significance of the impact which depends on the sensitivity, value and quality of the environment and the intensity, duration, magnitude and geographic extent of the impacts.

According to the Significant Impact Guidelines 1.1 an action is likely to have a significant impact on an endangered and vulnerable species if there is a possibility that it will trigger any one of nine criteria listed in Table 6 and 7.

Table 6: Significant Impact Criteria for Endangered Species

Criteria	Carnaby's Black Cockatoo
Lead to a long-term decrease in the size of a population	No
Reduce the area of occupancy of the species	No
Fragment an existing population into two or more populations	No
Adversely affect habitat critical to the survival of a species	No
Disrupt the breeding cycle of a population	No
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	No
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat	No
Introduce disease that may cause the species to decline	No
Interfere with the recovery of the species	No

Table 7: Significant Impact Criteria for Vulnerable Species

Criteria	Baudin's Black Cockatoo	Forest Red-tail Black Cockatoo
Lead to a long-term decrease in the size of an important population of a species	No	No
Reduce the area of occupancy of an important population	No	No
Fragment an existing important population into two or more populations	No	No
Adversely affect habitat critical to the survival of a species	No	No

Disrupt the breeding cycle of an important population	No	No
Modify, destroy, remove or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	No	No
Result in invasive species that are harmful to a vulnerable species becoming established in the Vulnerable species' habitat	No	No
Introduce disease that may cause the species to decline	No	No
Interfere substantially with the recovery of the species.	No	No

The potential impacts of clearing the remnant trees on the site have been assessed against the criteria for the three species listed as Endangered and Vulnerable under the EPBC Act 1999 that could forage on the site.

Given that the site has been historically cleared of native vegetation and the above significant impact criteria are not triggered it is PGV Environmental's view that the proposed development will not significantly impact on Commonwealth listed conservation significant.

3.2 State Legislation

3.2.1 Environmental Protection Act 1999

The EPA considered the Draft South East Corridor Structure Plan, Metropolitan Scheme Amendment No. 966/33 and Stormwater Management Strategy and Plans for New Urban Development at Byford and Mundijong and provided advice in EPA Bulletin 795 (1995). This advice was provided as a Strategic Environmental Assessment which not a formal environmental impact assessment under Part IV of the EP Act.

The EPA concluded that the Draft South East Corridor Structure Plan, Metropolitan Scheme Amendment No. 966/33 and Stormwater Management Strategy and Plans for New Urban Development at Byford and Mundijong could be made environmentally acceptable. In reaching this conclusion the EPA identified the following main environmental objectives and the proposal should meet:

- Avoid and minimise environmental damage to wetlands of local and regional significance;
- Reserve land that has been identified in the System 6 Report as having conservation and recreation value;
- Prevent nutrient enrichment and degradation of the groundwater and the surface water systems from on-site eft1uent disposal;
- Protect remnant bushland communities identified in the system 6 review;
- Minimise the potential impact of noise, dust and odour from existing poultry farms and piggeries on proposed adjoining land uses;
- Ensure changes to land use within the catchment to the Peel Harvey estuarine system are controlled so as to avoid and minimise environmental damage particularly in terms of nutrient export; and

- Ensure suitable transport strategies have been adopted to ensure that air quality and greenhouse gas emissions in the South East Corridor meet health and environmental standards.

These environmental objectives were considered in the structural planning process for the Mundijong Whitby DSP.

Under the EP Act, clearing of native vegetation requires a permit from the DEC unless there is an exemption under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*. Proposals that have approval by means of a Ministerial Statement and which are implemented in accordance with that Statement are exempt from requiring a clearing permit to clear native vegetation. In addition clearing in accordance with an approved subdivision is also exempt.

It is likely that any clearing that will be required for the development will be considered at he subdivision stage by the DEC and is likely to be exempt from the requirements of a clearing permit.

3.2.2 Wildlife Conservation Act 1950

Under the *Wildlife Conservation Act 1950* (WC Act) all native species of fauna are protected unless otherwise declared, and cannot be captured or killed without a licence. In addition some fauna species are determined to require special protection, in which additional consideration is given for the protection and conservation of these species. The lists of species under the WC Act are regularly updated, with the DEC maintaining this list.

The WC Act protects all flora species, but specifically Declared Rare Flora (DRF) and it is an offence to take rare flora for any purpose on lands without written consent.

There are no DRF within the site and the only native species of fauna that may infrequently visit the site are the Carnaby's Black Cockatoo, Forest Red-tailed Black Cockatoo and Baudin's Black Cockatoo. Clearing of foraging and potential roosting habitat for Black Cockatoos does not need approval under the WA Act.

3.2.3 Aboriginal Heritage Act 1972

The *Aboriginal Heritage Act 1972* (AHA) protects all Aboriginal sites whether or not they are known and registered under the AHA. One new Aboriginal site was found within the site and management strategies for the site are addressed in the Indigenous Heritage Assessment Report for the site (Ethnoscience, 2012).

3.3 State Policy

3.3.1 State Planning Policy No. 2.1 Peel-Harvey Coastal Plain Catchment (SPP 2.1)

SPP 2.1 was developed to ensure that land use changes within the Peel-Harvey Estuary System that are likely to cause environmental damage are brought under planning control and are prevented (Department of Planning 2003). Generally the policy states that any development, including the construction of buildings should aim to:

- Reduce the nutrient load discharging into the Peel-Harvey Estuary catchment.
- Encourage the retention and rehabilitation of existing remnant vegetation.
- Subdivision maximises consumption and retention of drainage on site.

- Consider the treatment of soils within open space with nutrient retention soil amendment, particularly in areas where phosphorus retention is low.

The site is located within the Peel-Harvey Coastal Plain Catchment and as such the considerations and requirements of this policy have been considered as part of this strategy in Section 5.

3.3.2 State Planning Policy No. 2.8 Bushland Policy for the Perth Metropolitan Region

SPP 2.8 in conjunction with Bush Forever (Government of Western Australia 2000) seeks to ensure the protection of at least 10 per cent of the original extent of each vegetation complex within the Perth Metropolitan Region. SPP 2.8 was developed to ensure that bushland protection and management issues were appropriately addressed and integrated as a part of future land use. Bush Forever identified approximately 51,200 hectares of regionally significant vegetation for retention. The management of these areas include reservation and acquisition by the State government, negotiated planning solutions with owners who are seeking urban and/or industrial development and advice, assistance and incentive programs to support private conservation.

The Bush Forever Site No 360 Mundijong Road and Watkins Road Bushland is mapped as occurring in the Mundijong Road reserve adjacent to the southern boundary of the site. Bush Forever Site No. 360 contains plant communities representative of the eastern side of the Swan Coastal Plain that are considered to be regionally significant (WAPC, 2000).

The road reserve to the north of Mundijong Road does not exhibit any conservation values. The reserve contains scattered trees largely over a weedy understorey.

3.3.3 State Planning Policy No. 2.9 Water Resources

- SPP 2.9 aims to ensure the protection and appropriate management of water resources in line with state guidelines is included within the planning framework. The broad aims of this policy are to: Protect, conserve and enhance water resources.
- Assist in ensuring the availability of suitable water resources to maintain essential requirements for human and other biological life and to maintain or improve the quality and quantity of water resources.
- Promote and assist in the management and sustainable use of water resources.

As a part of implementing this policy, the Better Urban Water Management (WAPC 2008) framework was developed. This framework provides detail on how water resources should be considered at each stage of planning by identifying the various actions and investigations required with regard to regional and local planning strategies, town planning schemes, structure plans, subdivisions, strata subdivision and development applications (WAPC 2008).

3.3.4 State Planning Policy No. 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning

SPP 5.4 addresses transport noise from within major transport corridors, including freight routes, and its impact on noise sensitive land uses. The policy aims 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 redeveloped transport infrastructure proposals.
- Facilitate the development and operation of an efficient freight network.
- Facilitate the strategic co-location of freight handling facilities.

Major transport (road) corridors are defined as:

- State roads and national highways;
- Urban primary distributors as described on the metropolitan functional road hierarchy (MRWA, local government) network;
- Other urban roads carrying more than 20,000 vehicles per day;
- Primary freight roads (Perth metropolitan region);
- Primary freight roads (South-West region); and
- Primary freight roads (State-wide).

Mundijong Road, located adjacent to the southern boundary of the site is described as a primary distributor within the metropolitan functional road hierarchy and as such the requirements of SPP 5.4 have been considered as part of this assessment. In addition, the future Tonkin Highway adjacent to the western boundary of the site will also be subject to this policy.

The noise criteria outlined in SPP 5.4 is applied to the outdoor areas of sensitive premises, and describes the level of noise which must be met. The noise criteria are provided below in Table 8. The noise target is the level of noise in which, when this target or lower is achieved, no further mitigation of noise is required. The noise limit represents an acceptable margin for compliance, in which a range of noise mitigation methods can be utilised to reach the noise target. In the policy it states that in greenfield developments there is an expectation that the design of the proposal will be consistent with achieving the target level.

Table 8: Noise Criteria

Time of Day Noise	Noise Target	Noise Limit
Day (6am – 10pm)	LAeq(Day) = 55dB (A)	LAeq(Day) = 60dB(A)
Night (10pm – 6am)	LAeq(Night) = 50dB(A)	LAeq(Day) = 55dB(A)

The noise criteria can be met through a variety of mitigation measures. An acoustic assessment at the subdivision stage of planning will be undertaken by the proponent.

3.3.5 Wetlands Conservation Policy for Western Australia

The Wetland Conservation Policy for Western Australia (Government of Western Australia 1997) outlines the State government's commitment to identify, maintain and manage the State's wetland resources which include lakes, swamps, marshes, springs, damplands, impoundments, intertidal flats and mangroves.

The objectives of the policy are to:

- Prevent further loss or degradation of valuable wetlands and wetland types.

- Include viable representation of all major wetland types within the conservation reserve.
- Maintain viable wild populations which include the species and genetic diversity of wetland dependant flora and fauna.
- Increase community awareness and appreciation for wetlands.

No wetlands of conservation significance are located within the site, with the Multiple Use Wetland identified retaining limited wetland values, given these areas are cleared paddocks.

A Conservation Category wetland is located in the reserve along Mundijong Road adjacent to the southern boundary of the site. The northern road reserve does not exhibit any values consistent with a Conservation Category wetland and it is likely that the broad spatial scale of the DEC mapping is not accurate.

The Local Water Management Strategy (Cardno 2010e) has provided for the management of these areas from a hydrological point of view.

3.3.6 Environmental Protection Authority Position Statement No. 4 Environmental Protection of Wetlands

EPA Position Statement No.4 Environmental Protection for Wetlands defines the important wetland values and functions of wetlands, and provides the EPA's position on protecting these values by establishing principles for wetland protection. The EPA recognises that the continued degradation and loss of wetland habitat in Western Australia, particularly on the Swan Coastal Plain, is a threat to conservation of wetlands and wetland biodiversity, maintaining that the remaining wetlands are important and require protection.

The key environmental values and functions of wetlands include:

- Primary production – provide nourishment for variety of organisms.
- Recreational and landscape amenity – provide a refuge for wildlife and humans and have an intrinsic natural beauty.
- Hydrological balance – provide important flood control and stormwater detention function.
- Water quality protection – remove pollutants such as sediments, nutrients, organic and inorganic matter and some pathogens.
- Wildlife habitat – provides a multitude of ecological niches and supports a variety of flora and fauna.

The principles the EPA will consider in determining potential impact on wetlands include:

- Protect, sustain and where possible restore biological diversity of wetland habitats.
- Protect the quality of wetlands through the application of ecological sustainable development and "wise-use". The term "wise-use" is taken from the Ramsar Convention and is taken to mean the sustainable utilisation for the benefit of humankind in a way compatible with the natural properties of the ecosystem, in which human use of wetland is undertaken in such a way that it may yield the greatest continual benefit for all.
- That there is no net loss of wetland values and functions (aspirational goal).

There is one wetland of conservation significance located to the south of the site and Mundijong Road and will need to be considered in terms of:

- Retention of wetlands;
- Management of wetlands to retain values and attributes; and
- Provision and management of buffers.

3.3.7 Environmental Protection Authority Guidance Statement No 33 Environmental Guidance for Planning and Development (EPA 2009)

The purpose of EPA Guidance Statement No.33 Environmental Guidance for Planning and Development is to outline the significance of environmental factors and provide the key definitions associated with the environmental factors. This document is primarily targeted at ensuring environmental factors are considered in line with the EPA's principals and objectives and within the planning framework. In particular, EPA Guidance Statement No.33 Environmental Guidance for Planning and Development aims to:

- Provide an overview to environmental protection processes and information;
- Describe the referral and environmental impact assessment process and process under Part IV of the EP Act; and
- Provide the EPA's position and advice on a range of environmental factors, outlining how to protect, conserve and enhance the environmental values.

3.4 Shire of Serpentine Jarrahdale

The Shire of Serpentine-Jarrahdale has a number of Local Planning Policies (LPP) which detail the Shire's expectations with regard to planning and development, and the factors that need to be considered throughout the planning process. Key LPPs applicable to the site and the environmental values within the site are outlined below:

- LPP 4 Revegetation Strategy;
- LPP 6 Water Sensitive Design;
- LPP 26 Biodiversity Planning; and
- LPP 22Water Sensitive Urban Design;

4 LOCAL STRUCTURE PLAN

4.1 Local Structure Plan

The LSP has been prepared for the site, utilising inputs of the project consultant team. The consultant team encompassed a range of technical disciplines, including environmental, civil engineering, urban design and town planning, traffic management, landscape architects and land-use economics.

A key consideration in the development of the LSP has been the Mundijong Whitby DSP which has been used to guide planning within the subject site. The Mundijong Whitby DSP was prepared by the Shire of Serpentine Jarrahdale to provide overall guidance on the structure, vision and objectives for the planning and development of Mundijong Whitby.

The LSP provides the next level of detailed planning which is based on the Mundijong Whitby DSP and provides general guidance for subdivision and detailed design. It is generally a spatial plan, with an inherent degree of flexibility in how it will be applied in the latter stages of planning, particularly as detailed site specific investigations are undertaken. The LSP is shown in Figure 3.

The environmental values of the site (outlined in Section 2) have been considered as a part of the design process through a variety of mechanisms. These include the retention of the environmental values, provision of public open space locations and road alignments to accommodate specific values and provide for the protection and management of these values.

The LSP is considered to be largely unconstrained from an environmental perspective. The most significant environmental values include:

- Location of the southern entry road to avoid TEC and CCW in Mundijong Road Reserve;
- Retention of healthy mature native trees where possible;
- Re-location of mature native species to POS;
- Location of POS to retain healthy paddock trees where possible;
- Location of larger lots along western boundary as a noise buffer adjacent to the future Tonkin Highway reserve and services corridor; and
- Stormwater drainage system that can be landscaped to increase the number of trees on the site and improve fauna habitat.

4.2 Landscape Masterplan

The Landscape Master Plan details the location of the particular types of public open space and is largely based on the environmental values present within the site and the desire to reflect the existing rural and ‘leafy green’ context that is evident in the existing Mundijong town site.

As with the LSP, this plan provides broad guidance on the development and management of the different open space opportunities. The Landscape Master Plan is provided in Appendix 4.

It outlines broad ‘typologies’ for the open space which are based on the size, type and function of the landscape treatment that is likely to be incorporated within the subject site as part of the LSP’s implementation.

5 OPPORTUNITIES AND CONSTRAINTS

5.1 Opportunities

The site has previously been cleared for agricultural purposes and is currently used for pasture crops and grazing. As the site contains no remnant vegetation apart from scattered paddock trees it is well placed for potential urban development.

5.1.1 Topography

The site is largely flat and will not require significant re-contouring for the proposed development.

5.1.2 Remnant Vegetation

The site does not contain any intact remnant vegetation and there is no ecologically significant vegetation. There are several isolated mature native trees in the paddocks which have some environmental and amenity value (Figure 8). Where possible the LSP has been designed around retaining the healthy mature trees.

The planted Sheoak stand is not of conservation significance and is not a constraint to development.

The completely degraded condition of the site is viewed as a benefit for future development as no clearing of native vegetation is required.

5.1.3 Conservation Significant Flora

None of the species listed as significant by DEC and DSEWPaC that have been previously recorded in the vicinity of the site was identified during the October 2011 flora survey.

Future development of the site will not result in loss of conservation significant flora.

5.1.4 Bush Forever Site No. 360

The Bush Forever site No. 360 is adjacent to the southern boundary of the LSP area in the Mundijong road reserve. The vegetation on the northern side of Mundijong Road is considered to be Completely Degraded and is not representative of plant communities of the eastern side of the Swan Coastal Plain. A large majority of the trees have been cultivated and the understorey consists of weed species and pasture.

The southern side of the road reserve however is representative of plant communities of the eastern side of the Swan Coastal Plain and the condition of the vegetation is considered to be Very Good.

The Bush Forever site on the northern side of Mundijong Road is not considered to be a constraint to the location of an entry road into the development.

5.1.5 Conservation Significant Fauna

The three species of Black Cockatoo (Carnaby's, Baudins and Forest Red-Tail) were identified as likely to be found infrequently on the site. These species are listed under the *Wildlife Conservation Act 1950* and the Commonwealth EPBC Act 1999.

Terrestrial Ecosystems (2011) identified 35 trees on the site that had a trunk diameter of 50cm or greater at breast height. Three of the trees appeared to have hollows but showed no evidence of use by Black Cockatoos for breeding purposes.

The migratory White-bellied Sea-eagle and Rainbow Bee-eater may on occasion fly over the site however they are not reliant on the site.

Future development of the site will result in a small loss of foraging habitat for the three species of Black Cockatoo. The impact is not considered significant according to the Significant Impact Guidelines 1.1. Retention of some of the mature trees on site will continue to provide habitat to ensure the Black Cockatoos continue to visit the site. Planting of Marri in POS and drainage reserves will lead to greater foraging habitat for Black Cockatoos on the site in the long term.

5.1.6 Surface Water Bodies/Wetlands

The site is mapped largely as a Multiple Use wetland which is not considered to contain significant environmental values.

The road reserve to the north of Mundijong Road (adjacent to the site) has been mapped as a Conservation Category Wetland in the *Geomorphic Wetlands of the Swan Coastal Plain* dataset (DEC, 2012). The mapping of the wetland follows the boundary of the Bush Forever site No. 360. The vegetation in the road reserve is largely cultivated and is not considered representative of wetland values (PGV, Environmental, 2012).

The mapped wetland on the northern side of Mundijong Road is not considered to be a constraint to development (see section 2).

Future development of the site will not result in loss of wetland values.

5.2 Constraints

The soils and groundwater characteristics within the site pose some limitations however these limitations can be mitigated and/or managed and are not considered being serious constraints to the future development of the site.

5.2.1 Drainage and Stormwater Runoff

Flooding is the temporary covering of land by water from overflowing streams and run-off from adjacent slopes. If a site is prone to flooding, which can be caused by inefficient drainage, then either the placement of fill or subsurface drainage should be considered as an integral component of engineering design.

Waterlogging is the condition of a soil which is saturated with water and in which most or all of the soil air has been displaced. Inundation occurs under severe waterlogging conditions when the land surface is covered by water.

The areas of the site that comprise of Bassendean Dune geomorphology generally have moderately well, to well-drained soils. Sandplain Plain systems in particular can be prone to swamp formations. The areas that would cause the most concern in terms of flooding would be the areas that have naturally poorly drained soils (i.e. Pinjarra Plain). Land capability assessment previously undertaken for the DSP area identified the site as being subject to seasonal waterlogging and inundation. The

Pinjarra P1b soil unit has a 95% risk of occurrence of water logging and the Bassendean B2 and B6 soil units have a 10% risk of occurrence of waterlogging (SMEC, 2009).

Appropriate management measures (refer to 6.1 Drainage and Stormwater Runoff) will be required to control runoff from roads, car parking areas, roofs of buildings and lawn/landscape areas.

5.2.2 Soils and Erosion

Nutrient retention ability refers to the ability of the soil profile to retain nutrients. Urban development is likely to increase the risk of phosphorous export from the MW Cell (Department of Agriculture and Food (DAF), 2000). Increased phosphorous export from the site is likely to contribute to the eutrophication of waterways and wetlands within the area and downstream watercourses, including the Peel-Harvey estuary.

The percentage risk of phosphorous export occurring within the site will only be increased by urbanisation. To reduce this risk any fill brought into the project area should maximise phosphorous retention time. This can be achieved by only importing soils with a low phosphorous export risk or by mixing high Phosphorous fixing materials (e.g. alkaloam) to soils with a high risk of phosphorous leaching.

The nutrient retention ability of soils can be demonstrated by the Phosphorus Retention Index (PRI) which measures how strongly P is adsorbed onto soil particles. SMEC (2009) identified that the Bassendean B2 and B6 have a high risk of occurrence (70% and 90% respectively) and the Pinjarra P1b has a low risk of occurrence (5%) of phosphorous export.

Wind erosion risk relates to the susceptibility of bare soil to be transported by wind. Severe wind erosion is generally limited to land which has been cleared, overstocked and grazed. Wind erosion can cause the loss of topsoil, leaving behind bleached/nutrient poor soils at the surface.

The Bassendean Dune System is subject to a high risk (35% occurrence) of wind erosion, due to lack of structure of the deep, grey, unvegetated sands which provide little resistance to wind when stripped of vegetation. In comparison, the Pinjarra land unit has a low risk (5% occurrence) wind erosion (SMEC, 2009).

5.2.3 Surface Water Flows

Water erosion can be caused by surface flow and take place in the form of sheet, rill, gully, stream bank or tunnel erosion which can cause soil loss and saltation as the result of poor planning or management. Erosion risk depends on climate, landform, soil factors and vegetation cover.

A very low risk of water erosion exists throughout the site due to the flat topography and the lack of significant watercourses.

5.2.4 Acid Sulphate Soils

The site has been classified as having a moderate to low risk of ASS occurring within 3m of the natural soil surface.

Whilst listed as a constraint, a preliminary ASS investigation will be required as part of the subdivision planning process to determine if ASS are present. Depending on the results of the investigation an ASS Management Plan may be required.

5.2.5 Noise

The site may be subject to transport noise constraints from Mundijong Road and the future Tonkin Highway to the west of the site.

Transport noise can be mitigated through a number of management strategies. Further investigation of potential noise impacts will be undertaken by the Proponent during the subdivision planning process.

6 ENVIRONMENTAL MANAGEMENT FOR FUTURE DEVELOPMENT

6.1 Vegetation

Mature trees to be retained or transplanted will be identified and marked appropriately prior to commencement of any pre-construction activities.

Five mature *Kingia australis* over pasture are located in the northern and southern end of the site. Where possible these will be retained or salvaged and replanted in POS.

No management practises are required for significant flora or TECs/PECs as none occur on the site.

6.2 Significant Fauna

The following management practices will be been made with respect to the three species of Black Cockatoo:

- Retention of the three significant trees from within the site identified by Terrestrial Ecosystems (2011) as having potential hollows;
- Where possible, the retention of mature native Eucalypt species will provide habitat for the three species of Black-Cockatoos; and
- Planting of Marri seedlings in POS and drainage reserves will occur.

6.3 Drainage and Stormwater Runoff

A Local Water Management Strategy (LWMS) has been prepared to support the LSP (Wave, 2012). Groundwater quality will be protected by the use of Water Sensitive Urban Design principles as outlined in the LWMS.

To ensure nutrient rich runoff (and other potential sources of contamination) does not directly enter the drainage channel the following management measures are proposed:

- In the vicinity of watercourses construct purpose built 'detention' basins that have the ability to trap sediments and nutrients. These basins will not be allowed to discharge directly to watercourses;
- Lawn areas (that require fertiliser, pesticide and/or herbicide application) will be minimised in areas of POS adjacent to watercourses; and
- During the subdivision of the site, the local community/new landowners will be provided with informative literature describing preventative methods they can implement themselves (i.e. reducing nutrient run-off) to reduce adverse impacts on the environment.

6.4 Soils and Erosion

To minimise potential for soil erosion to occur the following management measures are proposed:

- Ground disturbing activities will be kept to a minimum and carried out 'as required' (in stages) immediately prior to lots being released for sale as part of a 'staged' development of the site;
- Landscaping/stabilising/dust suppression of areas where ground disturbance has occurred will be scheduled to occur immediately after clearing/and or infrastructure construction has been completed; and
- Clearing activities have the potential to add clay 'fines' into the drainage channel creating turbid water downstream (drainage channel) and the installation of temporary drop-out basins to capture and aid in the settling of clay fines will be considered.

6.5 Acid Sulphate Soils

A preliminary site investigation will be undertaken at the subdivision planning stage to determine if ASS is present within the site.

If required an ASS and De-watering Management Plan will be prepared for the site in accordance with the DEC (2003) guidelines.

6.6 Noise

The Tonkin Highway alignment is adjacent to the western boundary of the LSP area. The LSP has been designed to have larger Lots backing onto the Tonkin Highway road reserve. Impacts of noise have not been assessed as the finished engineering levels and noise amelioration strategies proposed for the road reserve are not known.

An acoustic assessment at the subdivision stage is recommended to further detail the potential impacts of traffic noise from Mundijong Road and the future Tonkin Highway. The acoustic report will provide suitable noise mitigation and management strategies for the site.

6.7 Heritage Management

Indigenous Heritage issues and management are provided in a separate report (Ethnoscience, 2012) prepared to facilitate the LSP.

6.8 Fire Management

The site is predominantly cleared and is not situated within close proximity to any bushland with the exception of the narrow reserve to the south of the site and Mundijong Road.

7 CONCLUSIONS

The potential constraints and opportunities to the proposed development, in relation to the environmental attributes of the site outlined in Section 2 and 5. Appropriate management measures have been identified (Section 6) are recommendations made as to likely management practices to ameliorate the environmental constraints to the proposed development.

Based on the size and scope of the proposed development and the results of desktop and onsite assessments and mitigation measures identified, it is believed the potential for deleterious impacts on the biophysical environment as a result of the proposed development, are considered to be low with a high degree of confidence, and can be managed to minimise environmental harm.

Urban development of lot 50 Adams Road Mundijong is considered to be environmentally acceptable for the following reasons:

- The Site has largely been cleared of native vegetation and does not contain any conservation significant flora or vegetation;
- The site contains limited habitat for the three species of Black Cockatoo. Clearing trees will not cause a significant impact on the Black Cockatoos. Some habitat tress will be retained in the development. Planting of marri trees in POS and drainage reserves will lead to an increase in habitat in the long term;
- The site does not contain any significant wetlands;
- Access form Mundijong Road to the site can be achieved without impacting on the Threatened Ecological Community or Conservation Category Wetland in the Mundijong Road reserve;
- One Aboriginal heritage site is considered by the Aboriginal elders as not being a constraint to development;
- There are no European Heritage sites;
- Noise impacts from the future Tonkin Highway have been accommodated by large lots on the western side ; and
- A Local water Management Strategy has been prepared and incorporated intot he Local Structure Plan such that flooding on-site and downstream will be avoided and export of pollutants to the Peel Harvey Estuary will be minimised.

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FIGURES

PINPOINT CARTOGRAPHICS (08) 9562 7136 2012-048-f01.dgn

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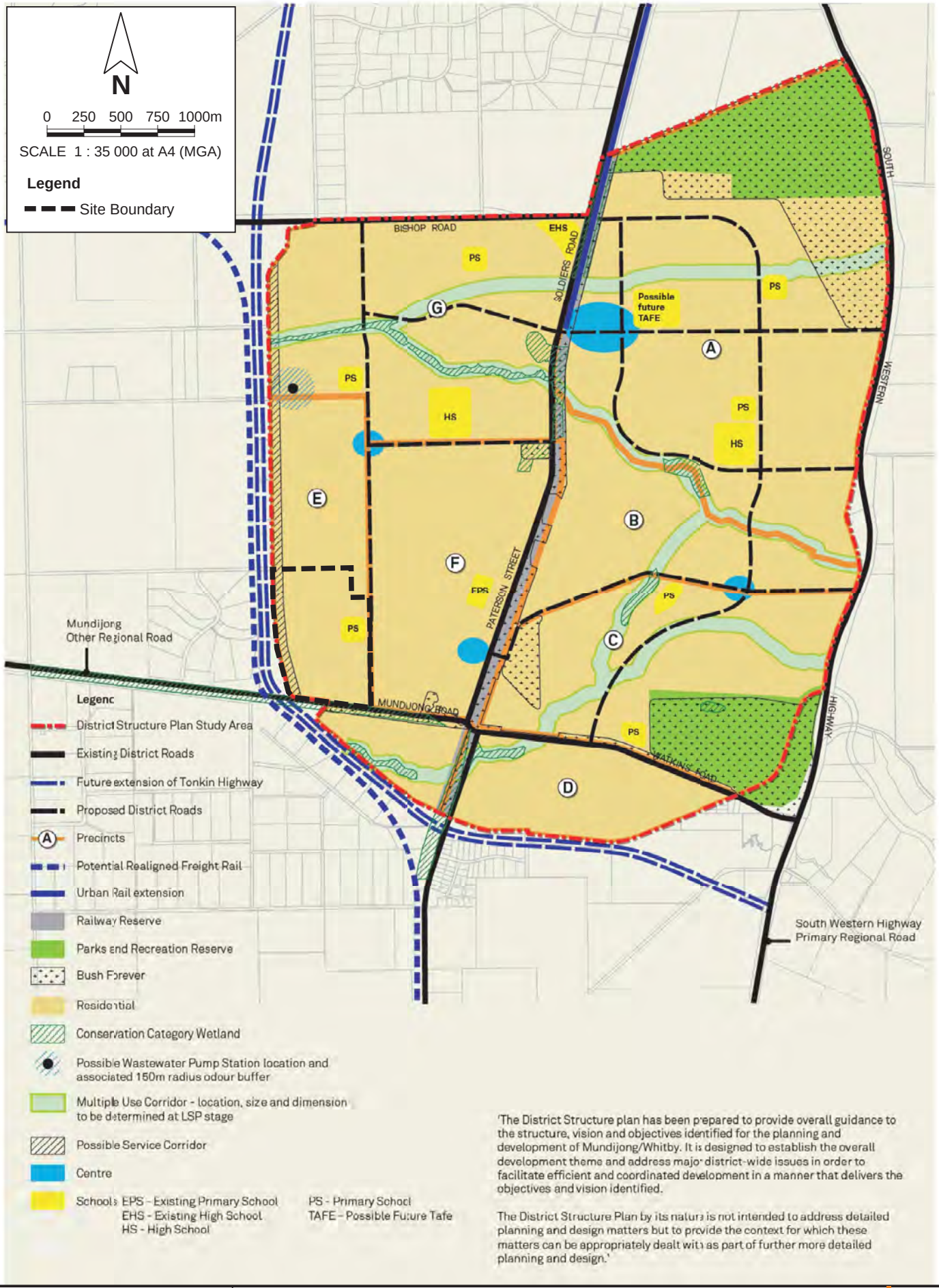
Peet Limited
ENVIRONMENTAL ASSESSMENT REPORT
LOT 50 MUNDIJONG ROAD, MUNDIJONG

Drawn: B. Heath	Date: 27 Sep 2012
Job: 10054	Revision: A

SITE LOCATION

Figure 1



PINPOINT CARTOGRAPHICS (08) 9562 7136 2012-048-f02.dgn

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MUNDIJONG WHITBY DISTRICT STRUCTURE PLAN

Figure 2

SOURCE: Taylor Burrell Barnett, Plan No. 08/039/020A, 06/08/2012.

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LOCAL STRUCTURE PLAN

Figure 3

PINPOINT CARTOGRAPHICS (08) 9562 7136 2012-048-f04.dgn

BASE SOURCE: Taylor Burrell Barnett.
AERIAL PHOTOGRAPH SOURCE: Taylor Burrell Barnett.

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CURRENT LAND USE AND TOPOGRAPHY

Figure 4

PINPOINT CARTOGRAPHICS (08) 9562 7136 2012-048-f05.dgn

403 000mE 403 250mE 403 500mE

6 427 000mN

6 426 750mN

6 426 500mN

6 426 250mN

SPARKMAN ROAD

ADAMS STREET

MUNDIJONG ROAD

ADONIS STREET

S10

Cs

N

0 25 50 75 100m

SCALE 1 : 3 000 at A3 (MGA)

Legend

- Site Boundary
- Cadastral Boundary
- Topographic Contour
- Geology Boundary

Geology Legend

Cs SANDY CLAY - white-grey to brown, fine to coarse-grained, subangular to rounded sand, clay of moderate plasticity gravel and silt layers near scarp

S10 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 strong, blocky, brown silts and clays

BASE SOURCE: Taylor Burrell Barnett.
AERIAL PHOTOGRAPH SOURCE: Taylor Burrell Barnett.
GEOLOGY SOURCE: Geological Survey of WA, 1:50 000 Environmental Geology Series.

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Job: 10054 | Revision: A

GEOLOGY AND SOILS

Figure 5

PINPOINT CARTOGRAPHICS (08) 9562 7136 2012-048-f06.dgn

403 000mE
403 250mE
403 500mE
6 427 000mN
6 426 750mN
6 426 500mN
6 426 250mN
6 426 000mN

SPARKMAN ROAD
ADAMS STREET
STREET
MUNDIJONG ROAD
ADONIS STREET

15785
14817
50
26
27
28
29

N

0 25 50 75 100m

SCALE 1 : 3 000 at A3 (MGA)

Legend

- Site Boundary
- Cadastral Boundary
- Groundwater Contour
- Conservation Category Wetland
- Multiple Use Wetland
- 14817 Wetland UFI

BASE SOURCE: Taylor Burrell Barnett.
WETLAND SOURCE: DEC, October 2012.
AERIAL PHOTOGRAPH SOURCE: Taylor Burrell Barnett.

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LOT 50 MUNDIJONG ROAD, MUNDIJONG

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Job: 10054 | Revision: A

HYDROLOGY

Figure 6

PINPOINT CARTOGRAPHICS (08) 9562 7136 2012-048-f07.dgn

403 000mE 403 250mE 403 500mE

6 427 000mN

SPARKMAN ROAD

N

0 25 50 75 100m

SCALE 1 : 3 000 at A3 (MGA)

Legend

- Site Boundary
- Cadastral Boundary
- Topographic Contour
- Bush Forever Site
- Vegetation Type Boundary

Cultivated
Casuarina obesa

ADAMS STREET

6 426 750mN

Isolated Native Trees over Pasture

Completely Degraded

50

6 426 500mN

6 426 250mN

MUNDIJONG ROAD

360

ADONIS STREET

6 426 000mN

BASE SOURCE: Taylor Burrell Barnett.
AERIAL PHOTOGRAPH SOURCE: Taylor Burrell Barnett.
BUSH FOREVER SOURCE: Department of Planning, 2007.

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Job: 10054	Revision: A

VEGETATION TYPES AND CONDITION

Figure 7

PINPOINT CARTOGRAPHICS (08) 9562 7136 2012-048-f08.dgn

403 000mE
403 250mE
403 500mE
6 427 000mN
6 426 750mN
6 426 500mN
6 426 250mN
SPARKMAN ROAD
ADAMS STREET
MUNDIJONG ROAD
ADONIS STREET
21
25
26
46
28
29
30
31

N

0 25 50 75 100m

SCALE 1 : 3 000 at A3 (MGA)

Legend

- Site Boundary
- Cadastral Boundary
- Topographic Contour
- Significant Tree Location
- Tree Containing Hollow

Significant Tree Species

- Dead
- *Eucalyptus* sp.
- Flooded Gum (*Eucalyptus rudis*)
- Marri (*Corymbia calophylla*)
- Southern Mahogany (*Eucalyptus botryoides*)
- Tasmanian Blue Gum (*Eucalyptus globulus*)

BASE SOURCE: Taylor Burrell Barnett.
AERIAL PHOTOGRAPH SOURCE: Taylor Burrell Barnett.
SIGNIFICANT TREES SOURCE: Terrestrial Ecosystems, Job No. 2011-040, 11 Nov 2011.

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LOT 50 MUNDIJONG ROAD, MUNDIJONG

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SIGNIFICANT TREES

Figure 8

PINPOINT CARTOGRAPHICS (08) 9562 7136 2012-048-f09.dgn

403 000mE
403 250mE
403 500mE
6 427 000mN
6 426 750mN
6 426 500mN
6 426 250mN

SPARKMAN ROAD
MUNDIJONG ROAD
ADONIS STREET
ADAMS STREET

Neighbourhood Connector
Service Corridor
Neighbourhood Connector

Residential
Residential
Residential
Residential
Public Open Space and Drainage
Primary School
Aboriginal Heritage Site

25 26 27 28 29 30 31 50

14817 360

Legend

- Site Boundary
- Cadastral Boundary
- Proposed Development
- Topographic Contour
- Bush Forever Site
- Conservation Category Wetland
- 14817 Wetland UFI
- Trees to be Retained Where Possible
- Fauna Habitat Trees to be Retained Where Possible

N

0 25 50 75 100m

SCALE 1 : 3 000 at A3 (MGA)

BASE SOURCE: Taylor Burrell Barnett.
WETLAND SOURCE: DEC, October 2012.
AERIAL PHOTOGRAPH SOURCE: Taylor Burrell Barnett.
BUSH FOREVER SOURCE: Department of Planning, 2007.
PROPOSED DEVELOPMENT SOURCE: TBB, Plan No. 08/039/020A, 06/08/2012.

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ENVIRONMENTAL ASSESSMENT REPORT
LOT 50 MUNDIJONG ROAD, MUNDIJONG

Drawn: B. Heath	Date: 26 Oct 2012
Job: 10054	Revision: A

ENVIRONMENTAL ASSETS

Figure 9

APPENDIX 1

Mature Native Species Recommended for Retention

Trees for Consideration for Transplanting				Date: 30 July 2012		Observer: Paul van der Moezel			
Tree Number	**Species**	**Easting MGA zn50**	**Northing MGA zn50**	**Photo Number**	**Height**	**Diameter**	**Second Branch**	**Third Branch**	**Notes (hollows, bees etc.)**
58	Liquidambar	65116.46	225410.64						Transplant
55	Caesalpinia	65095.40	225425.78						Transplant
54	Lemon tree	65078.41	225433.14						Transplant
68	Erythrina (Coral Tree)	65001.88	225387.17						Transplant
69	Erythrina (Coral Tree)	64989.00	225387.15						Transplant
70	Pine	64964.60	225409.12						Transplant, Stunted pine but nice specimen

Trees for Consideration for Retaining				Date: 30 July 2012		Observer: Paul van der Moezel and Shane Caddy			
Tree Number	Species	Easting MGA zn50	Northing MGA zn50	Photo Number	Height	Diameter	Second Branch	Third Branch	Notes (hollows, bees etc.)
38	Marri	64941.97	225897.84						nice stunted tree
39	Marri	64920.79	225891.74						small but nice tree
40	Marri	64912.67	225873.05						needs pruning
41	Marri	64877.64	225894.14						small but nice tree
42	Marri	64876.89	225896.45						small but nice tree
43	Marri	64883.74	225918.38						small but nice tree
44	Marri	64868.95	225932.61						small but nice tree
45	Marri	64851.57	225926.87						small but nice tree
77	Marri	64774.66	225140.17						nice tree
78	Marri	64798.00	225193.94						large good tree next to 79
79	Marri	64797.43	225196.49						large good tree next to 78
80	Kingia x 3	64864.53	225122.98						tall specimens
82	Marri	64888.94	225088.80						nice clump of healthy trees
83	Marri	64890.23	225092.01						nice clump of healthy trees
84	Marri	64892.89	225095.95						nice clump of healthy trees
85	Marri	64895.25	225096.78						nice clump of healthy trees
86	Marri	64897.51	225093.37						nice clump of healthy trees
87	Marri	64904.91	225119.67						nice tree
88	Marri	65099.78	225078.49						nice clump of healthy trees 88-90
89	Marri	65086.53	225092.67						nice clump of healthy trees 88-90
90	Marri	65075.92	225108.76						nice clump of healthy trees 88-90
49	Eucalyptus camaldulensis (River Red Gum)	65085.24	225500.35						nice tree but only in POS as it drops limbs
50	Eucalypts species	65088.62	225496.70						nice tree but only in POS as it drops limbs
46	Eucalyptus sideroxylon (Ironbark)	65086.42	225468.24						nice tree
56	Euclayptus rudis (Flooded Gum)	65116.34	225432.49						nice specimen of a Flooded Gum
94	Marri	65035.01	225335.02						nice double trunk tree
93	Marri	65042.09	225294.91						contains hollows, breeding 28 parrots
61	Euclayptus rudis (Flooded Gum)	65109.28	225368.38						nice tree
62	Eucalyptus camaldulensis (River Red Gum)	65096.89	225369.18						keep but only in POS. Part of a line of River Red Gums
66	Eucalyptus camaldulensis (River Red Gum)	65061.68	225388.41						keep but only in POS. Part of a line of River Red Gums
95	Eucalyptus camaldulensis (River Red Gum)	65051.24	225377.91						keep but only in POS. Part of a line of River Red Gums
96	Eucalyptus camaldulensis (River Red Gum)	65052.88	225377.35						keep but only in POS. Part of a line of River Red Gums
97	Eucalyptus camaldulensis (River Red Gum)	65061.52	225374.97						keep but only in POS. Part of a line of River Red Gums
98	Eucalyptus camaldulensis (River Red Gum)	65073.37	225370.07						keep but only in POS. Part of a line of River Red Gums
99	Eucalyptus camaldulensis (River Red Gum)	65085.89	225369.36						keep but only in POS. Part of a line of River Red Gums
100	Eucalyptus camaldulensis (River Red Gum)	65091.36	225369.02						keep but only in POS. Part of a line of River Red Gums

APPENDIX 2

Level 1 Fauna Report

Level 1 Fauna Assessment of Precinct G, Southern Site

Version 2. November 2011

Prepared for:

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DISCLAIMER

Front Cover: Galah (*Eolophus roseicapillus*)

TABLE OF CONTENTS

Chart

Plate

Tables

Figures

Appendices

EXECUTIVE SUMMARY

Peet Ltd is proposing to develop the southern site of its Precinct G in Mundijong. The project area (~54ha) is approximately 40km south south-east of the Perth CBD, is fenced and is currently being used as pasture. The project area contains a small (~ 1ha) fenced and treed (*Acacia* sp.) triangular plot on the northern boundary and scattered mature trees that are mostly along the eastern and southern boandaries.

The project has a low ecological value other than the few mature trees scattered across the paddock and is not part of any important ecological linkage in the bioregion.

Mature trees provide an important ecological resource for birds and small arboreal mammals and as such, where practical, they should be preserved and protected. Even large dead trees that are safe (i.e. unlikely to pose a risk through dropping branches or falling over) should be protected as they provide roosting and nesting sites for a variety of birds. Within this context, the design of any residential development should endeavour to protect and preserve as many of the mature trees as possible. Some of these trees will end up in street verges, others in public open space and some will be in residential lots. Caveats and other restrictions can be added to property titles to protect important trees.

Recommendation 1. Mature, healthy and safe trees that are currently in the paddocks should be preserved and protected where this is feasible within the design for the development of the project area.

1 INTRODUCTION

1.1 Background

Peet Ltd is proposing to develop the southern site of its Precinct G in Mundijong. The project area (~54ha) is approximately 40km south south-east of the Perth CBD, is fenced and is currently being used as pasture (Figures 1 and 2). Most of the land has been cleared with the exception of a triangular treed area on the northern boundary that has been planted with *Acacia* sp. and scattered trees in the pasture (Figure 2).

1.2 Project objectives and scope of work

Terrestrial Ecosystems was commissioned by PGV Environmental on behalf of Peet Ltd to undertake a Level 1 fauna risk assessment of the southern site of Precinct G (project area). The purpose of this Level 1 fauna risk assessment was to provide information to enable the appropriate government regulators to assess the potential impact of vegetation clearing on the fauna assemblages in the project area. The methodology broadly followed that described in the Environmental Protection Authority (EPA) *Position Statement No. 3: Terrestrial Biological Surveys as an Element of Biodiversity Protection* (EPA 2002), *Guidance Statement No. 56: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (EPA 2004) and the EPA/Department of Environment and Conservation (DEC) *Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment* (EPA / DEC 2010).

A Level 1 fauna risk assessment involves undertaking a desktop review and site inspection. The objectives of this fauna risk assessment were to:

- provide an indication of the vertebrate fauna assemblage (reptiles, amphibians, small mammals and birds) on and in the vicinity of the project area;
- identify the presence and/or potential risks of impacting on species of conservation significance that are present or likely to be present in the project area;
- determine if any additional surveys are required to assess the potential impact on fauna assemblages in the project area, in particular, impacts on species of conservation significance; and
- make recommendations that avoid, mitigate or minimise potential impacts on resident fauna.

To achieve these objectives, Terrestrial Ecosystems has:

- reviewed Terrestrial Ecosystems fauna survey database [includes Western Australian Museum (WAM) and DEC records] to identify potential vertebrate fauna within the area;
- reviewed DEC listed Threatened and Priority species as recorded in NatureMap that are likely to be in the area;
- searched the Commonwealth government's on-line database to identify fauna species of national environmental significance that are protected under the *Environment Protection and Biodiversity Conservation Act 1999* (*EPBC Act 1999*) potentially occurring in the area;
- reviewed previous fauna surveys conducted in the region;
- undertaken a site visit to identify available fauna habitat types and condition and to record all Eucalypt trees with a diameter of 50cm or greater at breast-height;
- undertaken an assessment of the potential risks to the fauna associated with clearing additional areas of native vegetation;
- provided a discussion of the likelihood of *EPBC Act 1999* and Western Australian (WA) *Wildlife Conservation Act 1950* listed species being present in the project area; and
- provided management recommendations to avoid, mitigate and minimise potential impacts on the fauna in the project area.

2 EXISTING ENVIRONMENT

2.1 Survey area

The project area (~ 54ha) is approximately 40km south south-east of the Perth CBD (Figure 1); it is fenced and used as pasture for cattle (Figure 2). Most of the land has been cleared with the exception of a triangular section on the northern boundary that is densely planted with young *Acacia* sp.. There are the remains of a building mid-way along the eastern boundary that is adjacent to cattle mustering yards. There is an abundance of rabbits in this area.

2.2 Climate

The Perth bioregion experiences a Mediterranean climate with hot summers from December to March and mild winters from May to August (Gentilli 1972). Chart 1 shows the average mean monthly maximum and minimum temperatures and rainfall for Jandakot airport (i.e. closest weather station). Temperatures are highest in January – February. Perth receives the majority of its annual rainfall in winter (Chart 1). This rain is usually the result of low pressure cells moving in a westerly direction which bring moisture bearing clouds over the south-west of Western Australia.

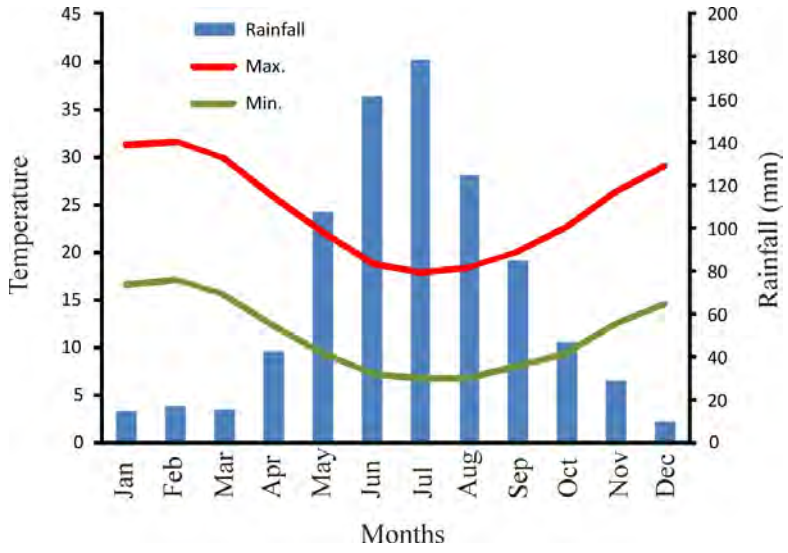

Chart 1. Mean monthly maximum and minimum temperatures and rainfall for Jandakot Airport (BOM July 2011; http://www.bom.gov.au/climate/averages/tables/cw_009172.shtml)

2.3 Land use

The predominant land use is pasture for cattle. Winter rains have resulted in low lying areas being wet under foot, and lush grass growth over most to the paddocks providing good pasture for cattle.

2.4 Biological context for the project area

The frogs, reptiles, mammals, birds and amphibians on the Swan Coastal Plain south of the Swan River have been surveyed on numerous occasions for a variety of purposes. Surveys in the vicinity of the project area which have been reviewed for this assessment include:

- 360 Environmental (2008) *Lot 9 Abernethy Road, Byford Spring Flora and Fauna Report*. Unpublished report for Australand Property Group, Perth.
- ATA Environmental (2006) *Vertebrate Fauna Assessment Brookdale Redevelopment Area*. Unpublished report for the Armadale Redevelopment Authority, Perth.
- Bamford Consulting Ecologists (2003) *Champion Lakes Master Plan; Fauna*. Unpublished report for Bowman Bishaw Gorham, Perth.
- Bamford Consulting Ecologists (2009) *Keane Road Strategic Link, Armadale Fauna Assessment*. Unpublished report for EnviroWorks Consulting, Perth.
- ENV Environment (2009) *Jandakot Airport Fauna Survey*. Unpublished report for Jandakot Airport Holdings Pty Ltd, Perth.
- Gole C.A. (2003) *Bird Survey in selected Perth Metropolitan Reserves. A Joint Biodiversity Conservation Project between Birds Australia WA and Perth Biodiversity Project*. Unpublished report Birds Australia and Perth Biodiversity Project, Perth.
- Harvey M.S., Dell J., How R.A. and Waldock J.M. (1997) *Ground Fauna of Bushland Remnants on the Ridge Hill Shelf and Pinjarra Plain Landforms Perth*. Unpublished report for the Australian Heritage Commission NEP Grant N95/49, Perth.
- How R.A. and Dell J. (2000) Ground vertebrate fauna of Perth's vegetation remnants: Impact of 170 years of urbanization. *Pacific Conservation Biology* 6, 198-217.
- How R.A., Harvey M.S., Dell J. and Waldock J.M. (1999) *Ground Fauna of Urban Bushland Remnants in Perth*. Unpublished report to the Australian Heritage Commission; NEP Grant N93/04, Perth.

The 360 Environmental (2008), ATA Environmental (2006) and Bamford Consulting Ecologists (2003, 2009) reports are for projects to the west and north of the project area but on the Swan Coastal Plain. The Western Australian Museum (Harvey et al. 1997, How et al. 1999, How and Dell 2000) and Gole (2003) reports are for fauna in remnant habitats in the region.

In addition to the above reports, Terrestrial Ecosystems fauna survey database contains records from NatureMap and the Western Australian Museum collection for this area. These records include the results of early surveys and incidental records that very often remain unreported. Many of the Western Australian Museum records are likely to be a subset of the NatureMap records, but there is no way of separating the data in NatureMap to isolate the records from the Museum.

3 METHODOLOGY

A review of the *EPBC Act 1999* list of protected species was undertaken to identify species of conservation interest to the Commonwealth Government. The search rectangle coordinates were 32.45°S, 115.88°E; 32.13 °S, 115.88 °E; 32.13 °S, 116.0 °E; 32.45 °S, 116.0 °E; 32.45 °S, 115.88 °E (Appendix A). In addition, a desktop search of the Terrestrial Ecosystems' fauna survey database was used to develop an appreciation of the vertebrate fauna assemblages in the relevant section of the bioregion in the vicinity of the project area. The DEC threatened and priority species database was searched via the records in NatureMap.

Other more general texts were also used to provide supplementary information on vertebrates in the bioregion, including Tyler *et al.* (2000) for frogs; Storr *et al.* (1983, 1990, 1999, 2002) for reptiles; Johnstone and Storr (1998, 2004) for birds; and Van Dyck and Strahan (2008) for mammals.

Because the project area is within the known distribution of Black-Cockatoos, a search was conducted to identify all trees with a trunk diameter at breast-height of 50cm or greater and those with hollows that could provide a nesting site for Black-Cockatoos. The site visit also looked for evidence of Black-Cockatoos feeding or actual birds foraging in the project area.

Collectively these sources of information were used to create lists of species expected to utilise the project area and broader bioregion. It should be noted that these lists will include species that have been recorded in the general region but are possibly vagrants and they will not generally be found in the project area due to a lack of suitable habitat (e.g. marine shore birds) and those found in the area before it was cleared but are no longer present. Vagrants can be recorded almost anywhere. Many of the bird, mammal, reptile and amphibian species have specific habitat requirements that may be present in the general area but not in the specific survey area. Also, the ecology of many of these species is often not well understood and it can sometimes be difficult to indicate those species whose specific habitat requirements are not present in the survey area. As a consequence many species will be included in the lists produced from database searches but will not be present in the actual project area.

3.1 Site visit

A site vist was undertaken on 20th September 2011 by Drs S and G Thompson. All sections of the project area were inspected. The location and type of all Eucalypt trees with a diameter of 50cm or greater at breast-height were recorded.

3.2 Limitations

This Level 1 fauna risk assessment is based on information contained in the Commonwealth Government database and other published and unpublished fauna survey data for the bioregion and a site visit. It is acknowledged that multiple surveys conducted in different seasons, repeated over several years are necessary to fully appreciate the fauna assemblage in the project area.

In addition, the project area is highly disturbed, with the consequence that it is unlikely to support a near-natural assemblage of the fauna that was present in the area before it was cleared. Determining whether a tree contained a hollow can be difficult from the ground, as all you can see is the opening, but not inside the hollow. It is therefore likely that many trees have been recorded as containing hollows, when on closer inspection that will not be the case, and even those that do contain hollows, only a few might be suitable as nesting sites for Black-Cockatoos.

The EPA *Guidance for Assessment of Environmental Factors: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia, No. 56* (2004) suggested that fauna surveys may be limited by many variables. Limitations associated with each of these variables are assessed in Table 1.

Table 1. Fauna survey limitations and constraints

Possible limitations	Constraint (yes/no); significant, moderate or negligible	Comment
Competency and experience of the consultant carrying out this assessment	No	The environmental scientists that prepared this assessment are familiar with the vertebrate fauna of this bioregion.
Scope	No	All aspects of the scope of works have been addressed.
Proportion of fauna identified, recorded and/or collected	No	Not applicable.
Accuracy of previous survey work	Yes, negligible	Terrestrial Ecosystems has reported fauna survey data recorded by various authors, but is not in a position to vouch for the accuracy of this information. It is acknowledged that the taxonomy of Western Australian vertebrates is continually being revised and the nomenclature of some of the species listed in the appendices may have changed since publication by the authors.
Sources of information	Yes, negligible	Vertebrate fauna information was available from an on-line database and unpublished and published reports of surveys conducted in the bioregion in a variety of habitat types. Many of these surveys employed a low level of trapping effort which significantly impacts on the capacity of these data to represent the fauna assemblages in the areas surveyed.
Timing/weather/ season/ cycle	No	Weather was suitable for a site visit.
Disturbances which affected results of the survey	No	The project area is highly disturbed. This has been taken into account in this assessment.
Intensity of survey effort	N/A	Not applicable.
Resources	No	Adequate resources were available.
Remoteness and/or access problems	No	There were no problems with access to the project area.
Availability of contextual information on the region	No	Fauna survey data are available for the general area.

Negligible – less than 20%; moderate -20-60%; significant – greater than 80%

4 RESULTS

4.1 Fauna habitats and condition

Project area contains two habitat types:

- fenced highly disturbed pasture with scattered mature native and planted trees (Plates 1a, b); and
- a small patch of fenced densely planted *Acacia* sp..

Plate 1a. Pasture with scattered mature native and planted trees

Plate 1b. Pasture with scattered mature native and planted trees

4.2 Location of conservation significant trees

All eucalypt trees in the project area were inspected to determine whether any showed signs of use or had the potential to support a nesting hollow for a Black-Cockatoo. Thirty five trees had a trunk diameter of 50cm or greater at breast-height in project area. The locations of these trees are shown on Figure 2 and Appendix B.

4.3 Bioregional vertebrate fauna

Appendix C provides a summary of the fauna survey data that are available in the vicinity of the project area. There are appreciable differences in the recorded fauna assemblages within and among fauna surveys shown in Appendix C. These differences are partially due to the low survey effort often deployed and they also reflect variations in soils and vegetation as well as temporal variations in the fauna assemblages.

Tables 2-5 provide a list of vertebrate species potentially found in the vicinity of the project area that have been compiled based on the fauna survey report results shown in Appendix C and information contained in Tyler *et al.* (2000) for frogs, Storr *et al.* (1983, 1990, 1999, 2002) for reptiles, Johnstone and Storr (1998, 2004) for birds, and Van Dyck and Strahan (2008) for mammals.

These lists are a significant over estimate of the actual species list likely to be present as many of these species have specific habitat requirements that are not available in the project area and the project area has been significantly degraded. The highly degraded nature of the project area means that the site would not support a fauna assemblage that was typical of the area before vegetation clearing.

Table 2. Birds potentially found in the vicinity of the project area

Family	Species	Common Name
Accipitridae	*Elanus axillaris*	Black-shouldered Kite
	Haliastur sphenurus	Whistling Kite
	Accipiter fasciatus	Brown Goshawk
	Accipiter cirrocephalus	Collared Sparrowhawk
	Circus approximans	Swamp Harrier
	Aquila audax	Wedge-tailed Eagle
	Hieraaetus morphnoides	Little Eagle
Anatidae	*Biziura lobata*	Musk Duck
	Stictonetta naevosa	Freckled Duck
	Cygnus atratus	Black Swan
	Tadorna tadornoides	Australian Shelduck
	Chenonetta jubata	Australian Wood Duck
	Anas gracilis	Grey Teal
	Anas superciliosa	Pacific Black Duck
	Aythya australis	Hardhead
Aegothelidae	*Aegotheles cristatus*	Australian Owlet-nightjar
Podargidae	*Podargus strigoides*	Tawny Frogmouth
Charadriidae	*Vanellus tricolor*	Banded Lapwing
Recurvirostridae	*Recurvirostra novaehollandiae*	Red-necked Avocet
Scolopacidae	*Calidris subminuta*	Long-toed Stint
	Calidris acuminata	Sharp-tailed Sandpiper
Stercorariidae	*Stercorarius longicauda*	Long-tailed Jaeger
Turnicidae	*Turnix velox*	Little Button-quail
Ardeidae	*Ardea pacifica*	White-necked Heron
	Egretta novaehollandiae	White-faced Heron
	Nycticorax caledonicus	Nankeen Night Heron
Pelecanidae	*Pelecanus conspicillatus*	Australian Pelican
Threskiornithidae	*Threskiornis molucca*	Australian White Ibis
	Threskiornis spinicollis	Straw-necked Ibis
Columbidae	*Columba livia*	Rock Dove
	Streptopelia senegalensis	Laughing Dove
	Streptopelia chinensis	Spotted Dove
	Phaps chalcoptera	Common Bronzewing
	Ocyphaps lophotes	Crested Pigeon
Alcedinidae	*Dacelo novaeguineae*	Laughing Kookaburra
	Todiramphus sanctus	Sacred Kingfisher
Meropidae	*Merops ornatus*	Rainbow Bee-eater
Cuculidae	*Chalcites basalis*	Horsfield's Bronze-Cuckoo
	Chalcites lucidus	Shining Bronze-Cuckoo

Family	Species	Common Name
	Cacomantis pallidus	Pallid Cuckoo
	Cacomantis flabelliformis	Fan-tailed Cuckoo
Caprimulgidae	*Eurostopodus argus*	Spotted Nightjar
Falconidae	*Falco cenchroides*	Nankeen Kestrel
	Falco berigora	Brown Falcon
	Falco longipennis	Australian Hobby
	Falco subniger	Black Falcon
Phasianidae	*Coturnix ypsilophora*	Brown Quail
Rallidae	*Porphyrio porphyrio*	Purple Swamphen
	Gallirallus philippensis	Buff-banded Rail
	Porzana tabuensis	Spotless Crake
	Gallinula tenebrosa	Dusky Moorhen
	Fulica atra	Eurasian Coot
Acanthizidae	*Sericornis frontalis*	White-browed Scrubwren
	Smicrornis brevirostris	Weebill
	Gerygone fusca	Western Gerygone
	Acanthiza chrysorrhoa	Yellow-rumped Thornbill
	Acanthiza inornata	Western Thornbill
	Acanthiza apicalis	Inland Thornbill
Acrocephalidae	*Acrocephalus australis*	Australian Reed-Warbler
Artamidae	*Artamus cinereus*	Black-faced Woodswallow
	Artamus cyanopterus	Dusky Woodswallow
	Cracticus torquatus	Grey Butcherbird
	Cracticus tibicen	Australian Magpie
Campephagidae	*Coracina novaehollandiae*	Black-faced Cuckoo-Shrike
	Lalage sueurii	White-winged Triller
Climacteridae	*Climacteris rufa*	Rufous Treecreeper
Corvidae	*Corvus coronoides*	Australian Raven
Estrildidae	*Stagonopleura oculata*	Red-eared Firetail
Hirundinidae	*Hirundo neoxena*	Welcome Swallow
	Petrochelidon nigricans	Tree Martin
	Petrochelidon ariel	Fairy Martin
Maluridae	*Malurus splendens*	Splendid Fairy-wren
	Malurus elegans	Red-winged Fairy-wren
Meliphagidae	*Acanthorhynchus superciliosus*	Western Spinebill
	Lichenostomus virescens	Singing Honeyeater
	Lichenostomus ornatus	Yellow-plumed Honeyeater
	Manorina flavigula	Yellow-throated Miner
	Anthochaera lunulata	Western Wattlebird

Family	Species	Common Name
	Anthochaera carunculata	Red Wattlebird
	Epthianura albifrons	White-fronted Chat
	Glyciphila melanops	Tawny-crowned Honeyeater
	Lichmera indistincta	Brown Honeyeater
	Phylidonyris novaehollandiae	New Holland Honeyeater
	Phylidonyris niger	White-cheeked Honeyeater
	Melithreptus brevirostris	Brown-headed Honeyeater
	Melithreptus lunatus	White-naped Honeyeater
Monarchidae	*Grallina cyanoleuca*	Magpie-Lark
	Anthus novaeseelandiae	Australasian Pipit
Nectariniidae	*Dicaeum hirundinaceum*	Mistletoebird
Neosittidae	*Daphoenositta chrysoptera*	Varied Sittella
Pachycephalidae	*Pachycephala pectoralis*	Golden Whistler
	Pachycephala rufiventris	Rufous Whistler
	Colluricincla harmonica	Grey Shrike-thrush
Pardalotidae	*Pardalotus punctatus*	Spotted Pardalote
	Pardalotus striatus	Striated Pardalote
Petroicidae	*Petroica multicolor*	Pacific Robin
	Petroica boodang	Scarlet Robin
	Petroica goodenovii	Red-capped Robin

Family	Species	Common Name
	Eopsaltria georgiana	White-breasted Robin
Rhipiduridae	*Rhipidura fuliginosa*	New Zealand Fantail
	Rhipidura albiscapa	Grey Fantail
	Rhipidura leucophrys	Willie Wagtail
Timaliidae	*Zosterops lateralis*	Silvereye
Cacatuidae	*Calyptorhynchus banksii naso*	Red-tailed Black-Cockatoo
	Calyptorhynchus latirostris	Carnaby's Black-Cockatoo
	Calyptorhynchus baudinii	Baudin's Black-Cockatoo
	Eolophus roseicapillus	Galah
	Cacatua sanguinea	Little Corella
Psittacidae	*Trichoglossus haematodus*	Rainbow Lorikeet
	Glossopsitta porphyrocephala	Purple-crowned Lorikeet
	Polytelis anthopeplus	Regent Parrot
	Platycercus icterotis	Western Rosella
	Barnardius zonarius	Australian Ringneck
	Purpureicephalus spurius	Red-capped Parrot
	Melopsittacus undulatus	Budgerigar
	Neophema elegans	Elegant Parrot
Strigidae	*Ninox novaeseelandiae*	Southern Boobook
Tytonidae	*Tyto alba*	Barn Owl

Table 3. Amphibians potentially found in the vicinity of the project area

Family	Species	Common Name
Hylidae	*Litoria adelaidensis*	Slender Tree Frog
	Litoria moorei	Motorbike Frog
Limnodynastidae	*Heleioporus eyrei*	Moaning Frog
	Heleioporus psammophilus	Sand Frog
	Limnodynastes dorsalis	Western Banjo Frog
Myobatrachidae	*Crinia georgiana*	Quacking Frog

Family	Species	Common Name
	Crinia glauerti	Clicking Frog
	Crinia insignifera	Squelching Froglet
	Crinia pseudinsignifera	Bleating Froglet
	Geocrinia leai	Ticking Frog
	Myobatrachus gouldii	Turtle Frog
	Pseudophryne guentheri	Crawling Toadlet

Table 4. Mammals potentially found in the vicinity of the project area

	Species	Common Name
Canidae	*Canis lupus*	Dog
	Vulpes vulpes	Red Fox
Felidae	*Felis catus*	House Cat
Molossidae	*Austronomus australis*	White-striped Freetail Bat
	Mormopterus species 4	Southern Freetail Bat
Vespertilionidae	*Chalinolobus gouldii*	Gould's Wattled Bat
	Nyctophilus geoffroyi	Lesser Longeared Bat
	Nyctophilus major	Western Longeared Bat
	Vespadelus regulus	Southern Forest Bat
Dasyuridae	*Antechinus flavipes*	Yellow-footed Antechinus
	Phascogale tapoatafa	Brush-tailed Phascogale
	Sminthopsis gilberti	Gilbert's Dunnart

	Species	Common Name
Burramyidae	*Cercartetus concinnus*	Southwestern Pygmy Possum
Macropodidae	*Macropus fuliginosus*	Western Grey Kangaroo
Phalangeridae	*Trichosurus vulpecula*	Common Brushtail Possum
Tarsipedidae	*Tarsipes rostratus*	Honey Possum
Leporidae	*Oryctolagus cuniculus*	European Rabbit
Tachyglossidae	*Tachyglossus aculeatus*	Short-beaked Echidna
Peramelidae	*Isoodon obesulus*	Southern Brown Bandicoot
Muridae	*Hydromys chrysogaster*	Water Rat
	Mus musculus	House Mouse
	Rattus fuscipes	Bush Rat
	Rattus rattus	Black Rat

Table 5. Reptiles potentially found in the vicinity of the project area

Family	Species
Agamidae	*Ctenophorus adelaidensis*
	Pogona minor
Boidae	*Morelia spilota imbricata*
Diplodactylidae	*Diplodactylus polyophthalmus*
	Strophurus spinigerus
Elapidae	*Acanthophis antarcticus*
	Brachyurophis fasciolata
	Brachyurophis semifasciata
	Demansia psammophis
	Echiopsis curta
	Elapognathus coronatus
	Neelaps bimaculatus
	Neelaps calonotos
	Notechis scutatus
	Parasuta gouldii
	Parasuta nigriceps
	Pseudonaja affinis
	Simoselaps bertholdi

Family	Species
Gekkonidae	*Christinus marmoratus*
Pygopodidae	*Aprasia pulchella*
	Aprasia repens
	Delma fraseri
	Delma grayii
	Lialis burtonis
	Pletholax gracilis
	Pygopus lepidopodus
Scincidae	*Acritoscincus trilineatum*
	Cryptoblepharus buchananii
	Ctenotus australis
	Ctenotus fallens
	Ctenotus gemmula
	Ctenotus impar
	Ctenotus labillardieri
	Egernia napoleonis
	Hemiergis initialis
	Hemiergis quadrilineata

Family	Species
	Lerista distinguenda
	Lerista elegans
	Lerista lineata
	Lerista lineopunctulata
	Menetia greyii
	Morethia lineoocellata
	Morethia obscura
	Tiliqua occipitalis
	Tiliqua rugosa
Typhlopidae	*Ramphotyphlops australis*
	Ramphotyphlops bituberculatus
	Ramphotyphlops pinguis
	Ramphotyphlops waitii
Varanidae	*Varanus gouldii*
	Varanus rosenbergi
	Varanus tristis
Chelidae	*Chelodina oblonga*

4.4 Conservation significant fauna

Conservation significant fauna are protected by the Commonwealth *EPBC Act 1999*, and this list includes species covered by international treaties such as the Japan-Australia Migratory Bird Agreement (JAMBA) and China-Australia Migratory Bird Agreement (CAMBA) and the Western Australia (WA) *Wildlife Conservation Act 1950*. The WA *Wildlife Conservation Act 1950* provided for the publishing of the *Wildlife Conservation (Specially Protected Fauna) Notice* that lists species under multiple categories. In addition, the DEC maintains a list of fauna that require monitoring under five priorities based on DEC's knowledge of their distribution, abundance and threatening processes. The *EPBC Act 1999* and *Wildlife Conservation Act 1950* imply legislative requirements for the management of anthropogenic impacts to minimise the effects of disturbances on species and their habitats. Priority species have no statutory protection, other than the DEC wishes to monitor potential impacts on these species. Environmental consultants and proponents of developments are encouraged to avoid and minimise impacts on these species. Definitions of the significant fauna under the *WA Wildlife Conservation Act* are provided in Appendix D.

Thirteen threatened species of fauna and 14 migratory species of birds identified under the *EPBC Act 1999* potentially occur in the project area. There are 27 Schedule species listed under the WA *Wildlife Conservation Act 1950* and 10 species listed on the DEC's Priority Fauna List that potentially occur in the project area. The following is an assessment of the likelihood of each of the species being found in the project area and Table 6 is a summary of this information.

The recently released Commonwealth government draft referral guidelines on Black-Cockatoos in Western Australia (Department of Sustainability Environment Water Population and Communities 2011) is also relevant as the project area potentially provides a foraging resource for Black-Cockatoos.

Table 6. Species that are potentially found in the vicinity of the project area and that are listed as being of conservation significance under state or commonwealth government legislation or with DEC

Species	Status under the Wildlife Conservation Act / DEC	Status under the *EPBC Act*	Comment on potential impact that vegetation clearing will have on conservation significant species
Neopasiphae simplicior Native bee	Schedule 1	Critically Endangered	Unlikely to be found in the project area. Low potential impact.
Phascogale calura Red-tailed Phascogale	Schedule 1	Endangered	Unlikely to be found in the project area. Low potential impact.
Calyptorhynchus latirotris Carnaby's Black-Cockatoo	Schedule 1	Endangered	Likely to be seen the project area. Low potential impact.
Botaurus poiciloptilus Australasian Bittern	Schedule 1	Endangered	Seen in the project area. Low potential impact.
Synemon gratiosa Graceful Sun-Moth	Schedule 1	Endangered	No suitable habitat. Low potential impact.
Sternula nereis nereis Fairy Term	Schedule 1	Endangered	Unlikely to be found in the project area. Low potential impact.
Bettongia penicillata Woylie	Schedule 1	Endangered	Unlikely to be found in the project area. Low potential impact.
Calyptorhynchus banksii naso Forest Red-tailed Black-Cockatoo	Schedule 1	Vulnerable	Likely to be seen in the project area. Low potential impact.
Calyptorhynchus baudinii Baudin's Black-Cockatoo	Schedule 1	Vulnerable	Likely to be seen in the project area Low potential impact.
Dasyurus geoffroii Chuditch	Schedule 1	Vulnerable	Unlikely to be found in the project area. Low potential impact.
Myrmecobius fasciatus Numbat	Schedule 1	Vulnerable	Unlikely to be found in the project area. Low potential impact.
Setonix brachyurus Quokka	Schedule 1	Vulnerable	Unlikely to be found in the project area. Low potential impact.
Apus pacificus Fork-tailed Swift	Schedule 3	Migratory	May infrequently fly over the project area. Low potential impact.
Haliaeetus leucogaster White-bellied Sea-eagle	Schedule 3	Migratory	May infrequently fly over the project area. Low potential impact.
Merops ornatus Rainbow Bee-eater	Schedule 3	Migratory	May be found in the vicinity of the project area. Low potential impact.
Calidris acuminata Sharp-tailed Sandpiper	Schedule 3	Migratory Wetland	Unlikely to be seen in the project area. Low potential impact.
Calidris canutus Red Knot	Schedule 3	Migratory Wetland	Unlikely to be seen in the project area. Low potential impact.
Calidris ferruginea Curlew Sandpiper	Schedule 3	Migratory Wetland	Unlikely to be seen in the project area. Low potential impact.
Calidris ruficollis Red-necked Stint	Schedule 3	Migratory Wetland	Unlikely to be seen in the project area. Low potential impact.
Ardea alba Great Egret	Schedule 3	Migratory Wetland	Unlikely to be seen in the project area. Low potential impact.
Ardea ibis Cattle Egret	Schedule 3	Migratory Wetland	Unlikely to be seen in the project area. Low potential impact.
Limosa lapponica Bar-tailed Godwit	Schedule 3	Migratory Wetland	Unlikely to be found in the project area. Low potential impact.
Limosa limosa Black-tailed Godwit	Schedule 3	Migratory Wetland	Unlikely to be found in the project area. Low potential impact.
Numenius minutus Little Curlew	Schedule 3	Migratory Wetland	Unlikely to be found in the project area. Low potential impact.
Tringa glareola Wood Sandpiper	Schedule 3	Migratory Wetland	Unlikely to be seen in the project area. Low potential impact.
Tringa stagnatilis Marsh Sandpiper	Schedule 3	Migratory Wetland	Unlikely to be seen in the project area. Low potential impact.
Morelia spilota imbricata Carpet Python	Schedule 4		Unlikely to be found in the project area. Low potential impact.
Falco peregrinus Peregrine Falcon	Schedule 4		May infrequently fly over the project area. Low potential impact.
Ctenotus gemmula	Priority 3		Unlikely to be found in the project area. Low potential impact.

Species	Status under the Wildlife Conservation Act / DEC	Status under the *EPBC Act*	Comment on potential impact that vegetation clearing will have on conservation significant species
Neelaps calonotos Black-striped Snake	Priority 3		Unlikely to be found in the project area. Low potential impact.
Lerista lineata Lined Skink	Priority 3		Unlikely to be found in the project area. Low potential impact.
Macropus irma Western Brush Wallaby	Priority 4		Unlikely to be found in the project area. Low potential impact.
Hydromys chrysogaster Water Rat	Priority 4		Unlikely to be found in the project area. Low potential impact.
Numenius madagascariensis Eastern Curlew	Priority 4		Unlikely to be found in the project area. Low potential impact.
Falsistrellus mackenziei Western False Pipistrelle	Priority 4		Unlikely to be found in the project area. Low potential impact.
Acanthorhynchus superciliosus Western Spinebill	Priority 4		Maybe in the project area. Low potential impact.
Isoodon obesulus fusciventer Southern Brown Bandicoot	Priority 5		Unlikely to be found in the project area. Low potential impact.

Native Bee (*Neopasiphae simplicior*) – Critically Endangered under the *EPBC Act 1999* and Schedule 1 under the *Wildlife Conservation Act 1950*

The Department of Sustainability, Environment, Water, Population and Communities (http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=6682) indicated that this critically endangered bee has been found in a single location within the Forrestdale Lake Nature Reserve, and it is known to occupy an area of about 1km^2. It has been collected from the flowers of Thread-leaved Goodenia (*Goodenia filiformis*), Slender Lobelia (*Lobelia tenulor*), *Angianthus preissianus* and *Velleia* sp. (Houston 2000).

The Forrestdale Lake is about 15km to the north-west of the project area. Terrestrial Ecosystems' assessment is that the proposed vegetation clearing is unlikely to impact on this species, as it is outside the species known geographic distribution.

Red-tailed Phascogale (*Phascogale calura*) – Endangered under the *EPBC Act 1999* and Schedule 1 under the *Wildlife Conservation Act 1950*

This species was formerly widespread in woodland habitat through much of inland southern and central Australia. It is now restricted to remnants of mature Wandoo or Rock Oak woodland in the southern wheatbelt.

Terrestrial Ecosystems' assessment is that given the lack of recent records of this species in the vicinity of the project area and a lack of suitable habitat, the Red-tailed Phascogale is unlikely to occur within the project area.

Carnaby's Black-Cockatoo (*Calyptorhynchus latirostris*) – Endangered under the *EPBC Act 1999* and Schedule 1 under the *Wildlife Conservation Act 1950*

Carnaby's Black-Cockatoo inhabits the south-west of Western Australia (Garnett et al. 2011). Its preferred nesting trees include the smooth-barked Salmon Gum (*Eucalyptus salmonophloia*) and Wandoo (*E. wandoo*), which contain deep hollows. Nesting also occurs in Marri (*Corymbia calophylla*) and Tuart (*E. gomphocephala*). Its main foods are the seeds of Hakeas, Grevilleas, Banksias, Eucalypts and introduced pines.

The project area contains some Marri (*Corymbia calophylla*) which are known feeding trees for Carnaby's Black-Cockatoo (Higgins 1999). Carnaby's Black-Cockatoos were recorded during other fauna surveys in the general area. Carnaby's Black-Cockatoo are likely to regularly feed in the native vegetation on the Mundijong Road verge on the southern boundary of the project area.

Loss of breeding habitat in the form of suitable hollows and adequate feeding resources in the vicinity of nesting hollows to enable adults to feed chicks is a primary threat. Competition for nesting hollows by other cockatoos, Galahs and feral Honey Bees appears to also be a significant threat (Garnett et al. 2011).

All eucalypt trees in the project area were inspected to determine whether any showed signs of use or had the potential to support a nesting hollow for a Black-Cockatoo. Thirty five trees had a trunk diameter of 50cm or

greater at breast-height in project area. The locations of these trees are shown on Figure 2 and Appendix B. Most of the large trees in project area are along the eastern or southern boundaries.

Determining whether a tree contained a hollow can be difficult from the ground, as all you can see is the opening, but not inside the hollow. Three trees may have contained hollows in the project area. Some of the trees that contained hollows contained nests of Australian Ringneck Parrots and Galahs. Johnstone and Kirkby (2011) indicated that there were no records of Carnaby's Black-Cockatoos breeding in the vicinity of the project area, and the closest nesting site was on the Darling Scarp to the east.

Australasian Bittern (*Botaurus poiciloptilus*) – Endangered under the *EPBC Act 1999* and Schedule 1 under the *Wildlife Conservation Act 1950*

The Australasian Bitterns' preferred habitat is beds of tall dense *Typha*, *Baumea* and sedges in the shallows of freshwater swamps (Johnstone and Storr 1998). Johnstone and Storr (1998) reported its distribution from Moora east to Cape Arid and the south-west of Western Australia. Johnstone and Storr (1998) reported it as locally common in the wetter parts of the south-west. Garnett et al. (2011) more recently indicated that the sub-population in Western Australia is restricted to a few records away from the south coast and Lake Muir wetlands, with few confirmed records from the Swan Coastal Plain since 1992.

Threats include drainage of permanent and ephemeral swamps for agriculture and urban development (Garnett et al. 2011). It was recorded in an earlier fauna survey of Thomson's Lake. It is unlikely to be in the project area due to a lack of suitable habitat.

Graceful Sun-moth (*Synemon gratiosa*) – Endangered under the *EPBC Act 1999* and Schedule 1 under the *Wildlife Conservation Act 1950*

This species has brightly coloured orange hind-wings, and is similar in appearance to a butterfly. The breeding season is late February to early April, during which time adults are active during the day and they are thought to breed exclusively on *Lomandra* species, in particular *L. hermaphrodita* and *L. maritima*. Graceful Sun-moths occur along the Swan Coastal Plain between Moore River and Preston Beach and the species is under threat due to vegetation clearing and damage to the environment.

No *Lomandra hermaphrodita* was observed in the project area, nor was there any Banksia woodland; therefore, Terrestrial Ecosystems' believes that it is highly unlikely that the Graceful Sun-moth is in the project area.

Fairy Tern (*Sternula nereis nereis*) – Endangered under the *EPBC Act 1999*

Garnett et al. (2011) reported that the Fairy Tern occurs in on sheltered coasts and saline wetlands in southern Australia from the Pilbara in Western Australia around to Botany Bay in NSW, excluding the Great Australian Bight. Garnett et al. (2011) reported that it mostly nests on predator-free islands in Western Australia.

It is unlikely to be seen in the vicinity of the project area due to a lack of suitable habitat.

Woylie (*Bettongia penicillata ogilbyi)* – Endangered under the *EPBC Act 1999* and Schedule 1 under the *Wildlife Conservation Act 1950*

Woylie numbers have significantly reduced in recent years after it was removed from the conservation significant species lists. The Woylie was once abundant in the south-west forest areas. Fox and cat predation, along with habitat destruction were thought to have significantly reduced its numbers (De Tores and Start 2008) but it is still unclear why its number have recently declined. The Woylie diet consists of underground fungi, tubes, bulbs and seeds.

Woylies have not been recorded in the vicinity of the project area in recent years and as a consequence they are unlikely to be impacted by vegetation clearing in the project area.

Forest Red-tailed Black-Cockatoo (*Calyptorhynchus banksii naso*) – Vulnerable under the *EPBC Act 1999* and Schedule 1 under the *Wildlife Conservation Act 1950*

Forest Red-tailed Black-Cockatoos frequent the humid to sub-humid south-west of Western Australia from Gingin in the north, to Albany in the south and west to Cape Leeuwin and Bunbury (Department of Sustainability Environment Water Population and Communities 2011). It nests in tree hollows with a depth of 1-5m, that are predominately Marri (*C. calophylla*), Jarrah (*E. marginata*) and Karri (*E. diversicolor*) and it feeds primarily on the seeds of Marri.

Loss of breeding habitat in the form of suitable hollows and adequate feeding resources in the vicinity of nesting hollows to enable adults to feed chicks is a primary threat. Competition for nesting hollows by other cockatoos, Wood Ducks, Galahs and feral Honey Bees appears to also be a significant threat (Garnett et al. 2011).

All eucalypt trees in the project area were inspected to determine whether any showed signs of use or had the potential to support a nesting hollow for a Black-Cockatoo. Thirty five trees had a trunk diameter of 50cm or greater at breast-height in project area. The locations of these trees are shown on Figure 2 and Appendix B. Most of the large trees in project area are along the eastern or southern boundaries.

Red-Tailed Black-Cockatoos have been recorded during other fauna surveys in the general area and probably feed in the native trees on the south side of Mundijong Road outside the project area. They may occasionally roost in the large trees on-site. There is no record to indicate that they breed in the vicinity of the project area (Johnstone and Kirkby 2011).

Baudin's Black-Cockatoo (*Calyptorhynchus baudinii*) – Vulnerable under the *EPBC Act 1999* and Schedule 1 under the *Wildlife Conservation Act 1950*

This species is most common in the far south-west of Western Australia. It is known to breed from the southern forests north to Collie and east to near Kojonup. Baudin's Black-Cockatoo is typically found in vagrant flocks and utilises the taller, more open Jarrah and Marri woodlands, where it feeds mainly on Marri seeds and various Proteaceous species. While they are seasonally present on the Swan Coastal Plain, Baudin's Black-Cockatoo are potentially seen in the vicinity of the project area (Garnett et al. 2011).

Garnett et al. (2011) reported the primary threat to this species is a lack of suitable hollows. Competition for hollows also comes from other cockatoos, Galahs, Wood Ducks and feral Honey Bees.

Loss of breeding habitat in the form of suitable hollows and adequate feeding resources in the vicinity of nesting hollows to enable adults to feed chicks is a primary threat. Competition for nesting hollows by other cockatoos, Galahs and feral Honey Bees appears to also be a significant threat (Garnett et al. 2011).

All eucalypt trees in the project area were inspected to determine whether any showed signs of use or had the potential to support a nesting hollow for a Black-Cockatoo. Thirty five trees had a trunk diameter of 50cm or greater at breast-height in project area. The locations of these trees are shown on Figure 2 and Appendix B. Most of the large trees in project area are along the eastern or southern boundaries.

Baudin's Black-Cockatoo may infrequently feed in the project area, but would more frequenly be seen foraging in the native vegetation on the south side of Mundijong Road, which is on the other side of the southern boundary of the project area.

Chuditch, Western Quoll (*Dasyurus geoffroii*) – Vulnerable under the *EPBC Act 1999* and Schedule 1 under the *Wildlife Conservation Act 1950*

The Chuditch was originally found in over 70% of Australian woodlands; however, since European settlement its range has diminished to a patchy distribution throughout the Jarrah forest and mixed Karri-Marri-Jarrah forest of south-west WA. They have been known to occupy a wide range of habitats including woodlands, dry sclerophyll forests, riparian vegetation, beaches and deserts. The Chuditch creates dens in hollow logs or burrows and have also been recorded in tree hollows and cavities. They are opportunistic feeders and forage on the ground at night, feeding on invertebrates, small mammals, birds and reptiles.

Terrestrial Ecosystems' believes that it is unlikely the Chuditch occurs within the project area due to a lack of suitable habitat and there are no recent records in the vicinity.

Numbat (*Myrmecobius fasciatus*) – Vulnerable under the *EPBC Act 1999* and Schedule 1 under the *Wildlife Conservation Act 1950*

The Numbat was originally widespread across southern semi-arid and arid Australia, from western NSW through SA and southern NT to the south-west of WA (Maxwell et al. 1996). There are currently two remnant native populations at Dryandra and Perup, WA and several reintroduced populations including Boyagin Nature Reserve, Tutanning Nature Reserve, Batalling block and Karroun Hill Nature Reserve (Friend and Thomas 1995).

There are no recent records of this species in the general area and the available habitat is not suitable. Terrestrial Ecosystems' assessment is that the Numbat is unlikely to occur within the project area.

Quokka (*Setonix brachyurus*) – Vulnerable under the *EPBC Act 1999* and Schedule 1 under the *Wildlife Conservation Act 1950*

Quokkas were originally very common on the Swan Coastal Plain, however, their distribution is now limited to Rottnest Island and a few isolated areas in the south-west of WA. On the mainland, they prefer densely vegetated areas around wetlands and streams, whereas on Rottnest Island they inhabit low scrubby coastal vegetation where water is not readily available year-round. They are herbivorous, and feed on leaves, bark, succulent plants and grasses. There are no recent records of Quokka being found in the vicinity of the project area.

Terrestrial Ecosystems' believes that Quokkas are unlikely to occur within the project area due to lack of suitable habitat and the presence of introduced predators.

Fork-tailed Swift (*Apus pacificus*) - Migratory under the *EPBC Act 1999* and Schedule 3 under the *Wildlife Conservation Act 1950*

The Fork-tailed Swift breeds in north-east and mid-east Asia and winters in Australia and south New Guinea (Johnstone and Storr 1998). They arrive in the Kimberley in late September and in the Pilbara in November and the south-west in December, leaving late in April. Johnstone and Storr (1998) reported them as common in the Kimberley and uncommon to moderately common along the north-west, west and south-east coasts and scarce elsewhere. They are often seen in large flocks and can be attracted to thunderstorms or cyclonic events in the northern parts of the state.

As this is a migratory species, ground disturbance activities on a localised scale are unlikely to significantly impact on Fork-tailed Swifts. They could infrequently be seen flying over the project area.

White-bellied Sea-Eagle (*Haliaeetus leucogaster*) – Migratory under the *EPBC Act 1999* and Schedule 3 under the *Wildlife Conservation Act 1950*

The White-bellied Sea-eagle is the second largest bird of prey found in Australia. This eagle has been seen in a variety of habitats and not always near the ocean, but they are more commonly seen in coastal areas. Birds form permanent pairs that inhabit territories throughout the year. These eagles are normally seen perched high in a tree, or soaring over waterways and adjacent land.

Terrestrial Ecosystems' assessment is that the White-bellied Sea-Eagle may infrequently be seen in the general area, but clearing the project area is unlikely to significantly impact on this species.

Rainbow Bee-eater (*Merops ornatus*) - Migratory under the *EPBC Act 1999* and Schedule 3 under the *Wildlife Conservation Act 1950*

Rainbow Bee-eaters are abundant in Australia, and found in many parts of Western Australia except the sandy deserts and dry arid interior. Johnstone and Storr (1998) described them as resident, breeding visitors and postnuptial nomads. They are generally migratory, moving south in late September and early October, having wintered from the Gascoyne to Indonesia.

Rainbow Bee-eaters are regularly seen across most of the wetter areas of Western Australia including around the project area. Given their abundance and wide spread distribution, ground disturbance activities on a localised scale are unlikely to significantly impact on Rainbow Bee-eaters.

Sharp-tailed Sandpiper (*Calidris acuminata*) – Migratory under the *EPBC Act 1999* and Schedule 3 under the *Wildlife Conservation Act 1950*

This species is found in a variety of habitats including tidal sandbars, mudflats, estuaries, swamps, inland lakes and shorelines, but is essentially confined to areas around water.

Terrestrial Ecosystems' believes it is unlikely to be recorded in the project area due to a lack of suitable habitat.

Red Knot (*Calidris canutus*) - Migratory under the *EPBC Act 1999* and Schedule 3 under the *Wildlife Conservation Act 1950*

The Red Knot is mostly found around mud and sand flats in estuaries, along sheltered coast lines and edges of salt lakes. It breeds in the New Siberian Islands wintering in Australia and New Zealand (Garnett et al. 2011).

Terrestrial Ecosystems' believes it is unlikely to be recorded in the project area due to a lack of suitable habitat.

Curlew Sandpiper (*Calidris ferruginea*) – Migratory under the *EPBC Act 1999* and Schedule 3 under the *Wildlife Conservation Act 1950*

This species breeds in north Siberia and winters from western Africa to Australia (Garnett et al. 2011). It occurs around the whole of the Australian coast line. It is mostly found in coastal brackish lagoons, tidal mud and sand flats, estuaries, salt marshes and occasionally on inland waterways.

Terrestrial Ecosystems' believes it is unlikely to be recorded in the project area due to a lack of suitable habitat.

Red-necked Stint (*Calidris ruficollis*) – Migratory under the *EPBC Act 1999* and Schedule 3 under the *Wildlife Conservation Act 1950*

The Red-necked Stint is a wader that prefers saline sand bars or tidal mudflats along the coast.

Terrestrial Ecosystems' believes it is unlikely to be recorded in the project area due to a lack of suitable habitat.

Great Egret (*Ardea alba*) - Migratory under the *EPBC Act 1999* and Schedule 3 under the *Wildlife Conservation Act 1950*

Herons and egrets all depend to some extent upon surface water for hunting. The Great Egret is the largest of the Australian egrets, and is an elegant, white wader dependent upon floodwaters, rivers, shallow wetlands and intertidal mudflats. Its diet consists of a range of small, aquatic invertebrates and small vertebrates (Firth 1976).

Terrestrial Ecosystems' believes it is unlikely to be recorded in the project area due to a lack of suitable habitat.

Cattle Egret (*Ardea ibis*) - Migratory under the *EPBC Act 1999* and Schedule 3 under the *Wildlife Conservation Act 1950*

The smallest of the Australian egrets, this species has undertaken an invasion of Australia from the north, where it was originally more common in the Indonesian archipelago than Australia (Simpson and Day 2004). This invasion may have been assisted by the opening up of farming land and irrigation schemes, providing the pasturelands and shallow wetlands in which it prefers to forage. Johnstone and Storr (1998) noted the species distribution in Western Australia as being confined to the irrigation areas surrounding Kununurra, however, its migratory nature and current invasive tendencies suggest that it may occur elsewhere in the state, and may still be expanding its distribution.

Terrestrial Ecosystems' believes it is unlikely to be recorded in the project area due to a lack of suitable habitat.

Bar-tailed Godwit (*Limosa lapponica*) – Migratory under the *EPBC Act 1999* and Schedule 3 under the *Wildlife Conservation Act 1950*

This species breeds in north-east Siberia and north-east Alaska and is found along the coasts of Australia (Garnett et al. 2011). It is a wader which is found along muddy coastlines, estuaries, inlets, mangrove fringed lagoons and sheltered bays.

Terrestrial Ecosystems' believes it is unlikely to be recorded in the project area due to a lack of suitable habitat.

Black-tailed Godwit (*Limosa limosa*) – Migratory under the *EPBC Act 1999* and Schedule 3 under the *Wildlife Conservation Act 1950*

The Black-tailed Godwit breeds in China, Mongolia and Russia and winters among other places along the Australian coast (Garnett et al. 2011). It is found in sheltered bays, estuaries and lagoons and near coastal wetlands (Garnett et al. 2011). It is most common in northern Australia and scattered down south in coastal areas.

Terrestrial Ecosystems' believes it is unlikely to be recorded in the project area due to a lack of suitable habitat.

Little Curlew (*Numenius minutes*) - – Migratory under the *EPBC Act 1999* and Schedule 3 under the *Wildlife Conservation Act 1950*

The Little Curlew is found on northern coastal plains and near coastal riverine plains south to Shark Bay and occasionally on the Swan Coastal Plain. Its preferred habitat is short grass plains, including sorghum, stubble, dry riverbeds and tidal mud flats (Johnstone and Storr 1998).

Terrestrial Ecosystems' believes it is unlikely to be recorded in the project area.

Wood Sandpiper (*Tringa glareola*) – Migratory under the *EPBC Act 1999* and Schedule 3 under the *Wildlife Conservation Act 1950*

The Wood Sandpiper prefers well watered coastal swamps, lagoons, waterways and dams is occasionally seen around brackish wetlands (Johnstone and Storr 1998).

Terrestrial Ecosystems' believes it is unlikely to be recorded in the project area due to a lack of suitable habitat.

Marsh Sandpiper (*Tringa stagnatilis*) – Migratory under the *EPBC Act 1999* and Schedule 3 under the *Wildlife Conservation Act 1950*

The Marsh Sandpiper is a distinctive wader with very long legs, a fine long bill and small body. This species prefers shallow fresh and brackish swamps, waterways and sewage ponds and is occasionally seen in estuaries and rarely along the coast (Johnstone and Storr 1998).

Terrestrial Ecosystems' believes it is unlikely to be recorded in the project area due to a lack of suitable habitat.

Carpet Python (*Morelia spilota imbricata*) – Schedule 4 under the *Wildlife Conservation Act 1950*

This species is a large python found across the south west of Western Australia, north to Geraldton and Yalgoo, and east to Kalgoorlie, Fraser Range and Eyre. Carpet Pythons inhabit forest, heath, or wetland areas and shelter in the hollows of large trees. They occur in relatively high abundance on Garden Island and have been caught in the Rockingham area. This species is widespread within the south-west, but is not in high density across its distribution. Carpet Pythons are rarely found on the coastal plain south of the Swan River, and there are no recent records in the vicinity of the project area, however, there are some old records on the Swan Coastal Plain west of the Darling Range scarp, so they may still be found in relatively undisturbed woodlands.

Terrestrial Ecosystems' believes it is unlikely to be recorded in the project area due to a lack of suitable habitat.

Peregrine Falcon (*Falco peregrinus*) - Schedule 4 under the *WA Wildlife Conservation Act 1950*

Johnstone and Storr (1998) reported the Peregrine Falcon as being widespread including on some off-shore islands, but was absent from most deserts. They went on to suggest it was mainly seen about cliffs along coasts, rivers and ranges and wooded watercourses and lakes, but Terrestrial Ecosystems has seen them in a variety of other habitats. Peregrine Falcons are rarely seen in the Perth metropolitan area.

Terrestrial Ecosystems' believes it is unlikely to be recorded in the project area due to a lack of suitable habitat.

Ctenotus gemmula – Priority 3 with DEC

There are three geographic populations for this small skink. One is on the sand plain north of Perth, one is on the sand plain around the greater metropolitan area and the largest geographic distribution is along the south coast of Western Australia. Storr et al. (1999) reported its habitat as white sandplains, mainly in semi-arid and subhumid zones. There is a single record in Terrestrial Ecosystems' fauna survey database for a *C. gemmula* about 10km west of the project area.

Terrestrial Ecosystems' assessment is that *Ctenotus gemmula* is unlikely to have been found in the project area before it was disturbed and less likely now, given the level of disturbance.

Black-striped Snake (*Neelaps calonotos*) – Priority 3 with DEC

This species occurs on dunes and sand-plains vegetated with heaths and eucalypt/banksia woodlands. It feeds largely on skinks and its distribution is restricted and threatened by urban development. The project area does not provide suitable habitat for the Black-striped snake and it has not been recorded in the vicinity of the project area.

Terrestrial Ecosystems' assessment is that it is unlikely to be found in the project because of a lack of suitable habitat.

Lined Skink (*Lerista lineata*) – Priority 3 with DEC

This species is found in coastal heaths and shrub lands on the lower west coast between Perth and Mandurah, including Rottnest Island, with isolated populations on the mid-west coast and Busselton. It has been caught on the sand plain south of the Swan River. It has not been caught within the vicinity of the project area.

Terrestrial Ecosystems' assessment is that it is highly unlikely to be found in the project because of a lack of suitable habitat.

Western Brush Wallaby (*Macropus irma*) – Priority 4 with DEC

This species was very common in the early days of settlement, however, its range has been seriously reduced and fragmented due to clearing for agriculture and there is a significant decline in abundance within most remaining habitat. It is now distributed across the south-west of WA from north of Kalbarri to Cape Arid. The optimum habitat is open forest or woodland, particularly favouring open, seasonally wet flats with low grasses and open scrubby thickets.

It was not seen during the site visit and Terrestrial Ecosystems' believes that it is unlikely to be found in the area because of a lack of suitable habitat.

Water Rat (*Hydromys chrysogaster*) – Priority 4 with DEC

The Water Rat is found mainly near permanent bodies of freshwater, occasionally at temporary waterholes. It is also found in the streams, wetland, lakes and estuaries on the Swan Coastal Plain. There are no records for Water Rats in Terrestrial Ecosystems database in the vicinity of the project area.

Terrestrial Ecosystems' believes it is unlikely to be recorded in the project area due to a lack of suitable habitat.

Eastern Curlew (*Numenius madagascariensis*) – Priority 4 with DEC

This species breeds on open mossy or transitional bogs, moss-lichen bogs and wet meadows, and on the swampy shores of small lakes. In the non-breeding season it is essentially coastal, occurring at estuaries, mangrove swamps, salt marshes and intertidal flats, particularly those with extensive seagrass meadows.

Terrestrial Ecosystems' believes that given the lack of suitable habitat it is unlikely to be seen in the project area.

Western False Pipistrelle (*Falsistrellus mackenziei*) – Priority 4 with DEC

This insectivorous species is the largest vespertilinoid in WA and is confined to south-west WA, south of Perth and east to the wheatbelt (Churchill 1998). It is known to utilise the mature Karri forests but has also been recorded in Jarrah and Tuart woodland on the Swan Coastal Plain. Terrestrial Ecosystems has a record of this species being heard just south of Serpentine, so it may be present in areas providing suitable habitat, but is unlikely to be present in an area that is largely cleared and used for pasture.

Terrestrial Ecosystems' believes that given the lack of suitable habitat it is unlikely to be seen in the project area.

Western Spinebill (*Acanthorhynchus superciliosus*) – Priority 4 with DEC

This species inhabits heath land, woodland, and open forest with healthy understorey and feed on banksias, eucalypts and numerous shrub species (Johnstone and Storr 2004). They also feed on insects. Their numbers have declined as a result of extensive habitat clearing and fires.

Western Spinebills have been recorded in other fauna surveys in the vicinity of the project area. It may be seen occasionally in the treed triangular area along the northern boundary.

Quenda or Southern Brown Bandicoot (*Isoodon obesulus fusciventer*) – Priority 5 with DEC

Quenda prefer dense scrub (up to one metre high), with swampy vegetation. They will often feed in adjacent forest and woodland that is burnt on a regular basis and in areas of pasture and crop land lying close to dense cover. This species has been recorded in the general area on multiple occasions in densely vegetated habitat.

Terrestrial Ecosystems' believes it is unlikely to be recorded in the project area due to a lack of suitable habitat.

4.5 Risk assessment

Fauna surveys to support Environmental Impact Assessments (EIA) are part of the environmental risk assessment undertaken to consider what potential impacts a development might have on the biodiversity in a particular area and region. Potential impacts on fauna from the proposed development are identified and briefly described above. The risk assessment is provisional as the proposed development has not been finalised and as such, a precautionary approach has been taken when conducting the risk assessment. Tables 7, 8 and 9 provide a summary of the risk assessment associated with this project.

The assessment contained in Table 9 is supported by more detailed discussion in sections above and the management recommendations below.

Table 7. Fauna impact risk assessment descriptors

Any risk assessment is a product of the likelihood of an impact occurring and the consequences of that impact. Likelihood and consequences are categorised and described below. These criteria do not fit all circumstances (e.g. adequacy of fauna survey data); however, they are useful in providing the reader with an appreciation of the level of likelihood and consequences of an event. The assessed risk level (likelihood x consequences) is then calculated as the overall risk for the development. This is followed by an assessment of the acceptability of the risk associated with each of the events or impacts. Disturbances and vegetation clearing have an impact on the fauna at multiple scales – site, local, landscape and regional. Each of these is considered in the risk assessment. This assessment should be considered in the context of the summary in Table 9.

Likelihood		
Level	Description	Criteria
A	Rare	The environmental event may occur or one or more conservation significant species may be present in exceptional circumstances.
B	Unlikely	The environmental event could occur or one or more conservation significant species could be present at sometime.
C	Moderate	The environmental event should occur or one or more conservation significant species should be present at sometime.
D	Likely	The environmental event will probably occur or one or more conservation significant species will be present in most circumstances.
E	Almost certain	The environmental event is expected to occur or one or more conservation significant species is expected be present in most circumstances.
Consequences		
Level	Description	Criteria
1	Insignificant	Insignificant impact on fauna of conservation significance or regional biodiversity, and the loss of individuals will be insignificant in the context of the availability of similar fauna or fauna assemblages in the area.
2	Minor	Impact on fauna localised and no significant impact on species of conservation significance in the project area. Loss of species at the local scale.
3	Moderate	An appreciable loss of fauna in a regional context or a limited impact on species of conservation significance in the project area.
4	Major	Significant impact on conservation significant fauna or their habitat in the project area and/or regional biodiversity and/or a significant loss in the biodiversity at the landscape scale.
5	Catastrophic	Loss of species at the regional scale and/or a significant loss of species categorised as ‘vulnerable’ or ‘endangered’ under the *EPBC Act (1999)* at a regional scale.
Acceptability of Risk		
Level of risk	Management of risk	
Low	No action required.	
Moderate	Avoid if possible, routine management with internal audit and review of monitoring results annually.	
High	Externally approved management plan to reduce risks, monitor major risks annually with external audit and review of management plan outcomes annually. Will require a referral to the Commonwealth under the *EPBC Act 1999*.	
Extreme	Unacceptable, project should be redesigned or not proceed.	

Table 8. Levels of acceptable risk

		Likelihood				
		Rare or very low (A)	Unlikely or low (B)	Moderate (C)	Likely (D)	Almost certain (E)
Consequences	Insignificant (1)	Low	Low	Low	Low	Low
	Minor (2)	Low	Low	Low	Moderate	Moderate
	Moderate (3)	Low	Moderate	Moderate	High	High
	Major (4)	Moderate	Moderate	High	High	Extreme
	Catastrophic (5)	Moderate	High	High	Extreme	Extreme

Table 9. Risk assessment

		Before Management				With Management		
Factor	Potential Impact	Inherent Risk			Risk Controls / Management	Residual Risk		
		Likelihood	Consequence	Significance		Likelihood	Consequence	Significance
Inadequate fauna survey data.	Unknown loss of fauna, fauna of conservation significance, fauna assemblage(s) in development site.	B	2	Low				
Inadequate knowledge of potential impacts.	Unknown or poorly assessed impact(s) on fauna assemblage and conservation significant species.	B	2	Low				
Inadequate bioregional data for contextual purposes.	Incomplete analysis of data and appreciation of impacts on biodiversity values in a regional context.	B	2	Low				
Removal of habitat – site scale.	Almost complete loss of terrestrial fauna in cleared areas, severe impact on local fauna assemblage.	E	2	Low				
Significant reduction of habitats – local scale.	Loss of fauna and fauna habitat and impacts on local fauna assemblage (excluding conservation significant species).	B	2	Low				
Significant reduction of habitats – landscape scale.	Loss of fauna and fauna habitat and impacts on fauna in a landscape context (excluding conservation significant species).	A	1	Lowe				
Significant reduction of habitats – regional scale.	Loss of fauna and fauna habitat and impacts on fauna in a bioregional context (excluding conservation significant species).	A	1	Low				

		Before Management				With Management		
Factor	Potential Impact	Inherent Risk			Risk Controls / Management	Residual Risk		
		Likelihood	Consequence	Significance		Likelihood	Consequence	Significance
Impact on resident or visiting conservation significant terrestrial species.	Loss of a localised population or a few individuals – *Calyptorhynchus banksii naso.*	A	3	Low				
	Loss of a localised population or a few individuals – *Calyptorhynchus latirotris.*	A	4	Low				
	Loss of a localised population or a few individuals – *Calyptorhynchus baudinii.*	A	3	Low				
	Loss of a localised population or a few individuals – *Haliaeetus leucogaster*.	A	2	Low				
	Loss of a localised population or a few individuals – *Merops ornatus.*	A	2	Low				
	Loss of a localised population or a few individuals – *Hydromys chrysogaster*.	A	2	Low				
	Loss of a localised population or a few individuals – *Isoodon obesulus fusciventer*.	A	2	Low				
	Loss of a localised population or a few individuals – *Acanthorhynchus superciliosus*.	A	2	Low				

5 DISCUSSIONADEQUACY OF AVAILABLE VERTEBRATE FAUNA DATA

The EPA *Terrestrial Biological Surveys as an Element of Biodiversity Protection:* Position Statement No. 3 (EPA 2002), *Guidance Statement for Assessment of Environmental Factors: Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia No. 56* (EPA 2004) and the *Technical Guide – Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment* (EPA / DEC 2010) are the three relevant documents to assess the adequacy of the available information and reporting for vertebrate fauna surveys in Western Australia.

Reports by 360 Environmental (2008), ATA Environmental (2006), Bamford Consulting Ecologists (2003, 2009), Harvey et al. (1997), How et al. (1999), How and Dell (2000) and Gole (2003) provide an indication of the vertebrate species that could have been present in the project area before it was cleared and used to graze cattle. These data are supported by records contained in NatureMap and the Western Australian Museum records.

Had the area supported relatively undisturbed native vegetation, then a more comprehensive survey of the project area would have been required (EPA 2004, EPA / DEC 2010). The level of disturbance has meant little of the original fauna would now be present in the area. The data available are adequate to assess potential impacts on fauna.

5.1 Biodiversity values of the site

5.1.1 Condition of fauna habitat and extent of habitat degradation

The cleared pasture has almost no ecological value from a native fauna perspective. There are a few mature trees in the paddocks, some of which contain hollows which are currently providing nesting sites for Galahs and Australian Ringneck Parrots.

5.1.2 Ecological linkages

There are four substantial areas set aside as Bush Forever sites nearby; Byford to Serpentine Rail/Road Reserves and adjacent bushland (BFS 350), Norman Road Bushland (BFS 354/361), Cardup Nature Reserve and adjacent bushland (BFE 352) and Roman Road Bushland (BFS 362). Avian fauna would regularly move through and between these areas. The southern site of Precinct G does not form part of an ecological linkage through the general area.

5.1.3 Size and scale of the proposed disturbance and potential impacts

The project area is approximately 54ha and contains a small (~1ha) fenced triangular section on the northern boundary that is planted with *Acacia* sp.. It is a relatively large area but its highly degraded condition means that any subsequent development of the site is unlikely to have a significant impact on native vertebrate fauna.

5.1.4 Conservation significant species

Conservation significant species that probably infrequently utilise the project area include Carnaby's Black-Cockatoo (*Calyptorhynchus latirostris*), Forest Red-tailed Black-Cockatoo (*C. banksii naso*) and Baudin's Black-Cockatoo (*C. baudinii*). The Western Spinebill (*A. superciliousus*) may infrequently be seen in the small triangular fenced area along the northern boundary. Migratory Rainbow Bee-eaters and the White-bellied Sea-eagle may infrequently be seen in the area, but will readily move when development commences and are unlikely to be significantly impacted.

5.2 Potential environmental impacts

Clearing of vegetation and developing the project area will potentially affect vertebrate fauna in a number of ways, including:

- death/injury of fauna during vegetation clearing and development;

- loss of habitat; and
- further fragmentation of fauna habitat.

Given the project area has been cleared for pasture, contains a small number of mature native and planted trees, vegetation clearing impacts would be low.

5.2.1 Black-Cockatoos

Carnaby's Black-Cockatoo, Baudin's Black-Cockatoo and the Forest Red-tailed Black-Cockatoo will probably infrequently forage in the project area. The project area contains a small number of Eucalypt trees with a trunk diameter greater than 50cm at breast-height and a few of these appear to contain hollows. None of the trees showed evidence of use by Black-Cockatoos for breeding purposes. The Johnstone and Kirkby (2011) report on Black-Cockatoo foraging and breeding locations on the Swan Coastal Plain provided no indication that Black-Cockatoos bred or are likely to breed in the vicinity of the project area.

The previous Commonwealth Department of Environment and Heritage (2009) indicated what was a significant impact for critically endangered, endangered and vulnerable species. An action is likely to have a significant impact on an endangered and vulnerable species if there is a possibility that it will trigger any one of nine criteria listed in Table 10. The potential impacts of clearing the vegetation in the project area have been assessed against the criteria for the three species listed as endangered and vulnerable under the *EPBC Act 1999* that could forage in the project area.

Table 10. Criteria to determine whether an action will have a significant impact on an endangered species

Criteria	Carnaby's Black-Cockatoo	Baudin's Black-Cockatoo	Forest Red-tail Black-Cockatoo
Lead to a long-term decrease in the size of a population	No	No	No
Reduce the area of occupancy of the species	No	No	No
Fragment an existing population into two or more populations	No	No	No
Adversely affect habitat critical to the survival of a species	No	No	No
Disrupt the breeding cycle of a population	No	No	No
Modify, destroy, remove, isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline	No	No	No
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat	No	No	No
Introduce disease that may cause the species to decline	No	No	No
Interfere with the recovery of the species	No	No	No

The recently released Commonwealth government referral guideline on Black-Cockatoos (Department of Sustainability Environment Water Population and Communities 2011) provided a referral decision making tree and criteria for deciding whether a project should be referred to the Commonwealth minister responsible for the environment (Appendix E). Although this guideline has not been formally approved, it is understood that the Commonwealth department officers are using this in their assessment of potential impacts. The project area contains less than 1ha of quality foraging habitat and would not trigger any of the criterion if it was developed. A referral under the *EPBC Act 1999* is therefore not recommended.

5.2.2 Impacts on the fauna assemblage and fauna habitat

Level 1 fauna assessments are, in essence, an assessment of the risks associated with the proposed disturbance on the fauna either known or potentially in the area. Table 11 is a summary of that risk assessment for clearing vegetation and developing the southern site of Precinct G in Mundijong. The level of alteration to the natural habitat is generally high.

Table 11. A summary of the assessed risk of impact on the fauna and fauna habitat it the project area

Issues	**Assessment**				
Formal conservation status for the area:	No			Yes	
Specifically for fauna	X				
Level of alteration to the original faunal habitat	Very High				Very Low
	1	2	3	4	5
surface soil		X			
vegetation	X				
by salinity					X
by non-farmed exotic species				X	
by farmed species	X				
level of habitat fragmentation	X				
Knowledge of:	Very High				Very Low
	1	2	3	4	5
species in each biotope				X	
assemblage structure per biotope				X	
presence of rare and protected species		~~X~~	X		
presence of range restricted species			X		
presence of short range endemic invertebrates					X
presence of stygofauna					X
ecosystem values	X				
regional species and regional assemblages			X		
regional ecosystems			X		
Capacity to assess biodiversity values for each biotope at:	Very High				Very Low
	1	2	3	4	5
species level	X				
ecosystem levels	X				
ecological functional values	X				
regional significance of faunal assemblage	X				
Consequences of the proposed disturbance in the context of the:	Very High				Very Low
	1	2	3	4	5
level of existing disturbance					X
size of area to be disturbed				X	
scale of the disturbance					X
significance of fauna habitat in a regional context					X
extent to which the area is a refuge for fauna				X	
extent to which the disturbance will impact on rare or protected fauna					X
extent to which the fauna habitat is an ecologically important remnant					X
extent to which the habitat provides an ecological linkage(s) or corridor(s)					X
heterogeneity of habitat					X
abundance of the habitat in the bioregion	X				

5.2.3 Native vegetation clearing principles

The *Environmental Protection Act* (*1986*) provides criteria to judge the potential impact of a development on clearing native vegetation. These criteria have been listed in Table 12 with a response to indicate how clearing of the vegetation in the project area might be judged against these principles.

Table 12. Assessment of impact on fauna using the Native Vegetation Clearing Principles

Principle	Response
It comprises a high level of biological diversity.	Clearing vegetation will not compromise a high level of biodiversity.
It comprises the whole or a part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to Western Australia.	Clearing the vegetation is unlikely to result in the significant loss of habitat for Carnaby's Black-Cockatoos, Forest Red-tailed Black-Cockatoos and Baudin's Black-Cockatoos.
It includes, or is necessary for the continued existence or, rare flora.	Not applicable.
It comprises the whole or a part of, or is necessary for the maintenance of, a threatened ecological community.	The area does not contain a threatened ecological fauna community, but could support a few individuals from a conservation significant species.
It is significant as a remnant of native vegetation in an area that has been extensively cleared.	The project area does not contain remnant bushland.
It is growing in, or in association with, an environment associated with a watercourses or wetland.	The project area does not contain a water course or wetland.
The clearing of the vegetation is likely to cause appreciable land degradation.	Not applicable.
The clearing of the vegetation is likely to have an impact on the environmental values of any adjacent or nearby conservation area.	Clearing of vegetation is unlikely to impact on the environmental values of nearby conservation areas.
The clearing of the vegetation is likely to cause deterioration in the quality of surface or underground water.	Not applicable.
The clearing of the vegetation is likely to cause, or exacerbate the incidence of flooding.	Not applicable.

6 SUMMARY, CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS

Peet Ltd is seeking to develop the southern site in Precinct G near Mundijong. The project area has been substantially cleared and is currently used as pasture for cattle. The project area contains a small (~ 1ha) fenced and triangular plot planted with *Acacia* sp. on the northern boundary and scattered mature trees that are mostly along the eastern and southern boandaries. The project has a low ecological value other than the few mature trees scattered across the paddock and is not part of any important ecological linkages in the bioregion.

Mature trees provide an important ecological resource for birds and small arboreal mammals and as such, where practical, they should be preserved and protected. Even large dead trees that are safe (i.e. unlikely to pose a risk through dropping branches or falling over) should be protected as they provide roosting and nesting sites for a variety of birds. Within this context, the design of any residential development should endeavour to protect and preserve as many of the mature trees as possible. Some of these trees will end up in street verges, others in public open space and some will be in residential lots. Caveats and other restrictions can be added to property titles to protect important trees.

Recommendation 1. Mature, healthy and safe trees that are currently in the paddocks should be preserved and protected where this is feasible within the design for the development of the project area.

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PINPOINT CARTOGRAPHICS (08) 9562 7136 2011-040-STH-f01.dgn

TERRESTRIAL ECOSYSTEMS

PGV Environmental
PRECINCT G SOUTHERN SITE
MUNDIJONG

Figure 1

REGIONAL LOCATION

Drawn: G. Thompson | Date: 18 Oct 2011 | Job: 2011-040

PINPOINT CARTOGRAPHICS (08) 9562 7136 2011-040-STH-f02.dgn

N

0 25 50 75 100m

SCALE 1 : 3 000 at A3 (MGA)

Legend

- Site Boundary
- Cadastral Boundary
- Topographic Contour
- Significant Tree Location
- Tree Containing Hollow

SPARKMAN ROAD

ADAMS STREET

MUNDIJONG ROAD

ADONIS STREET

21 25 26 27 28 29 30 31 46

Significant Tree Species

- Dead
- *Eucalyptus* sp.
- Flooded Gum (*Eucalyptus rudis*)
- Marri (*Corymbia calophylla*)
- Southern Mahogany (*Eucalyptus botryoides*)
- Tasmanian Blue Gum (*Eucalyptus globulus*)

BASE SOURCE: Taylor Burrell Barnett.
WETLANDS SOURCE: DEC, March 2011.
AERIAL PHOTOGRAPH SOURCE: Taylor Burrell Barnett.

TERRESTRIAL ECOSYSTEMS

Drawn: G. Thompson | Date: 11 Nov 2011

PGV Environmental
PRECINCT G SOUTHERN SITE
MUNDIJONG

SIGNIFICANT TREE LOCATIONS

Figure 2

Job: 2011-040

Appendix A

Search Results from the *EPBC Act* (1999) On-line Database

Level 1 Vertebrate Fauna Assessment – Southern Site Precinct G

TERRESTRIAL ECOSYSTEMS

Australian Government
Department of Sustainability, Environment, Water, Population and Communities

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.

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

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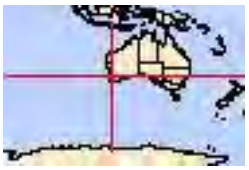

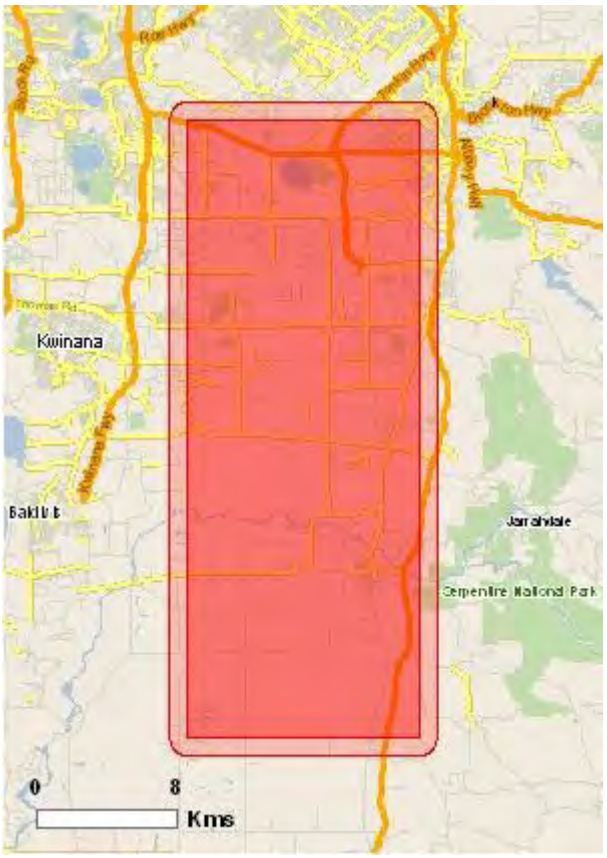

Coordinates

Buffer: 1.0Km

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance - 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):	3
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Threatened Ecological Communitites:	2
Threatened Species:	25
Migratory Species:	16

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:	24
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:	15
State and Territory Reserves:	14
Regional Forest Agreements:	1
Invasive Species:	18
Nationally Important Wetlands:	2

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
Becher point wetlands	Upstream from Ramsar site

Threatened Ecological Communities [Resource Information]

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Name	Status	Type of Presence
Corymbia calophylla - Kingia australis woodlands on heavy soils of the Swan Coastal Plain	Endangered	Community known to occur within area
Corymbia calophylla - Xanthorrhoea preissii woodlands and shrublands of the Swan Coastal Plain	Endangered	Community known to occur within area

Threatened Species [Resource Information]

Name	Status	Type of Presence
BIRDS		
Botaurus poiciloptilus Australasian Bittern [1001]	Endangered	Species or species habitat known to occur within area
Calyptorhynchus banksii naso Forest Red-tailed Black-Cockatoo [67034]	Vulnerable	Species or species habitat may occur within area
Calyptorhynchus baudinii Baudin's Black-Cockatoo, Long-billed Black-Cockatoo [769]	Vulnerable	Roosting known to occur within area

Calyptorhynchus latirostris Carnaby's Black-Cockatoo, Short-billed Black-Cockatoo [59523]	Endangered	Breeding likely to occur within area
Sternula nereis nereis Fairy Tern (Australian) [82950]	Vulnerable	Species or species habitat may occur within area
INSECTS		
Neopasiphae simplicior A native bee [66821]	Critically Endangered	Species or species habitat likely to occur within area
Synemon gratiosa Graceful Sun Moth [66757]	Endangered	Species or species habitat may occur within area
MAMMALS		
Bettongia penicillata ogilbyi Woylie [66844]	Endangered	Species or species habitat may occur within area
Dasyurus geoffroii Chuditch, Western Quoll [330]	Vulnerable	Species or species habitat 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 Spider-orchid [7309]	Endangered	Species or species habitat likely to occur within area
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
Drakaea elastica Glossy-leaved Hammer-orchid, Praying Virgin [16753]	Endangered	Species or species habitat likely to occur within area
Drakaea micrantha Dwarf Hammer-orchid [56755]	Vulnerable	Species or species habitat likely to occur within area
Eucalyptus balanites Cadda Road Mallee, Cadda Mallee [24264]	Endangered	Species or species habitat known to occur within area
Grevillea curviloba subsp. incurva Narrow curved-leaf Grevillea [64909]	Endangered	Species or species habitat may occur within area
Lasiopetalum pterocarpum Wing-fruited Lasiopetalum [64922]	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

Synaphea sp. Fairbridge Farm (D.Papenfus 696)		
Selena's Synaphea [82881]	Critically Endangered	Species or species habitat known to occur within area
Synaphea stenoloba		
Dwellingup Synaphea [66311]	Endangered	Species or species habitat may occur within area
Thelymitra stellata		
Star Sun-orchid [7060]	Endangered	Species or species habitat likely to occur within area
Verticordia plumosa var. pleiobotrya		
Narrow-petalled Featherflower [55803]	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]		Roosting known to occur within area
Calidris canutus		
Red Knot, Knot [855]		Roosting known to occur within area
Calidris ferruginea		
Curlew Sandpiper [856]		Roosting known to occur within area
Calidris ruficollis		
Red-necked Stint [860]		Roosting known to occur within area
Limosa lapponica		
Bar-tailed Godwit [844]		Roosting known to occur within area
Limosa limosa		
Black-tailed Godwit [845]		Roosting known to occur within area
Numenius minutus		
Little Curlew, Little Whimbrel [848]		Roosting likely to occur within area
Tringa glareola		
Wood Sandpiper [829]		Roosting known to occur within area

Tringa stagnatilis Marsh Sandpiper, Little Greenshank [833]	Roosting known to occur within area

Other Matters Protected by the EPBC Act

Commonwealth 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]		Roosting known to occur within area
Calidris canutus Red Knot, Knot [855]		Roosting known to occur within area
Calidris ferruginea Curlew Sandpiper [856]		Roosting known to occur within area
Calidris melanotos Pectoral Sandpiper [858]		Roosting known to occur within area
Calidris ruficollis Red-necked Stint [860]		Roosting known to occur within area
Calidris subminuta Long-toed Stint [861]		Roosting known to occur within area
Charadrius dubius Little Ringed Plover [896]		Roosting known to occur within area
Charadrius ruficapillus Red-capped Plover [881]		Roosting known to occur within area
Gallinago megala Swinhoe's Snipe [864]		Roosting likely to occur within area
Gallinago stenura Pin-tailed Snipe [841]		Roosting likely to occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Himantopus himantopus Black-winged Stilt [870]		Roosting known to occur within area
Limosa lapponica Bar-tailed Godwit [844]		Roosting known to occur within area
Limosa limosa Black-tailed Godwit [845]		Roosting known to occur within area
Merops ornatus		

Rainbow Bee-eater [670] Numenius minutus	Species or species habitat may occur within area
Little Curlew, Little Whimbrel [848] Philomachus pugnax	Roosting likely to occur within area
Ruff (Reeve) [850] Recurvirostra novaehollandiae	Roosting known to occur within area
Red-necked Avocet [871] Thinornis rubricollis	Roosting known to occur within area
Hooded Plover [59510] Tringa glareola	Roosting known to occur within area
Wood Sandpiper [829] Tringa stagnatilis	Roosting known to occur within area
Marsh Sandpiper, Little Greenshank [833]	Roosting 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	
Forrestdale Lake & Adjacent Wetlands WA	Indicative Place
Gibbs Road Wetland System WA	Indicative Place
Modong Nature Reserve WA	Indicative Place
Banksia Road Nature Reserve WA	Registered
Brickwood Bushland WA	Registered
Cardup Bushland WA	Registered
Forrestdale Lake WA	Registered
Karnet Nature Reserve WA	Registered
Lowlands and Riverlea Bushland WA	Registered
Reserve 23012 WA	Registered
Serpentine National Park WA	Registered
Wandi Nature Reserve WA	Registered
Historic	
Keysbrook Farmhouse WA	Indicative Place
Turner Cottage WA	Indicative Place
Lowlands WA	Registered

State and Territory Reserves [Resource Information]

Gibbs Road, WA
Cardup, WA
Piara, WA
Wandi, WA
Lambkin, WA
Unnamed WA42044, WA
Banksia, WA
Karnet, WA
Modong, WA
Watkins Road, WA
Serpentine, WA
Unnamed WA46587, WA

Forrestdale Lake, WA
Unnamed WA46818, WA

Regional Forest Agreements [Resource Information]

Note that all areas with completed RFAs have been included.

South West WA RFA, Western Australia

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		
Capra hircus Goat [2]		Species or species habitat likely to occur within area
Felis catus Cat, House Cat, Domestic Cat [19]		Species or species habitat likely to occur within area
Oryctolagus cuniculus Rabbit, European Rabbit [128]		Species or species habitat likely to occur within area
Sus scrofa Pig [6]		Species or species habitat likely to occur within area
Vulpes vulpes Red Fox, Fox [18]		Species or species habitat likely to occur within area
Plants		
Asparagus asparagoides Bridal Creeper, Bridal Veil Creeper, Smilax, Florist's Smilax, Smilax Asparagus [22473]		Species or species habitat likely to occur within area
Brachiaria mutica Para Grass [5879]		Species or species habitat may occur within area
Cenchrus ciliaris Buffel-grass, Black Buffel-grass [20213]		Species or species habitat may occur within area
Chrysanthemoides monilifera Bitou Bush, Boneseed [18983]		Species or species habitat may occur within area
Genista sp. X Genista monspessulana Broom [67538]		Species or species habitat may occur within area
Lantana camara Lantana, Common Lantana, Kamara Lantana, Large-leaf Lantana, Pink Flowered Lantana, Red Flowered Lantana, Red-Flowered Sage, White Sage, Wild Sage [10892]		Species or species habitat likely to occur within area
Lycium ferocissimum African Boxthorn, Boxthorn [19235]		Species or species habitat 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 likely to occur within area
Salix spp. except S.babylonica, S.x calodendron & S.x reichardtiji	
Willows except Weeping Willow, Pussy Willow and Sterile Pussy Willow [68497]	Species or species habitat likely to occur within area
Salvinia molesta	
Salvinia, Giant Salvinia, Aquarium Watermoss, Kariba Weed [13665]	Species or species habitat likely to occur within area
Tamarix aphylla	
Athel Pine, Athel Tree, Tamarisk, Athel Tamarisk, Athel Tamarix, Desert Tamarisk, Flowering Cypress, Salt Cedar [16018]	Species or species habitat likely to occur within area

Nationally Important Wetlands **[Resource Information]**

Gibbs Road Swamp System, WA

Forrestdale 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

-32.45 115.88,-32.13 115.88,-32.13 116.0,-32.45 116.0,-32.45 115.88

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

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

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Appendix B
Location of Conservation Significant Trees
Level 1 Vertebrate Fauna Assessment – Southern Site Precinct G

TERRESTRIAL ECOSYSTEMS

Appendix B. Location of conservation significant trees

UTM Zone	UTM Easting	UTM Northing	Tree type
50	403570	6426083	Dead
50	403619	6426234	Dead
50	403657	6426235	Dead
50	403678	6426333	Dead
50	403679	6426348	Dead
50	403646	6426482	Dead
50	403666	6426446	*Eucalyptus* sp.
50	403667	6426447	*Eucalyptus* sp.
50	403667	6426470	*Eucalyptus* sp.
50	403667	6426348	Flooded Gum (*Eucalyptus rudis*)
50	403649	6426349	Flooded Gum (*Eucalyptus rudis*)
50	403641	6426355	Flooded Gum (*Eucalyptus rudis*)
50	403634	6426357	Flooded Gum (*Eucalyptus rudis*)
50	403641	6426370	Flooded Gum (*Eucalyptus rudis*)
50	403665	6426475	Flooded Gum (*Eucalyptus rudis*)
50	403565	6426938	Flooded Gum (*Eucalyptus rudis*)
50	403685	6426348	Flooded Gum (*Eucalyptus rudis*)
50	403696	6426413	Flooded Gum (*Eucalyptus rudis*)
50	403680	6426060	Marri (*Corymbia calophylla*)
50	403476	6426069	Marri (*Corymbia calophylla*)
50	403668	6426072	Marri (*Corymbia calophylla*)
50	403481	6426072	Marri (*Corymbia calophylla*)
50	403468	6426085	Marri (*Corymbia calophylla*)
50	403660	6426089	Marri (*Corymbia calophylla*)
50	403492	6426089	Marri (*Corymbia calophylla*)
50	403356	6426114	Marri (*Corymbia calophylla*)
50	403383	6426166	Marri (*Corymbia calophylla*)
50	403379	6426168	Marri (*Corymbia calophylla*)
50	403623	6426283	Marri (*Corymbia calophylla*)
50	403618	6426319	Marri (*Corymbia calophylla*)
50	403488	6426854	Marri (*Corymbia calophylla*)
50	403492	6426869	Marri (*Corymbia calophylla*)
50	403565	6426953	Southern Mahogany (*Eucalyptus botryoides*)
50	403610	6426391	Tasmanian Blue Gum (*Eucalyptus globulus*)
50	403694	6426442	Tasmanian Blue Gum (*Eucalyptus globulus*)

Appendix C
Fauna Surveys in the Vicinity of the Project Area

Level 1 Vertebrate Fauna Assessment – Southern Site Precinct G

TERRESTRIAL ECOSYSTEMS

Appendix C(1). Fauna survey data in the vicinity of the project area

		Surveys	A	B				C						D	E	
Family	**Species**	**Common Name**	**Abernethy Rd Byford**	**Site 1**	**Site 2**	**Site 3**	**Opportunistic**	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 6**	**Opportunistic**	**Keane Rd**	**Jandakot Airport 1**	**Jandakot Airport 2**
Birds																
Accipitridae	*Elanus axillaris*	Black-shouldered Kite											X			
	Haliastur sphenurus	Whistling Kite					2									
	Accipiter fasciatus	Brown Goshawk													1	2
	Accipiter cirrocephalus	Collared Sparrowhawk											X			
	Hieraaetus morphnoides	Little Eagle											X			7
	Pandion haliaetus	Osprey														
Anatidae	*Biziura lobata*	Musk Duck														
	Stictonetta naevosa	Freckled Duck														
	Cygnus atratus	Black Swan					1									
	Tadorna tadornoides	Australian Shelduck					25							X		
	Chenonetta jubata	Australian Wood Duck					59							X		
	Anas gracilis	Grey Teal					8									
	Anas castanea	Chestnut Teal														
	Anas superciliosa	Pacific Black Duck					26						X	X		
	Oxyura australis	Blue-billed Duck														
Podargidae	*Podargus strigoides*	Tawny Frogmouth					1									
Charadriidae	*Charadrius ruficapillus*	Red-capped Plover														
	Elseyornis melanops	Black-fronted Dotterel														
	Erythrogonys cinctus	Red-kneed Dotterel														
	Vanellus tricolor	Banded Lapwing											X			
Laridae	*Chlidonias hybridus*	Whiskered Tern														
	Chroicocephalus novaehollandiae	Silver Gull														
Recurvirostridae	*Himantopus himantopus*	Black-winged Stilt														
	Recurvirostra novaehollandiae	Red-necked Avocet														
	Cladorhynchus leucocephalus	Banded Stilt														
Scolopacidae	*Actitis hypoleucos*	Common Sandpiper														
	Tringa stagnatilis	Marsh Sandpiper														
	Calidris subminuta	Long-toed Stint														
	Calidris acuminata	Sharp-tailed Sandpiper														
Stercorariidae	*Stercorarius longicauda*	Long-tailed Jaeger														
Turnicidae	*Turnix varius*	Painted Button-quail														
	Turnix velox	Little Button-quail														

		Surveys	A	B				C						D	E	
Family	**Species**	**Common Name**	**Abernethy Rd Byford**	**Site 1**	**Site 2**	**Site 3**	**Opportunistic**	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 6**	**Opportunistic**	**Keane Rd**	**Jandakot Airport 1**	**Jandakot Airport 2**
Ardeidae	*Ardea alba*	Great Egret														
Ardeidae	*Ardea pacifica*	White-necked Heron					3									
	Egretta novaehollandiae	White-faced Heron					31									
	Nycticorax caledonicus	Nankeen Night Heron					1									
Pelecanidae	*Pelecanus conspicillatus*	Australian Pelican					1									
Threskiornithidae	*Plegadis falcinellus*	Glossy Ibis														
	Threskiornis molucca	Australian White Ibis					28						X			
	Threskiornis spinicollis	Straw-necked Ibis					238							X		
	Platalea flavipes	Yellow-billed Spoonbill														
Columbidae	*Columba livia*	Rock Dove														
	Streptopelia senegalensis	Laughing Dove					24						X	X	14	
	Streptopelia chinensis	Spotted Dove					7						X			
	Phaps chalcoptera	Common Bronzewing					15						X	X		
	Ocyphaps lophotes	Crested Pigeon					8						X	X		
Alcedinidae	*Dacelo novaeguineae*	Laughing Kookaburra					6									
	Todiramphus sanctus	Sacred Kingfisher					7								2	
Meropidae	*Merops ornatus*	Rainbow Bee-eater					34								3	1
Cuculidae	*Chalcites basalis*	Horsfield's Bronze-Cuckoo					1						X	X		
	Chalcites lucidus	Shining Bronze-Cuckoo					11						X	X		
	Cacomantis pallidus	Pallid Cuckoo												X		
	Cacomantis flabelliformis	Fan-tailed Cuckoo					1						X			
Caprimulgidae	*Eurostopodus argus*	Spotted Nightjar														
Falconidae	*Falco cenchroides*	Nankeen Kestrel					21						X	X		
	Falco berigora	Brown Falcon					1									
	Falco longipennis	Australian Hobby											X			
	Falco subniger	Black Falcon														
Phasianidae	*Coturnix ypsilophora*	Brown Quail					1						X			
Rallidae	*Porphyrio porphyrio*	Purple Swamphen					9									
	Gallirallus philippensis	Buff-banded Rail														
	Porzana pusilla	Baillon's Crake														
	Porzana fluminea	Australian Spotted Crake														
	Porzana tabuensis	Spotless Crake														
	Tribonyx ventralis	Black-tailed Native-hen														
	Gallinula tenebrosa	Dusky Moorhen														
	Fulica atra	Eurasian Coot					20									

		Surveys	A	B				C						D	E	
Family	**Species**	**Common Name**	**Abernethy Rd Byford**	**Site 1**	**Site 2**	**Site 3**	**Opportunistic**	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 6**	**Opportunistic**	**Keane Rd**	**Jandakot Airport 1**	**Jandakot Airport 2**
Acanthizidae	*Sericornis frontalis*	White-browed Scrubwren					3							X		
	Smicrornis brevirostris	Weebill					3							X		
	Gerygone fusca	Western Gerygone					42						X	X	2	7
	Acanthiza chrysorrhoa	Yellow-rumped Thornbill					169						X	X		
	Acanthiza inornata	Western Thornbill														
	Acanthiza apicalis	Inland Thornbill					14							X		
Acrocephalidae	*Acrocephalus australis*	Australian Reed-Warbler														
	Cincloramphus mathewsi	Rufous Songlark														
Artamidae	*Artamus cinereus*	Black-faced Woodswallow														
	Artamus cyanopterus	Dusky Woodswallow														
	Cracticus torquatus	Grey Butcherbird					21						X	X	1	2
	Cracticus tibicen	Australian Magpie					155						X	X	13	6
	Strepera versicolor	Grey Currawong														
Campephagidae	*Coracina novaehollandiae*	Black-faced Cuckoo-Shrike					29						X	X	3	2
	Lalage sueurii	White-winged Triller					4									
Climacteridae	*Climacteris rufa*	Rufous Treecreeper														
Corvidae	*Corvus coronoides*	Australian Raven					198						X	X	42	26
	Corvus splendens	House Crow														
Estrildidae	*Stagonopleura oculata*	Red-eared Firetail														
Hirundinidae	*Cheramoeca leucosterna*	White-backed Swallow														
	Hirundo neoxena	Welcome Swallow					26								4	1
	Petrochelidon nigricans	Tree Martin					25						X	X	42	9
	Petrochelidon ariel	Fairy Martin														
Maluridae	*Malurus splendens*	Splendid Fairy-wren					173						X	X	9	9
	Malurus elegans	Red-winged Fairy-wren														
Meliphagidae	*Acanthorhynchus superciliosus*	Western Spinebill											X	X	15	3
	Lichenostomus virescens	Singing Honeyeater					29						X	X	36	23
	Manorina flavigula	Yellow-throated Miner														
	Anthochaera lunulata	Western Wattlebird					3						X	X		
	Anthochaera chrysoptera	Little Wattlebird													2	
	Anthochaera carunculata	Red Wattlebird					70						X	X	35	3
	Epthianura albifrons	White-fronted Chat														
	Glyciphila melanops	Tawny-crowned Honeyeater												X		
	Lichmera indistincta	Brown Honeyeater					120						X	X	43	35
	Phylidonyris novaehollandiae	New Holland Honeyeater					63						X	X	35	10

		Surveys	A	B				C						D	E	
Family	**Species**	**Common Name**	**Abernethy Rd Byford**	**Site 1**	**Site 2**	**Site 3**	**Opportunistic**	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 6**	**Opportunistic**	**Keane Rd**	**Jandakot Airport 1**	**Jandakot Airport 2**
	Phylidonyris niger	White-cheeked Honeyeater											X	X	11	1
	Melithreptus brevirostris	Brown-headed Honeyeater														
	Melithreptus lunatus	White-naped Honeyeater														
Monarchidae	*Grallina cyanoleuca*	Magpie-Lark					94						X	X	8	
Motacilidae	*Anthus novaeseelandiae*	Australasian Pipit					16							X		
Nectariniidae	*Dicaeum hirundinaceum*	Mistletoebird					1									
Neosittidae	*Daphoenositta chrysoptera*	Varied Sittella													2	2
Pachycephalidae	*Pachycephala pectoralis*	Golden Whistler											X	X		
	Pachycephala rufiventris	Rufous Whistler					32						X	X	28	27
	Colluricincla harmonica	Grey Shrike-thrush					8						X	X		6
Pardalotidae	*Pardalotus punctatus*	Spotted Pardalote														
	Pardalotus striatus	Striated Pardalote					11						X		10	4
Petroicidae	*Petroica multicolor*	Pacific Robin					2									
	Petroica goodenovii	Red-capped Robin												X		
	Eopsaltria georgiana	White-breasted Robin														
Rhipiduridae	*Rhipidura fuliginosa*	New Zealand Fantail					67								7	
	Rhipidura albiscapa	Grey Fantail												X		
	Rhipidura leucophrys	Willie Wagtail					53						X	X	24	1
Timaliidae	*Zosterops lateralis*	Silvereye					293						X	X	7	3
Phalacrocoracidae	*Microcarbo melanoleucos*	Little Pied Cormorant					5									
	Phalacrocorax carbo	Great Cormorant														
	Phalacrocorax sulcirostris	Little Black Cormorant					2									
	Phalacrocorax varius	Pied Cormorant														
Podicipedidae	*Tachybaptus novaehollandiae*	Australasian Grebe					2									
	Podiceps cristatus	Great Crested Grebe														
Procellariidae	*Daption capense*	Cape Petrel														
	Pachyptila desolata	Antarctic Prion														
	Pterodroma macroptera	Great-winged Petrel														
Cacatuidae	*Calyptorhynchus banksii naso*	Red-tailed Black-Cockatoo	20				26						X			
	Calyptorhynchus latirostris	Carnaby's Black-Cockatoo	4				2						X			
	Calyptorhynchus baudinii	Baudin's Black-Cockatoo														
	Eolophus roseicapillus	Galah					85						X	X		
	Cacatua pastinator	Western Corella											X			
	Cacatua sanguinea	Little Corella					6									
Psittacidae	*Trichoglossus haematodus*	Rainbow Lorikeet					56						X	X		

		Surveys	A	B				C						D	E	
Family	**Species**	**Common Name**	**Abernethy Rd Byford**	**Site 1**	**Site 2**	**Site 3**	**Opportunistic**	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 6**	**Opportunistic**	**Keane Rd**	**Jandakot Airport 1**	**Jandakot Airport 2**
	Polytelis anthopeplus	Regent Parrot					14									
	Platycercus icterotis	Western Rosella														
	Barnardius zonarius	Australian Ringneck					60						X	X	1	
	Purpureicephalus spurius	Red-capped Parrot					52						X	X	4	1
	Neophema elegans	Elegant Parrot					6									
Strigidae	*Ninox novaeseelandiae*	Southern Boobook					2									
Tytonidae	*Tyto alba*	Barn Owl					1									
Mammals																
Suidae	*Sus scrofa*	Pig														
Canidae	*Canis lupus*	Dog												X		
	Vulpes vulpes	Red Fox	1	1	1									X		
Felidae	*Felis catus*	House Cat		1	1									X		
Molossidae	*Austronomus australis*	White-striped Freetail Bat											X			
Pteropodidae	*Pteropus scapulatus*	Little Red Flying Fox														
Vespertilionidae	*Chalinolobus gouldii*	Gould's Wattled Bat		1									X			
	Nyctophilus geoffroyi	Lesser Longeared Bat														
	Nyctophilus major	Western Longeared Bat														
	Vespadelus regulus	Southern Forest Bat											X			
Dasyuridae	*Antechinus flavipes*	Yellow-footed Antechinus														
	Phascogale tapoatafa	Brush-tailed Phascogale														
Macropodidae	*Macropus fuliginosus*	Western Grey Kangaroo												X		
Phalangeridae	*Trichosurus vulpecula*	Common Brushtail Possum		18												
Tarsipedidae	*Tarsipes rostratus*	Honey Possum														
Leporidae	*Oryctolagus cuniculus*	European Rabbit			4									X		
Tachyglossidae	*Tachyglossus aculeatus*	Short-beaked Echidna														
Peramelidae	*Isoodon obesulus*	Southern Brown Bandicoot			25			4	3	7				X		
Muridae	*Mus musculus*	House Mouse		26	23					1		2				
	Rattus fuscipes	Bush Rat		1												
	Rattus rattus	Black Rat			5			2								
Amphibians																
Hylidae	*Litoria adelaidensis*	Slender Tree Frog		7	4	10								X		
	Litoria moorei	Motorbike Frog		8	36	9										
Limnodynastidae	*Heleioporus eyrei*	Moaning Frog		518	81											2
	Heleioporus psammophilus	Sand Frog						4								
	Limnodynastes dorsalis	Western Banjo Frog		1	2				1	1				X	6	1

		Surveys	A	B				C						D	E	
Family	**Species**	**Common Name**	**Abernethy Rd Byford**	**Site 1**	**Site 2**	**Site 3**	**Opportunistic**	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 6**	**Opportunistic**	**Keane Rd**	**Jandakot Airport 1**	**Jandakot Airport 2**
Myobatrachidae	*Crinia georgiana*	Quacking Frog		158												
	Crinia glauerti	Clicking Frog		11	1	4										
	Crinia insignifera	Squelching Froglet		X										X	X	
Myobatrachidae	*Myobatrachus gouldii*	Turtle Frog														1
	Pseudophryne guentheri	Crawling Toadlet														
Reptiles																
Agamidae	*Ctenophorus adelaidensis*	Southern Heath Dragon														
	Pogona minor	Bearded Dragon						1							2	
Diplodactylidae	*Diplodactylus polyophthalmus*															
	Strophurus spinigerus															
Elapidae	*Brachyurophis fasciolata*															
	Brachyurophis semifasciata															
	Demansia psammophis							1	2	2						
	Echiopsis curta	Bardick														
	Elapognathus coronatus	Crowned Snake														
	Neelaps bimaculatus	Black-naped Snake														
	Notechis scutatus	Tiger Snake		3	2											
	Parasuta gouldii															1
	Parasuta nigriceps															
	Pseudechis australis	Mulga Snake														
	Pseudonaja affinis	Dugite		2	1											1
	Pseudonaja mengdeni	Gwardar														
	Simoselaps bertholdi	Jan's Banded Snake														
	Simoselaps littoralis	West Coast Banded Snake														
Gekkonidae	*Christinus marmoratus*	Marbled Gecko		1												
Pygopodidae	*Aprasia pulchella*															
	Aprasia repens			2												
	Delma fraseri									1					2	3
	Delma grayii															
	Lialis burtonis			5												2
	Pletholax gracilis	Keeled Legless Lizard														2
	Pygopus lepidopodus	Common Scaly Foot						1	2		1					
Scincidae	*Acritoscincus trilineatum*			30	2						1					
	Cryptoblepharus buchananii			36	3	9					1				2	5
	Ctenotus australis				13										1	4

TERRESTRIAL ECOSYSTEMS

		Surveys	A	B				C						D	E	
Family	**Species**	**Common Name**	**Abernethy Rd Byford**	**Site 1**	**Site 2**	**Site 3**	**Opportunistic**	**Site 1**	**Site 2**	**Site 3**	**Site 4**	**Site 6**	**Opportunistic**	**Keane Rd**	**Jandakot Airport 1**	**Jandakot Airport 2**
	Ctenotus fallens															
	Ctenotus gemmula	(Swan Coastal plain)														
	Ctenotus impar															
	Ctenotus labillardieri															
	Egernia napoleonis															
	Hemiergis initialis															
	Hemiergis quadrilineata									1	1					
	Lerista distinguenda															
	Lerista elegans			11	9					1					12	14
	Lerista lineata														1	8
	Lerista lineopunctulata															
	Menetia greyii			14	3	1			1	1	1				12	28
	Morethia lineoocellata				1											
	Morethia obscura			4												
	Tiliqua occipitalis	Western Bluetongue														
	Tiliqua rugosa			3	3				1	1				X	2	3
Typhlopidae	*Ramphotyphlops australis*			2											1	
Varanidae	*Varanus gouldii*	Bungarra or Sand Monitor			3									X		
	Varanus rosenbergi	Heath Monitor		1												
	Varanus tristis	Racehorse Monitor														
Chelidae	*Chelodina oblonga*	Oblong Turtle														

A 360 Environmental (2008) *Lot 9 Abernethy Road, Byford Spring Flora and Fauna Report*. Unpublished report for Australand Property Group, Perth.

B ATA Environmental (2006) *Vertebrate Fauna Assessment Brookdale Redevelopment Area*. Unpublished report for the Armadale Redevelopment Authority Perth.

C Env (2009) *Jandakot Airport Fauna Survey*. Unpublished report for Jandakot Airport Holdings Pty Ltd, Perth.

D Bamford Consulting Ecologists (2009) *Keane Road Strategic Link, Armadale Fauna Assessment*. Unpublished report for EnviroWorks Consulting, Perth.

E How R.A., Harvey M.S., Dell J. and Waldock J.M. (1999) *Ground Fauna of Urban Bushland Remnants in Perth*. Unpublished report to the Australian Heritage Commission; NEP Grant N93/04; Perth.

X Presence only

Appendix C(2). Fauna survey records in the vicinity of the project area

		Surveys	A	B			C							D	E
Family	**Species**	**Common Name**	**Wright Lake**	**Ken Hurst Park**	**Manjedal Brook**	**Shreeve Road Wetland**	**Brickwood Reserve 2**	**Brickwood Reserve 3**	**Cardup Reserve 1**	**Cardup Reserve 2**	**Cardup Reserve 3**	**Norman Road 1**	**Norman Road 2**		
Birds															
Accipitridae	*Elanus axillaris*	Black-shouldered Kite				X								5	
	Accipiter fasciatus	Brown Goshawk		X	X			7	3	1				10	
	Accipiter cirrocephalus	Collared Sparrowhawk			X							1	1	15	
	Circus assimilis	Spotted Harrier												5	
	Circus approximans	Swamp Harrier												5	
	Aquila audax	Wedge-tailed Eagle	X											10	
	Hieraaetus morphnoides	Little Eagle					1	1	1		5				
	Pandion haliaetus	Osprey		X											
Anatidae	*Dendrocygna arcuata*	Wandering Whistling-Duck	1												
	Biziura lobata	Musk Duck												20	
	Stictonetta naevosa	Freckled Duck												5	
	Cygnus atratus	Black Swan	11												
	Tadorna tadornoides	Australian Shelduck	29			X									
	Chenonetta jubata	Australian Wood Duck			X	X				1					
	Malacorhynchus membranaceus	Pink-eared Duck	1												
	Anas rhynchotis	Australasian Shoveler	6												
	Anas gracilis	Grey Teal	480			X								10	
	Anas superciliosa	Pacific Black Duck	192		X	X								15	
Aegothelidae	*Aegotheles cristatus*	Australian Owlet-nightjar												5	
Podargidae	*Podargus strigoides*	Tawny Frogmouth												3	
Charadriidae	*Charadrius ruficapillus*	Red-capped Plover	1												
	Elseyornis melanops	Black-fronted Dotterel	15			X									
	Vanellus tricolor	Banded Lapwing												1	
Laridae	*Chroicocephalus novaehollandiae*	Silver Gull	2												
Recurvirostridae	*Himantopus himantopus*	Black-winged Stilt				X									
	Recurvirostra novaehollandiae	Red-necked Avocet												1	
Scolopacidae	*Calidris subminuta*	Long-toed Stint												15	
	Calidris acuminata	Sharp-tailed Sandpiper												15	
Stercorariidae	*Stercorarius longicauda*	Long-tailed Jaeger												1	
Turnicidae	*Turnix varius*	Painted Button-quail												1	
Ardeidae	*Ardea alba*	Great Egret	1			X									
	Ardea pacifica	White-necked Heron			X										

		Surveys	A	B			C							D	E
Family	**Species**	**Common Name**	**Wright Lake**	**Ken Hurst Park**	**Manjedal Brook**	**Shreeve Road Wetland**	**Brickwood Reserve 2**	**Brickwood Reserve 3**	**Cardup Reserve 1**	**Cardup Reserve 2**	**Cardup Reserve 3**	**Norman Road 1**	**Norman Road 2**		
	Egretta novaehollandiae	White-faced Heron	5		X	X									
	Nycticorax caledonicus	Nankeen Night Heron												1	
Threskiornithidae	*Threskiornis molucca*	Australian White Ibis	1			X									
	Threskiornis spinicollis	Straw-necked Ibis				X									
Columbidae	*Columba livia*	Rock Dove	X	X	X		1				1				
	Streptopelia senegalensis	Laughing Dove	X	X	X			1						4	
	Streptopelia chinensis	Spotted Dove	X	X											
	Phaps chalcoptera	Common Bronzewing	X	X	X	X				1					
	Ocyphaps lophotes	Crested Pigeon	X												
Alcedinidae	*Dacelo novaeguineae*	Laughing Kookaburra	X		X	X	2	2	13	1	2	2			
	Todiramphus sanctus	Sacred Kingfisher			X		5	4	12	3	2	5	1	1	
Meropidae	*Merops ornatus*	Rainbow Bee-eater		X	X				3	1	1	1	1	10	
Cuculidae	*Chalcites basalis*	Horsfield's Bronze-Cuckoo			X										
	Chalcites lucidus	Shining Bronze-Cuckoo			X						2				
	Cacomantis pallidus	Pallid Cuckoo					1				1			5	
	Cacomantis flabelliformis	Fan-tailed Cuckoo												5	
Caprimulgidae	*Eurostopodus argus*	Spotted Nightjar												5	
Falconidae	*Falco cenchroides*	Nankeen Kestrel	X											5	
	Falco longipennis	Australian Hobby		X					1					5	
	Falco subniger	Black Falcon												5	
Phasianidae	*Coturnix ypsilophora*	Brown Quail												5	
Rallidae	*Porphyrio porphyrio*	Purple Swamphen	2			X									
	Gallirallus philippensis	Buff-banded Rail												5	
	Porzana pusilla	Baillon's Crake												1	
	Porzana fluminea	Australian Spotted Crake				X									
	Porzana tabuensis	Spotless Crake												1	
	Gallinula tenebrosa	Dusky Moorhen				X								5	
	Fulica atra	Eurasian Coot	48			X									
Acanthizidae	*Sericornis frontalis*	White-browed Scrubwren			X	X								1	
	Smicrornis brevirostris	Weebill			X						1	X	9	3	
	Gerygone fusca	Western Gerygone		X	X	X	23	6	44	15	36	26	34	20	
	Acanthiza chrysorrhoa	Yellow-rumped Thornbill	X		X	X			3	1	3	5	5	15	
	Acanthiza inornata	Western Thornbill			X							X		35	
	Acanthiza apicalis	Inland Thornbill	X		X	X								25	
Acrocephalidae	*Acrocephalus australis*	Australian Reed-Warbler				X								25	

		Surveys	A	B			C							D	E
Family	**Species**	**Common Name**	**Wright Lake**	**Ken Hurst Park**	**Manjedal Brook**	**Shreeve Road Wetland**	**Brickwood Reserve 2**	**Brickwood Reserve 3**	**Cardup Reserve 1**	**Cardup Reserve 2**	**Cardup Reserve 3**	**Norman Road 1**	**Norman Road 2**		
Artamidae	*Artamus cinereus*	Black-faced Woodswallow	X			X	2							10	
	Artamus cyanopterus	Dusky Woodswallow			X		1		2	2	17				
	Cracticus torquatus	Grey Butcherbird	X	X	X				1	1	X	1			
	Cracticus tibicen	Australian Magpie	X	X	X	X	2	1	5	2	6	4	2	50	
Campephagidae	*Coracina novaehollandiae*	Black-faced Cuckoo-Shrike	X	X	X	X	8	7	3	3	6	3	2	5	
	Lalage sueurii	White-winged Triller			X						1				
Climacteridae	*Climacteris rufa*	Rufous Treecreeper												5	
Corvidae	*Corvus coronoides*	Australian Raven	X	X	X	X	6	7	16	6	6	7	11	35	
	Corvus splendens	House Crow												5	
Estrildidae	*Stagonopleura oculata*	Red-eared Firetail												1	
Hirundinidae	*Hirundo neoxena*	Welcome Swallow		X	X	X									
	Petrochelidon nigricans	Tree Martin			X	X	12	21	12	35	1				
	Petrochelidon ariel	Fairy Martin												5	
Maluridae	*Malurus splendens*	Splendid Fairy-wren	X	X	X	X			16	8	22	1		15	
	Malurus elegans	Red-winged Fairy-wren												35	
Meliphagidae	*Acanthorhynchus superciliosus*	Western Spinebill		X			1	3	2	17	13	9	21	40	
	Lichenostomus virescens	Singing Honeyeater		X	X	X									
	Lichenostomus ornatus	Yellow-plumed Honeyeater			X										
	Manorina flavigula	Yellow-throated Miner												15	
	Anthochaera lunulata	Western Wattlebird												10	
	Anthochaera chrysoptera	Little Wattlebird		X											
	Anthochaera carunculata	Red Wattlebird	X	X	X	X	1		11	7	1	1		20	
	Epthianura albifrons	White-fronted Chat						1						5	
	Glyciphila melanops	Tawny-crowned Honeyeater												1	
	Lichmera indistincta	Brown Honeyeater	X	X	X	X	32	26	30	37	34	35	21		
	Phylidonyris novaehollandiae	New Holland Honeyeater		X	X	X								8	
	Phylidonyris niger	White-cheeked Honeyeater		X	X									2	
	Melithreptus brevirostris	Brown-headed Honeyeater												5	
	Melithreptus lunatus	White-naped Honeyeater			X									15	
Monarchidae	*Grallina cyanoleuca*	Magpie-Lark	X	X	X	X		1						5	
Motacilidae	*Anthus novaeseelandiae*	Australasian Pipit	X											5	
Nectariniidae	*Dicaeum hirundinaceum*	Mistletoebird			X		1	1	2		1				
Neosittidae	*Daphoenositta chrysoptera*	Varied Sittella		X	X		2	14			7				
Pachycephalidae	*Pachycephala pectoralis*	Golden Whistler			X										
	Pachycephala rufiventris	Rufous Whistler		X	X	X	22	19	36	27	31	18	20	4	

		Surveys	A	B			C							D	E
Family	**Species**	**Common Name**	**Wright Lake**	**Ken Hurst Park**	**Manjedal Brook**	**Shreeve Road Wetland**	**Brickwood Reserve 2**	**Brickwood Reserve 3**	**Cardup Reserve 1**	**Cardup Reserve 2**	**Cardup Reserve 3**	**Norman Road 1**	**Norman Road 2**		
	Colluricincla harmonica	Grey Shrike-thrush		X					3		7			5	
Pardalotidae	*Pardalotus punctatus*	Spotted Pardalote			X									4	
	Pardalotus striatus	Striated Pardalote		X	X	X	4	16	35	28	20	10	4	3	
Petroicidae	*Petroica multicolor*	Pacific Robin		X	X									7	
	Petroica boodang	Scarlet Robin										2			
	Petroica goodenovii	Red-capped Robin			X										
	Eopsaltria georgiana	White-breasted Robin												10	
Rhipiduridae	*Rhipidura fuliginosa*	New Zealand Fantail												1	
	Rhipidura albiscapa	Grey Fantail	X	X	X	X		8	10	1	17				
	Rhipidura leucophrys	Willie Wagtail	X	X	X	X	2							1	
Timaliidae	*Zosterops lateralis*	Silvereye		X	X	X	4	2	4	3	9	3	2	8	
Anhingidae	*Anhinga melanogaster*	Australasian Darter												5	
Phalacrocoracidae	*Microcarbo melanoleucos*	Little Pied Cormorant	8			X									
	Phalacrocorax sulcirostris	Little Black Cormorant				X									
Podicipedidae	*Tachybaptus novaehollandiae*	Australasian Grebe	8			X								1	
	Poliocephalus poliocephalus	Hoary-headed Grebe	6												
	Podiceps cristatus	Great Crested Grebe												2	
	Pachyptila desolata	Antarctic Prion												2	
	Lugensa brevirostris	Kerguelen Petrel												2	
	Pterodroma lessonii	White-headed Petrel												2	
Cacatuidae	*Calyptorhynchus banksii naso*	Red-tailed Black-Cockatoo			X				1		2				
	Calyptorhynchus latirostris	Carnaby's Black-Cockatoo		X	X										
	Calyptorhynchus baudinii	Baudin's Black-Cockatoo					1					1			
	Eolophus roseicapillus	Galah	X	X	X	X	1				2				
	Cacatua sanguinea	Little Corella			X										
Psittacidae	*Trichoglossus haematodus*	Rainbow Lorikeet	X	X											
	Glossopsitta porphyrocephala	Purple-crowned Lorikeet												5	
	Polytelis anthopeplus	Regent Parrot			X										
	Platycercus icterotis	Western Rosella						1	31					1	
	Barnardius zonarius	Australian Ringneck	X	X	X	X	2	5	9	3	9	1		2	
	Purpureicephalus spurius	Red-capped Parrot		X	X	X	3	1	32	10	22	5	2	6	
	Melopsittacus undulatus	Budgerigar												55	
	Neophema elegans	Elegant Parrot					1		2	1	2				
Strigidae	*Ninox novaeseelandiae*	Southern Boobook												4	
Tytonidae	*Tyto alba*	Barn Owl												3	

		Surveys	A	B			C							D	E
Family	**Species**	**Common Name**	**Wright Lake**	**Ken Hurst Park**	**Manjedal Brook**	**Shreeve Road Wetland**	**Brickwood Reserve 2**	**Brickwood Reserve 3**	**Cardup Reserve 1**	**Cardup Reserve 2**	**Cardup Reserve 3**	**Norman Road 1**	**Norman Road 2**		
Mammals															
Suidae	*Vulpes vulpes*	Red Fox	X						X	X	X			2	1
Felidae	*Felis catus*	House Cat	X											10	
Molossidae	*Austronomus australis*	White-striped Freetail Bat	X												
Vespertilionidae	*Chalinolobus gouldii*	Gould's Wattled Bat	X											5	1
	Falsistrellus mackenziei	Western Falsistrelle													1
	Nyctophilus geoffroyi	Lesser Longeared Bat	X											1	1
	Nyctophilus major	Western Longeared Bat	X												
Dasyuridae	*Antechinus flavipes*	Yellow-footed Antechinus										1		20	2
	Dasyurus geoffroii	Western Quoll													6
	Phascogale tapoatafa	Brush-tailed Phascogale												10	10
	Sminthopsis gilberti	Gilbert's Dunnart												1	1
Myrmecobiidae	*Myrmecobius fasciatus*	Numbat													2
Burramyidae	*Cercartetus concinnus*	Southwestern Pygmy Possum										1		5	
Macropodidae	*Macropus fuliginosus*	Western Grey Kangaroo					X	X				X	X		
	Macropus irma	Western Brush Wallaby													2
	Setonix brachyurus	Quokka													7
Petauridae	*Petaurus breviceps*	Sugar Glider												1	
Phalangeridae	*Trichosurus vulpecula*	Common Brushtail Possum												15	13
Potoroidae	*Bettongia lesueur*	Burrowing Bettong												5	
Tarsipedidae	*Tarsipes rostratus*	Honey Possum												11	11
Leporidae	*Oryctolagus cuniculus*	European Rabbit	X				X	X	X	X	X	X	X	2	2
Tachyglossidae	*Tachyglossus aculeatus*	Short-beaked Echidna												1	1
Peramelidae	*Isoodon obesulus*	Southern Brown Bandicoot	X				X	X	X						31
Muridae	*Hydromys chrysogaster*	Water Rat													1
	Mus musculus	House Mouse					15	7	9	20	7	21	35	20	5
	Rattus fuscipes	Bush Rat													
	Rattus rattus	Black Rat												9	8
Amphibians															
Hylidae	*Litoria adelaidensis*	Slender Tree Frog												5	1
	Litoria moorei	Motorbike Frog												40	6
Limnodynastidae	*Heleioporus eyrei*	Moaning Frog					78	34	6	11	1	8	3	425	87
	Heleioporus psammophilus	Sand Frog												10	3
	Limnodynastes dorsalis	Western Banjo Frog										4	7	15	4
	Neobatrachus pelobatoides	Humming Frog												5	1

		Surveys	A	B			C							D	E
Family	**Species**	**Common Name**	**Wright Lake**	**Ken Hurst Park**	**Manjedal Brook**	**Shreeve Road Wetland**	**Brickwood Reserve 2**	**Brickwood Reserve 3**	**Cardup Reserve 1**	**Cardup Reserve 2**	**Cardup Reserve 3**	**Norman Road 1**	**Norman Road 2**		
Myobatrachidae	*Crinia georgiana*	Quacking Frog					5	8	2			2	X	265	54
	Crinia glauerti	Clicking Frog						2	1					75	19
	Crinia insignifera	Squelching Froglet					24	4	22	30	9	2	3	440	90
	Crinia pseudinsignifera	Bleating Froglet												20	4
	Geocrinia leai	Ticking Frog												15	3
	Myobatrachus gouldii	Turtle Frog												15	3
	Pseudophryne guentheri	Crawling Toadlet					2							6	6
Reptiles															
Agamidae	*Ctenophorus ornatus*	Ornate Crevice Dragon												10	2
	Pogona minor	Bearded Dragon					10		1	4	3	5	10	7	9
Boidae	*Morelia spilota imbricata*	Carpet Python													4
Carphodactylidae	*Underwoodisaurus milii*	Barking Gecko												5	3
Diplodactylidae	*Diplodactylus granariensis*													5	1
	Diplodactylus polyophthalmus													35	8
Elapidae	*Acanthophis antarcticus*	Southern Death Adder													7
	Brachyurophis semifasciata													25	5
	Demansia psammophis													5	1
	Echiopsis curta	Bardick						1					X	5	1
	Elapognathus coronatus	Crowned Snake												15	3
	Neelaps bimaculatus	Black-naped Snake												15	3
	Notechis scutatus	Tiger Snake												27	28
	Parasuta gouldii						1				3			11	11
	Pseudonaja affinis	Dugite						1					X	55	57
	Pseudonaja mengdeni	Gwardar												2	2
	Simoselaps bertholdi	Jan's Banded Snake												1	1
Gekkonidae	*Christinus marmoratus*	Marbled Gecko												15	3
Pygopodidae	*Aprasia pulchella*													10	2
	Aprasia repens						2	4	1	3	5	10	4	45	9
	Delma fraseri													45	9
	Delma grayii													15	3
	Lialis burtonis								1					85	18
	Pygopus lepidopodus	Common Scaly Foot												3	3
Scincidae	*Acritoscincus trilineatum*						4	4	2	4	2			85	14
	Cryptoblepharus buchananii						4	2	2	2	1	1	5	65	14
	Ctenotus australis													40	7

		Surveys	A	B			C							D	E
Family	**Species**	**Common Name**	**Wright Lake**	**Ken Hurst Park**	**Manjedal Brook**	**Shreeve Road Wetland**	**Brickwood Reserve 2**	**Brickwood Reserve 3**	**Cardup Reserve 1**	**Cardup Reserve 2**	**Cardup Reserve 3**	**Norman Road 1**	**Norman Road 2**		
	Ctenotus delli														1
	Ctenotus fallens								1			4	4	15	3
	Ctenotus impar						5	X	1	5	1	1		135	28
	Ctenotus labillardieri													30	6
	Egernia kingii	King's Skink												15	3
	Egernia napoleonis													5	1
	Hemiergis initialis													35	7
	Hemiergis quadrilineata													5	1
	Lerista distinguenda													25	5
	Lerista elegans						1	13	10	7	17	9	6	150	31
	Lerista lineata														2
	Menetia greyii						2		23	11	5	2	9	115	23
	Morethia lineoocellata													5	1
	Morethia obscura						8	5		1	10	6	16	30	7
	Tiliqua occipitalis	Western Bluetongue												2	2
	Tiliqua rugosa						3	2	7	2		X	2	3	1
Typhlopidae	*Ramphotyphlops australis*						6	1	4	1	3	1	2	14	14
	Ramphotyphlops bituberculatus													1	1
	Ramphotyphlops pinguis													1	1
	Ramphotyphlops waitii													3	3
Varanidae	*Varanus gouldii*	Bungarra or Sand Monitor							1	2	1	1		2	2
	Varanus rosenbergi	Heath Monitor												1	1
	Varanus tristis	Racehorse Monitor					X	4						2	2
Chelidae	*Chelodina oblonga*	Oblong Turtle												5	1

A Bamford Consulting Ecologists (2003) *Champion Lakes Master Plan; Fauna*. Unpublished report for Bowman Bishaw Gorham, Perth.

B Gole C.A. (2003) *Bird Survey in selected Perth Metropolitan Reserve*s. A Joint Biodiversity Conservation Project between Birds Australia WA and Perth Biodiversity Project. Unpublished report Birds Australia and Perth.

C Harvey M.S., Dell J., How R.A. and Waldock J.M. (1997) *Ground Fauna of Bushland Remnants on the Ridge Hill Shelf and Pinjarra Plain Landforms Perth*. Unpublished report for the Australian Heritage Commission NEP Grant.

D NatureMap records

E Western Australian Museum records

X Presence only

Appendix D
Definitions of Significant Fauna under the WA *Wildlife Conservation Act 1950*

Level 1 Vertebrate Fauna Assessment – Southern Site Precinct G

TERRESTRIAL ECOSYSTEMS

APPENDIX D
DEFINITIONS OF SIGNIFICANT FAUNA UNDER THE WESTERN AUSTRALIAN *WILDLIFE CONSERVATION ACT 1950*

In Western Australia, all native fauna species are protected under the Western Australian *Wildlife Conservation Act 1950-1979*. Fauna species that are considered rare, threatened with extinction or have a high conservation value are specially protected under the Act. In addition, some species of fauna are covered under the 1991 ANZECC convention, while certain birds are listed under the Japan and Australian Migratory Bird Agreement (JAMBA) and the China and Australian Migratory Bird Agreement (CAMBA).

Classification of rare and endangered fauna under the *Wildlife Conservation (Specially Protected Fauna) Notice 2010* recognises four schedules of taxa. These are:

Schedule 1 – fauna which are rare or likely to become extinct and are declared to be fauna in need of special protection;

Schedule 2 – fauna which are presumed to be extinct and are declared to be fauna in need of special protection;

Schedule 3 – birds which are subject to an agreement between the governments of Australia and Japan relating to the protection of migratory birds and birds in danger of extinction which are declared to be fauna in need of special protection; and

Schedule 4 – fauna that are in need of special protection, for reasons other than mentioned in Schedules 1, 2 or 3.

In addition to the above classifications, DEC also classifies fauna under five different Priority codes:

Priority one – ***Taxa with few, poorly known populations on threatened lands*.** Taxa which are known from few specimens or sight records from one or a few localities on lands not managed for conservation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

Priority two – *Taxa with few, poorly known populations on conservation lands, or taxa with several, poorly known populations not on conservation lands.* Taxa which are known from few specimens or sight records from one or a few localities on lands not under immediate threat from habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

Priority three – *Taxa with several, poorly known populations, some on conservation lands*. Taxa which are known from few specimens or sight records from several localities, some of which are on lands not under immediate threat of habitat destruction or degradation. The taxon needs urgent survey and evaluation of conservation status before consideration can be given to declaration as threatened fauna.

Priority four – *Taxa in need of monitoring*. Taxa which are considered to have been adequately surveyed or for which sufficient knowledge is available and which are not considered currently threatened or in need of special protection, but could if present circumstances change. These taxa are usually represented on conservation lands. Taxa which are declining significantly but are not yet threatened.

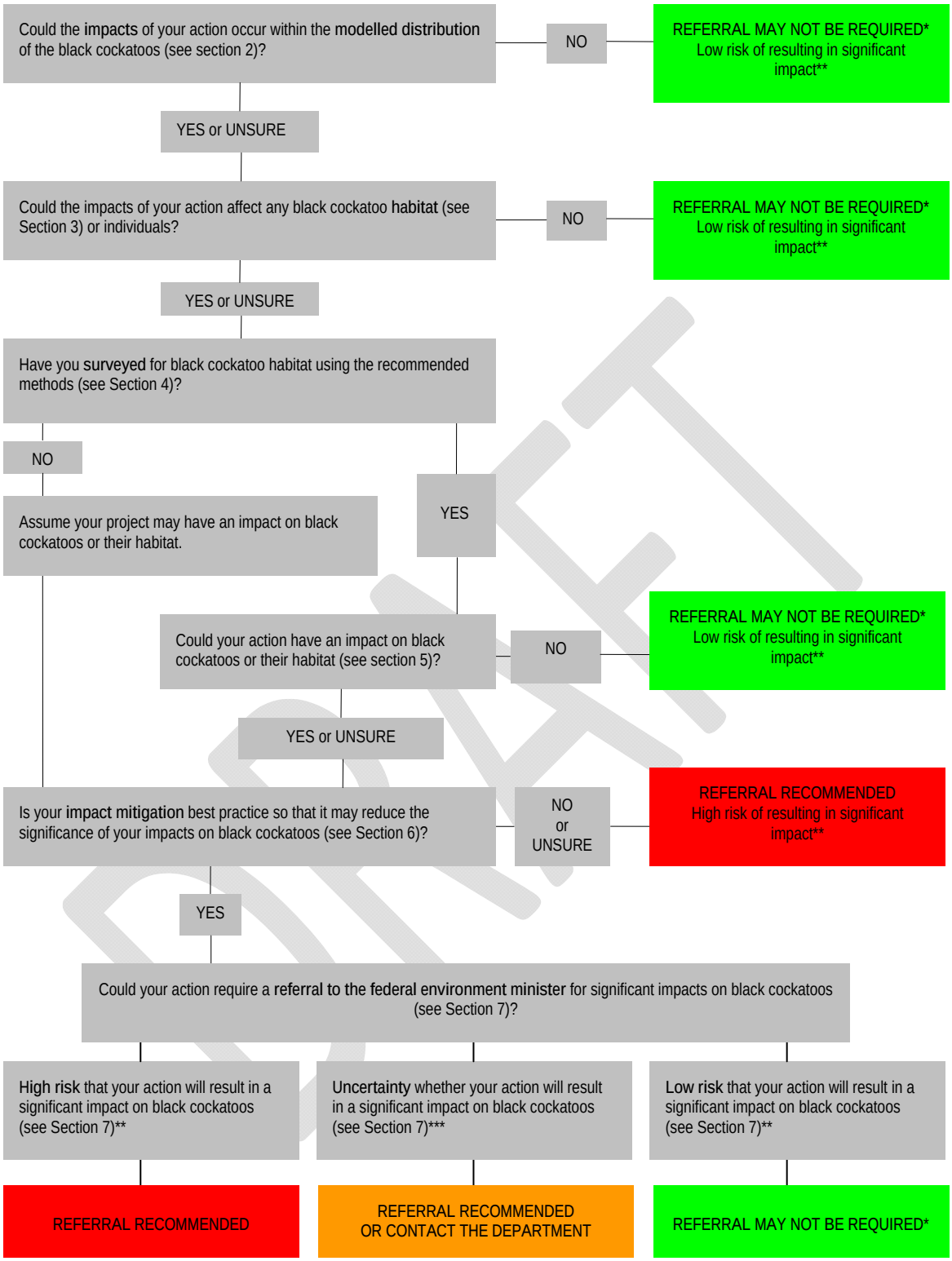
Priority five – *Taxa in need of monitoring.* Taxa which are not considered threatened but are subject to a specific conservation program, the cessation of which would result in the species becoming threatened within five years.

Appendix E
Referral Decision Tree for Black Cockatoos (Department of Sustainability Environment Water Population and Communities 2011)

Level 1 Vertebrate Fauna Assessment – Southern Site Precinct G

TERRESTRIAL ECOSYSTEMS

Figure 1: Decision making



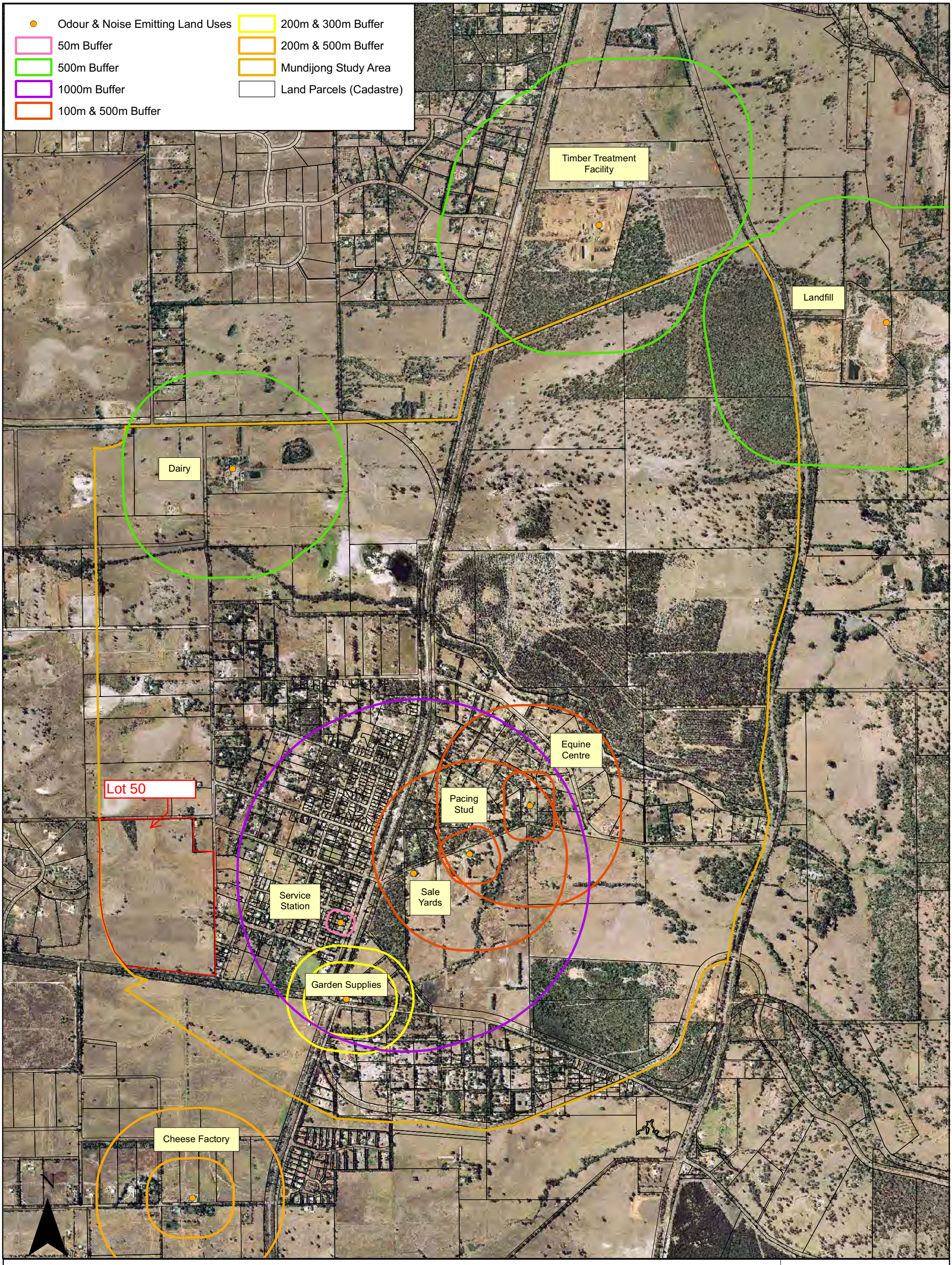
* Although it would appear a referral may not be required, you may still refer your proposed action if unsure, or if you think the proposal would not have significant impacts on matters of national environmental significance, but would like legal certainty. An example may be when other matters of national environmental significance, in addition to black cockatoos, are potentially affected.

** Risk is the chance of something happening that will have a [significant] impact on objectives [for example, protecting matters of national environmental significance] (adapted from Australian / New Zealand Risk Management Standard 4360: 2004).

*** If you are uncertain about the need to refer then you may also contact the federal environment department to discuss your action by emailing epbc.referrals@environment.gov.au

APPENDIX 3

DSP Odour and Noise Sources



JOB TITLE	Environmental Study - Mundijong/Whitby District Structure Plan				
FIGURE TITLE	Noise & Odour Emitting Land Uses	REFERENCE	Shire of Serpentine Jarrahdale	AUTHOR	J Levett
FIGURE No.	Figure 22	SCALE	1 : 20 000		
DATE	19/06/2008	PROJECT No.	3006110	0 125 250 500 750 1,000 Meters	

SMEC

APPENDIX 4

Landscape Master Plan

September 2012

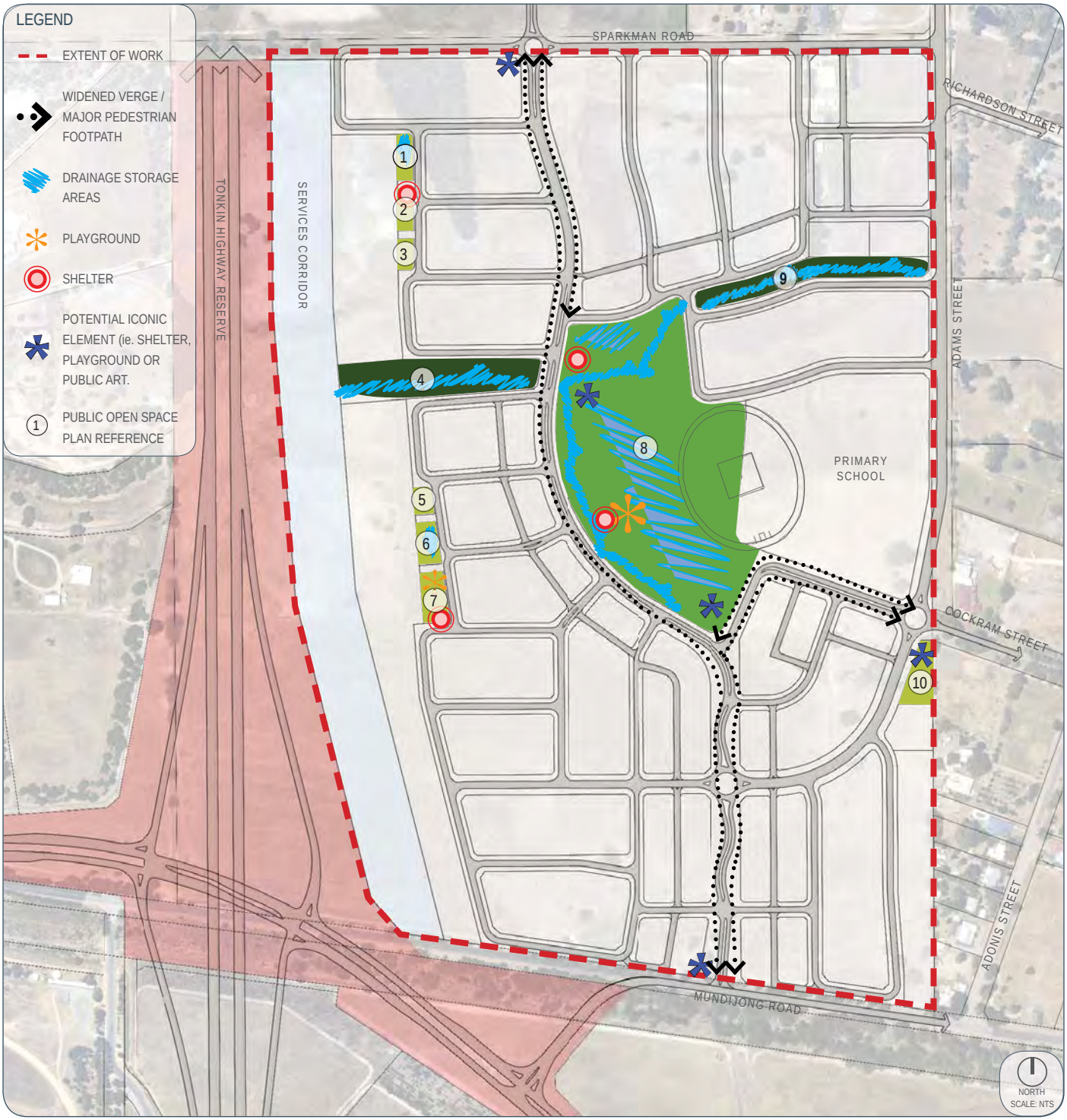
Lot 50 Cockram St, Mundijong

Local Structure Plan - Landscape Strategy

emerge ASSOCIATES

Integrated Science & Design

LANDSCAPE STRATEGY PLAN



PUBLIC OPEN SPACE SUMMARY

LOCAL PARK (POS 1, 2, 3, 5, 6, 7 & 10)

- Predominantly native planted areas with pockets of turf.
- Retention of existing significant trees where possible.
- Small gathering nodes and basic picnic facilities with shade structures.
- Path network which links into the greater development.
- Primary focus on passive recreation.
- Fully irrigated.

LINEAR POS / DRAINAGE SWALE (POS 4 & 9)

- Predominantly native planted areas with pockets of turf.
- Retention of existing significant trees where possible.
- Drainage retention and conveyance through a vegetated and stabilised swale.
- Pedestrian bridge crossings over landscaped drainage swales.
- Informal active recreation uses on open grassed areas.
- Small gathering nodes with picnic / BBQ facilities.
- Path network which links into the greater development.
- Manicured landscape areas fully irrigated.

NEIGHBOURHOOD PARK (POS 8)

- Centrally located and easily accessible to the greater community.
- Predominantly native planted areas with pockets of turf.
- Retention of existing significant trees where possible.
- Drainage retention and conveyance through vegetated and stabilised swales.
- Formal active recreation uses through shared oval with School site.
- Informal active recreation used on open grassed areas.
- Playground with informal seating.
- Large gathering nodes with picnic / BBQ facilities and shade structures.
- Path network which links into the greater development.
- Manicured landscape areas fully irrigated.

LOT 50 COCKRAM ST, MUNDIJONG - STRUCTURE PLAN

LANDSCAPE JOB NUMBER : MG01 : SEPTEMBER 2012 : REV A

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LANDSCAPE MASTER PLAN

CONSIDERED

HOMELY

COMFORTABLE

INTERACTIVE

TEXTURAL

CONNECTED

LOT 50 COCKRAM ST, MUNDIJONG - STRUCTURE PLAN

LANDSCAPE JOB NUMBER : MG01 : SEPTEMBER 2012 : REV A

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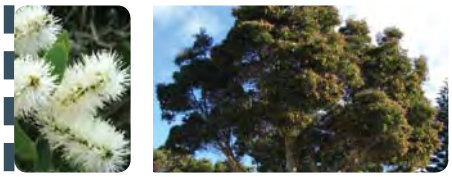
STREET TREE MASTER PLAN

Liquidambar styraciflua - Red Gum

Eucalyptus sideroxylon - Red Ironbark

Eucalyptus nicholii - Narrow Leaved Paperbark

Agonis flexuosa - WA Peppermint



Melaluca quinquinervia - Paperbark

Corymbia maculata - Spotted Gum

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POS TREE PLANTING PALETTE


Agonis flexuosa


Liquidambar styraciflua


Kingia Australis


Corymbia maculata


Casuarina cunninghamiana


Corymbia calophylla


Corymbia ficifolia


Eucalyptus nicholii


Eucalyptus rudis


Eucalyptus wandoo


Eucalyptus sideroxylon


Eucalyptus camaldulensis


Eucalyptus marginata


Melaleuca quinquernervia


Xanthorrrhoea preissii

LOT 50 COCKRAM ST, MUNDIJONG - STRUCTURE PLAN

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POS 8 CONCEPT

POS TYPOLOGY

- Neighbourhood Park.

SIZE

- 43,910m2 + 3,390m2 verge.

CONCEPT

- Provide an active recreation POS with a large flat grassed oval for formal recreation in a shared arrangement with the proposed school site (primary school sized oval).
- Drainage retention and conveyance through vegetated and stabilised swales.
- Grassed amphitheatre for viewing sporting activities.
- Possible small community building (by others) to provide public facilities such as a toilets / changerooms / meeting rooms in conjunction with oval uses.
- Large gathering nodes with picnic / BBQ facilities and shade structures.
- Large adventure playground with informal seating opportunities co-located with picnic / BBQ facilities.
- Path network to disability codes which links into the greater development.

FUNCTIONS / MATERIALS

- Provide for stormwater retention and conveyance through vegetated and rock stabilised swales and streams.
- Provide for formal active recreation uses on a large grassed area in a shared arrangement with the proposed school.
- Provide for a large adventure playground with informal seating.

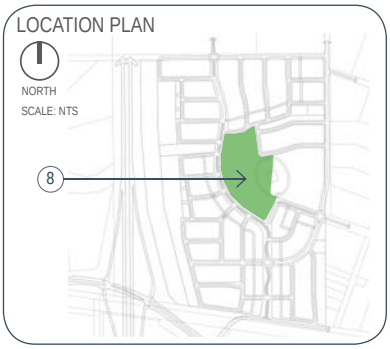
ENVIRONMENTAL CONSIDERATIONS

- Retention and polish of stormwater runoff
- Waterwise Plant Strategy.
- Hydrozoning of plant species.
- Controlled fertiliser application to landscape areas.
- Retain existing trees (where possible).

DRAINAGE CONSIDERATIONS

Swale A	1:1yr Storm Volume = 810m2
	1:5yr Storm Volume = 2,400m2
	1:100yr Storm Volume = 3,900m2
Swale B	1:1yr Storm Volume = 3,680m2
	1:5yr Storm Volume = 11,900m2
	1:100yr Storm Volume = 14,500m2
Drain A	1:5yr Flood Width = 9m
	1:100yr Flood Width = 10m
Drain B	1:5yr Flood Width = 7m
	1:100yr Flood Width = 10m

LOCATION PLAN



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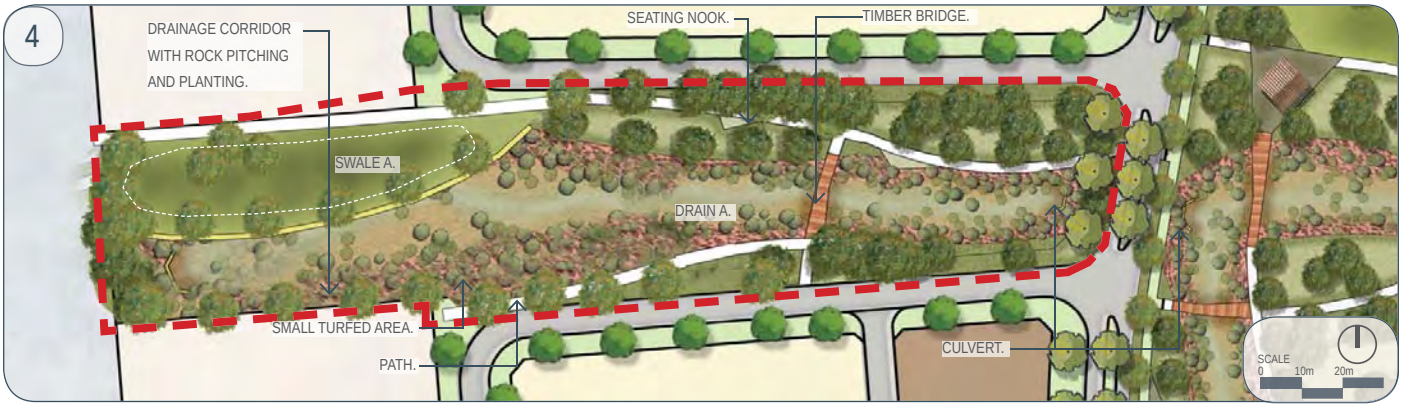
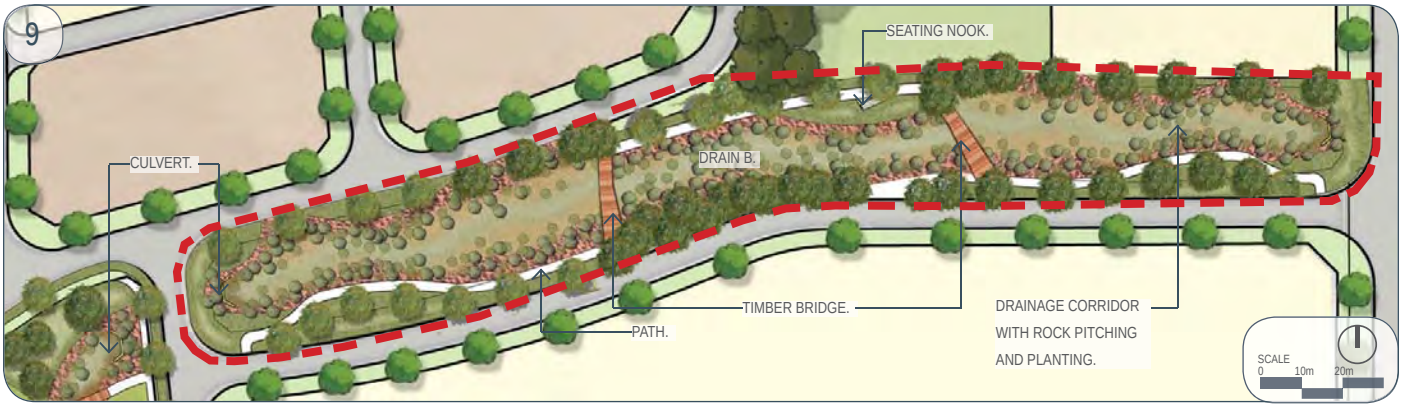
POS 4 & 9 CONCEPT





POS TYPOLOGY

- Linear POS / Drainage Swale

SIZE

- **POS 4** - 7,154m2 + 1,210m2 verge.
- **POS 9** - 4,663m2 + 1,761m2 verge.

CONCEPT

- Provide a POS which caters for drainage retention and conveyance through a vegetated and stabilised swale.
- Path network to disability codes which links into the greater development.
- Shaded seating nooks along path network.

FUNCTIONS / MATERIALS

- Provide for stormwater retention and conveyance through vegetated and rock stabilised swales and streams.
- Provide for informal recreation uses with small gathering nodes with picnic / BBQ facilities.

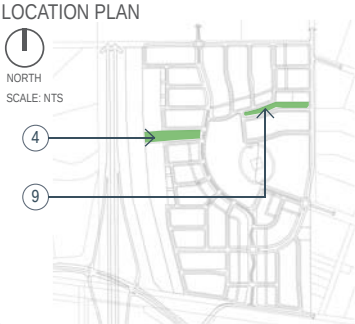
ENVIRONMENTAL CONSIDERATIONS

- Retention and polish of stormwater runoff
- Waterwise Plant Strategy.
- Hydrozoning of plant species.
- Controlled fertiliser application to landscape areas.
- Retain existing trees (where possible).

DRAINAGE CONSIDERATIONS

Swale A	1:1yr Storm Volume = 410m2
	1:5yr Storm Volume = 1,200m2
	1:100yr Storm Volume = 2,600m2
Drain A	1:5yr Flood Width = 12m
	1:100yr Flood Width = 15m
Drain B	1:5yr Flood Width = 8m
	1:100yr Flood Width = 11m

LOCATION PLAN



LOT 50 COCKRAM ST, MUNDIJONG - STRUCTURE PLAN
LANDSCAPE JOB NUMBER : MG01 : SEPTEMBER 2012 : REV A

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POS 1-3 & 5-7 CONCEPT

POS TYPOLOGY

- Local Parks

SIZE

- **POS 1** - 734m2
- **POS 2** - 672m2
- **POS 3** - 490m2
- **POS 5** - 486m2
- **POS 6** - 887m2
- **POS 7** - 1,265m2

CONCEPT

- Provide a series of POS' primarily focussed on passive receration with pockets of turf and feature nodes. on key axis'.
- Feature shelters with picnic and BBQ facilities.
- Provide seating nooks along path network.
- Predominantly native planted garden beds.
- Small playground with informal seating.

FUNCTIONS / MATERIALS

- Provide for stormwater retention in turf and vegetated swales.
- Provide for informal recreation uses with small gathering nodes with picnic / BBQ facilities.

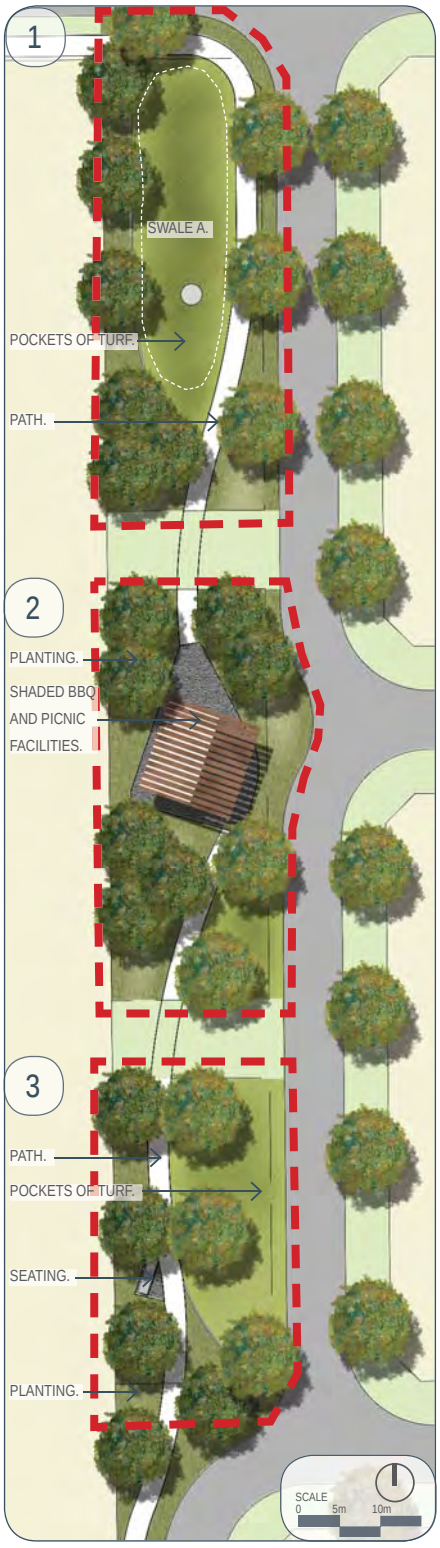
ENVIRONMENTAL CONSIDERATIONS

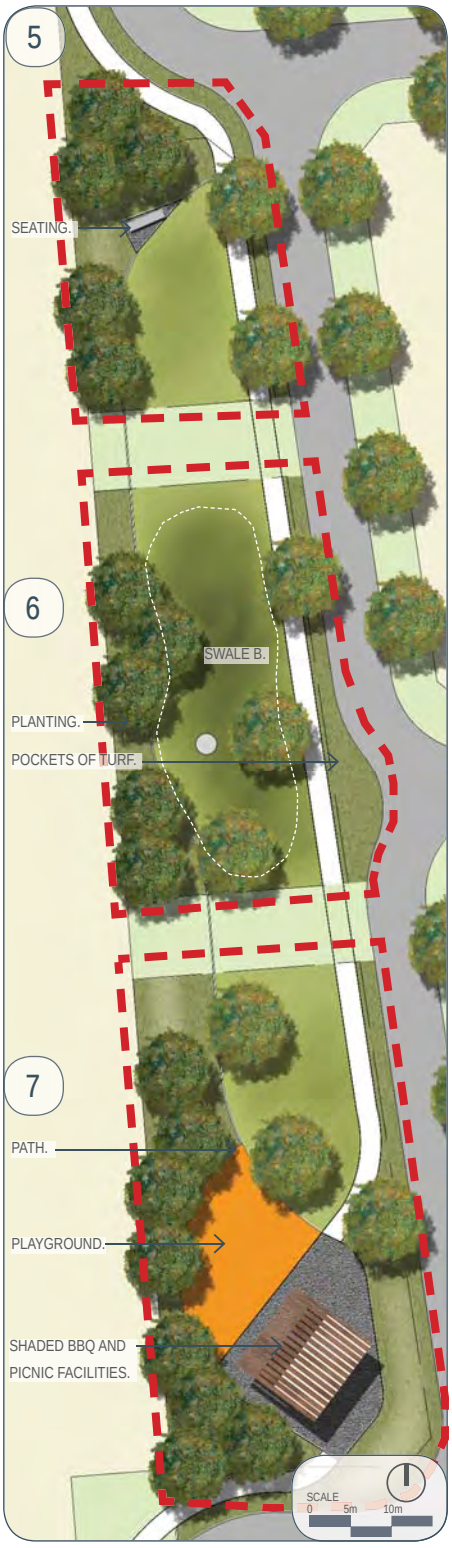
- Waterwise Plant Strategy.
- Hydrozoning of plant species.
- Controlled fertiliser application to landscape areas.
- Retain existing trees (where possible).

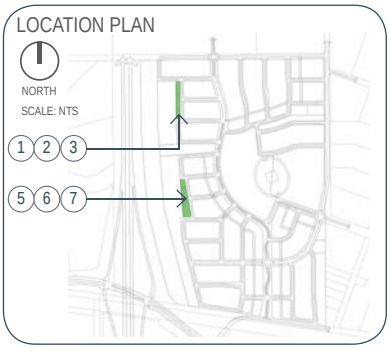
DRAINAGE CONSIDERATIONS

Swale A
1:1yr Storm Volume = 420m2
1:5yr Storm Volume = 1,000m2
1:100yr Storm Volume = 1,100m2

Swale B
1:1yr Storm Volume = 1,080m2
1:5yr Storm Volume = 2,100m2
1:100yr Storm Volume = 2,600m2







LOT 50 COCKRAM ST, MUNDIJONG - STRUCTURE PLAN

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POS 10 CONCEPT

POS TYPOLOGY

- Local Park

SIZE

- 1,437m2 + 623m2 verge.

CONCEPT

- Provide a POS primarily focussed on passive receration with pockets of turf and seating nooks.
- Predominantly native planted garden beds.
- Retention of existing trees.

FUNCTIONS / MATERIALS

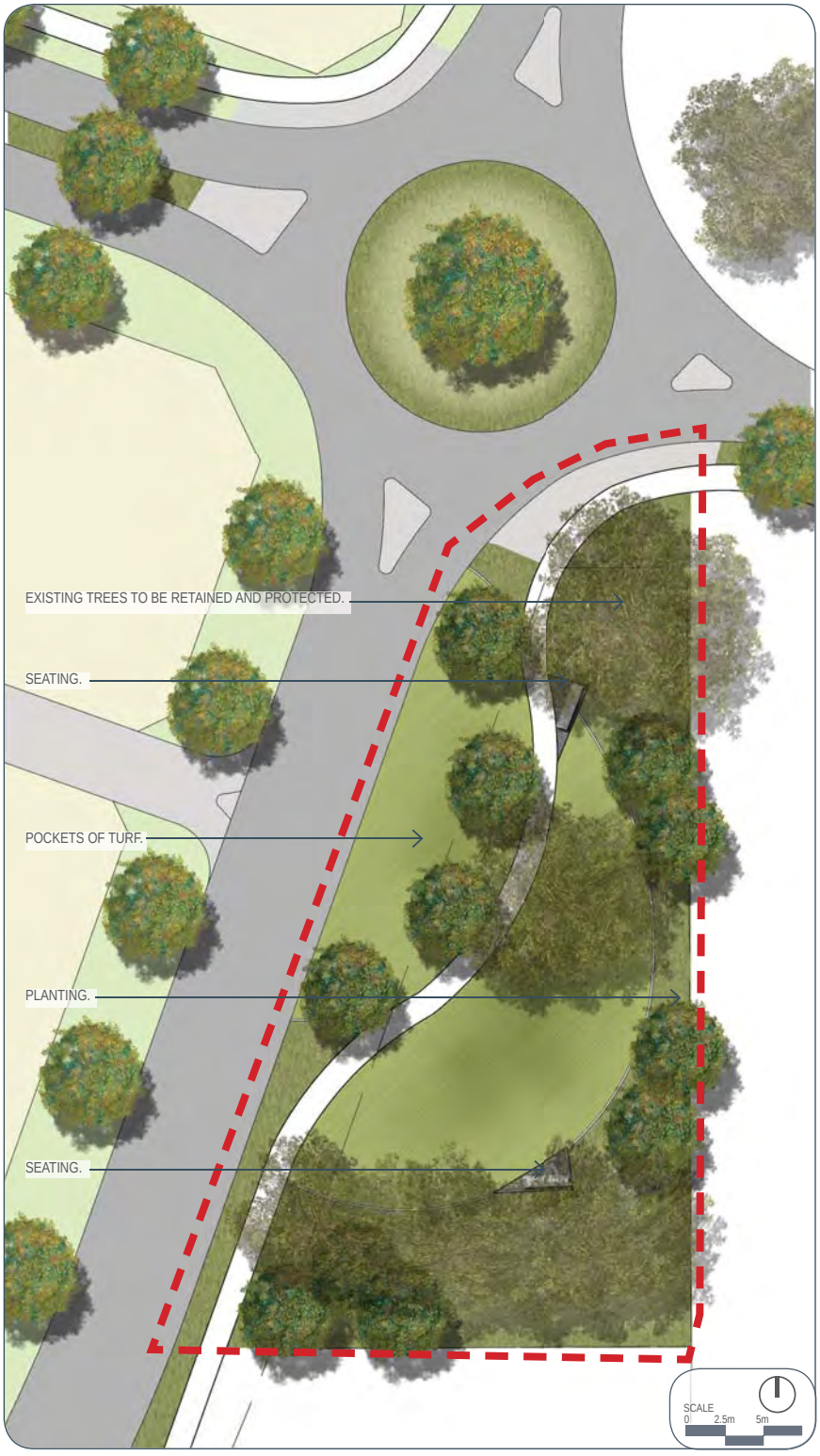
- Provide for informal recreation uses with small gathering nodes.

ENVIRONMENTAL CONSIDERATIONS

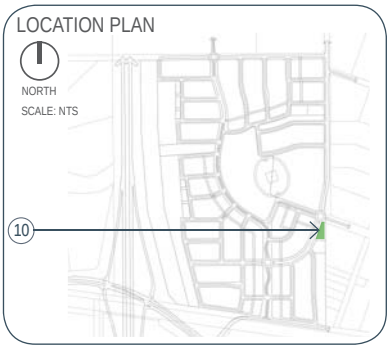
- Waterwise Plant Strategy.
- Hydrozoning of plant species.
- Controlled fertiliser application to landscape areas.
- Retain existing trees (where possible).

DRAINAGE CONSIDERATIONS

N/A



LOCATION PLAN



LOT 50 COCKRAM ST, MUNDIJONG - STRUCTURE PLAN

LANDSCAPE JOB NUMBER : MG01 : SEPTEMBER 2012 : REV A

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APPENDIX 5
ABORIGINAL HERITAGE SURVEY REPORT

Ethnosciences

ABN 47 065 099 228

Aboriginal Heritage

Draft Report on the Results of Archaeological and Ethnographic Surveys of Lot 50 Mundijong Road, Mundijong

Prepared for Peet Limited

By Edward M. McDonald (Ethnosciences) and Jo-Anne Thomson (Thomson Cultural Heritage Management)

August 2012

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Email: dredward@iinet.net.au

Ethnosciences

ABN 47 065 099 228

Aboriginal Heritage

Disclaimer

The results, conclusions and recommendations contained within this report are based on information available at the time of its preparation. Whilst every effort has been made to ensure that all relevant data has been collated, the authors can take no responsibility for omissions and/or inconsistencies that may result from information becoming available subsequent to the report's completion.

Abbreviations

ACMC:	Aboriginal Cultural Material Committee
AHA:	*Aboriginal Heritage Act 1972*
AHIS:	Aboriginal Heritage Inquiry System
Bilya:	Bilya Noongar Organisation
DIA:	Department of Indigenous Affairs
GKB:	Gnaala Karla Booja Native Title Claimants
MHA:	McDonald, Hales and Associates
SAAS:	Swan Area Archaeological Survey
SWALSC:	South West Aboriginal Land & Sea Council
TCHM:	Thomson Cultural Heritage Management
WAC:	Winjan Aboriginal Corporation
WAGR:	Western Australian Government Railway

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Summary and Recommendations

Ethnosciences was commissioned by Peet Limited to undertake an Aboriginal heritage assessment of Lots 9000, 98 and 37 Bishop Road and Lot 50 Mundijong Road, Mundijong. Ethnosciences contracted Thomson Cultural Heritage Management (TCHM) to undertake the archaeological field survey of the Peet Lots.

This report presents the findings of the desktop and ethnographic and archaeological field surveys in relation to Lot 50 Mundijong Road, Mundijong. The findings in relation to the remaining land will be reported under a separate cover.

Edward McDonald and Lois Hall (Ethnosciences) undertook the desktop research and McDonald carried out the ethnographic field research. Jo-Anne Thomson (TCHM) undertook additional archaeological desktop research and undertook the archaeological field survey with the assistance of Christine Martin.

The study area is located within the Gnaala Karla Booja (WC98/58) Native Title Claim for which the South West Aboriginal Land and Sea Council (SWALSC) is the representative body. SWALSC was contacted about the Mundijong project in late 2011; however, the Council was unable to respond to the request to nominate Aboriginal consultants or to have the matter considered by the Gnaala Karla Booja Working Party in a timely fashion. In order to avoid unacceptable delays to the project, it was decided to contact two regionally-based Aboriginal groups —the Bilya Noongar Organisation (Bilya) and the Winjan Aboriginal Corporation (WAC)— whose members are GKB claimants and have demonstrated associations with, and knowledge of, the Aboriginal heritage values of the country encompassing the survey area. These two groups were invited to nominate consultants for the survey. The ethnographic survey involved eight Aboriginal consultants drawn from these two groups and was undertaken on 12th and 13th April 2012 with Bilya and Winjan respectively.

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The search of the Register of Aboriginal Sites revealed that there are no previously recorded ethnographic sites on Lot 50. No ethnographic sites were reported on the land during the ethnographic survey which involved representatives of Bilya and WAC Corporation who have long-standing associations with the region. Two of the WAC consultants had actually lived in Mundijong for a period and had attended primary school in town. Both recall use of the area's natural resources by Nyungars living in town, on farms and in fringe camps in the area.

One archaeological site (MJ-06), an artefact scatter, was located on Lot 50 during the archaeological survey. MJ-06 is a small, medium-density, open quartz artefact scatter situated on a Bassendean sand dune above seasonally inundated wetlands. The site represents either the by-products of task specific activities or a short term or infrequently used occupation site.

It is the opinion of the authors that MJ-06 constitutes a site within the meaning of Section 5(a) of the *Aboriginal Heritage Act 1972*. However, MJ-06 is assessed as currently being of low archaeological significance. No further recording of the surface assemblage of MJ-06 is required.

The consultants of both groups were of the view that Site MJ-06 — the artefact scatter identified on Lot 50 during the archaeological survey — was of low cultural significance and did not oppose Peet Limited applying for Section 18 consent for the site. However, they differed in how the site should then be treated. The former wants the material left *in situ*; the latter wants the material salvaged and appropriately stored. At present, it is not possible to reconcile these opposing views.

Recommendations

1. It is recommended Peet's proposed development of Lot 50 Mundijong Road, Mundijong proceed.
2. It is recommended that Peet and its contractors are:
    a. advised of the existence and location of archaeological site MJ-06; and

b. informed that the *Aboriginal Heritage Act 1972* (s5) may apply to MJ-06 and therefore it should not be impacted upon in any way without Ministerial consent under Section 18 of the AHA or the authority of the Registrar under Section 16.

3. It is recommended that Ministerial consent be given for the land on which archaeological site MJ-06 (artefact scatter) is located.
4. It is recommended that further consultation is undertaken with the Bilya Noongar Organisation and the Winjan Aboriginal Corporation regarding the disposition of the artefactual material in site MJ-06.

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Table of Contents

List of Tables

PO Box 121, MELVILLE WA 6956

Phone (08) 9339 8431; Fax: (08) 9438 1717; Mobile: 0419957140

Email: dredward@iinet.net.au

List of Figures

List of Plates

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Ethnosciences

ABN 47 065 099 228

Aboriginal Heritage

Introduction

Ethnosciences was commissioned by Peet Limited to undertake an Aboriginal heritage assessment of Lots 9000, 98 and 37 Bishop Road and Lot 50 Mundijong Road, Mundijong.

This report presents the findings of the desktop and field surveys in relation to Lot 50 Mundijong Road, Mundijong, which lies approximately 40km southwest of Perth (Figures 1 and 2). Peet Limited proposes to develop 0.6943 sq km (64.93 hectares) of land on Lot 50 for a residential subdivision (see Figure 1). The findings in relation to the remaining land will be reported under a separate cover.

Edward McDonald and Lois Hall (Ethnosciences) undertook the desktop research and McDonald carried out the ethnographic field research on 12th and 13th April 2012. Archaeologist Jo-Anne Thomson of Thomson Cultural Heritage Management (TCHM) was subcontracted to undertake the archaeological field survey of the Peet Lots, including and Lot 50 Mundijong Road. The archaeological field survey was undertaken by Jo-Anne Thomson and Ms Christine Martin on 3rd and 4th April 2012.

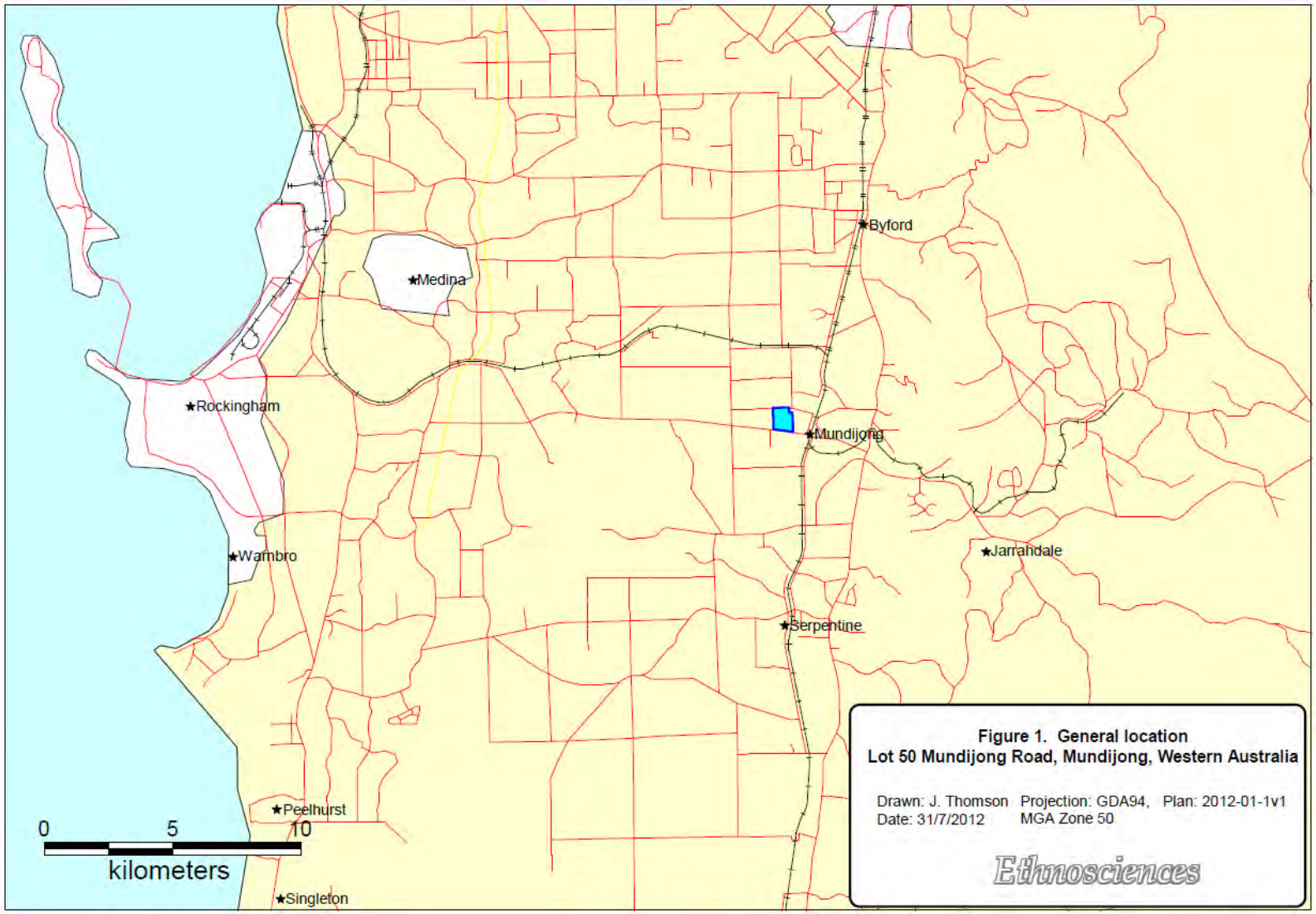

Figure 1: General location of Peet's Lot 50 Mundijong Road development area

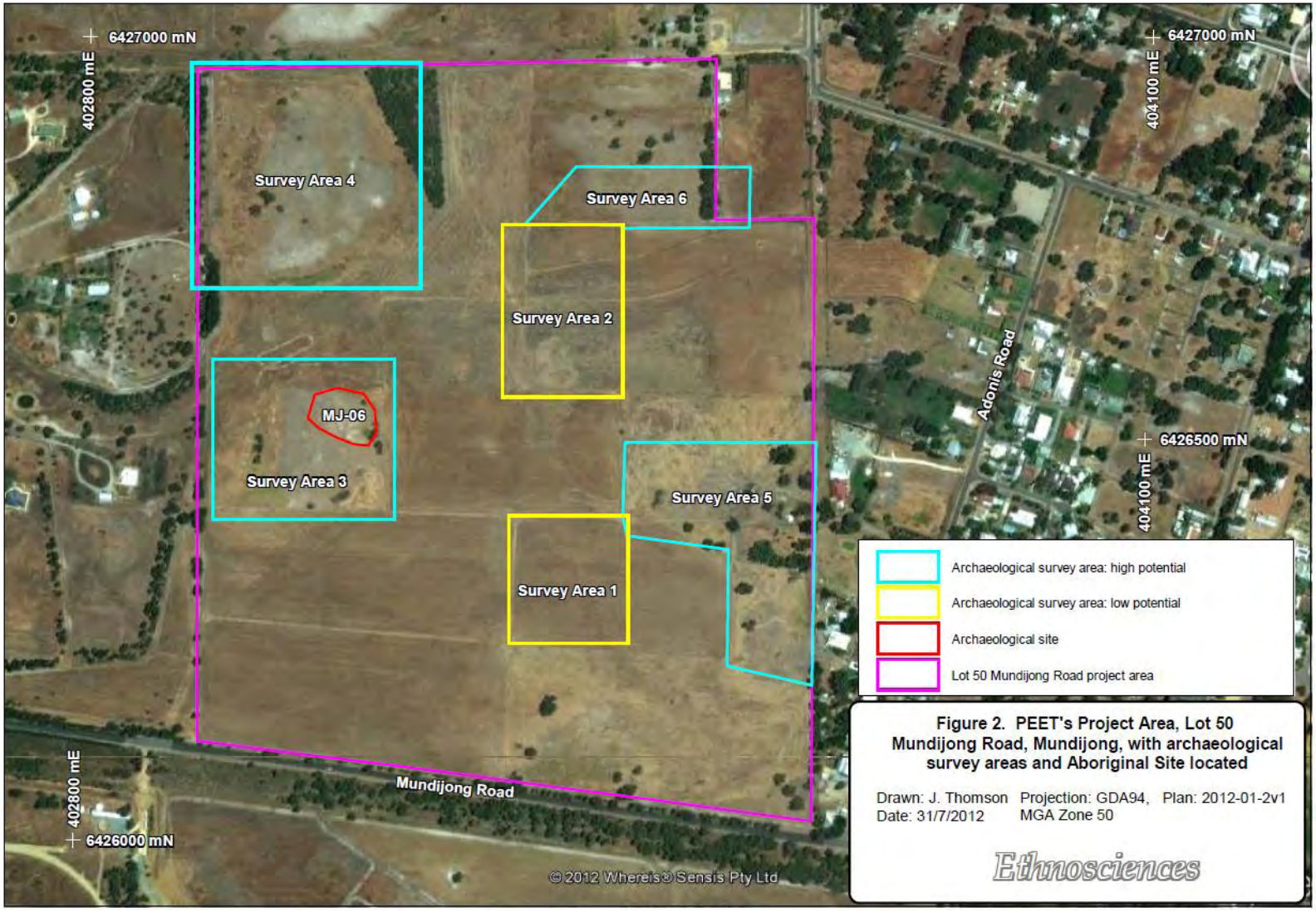

Figure 2: The Peet project area, Lot 50 Mundijong Road, Mundijong with archaeological survey areas and Aboriginal Site located

Figure 3: Peet's concept plan for Lot 50 Mundijong Road, Mundijong (Source: Peet, May 2012)

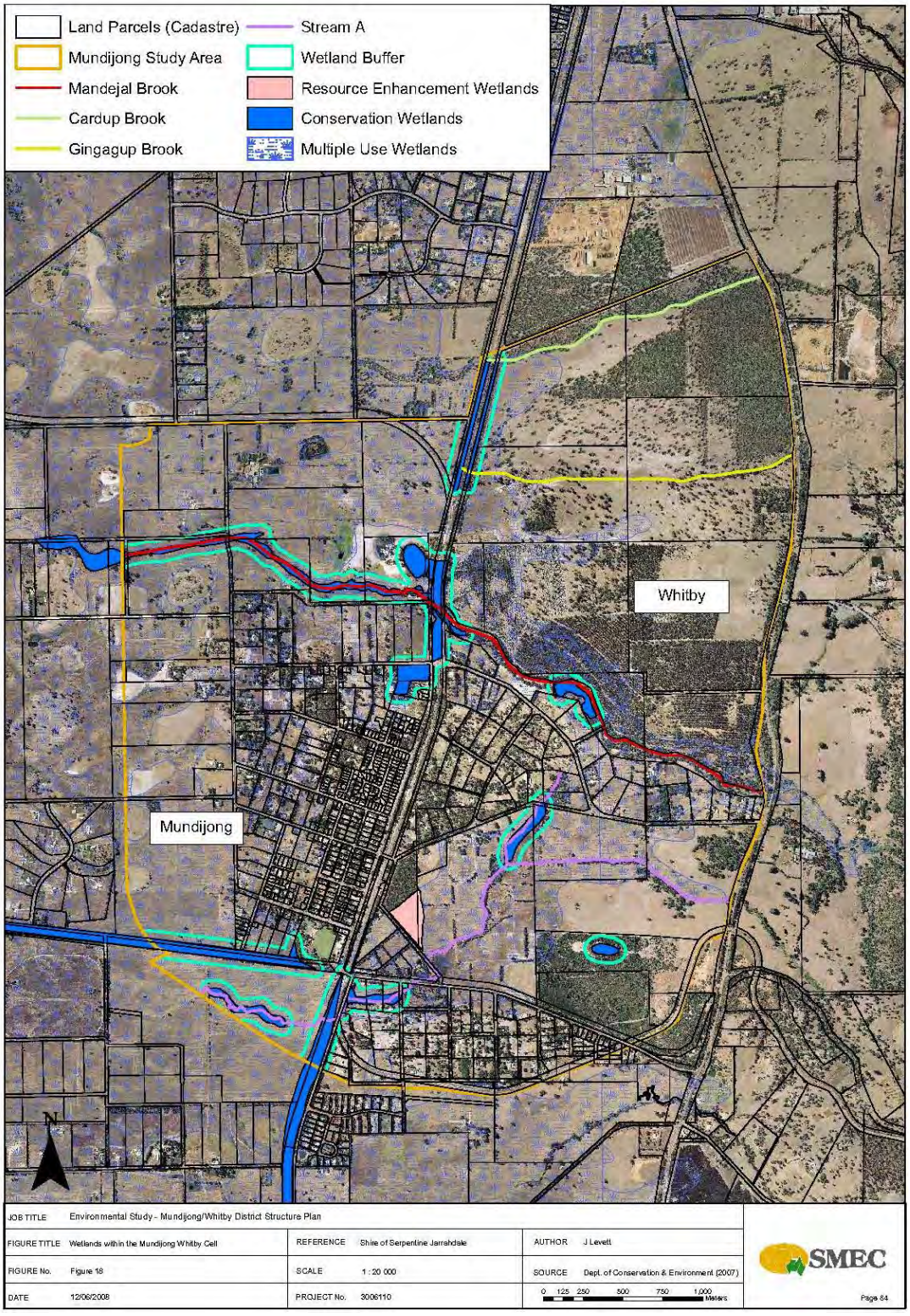

Figure 4: Geomorphic wetland regimes (Source: SMEC 2009: 84)

Part 1: Ethnographic Survey

Ethnographic Survey & Consultation Methods

The ethnographic survey and consultation was undertaken in the following stages:

- Desktop research;
- Selection of the Aboriginal consultants;
- Ethnographic survey and consultation regarding the archaeological sites; and
- Report preparation.

Edward McDonald and Lois Hall undertook the desktop research which in the first instance involved an examination of the Register of Aboriginal Sites using the DIA's online Aboriginal Heritage Inquiry System (AHIS).

A review of previous consultancy reports and other published and unpublished ethnographic research material was also undertaken. This included reports of previous heritage studies conducted in the area. Of particular relevance are the reports of heritage surveys undertaken by McDonald, Hales and Associates (see Blockley & Greenfield 1995; Blockley *et al* 1996); Edwards & McDonald (1999); and Western Infrastructure (2001).

Previous Surveys

The Mundijong area has been subjected to previous ethnographic and archaeological surveys.

Report of an Aboriginal Heritage Survey: South-East Corridor Structure Plan

In May 1995, the Ministry for Planning commissioned McDonald, Hales and Associates (MHA) to undertake detailed Aboriginal Heritage investigations for the proposed Tonkin Highway extension easement (PTEE), with the proposed urban village (PUV) developments at both Byford and Mundijong to be covered at the overview level.

The focus of this heritage research within the South-East Planning Corridor consisted of a corridor approximately 20km long and 100m wide extending from Ranford Road in the north to Mundijong Road in the south. The PUV sites were expected to cover approximately 2,263 hectares of land surrounding the already existing Byford and Mundijong townsites. The area covered by the heritage study had historically been used for agricultural purposes and urban development which, as a consequence, had resulted in the original native vegetation being cleared and introduced species gaining dominance.

Representatives from Winjan Aboriginal Corporation, Nyungah Land Council, Murray Districts Aboriginal Corporation and Ballaruk Community Incorporated, as well as five members of the Nyoongar Circle of elders were consulted (Blockley & Greenfield 1995:71). One previously recorded ethnographic site (DIA Site No. S2602 Wungong Brook) was located and two new ethnographic sites (DIA Site Nos. S2960 Camping and Meeting Place & S2961 Camping Area) were recorded. However, none of these places are located within the present survey area.

The authors of the report recommended that a 30m buffer zone around water sources such as Manjedal Brook be observed. Manjedal Brook is not located in the present study area.

<u>Revised Report of an Aboriginal Heritage Survey: South-East Corridor Structure Plan</u>

This is essentially an extension to the previous report by MHA, instigated by the Aboriginal Cultural Material Committee (ACMC) in response to an application lodged by Main Roads Western Australia with regards to the PTEE. As a result, the Ministry for Planning commissioned further research with emphasis on the preferred alignment option 1C (Blockley *et al.* 1996).

Recommendations were made that included plaques being erected to acknowledge Aboriginal occupation of the area. It was also recommended that 30m buffer zones around the water sources of Cardup Brook, Manjedal Brook and the south branch of

Wungong Brook be implemented to ensure that they, and the surrounding vegetation, were not disturbed. If this was not feasible, then it was recommended that Section 18 applications for Ministerial permission to disturb the watercourses be sought and granted. It was further recommended that when specific plans had been developed for the PUVs, that a comprehensive heritage survey be conducted in those areas.

Report of an Aboriginal Heritage Survey: Proposed Tonkin Highway Extension and Mundijong Road Realignment Project

BSD Consultants commissioned this study by Edwards and McDonald, on behalf of Main Roads Western Australia, in September 1998. It covered the areas of the proposed Tonkin Highway extension and the Mundijong Road Realignment Project.

Selecting the Aboriginal Consultants

Under subsection 1.10 of the DIA's new *Cultural Heritage Due Diligence Guidelines*, the DIA and ACMC identify four categories of "relevant Aboriginal people" to be considered for consultation in relation to projects that have the potential to impact Aboriginal Sites. They are:

1. Native Title Holders;
2. those who are registered Native Title Claimants;
3. persons named as informants on Aboriginal site recording forms held on the Register of Aboriginal Sites at the DIA; and
4. any other Aboriginal persons who can demonstrate relevant cultural knowledge in a particular area (DIA 2011).[1]

A search of the National Native Title Tribunal's online schedule and register was conducted in order to determine which Native Title Claims overlap the study area. This search found that the study area is located within the Gnaala Karla Booja

[1] The latest guidelines can be accessed on the DIA's website: http://www.dia.wa.gov.au/Documents/HeritageCulture/Heritage%20management/AHA_Due_Diligence_Guidelines.pdf

(WC98/58) claim area. The South West Aboriginal Land & Sea Council (SWALSC) is the representative body for the Gnaala Karla Booja (GKB) Native Title Claimants.

SWALSC was initially contacted about the Mundijong project in late 2011. However, the Council was unable to respond to the request to nominate Aboriginal consultants or to have the matter considered by the Gnaala Karla Booja Working Party in a timely fashion. As a result, it was likely that unacceptable delays to the project would occur, as had been experienced in a number of other projects Ethnosciences has worked on in the past year in the Metropolitan area and the wider South West region. As a result, it was decided to contact two regionally-based Aboriginal groups: (the Bilya Noongar Organisation (Bilya) and the Winjan Aboriginal Corporation (WAC)) whose members are GKB claimants and have demonstrated associations with, and knowledge of, the Aboriginal heritage values of the country encompassing the survey area. These groups were invited to nominate consultants for the survey.

The ethnographic survey involved eight Aboriginal consultants drawn from these two groups. Clarry Walley led the team from the Bilya which included John Abraham, Barbara Abraham and Mary Walley while Harry Nannup Snr headed the WAC team, the other members being Franklin Nannup, Harry Nannup Jnr and Harry Nannup III (Plate 1 & Plate 2). The ethnographic survey was undertaken on 12th and 13th April 2012 with Bilya and Winjan respectively.

The ethnographic survey, which was conducted by Edward McDonald, employed a site identification methodology:

> *In this type of survey, sites are located and documented and the spatial extent and significance of sites to Aboriginal people is recorded. This information may be made available to the proponent in report form, subject to agreement from the relevant Aboriginal people. Alternatively, confidential information may be presented in a restricted report to the ACMC, usually via the DIA. The report should contain recommendations on steps to be taken by the proponent to ensure compliance with the AHA* (Department of Indigenous Affairs 2002:17).

The survey party inspected the survey by 4WD vehicle and on foot. The proposed development was explained by McDonald and the results of the desktop research and archaeological field survey were outlined.

Ethnographic Background

Berndt (1979), drawing on Tindale (1974), concludes that at the time of British colonisation, the South West was occupied by thirteen 'tribes' or, as Berndt prefers, socio-dialectal groups, which formed a discrete socio-cultural bloc. Aboriginal people in this area now generally refer to themselves as *Nyungar*.

Traditionally, the area around Perth, these researchers suggest, was part of the territory of the *Whadjuk* or *Whadjug* (Tindale 1974; Berndt 1979). Tindale (1974) describes this group's territory as extending:

> *[From the] Swan River and northern and eastern tributaries inland to beyond Mount Helena; at Kalamunda, Armadale, Victoria Plains, south of Toodyay, and western vicinity of York; at Perth; south along the coast to near Pinjarra.*

According to Tindale (1974:256), the territory of the *Pindjarup* was located to the south of the survey area. Bates (1985), on the other hand, uses the term *Bibbulmun* to refer to people who would today refer to themselves *Nyungar*. However, Tindale (1974) and Berndt (1979) reserve the use of the term *Pibelmen/Bibelmen* for a tribe on the Lower Blackwood River and the south coast of Western Australia. Bates (1985:52–54) says that the Aboriginal people of the Perth/Swan River area were known as the *Yabbaru Bibbulmun* [northern Bibbulmun] or *Illa kuri wongi*.[2] She reports that the people of the Murray District were the *Kuri wongi*. Bates (1985:53) gives the Serpentine River as the boundary between the Swan and Murray River people. This roughly corresponds to the boundary noted by Tindale (1974, see also Australia S.W. Sheet – Tribal Boundaries Map).

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[2] From the words for coming directly = *Illa kuri* and speech or talk = *wongi* .In other words the group that has the phrase "*Illa kuri*" in their dialect.

Keen (1997:261) has recently suggested that anthropologists should "get away from the idea of discrete Aboriginal 'societies' 'cultures', 'groups' or 'communities' as basic elements, and to substitute a more regional perspective." He (1997:261, 273) notes that most ethnography is based on the assumption that Australia was divided into a number of discrete 'cultures', 'societies' or 'tribes' and that the 'tribe' model "has been found wanting". The works of Tindale and Berndt are clearly based on such a model, though the latter presents a different picture with respect to the Western Desert. In contrast, Keen's (1997:272–73) concept of 'focused networks' and 'regional system(s)' focuses on:

> *A nexus of adjacencies, of chains of connection, and of a dynamic, open, and transforming systemic network, broken here and there by fissures and lesions. A 'local system' becomes defined in a relative way. It is possible that somewhat uniform and reproduced systems of interconnected practices might be detected, but on the other hand, what might be found is a pattern of continuous variations in one place, or a mosaic of overlapping differences in another. Whatever the pattern, any local system must be set in its wider context.*

The differences between Tindale/Berndt's and Bates' descriptions may result from Bates' fuller appreciation of the 'focused networks' which characterised Nyungar social organisation. While Bates (1985) uses the term 'tribe' to discuss the social organisation of the South West and other parts of the State, her actual description would seem to be closer to the model outlined by Keen with all its apparent contradictions of 'continuous variations' and 'mosaic of overlapping differences'.

The social organisation of west coast Nyungar groups, such as the *Whadjug/ Illa kuri wongi*, included matrilineal moieties, with two exogamous clans in each (Bates 1985; see also Berndt 1979 on 'Perth' type of social organisation). Clans had totemic associations connecting their members to their physical and biological environments. However, ritual affiliations to sites occurred through an individual's father. Berndt

(1979) adds that there may have been local patrilineal descent groups, which focussed on particular totemic sites in defined stretches of country.[3]

The basic unit of Nyungar social organisation was the family, while the fundamental economic unit was the band, typically comprised of two or more family units. However, the actual numbers making up the band at any one time depended on a range of seasonal and social factors. Early settlers quite often referred to bands as 'tribes' and imposed further European concepts in describing both territorial affiliations and the description of Aboriginal 'leaders'. Various 'territories' have been described in which these social units were principally located and moved.

According to Lyon (in Green (ed.) 1979), the survey area lies within the Aboriginal country known as *Beeliar*, which was associated with the band that included legendary Aborigines Midgegooroo and his son Yagan. To the south, marked by a line from Mangle's Bay to the Darling Range, was the land of the band headed by Banyowla (Lyon in Green 1979). Other early commentators (e.g., Armstrong and Symmons) paint a somewhat different picture of land holdings and band composition shortly after colonisation (Hallam & Tilbrook 1990 discuss some of these differences; see also Brown 1983). Armstrong (1836, cited in Hallam & Tilbrook 1990), for example, wrote of the "Canning Tribe" (see Figure 2 in Brown 1983). These differences may have resulted from a lack of understanding of the complex nature and fluidity of Nyungar social organisation on the one hand and changes due to Aboriginal adjustments to the usurpation by colonists on the other. Hallam (1975) points out that this emerging picture of Aboriginal life contradicted European observers' focus on geographic areas and patrilineal relationships. A more accurate description is that of a system of overlapping sets of ritual and social connections

[3] Berndt's classification of South West social organisational types has been criticised on a number of grounds. Importantly, it suffers from marrying the broad mapping of social organisational types by Radcliffe-Brown with the specific boundaries of Tindale's tribal map (see McDonald & Christensen n.d.).

with land usage rights based on both patri- and matri- filiation. Individuals, families and bands moved between areas, generating a fluid local population size and composition.

The ethnohistorical evidence shows that rivers, creeks and wetlands in this region were most intensively occupied, given the availability of fresh water and food resources. In particular, the alluvial plains and the associated *warran* or native yam grounds and riparian resources such as *Typha* were of crucial economic importance to Aborigines (Hallam 1975). This conclusion is supported by the archaeological data. The history of contact and conflict between Aborigines and colonists in the Armadale and surrounding areas also demonstrates the importance of watercourses and wetlands to Aboriginal social and economic life (see, for example, Popham 1980; Cooper & McDonald 1988). Coy (1984:4), on the other hand, reports that according to oral history the relations between colonists and Nyungars in the Serpentine area were more peaceful than that experienced on the Canning or Murray rivers.

Wetlands and rivers were connected by a series of pads (*bidi*) that extended through this territory and from the present-day Perth area south to Mandurah and Pinjarra on the Murray River and north to Cockleshell Gully (Jurien Bay) and beyond (Bates 1985; Hammond 1933). A number of major roads in the South West follow the general alignment of the original Aboriginal pads. For example, Popham (1980:17) notes that Albany Highway follows a route surveyed by Hillman in 1836 which "followed the worn pathways of the Aboriginals (sic) and the course of the Neerigen Brook". Similarly, Coy (1984:4) reports "[t]he South Western Highway, known originally as the Foothills Track, vaguely follows a major *Nyungar* walking pad, which ran from the Perth Causeway to Pinjarra, then southwards to the Blackwood."

European colonisation heralded the destruction of Aboriginal social organisation, beginning in the Perth area and expanding relentlessly into the South West. The Nyungar population was decimated during this process. Epidemics, shootings by Europeans and draconian policies introduced by the colonial administration (e.g., forced exclusion from urban areas, concentration on reserves, restrictions on

movement and labour and so on) resulted in the attenuation of traditional ties with the land and with sites (Berndt 1979; see also Hammond 1933; Popham 1980; Coy 1984; McDonald & Copper 1988). As a result of this dislocation, there has been some loss of traditional mythological and ceremonial associations with the land along with the knowledge which underpins these connections. However, there are still some members of the Nyungar community who hold knowledge of mythological and other sites.

The ravages wrought by the European presence upon Nyungar society did not destroy Nyungar social bonds or identity completely. Nyungars did not merely disappear into history as is the impression given by a number of historical discussions, including the local histories cited in this report. Typically, local historical works discuss Aboriginal prehistory, culture and "contact" history (colonisation) in the early chapters and then rarely, if ever, mention them again. For example, McDonald & Copper's (1988) *The Gosnells Story* does not have an indexed listing of "Aborigine" after Chapter 3 (pp. 36–46) dealing with the period 1833 to 1865. The other local histories fair little better.

Rather than disappearing, Aboriginal people continued to play a part, albeit marginal, in local social and economic life. Popham (1980:18) reports that in the Kelmscott area Aboriginal people were working in the colonial economy as domestics, herders, trackers and guides. Pope (1993:57–77) documents how Aboriginal people in the South West, particularly men, were employed as mail carriers between the early 1830s and the early 1850s. Coy (1984:65) makes a similar note in respect of the mail delivery in the Serpentine area in 1846. Aboriginal involvement in the local economy also meant that Aboriginal people lived in or on the fringes of the local community(s).

The history of Aboriginal post-colonial habitation and participation in the local economy is not documented in as much detail for the south metropolitan region, including the survey area(s), as say in the Swan Valley and surrounding areas (Bourke 1987; Carter 1986, see also Biskup 1973). Nevertheless, Nyungars were part

of the wider community south of the Swan River and participated in the local economy. There was also considerable movement of Nyungars between the Perth Metropolitan area and country locations. Their social and economic position, however, was further eroded by the introduction of the *1905 Aborigines Act* (Haebich 1988).

Nyungars were camping, for example, in a number of locations near Armadale in the 1930s and 1940s. Camps were located, for instance, in Forrestdale, Cardup, Bedfordale and so on. From camps such as these, Nyungars were employed seasonally on farms or in local industry or were engaged in marginal economic activities such as stick cutting (for clothes line props and crayfish pots). Popham (1980:120) reports Aborigines exchanging "the scraped-off wood of zamia palms, which were used as pillow filling in exchange for tea and flour" at the turn of the twentieth century. A number of the archaeological sites in the Armadale area show evidence of post-contact habitation (e.g., use of bottles for flaking blades) (Edwards & McDonald 1999). Further research is required to detail Aboriginal habitation in the Serpentine area from the commencement of colonisation to the 1970s. Aboriginal history is also reflected in the continuing use of Nyungar placenames in the region (albeit often modified).

The adversity faced by Nyungars strengthened a sense of common identity and social bonds. New links with the country have been forged based on biographical and historical associations. In the last three decades, there has been a growing movement to reconstruct Nyungar culture. This has been made through efforts at cultural retrieval or revitalisation as well as re-invention. These two strands have been fused, often in the crucible of political and economic interest in response to various governments' policies concerning native title.

Some Nyungars report that they can feel the presence of spirits at sites of significance. Typically, the presence of sites in these circumstances is accompanied by empirical evidence, stories and names of people accompanied with the movement 'run' or site. Blockley and Greenfield point out that archaeological sites are becoming

increasingly important in this regard, often being seen as physical evidence for these movements (Blockley & Greenfield 1995). Notably, this was demonstrated by some of the Aboriginal Consultants involved in heritage surveys of the areas under scrutiny in this particular project. They believe that the artefactual remains that have been previously catalogued are concrete evidence of these historical 'runs' (Blockley & Greenfield 1995).

Ethnographic Survey Results

Results of the Desktop Research

A search of the AHIS revealed that no ethnographic sites are listed within Lot 50. A review of the previous heritage reports and the ethnohistorical literature also indicated that there were no previously recorded heritage values that might reasonably be considered to the (ethnographic) Aboriginal sites on the land.

Results of the Ethnographic Field Survey

No ethnographic sites were reported on the land by the Bilya or WAC in the present survey area.

Two of the Aboriginal consultants from the WAC team (an uncle in his sixties and nephew in his fifties) reported that they lived and attended primary school in Mundijong. They reported that their families and other kin lived in and around the town including in bush camps. Apparently, there was a fairly large Western Australian Government Railway (WAGR) line gang based in the town which, according the Winjan consultants, was almost entirely Nyungar.

Others, including the senior WAC consultant's father, worked on farms in the area. The Nyungar population of the area were reported to use the bush to hunt and forage. However, neither of the senior men recalled any particular use of Lot 50 during their time in Mundijong.

Consultation Regarding the Archaeological Findings

As noted above, the archaeological survey undertaken by TCHM discovered one archaeological site within Lot 50 Mundijong Road. Site MJ-06 comprises a stone artefact scatter eroding out of a deflation in an elevated white sandy lens. The surface expression of the site is approximately 70m (N–S) x 83m (E–W). A sample of fourteen quartz flaked stone artefacts was recorded on the surface within the site.

Both the Bilya consultants and the WAC representatives were of the view that Site MJ-06 was of low cultural significance, particularly when compared to DIA Site ID 3648 located in the southeastern corner of Lot 9000 Bishop Road, adjacent to the two freshwater lakes and Manjedal Brook to the north.[4] This land is also part of Peet's larger Mundijong development plans. However, development will occur at a later date and results of the ethnographic and archaeological surveys pertaining to DIA Site ID 3648 and other archaeological sites will be reported under a separate cover.

The preferred position of both Bilya and the WAC is that, where possible, other archaeological sites be avoided and preserved. In the event that sites cannot be avoided, both groups support Peet lodging a Notice under Section 18 of the AHA for Ministerial consent to use the land on which the site is located. However, both groups differ in their view regarding mitigation (e.g., salvage and storage). Bilya's consistent view is that once any necessary detailed recording has been undertaken, the archaeological material should be left *in situ* and developed over. The WAC, on the other hand, is in favour of material being salvaged and appropriately stored.

[4] Refer to the archaeological section of this report for further information regarding DIA ID 3648 Soldier's Road.

Plate 1: Members of the Bilya survey team (from left): John Abraham, Barbara Abraham, Clarry Walley and Mary Walley

Plate 2: Members of the Winjan survey team (from left): Harry Nannup Jnr, Harry Nannup Snr, Franklin Nannup and Harry Nannup III

Part 2: Archaeological Survey

Archaeological Scope of Work

The objectives of the archaeological survey were to:

1. conduct an archaeological survey and assessment of the proposed Peet Lot 50 Mundijong Road residential subdivision, to locate any Indigenous archaeological sites that may be defined as Aboriginal Sites under Section 5 of the *Aboriginal Heritage Act 1972* (AHA);
2. record any Indigenous archaeological sites located to Section 18 standard;
3. make recommendations regarding the archaeological significance of any sites located; and
4. make recommendations for the management, mitigation or salvage of any sites located within Peet's Mundijong residential development.

Environmental Context

Location

Peet's residential land development is located at Lot 50 Mundijong Road, Mundijong. Lot 50 is located to the west of the Mundijong town site, on the northern side of Mundijong Road and to the east of Adams Road (see Figure 2).

Mundijong is located in the Shire of Serpentine-Jarrahdale, approximately 40km southeast of Perth's Central Business District, 16km south of the Armadale Regional Centre and 25km east of the Rockingham Regional Centre. It is located approximately 25km east of the Indian Ocean coastline and approximately 3.5km from the foot of the Darling Scarp.

This development will comprise 410 residential lots, five public open spaces and a proposed primary school site (see Figure 3).

Physiography

The project area is located at the base of the Darling Scarp on the Swan Coastal Plain physiographic unit, which is a narrow 20–30km wide strip generally low in relief and comprised mainly of Quaternary and Aeolian sediments (Anderson 1984).

SMEC (2009:68) reports that there are three soil complexes within the Mundijong-Whitby Structure Plan study area including Forrestfield, Pinjarra and Bassendean. Within the current project area, the Pinjarra and Bassendean soils are predominant. SMEC (2009:99) describes the Pinjarra soils within the study area as comprising "alluvial materials deposited across the plain extending from north to south adjacent to the Forrestfield group, including through the centre of the Shire to its Western boundary". They also note that in isolated pockets, the alluvial soils are overlain by windblown sand typical of the Bassendean System.

SMEC (2009) identify three types of geomorphic wetland present within the Mundijong/Whitby Structure Plan study area, including:

- Plausiplain – a seasonally waterlogged flat;
- Sumplands – a seasonally inundated basin of variable size and shape; and
- Creeks – a seasonally inundated channel.

A significant proportion of the current project area is comprised of plausiplain wetland (see Figure 4), interspersed by elevated sandy rises or dunes of Bassendean sands.

Flora and Fauna

The project area is situated within the Drummond Sub District vegetation system of the South West Botanical Province (Beard 1990). SMEC (2009:25) describe the general vegetation of the Pinjarra plain as represented by *Corymbia calophylla* (marri) open forest and the Bassandean System by banksia low woodland, generally *Banksia attenuata* (slender banksia), *Banksia menziesii* (firewood banksia), *Banksia ilicifolia*

(holly leaf banksia), *Eucalyptus todtiana* (coastal blackbutt) and *Nuytsia floribuna* (native Christmas tree).

SMEC (2009:16) report that the current project area includes only remnants of the Guildford and Forrestfield vegetation complexes due to previous land clearing. SMEC (2009:31) characterise the vegetation complexes present within the current project area as follows.

- Forrestfield vegetation system: ranges from open forest of *E. calophylla – E. Wandoo – E. Marginata* to open forest of *E. Marginata – E. Calophylla – C. Fraseriana – Banksia sp*. Fringing woodland of *E. rudis* in the gullies that dissect this landform; and
- Guildford vegetation system: comprises a mixture of open forest to tall open forest of *E. calophylla – E. Wandoo – E. marginata* and woodland of E. wandoo (with rare occurrences of *E. lane-poolei*). Minor components include *E. rudis – M. rhaphiophylla*.

SMEC (2009:47) indicated that despite the previous vegetation clearance, local flora studies suggest that to the east (towards the base of the Darling Range) a rich and diverse suite of faunal assemblages still exists. Key fauna identified include the Brushtail Possum, Brush-tailed Phascogale, Chuditch and Western Grey kangaroo.

Hydrology

No significant watercourses are located within the current project area. Two small wetland lakes and Mandejal Brook are located approximately 1.8km to the northeast. Cardup Brook and Gingagup Brook lie approximately 2.8km kilometres further to the northeast and Medulla Brook is approximately 2.3km to the southeast of the project area.

Both SMEC (2009) and GHD (2009:8) highlight that the Mundijong-Whitby area is known to experience regular waterlogging in the low-lying areas of the study area, such as on the plausiplains. This inundation is due to a combination of persistent winter rainfall elevating the shallow water table which rises to the surface and inundates vast areas of the flat terrain, as well as sparse drainage, with insufficient

capacity that does not allow runoff to leave the area. There is also the potential for wetlands within the study area to receive additional flood water from outside their natural catchment by overtopping of drains and watercourses.

Previous Land Use

SMEC (2009) report that approximately 87% of the land within the Mundijong/Whitby Structure Plan study area has been previously cleared of vegetation. Within the project area agriculture has been the primary land use since European colonisation.

In a review of historic aerial photos from 1953 to 2006, SMEC noted that during the 1950s and 1960s, land use within the project area predominantly comprised low density agriculture with some residential development. Past and current agricultural activity has included land clearing, ground excavation of some areas for landfill and rubbish dumps, construction of tracks, fences, farm infrastructure and buildings, running of stock and growing crops. SMEC note the historical presence of dairy and poultry farms and a timber mill. Other noted changes in the use of the landscape included the extension of residential housing along Paterson Street in Mundijong in the 1970s, the appearance of pine plantations in the 1980s and extension of residential developments in the 2000s.

The project area has been previously cleared of vegetation and has been subject to agricultural activities. In addition, some of the sandy rises located in the project area have been excavated and the sand spread across the low lying plausiplain areas.

Archaeological Background

Regional Archaeological Theory and Research

Three regional level studies relating to the archaeology of the Swan Coastal Plain have all presented predictions relating to site location on the Swan Coastal Plain (Hallam 1987; Anderson 1984; Strawbridge 1987). To date, the majority of archaeological consultancy work conducted on the Swan Coastal Plain has not refuted these predictions, though they have been refined. A brief overview of each is presented below.

Swan Area Archaeological Survey (SAAS)

Hallam conducted the earliest systematic regional level investigation on the Swan Coastal Plain in the 1970s. This study, known as the Swan Area Archaeological Survey (SAAS), involved the examination of a 420 sq km transect across the Perth metropolitan area from the coast to the foot of the Darling scarp (Hallam 1987:22).

The aim of the study was to relate population to resources by mapping demographic patterns across different ecological zones and sub-zones for successive phases of Aboriginal occupation of the Swan Coastal Plain and its immediate hinterland (Anderson 1984:1). Hallam combined ethnographic data with archaeological survey and excavated data in order to adopt a social rather than exclusively and mechanistically environmental approach to changing Aboriginal adaptations and life patterns (Strawbridge 1987:11).

During the SAAS, over 400 sites were recorded, with more than half being interpreted as indicative of ephemeral usage of the landscape by small groups. The remainder of sites included large sites comprised of tens of thousands of surface artefacts such as retouched artefacts, cores, debitage and grinding and percussion material, with the latter few types being interpreted as reflecting the presence of

women and family groups. Thus the large sites were seen as representing occupation for long periods of time by large groups of Aboriginal people (Edwards 2008:5).

Due to the lack of dateable archaeological sites within the Swan Coastal Plain, Hallam developed a relative dating scheme for surface artefact scatters based on the presence/absence of temporal markers such as fossiliferous chert. Hallam defined four primary phases of occupation:

- Early (pre-5000 BP) – assemblages containing artefacts made of Eocene fossiliferous chert;
- Middle (5000–1000 BP) – assemblages containing backed artefacts and elements of the 'Australian Small Tool Tradition';
- Late (post-1000 BP) – quartz-rich assemblages with high proportions of waste flakes; and
- Final (post-contact) – artefacts made on European materials such as glass or ceramics.

Analysis of the SAAS data indicated the following spatial and temporal patterns in site distribution (Hallam 1987:20):

- in all phases, virtually no sites within the zone of the most seaward dunes (Quindalup);
- the limestone belt (Spearwood) has relatively few sites, most of those are towards its eastward margin;
- the majority of sites lie to the east, on the coastal sand plain (Bassendean Sands) and on the alluvium of the Pinjarra Plain;
- the foothills appear to be well used, but the small sample of the scarp and uplands showed little use.

In addition, Hallam examined the distribution of sites according to artefact population and noted that densities were initially similar in the sand plain and alluvial zones, with the alluvial zone showing higher density in the Middle Phase. The Late Phase saw an increase in numbers on the sand plain due to an increase in smaller sites, whilst the alluvial zones displayed greater concentration of usage into larger sites. Final Phase figures show Europeans becoming the resource and

Aboriginal usage of the landscape peaking around homesteads and in the fertile alluvial zone (Hallam 1987:20–23).

The conclusions from the SAAS indicated that the Swan Coastal Plain with its lakes and swamps, along with the alluvial zone with similar wetlands and rich alluvial soils, attracted the heaviest use and exploitation over time. However, Hallam argues that at all periods the seaward margin failed to show significant usage, and although detail shifts between phases, the general picture of densities highest near the scarp and lowest towards the sea holds throughout (Hallam 1987:23).

Anderson's Land Use Model

Anderson's (1984) study used additional data from surveys at North Dandalup, South Canning, Perth Airport, Avon headwaters and the Canning River catchment area to build on the results of the SAAS project. Anderson proposed a land-use model that "delineates a flexible but structured usage of the resources of the Swan Coastal Plain, the central and northern jarrah forest, and the western plateau area, and which allows for the movement between areas required by social and ritual activities" (Anderson 1984:37).

Anderson (1984:34) found that the archaeological evidence indicated a greater exploitation, spatially and/or temporally, in the coastal environment than in either the forest or plateau areas. Site density on the Swan Coastal Plain was three to six times greater than forested areas and two to four times that at the Avon headwaters. Sites were mainly located adjacent to water sources across all areas; however whilst sites on the plateau were situated on low-lying and gently sloping ground, sites on the coastal sand plain are commonly located on elevated dunes or sand ridges. The major sites on the Swan Coastal Plain contained grinding stones, a broader range of raw materials and more recognisable tool forms, and large amounts of debitage which indicates more permanent and/or more frequently visited camp sites where artefact manufacture also took place (Anderson 1984:34).

The range of lithic types present on the Swan Coastal Plain is also much broader than in the forest or on the plateau, but relative proportions vary at different sites. Quartz is nearly always dominant, except at a very few sites of the post-contact period where European glass only is found, or where fossiliferous chert (the next most prevalent material) occurs in high concentrations. The variable proportion of the latter is attributed to both distance of sites from the probable source of the chert to the west of the present coastline, and to its unavailability when the sea reached its present level in mid-Holocene times. Dolerite and mylonite both occur to a much lesser extent, the former usually as larger tools like steep-edged scrapers, hammerstones or grinding material, and the latter possibly as a replacement for fossiliferous chert when it became unobtainable. Silcrete is represented only in very minor quantities. Anderson also notes that except for the fossiliferous chert, all lithic materials had to be transported or traded from beyond the Yilgarn block or from other distant areas (Anderson 1984:25).

Anderson (1984:34) interpreted the distribution of site types and sizes in the three environmental zones as reflecting actual resources available to Aboriginal people in those respective environments; the period of the year when they were obtainable; and the more intangible facets of the Aboriginal life way which laid such stress on social and ritual activities. The Swan Coastal Plain had food resources to sustain a relatively large population for most of the year, which would explain the existence of the major sites found on the plain (Anderson 1984:35).

Anderson's model proposed that during summer and autumn, Aboriginal groups gathered on the coastal plain around estuaries, wetlands, swamps and other water sources in order to exploit their resources. Hence, the major sites on the Swan Coastal Plain were generated as a result of annual visits to the area. During winter and spring, groups would disperse into the forest and plateau areas in order to relieve pressure on the water-based resources. The relatively small size of sites within those two areas is seen as reflecting high group mobility necessitated by less predictable

resources and pursuit of game animals. During spring, groups gradually moved back to the coastal areas (Anderson 1984; Edwards 2008).

Perth Metropolitan Region Planning Strategy Analysis

In 1987, Strawbridge undertook the collation and computer analysis of the data generated by Hallam's SAAS project as part of the Perth Metropolitan Region's planning strategy. The analysis identified a number of key environmental factors relating to the location and distribution of archaeological sites on the Swan Coastal Plain. In summary, sites are (after Edwards 2008:10):

- most likely to be situated on sandy, well drained dune ridges;
- most likely to be located within 350m of a potential water source, including (in decreasing frequency) swamps, creeks, rivers, lakes, surface water, springs and soaks;
- unlikely to be located in low-lying, poorly drained or seasonally inundated areas; and
- unlikely to be located more than 350m away from potential water sources.

Strawbridge (1987:16–17) also formulated a set of research questions relating to the themes of site formation processes, site distribution and environmental change, and stone tool technological change, which are frequently used in contemporary archaeological assessments.

Pinjarra Plains Geomorphic Unit

The Pinjarra Plains geomorphic unit has generally been considered in conjunction with the Bassendean Sands and, as Hallam identifies above, is commonly assumed to contain a significant proportion of the Swan Coastal Plain's archaeological sites. Three recent studies in the Pinjarra Plains unit have identified a distinct spatial patterning of the location of sites.

Tempus Archaeology (2006) conducted an archaeological survey for a proposed residential development at Byford in 2005. The project area was located within

Guildford formation sandy clay soils (a unit of the Pinjarra Plain alluvials) which were overlain by a thin veneer of Bassendean Sands. Tempus (2006:1) indicated that the vast majority of the project area would have "formed part of a vast seasonal wetland extending between the Foothills to the east and the Bassendean Dunes to the west" prior to colonisation. Similar to the current project area, the Byford survey area had been cleared of the majority of vegetation and used for agricultural purposes. The Tempus survey examined an area of 367 hectares by a combination of intensive systematic pedestrian survey and purposive pedestrian survey. Eight sites were located, all of which were found within either elevated sand dunes or rises, or on lower-lying sand lenses within the sandy clay formations.

Additional surveys were conducted at Lot 2 Nettleton Road Byford by Tempus Archaeology in 2006 (Edwards 2007). This survey examined 38 hectares of land which consisted of Bassendean sand dunes and think lenses of Bassendean sand overlaying Guildford formation plausiplain and alluvials. The survey employed both systematic pedestrian survey transects and additional purposive transects of all fire breaks, tracks and other areas of relatively high ground surface visibility. In total, six archaeological sites were located in the survey area, all of which comprised open flaked stone artefact scatters and all situated on either deflating Bassendean sand dunes or thin lenses of Bassendean sand overlying the alluvial deposits.

Further to this, a survey conducted by Thomson (2011) at Pinjarra, approximately 40km south of the current project area, provides a specific examination of site distribution within the Pinjarra Plain plausiplains geomorphic system. This survey examined an area of 3.457 sq km (345.7 hectares) which consisted of low-lying wetland subject to seasonal inundation, interspersed with elevated white Bassendean sand rises and remnant dunes. Similar to the current project area, the Pinjarra survey area had been previously used for agricultural purposes. This area was intensively surveyed by systematic pedestrian transects spaced at 20m apart, with additional purposive examination of all elevated sand rises and dunes. The survey not only confirmed the association of artefact scatters and sites with elevated sand rises and

dunes within the Pinjarra Plain plausiplain geomorphic context, but further elucidated that within these sand dunes, surface artefacts were consistently exposed on the tops and eastern slopes of the sand rises and dunes. Very few isolated artefacts were located within the low-lying plausiplain areas.

Considering the consistency in results between these studies and also with Strawbridge's GIS-based predictions that sites are mostly likely to be situated on sandy, well-drained dune ridges and unlikely to be situated within in low-lying, poorly drained or seasonally inundated areas, it is more than plausible to hypothesise that within the Pinjarra Plains geomorphic unit, all elevated Bassendean sand dunes, hills and rises overlaying the alluvial plausiplain will have high potential for containing archaeological material, whilst the low-lying plausiplain areas will conversely have low potential for locating any archaeological material.

Previous Excavations

Bowdler, Strawbridge & Schwede reported in 1991 that thirty five sites had been test-pitted within the Swan Coastal Plain, of which 74% were located on the Bassendean Sands. They note that there is a

> *consistent lack of good stratified sites. This has been verified not only by a considerable amount of mitigation work, but also by recent purposive efforts by post-graduate students (Schwede, Anderson) to locate such sites* (Bowdler et al. 1991:21).

and they conclude from their analysis that

> *Sufficient test-pits... have now been excavated in archaeological sites on Bassendean Sands to warrant the conclusion that any more would be a complete waste of time and money... there are very few stratified archaeological sites in this region... With respect to open sites, only three to five are known with any kind of stratigraphic integrity, and these are not all straightforward cases (*Bowdler et al. 1991:24).

Of the five sites referred to, four were located within the Swan River Alluvial Deposits and the fifth (Walyunga) was located in a unique geomorphic context in "a sand dune part of the Yoganup formation, comprising fossil shoreline sands on the

Ridge Hill Shelf" (Bowdler et al. 1991:24). Bowdler *et al* highlight the impact of the nature of the Bassendean Sands on the integrity of sites, stating that because the Bassendean Sands dune system consisted of a stable core with a superficial mobile layer of continually reworking sands, artefacts which may have been deposited over a long period of time will have become mixed on one level due to continual deflation and reworking. Adding to this, the impacts of European farming practices have further served to disturb any site integrity.

Two sites that have been excavated within the vicinity of Mundijong are DIA Site ID 3648 Soldier's Road Mundijong and DIA ID 3405 Baldivis Road, Baldivis.

DIA Site ID 3648 Soldier's Road Mundijong

This site is located approximately 2.4km to the northeast of the project area. DIA Site ID 3648 is situated within a white Bassendean sand dune adjacent to two freshwater lakes to the north of Mandejal Brook, north Mundijong. The site was investigated by Pearce in 1979 who excavated a stepped 1 x 1m trench and collected surface artefacts from six 5 x 5m sample squares. Pearce recovered 1,781 artefacts from the trench which was excavated to a depth of 75cm. The artefacts were mainly comprised of quartz debris measuring less than 15mm long. Eleven backed tools were found in the lower half of the trench. The density of artefacts was not uniform in the deposit with two peaks at 20cm and 60cm depth. Pearce attributed this to two potential reasons including changes in density of occupation or changes in the rates of erosion and accumulation of sand. Ochre was also located in the trench and one charcoal sample from the 10–20cm spit returned a date of 1620 ±105 bp (SUA 646).

DIA Site ID 3405 Baldivis: Baldivis Road

DIA Site ID 3405 is located approximately 14.6km west-southwest of the current project area. The site was located within a high Bassendean sand dune, which had been partially disturbed. Thomson and Slack (2011) conducted mitigative test pitting of the site as part of a Section 18 consent. Five 1 x 1m test pits were excavated, targeting the periphery of the disturbed area in order to determine how much of the site remained. Three artefacts were recovered from the test pits, of which two were located in near surface contexts. One small proximal quartz flake was found at a depth of approximately 50–60cm. Thomson and Slack concluded that the internal structure of the site was highly disturbed and consequently no dating was

attempted. The results were thus congruent with Bowdler et al.'s (1991) conclusions outlined above.

Local Archaeological Investigations

The Department of Indigenous Affairs' (DIA) Aboriginal Heritage Inquiry System (AHIS) indicates that there have been eight previous archaeological surveys undertaken within approximately 5 m of the current project area:

- Quartermaine (1986) – Dampier to Perth gap pipeline: Carnarvon gas pipeline lateral.
- O'Connor & Quartermaine (1989) – Byford-Collie and Ongerup-Jerramungup sections of the Perth to Adelaide optic fibre route. Involved vehicle transects with pedestrian spot checks at regular intervals and at all watercourses along two corridors approximately 140km and 70km in length by 100m wide. Three new sites were located.
- Quartermaine & Heine (1996) – road works at Mundijong Road.
- Blockley & Greenfeld (1995) – South-East corridor structure plan. Archaeological survey of a 20km long by 100m wide corridor from Ranford Road in Armadale to Mundijong Road, plus 2,263 hectares around Byford and Mundijong town sites. Included vehicle transects along existing roads and tracks and pedestrian inspection of elevated areas, rivers and other prominent features. Located six previously recorded and four new sites, all artefact scatters. All archaeological material, including isolated artefacts, was located on deflated or disturbed sand dunes.
- Blockley et al. (1996) – South-East corridor structure plan, revised report. Re-examined the survey corridor previously surveyed by Blockley & Greenfeld (1995) in further detail. Located seven new sites, all artefact scatters.
- McDonald, Hales & Associates (Prince et al. 1996) – Byford village, Byford. Located nineteen archaeological sites, all artefact scatters. Sites primarily located on elevated sand rises, dunes or exposed areas.
- McDonald, Hales & Associates (Burke et al. 1998) – Byford village, Byford.
- Edwards & McDonald (1999) – Proposed Tonkin Highway extension and Mundijong Road realignment project. Comprised pedestrian transects walked in a zigzag pattern along the length of the corridor, spaced at 10–20m apart, with additional purposive investigation of areas with higher ground surface visibility. Estimated 30% of survey area investigated in total, with poor ground surface visibility (<30%). Sixteen new artefact scatters, seven

> previously recorded sites and 11 isolated artefacts were located. Edwards and McDonald conclude that the locations of sites conform to Anderson's predictions regarding site location and composition; that is, larger more complex stone artefact scatters are located in well-drained and relatively elevated topographic positions, often in close proximity to wetlands or other drainage features. The isolated artefacts were found mainly in disturbed areas.

Whilst not all surveys conducted comprised systematic pedestrian surveys, collectively the results of the surveys all indicate that archaeological sites, in particular artefact scatters, are most likely to be located on or within elevated sand rises, hills or dunes, and within approximately 300m of a water source.

Previously Reported Aboriginal Sites

A search of the DIA's AHIS was undertaken on 6 March 2012 to confirm the number and nature of any previously located Aboriginal Sites within a 5 km radius of the survey area. The search boundary was defined by a box with the following diagonally opposite corner points (GDA94, MGA Zone 50):

1. 397460 mE 6434378 mN
2. 409908 mE 6421013 mN

The search identified that 58 sites, including 29 Registered Aboriginal Sites and 29 Other Heritage Places are located within 5 sq km of the project area (see Appendix 1). No Aboriginal Sites are located within or intersect with the current project area.

Archaeological Site Characterisation

Of the 29 Registered Aboriginal Sites and 29 Other Heritage Places, 57 have archaeological components. Only limited information was available about these sites at the time of preparation of this report (see Table 1 and Table 2). Using this limited data, the following characterisation of archaeological sites within the search area was made.

- The most dominant type of archaeological site, or more precisely archaeological feature, are artefact scatters (n=54, 94.75%), with single occurrences of archaeological deposit (n=1, 1.75%), shell (n=1, 1.75%) and a modified tree (n=1, 1.75%);
- Artefact scatters are predominantly minor in size (less than 7500 sq m);
- Artefact scatter assemblages are typically dominated by quartz (over 90%) with minor (less than 10%) amounts of fossiliferous chert, mylonite, dolerite, crystal quartz, quartzite, silcrete, basalt, granite and glass;
- Previous studies have indicated a pattern of larger sites being closer to water sources, with larger sites being less than 300m from a water source and smaller sites being further than 300m;
- Regional archaeological research and assessments have indicated that artefact scatters on the Swan Coastal Plain are more commonly minor in size, low–medium density, dominated by quartz with some potential for fossiliferous chert, dolerite, granite, silcrete, crystal quartz, quartzite or glass, and comprised predominantly of debitage with very few specialised or 'formal' tool types.

Pinjarra Plains Predictive Model

As outlined above, a predictive model was developed for the current project area based upon previous archaeological studies undertaken on the Swan Coastal Plain and within the Pinjarra Plains geomorphic unit. The model hypothesised that:

- all elevated sand dunes, hills and rises will have high potential for containing archaeological material;
- low-lying plausiplain areas will conversely have low potential for locating any archaeological material.

Non-Indigenous Heritage

SMEC's (2009:136–37) environmental assessment report reviewed the Register of Heritage Places and Municipal Inventory for non-Indigenous historical places. This review indicated that there are no sites listed on the Register of Heritage Places within the study area. Thirteen sites were listed on the Shire of Serpentine-

Jarrahdale's municipal heritage inventory; however, none of these sites are located within the Survey Area.

Table 1: Details of Registered Aboriginal Sites with archaeological components located within 5 km of the project area

DIA Site ID	Site Name	Site type	Dimensions	Site size (sq m)	distance to water (m)	Topographic unit	Physiographic unit	Site integrity	Artefact density (per sq m)	Assemblage character
396	South-East Corridor 07 / Cardup Siding	Artefact scatter	240 x 65m	15600	180	Low sand dune ridge	Bassendean sands overlying Guildford formation	-	-	-
448	South-East Corridor 01	Artefact scatter	100 x 60m	600	700	Eroded dune ridge	Bassendean sands	-	13	Artefacts = flake (n= 7), flake fragment (n=3), core fragment (n=1), transverse broken flake (n=1), backed blade (n=1) Lithologies = quartz (n=8), fine grained sedimentary material (n=5) also noted at site metamorphic, silcrete, glass
449	South-East Corridor 02	Artefact scatter	15 x 5m	75	430	Low sand dune	Bassendean sands	Disturbed	7	Artefacts = flake (n=3), core fragment (n=3), transverse broken flake (n=1) Lithologies = quartz (n=7)
450	South-East Corridor 03	Artefact scatter	100 x 150m	20670	420	White sand dune	Bassendean Sands	Partially disturbed	20-85	Artefacts = flake (n=4), core fragment (n=1), Transverse broken flake (n=6), longitudinal broken flake (n=5), cores (n=2), grinding implement (n=1) Lithologies = quartz (n=13), fine grained sedimentary material (n=4), Quartzite (n=1), medium grained sedimentary material (n=1)
3648	Soldiers Road, Mundijong	Artefact scatter Archaeological deposit	50 x 30m	1500	0	White sand dune	Bassendean Sands	Partially disturbed	20.8	Artefacts = wide variety of cores, scrapers, bipolar flakes, bipolar cores, flakes and debris Lithologies = quartz, metamorphic, fossiliferous chert, mylonite

DIA Site ID	Site Name	Site type	Dimensions	Site size (sq m)	distance to water (m)	Topographic unit	Physiographic unit	Site integrity	Artefact density (per sq m)	Assemblage character
16089	Byford 01	Artefact scatter	2 x 5m	10	450	Sandy exposure	Bassendean sands	Partially disturbed	0.8	Artefacts = 8 artefacts Lithologies = quartz (n=5), glass (n=3)
16090	Byford 02	Artefact scatter	3 x 5m	15	570	Sandy exposure	Bassendean sands	Partially disturbed	0.27	Artefacts = 4 artefact Lithologies = quartz (n=4)
16091	Byford 03	Artefact scatter	2 x 2.5m	5	500	Sandy exposure	Bassendean sands	Partially disturbed	1.4	Artefacts = 15 artefacts Lithologies = quartz (n=15)
16092	Byford 04	Artefact scatter	1 x 2m	2	450	Sandy exposure	Bassendean sands	Partially disturbed	2	Artefacts = 4 artefacts Lithologies = quartz (n=2), glass (n=2)
16093	Byford 05	Artefact scatter	3 x 5m	15	460	Sand dune deflation	Bassendean sands	Partially disturbed	1.8	Artefact = 27 artefacts Lithologies = chert (n=1), quartz (n=26)
16094	Byford 06	Artefact scatter	-	-	590	Sandy exposure	Bassendean sands	Disturbed	-	Artefacts = hammer stone (n=1), flaked pieces (n=6) Lithologies = granite (n=1), quartz (n=6)
16095	Byford 07	Artefact scatter	2 x 2.5m	5	550	Sandy exposure	Bassendean sands	Disturbed	2	Artefacts = 10 artefacts Lithologies = quartz (n=9), silcrete (n=1)
16096	Byford 08	Artefact scatter	200 x 50m	10000	300	Sandy exposure	Bassendean sands	-	0.4	Artefacts = 66 artefacts Lithologies = quartz (n=62), riverine quartz (n=1), chert (n=1), dolerite (n=1), basalt (n=1)

DIA Site ID	Site Name	Site type	Dimensions	Site size (sq m)	distance to water (m)	Topographic unit	Physiographic unit	Site integrity	Artefact density (per sq m)	Assemblage character
16097	Byford 09	Artefact scatter Shell	-	-	690	Sandy exposure	-	-	-	1 piece of abalone shell and 8 quartz artefacts
16098	Byford 10	Artefact scatter/ reduction area	1 x 2m	2	500	Gravel exposure	-	-	5	10 dolerite flaked pieces. Non-conjoins
16099	Byford 11	Artefact scatter	1 x 2m	2	640	Gravel exposure	-	-	1.5	3 quartz artefacts
16100	Byford 12	Artefact scatter	4 x 10m	40	250	Sandy exposure	Bassendean sands	-	0.075	**Duplicate of DIA Site ID 22056 3 quartz artefacts
16101	Byford 13	Artefact scatter	-	-	100	Sandy firebreak	Bassendean sands	Partially disturbed	-	**Duplicate of DIA Site ID 22057 13 quartz artefacts
16102	Byford 14	Artefact scatter	-	-	15	-	-	-	9	Artefacts = flakes pieces (n=8), hammer stone (n=1) Lithologies = quartz (n=1), riverine quart pebble (n=1)
16103	Byford 15	Artefact scatter	-	-	-	Escarpment above tributary	-	-	-	13 artefact recorded

DIA Site ID	Site Name	Site type	Dimensions	Site size (sq m)	distance to water (m)	Topographic unit	Physiographic unit	Site integrity	Artefact density (per sq m)	Assemblage character
16104	Byford 16	Artefact scatter	-	-	-	Sandy exposure	Bassendean sands	Disturbed	-	Artefacts = hammerstone (n=1), undescribed (n=1) Lithologies = riverine quartz pebble (n=1), quartz (n=11)
16105	Byford 17	Artefact scatter	-	-	-	White sandy deposit	Bassendean sands	-	-	19 quartz artefacts
16106	Byford 18	Artefact scatter	-	-	-	Sandy patch	Bassendean sands	-	-	17 artefacts recorded
16107	Byford 19	Artefact scatter	1 x 2m	2	-	Sandy surface	Bassendean sands	-	5	Artefacts = quartz (n=8), mylonite (n=1), crystal quartz (n=1) No indication of artefact types or size
18187	Tonkin Highway – Mundijong Road Scatter #11	Artefact scatter	-	-	270	Low sandy rise	Bassendean sands overlying Guildford formation	Disturbed	0.02	Artefacts = Debitage (n=16) Artefact size = maximum dimensions rang 6.4 – 23.3mm, mean = 14.6mm Lithologies = all artefacts made from quartz
18188	Tonkin Highway – Mundijong Road Scatter #12	Artefact scatter	50 x 40m	200	100	North face of low sand dune ridge	Bassendean sands overlying Guildford formation	Partially disturbed	0.12	Artefacts = debitage (n=23), core fragment (n=1) Size = mean maximum dimension 16.8mm Lithologies = quartz (n=23), mylonite (n=1)
18191	Tonkin Highway – Mundijong Road Scatter #15	Artefact scatter	-	-	40	-	Unidentified loamy sediment unit	Partially disturbed	0.2	Artefacts = total of 8 Lithologies = chert (n=3), quartz (n=3), chalcedony (n=1), silcrete (n=1)

DIA Site ID	Site Name	Site type	Dimensions	Site size (sq m)	distance to water (m)	Topographic unit	Physiographic unit	Site integrity	Artefact density (per sq m)	Assemblage character
23917	Byford archaeological survey 004	Artefact scatter	20 x 15m	300	110	Low sandy rise	Bassendean sands overlying Guildford formation	Disturbed	0.9	Artefacts = debris (n=23), flake fragments (n=12), complete flakes (n=5), broken flakes (n=3), bipolar flake (n=1), bipolar core (n=1), manuport (n=1) Lithologies = quartz (n=43), rose quartz (n=1), greenstone (n=1), igneous (n=1)

Table 2: Details of Other Heritage Places with archaeological components located within 5 km of the project area

DIA Site ID	Site Name	Register status	Site type	Dimen-sions	Site size (sq m)	distance to water (m)	Topographic unit	Physiographic unit	Site integrity	Artefact density (per sq m)	Assemblage character
3310	Cardup	Stored	Artefact scatter	-	-	-	-	-	-	-	-
3313	Mundijong	Insufficient information	Artefact scatter	-	-	-	-	-	-	-	-
3590	Whitby	Insufficient information	Artefact scatter	30 x 10m	300	100	Sandy-clay exposure on road verge	-	Disturbed	-	Numerous stone flakes mainly quartz
3591	Yarrabah	Insufficient information	Artefact scatter	40 x 40m	1600	850	Sandy-clay exposure on road verge	-	Disturbed	-	Numerous stone pieces including quartz flakes and retouched scrapers as well as quartz and mylonite backed tools.
17923	If #2	Stored	Isolated artefacts	-	-	-	-	-	-	-	-
18189	Tonkin Highway – Mundijong Road Scatter #13	Stored	Artefact scatter	30 x 20m	600	410	Low sandy rise	Bassendean Sands	-	0.23	No detailed artefact information given

DIA Site ID	Site Name	Register status	Site type	Dimen-sions	Site size (sq m)	distance to water (m)	Topographic unit	Physiographic unit	Site integrity	Artefact density (per sq m)	Assemblage character
18190	Tonkin Highway – Mundijong Road Scatter #14	Stored	Artefact scatter	Not given	2	1100	Not given	Not given	Disturbed	1.0	Four artefacts recorded, not likely in original context
18192	Tonkin Highway – Mundijong Road Scatter #16	Stored	Artefact scatter	100 x 2m	200	170	Not given	Bassendean sands	Disturbed	0.03	No details
21305	Byford village isolated finds	Stored	Isolated artefacts	-	-	-	-	-	-	-	-

DIA Site ID	Site Name	Register status	Site type	Dimen-sions	Site size (sq m)	distance to water (m)	Topographic unit	Physiographic unit	Site integrity	Artefact density (per sq m)	Assemblage character
23914	Byford archaeological survey 001	Stored	Artefact scatter Modified tree	33 x 19m	625	80	Low sandy rise	Bassendean sands overlying Guildford formation	Partially disturbed	0.25-1.25, average = 0.05	Artefacts = debris (n=17), complete flakes (n=6), flake fragments (n=6), broken flakes (n=3), possible manuports (n=2) Small in size, ranging between 6.4mm – 29mm (mean = 13.1m) All artefacts made from quartz Artefacts clustered around erosion areas Modified tree = Marri (?) tree with two scars, had been felled.

DIA Site ID	Site Name	Register status	Site type	Dimen-sions	Site size (sq m)	distance to water (m)	Topographic unit	Physiographic unit	Site integrity	Artefact density (per sq m)	Assemblage character
23915	Byford archaeological survey 002	Stored	Artefact scatter	6 x 12m	12	20	Sandy exposure/lens	?Pinjarra Plain colluviums	Partially disturbed by stock movement	0.5	Artefacts = Debris (n=3), complete flakes (n=2), bipolar broken flake (n=1) Artefact size = maximum dimension range 5.2-21.3mm, mean size is 11.6mm All artefacts manufactured from quartz
23916	Byford archaeological survey 003	Stored	Artefact scatter	20 x 12m	240	115	Low sandy rise	Bassendean sands overlying Guildford formation	Disturbed	0.1	Artefacts = debris (n=7), complete flakes (n=3), flake fragments (n=2), bipolar flakes (n=1), SPC (n=1) Size = maximum dimension range 7.6-41.3mm, mean = 16.9mm Lithology = all artefact manufactured from quartz

DIA Site ID	Site Name	Register status	Site type	Dimen-sions	Site size (sq m)	distance to water (m)	Topographic unit	Physiographic unit	Site integrity	Artefact density (per sq m)	Assemblage character
23918	Byford archaeological survey 005	Stored	Artefact scatter	36 x 12m	436	90	Low sandy rise	Bassendean sands overlying Guildford formation	Partially disturbed	0.05	Artefacts = debris (n=10), flake fragments (n=6), bipolar flakes (n=4), bipolar core (n=1), manuport (n=1) Artefact size = maximum dimension range 5 – 25.5mm, mean = 14.6mm Lithologies = all artefacts manufactured from quartz
23919	Byford archaeological survey 006	Insufficient information	Artefact scatter	80 x 3m	240	140	Low sandy rise	Bassendean sands overlying Guildford formation	Partially disturbed	0.125	30 quartz flaked stone artefacts
23920	BAS / Iso - 001	Stored	Isolated artefacts	-	-	-	-	-	-	-	-

DIA Site ID	Site Name	Register status	Site type	Dimen-sions	Site size (sq m)	distance to water (m)	Topographic unit	Physiographic unit	Site integrity	Artefact density (per sq m)	Assemblage character
23921	BAS / Iso – 002	Stored	Isolated artefacts	-	-	-	-	-	-	-	-
23922	BAS / Iso - 003	Stored	Isolated artefacts	-	-	-	-	-	-	-	-
23923	BAS / Iso - 004	Stored	Isolated artefacts	-	-	-	-	-	-	-	-
23924	BAS / Iso - 005	Stored	Isolated artefacts	-	-	-	-	-	-	-	-
23925	BAS / Iso - 006	Stored	Isolated artefacts	-	-	-	-	-	-	-	-

DIA Site ID	Site Name	Register status	Site type	Dimen-sions	Site size (sq m)	distanc e to water (m)	Topographic unit	Physiographic unit	Site integrity	Artefact density (per sq m)	Assemblage character
24979	Nettleton Road 19-09-07/001	Stored	Artefact scatter	3 x 1.5m	4.5	10	Gravel and sand exposure	Bassendean sands overlying Guildford formation	-	0.88	Artefacts = flake fragments (n=2), complete flakes (n=1), debris (n=1) Lithologies = greenstone (n=2), quartz (n=2)
24980	Nettleton Road 19-09-07/002	Stored	Artefact scatter	4 x 1m	4	123	Sandy firebreak	-	Partial disturbance	0.75	Artefacts = flakes (n=1), flake fragments (n=1), debris (n=1) Lithologies = quartz (n=3)
24981	Nettleton Road 19-09-07/003	Stored	Artefact scatter	18 x 9m	162	150	Deflated dunes	Bassendean sands overlying Guildford formation	Partial disturbance	0.07	Artefacts = flakes (n=1), broken bipolar flakes (n=1), flake fragment (n=1), debris (n=1) Lithologies = quartz (n=4)
24982	Nettleton Road Isolated Finds	Stored	Isolated artefacts	-	-	-	-	-	-	-	-

DIA Site ID	Site Name	Register status	Site type	Dimen-sions	Site size (sq m)	distanc e to water (m)	Topographic unit	Physiographic unit	Site integrity	Artefact density (per sq m)	Assemblage character
24983	Nettleton Road 1-06	Stored	Artefact scatter	35 x 5m	175	147	Deflation area within dunes	Bassendean sands overlying Guildford formation	-	0.03	Artefacts = flakes (n=4), manuport (n=1) Lithologies = quartz (n=4), igneous (n=1)
24984	Nettleton Road 2-06	Stored	Artefact scatter	30 x 9m	270	342	Sandy exposure	Bassendean sands	Disturbed	0.06	17 flaked quartz stone artefacts
24985	Nettleton Road 3-06	Stored	Artefact scatter	13 x 10m	130	490	Sandy exposure	Bassendean sands	Disturbed	0.06	8 quartz flaked stone artefacts

Archaeological Methodology

Research Design

The following research questions are posed in order to guide field investigations and assessment of archaeological significance. The questions are intended to assist in articulating the archaeological signature of the area including the spatial distribution of sites, site types and activities undertaken within the sites and the local region, as well as the effects of taphonomic and other disturbances on the archaeological record and resource use. The research questions will also assist in the assessment of archaeological significance. The following questions were developed based on the review of the regional archaeological context, Thomson (2011) and Strawbridge (1987).

Site Location

- Is the hypothesis that sites are located on elevated Bassendean white sand dunes or rises and/or adjacent to water sources supportable?
- Is Thomson's (2011) finding that artefacts within sites located on sandy rises and dunes are predominantly located on the top and eastern slopes supportable?
- Is there an association between dune aspect or erosion surface orientation and artefact types/densities?
- Is there an association between dune altitude and artefact types and/or densities?
- How does the density of sites within the survey area compare with the regional context?
- What does the apparent site distribution indicate? To what degree is it skewed by concentrated urban development? (after Strawbridge 1987).

Site Content and Function

- What is the variability between sites in terms of artefact type, lithology and size?
- What activities can be identified at the site? What was the site function(s)? Are there any identifiable links with local ethnographic places or sites?

- Is the level of reduction of fossiliferous chert greater away from the coast (the predicted source location)?
- Does the amount of fossiliferous chert within an assemblage decrease or increase with proximity to the coast (i.e. the proposed source), or proximity to other water sources?
- What is the level and character of variability between sites classified according to Hallam's four phases?

Taphonomic Issues

- What are the effects of ploughing and agricultural-related ground disturbance on the subsurface deposit?
- What is the relationship between the yellow and white sands and is there any association between either sand type or the presence of artefacts?
- Is the size and type of artefacts found within subsurface deposits a function of taphonomic processes or site function?
- How does the surface distribution and composition of artefacts compare to the artefact distribution and composition of the subsurface deposit?
- Does the surface artefact distribution and composition relate to erosion and visibility or is it different?
- Is there any size selection/grading of artefacts within the subsurface deposit?

Subsurface Deposits

- What lithologies are located in the subsurface deposit?
- Can we identify any relic dune systems between sites? Can these systems be identified in multiple sites? Is it possible to date sites or occupation episodes relative to other sites?
- Are all sites contemporary and were they being used during the same time periods? What can be said about population density over time?
- Does the site contain stratified subsurface cultural material in an undisturbed context? Is the deposit dateable? If so:
    - Are Hallam's four phases of occupation supportable?
    - What changes are there over time in the density of artefacts? How far can this be taken as an indication of population changes or technological innovations?

- Are there any detectable technological changes in the assemblage that correspond with the decline in supply of fossiliferous chert (after Strawbridge 1987)?

❖ Can sites within Hallam's four phases of occupation be further characterised in terms of artefact types, density, lithology, location and evident technologies?

❖ What stone tool technologies (i.e. reduction sequences) were being employed during the early phase on the Swan Coastal Plain?

❖ If the supply of fossiliferous chert found on sites was lost when the sea level rose, can we detect technological changes in assemblages as a result of the decline of this stone resource (after Strawbridge 1987)?

Archaeological Survey Methods

Based on the scope of work, results of the desktop review and other previous archaeological surveys within the local region, and taking into consideration the limited timeline and budget allocated to complete the archaeological assessment, the archaeological assessment employed a purposive sample, pedestrian survey methodology.

A proposed sampling methodology was provided to the DIA's Heritage and Culture Branch for comment in early March 2012. A meeting was held with DIA staff Dr Kathryn Przywolnik (Registrar of Aboriginal Sites), Ms Christine Lewis (Manager Heritage South) and Mr Aidan Ash (Senior Heritage Advisor) on 7 March 2012 to discuss the methodology. A subsequent email from Ms Lewis following the meeting (12 March 2012) indicated that DIA regarded the proposed methodology to be "a reasonable approach to the proposed heritage work and the research questions it raises are considered relevant for section 18 purposes".

Identifying Survey Sample Areas

Results of previous surveys undertaken within the Pinjarra Plains geomorphic unit all indicated a strong spatial site distribution pattern, with all archaeological sites being associated with and located upon lenses or dunes of white Bassendean sands which overlay Pinjarra alluvial soils and plausiplains. This predictive model was

used to inform the selection of areas for pedestrian survey. Sample areas thus comprised:

- all areas of high archaeological potential including all elevated sand rises, hills and dunes located within the project area; and
- two control sample areas within areas of low archaeological potential; that is, within the low-lying plausiplain areas.

Aerial photography, topographic, environment and soil maps were examined in order to identify areas of high and low archaeological potential. In addition, some of the survey areas were designed so that the transition area between the sand rises and the alluvial soils were also examined. Table 3 below identifies the location of the selected sample survey areas.

In total, 0.2203 sq km (33.9%) of the project area was examined by intensive pedestrian survey. Of this, 0.1673 sq km (25.7%) comprised areas of high archaeological potential and 0.053 sq km (8%) comprised areas of low archaeological potential. See Figure 2.

Survey Methods

The archaeological survey of the sample areas of high and low archaeological potential involved intensive pedestrian survey, with approximately parallel transects spaced between 5–10 m apart and oriented north–south.

Table 3: Archaeological survey areas, Lot 50 Mundijong Road, Mundijong

Survey Area	Archaeological Potential	Area (sq km)	Node	Easting (mE)	Northing (mN)
1	Low	0.023	1	403328	6426244
			2	403328	6426403
			3	403471	6426244
			4	403471	6426403
2	Low	0.03	1	403313	6426550
			2	403313	6456765
			3	403456	6456765
			4	403456	6426550
3	High	0.0438	1	402962	6426398
			2	402962	6426598
			3	403181	6426598
			4	403181	6426398
4	High	0.077	1	402930	6426686
			2	402930	6426967
			3	403205	6426967
			4	403205	6426686
5	High	0.0465	1	403464	6426495
			2	403698	6426495
			3	403699	6426193
			4	403595	6426217
			5	403594	6426362
			6	403469	6426379
			7	403464	6426402

Survey Area	Archaeological Potential	Area (sq km)	Node	Easting (mE)	Northing (mN)
6	High	0.018	1	403397	6426838
			2	403610	6426837
			3	403611	6426762
			4	403455	6426761
			5	403456	6426765
			6	403336	6426766

Archaeological Site Identification and Recording Methods

The scope of work requires that all sites located during the survey will be recorded to Section 18 level, which comprises sufficient detail about each site to aid the DIA and ACMC in the decision-making process under Sections 5 and 39 of the *Aboriginal Heritage Act 1972*. Specific recording methods and variables are determined by several factors including comparability and the relevance and appropriateness of site and artefact variables recorded to answer or contribute to the research questions identified above.

Site Type

From previous research undertaken within the Swan Coastal Plain, the following archaeological site types or features may be expected:

- Artefacts/scatter
- Historic
- Skeletal remains/burial
- Modified tree
- Archaeological deposit

See Appendix 2 for full definitions of site types.

In Western Australia, distinctions are often drawn between artefact scatter 'sites' (i.e. dense, localised concentrations of archaeological material) and 'isolated artefacts' or 'background scatter' (random, sparse distributions of artefacts present within a landscape). Within the Swan Coastal Plain, the commonly accepted definition of a 'site' is where two or more different artefacts, or different classes of artefacts, are present within a radius of 5m of each other. Isolated artefacts are defined as being spatially discrete and are unlikely to reflect any purposeful activity (Edwards 2008:13).

Site Scale

The following definitions were used during the assessment to classify sites.

Site size

- Small: sites that measure less than 7,500 sq m
- Medium: sites that measure between 7,500 sq m and 50,000 sq m
- Large: sites that measure >50,000 sq m

Artefact density

- Low: <0.1/m^2
- Medium: 0.1 – 1/m^2
- High: >1/m^2

Raw material diversity

- Low: >90% of one raw material
- Medium: two raw material types >10% each
- High: three or more raw material types >10% each

Site Recording

Section 18 level recording entails sufficiently detailed information about each site to enable an accurate assessment of its archaeological significance. Specifically, the following information will be recorded in line with the standards outlined in the

DIA's *Draft Guidelines for Aboriginal Heritage Assessment in Western Australia* and *Draft Spatial Standards,* and the proposed research questions identified above:

- location and boundary of the site, including multiple GPS coordinates to define a polygon representative of the site's boundary;
- site type;
- environmental context;
- site description including nature of site, major cultural features, site dimensions, orientation and size;
- a sample of the artefact assemblage including artefact density, lithology, types and metrics;
- an estimate of the total number of artefacts within the site;
- assessment of the site's potential for stratified subsurface deposit;
- site condition and integrity including the nature and origin of any disturbance to the site;
- site plan and profile; and
- photographs of the site and its context.

Site boundaries of artefact scatters are defined by the placement of a systematic grid of 1m by 1m sample squares spaced at 2m intervals across the site. The site's boundary is thus determined where no artefacts occur in two or more consecutive sample squares along any given axis. The potential for subsurface deposit is assessed based on the topographic and geomorphologic contexts and the physical integrity of the site.

Artefact Identification and Recording Methods

Identification

The primary types of artefacts that may be expected to be located during the survey include:

- flaked stone artefacts;
- ground stone artefacts;
- manuports;

- shell material.

An overview of artefact identification and methods for recording the main types of artefacts is included in Appendix 3.

Analysis

Based on the research questions identified above, the following artefact analysis methods will be employed:

- Total estimated artefact count is calculated using the minimum number of flakes (MNF) formula: MNF = C+T+L , per raw material.
- The assemblage character of each site is generated by quantifying the ordinal value of artefact types, lithology and size (including length, width and weight).
- Site size comparison is undertaken using MapInfo data gained from the DIA and available unpublished survey reports. Site size is classified according to the categories outlined above.
- Density is calculated using the following formula Density = MNF/Area (where area = total recorded ground surface in sq m). Average density of artefact scatters can then be compared to other sites on the Pinjarra Plain and within the local region.
- Distance to water is calculated from the centre of the recorded site to the closest potable water source (namely swamp and lake areas). This analysis is undertaken using MapInfo and datasets obtained from DIA and the Australian Government Office of Spatial Information. Topographic data was only available at the scale of 1:250,000 at the time of analysis.
- The level of retouch within assemblages at each site is generated by quantifying the ordinal value of the number of retouched artefacts and level of invasiveness of the retouch, calculated by measuring the area of the negative flake scars identified as retouch in relation to the overall flake.

Archaeological Significance Assessment

Archaeological Significance in the Australian Context

Heritage significance is the degree to which a place, object or activity possesses a certain valued attribute. Current definitions of significance acknowledge that value is not inherent in objects or places but rather people attribute value to these entities (Thomson 2012:10). Further, cultural heritage will often have multiple values which can be contested (Truscott 1992; Tunbridge & Ashworth 1996; Greer & Henry 1996; Harrington 2004).

In Australian cultural heritage management practice, the Burra Charter (Australia ICOMOS 1999) model is commonly adopted for significance assessments of heritage places. This model divides significance into four types: aesthetic, historical, scientific and social. Although none of these categories are mutually exclusive, the scope of this report requires primarily the assessment of the scientific significance of any archaeological sites located. The Burra Charter states that "the scientific or research value of a place will depend upon the importance of the data involved, on its rarity, quality or representativeness, and on the degree to which the place may contribute further substantive information" (Byrne et al. 2003).

In Western Australia, the ACMC determines whether a place is an Aboriginal Site according to Section 5 of the AHA. Under Section 5, places must be shown to have an importance or significance distinct from their surroundings. Further, the ACMC is directed by Section 39(2) to have regard to the following in evaluating the importance of places and objects:

(a) any existing use or significance attributed under relevant Aboriginal custom;

(b) any former or reputed use or significance which may be attributed upon the basis of tradition, historical association, or Aboriginal sentiment;

(c) any potential anthropological, archaeological or ethnographical interest; and

(d) aesthetic values.

Section 39(3) also states that "Associated sacred beliefs, and ritual or ceremonial usage, in so far as such matters can be ascertained, shall be regarded as the primary considerations to be taken into account in the evaluation of any place or object for the purposes of the Act".

When providing recommendations with regards to the archaeological significance of a place, the DIA requires the following attributes to be considered and articulated in archaeological reports:

- Research potential – the potential of an Aboriginal site to contribute to timely and specific research questions. This depends on a number of factors including its state of preservation and the range of past human activities reflected at that site.
- Representativeness – the extent to which the archaeology of a particular Aboriginal site is represented at other localities within the region. Unusual or unique sites are normally accorded a higher archaeological significance than sites that are very common.[5]

These requirements are based on Bowdler's framework for significance assessment which recommends that "...the significance of archaeological resources should be assessed according to 'timely and specific research questions' on the one hand, and representativeness on the other. The latter takes care of the argument that we cannot predict next year's or next century's research capabilities and interests, but itself requires research"(Bowdler 1981:129). Bowdler further highlights that archaeological significance "is a mutable, even transformational, quality, which changes as the subject changes" (Bowdler 1984:7).

Bickford and Bowdler (in Bowdler 1984:1–2; Bickford & Sullivan 1984:23–24; Sullivan 1983) developed the following set of questions to aid with the assessment of research potential:

1. Can this site contribute knowledge which no other site can?

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[5] See http://www.dia.wa.gov.au/en/Section-18-Applications/Heritage-management/Aboriginal-heritage-surveys/Guidelines-for-preparing-Aboriginal-heritage-survey-reports/#13

2. Can this site contribute knowledge which no other resource, such as documents or oral history or previous research can?
3. Is this knowledge relevant to specific or general questions about human history or behaviour or some other substantive topic?

It should be noted, however, that the two concepts of research value and representativeness are not unproblematic (see Thomson 2012). The use of research questions or agendas has been criticised, amongst other things, for their inherent biases and failure to predict or cater for unanticipated or future research questions (Bruier & Mathers 1997; Smith 2004; Dixon 1977; Dunnell 1984; Raab & Klinger 1979). The concept of representativeness was conceived as a solution to these problems; however, as Smith (1994:27–28; 2004:119–20) has demonstrated, every site is unique in some respect and every site in a group of sites will be different. Hence, defining representativeness actually depends on the research questions asked and the criteria used to assess the resource.

Smith's (1991) research on defining a site type profile for artefact scatters determined that any move towards a representative sample must include sites from different time periods, different environmental units, different cultural and land management units and that the sample should also include different sized sites (based on artefact numbers and densities), sites containing different percentages of raw materials and artefact types, and that such variations should be considered for each time period, environmental, cultural and land management unit (Smith 1994:28). Smith highlights the practical issue of how viable, in a logistical sense, are representative samples and questions whether any of these attributes have any meaning in the context of archaeological theory and research (Smith 1994:28; Thomson 2012:12–13). Smith (1994:28–29) also emphasises Bowdler's point that the archaeological 'resource' and archaeological values are highly dynamic and change over time.

Further, it should also be noted that there are significant issues with the data available to inform assessments of representativeness. As McDonald, Hales and Associates (2001:34–35) note, the process of assessing representativeness is

predicated on the availability of high quality and up-to-date information. The main source of data is the DIA's AHIS which has several issues including very broadly defined site types which do not facilitate identification of sub-classes of sites (for example, different types of artefact scatters or shell scatters). Secondly, data on sites that have been destroyed in a region either through official sanction or illegally is not available. This lack of information can dramatically skew determinations of representativeness in a region. Thirdly, as some Aboriginal people, landowners and consultants choose not to submit consultancy reports to the DIA for a variety of reasons, the AHIS does not contain a complete record of surveys and site information in some regions. There is also significant variability in the quality and detail of information submitted to DIA as a result of the varying skills and experience of the site assessor; variation in technical, methodological or definitional differences between consultants; and differences in the timing, location and intensity of archaeological research (MHA 2001:34–35; see also Mathers et al. 2005). This variability can result in the incomparability of data and lead to a limited number of factors (such as site type) that can be compared in the assessment of representativeness (Thomson 2012:28).

Archaeological Significance Assessment Methodology

Any sites located during this inspection will be assessed for archaeological significance in terms of research potential in reference to the research questions outlined above and in reference to Bickford and Bowdler's questions also outlined above. In addition, research potential is also considered in light of a site's integrity, internal complexity, ability to be placed into a temporal context, and its potential for technological, spatial and microscopic analysis (such as residue and use wear analysis) and its connectedness to other sites within the local and regional context.

As consideration of representativeness is currently required by DIA, a very limited examination of a site's representativeness will be undertaken. However, it is employed and acknowledged as a flawed concept and will not be given precedence

in the assessment process. Available site variables used to compare sites for the purpose of representativeness include site type, site size, site location, artefact density, artefact assemblage composition and artefact assemblage raw material diversity.

It is re-emphasised here that evaluating archaeological significance is always contextual and will depend on and be determined by what the contemporary research agenda at the time is; what the current regional profile of representativeness of a particular site type is; and what scale the assessment is being made at. As Bowdler (1984) identified, archaeological significance is a 'mutable' and changeable quality and therefore the significance attributed to a site today may be subject to change in the future.

Degrees of Archaeological Significance

Within Western Australian archaeological grey literature[6], it is common to rank significance using designations such as low, medium and high, or similar. Although there is some conjecture about assigning levels of significance to heritage places or objects, it is currently deemed a useful tool to assist the ACMC in determining the value of a site in relation to other sites.

The following guiding principles will be used in this assessment to determine the degree of archaeological significance of a site (see Table 4). It should be noted, however, that these are not definitive and any level of significance will be explained within the significance assessment of each individual site. It should also be noted that a site possessing low archaeological significance does not imply non-significance.

[6] Unpublished archaeological reports and data including consultancy reports, theses etc.

Table 4: Definition of degrees of archaeological significance

Degree of archaeological significance	Principles
Low	• no or limited ability to provide information not available from other sources or sites • no or limited ability to contribute to or answer any pertinent research questions • common site represented at other localities within region • low total artefact assemblage • low artefact diversity and/or density • relatively disturbed
Medium	• some ability to provide information not available from other sources or sites • some ability to contribute to or answer any pertinent research questions • medium artefact diversity and/or density • moderate to good preservation • depth of archaeological deposit
High	• good ability to provide information not available from other sources or sites • good ability to contribute to or answer any pertinent research questions • rare site type • sites with features not commonly found together • good depth of archaeological deposit • relatively undisturbed • potential for high scale of significance – i.e. state or national importance

Archaeological Assessment Results

Archaeological Survey

The archaeological survey was undertaken by Ms Jo-Anne Thomson and Ms Christine Martin of TCHM on 3 and 4 April 2012.

The six sample survey areas totalled 0.2203 sq km (22.03 hectares, 33.9% of the total project area), of which 0.1673 sq km (16.73 hectares, 25.7% of project area) comprised areas of high archaeological potential and 0.053 sq km (5.3 hectares, 8%of project area) comprised areas of low archaeological potential. The survey areas were bounded by the MGA coordinates listed in Table 3 above (see also Figure 2). Pedestrian transects were spaced 5–10 m apart and walked on a north–south orientation across each of the six survey areas.

The majority of the project area consisted of flat, low-lying plausiplain alluvial soils, which become seasonally inundated, interspersed with occasional white Bassendean sand dunes or rises, overlaying the plausiplain. In some parts of the project area the sand rises have been excavated and sands deposited across the plausiplain.

The project area currently comprises farming paddocks and has been previously cleared and used for agricultural purposes. Several fences and vehicle tracks dissect the project area and a demolished cattle yard and sheds were located along the eastern boundary of the property. Cattle were present in some of the paddocks at the time of the survey and several animal burrows were also noted in the northeast of the project area.

Remnant vegetation, comprising *Eucalyptus sp.* trees, exists along the northern and eastern boundaries of the property (see Figure 2). Ground cover consisted of low grasses. Visibility was reasonably low and consistent across all survey areas, ranging between 5 and 15% and averaging approximately 10%.

Plate 3: Lot 50 Mundijong Road survey area 1, view south

Plate 4: Lot 50 Mundijong Road survey area 2, view north

Plate 5: Lot 50 Mundijong Road survey area 3, view north

Plate 6: Lot 50 Mundijong Road survey area 3, view west

Plate 7: Lot 50 Mundijong Road survey area 4, view northwest

Plate 8: Lot 50 Mundijong Road survey area 5, view east

Plate 9: Lot 50 Mundijong Road survey area 5, view east-northeast

Plate 10: Lot 50 Mundijong Road survey area 6, view east

Plate 11: Lot 50 Mundijong Road survey area 6, view north of animal burrow

Archaeological Sites Located

One archaeological site (MJ-06), an artefact scatter, was located during the survey. A detailed site description is provided below.

Isolated Artefacts Located

Five isolated artefacts were located and recorded in detail during the survey (see Table 5). All of the isolated artefacts comprised small quartz flaked pieces, all weighing less than approximately 5g (see Plate 12 & Plate 13).

No retouch was observed on any of the pieces. These five isolated artefacts are considered by the author, and are recommended to the ACMC, as **not** constituting an Aboriginal Site under Section 5 of the AHA.

Plate 12: Isolated artefact IA-02, survey area 6

Plate 13: Isolated artefact IA-03, survey area 6

Table 5: Isolated artefacts located within Lot 50 Mundijong Road, Mundijong

Artefact #	Easting (mE)	Northing (mN)	Artefact Type	Lithology	Artefact Dimensions			Platform Type	Platform Dimensions	
					Length	**Width**	**Depth**		**Length**	**Width**
IA-01	403066	6426859	FP	WQ	34.5	16.4	6.6	-	-	-
IA-02	403422	6426818	FP	PQ	15.5	15.6	6.1	-	-	-
IA-03	403420	6426811	FP	WQ	15.9	8.8	9.4	-	-	-
IA-04	403576	6426771	FP	WQ	13.5	10.7	7.9	-	-	-
IA-05	403476	6426766	FP	WQ	8.4	5.2	4.7	-	-	-

Artefact #	# Dorsal flake scars	Cortex%	Parallel Arrises	Retouch/ Utilisation?	R/U Location	R/U Length	Weight (g)
IA-01	1	0	0	N	-	-	5.1
IA-02	1	0	0	N	-	-	2
IA-03	2	0	0	N	-	-	1.5
IA-04	1	15	0	N	-	-	2.3
IA-05	1	0	0	N	-	-	0.2

Archaeological Site Description

MJ-06 – Artefact scatter

Grid References

1.	403114 mE	6426523 mN	6.	403154 mE	6426488 mN
2.	403130 mE	6426527 mN	7.	403144 mE	6426479 mN
3.	403149 mE	6426519 mN	8.	403121 mE	6426483 mN
4.	403158 mE	6426513 mN	9.	403109 mE	6426496 mN
5.	403160 mE	6426503 mN	10.	403108 mE	6426516 mN

Location

MJ-06 is located in the central western portion of Lot 50 Mundijong Road, Mundijong. It is approximately 750m west of Adonis Street and 410m north of Mundijong Road (see Figure 2).

Environment

The artefact scatter is located on a white Bassendean sand dune surrounded by low-lying plausiplain. The dune is approximately 5m high with an elevation of 34.5m at the highest point of the dune and 29.6m at its base. Sand has been excavated out of part of the eastern face of the dune and it has subsequently formed a deflation area. The dune has been previously cleared of vegetation. Three *Eucalyptus sp.* trees line the eastern base of the dune and the base of the deflation is densely grassed. The rise is relatively intact, with the exception of the deflation area, and the site has been subject to some minor disturbance by pastoral activities and grazing stock. The ground surface comprises fine white sand and visibility at the time of recording was approximately 50% (see Plate 14 & Plate 19).

The nearest potable water source to MJ-06 is Mandejal Brook, located 1.89km to the north. Medulla Brook is located 2.9km to the southeast. The surrounding low-lying plausiplain would have been inundated seasonally during the winter months.

Description

MJ-06 comprises a small stone artefact scatter with a medium artefact density and a low level of raw material diversity. Artefacts are visible over an area of 52m (east–west) by 48m (north–south), or 1877 sq m, in an east-facing deflation within the sand dune. A 5.3% sample of the site's surface expression was examined and 15 artefacts were recorded.

Based on the data collected from 99 sample squares (1 x 1m in size), the average artefact density is medium (0.15/sq m) and the estimated total surface artefact population is 282 artefacts. Artefact types recorded within the site included debris (n=7, 50%), flaked pieces (n=6, 42.9%) and one flake (n=1, 7.1%) (see Figure 5).

The majority of artefacts were manufactured from white quartz (n=13, 92.9%) with one artefact made from crystal quartz being recorded (n=1, 7.1%) (see Figure 6). The majority of artefacts were also small in size, with 13 (92.9%) artefacts weighing less than 1 gram (Figure 7).

The cross-sectional shape of the artefacts varied, with wedge-shaped (n=4, 28.6%) and irregularly-shaped (n=4, 28.6%) artefacts being most common, followed by lenticular (n=3, 21.4%), tabular (n=2, 14.3%) and triangular (n=1, 7.1%) (see Figure 8).

No retouch was noted on any of the recorded artefacts.

See Table 6 for full artefact metrics.

Figure 5: MJ-06 artefact types and quantities

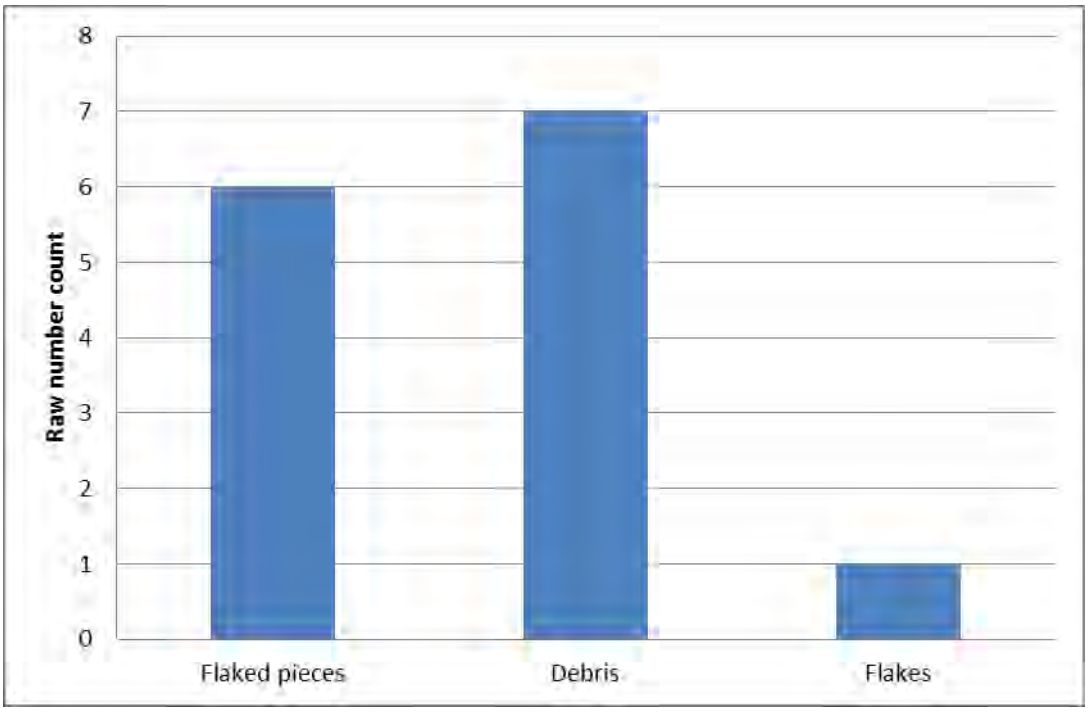

Figure 6: MJ-06 artefact lithologies and quantities

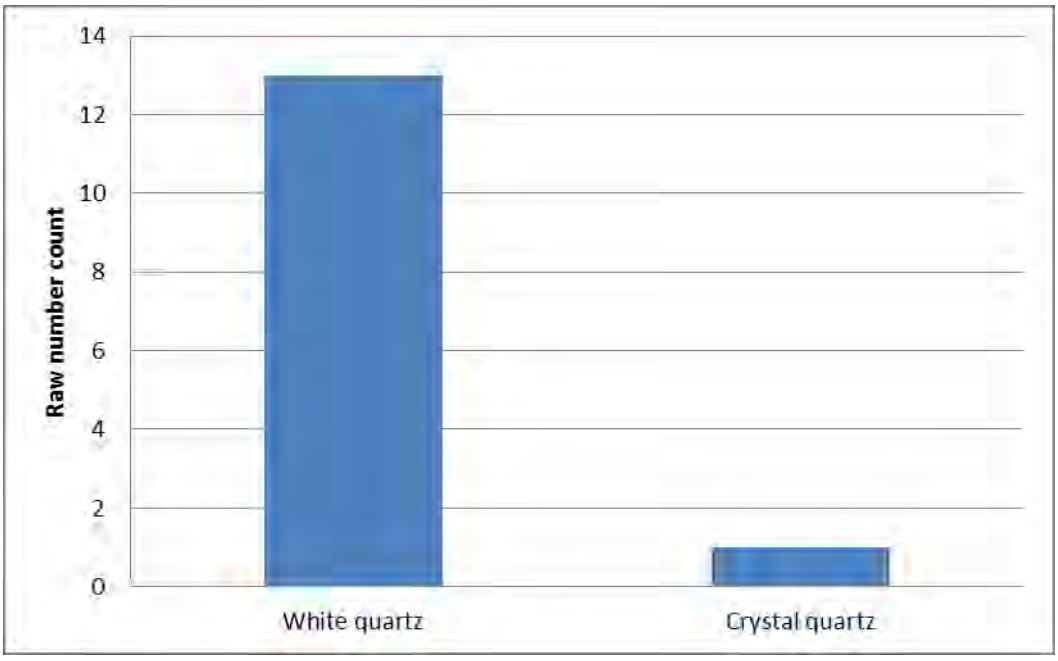

Figure 7: MJ-06 artefact weights

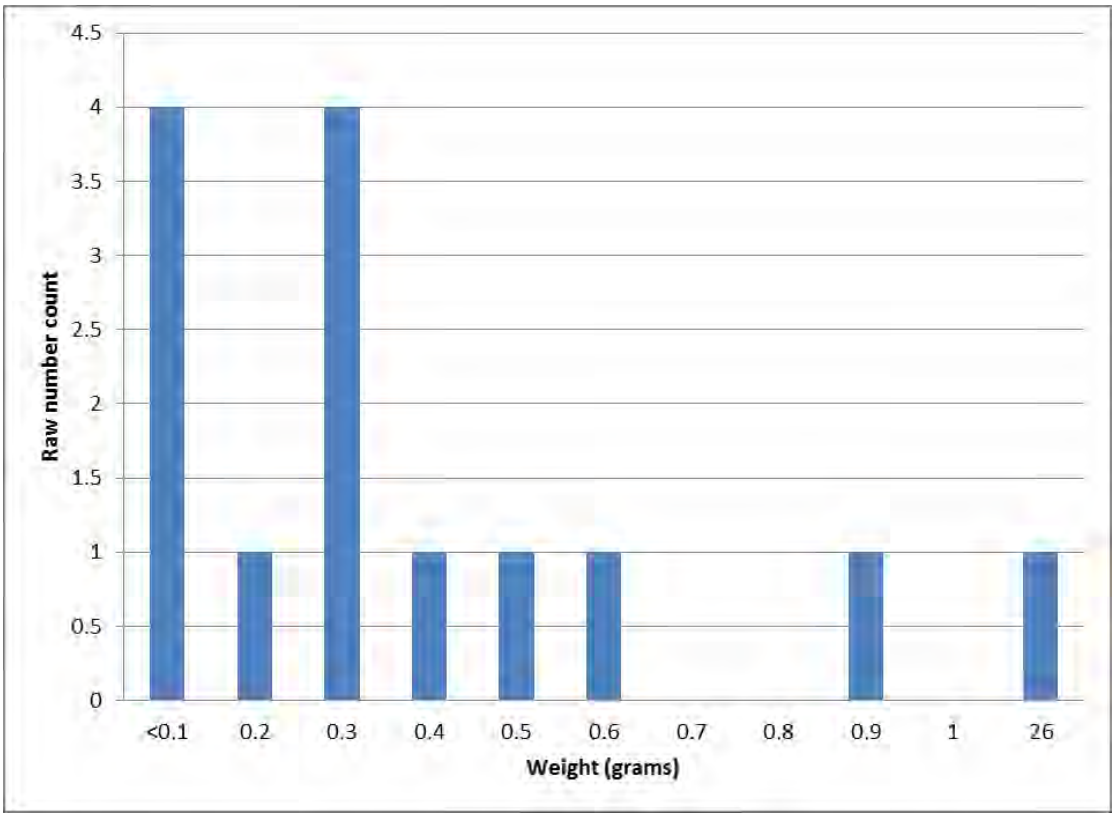

Figure 8: MJ-06 flaked artefact cross-sectional shape

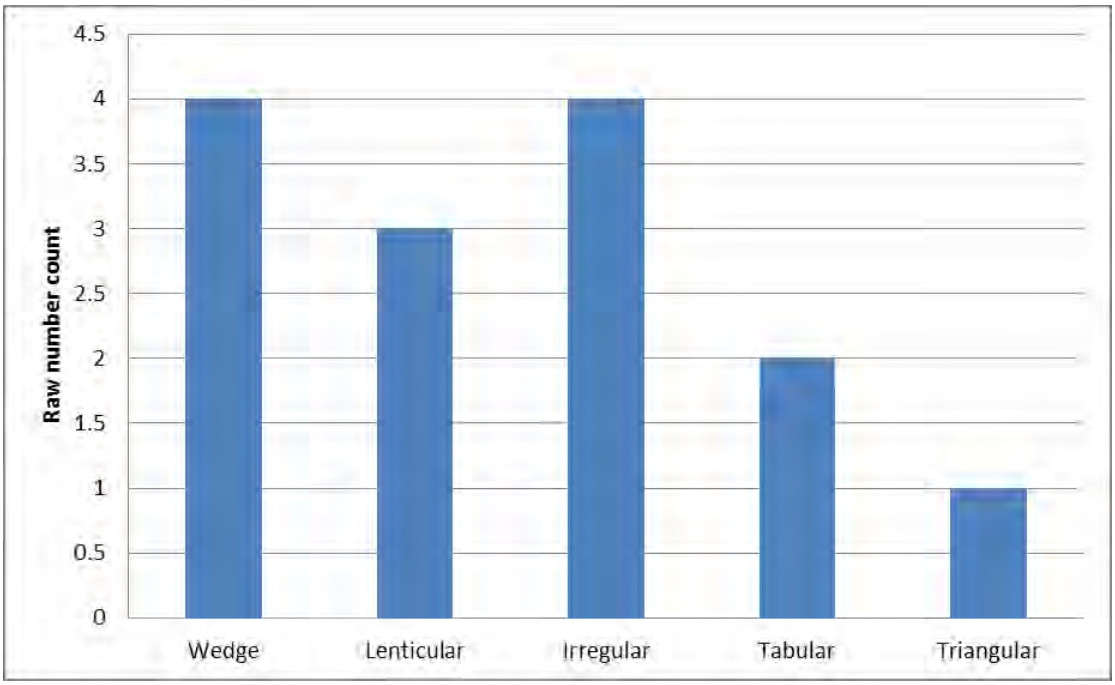

Table 6: MJ-06 artefact data

Sample square	Artefact #	Artefact Type	Lithology	Cross-section	Artefact Dimensions			Platform Type	Platform Dimensions	
					Length	Width	Depth		Length	Width
W16	1	FP	WQ	W	9.1	9	3.3	-	-	-
W16	2	FP	WQ	L	11.8	8.3	1.5	-	-	-
W16	3	DB	WQ	W	6.8	2.6	1.3	-	-	-
W17	1	DB	WQ	W	4.1	3.3	1.1	-	-	-
E11	1	FP	WQ	I	15.1	6.4	3.7	-	-	-
W27	1	DB	WQ	TB	6.1	3.4	0.8	-	-	-
W20	1	DB	WQ	L	4.6	2.5	1	-	-	-
E15	1	DB	WQ	I	11.7	10.2	2.6	-	-	-
W37	1	DB	WQ	W	9.7	4.6	4.4	-	-	-
W40	1	DB	CQ	TG	6.8	4.5	2.1	-	-	-
W52	1	FP	WQ	I	10.7	8.3	3.3	-	-	-
W50	1	FP	WQ	TB	14.5	7.9	2.6	-	-	-
W50	2	FP	WQ	I	16.2	11.1	2.9	-	-	-
-	"F"	F	WQ	L	16.8	13.8	3.7	FO	-	-

Sample square	Artefact #	Termination	# Dorsal flake scars	Cortex%	Parallel Arrises	Retouch/ Utilisation?	R/U Location	R/U Length	Weight (g)
W16	1	-	2	0	0	N	-	-	0.3
W16	2	-	1	5	0	N	-	-	0.3
W16	3	-	-	0	0	N	-	-	0.3
W17	1	-	-	0	0	N	-	-	<0.1
E11	1	-	-	0	0	N	-	-	26
W27	1	-	-	0	0	N	-	-	<0.1
W20	1	-	-	0	0	N	-	-	<0.1
E15	1	-	-	0	0	N	-	-	0.5
W37	1	-	-	0	0	N	-	-	0.2
W40	1	-	-	0	0	N	-	-	<0.1

Sample square	Artefact #	Termination	# Dorsal flake	Cortex%	Parallel Arrises	Retouch/ Utilisation?	R/U Location	R/U Length	Weight (g)
W52	1	-	1	0	0	N	-	-	0.4
W50	1	-	2	0	0	N	-	-	0.3
W50	2	-	2	0	0	N	-	-	0.6
-	"F"	-	1	0	0	N	-	-	0.9

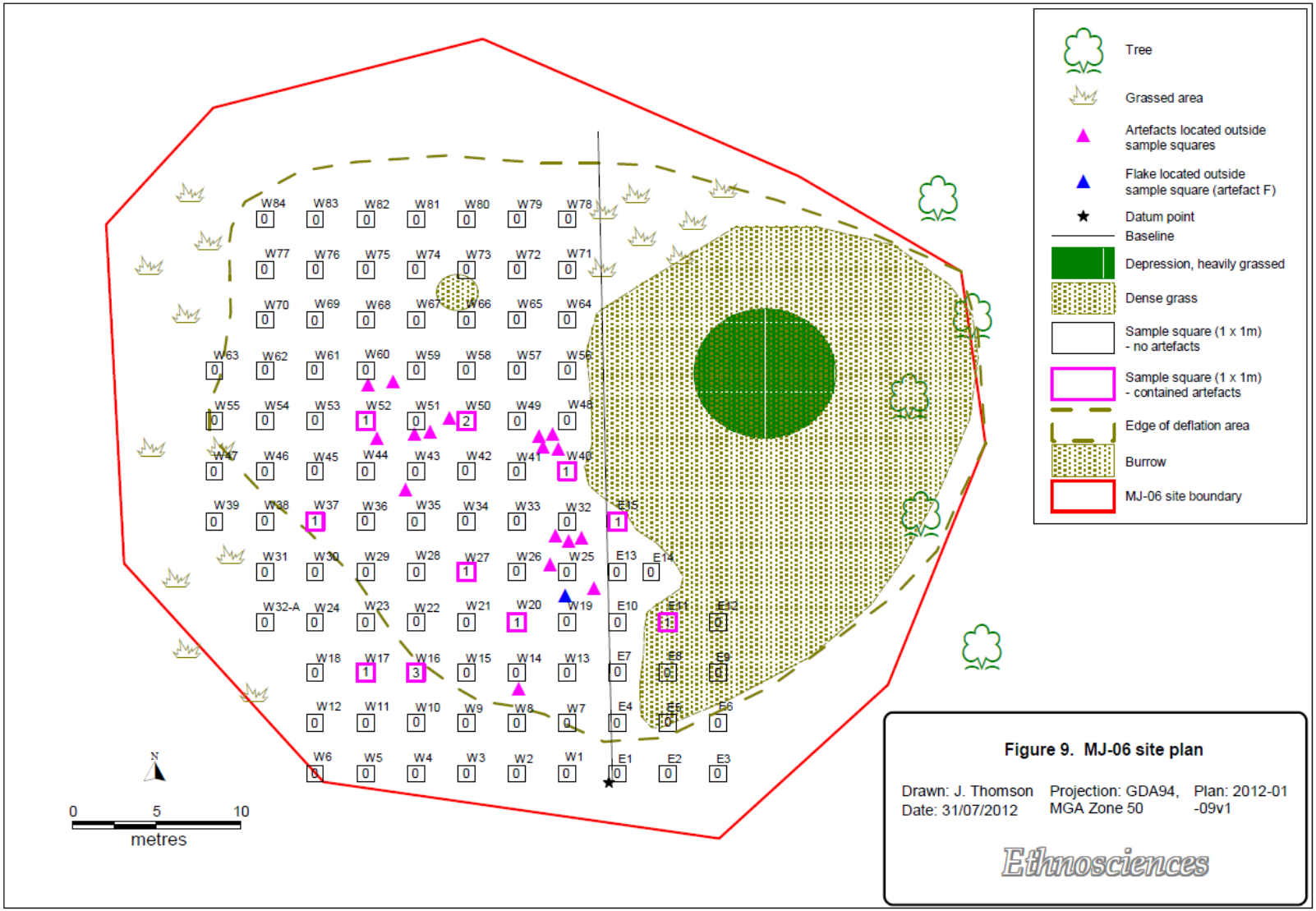

Figure 9: MJ-06 Site Plan

Site Interpretation

Based on the dominance of debris and flaked pieces in the site, the absence of formal tools or retouched pieces, the density and the low raw material diversity, and the long distance to any major water source, MJ-06 is interpreted as representing either the by-products of task-specific activities or a short-term or relatively infrequently utilised occupation site, reflective of high residential mobility. The assemblage at this site reflects a technological process of on-site manufacture of cores and/or other artefacts prior to their removal and use in other parts of the landscape, leaving the discarded debitage component behind. Following Hallam's relative dating scheme, the site could be classified as a Late Phase site as it is comprised of a quartz-rich assemblage with a high proportion of waste flakes.

MJ-06's assemblage composition may also be influenced by the periodic erosion of the sand dune and additional impacts by agricultural activities. As identified by Anderson (1983 in Bowdler et al 1991:25), the Bassendean dune system consists of a stable core with a superficial mobile layer of continually reworking sands, within which artefacts may have been deposited over time, but which became completely mixed on one level due to continual deflation. Therefore, the assemblage's current appearance, consisting of relatively small debitage, may in fact be a product of taphonomic processes and subsequent disturbance of the site.

Based on the nature of the landform unit within which MJ-06 is situated, there is some potential for the dune to contain subsurface archaeological materials; however, noting the results of other excavations within the Bassendean Sands unit and the local region, it is unlikely that the site will contain stratified or dateable subsurface deposit.

It is the opinion of the authors that MJ-06 constitutes a site within the meaning of Section 5(a) of the *Aboriginal Heritage Act 1972*.

Archaeological Significance Assessment

The data that has been collected from this site can contribute to a significant proportion of the research questions identified above relating to site location, in that it supports the hypothesis that sites are located in deflations on the eastern and top of elevated Bassendean white sand dunes or rises. Beyond site distribution, data from the site can only contribute to questions regarding the variability of artefact assemblages and site function (from a strictly technological perspective).

Whilst MJ-06 is able to contribute information and data towards answering many of the identified research questions, the site is relatively low in complexity and the collected data does not provide any substantially different information or new data in comparison with the existing knowledge base. The potential for technological analyses of the artefact assemblage is also limited as the assemblage comprises mainly debris from which very little can be determined with regards to manufacturing processes and stone tool technology. On a microscopic scale, whilst it may be possible to extract residue samples from the artefacts or conduct use-wear analyses, it is unlikely given that much of the assemblage comprises very small debitage and debris that such investigations will reveal much.

The excavation of sand and erosion of the dune within which the site occurs has reduced the ability to investigate research questions relating to the subsurface deposits or temporal aspects. However, other parts of the dune outside the deflation are still relatively intact and therefore the site's potential to contribute further information regarding subsurface deposit has not been completely affected by the disturbance.

There is little evidence of the connectedness of MJ-06 with other sites in the region and it does not constitute part of a site complex.

The representativeness of MJ-06 can only be assessed, due to limited available data, in terms of site type, topographic location, site size, distance to water, artefact assemblage composition (including artefact types, size and lithology) and artefact

density. MJ-06 comprises the most common site type located both within the local region (5km radius) and on the Swan Coastal Plain. MJ-06 can be regarded as very typical of open flaked stone artefact scatters, both within the local region and on the Swan Coastal Plain, as it is small in size, of medium density, over 300m away from a water source, is located in a partially disturbed context on Bassendean sands and its assemblage is dominated by small-sized quartz debitage.

In light of the above, MJ-06 is assessed as having relatively low archaeological research potential and as being a typical example of a common site type. MJ-06 is assessed, therefore, as currently being of **low archaeological significance**.

Plate 14: Site MJ-06, view west

Plate 15: Site MJ-06, view northwest

Plate 16: Site MJ-06, view north

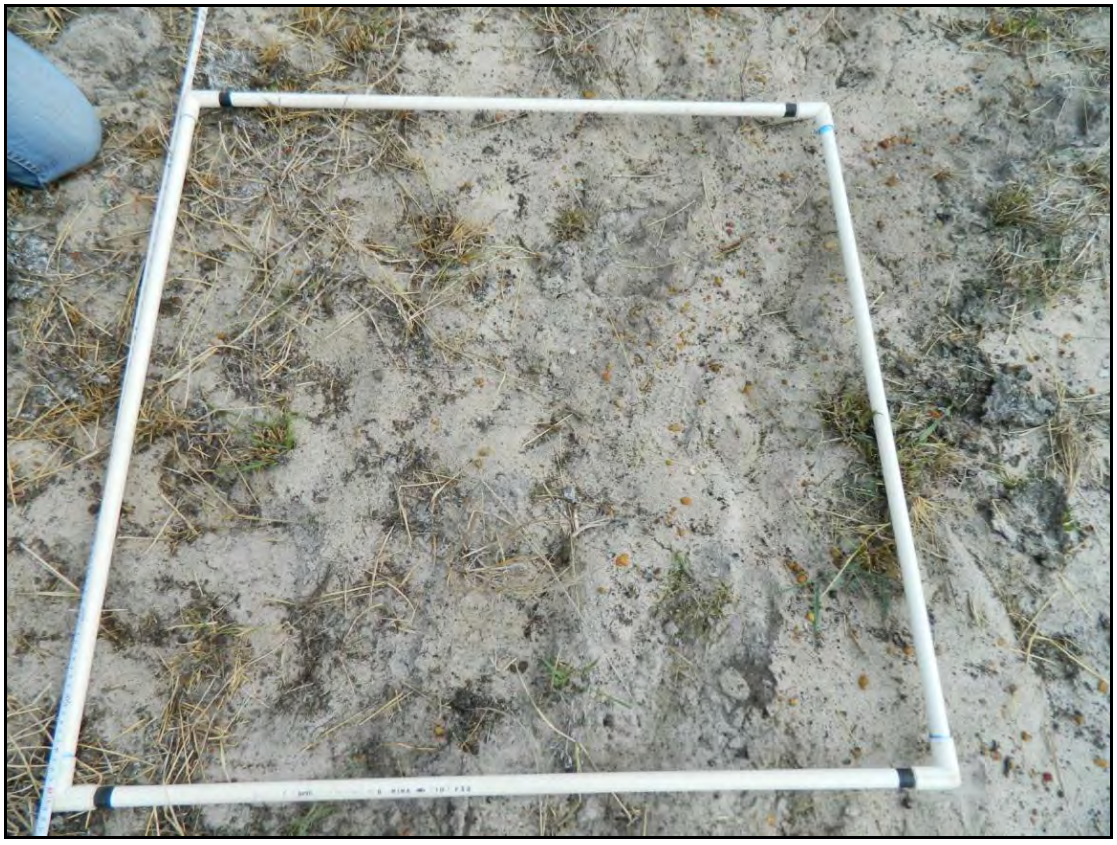

Plate 17: Site MJ-06, sample square E11

Plate 18: Site MJ-06 quartz artefact in sample square E11

Plate 19: Site MJ-06, quartz flake

Part 3 – Conclusions and Recommendations

The search of the Register of Aboriginal Sites revealed that there are no previously recorded ethnographic sites on the land.

No ethnographic sites were reported on the land during the ethnographic survey which involved representatives of the Bilya Noongar Organisation and Winjan Aboriginal Corporation, both of which have long-standing associations with the region and whose membership are claimants in the Gnaala Karla Booja (WC98/58). Two of the WAC consultants had actually lived in Mundijong for a period and had attended primary school in town. Both recall use of the area's natural resources by Nyungars living in town, on farms and in fringe camps in the area.

One archaeological site (MJ-06), an artefact scatter, was located on Lot 50 during the archaeological survey. Five isolated artefacts were also located and recorded.

MJ-06 is a small, medium-density, open quartz artefact scatter situated on a Bassendean sand dune above seasonally inundated wetlands. The artefacts are located within a deflation in the sand dune, which appears to have been previously excavated during agricultural activities. The site represents either the by-products of task specific activities or a short term or infrequently used occupation site. It is the opinion of the authors that MJ-06 constitutes a site within the meaning of Section 5(a) of the *Aboriginal Heritage Act 1972*. However, MJ-06 is assessed as currently being of low archaeological significance. No further recording of the surface assemblage of MJ-06 is required.

The consultants of both groups were also of the view that Site MJ-06 was of low cultural significance and do not oppose Peet Limited applying for Section 18 consent in relation to this site. They differed, however, in how the site should then be treated. The former wants the material left *in situ*, while the latter wants the material salvaged and appropriately stored. At present it is not possible to reconcile these opposing views.

Recommendations

1. It is recommended Peet's proposed development of Lot 50 Mundijong Road, Mundijong proceed.
2. It is recommended that Peet and its contractors are:
    a. advised of the existence and location of archaeological site MJ-06; and
    b. informed that the *Aboriginal Heritage Act 1972* (s5) may apply to MJ-06 and therefore it should not be impacted upon in any way without Ministerial consent under Section 18 of the AHA or the authority of the Registrar under Section 16.
3. It is recommended that Ministerial consent be given for the land on which archaeological site MJ-06 (artefact scatter) is located.
4. It is recommended that further consultation is undertaken with the Bilya Noongar Organisation and the Winjan Aboriginal Corporation regarding the disposition of the artefactual material in site MJ-06.

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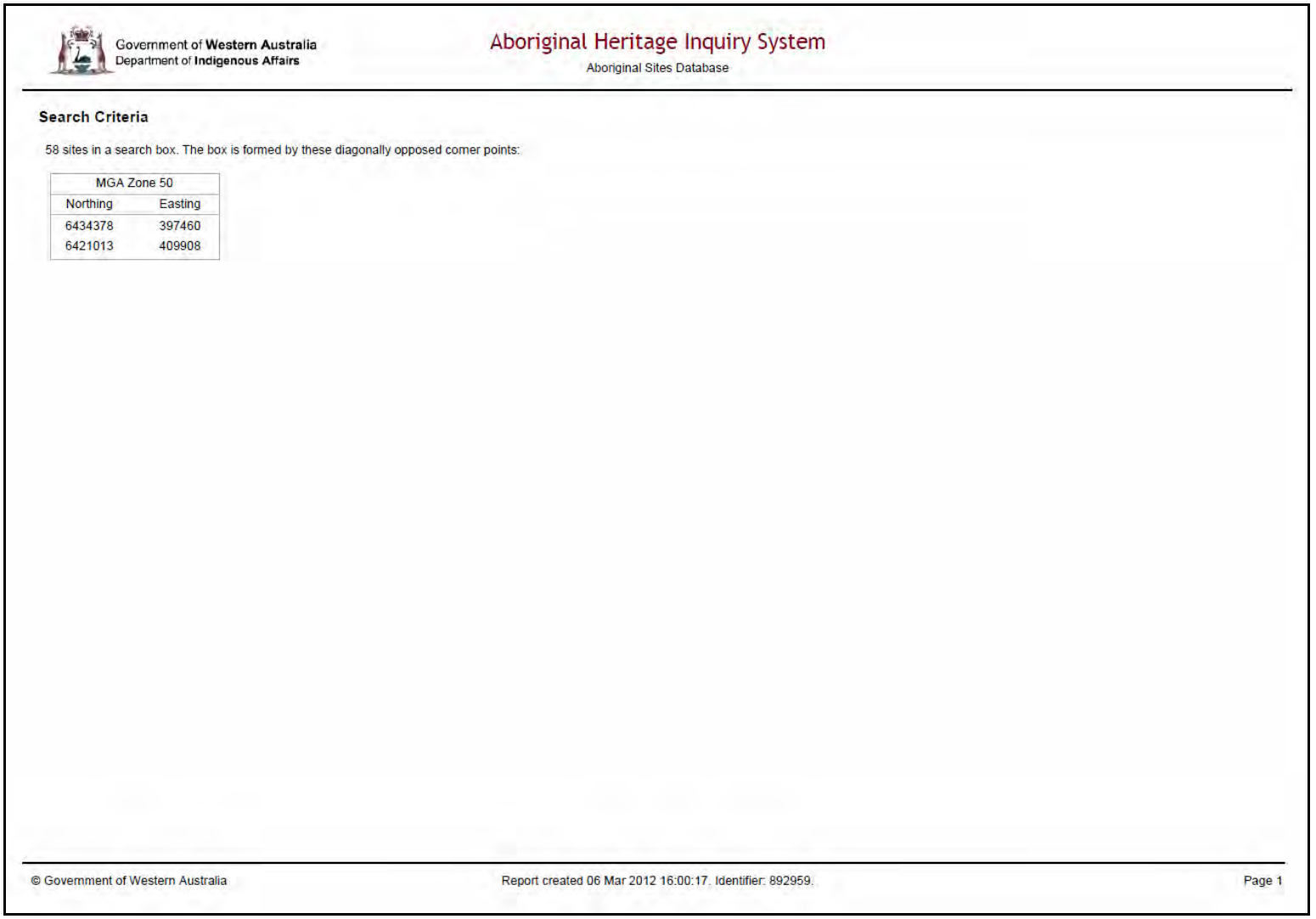
Appendix 1 – DIA Aboriginal Heritage Information System Search Results



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Search Criteria

58 sites in a search box. The box is formed by these diagonally opposed corner points:

MGA Zone 50	
Northing	Easting
6434378	397460
6421013	409908

Report created 06 Mar 2012 16:00:17. Identifier: 892959.

Page 1

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Aboriginal Sites Database

Disclaimer

Aboriginal sites exist that are not recorded on the Register of Aboriginal Sites, and some registered sites may no longer exist. Consultation with Aboriginal communities is on-going to identify additional sites. The AHA protects all Aboriginal sites in Western Australia whether or not they are registered.

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Legend

Restriction

N	No restriction
M	Male access only
F	Female access

Access

C	Closed
O	Open
V	Vulnerable

Coordinate Accuracy

Accuracy is shown as a code in brackets following the site coordinates.

[Reliable]	The spatial information recorded in the site file is deemed to be reliable, due to methods of capture.
[Unreliable]	The spatial information recorded in the site file is deemed to be unreliable due to errors of spatial data capture and/or quality of spatial information reported.

Status

L - Lodged		ACMC Decision Made
Information lodged, awaiting assessment	→	**R - Registered Site** **I - Insufficient information** **S - Stored Data**

Spatial Accuracy

Index coordinates are indicative locations and may not necessarily represent the centre of sites, especially for sites with an access code "closed" or "vulnerable". Map coordinates (Lat/Long) and (Easting/Northing) are based on the GDA 94 datum. The Easting / Northing map grid can be across one or more zones. The zone is indicated for each Easting on the map, i.e. '5000000:Z50' means Easting=5000000, Zone=50.

Sites Shown on Maps

Site boundaries may not appear on maps at low zoom levels

Report created 06 Mar 2012 16:00:17. Identifier: 892959.

Page 2

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List of 29 Registered Aboriginal Sites with Map

Site ID	Status	Access	Restriction	Site Name	Site Type	Additional Info	Informants	Coordinates	Site No.
396	R	O	N	South-East Corridor 07 / Cardup Siding	Artefacts / Scatter			403514mE 6432467mN Zone 50 [Reliable]	S02959
448	R	O	N	South-East Corridor 01	Artefacts / Scatter			403350mE 6431996mN Zone 50 [Reliable]	S02953
449	R	O	N	South-East Corridor 02	Artefacts / Scatter			403039mE 6429389mN Zone 50 [Reliable]	S02954
450	R	O	N	South-East Corridor 03	Artefacts / Scatter			402915mE 6428941mN Zone 50 [Reliable]	S02955
3582	R	C	N	Serpentine River	Ceremonial, Mythological		*Registered Informant names available from DIA.	Not available for closed sites	S02407
3648	R	O	N	Soldiers Road,mundijong.	Artefacts / Scatter	Archeological Deposit, [BP Dating: 1620BP]		404714mE 6428249mN Zone 50 [Reliable]	S02329
16089	R	O	N	Byford 01	Artefacts / Scatter			407178mE 6433329mN Zone 50 [Unreliable]	
16090	R	O	N	Byford 02	Artefacts / Scatter		*Registered Informant names available from DIA.	407169mE 6433099mN Zone 50 [Unreliable]	
16091	R	O	N	Byford 03	Artefacts / Scatter		*Registered Informant names available from DIA.	407119mE 6432899mN Zone 50 [Unreliable]	
16092	R	O	N	Byford 04	Artefacts / Scatter		*Registered Informant names available from DIA.	407049mE 6432879mN Zone 50 [Unreliable]	

Report created 06 Mar 2012 16:00:17. Identifier: 892959.
Page 3

Government of Western Australia
Department of Indigenous Affairs

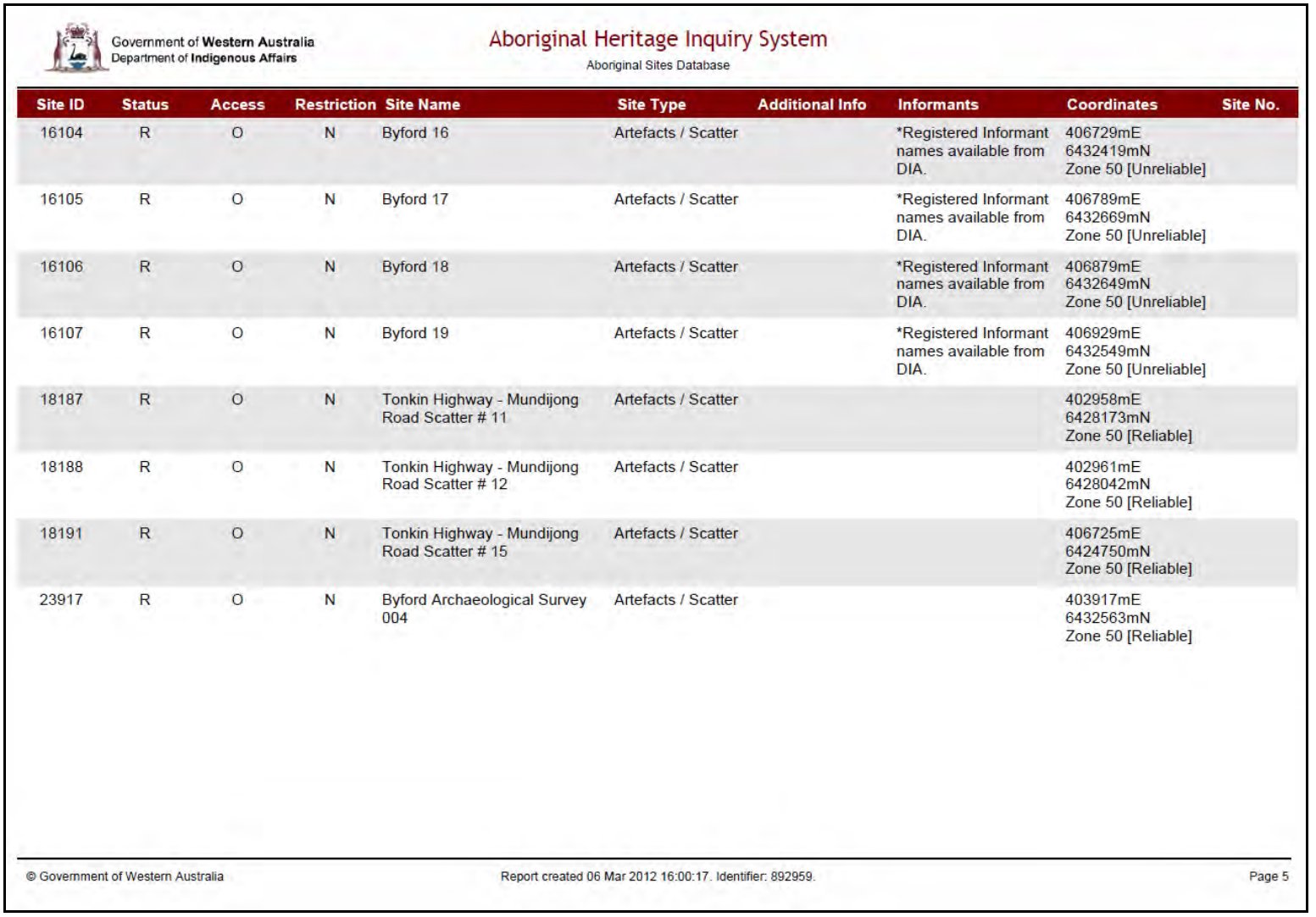
Aboriginal Heritage Inquiry System

Aboriginal Sites Database

Site ID	Status	Access	Restriction	Site Name	Site Type	Additional Info	Informants	Coordinates	Site No.
16093	R	O	N	Byford 05	Artefacts / Scatter		*Registered Informant names available from DIA.	406899mE 6432879mN Zone 50 [Unreliable]	
16094	R	O	N	Byford 06	Artefacts / Scatter		*Registered Informant names available from DIA.	406479mE 6433489mN Zone 50 [Unreliable]	
16095	R	O	N	Byford 07	Artefacts / Scatter		*Registered Informant names available from DIA.	406579mE 6433489mN Zone 50 [Unreliable]	
16096	R	O	N	Byford 08	Artefacts / Scatter		*Registered Informant names available from DIA.	406429mE 6432829mN Zone 50 [Unreliable]	
16097	R	O	N	Byford 09	Artefacts / Scatter	Shell	*Registered Informant names available from DIA.	406539mE 6433359mN Zone 50 [Unreliable]	
16098	R	O	N	Byford 10	Artefacts / Scatter		*Registered Informant names available from DIA.	406729mE 6433489mN Zone 50 [Unreliable]	
16099	R	O	N	Byford 11	Artefacts / Scatter		*Registered Informant names available from DIA.	406599mE 6433399mN Zone 50 [Unreliable]	
16100	R	O	N	Byford 12	Artefacts / Scatter			407153mE 6432454mN Zone 50 [Unreliable]	
16101	R	O	N	Byford 13	Artefacts / Scatter			407100mE 6432337mN Zone 50 [Unreliable]	
16102	R	O	N	Byford 14	Artefacts / Scatter		*Registered Informant names available from DIA.	406919mE 6432399mN Zone 50 [Unreliable]	
16103	R	O	N	Byford 15	Artefacts / Scatter		*Registered Informant names available from DIA.	406819mE 6432419mN Zone 50 [Unreliable]	

Report created 06 Mar 2012 16:00:17. Identifier: 892959.

Page 4



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16104	R	O	N	Byford 16	Artefacts / Scatter		*Registered Informant names available from DIA.	406729mE 6432419mN Zone 50 [Unreliable]	
16105	R	O	N	Byford 17	Artefacts / Scatter		*Registered Informant names available from DIA.	406789mE 6432669mN Zone 50 [Unreliable]	
16106	R	O	N	Byford 18	Artefacts / Scatter		*Registered Informant names available from DIA.	406879mE 6432649mN Zone 50 [Unreliable]	
16107	R	O	N	Byford 19	Artefacts / Scatter		*Registered Informant names available from DIA.	406929mE 6432549mN Zone 50 [Unreliable]	
18187	R	O	N	Tonkin Highway - Mundijong Road Scatter # 11	Artefacts / Scatter			402958mE 6428173mN Zone 50 [Reliable]	
18188	R	O	N	Tonkin Highway - Mundijong Road Scatter # 12	Artefacts / Scatter			402961mE 6428042mN Zone 50 [Reliable]	
18191	R	O	N	Tonkin Highway - Mundijong Road Scatter # 15	Artefacts / Scatter			406725mE 6424750mN Zone 50 [Reliable]	
23917	R	O	N	Byford Archaeological Survey 004	Artefacts / Scatter			403917mE 6432563mN Zone 50 [Reliable]	

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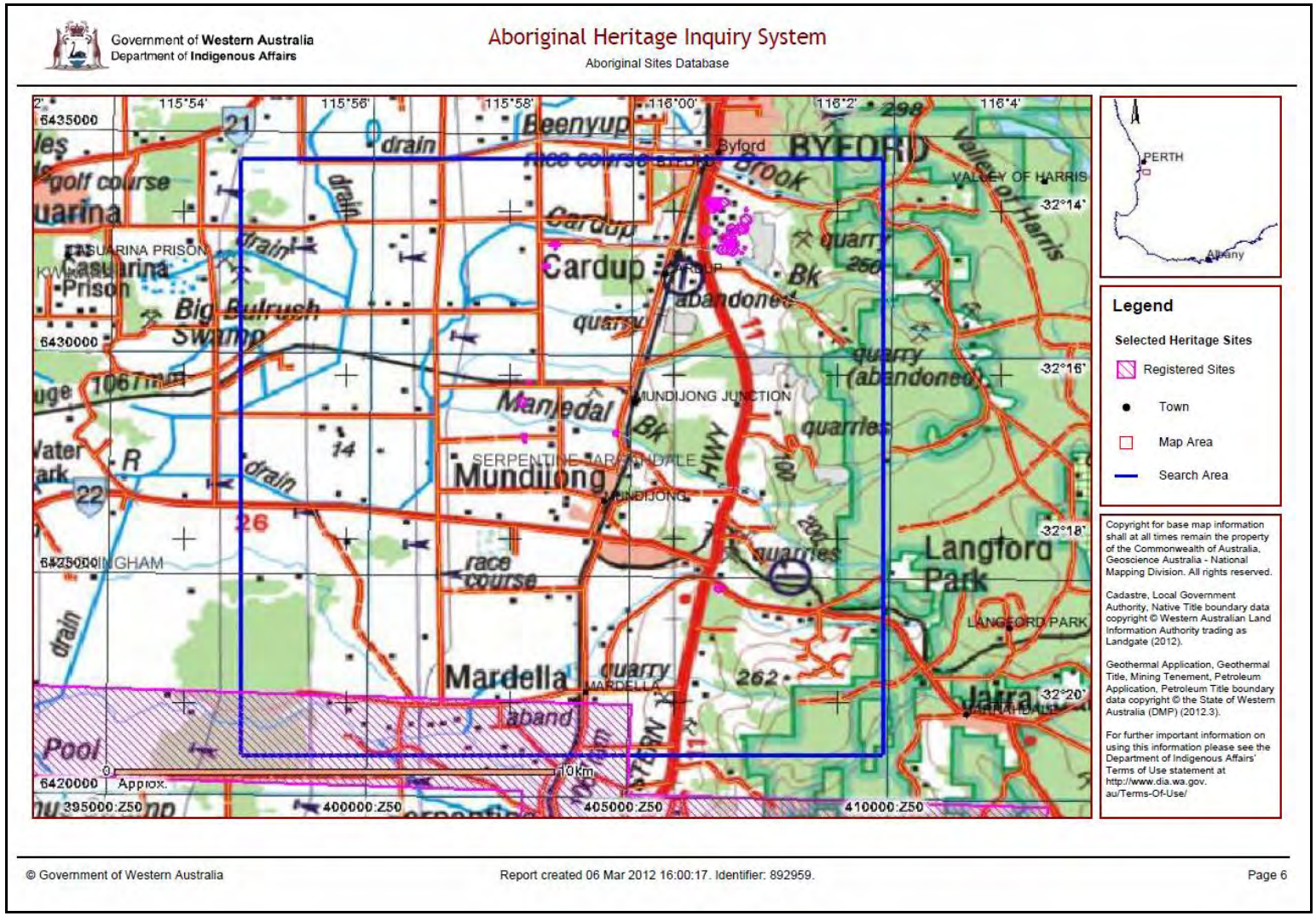
Page 5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Beenyup
Byford
BYFORD
Cardup
MUNDIJONG JUNCTION
Mundijong
Mardella
Langford Park
Jarrahdale
Big Bulrush Swamp
Pool
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Map Area
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Page 6

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List of 29 Other Heritage Places with Map

Site ID	Status	Access	Restriction	Site Name	Site Type	Additional Info	Informants	Coordinates	Site No.
3310	S	O	N	Cardup.	Artefacts / Scatter	Camp		404190mE 6432718mN Zone 50 [Unreliable]	S00206
3313	I	O	N	Mundijong.	Artefacts / Scatter	Camp		406065mE 6426234mN Zone 50 [Unreliable]	S00209
3590	I	O	N	Whitby	Artefacts / Scatter			407195mE 6427120mN Zone 50 [Unreliable]	S02416
3591	I	O	N	Yarrabah	Artefacts / Scatter			406870mE 6425980mN Zone 50 [Unreliable]	S02417
16108	S	O	N	Cardup Brook	Mythological			407530mE 6431805mN Zone 50 [Reliable]	
17923	S	O	N	If #2	Artefacts / Scatter			403038mE 6427638mN Zone 50 [Reliable]	
18189	S	O	N	Tonkin Highway - Mundijong Road Scatter # 13	Artefacts / Scatter			403043mE 6427990mN Zone 50 [Reliable]	
18190	S	O	N	Tonkin Highway - Mundijong Road Scatter # 14	Artefacts / Scatter			404475mE 6425300mN Zone 50 [Reliable]	
18192	S	O	N	Tonkin Highway - Mundijong Road Scatter # 16	Artefacts / Scatter			407050mE 6424150mN Zone 50 [Reliable]	
21305	S	O	N	Byford Village Isolated Finds	Artefacts / Scatter	[Other: Multiple Isolated Finds]		406780mE 6433772mN Zone 50 [Unreliable]	

Report created 06 Mar 2012 16:00:17. Identifier: 892959.
Page 7

Government of Western Australia
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Aboriginal Heritage Inquiry System

Aboriginal Sites Database

Site ID	Status	Access	Restriction	Site Name	Site Type	Additional Info	Informants	Coordinates	Site No.
23914	S	O	N	Byford Archaeological Survey 001	Modified Tree, Artefacts / Scatter			405373mE 6432652mN Zone 50 [Reliable]	
23915	S	O	N	Byford Archaeological Survey 002	Artefacts / Scatter			404363mE 6432537mN Zone 50 [Reliable]	
23916	S	O	N	Byford Archaeological Survey 003	Artefacts / Scatter			403847mE 6432559mN Zone 50 [Reliable]	
23918	S	O	N	Byford Archaeological Survey 005	Artefacts / Scatter			404185mE 6433441mN Zone 50 [Reliable]	
23919	I	O	N	Byford Archaeological Survey 006	Artefacts / Scatter			403254mE 6433533mN Zone 50 [Reliable]	
23920	S	O	N	Bas/iso - 001	Artefacts / Scatter			404022mE 6432479mN Zone 50 [Reliable]	
23921	S	O	N	Bas/iso - 002	Artefacts / Scatter			404809mE 6432444mN Zone 50 [Reliable]	
23922	S	O	N	Bas/iso - 003	Artefacts / Scatter			404364mE 6434301mN Zone 50 [Reliable]	
23923	S	O	N	Bas/iso - 004				404343mE 6434232mN Zone 50 [Reliable]	
23924	S	O	N	Bas/iso - 005	Artefacts / Scatter			404386mE 6434106mN Zone 50 [Reliable]	
23925	S	O	N	Bas/iso - 006	Artefacts / Scatter			404377mE 6434111mN Zone 50 [Reliable]	

Report created 06 Mar 2012 16:00:17. Identifier: 892959.

Page 8

Government of Western Australia
Department of Indigenous Affairs

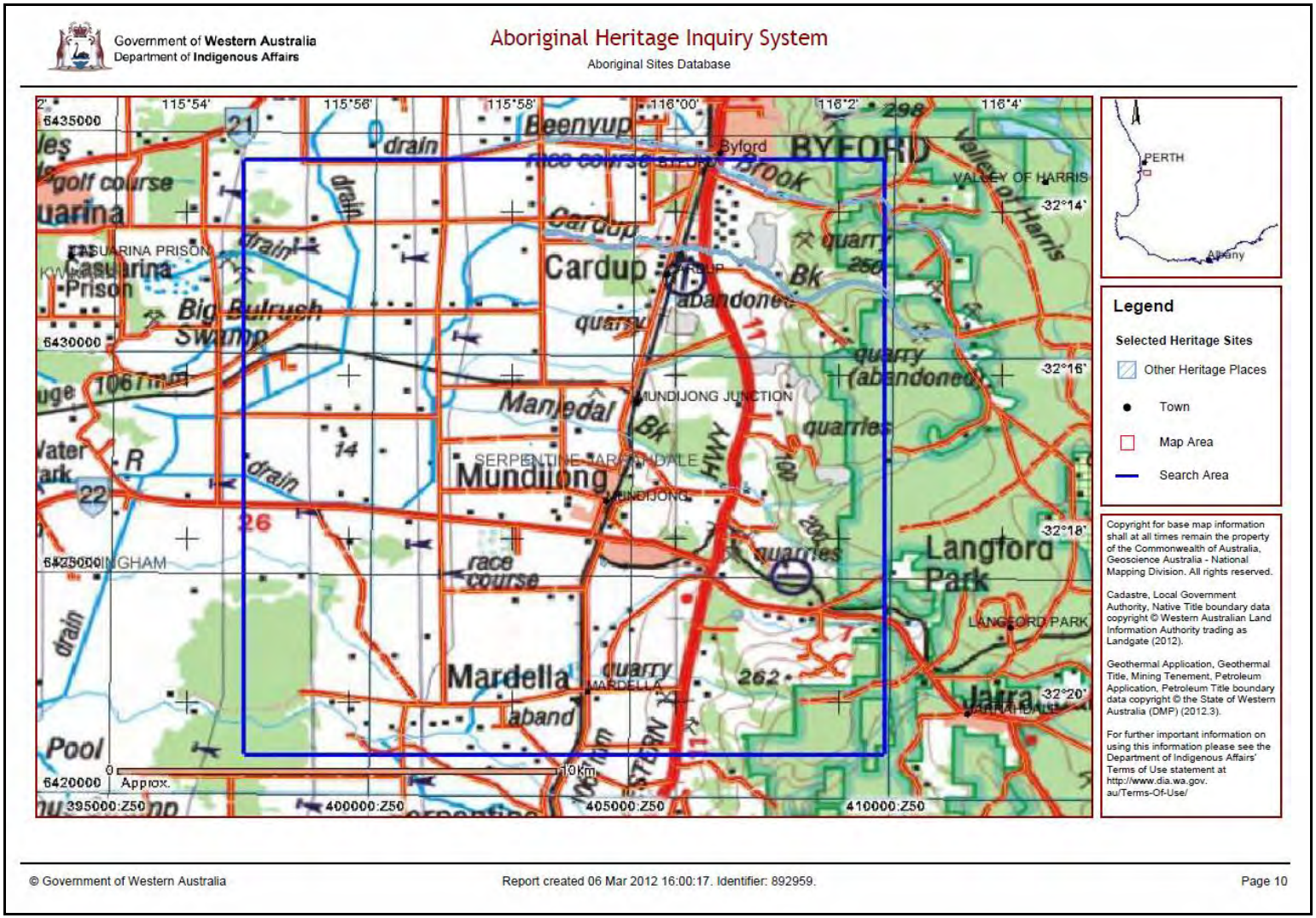
Aboriginal Heritage Inquiry System

Aboriginal Sites Database

Site ID	Status	Access	Restriction	Site Name	Site Type	Additional Info	Informants	Coordinates	Site No.
24979	S	O	N	Nettleton Road 19-09-07/001	Artefacts / Scatter		*Registered Informant names available from DIA.	406625mE 6434289mN Zone 50 [Reliable]	
24980	S	O	N	Nettleton Road 19-09-07/002	Artefacts / Scatter		*Registered Informant names available from DIA.	406896mE 6433922mN Zone 50 [Reliable]	
24981	S	O	N	Nettleton Road 19-09-07/003	Artefacts / Scatter		*Registered Informant names available from DIA.	406992mE 6434247mN Zone 50 [Reliable]	
24982	S	O	N	Nettleton Road Isolated Finds	Artefacts / Scatter		*Registered Informant names available from DIA.	406980mE 6434342mN Zone 50 [Reliable]	
24983	S	O	N	Nettleton Road 1-06	Artefacts / Scatter		*Registered Informant names available from DIA.	406895mE 6434284mN Zone 50 [Reliable]	
24984	S	O	N	Nettleton Road 2-06	Artefacts / Scatter		*Registered Informant names available from DIA.	407280mE 6434370mN Zone 50 [Reliable]	
24985	S	O	N	Nettleton Road 3-06	Artefacts / Scatter		*Registered Informant names available from DIA.	407357mE 6434486mN Zone 50 [Reliable]	
24991	S	O	N	Beenyup Brook	Mythological	Natural Feature	*Registered Informant names available from DIA.	407501mE 6433928mN Zone 50 [Reliable]	

Report created 06 Mar 2012 16:00:17. Identifier: 892959.

Page 9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Page 10


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Aboriginal Sites Database
Map Showing Registered Aboriginal Sites and Other Heritage Places
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Page 11

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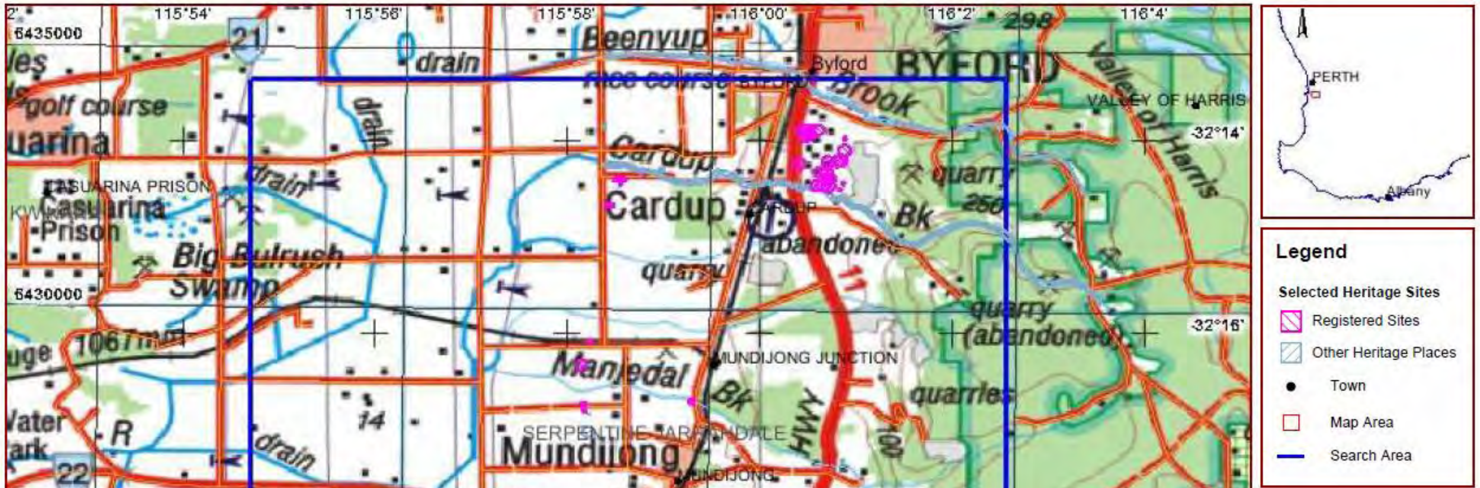

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 Report created 06 Mar 2012 16:00:17. Identifier: 892959. Page 12

Appendix 2 – Archaeological Site Type Definitions

Artefact scatter

An artefact scatter is a place where human activity is identifiable by the presence of portable object(s) (e.g., stone, glass, bone, shell) utilised or modified by Aboriginal people in relation to traditional cultural life past or present.

Background scatter

The number of isolated artefacts (see definition below) recorded in a given area is used to calculate the density of the background scatter.

To calculate the estimated density of the background scatter, the following formula is used:

$B = N/A1$

B: estimated background scatter density (expressed as number of artefacts/km² and m²)

N: number of artefacts observed

A1: is estimated area viewed (see below).

A variety of factors can affect the survey intensity including visibility of the ground surface, limit of peripheral vision, width of transects etc. To account for these factors, the following formula is commonly used to determine the estimate the of area actually viewed (also known as survey intensity). (After Hiscock 1988: 73-79).

$A1 = LxWxV$

A1: estimated area viewed

L: length of the survey area

W: width of the area inspected (such as the width of the transect)

V: percentage of ground surface visible

Burial (skeletal material)

A place where Aboriginal skeletal material is buried and/or where mortuary practices occurred. DIA require at least one of the following pieces of evidence to establish that the reported place is of Aboriginal origin:

- Aboriginal skeletal material is visible;
- Aboriginal mortuary/burial markers and or ethnographic evidence about the burial/skeletal material

Engraving

A motif (either figurative or non-figurative) on a rock surface produced by percussion or abrasion. Engravings are also often referred to as petroglyphs.

Gnamma hole

A natural or artificial rock cavity which holds water after rain or is linked to the water table. May or may not include a cap stone.

Grinding material

Grinding patches or grooves are smoothed areas or grooves on rock

surfaces (non-portable) that have been created by grinding activity associated with food production such as seed milling, preparation of pigments, tool manufacture and/or maintenance and ritual.

Historical A place that has historical associations with Aboriginal people and may or may not contain physical evidence of those associations.

Isolated artefact Artefact(s) that are not of sufficient density or number to be determined a site.

Midden A place where there is an accumulation of shell refuse that is derived from exploitation of a mollusc resource by Aboriginal people. Such sites may also contain artefacts, fireplaces, burnt shell and bones. Natural events (e.g. storms) may result in the formation of "midden like" features. Such features are distinguishable from middens by their lack of artefactual material, burnt shell or their composition being of non-edible mollusc species. Therefore, DIA require at least two of the following pieces of evidence to establish that the accumulation of shells is of Aboriginal origin:

- presence of charcoal, burnt wood, blackened shells, hearths;
- presence of bones of other edible species;
- presence of artefactual material;
- presence of layers indicating cultural rather than natural deposition;
- evidence that the shell fish have been exploited by human beings, e.g., broken open backs, edible size;
- demonstrable selection of edible, mature, shell fish species;
- ethnographic and/or historical evidence related to the accumulated shell refuse.

Modified tree One or more tree(s), living or dead, which has been modified by Aboriginal people by removing the bark or wood resulting in the formation of a scar. This sort of modification was and is frequently done for the making of implements, tools or other materials that were used in traditional cultural practices. DIA require at least two of the following pieces of evidence to establish that a scar is of Aboriginal origin:

- the scarred tree is an indigenous species and a mature individual;
- the scar base normally begins above ground level;
- the scar is roughly parallel-sided and fairly symmetrical in its overall shape;
- the bark regrowth is generally regular;
- the scar terminations are either squared off or pointed as a result of bark regrowth;

	• axe marks are present; • suspected toe holes are arranged in a usable pattern.
PAD (Potential archaeological deposit)	An accumulation of cultural material and sediment deposited over time.
Painting	Places where Aboriginal people have painted on surfaces. Paintings (including daubings, drawings, stencils, prints) can be figurative or non-figurative markings or motifs on surfaces such as rocks, rock walls and trees at fixed locations that are produced by adding pigments and or mediums, such as ochre, blood, beeswax, animal fats, vegetable dyes, tree saps.
Quarry	Places where there is evidence for the extraction of stone or ochre. DIA require at least two of the following pieces of evidence to establish that a natural occurrence of raw material has been used as a quarry: • evidence for the removal of material/modified surfaces in the form of negative scarring, crushing, areas of excavation etc; • presence of implements used during extraction (e.g. hammerstones, fire-hardened sticks) at the source; • evidence of flaking and reduction of the stone material at the source. • presence of partially-worked material at the source; • ethnographic evidence relating to the extraction of raw material at the source.
Reduction area	Reduction area refers to a cluster of stone artefacts which represent the remains of the flaking of a core. Artefacts within a reduction area can usually be conjoined back together.
Repository/cache	A place where cultural or utilitarian objects are/were taken or stored by Aboriginal people, either past or present.
Rock shelter	A place recognisable as a cave or overhang that may have been utilised by Aboriginal people.
Structure	The placement or arrangement by Aboriginal people of stone, wood or other material made into a structure for ceremonial or utilitarian purposes.
Water source	A source of water, (e.g., gnamma holes, soaks, springs, rock holes), with ethnographic evidence of its use or modification for use by Aboriginal people in connection with traditional cultural life past or present.

Appendix 3 – Artefact Identification and Recording

Flaked artefact identification

Flaked stone is identified on the basis of the presence of one or more of the following features (see Plate 20 and Plate 21):

- a positive or negative ring crack;
- a distinct negative or positive bulb of percussion or force;
- a definite eraillure scar beneath a striking platform;
- definite remnants of flake scars (e.g. dorsal scars and ridges);
- fracture termination.

Stone not exhibiting these features is regarded as not artefactual.

Plate 20. Features of the ventral surface of a flake produced through conchoidal fracture (Holdaway and Stern 2004:1.3.1)

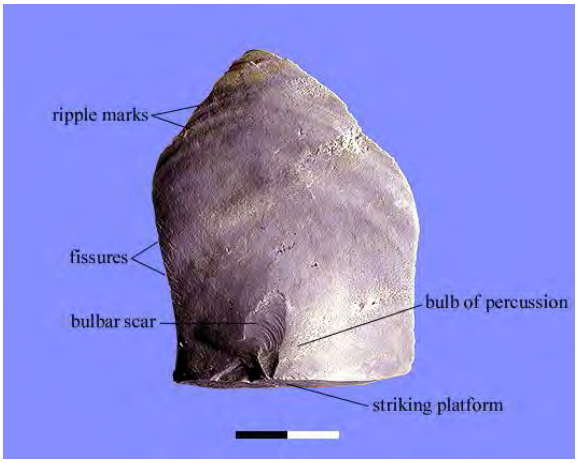

Plate 21. Features of the dorsal surface of a flake produced through conchoidal fracture (Holdaway and Stern 2004:1.3.1)

Flaked stone artefacts are classified into four types:

- flakes – exhibiting one positive ventral surface or part thereof;
- retouched flakes – containing negative flake scars created after the formation of the ventral surface;
- cores – contains one or more negative flake scars and no positive flake surfaces; and
- flaked pieces – items that cannot be placed unambiguously into one of the three above categories.

Flakes are characterised into four subcategories including complete flakes, longitudinally broken, transversely broken and flake fragments.

Artefact recording

The artefact analysis consisted of a full metrical recording of artefacts located. All artefacts located comprised material that appeared to be flaked, whilst no examples of ground stone were recorded. The following attributes were recorded for each artefact located.

Flakes

- Raw material
- colour
- completeness
- length
- width
- technological type (core, retouched flake, flake and parts thereof)
- thickness
- termination type
- platform type
- platform width
- platform thickness
- number of scars present on the dorsal surface
- presence of retouch
- number of retouch scars
- length and invasiveness of retouch
- use wear presence/absence and location
- presence/absence of platform preparation (faceting, overhang removal)

Cores

- Raw material
- colour
- type (based on number of platforms),
- quantification of flake scars and platform characteristics

Artefact Metric Measurements

Flakes

Length	Distance along the percussion axis from the ring crack to the distal margin.
Width	Distance between the lateral margins measured at right angles to the percussion axis half way between the ring crack and distal margin.
Thickness	Maximum distance between the ventral and dorsal surface of the flake half way between the ring crack and the distal margin.
Platform Width	Distance along the striking platform from one lateral margin to the other.
Platform Thickness	Distance across the striking platform from the centre of the ring crack to the dorsal surface.
Platform Type	Type of platform may be one of the following:

	• Flat – platform where it is not possible to determine whether it has a partial single flake scar, or if it has been heat fractured • Flaked – striking platform formed by one flake scar • Faceted – striking platform has a number of flake scars resulting from rotation of the core • Cortical – unmodified platform consisting entirely of the outer surface of the parent rock • Crushed – the proximal end of the flake is constituted by a sharp edge lacking a distinct platform
# Dorsal Flake Scars	Number of flakes taken off the dorsal side during production.
Cortex%	The amount of cortex (chemical or mechanical weathered surface on rocks) on the dorsal side of a flake.
Overhang Removal	Presence/absence of overhand removal, small flakes are removed from the edge of the platform.
Retouch/Utilisation	Presence/absence of edge modification by the removal of small flakes. Both the length of retouch and location on the artefact is recorded.
Termination types	The type of termination may be one of the following: • Feather – straight to the bottom of the flake with no deviation • Hinge – closing bend towards nearest free surface • Step – angled change of direction towards nearest free surface • Outré passé – plunging backwards towards the other side of the core
Cores	
Length	Size recorded along maximum dimensions.
Width	Size perpendicular to length.
Thickness	Size measured at 90° to both the width and the length.
# Platforms	Count number of platforms on the core.
Flake Scars	Total number, length and width of flake scars present on the core.
% Cortex	The amount of cortex (chemical or mechanical weathered surface on rocks) on the core.
Retouch/utilisation	Presence/absence of edge modification by the removal of small flakes.

Artefact recording acronyms

The following acronyms are used for recording artefact type and lithology.

CF or F	Complete flake
FF	Flake fragment
LBF	Longitudinally broken flake
TBF	Transversely broken flake
RUF	Retouched/utilised flake
RUP	Retouch/utilised piece
BL	Blade
DB	Debris
GS	Grindstone
SPC	Single platform core
MPC	Multiplatform core
CF	Core fragment
MANU	Manuport
CH	Chert
BIF	Banded Ironstone Formation
DOL	Dolorite
BAS	Basalt
CL	Chalcedony
IS	Ironstone
SIL	Silcrete
QU	Quartz
QZ or QZT	Quartzite
MS	Mudstone
GR	Granite
SS	Sandstone
CQ	Crystal Quartz

Ground stone artefacts

Ground stone artefacts can be classified into four categories including mullers, millstones, pestles and mortars.

The following attributes are generally recorded for ground material.

Length	Size recorded along maximum dimensions.
Width	Size perpendicular to length.
Thickness	Size measured at 90° to both the width and the length.
# Ground surfaces	Number of surfaces with ground patches.
Dimensions of ground surfaces	Length and width of all ground surfaces/patches.
Presence and type of any modification	E.g. pitting or hammer dressing to shape the artefact.

Other stone artefacts

Other stone artefacts include manuports, anvils and hammer stones. Manuports are natural objects that have been transported but not necessarily flaked or modified. Anvils comprise blocks or slabs of rock that have been used to support hammering of other objects and will exhibit pitting or indentations from these objects being struck. Hammer stones are usually round or ovoid rocks used to strike flakes off a core. Hammer stones usually have pitting on one or more surfaces from the percussion of other rock.

The following attributes are generally recorded for manuports, anvils, shell or hammer stones.

Length	Size recorded along maximum dimensions.
Width	Size perpendicular to length.
Thickness	Size measured at 90° to both the width and the length.
Modifications	Description of any modifications, e.g. pitting, indentations, or hammer dressing to shape artefact, plus the location and extent of each modification.

Modified trees

Modified trees are trees that have been scarred by people through the removal of bark. Scars made by people tend to be regular in shape, located above ground level and will often show evidence of axe marks (Burke and Smith 2004:226–27).

The following attributes are generally recorded for modified trees.

Type of tree	Tree species
Height of tree	Used to calculate the extent of the root system and therefore the boundary of the site.
Girth of tree	How wide the tree is around the middle.
# scars/modifications	Number of scars in the tree.
Type of scar	E.g. containers, canoes, access to honey.
General location of scar	General location of scar or modification on the tree

Height of scar	Height from base of tree.
Scar orientation and aspect	Direction of longest axis of each scar and compass bearing/direction scar is facing.
Scar shape	E.g. round, elongated, oval, irregular.
Degree of scar	How much bark has been removed
Scar dimensions	• length – maximum vertical dimension of scar • width – maximum horizontal dimension of scar • depth – distance between inner exposed wood and outer bark
Regrowth	Extent and depth of regrowth.
Implement	Type of implement used to create the scar or modification, e.g. evidence of stone axe or metal axe, where determinable.
Carvings	Presence and description of any carvings.

APPENDIX 6
LANDSCAPE AND PUBLIC OPEN SPACE STRATEGY

emerge ASSOCIATES
Integrated Science & Design

LANDSCAPE & PUBLIC OPEN SPACE STRATEGY

LOT 50 COCKRAM STREET, MUNDIJONG

Prepared for Peet Ltd
February 2013

Document Control

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D					
E					

Executive Summary

This report has been prepared by Emerge Associates to accompany the Lot 50 Cockram Street, Mundijong Local Structure Plan submission to be developed by Peet Limited. The report outlines the proposed Public Open Space (POS) and streetscapes landscape strategy for the Development Area.

The Development Area has the established township of Mundijong to the eastern boundary. Mundijong Road runs along its southern boundary while open farmland exists to the north. The western boundary comprises land reserved for further residential development. Between this Development Area and the adjoining subdivision is Reserve land for the future extension of the Tonkin Highway with an adjoining sixty metre wide Service Corridor.

All landscape concepts outlined in this report and shown on the included Landscape Concept Masterplan, have been prepared based on the Development Plan prepared by Taylor Burrell Barnett Town Planning and Design with considerable inputs from the project's Environmental Scientist, Civil Engineer and Landscape Architect.

The report details existing site conditions and environment, typical POS typologies and generic landscape treatments of POS areas, including but not limited to:

- Typical POS Recreation Facilities Provided,
- Treatment of Proposed Stormwater Drainage in Landscaped Areas,
- Retention of Existing Significant Vegetation,
- Irrigation Strategy, and
- Landscape Maintenance.

Table of Contents

List of Plates

Appendices

1 Existing Site Conditions and Environment

1.1 Site Character and Adjacent Land Uses

1.1.1 Generally

The existing site is best described as flat to gently undulating and exhibits minimal change in ground elevation with the low point being at approx 26m AHD in the north western corner, rising evenly to approx 31m AHD in the south eastern corner.

The existing site's former land use as a grazing / pastoral property has resulted all but a very small percentage of the existing vegetation being cleared. The occasional remnant tree remains, which ha been supplemented with occasional introduced tree plantings which could have been acting as windbreaks to paddocks and / or for spatial definition arounds sheds and other farming infrastructure. Fruit trees indicate a possible small orchard previously existed on part of the site. No understorey vegetation exists at all with the exception of pasture grasses.

1.2 Focal Points and Views

1.2.1 Generally

Given the site's gentle undulation as outlined previously, there are no strong views or vistas from vantage points located within the site.

The important focal points and views to be considered, retained and reinforced through the urban and landscape design process relate to the dominant landform features surrounding the site, of which there are two distinctive features, being :

1. The Darling Scarp
2. Swan Coastal Plain

All of the subject site is located on the low lying, gently undulating Swan Coastal Plain. The nature of the landscape of the Swan Coastal Plain in the immediate vicinity is largely unvegetated, with a predominant rural character. Views are dominated by the Darling Scarp to the east.

The Darling Scarp is the most dominant physical feature of the South West of Western Australia and the retention of views from the subject site onto the Scarp will be critical in ensuring a rural character with green values can be promoted to enhance the built environment.

The views and vistas to the Scarp will typically occur through the creation and reinforcement of long vistas along east west aligned roads and public open space links within the proposed development. These views and vistas should be reinforced and /or framed through the consideration of tree placement.

1.3 Recreation Connections

1.3.1 Generally

There are no existing recreation connections around the existing site. The site is located at the end of Cockram St and therefore is within 500m walking distance to the existing Mundijong Sporting Oval.

The installation of a dual use path along Cockram Street to the existing town centre and sporting oval would create a strong recreation connection to the proposed open space areas within the Development Plan.

1.4 Significant Trees

1.4.1 Generally

The extensive pasture / grazing activity during the site's previous land uses has resulted in little to no remnant vegetation remaining on the site and as such significant trees that could be retained within the development are few and far between. There are the occasional examples of endemic and introduced trees which could be incorporated into the urban design and / or public open space to provide instant amenity as follows :

Towards to southern boundary of the site, a group of approximately six (6) *Corymbia calophylla* (Marri) exist which could be incorporated into an entry statement of Mundijong Road. It is planned that these trees be retained in a widened verge on the major boulevard running north south in the Development Plan. Also within close proximity to this stand of Marri trees are three (3) *Kingia australis* (Bullanock) which if unable to be incorporated in the urban design are able to be relocated to public open space.

At the current Cockram Street cul-de-sac end of the site on the eastern boundary a number of introduced trees exist which appear to have been related to the previous farming operations of the site. A group of *Eucalytpus camaldulensis* (Northern River Red Gum) are the main species in this location which are suitable for retention in Public Open Space (POS) only due to the propensity of this species to unpredictably drop large limbs. If retained in POS, it should be ensured that these trees are retained in garden beds away from POS infrastructure such as playgrounds or bench seats.

In addition to the Northern River Red Gum's a variety of exotic trees exist which could possibly be relocated into POS areas, including the following species :

- One (1) *Citrus limon* (Lemon Tree)
- One (1) *Liquidamber styraciflua* (American Sweetgum)
- One (1) *Caesalpinia ferrea* (Leopard Tree)
- Two (2) *Erythrina indica* (Coral Tree)
- One (1) *Pinus radiate* (Monterey Pine)

Towards the northern boundary of the site, adjacent Sparkman Road, another group of approximately five (5) Corymbia calophylla exist which could be incorporated into the urban design if possible. A further four (4) Kingia australis are also present in this location which are suitable for transplant into POS areas.

In the north western corner of the site, a large triangular grove of Casuarina obesa (Swamp She-Oak) have planted in regularly defined rows. The density of planting and the locally wet depression that these trees are located has resulted in the no opportunity for incorporation of these specimens in a worthwhile urban design or POS outcome and their removal is recommended.

In the north eastern corner of the site, a north south orientated row of Eucalyptus plantings exist as a windbreak, which sit just in the adjacent landowners property, but are planned to be retained in the Development as part of the road layout in this area.

2 Landscape Design / Public Open Space Strategy

This section of the report describes the basic principles of the overall Public Open Space (POS) strategy for Lot 50 Cockram Street, Mundijong. The proposed residential subdivision is to be developed around a range of open space opportunities. There are 3 different categories of open space described which include:

- Multiple Use Corridors
- Large Parks
- Pocket Parks

It is envisaged that no resident will be more than approximately 400m away from an open space area. A preliminary Landscape Masterplan Concept for the Development Area is included, which outlines the landscape design for all POS areas.

2.1 Public Open Space Principles

2.1.1 Generally

The landscape strategy behind public open space development is to provide a readily useable, aesthetic and liveable environment to potential residents from day one. Landscaped open space areas shall incorporate features and facilities to both encourage residential growth and to provide public, aesthetic and site character building amenities to residents. Landscape works shall contain and maximise both aesthetic and functional uses where possible.

Part of the successful delivery of aesthetic and functional POS areas will be the retention of the site's existing significant trees where possible in accordance with proposed Civil Engineering design levels. The retention of existing significant trees will assist in establishing the site's Sense of Place, which will be reinforced through the landscape materials palette.

2.1.2 Materials Palette

It is proposed that close attention to detail will be provided in the landscape detailing and materials selection to ensure the development comprises a palette that is relevant to its locality while creating a quality open space environment.

The inclusion and use of some the following detailing is proposed to achieve this outcome within the project area:

- Paving styles and colours will be chosen to create visual interest, assist in differentiation between area uses and provide hard-wearing surfaces of varying textures.
- Wall detailing through the use of local stone features and laterite coloured limestone retaining where required.
- Durable street furniture of a style and colour palette to co-ordinate with the overall POS design.

- Tree and shrub planting palettes that are aesthetically pleasing while responding to the surrounding natural environment, incorporating water sensitive design species while creating view shafts to develop community value.

2.1.3 Planting Palette

It is proposed that the following indicative planting palette will be used in the amenity areas of the public open space and streetscape hierarchies.

INDICATIVE PUBLIC OPEN SPACE AND STREETSCAPES PLANTING PALETTE

LATIN NAME	COMMON NAME
TREES	
Corymbia calophylla	Marri
Eucalyptus ficifolia	Red Flowering Gum
Eucalyptus leucoxylon rosea	White Ironbark
Eucalyptus lane-poolei	Salmon White Gum
Eucalyptus marginata	Jarrah
Eucalyptus rudis	Flooded Gum
Eucalyptus wandoo	Wandoo
Fraxinus raywoodii	Claret Ash
Jacaranda mimosaefolia	Jacaranda
Liquidamber styraciflua	Liquidamber
Melaleuca preissiana	Modong
Melaleuca rhaphiophylla	Swamp Paperbark
Platanus acerifolia	London Plane Tree
Platanus orientalis digitata	Cut Leaf Oriental Plane Tree
Pyrus calleryana ‘Bradford’	Bradford Pear
Pyrus nivalis	Snow Pear
Pyrus usseriensis	Manchurian Pear
Ulmus parvifolia	Chinese Elm
Zelkova serrata	Japanese Elm
SHRUBS	
Adenathos sericea	Albany Woolly Bush
Acacia lasiocarpa	Panjang
Agonis flexuosa ‘nana’	Dwarf Willow Peppermint
Agonis linearifolia	Swamp Peppermint
Allocasuarina humilis	Dwarf She-oak
Anigozanthos sp	Kangaroo Paws
Callistemon ‘Little John’	Dwarf Bottlebrush
Callistemon phoenicius	Lesser Bottlebrush
Calothamnus quadrifidus	One-sided Bottlebrush
Conostylis candicans	Grey Cottonheads
Dianella ‘Little Jess’	Dwarf Flax Lily
Dianella revoluta	Flax Lily
Dianella revoluta variegata	Variegated Flax Lily
Hypocalymma angustifolium	White Myrtle
Leucophyta brownii	Silver Cushion Bush
Melaleuca lateritia	Robin Red-breast
Melaleuca ‘Little Nessie’	Dwarf Nesophila
Melaleuca teretifolia	Banbar
Melaleuca uncinata	Broom Bush
Melaleuca viminea	Monah
Olearia ‘Little Smokie’	Coastal Daisy Bush
Patersonia occidentalis	Purple Flag
Pimelea sp.	Rose Banjine
Verticordia plumosa	Plumed Feather Flower
Westringia fruticosa	Native Rosemary
Westringia fruticosa variegata	Variegated Native Rosemary

GROUNDCOVERS	
Acacia drummondii	Drummond's Wattle
Acacia cognata 'Limelight'	Acacia
Casuarina glauca 'Cousin It'	Casuarina
Dampiera diversofolia	Dampiera
Dryandra nivea	Honeypot Dryandra
Eremophila glabra	Emu Bush
Eremophila 'Kalbarri Carpet'	Emu Bush
Grevillea bipinnatifida	Fuchsia Grevillea
Grevillea crithmifolia	Coastal Grevillea
Grevillea 'Gin Gin Gem'	Grevillea
Grevillea thelmanniana	Spider Net Grevillea
Scaevola sp.	Fan Flower
Westringia 'White Rambler'	Prostrate Native Rosemary
RUSHES / GRASSES	
Baumea articulata	Jointed Twig Rush
Baumea juncea	Bare Twig Rush
Carex appressa	Tall Sedge
Carex fascicularis	Tassel Sedge
Ficinia nodosa	Knotted Club Rush
Juncus pallidus	Pale Rush
Juncus pauciflorus	Loos Flower Rush
Lomandra longifolia	Mat Rush
Lomandra 'Seascape'	Fine Leaf Mat Rush
Lomandra 'Tanika'	Mat Rush
Viminaria juncea	Swishbush

Table 1: Indicative Public Open Space & Streetscapes Planting Palette

2.2 Multiple Use Corridors

Three major Public Open Space [POS 4, 8 & 9] areas have been designated to include the site's overland drainage paths whilst also designed to accept major and minor stormwater drainage events in an attractive landscape setting. (Refer to the attached Landscape Masterplan). Ranging in size between 6,769 square metres and 4.3 hectares, these open space areas will contain the swales and overland flow path that will be created, contoured and stabilised where necessary to provide a multiple use - drainage / landscaped response. This will be critical to establishing an immediate informal active and passive recreation opportunity as the centrepiece to the development area.

Plate 1: Typical Multiple Use Corridor Landscape Response.

To facilitate multiple uses, it is proposed 1:1 year and 1:10 year stormwater events will be contained within landscaped drainage channels within the POS and the 1:100 year stormwater event contained within the adjacent drainage basins. The drainage channels will typically be planted with side slopes no greater than 1:3 or grassed areas with maximum side slopes of 1:6 grade to allow for ongoing maintenance activities and safe egress in the event of a large stormwater event. Occasional small walls no greater than 900mm in height could exist to provide definition to the drainage channels.

All outlet structures into POS areas will incorporate stabilised water entry points, smooth and even grading of contours and mass planting of suitable native water tolerant tree and shrub species for maintenance minimisation.

All associated landscape infrastructure such as picnic shelters, playgrounds, footpaths and the like will be constructed above the 1:10 year stormwater flood levels. The 1:10 year stormwater levels will not exceed 900mm deep in POS areas and similarly the 1:100 year stormwater flood levels will not exceed 1100mm deep when full.

Pedestrian crossings over the drainage channels will be incorporated into the overall footpath network which will be constructed of all metal subframe with timber or composite decking products as agreed

with the Shire. Balustrading will be provided where the fall heights exceed the requirements of the Building Code of Australia (typically 900mm in height)

There is currently limited to no remnant native vegetation on a large portion of the MUC area proposed within the development area. The existing vegetation over the site has been highly modified through previous farming and land use practices. Several large existing trees are to be retained adjacent to the north-eastern MUC and will remain elevated above any drainage basins to ensure their long term health and viability. These trees [and any other retained vegetation through the site] will have remedial pruning undertaken to ensure accordance with the requirements of fire management techniques.

Edge treatment to the swales will include planted garden beds with mowing kerbs and / or hard edge treatments as a maintenance edge between adjoining turf areas within the open space. Hard edge interfaces will include either one of the following:

- Limestone retaining wall
- Concrete mowing kerb
- Informal granite rockwork

Plate 2: Typical Edging Treatment between Landscape Interfaces.

Plate 3: Typical Multiple Use Corridor Recreational Facilities.

The MUC areas shall incorporate dual use and pedestrian path systems with built in vehicular crossing and access points for maintenance purposes. Dual use and pedestrian systems shall provide smooth and easy access to all features of the open space and link accordingly into residential and other areas adjacent as part of a greenbelt system across the development. Disability access will be given a high priority and will be designed in accordance with relevant Australian Standards.

2.3 Large Parks

One large Public Open Space will be developed as part of the development plan. It will be positioned central to the development and co-located to a proposed Primary School incorporating a shared playing field. This POS will be 4.3 hectares in size and shall incorporate dual use and pedestrian path systems with built in vehicular crossing and access points for landscape maintenance purposes. Dual use and pedestrian systems shall provide smooth and easy access to all features of the open space and link accordingly into residential and other areas adjacent. Disability access will be given a high priority in all large parks and will be designed in accordance with relevant Australian Standards where practicable.

Plate 4: Typical Large Park Amenity Facilities.

The large park will be a parkland area which will offer a range of recreation and community facilities. This area will provide both informal active and passive recreation functions. The parkland shall consist of open grassed spaces bounded and defined by both feature avenue trees and native tree groupings. The western boundary will be defined by a swale with drifts of native plantings and a three row avenue of street trees running up the central boulevard.

Shrub plantings are planned to strategic areas to provide spatial definition and colour where required. Shrub planting shall primarily consist of lower growing species to enable clear vision and security through passive surveillance. It is proposed that the shrubs will consist of native species, with consideration and adherence to Waterwise principles.

Access to the large central POS shall be via the path system running along the east-west tending MUC as well as four additional pathways leading from the central boulevard spine across the swale. These entrances will incorporate gateway features principally situated along the axes of side streets. Through the development of manicured landscaped areas and its associated facilities will be the provision for picnic settings and informal gathering spaces. One of these gathering spaces will be located adjacent to the formal playing field. A shelter will allow surveillance over both the playing field and the informal recreation area to the other side. A piece of play equipment and BBQ will enable a variety of use.

A main playground with feature shelter is to be located adjacent to the north south aligned boulevard road through the development but with strong views and vistas across the open space and from the proposed road network to draw users into the space. Shelters, seating, BBQ's and shade trees will position this as the predominant passive and community activation space within the POS. Positioning of all facilities within the large park will maximise available views towards the Darling Range wherever possible.

The large park will be required to accept some stormwater runoff from the surrounding development area in a multi-use drainage channel as outlined in the Multiple Use Corridor section of this report.

2.4 Pocket Parks

A series of eight (8) smaller to medium sized POS areas, ranging in size from 486sqm up to 2106sqm will also be provided within the development. (POS areas 1-3, 5-7 and 10 on the attached Landscape Masterplan). These parks shall incorporate elements of all the items outlined previously, with the exception of larger informal recreation / kickabout areas and communal features such as BBQ's. The five (5) smallest POS areas will act as enlarged road reserves as a transition from the smaller lot densities to large lifestyle sized lots and consist of feature paths, turf with tree and amenity shrub planting. These Pocket Parks are not designed to accept any stormwater drainage. Their path systems will link to the adjoining residential streets to provide access as necessary. Avenues of trees and minimal shrub planting are preferred. Species will be a mix of native and exotic tree species and native groundcovers that are Waterwise.

The three (3) largest of these parks will typically consist of a central built feature such as a picnic shelter or playground only. The Pocket Park adjacent to the end of Cockram Street will retain a group of existing trees. The elements proposed for this POS will be positioned around these plantings to maximise shade and amenity values whilst considering the tree species habit outlined previously in this report.

Plate 5: Typical Pocket Park Play Area.

2.5 Streetscapes

Streetscapes throughout the development shall incorporate a variety of treatments in response to the road hierarchy system. In all cases landscape works shall incorporate tree planting in accordance with accepted traffic standards on the standard street tree alignment in relation to the service utility corridor. Treatments may include soft works such as street trees, hedge planting and groundcovers.

Final tree species are yet to be agreed however an indicative street tree plan has been included in the appendix to this report and primarily consist of Australian native and West Australian native species. The timing of installation will be to occur at the completion of civil engineering works, prior to the construction of homes. Street trees shall be allocated at one per lot for standard lots and three per lot for corner blocks. Trees will be placed typically centre of lot and / or a minimum of 8m from any boundary to allow for driveway crossovers and in accordance with the corridor provided by utility service providers, being 2.7m from lot boundary.

The retention of existing significant trees to the Mundijong Road boundary and the main boulevard running from that road will enhance the project's landscape theme. The trees will serve an important visual buffer and amenity function in reinforcing the rural character of Mundijong. Within the entrance from Mundijong Road the road reserve has been increased to allow for the proposed retained trees to be accommodated within a wide verge to allow suitable width for long term tree health and maintenance minimisation.

Plate 6: Example of Retained Eucalypts in Medians

2.6 Irrigation Strategy

In general terms the project is committed to undertaking water sensitive design with minimal impact on good quality groundwater sources and preserving water quality.

It is anticipated that irrigation water will be provided through a series of deep aquifer groundwater bores constructed across the open space areas. The flow rate of the production bores will determine the number of bores required, however, it is envisaged that up to three deep aquifer bores will be required for this development. The use of large droplet format sprinklers within turf areas and subsurface drip line irrigation within garden beds will assist in reducing evaporation and aid water conservation.

All irrigation shall be installed to the local authorities' standard specifications and industry best practice. Maintenance minimisation processes will apply in all circumstances. Controllers shall be

keyed and accessed in accordance with the local authorities standards. Irrigation shall be designed to incorporate stations that can be terminated as agreed upon planting establishment and maintenance handover to the Council in accordance with relevant policies.

2.7 Landscape Maintenance

The industry accepted standard Developer funded and managed landscape and irrigation maintenance period is typically two (2) summers as outlined in Liveable Neighbourhoods. Following this period, the landscape and irrigation maintenance will be handed over to the Serpentine Jarrahdale Shire to manage, unless otherwise negotiated.

Typically the first year is an establishment period, followed by a second year of consolidation. Irrigation requirements are to be scheduled to be wound back during this period to a point of almost self sufficiency at the time of handover to the Council.

As part of the ongoing approval process, every public open space landscape and irrigation design will be submitted to and approved by the Serpentine Jarrahdale Shire for Development Application prior to construction commencing.

The Landscape Design will incorporate recreation and environmental requirements, whilst focusing on maintenance minimisation principles and techniques. The developer is committed to working with the local authority to deliver outcomes in this process to reflect best practice throughout the development.

APPENDIX A

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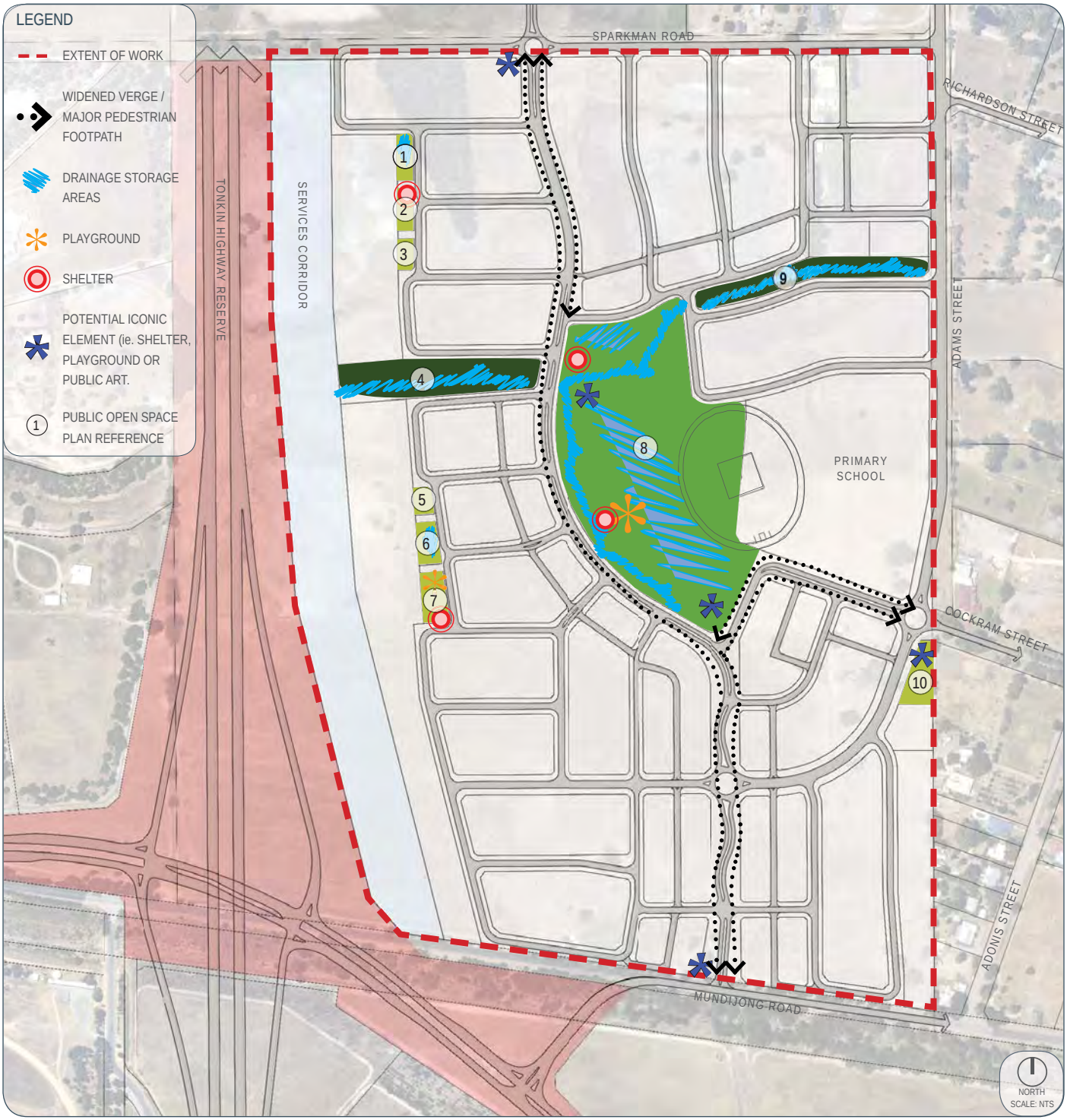
LANDSCAPE STRATEGY PLANS

LANDSCAPE STRATEGY PLAN



PUBLIC OPEN SPACE SUMMARY

LOCAL PARK (POS 1, 2, 3, 5, 6, 7 & 10)

- Predominantly native planted areas with pockets of turf.
- Retention of existing significant trees where possible.
- Small gathering nodes and basic picnic facilities with shade structures.
- Path network which links into the greater development.
- Primary focus on passive recreation.
- Fully irrigated.

LINEAR POS / DRAINAGE SWALE (POS 4 & 9)

- Predominantly native planted areas with pockets of turf.
- Retention of existing significant trees where possible.
- Drainage retention and conveyance through a vegetated and stabilised swale.
- Pedestrian bridge crossings over landscaped drainage swales.
- Informal active recreation uses on open grassed areas.
- Small gathering nodes with picnic / BBQ facilities.
- Path network which links into the greater development.
- Manicured landscape areas fully irrigated.

NEIGHBOURHOOD PARK (POS 8)

- Centrally located and easily accessible to the greater community.
- Predominantly native planted areas with pockets of turf.
- Retention of existing significant trees where possible.
- Drainage retention and conveyance through vegetated and stabilised swales.
- Formal active recreation uses through shared oval with School site.
- Informal active recreation used on open grassed areas.
- Playground with informal seating.
- Large gathering nodes with picnic / BBQ facilities and shade structures.
- Path network which links into the greater development.
- Manicured landscape areas fully irrigated.

LOT 50 COCKRAM ST, MUNDIJONG - STRUCTURE PLAN

LANDSCAPE JOB NUMBER : MG01 : MARCH 2013 : REV B

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LANDSCAPE MASTER PLAN

CONSIDERED

HOMELY

COMFORTABLE

INTERACTIVE

TEXTURAL

CONNECTED

LOT 50 COCKRAM ST, MUNDIJONG - STRUCTURE PLAN

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STREET TREE MASTER PLAN

Liquidambar styraciflua - Red Gum

Corymbia ficifolia - Red Flowering Gum

Eucalyptus wandoo - Wandoo

Corymbia calophylla - Marri

Eucalyptus marginata - Jarrah

Eucalyptus lane-poolei - Salmon White Gum

LOT 50 COCKRAM ST, MUNDIJONG - STRUCTURE PLAN

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POS TREE PLANTING PALETTE


Corymbia calophylla


Melaleuca preissiana


Eucalyptus rudis


Liquidamber styraciflua


Ulmus parvifolia


Corymbia ficifolia


Eucalyptus lane-Poolei


Eucalyptus wandoo


Melaleuca rhaphiophylla


Jacaranda mimisipholia


Eucalyptus leucoxylon rosea


Eucalyptus marginata


Kingia australis


Pyrus nivalis


Xanthorrrhoea preissii

LOT 50 COCKRAM ST, MUNDIJONG - STRUCTURE PLAN

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POS 8 CONCEPT

POS TYPOLOGY

- Neighbourhood Park.

SIZE

- 43,910m2 + 3,390m2 verge.

CONCEPT

- Provide an active recreation POS with a large flat grassed oval for formal recreation in a shared arrangement with the proposed school site (primary school sized oval).
- Drainage retention and conveyance through vegetated and stabilised swales.
- Grassed amphitheatre for viewing sporting activities.
- Possible small community building (by others) to provide public facilities such as a toilets / changerooms / meeting rooms in conjunction with oval uses.
- Large gathering nodes with picnic / BBQ facilities and shade structures.
- Large adventure playground with informal seating opportunities co-located with picnic / BBQ facilities.
- Path network to disability codes which links into the greater development.

FUNCTIONS / MATERIALS

- Provide for stormwater retention and conveyance through vegetated and rock stabilised swales and streams.
- Provide for formal active recreation uses on a large grassed area in a shared arrangement with the proposed school.
- Provide for a large adventure playground with informal seating.

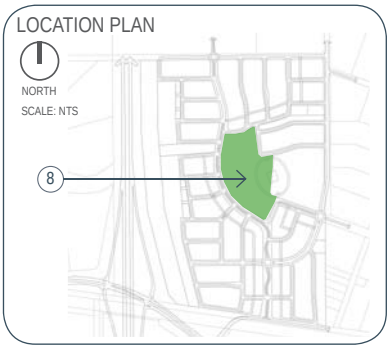
ENVIRONMENTAL CONSIDERATIONS

- Retention and polish of stormwater runoff
- Waterwise Plant Strategy.
- Hydrozoning of plant species.
- Controlled fertiliser application to landscape areas.
- Retain existing trees (where possible).

DRAINAGE CONSIDERATIONS

Basin 4	1:1yr Storm Volume = 480m2 1:5yr Storm Volume = 1,600m2 1:100yr Storm Volume = 1,900m2
Basin 5 & 6	1:1yr Storm Volume = 1,750m2 1:5yr Storm Volume = 5,700m2 1:100yr Storm Volume = 7,000m2
Basin 7	1:1yr Storm Volume = 1,710m2 1:5yr Storm Volume = 3,400m2 1:100yr Storm Volume = 3,900m2
Drain A	1:5yr Flood Width = 9m 1:100yr Flood Width = 10m
Drain B	1:5yr Flood Width = 7m 1:100yr Flood Width = 10m

LOCATION PLAN



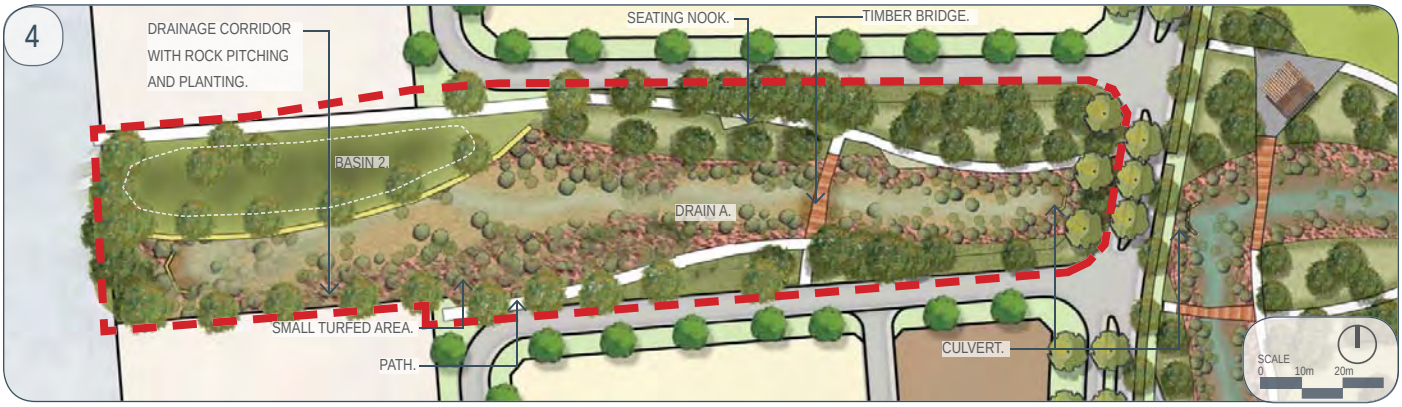
LOT 50 COCKRAM ST, MUNDIJONG - STRUCTURE PLAN

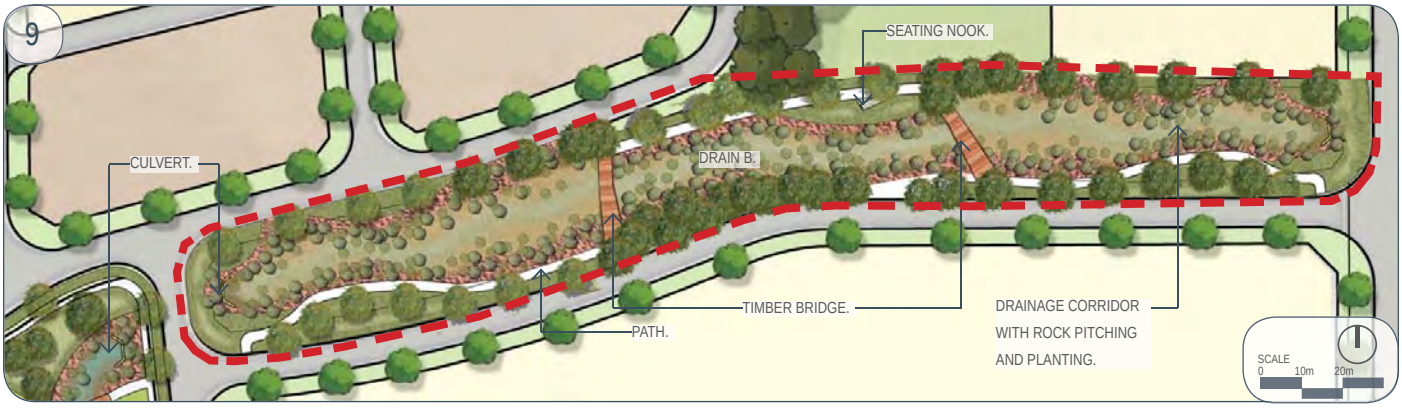
LANDSCAPE JOB NUMBER : MG01 : MARCH 2013 : REV B

emerge ASSOCIATES Integrated Science & Design

THIS DRAWING IS INDICATIVE ONLY AND MAY NOT REPRESENT THE FINAL SCOPE OF LANDSCAPE WORKS

POS 4 & 9 CONCEPT





POS TYPOLOGY

- Linear POS / Drainage Swale

SIZE

- **POS 4** - 7,154m2 + 1,210m2 verge.
- **POS 9** - 4,663m2 + 1,761m2 verge.

CONCEPT

- Provide a POS which caters for drainage retention and conveyance through a vegetated and stabilised swale.
- Path network to disability codes which links into the greater development.
- Shaded seating nooks along path network.

FUNCTIONS / MATERIALS

- Provide for stormwater retention and conveyance through vegetated and rock stabilised swales and streams.
- Provide for informal recreation uses with small gathering nodes with picnic / BBQ facilities.

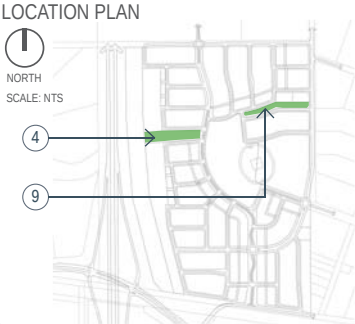
ENVIRONMENTAL CONSIDERATIONS

- Retention and polish of stormwater runoff
- Waterwise Plant Strategy.
- Hydrozoning of plant species.
- Controlled fertiliser application to landscape areas.
- Retain existing trees (where possible).

DRAINAGE CONSIDERATIONS

Basin 2	1:1yr Storm Volume = 540m2
	1:5yr Storm Volume = 1,000m2
	1:100yr Storm Volume = 1,300m2
Drain A	1:5yr Flood Width = 12m
	1:100yr Flood Width = 15m
Drain B	1:5yr Flood Width = 8m
	1:100yr Flood Width = 11m

LOCATION PLAN



LOT 50 COCKRAM ST, MUNDIJONG - STRUCTURE PLAN

LANDSCAPE JOB NUMBER : MG01 : MARCH 2013 : REV B

emerge ASSOCIATES Integrated Science & Design

THIS DRAWING IS INDICATIVE ONLY AND MAY NOT REPRESENT THE FINAL SCOPE OF LANDSCAPE WORKS

POS 1-3 & 5-7 CONCEPT

POS TYPOLOGY

- Local Parks

SIZE

- **POS 1** - 734m2
- **POS 2** - 672m2
- **POS 3** - 490m2
- **POS 5** - 486m2
- **POS 6** - 887m2
- **POS 7** - 1,265m2

CONCEPT

- Provide a series of POS' primarily focussed on passive receration with pockets of turf and feature nodes. on key axis'.
- Feature shelters with picnic and BBQ facilities.
- Provide seating nooks along path network.
- Predominantly native planted garden beds.
- Small playground with informal seating.

FUNCTIONS / MATERIALS

- Provide for stormwater retention in turf and vegetated swales.
- Provide for informal recreation uses with small gathering nodes with picnic / BBQ facilities.

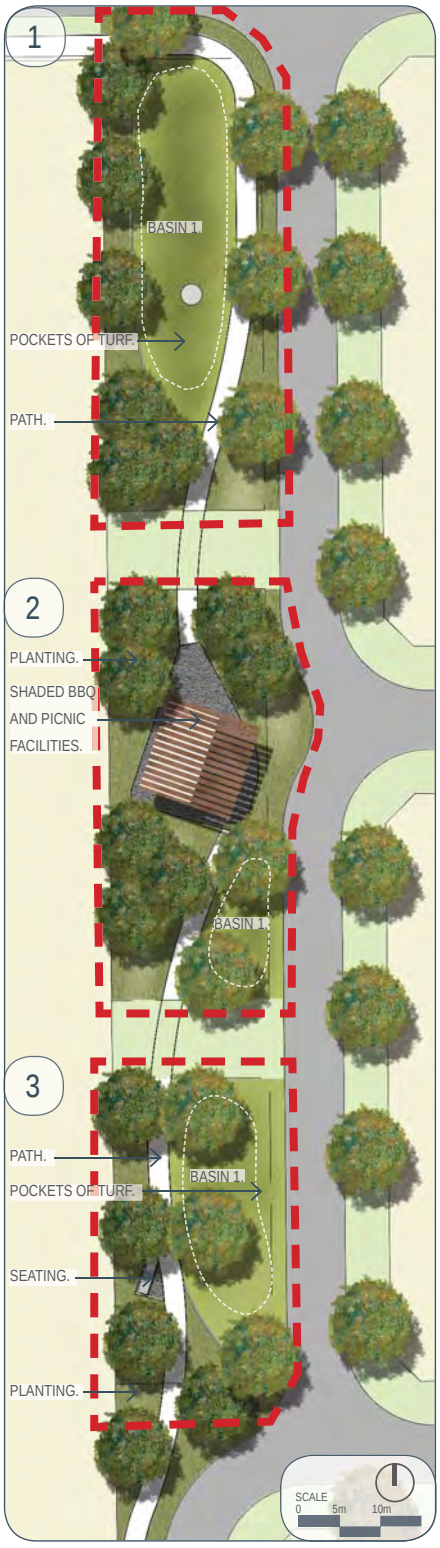
ENVIRONMENTAL CONSIDERATIONS

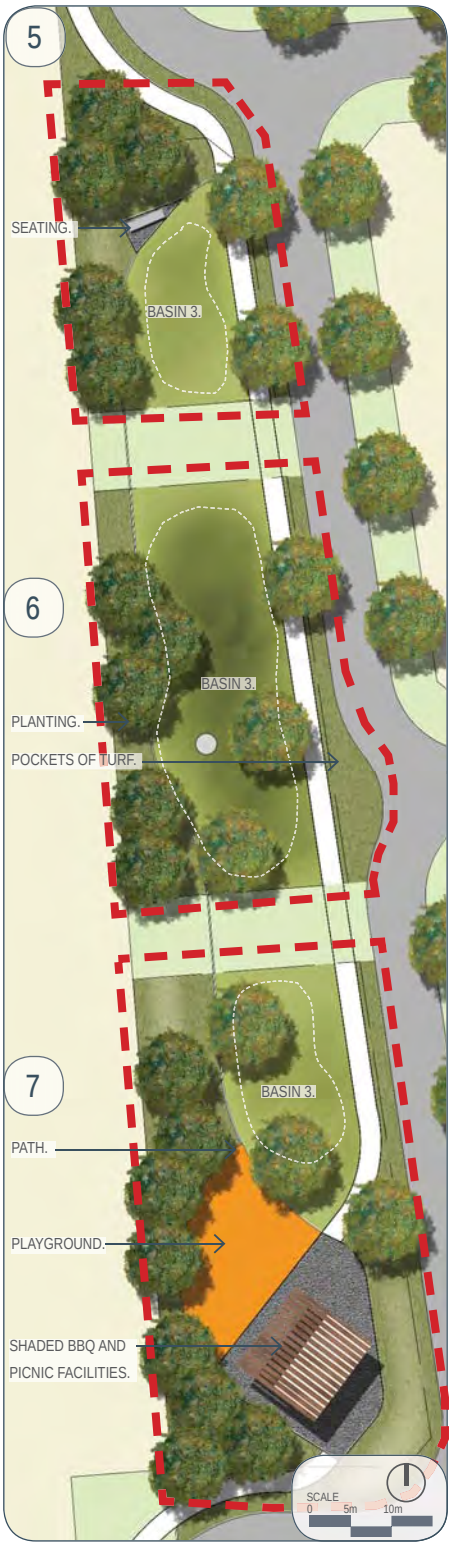
- Waterwise Plant Strategy.
- Hydrozoning of plant species.
- Controlled fertiliser application to landscape areas.
- Retain existing trees (where possible).

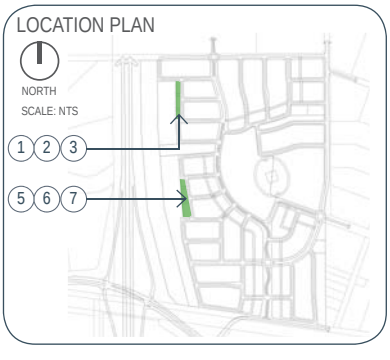
DRAINAGE CONSIDERATIONS

Basin 1
1:1yr Storm Volume = 370m2
1:5yr Storm Volume = 1,000m2
1:100yr Storm Volume = 1,300m2

Basin 3
1:1yr Storm Volume = 1,050m2
1:5yr Storm Volume = 1,800m2
1:100yr Storm Volume = 2,300m2







LOT 50 COCKRAM ST, MUNDIJONG - STRUCTURE PLAN

LANDSCAPE JOB NUMBER : MG01 : MARCH 2013 : REV B

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POS 10 CONCEPT

POS TYPOLOGY

- Local Park

SIZE

- 1,437m2 + 623m2 verge.

CONCEPT

- Provide a POS primarily focussed on passive receration with pockets of turf and seating nooks.
- Predominantly native planted garden beds.
- Retention of existing trees.

FUNCTIONS / MATERIALS

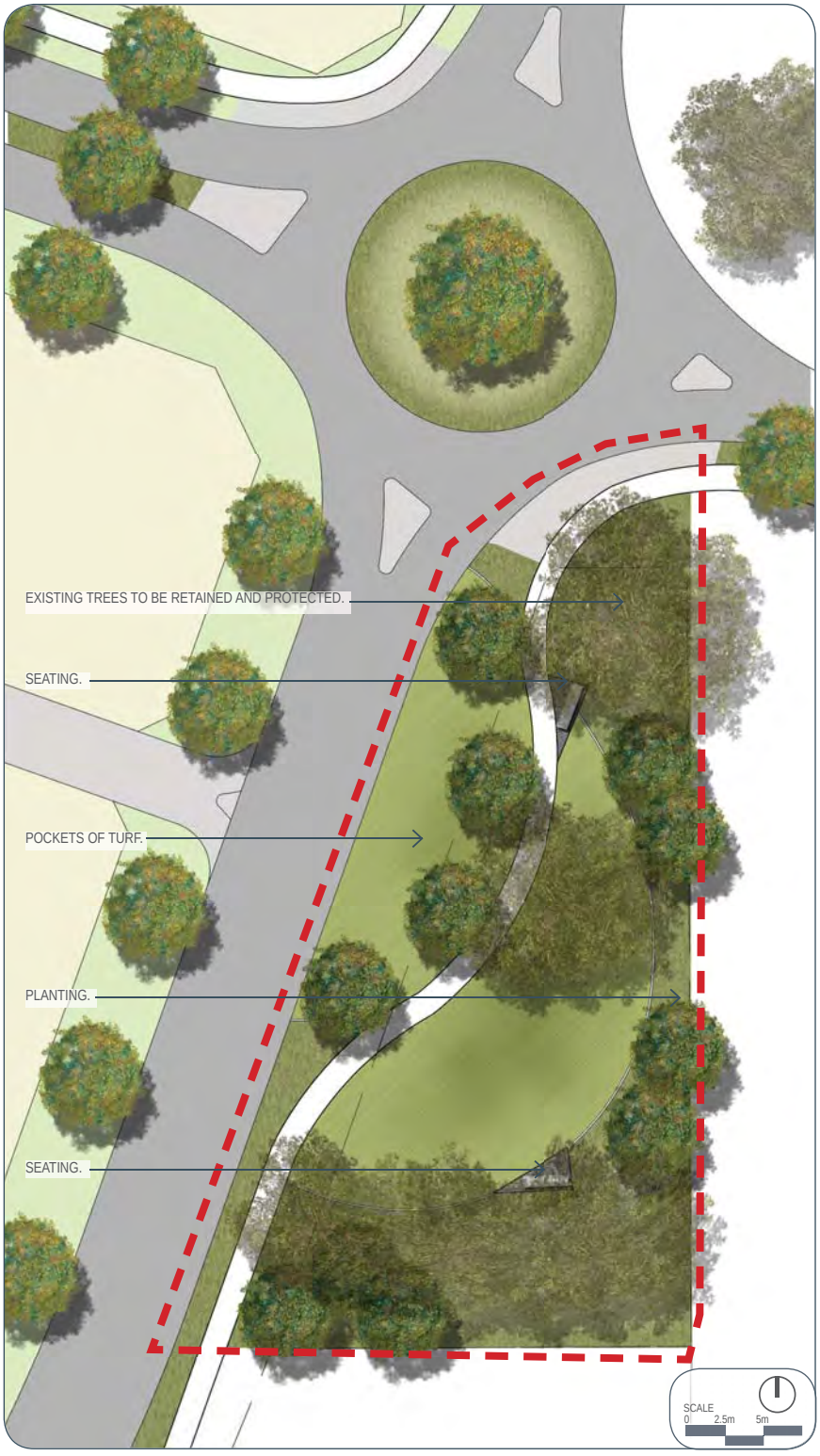
- Provide for informal recreation uses with small gathering nodes.

ENVIRONMENTAL CONSIDERATIONS

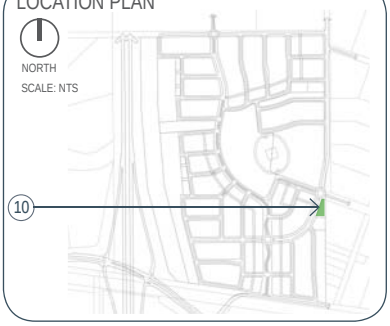
- Waterwise Plant Strategy.
- Hydrozoning of plant species.
- Controlled fertiliser application to landscape areas.
- Retain existing trees (where possible).

DRAINAGE CONSIDERATIONS

N/A



LOCATION PLAN



LOT 50 COCKRAM ST, MUNDIJONG - STRUCTURE PLAN

LANDSCAPE JOB NUMBER : MG01 : MARCH 2013 : REV B

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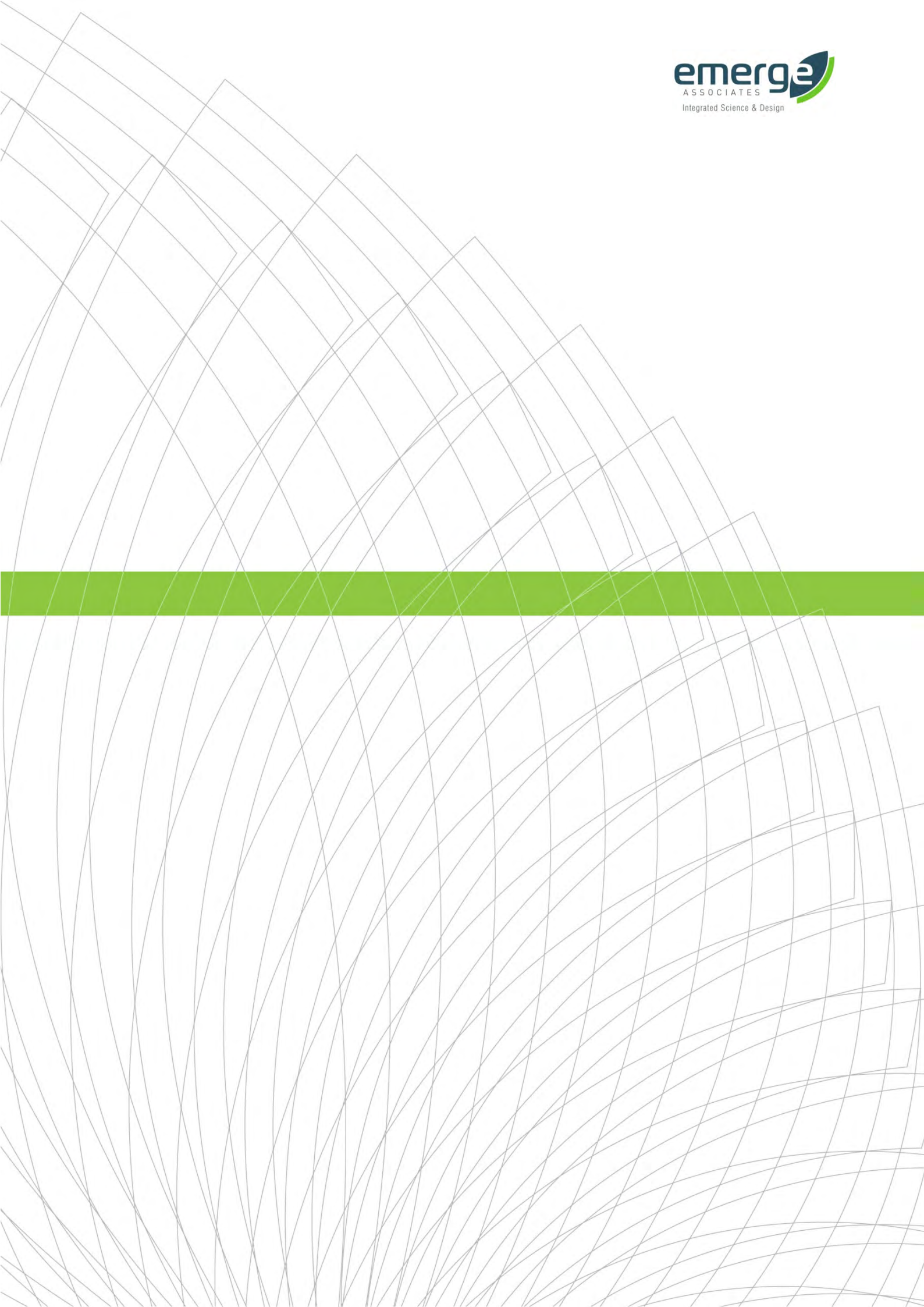
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APPENDIX 7
STRUCTURE PLAN TRAFFIC REPORT

PEET 88 PTY LTD

LOT 50 MUNDIJONG ROAD, MUNDIJONG

STRUCTURE PLAN TRAFFIC REPORT

September 2012

Riley Consulting

PO BOX Z5578

Perth WA 6831

0413 607 779 Mobile

Issued on	12 September 2012	Amendments	Date
Version	V2	Road network amendments	August
Reference	648		

CONTENTS

1.0 EXECUTIVE SUMMARY

Riley Consulting has been commissioned by Peet 88 PTY LTD to consider the traffic and transport impacts of developing Lot 50, Mundijong Road. The development proposes residential dwellings west of Taylor Street between Sparkman Road and Mundijong Road, Mundijong. The key findings of the traffic overview are:

- Lot 50 Mundijong Road is to be developed to provide about 532 dwellings. It is expected that with full development the site will generate about 4,256 vehicle movements per day.

- The traffic assessment undertaken for the structure plan for Lot 50 Mundijong Road has used a Saturn model to derive daily traffic flows on local streets. The model includes traffic generated within the Whitby-Mundijong district structure plan to ensure adjacent development traffic movements are fully considered.

- The development of Lot 50 Mundijong Road has already been included in the traffic planning undertaken for the Whitby-Mundijong district structure plan. The longer term road network requirements should be included in the Whitby-Mundijong district structure plan.

- Development of Lot 50 Mundijong Road in isolation is shown to have little impact to the current operation of the surrounding road network. All external roads are shown to maintain current Levels of Service, except Mundijong Road west, which has a reduced Level of Service from B to C. This is considered a good operating environment.

- Access to Lot 50 can be achieved from Mundijong Road and in the longer term to Adams Street and Cockram Road to include the subdivision within the residential environment of Mundijong. Analysis of the access to Mundijong Road indicates that a priority controlled tee intersection can accommodate the full development of Lot 50.

- In the longer term, as development proceeds to the north of Lot 50 Mundijong Road, additional road links will attract traffic through Lot 50 to access Mundijong Road. Analysis indicates that a single lane roundabout could accommodate the longer term

traffic demands as a result of the development of the Whitby-Mundijong district structure plan. The need for intersection control can be reviewed once the priority tee intersection is deemed to require upgrading. It is considered that development to the north may result in the need for this intersection to be upgraded.

- The road hierarchy developed for Lot 50 Mundijong Road is cognisant of the road network planning for the Whitby-Mundijong district structure plan. Adams Street is shown as a neighbourhood connector. All other streets are shown to carry traffic demands appropriate for access streets. A minimum road reservation of 20 metres is suggested for neighbourhood connectors, 16 metres for higher order access streets and 15 metres for lower order access streets.

- The internal road network has been planned to achieve a 40kph local traffic speed and no additional traffic management measures are considered to be required. Internal intersections are recommended for roundabout control where daily volumes are above the criteria set by *Liveable Neighbourhoods*, or high turning movements are expected.

- All access streets have low daily traffic volumes and are considered appropriate for on-street cycling. A principal shared path is indicated in the Whitby-Mundijong district structure plan adjacent to the future Tonkin Highway. This path provides a convenient north-south connection, but access to the structure plan area may be compromised by the proposed service corridor. This matter need to be addressed once regional planning has determined the accessibility over the service corridor.

- The majority of dwellings in Lot 50 Mundijong Road will be within 400 metres of the proposed bus route identified in the Whitby-Mundijong district structure plan.

2.0 THE SITE AND SURROUNDING ROAD NETWORK

Mundijong is located approximately 40 kilometres south east of Perth. The area falls within the Shire of Serpentine - Jarrahdale and is accessed from the South Western Highway and Mundijong Road. Figure 1 shows the location of the subject land. Roads of importance are discussed below.

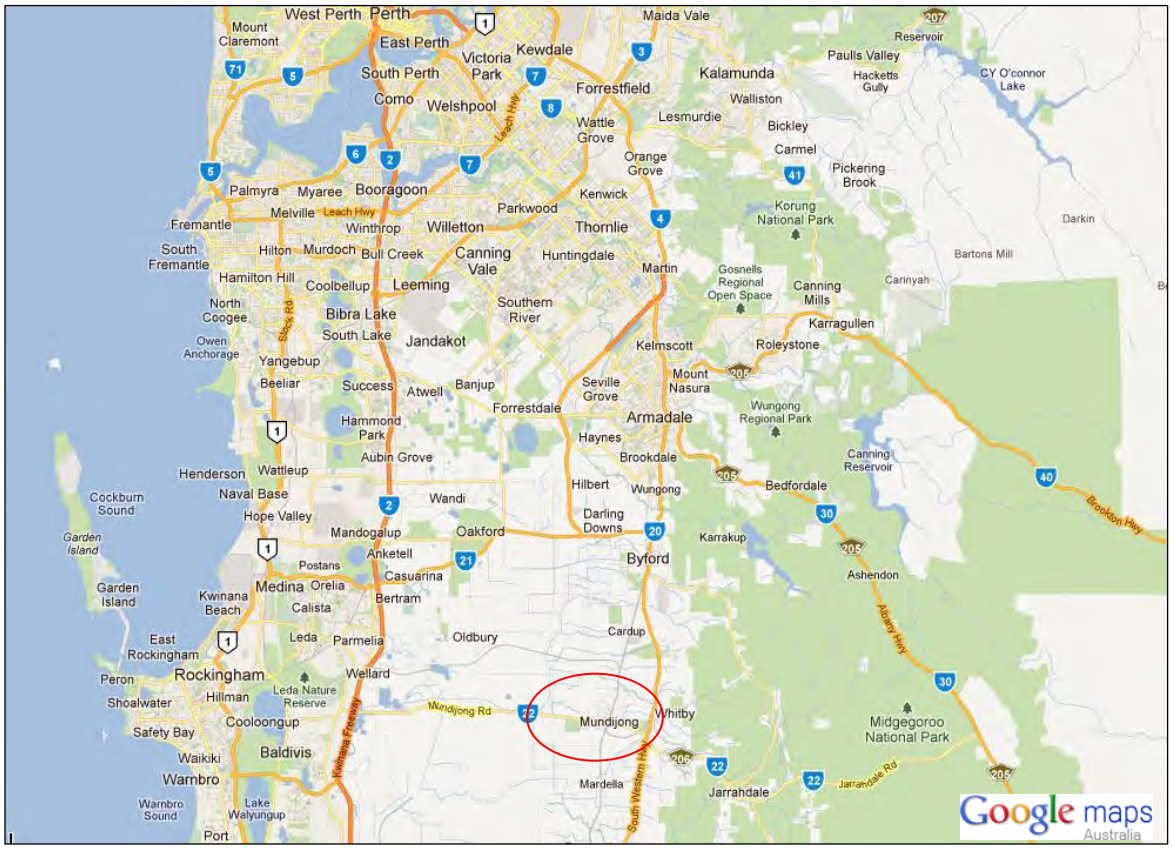


Figure 1 Site Location

South Western Highway

The South Western Highway is a primary regional road under the control of Main Roads Western Australia (MRWA). It provides a major traffic and freight route between Pinjarra to the south and the eastern industrial areas of Perth (Kewdale and the airport etc). It also provides connectivity at a regional level to the Tonkin Highway and Albany Highway.

Photograph 1 South Western Highway

Photograph 1 shows the view looking north along the South Western Highway to Watkins Road (Mundijong Road).

The South Western Highway is generally constructed as a rural standard single lane road with 2 traffic lanes. A northbound overtaking lane exists at the intersection of Watkins Road, which will make egress from Watkins Road difficult and potentially dangerous during busy periods. A right turn deceleration lane is provided on the highway for southbound traffic. The South Western Highway has a posted speed limit of 90kph adjacent to the locality of Mundijong.

Current traffic data provided by MRWA indicates 9,110 vehicle movements per day (11.8% HGV) to the south of Watkins Road. This daily volume picks up the regional freight movements from Jarrahdale Road to the south.

Watkins Road – Mundijong Road

Watkins Road is the continuation of Mundijong Road to the east of the Perth – Bunbury rail line. It is constructed as a single carriageway road with 2 traffic lanes. A standard 7.2 metre carriageway is provided. A controlled level crossing is provided at the railway line. A 60kph posted limit applies through the townsite area. To the west, about 200m west of Patterson Street, an 80kph posted limit applies. Approximately 50 metres west of Adonis Street a 100kph posted limit applies.

Photograph 2 Watkins Road


Photograph 3 Mundijong Road

Photograph 2 shows Watkins Road looking towards Mundijong. Photograph 3 shows Mundijong Road west of the town looking to the west.

Current traffic data (2008/09) provided by MRWA indicates 2,400 vehicle movements per day on Watkins Road to the west of the South Western Highway. The current level of traffic movements at this location supports the current provision of yield control to Watkins Road.

Traffic data sourced for Mundijong Road shows:

- 3,280vpd west of Patterson Street
- 2,790vpd east of Baldivis Road
- 3,430vpd east of the Kwinana Freeway

Overall it can be seen that Watkins Road and Mundijong Road are operating well within their derived operational capacity and will experience very good Levels of Service.

Patterson Street / Soldiers Road

Patterson Street is the main street to the Mundijong townsite and is constructed with a wide 9 metre carriageway (approximate). Photograph 4 shows Patterson Street at Mundijong town centre. Patterson Street links Mundijong Road to Abernethy Road in Byford. It is classified as a district distributor type A road in the MRWA *Functional Road Hierarchy.* Historical traffic data from MRWA (2004/05) indicates 2,200 vehicle movements per day. It is unlikely that this daily volume has changed significantly.

Photograph 4 Patterson Street

Bishop Road

Bishop Road provides an east-west connection between Kargotich Road and Soldiers Road. It is classified as a local distributor road and lies to the south of the freight rail line and to the northern side of the Mundijong structure plan area. Photograph 5 shows the view looking along Bishop Road.

Photograph 5 Bishop Road

No traffic data is available, although it can be expected that current volumes are well below 500 vehicles per day. Close to the intersection of Soldiers Road is a school that can be expected to increase traffic flows at the eastern end. However, such increases would only affect school pick-up / drop-off periods typically between 08:15 – 09:00 and then 14:30 to 15:30.

Kargotich Road

Kargotich Road is classified as a district distributor type B road in the MRWA *Functional Road Hierarchy*. It provides a currently important north-south connection between Mundijong Road and Thomas Road. However, construction of the future Tonkin Highway will attract the majority of traffic using this road.

Traffic data from MRWA indicates 1,730 vehicle movements per day to the north of Bishop Road.

Taylor Road / Adams Street

Classified as local distributor roads, Taylor Road and Adams Street provide a convenient north-south link between Richardson Street and Bishop Road. Photograph 6 shows the view looking north along Taylor Road close to Lang Road.

Photograph 6 Taylor Road

The current sealed width of Taylor Road / Adams Street is about 6 metres (approximately) and may require additional width to cater for significant increases in traffic demand. There is an existing bridge over Manjedal Brook approximately 400 metres south of Bishop Road.

At Bishop Road a left-right stagger leads to Hopkinson Road, which is classified as a district distributor type B road. Hopkinson Road provides a convenient link to the south of Armadale and may be attractive to commuter traffic. However, the development of the Tonkin Highway will negate Hopkinson Road as a desirable route.

Livesey Street and Tonkin Street

These two streets are existing east-west connections between Patterson Street and Adams Street. Constructed with standard 7.2 metre wide carriageways, these streets are rural residential in nature.

Cockram Street

Cockram Street is a local access street that links Adonis Street through to Patterson Street. It is bounded by larger residential lots and provides access to local sporting facilities. It is constructed with a standard 7.2 metre wide carriageway (approximate). Present day traffic

movements would be expected to be less than 500 vehicles per day. West of Butcher Street a standard 20 metre wide road reservation is provided.

Adonis Street

Adonis Street is a local access street that links Richardson Street to Mundijong Road. It is bounded by larger lots and provides access to about 8 properties south of Cockram Street. It is constructed with a standard 7.2 metre wide carriageway (approximate). Present day traffic movements would be expected to be less than 500 vehicles per day.

Kiernan Street

Kiernan Street is a local access street providing an east-west connection between Patterson Street and Taylor Road. Photograph 7 shows the view along Kiernan Street.

Photograph 7 Keirnan Street

No traffic data is available for Kiernan Street, but based on current levels of development accessed from this link, a daily flow of less than 500 vehicles would be expected.

Tonkin Highway

To the west of Lot 50, an existing road reservation is set aside for the construction of the future Tonkin Highway. At present the construction of the Tonkin Highway is not in the MRWA 4-year programme. It can be expected to be required at the time when daily volumes on the South Western Highway reach about 15,000vpd. At this point a poor Level of Service will exist for regional movements and widening would be warranted. However, the construction of the Tonkin Highway would negate the need to widen the South Western Highway.

Appendix A shows the current MRWA / DPI planning for the Tonkin Highway adjacent to Mundijong. As part of the highway proposal, a re-alignment of Mundijong Road to provide a connection to Jarrahdale Road has been indicated.

Current traffic volumes on the Tonkin Highway north of Armadale Road are about 13,000vpd. It would be expected that the future extension would carry about 9,000vpd on opening.

Mundijong – Whitby District Structure Plan

A district structure plan has already been prepared for the Whitby – Mundijong locality and is provided on the Shire of Serpentine – Jarrahdale website. Traffic forecasts have been provided and are attached as Appendix B.

As a result of the traffic forecasting for the district, the following works can be expected:

- Mundijong Road – Forecast flow of 12,000vpd. Single lane road would operate but with increased delay in peak periods. If railway crossings removed, the volume increases to 16,000vpd. Therefore assume road reservation of 30 metres for future duplication to be required.

- Taylor Road / Adams Street – Forecast flow of 5,000vpd. Therefore assume road reservation of 20 metres for neighbourhood connector to be required.

Figure 2 shows the local structure plan used for the traffic analysis.

Figure 2 **Draft Structure Plan** (refer to planner for detail)

3.0 TRAFFIC GENERATION AND DISTRIBUTION

The development of residential land at Mundijong will provide for the growing population forecast for Perth and the south eastern rural areas.

Reference to trip generation source documents suggest that the trip generation of a typical household can vary from 5 trips to 11 trips per day. Traffic analysis of similar development to the north of Mundijong identified a residential trip rate of 8 trips per dwelling per day, which is slightly higher than the Perth metropolitan average rate of 7 trips per day. The trip rate is based on typical R20 density which is attractive to families.

It is understood that other developments have indicated a higher density level of development in Mundijong that may be expected to generate a lower average rate per household. However, the use of 8 trips per dwelling will provide a robust assessment of the road network and provide flexibility for future planning to meet customer demands.

The concept plan indicates a yield of 532 residential lots and on the basis of 8 trips per lot the site can be expected to generate (532 x 8) 4,256 vehicle movements per day.

Lot 50 Mundijong Road is expected to generate 4,256 trips per day.

The subject land will provide a primary school which will retain traffic within the developable area.

Distribution

Table 1 shows the distribution assumptions by trip purpose used to assign traffic onto the external road network.

The traffic generation and distribution has been used to prepare a matrix for the Saturn traffic model.

Table 1 Composition of Residential Trips

Purpose of trips	% of Total	North Tonkin	North SW Highway	East	South – SW Highway	South - Freeway	West Rockingham / Freeway north
Home Based – Work	29%	30%	8%	2%	10%	10%	40%
Home Based – Education	Assigned by school						
Home Based – Other	36%	15%	5%	5%	10%	15%	50%
Home Based – Evening	21%	30%	10%	0%	0%	10%	50%
Non-Home Based	14%	50%	5%	0%	3%	7%	35%

Traffic Modelling

The development of Lot 50 Mundijong Road will need to be considered in regard to development within the Mundijong district structure plan area as indicated in Appendix C. A traffic model has been created using Saturn to assign traffic to the future road network. The model uses the trip generation and distribution assumptions discussed above applied to the district structure plan area.

The following assumptions have been made with regard to traffic accessing the surrounding road network. The speeds are the estimated journey time speeds including movement delays at intersections etc - they may not match the free-flow posted speed.

- New residential roads operate with a speed of 40kph and 30kph.
- Neighbourhood connectors operate at 50kph.
- Mundijong Road operates at 60kph between Tonkin Highway and the rail crossing, then 70kph.
- Tonkin Highway / Mundijong Road re-alignment operates at 80kph (long term)
- South Western Highway 110kph
- Freeway and Tonkin Highway 100kph
- Bishop Road operates at 60kph
- Soldiers Road operates at 60kph and 70kph north of Bishops Road

Trips to schools are based on the Education Department's assessment of 0.35 pupils per household. 30% of home based other trips are assigned to localised shopping (Whitby district centre and Mundijong town centre).

4.0 DEVELOPMENT TRAFFIC IMPACTS

The development of Lot 50 is anticipated to generate a total of 4,256 trips per day and it can be expected that this development may be one of the first to occur. Assuming that direct access is taken to Mundijong Road and developments to the north are not connective, Figure 3 shows the forecast traffic movements. The daily flows indicated assume no facilities within Lot 50 such as a primary school and local shops (thus 100% of traffic leaves the site) Table 2 shows the anticipated road network impacts.

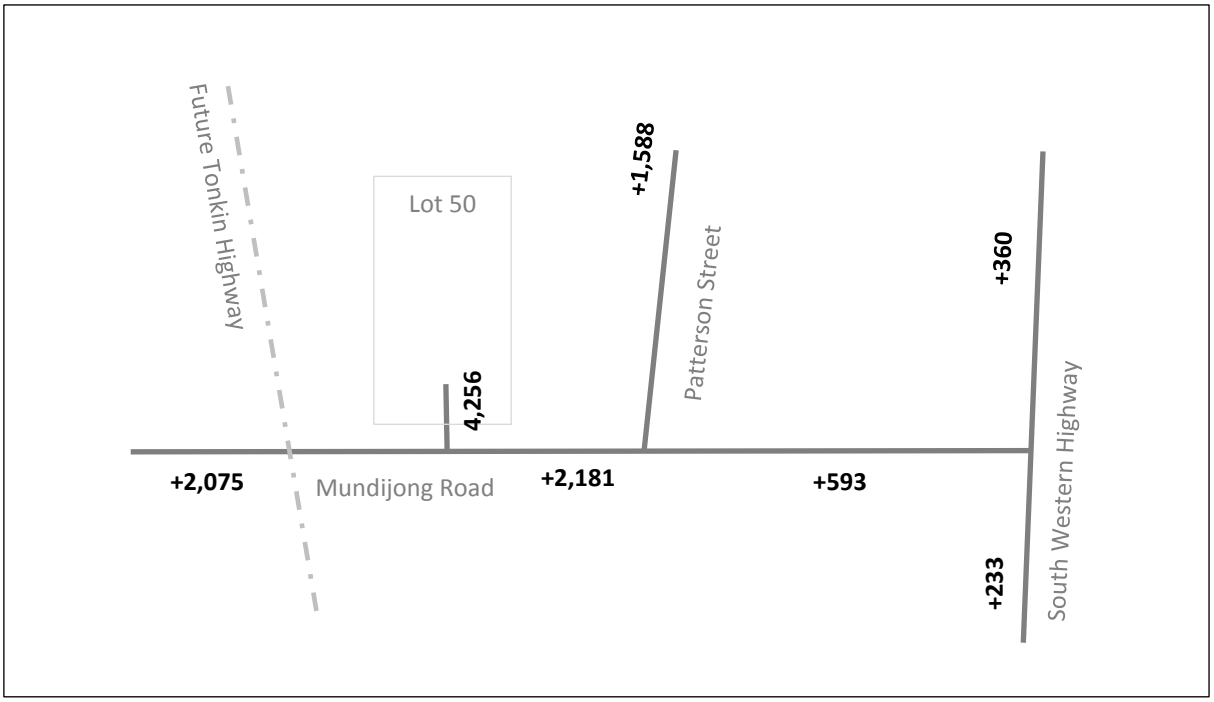


Figure 3 Forecast Traffic Flows

Table 2 is based on current traffic flows in the locality. Whilst it could be argued that growth will occur to current traffic flows, the traffic "growth" will be as a result of development in the locality and thus factoring up current data to a forecast year would result in an artificially higher traffic flow (in effect, double counting the proposed developments). Table 2 shows that the development of Lot 50 in isolation would not warrant any upgrading to the existing road network.

Table 2 Lot 50 Traffic Volumes and Levels of Service

Road	Type	Lot 50	Forecast	LoS
Mundijong Rd west of Patterson St	1	2,181	5,461	C
Mundijong Road east of Tonkin	1	2,075	4,865	C
Mundijong Rd east of Baldivis Rd	1	1,343	4,133	B
Watkins Rd	1	593	2,993	B
South Western Highway north	1	360	9,470	D
Patterson St	1	1,588	3,788	B
Soldiers Rd	1	1,588	3,788	B
Lot 50 Access Rd	1	4,256	4,256	B
Taylor Rd	1	0	500	A
Adams St	1	0	500	A

The LoS is based on Appendix A

Analysis of the proposed access to Mundijong Road is provided within the Access section of this report to determine if any form of control is required in the interim periods prior to development to the north being connective.

The existing road network can accommodate the development of Lot 50.

Development within the Whitby – Mundijong DSP

As has been stated, Lot 50 falls within the Whitby – Mundijong district structure plan and the traffic associated with the proposed development of Lot 50 has already been considered from a district perspective. Based on the traffic forecast of the district structure plan (attached as Appendix B), the following district road upgrades can be expected.

Mundijong Road

Full development of the Whitby - Mundijong structure plan area will result in significant traffic increases to Mundijong Road west of Mundijong townsite. The modelling undertaken indicates that a future demand of up to 16,000vpd could be experienced between the Mundijong Road re-alignment and the access to Lot 50. A boulevard would be expected to cater for this forecast demand, but would operate with lower Levels of Service during peak periods. As the access of Mundijong Road to the Mundijong Road re-alignment is likely to be controlled by traffic signals in the longer term, capacity of Mundijong Road will be

controlled by the intersection. The duplication of Mundijong Road is unlikely to provide any additional capacity.

It is noted that a 40m blue road reservation is included in the MRS west of the Tonkin Highway alignment that would accommodate a four-lane divided road. To the east a 20m road reserve is shown with an additional 40m indicated to the south. The whole road reserve is indicated as being subject to Bush Forever.

Between the Tonkin Highway and the Mundijong Road re-alignment, a four-lane divided road would be required. Future planning has already indicated that Mundijong Road west of the Tonkin Highway would be upgraded to provide a four-lane divided road.

It is considered that regional planning has set aside sufficient land for any future widening of Mundijong Road within the Whitby-Mundijong district structure plan area.

Whilst indicatively the forecast volume on Mundijong Road may suggest duplication, it is considered that such duplication will achieve little benefit.

Lot 50 Access Road

Primary access to Lot 50 and development to the north will be taken via the Lot 50 access road. Ultimately, the daily traffic volumes on this link are shown to be in the order of 10,000vpd approaching Mundijong Road, but quickly dissipate as the road heads north. The forecast traffic flow can be accommodated by a standard 7.2 metre wide carriageway, although widening at major intersections may be necessary.

It should also be noted that the higher volume using the Lot 50 access road could be reduced by traffic redistributing to Adonis Street. The modelling indicates that this is not a desirable route for Lot 50 traffic accessing Mundijong Road, but would be attractive to development further north.

Adams Street / Taylor Road

Adams Street is currently provided with a 20 metre road reservation. In isolation, Lot 50 is highly unlikely to increase traffic movements on Adams Street / Taylor Road until the development connects to Adams Street. This connection will be progressively upgraded as adjacent land is developed.

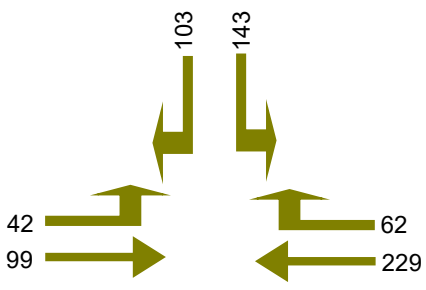
5.0 ACCESS

Lot 50 is presently accessed from Mundijong Road and has a frontage to the road reserve of Adams Street (unmade) and also frontage to Sparkman Road to the north. It is possible to develop Lot 50 in isolation with access taken purely from Mundijong Road. In the longer term, the development of Lot 50 would become part of Mundijong and will accommodate the neighbourhood connector of Adams Street / Taylor Road.

Access to streets other than Mundijong Road will be created as new streets are planned in accordance with *Liveable Neighbourhoods*. The operation of these streets is considered in the next section of this report.

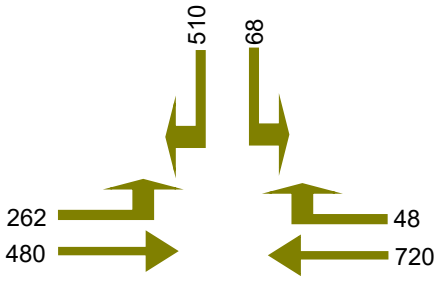
As discussed, access to Lot 50 will be taken directly to Mundijong Road and in the first years of development would operate as a priority controlled intersection. In the longer term, traffic associated with developments to the north will pass through Lot 50 and affect the operation of the proposed intersection with Mundijong Road.

Based on the traffic modelling, Figure 4 indicates the anticipated peak hour movements (indicative) with Lot 50 developed in isolation and with the full development of the district structure plan area.



Assume reverse for PM peak

Interim Lot 50 Development



Assume reverse for PM peak

Note distribution changes as a result of Tonkin Highway

Whitby-Mundijong DSP Development

Figure 4 Lot 50 Access / Mundijong Road Forecast AM Peak Hour Movements

The Sidra analysis of the intersections is attached as Appendix F for the full development of Lot 50 in isolation and Appendix G for the Lot 50 Access with full development of the district structure plan. Table 3 provides a summary of the analysis shown in Appendix F.

Table 3 Lot 50 Access to Mundijong Road - Peak Hour Assessment

Approach	V/C	Delay	LoS
AM Peak			
Mundijong Road east	0.126	2s	A
Lot 50 Access	0.233	11s	A
Mundijong Road west	0.079	2.5s	A
PM Peak			
Mundijong Road east	0.151	5.9s	A
Lot 50 Access	0.116	12.3s	B
Mundijong Road west	0.186	2.6s	A

Where V/C = volume of capacity
Delay is average delay per vehicle
LoS = Level of Service

Table 3 indicates that the full development of Lot 50 need only be provided with a simple tee intersection to Mundijong Road. It is recommended that an urban standard right turn lane be provided to shelter turning traffic.

A simple tee intersection to Mundijong Road will support full development of Lot 50.

Whitby – Mundijong District Structure Plan

At some future time, land to the north of Lot 50 will be developed and the traffic forecasts indicate a potential for about 9,000vpd to use the Lot 50 access to Mundijong Road. As a result of development elsewhere, traffic flows are forecast to increase on Mundijong Road and the DSP modelling suggests an increase to 12,000vpd (refer Appendix B). Figure 4 shows the likely peak hour traffic demands at the Lot 50 Access with the traffic from the DSP modelling. It is a given that with a demand of 12,000vpd on Mundijong Road, a priority tee intersection will fail to operate in a safe and acceptable manner. It is anticipated that a single lane roundabout would provide sufficient capacity to cater for the forecast movements. The analysis is attached as Appendix G and summarised in Table 4.

Table 4 Lot 50 Access to Mundijong Road with DSP - Peak Hour Assessment

Approach	V/C	Delay	LoS
AM Peak			
Mundijong Road east	0.984	48.5s	D
Lot 50 Access	0.645	17.2s	B
Mundijong Road west	0.525	5.1s	A
PM Peak			
Mundijong Road east	0.509	7s	A
Lot 50 Access	0.48	17s	B
Mundijong Road west	0.838	5.8s	A

Where V/C = volume of capacity
Delay is average delay per vehicle
LoS = Level of Service

Table 4 indicates that the provision of a single lane roundabout should be able to cater for the forecast traffic demands at the Lot 50 Access to Mundijong Road, based on the forecast of 12,000vpd using Mundijong Road. However, it should be noted that a roundabout will be sensitive to fluctuations in turning movements and traffic movements should be checked when upgrading of the priority intersection occurs.

The future provision of a roundabout to the Lot 50 Access to Mundijong Road will be as a result of other development in the locality. The cost of the roundabout should therefore be a condition of future development to the north of Lot 50. However, if additional use of Adonis Street is made, a roundabout may not be necessary.

6.0 THE INTERNAL ROAD NETWORK

The traffic model has been used to determine the anticipated daily traffic flows on local streets. Figures 5 through 8 show the modelled forecast flows. The forecasts assume full development of the Mundijong and Whitby localities.

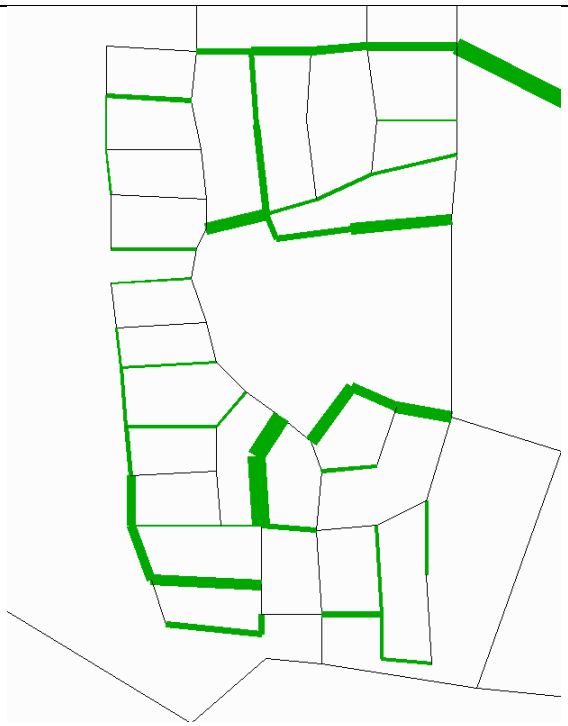


Figure 5 Roads less than 1,000vpd

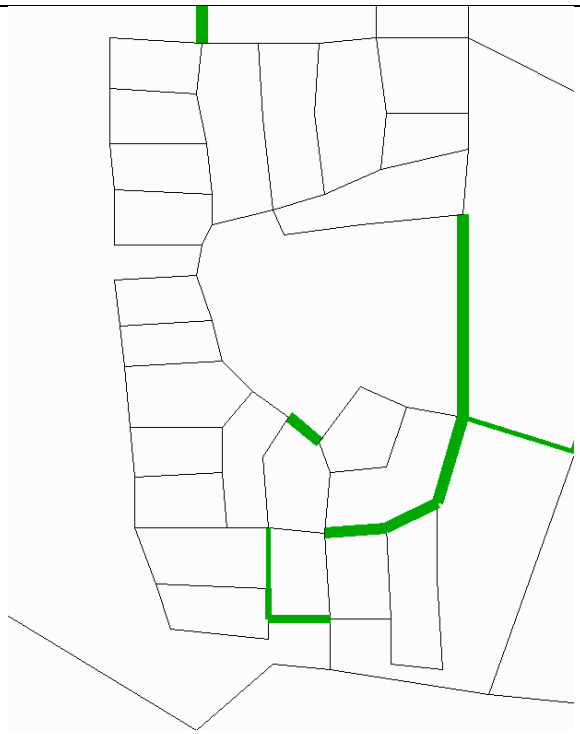


Figure 6 Roads 1,000-3,000vpd

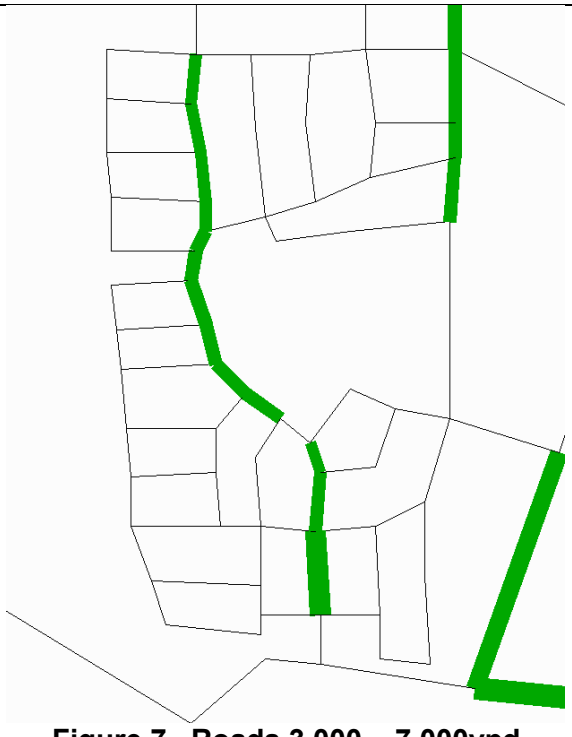


Figure 7 Roads 3,000 – 7,000vpd

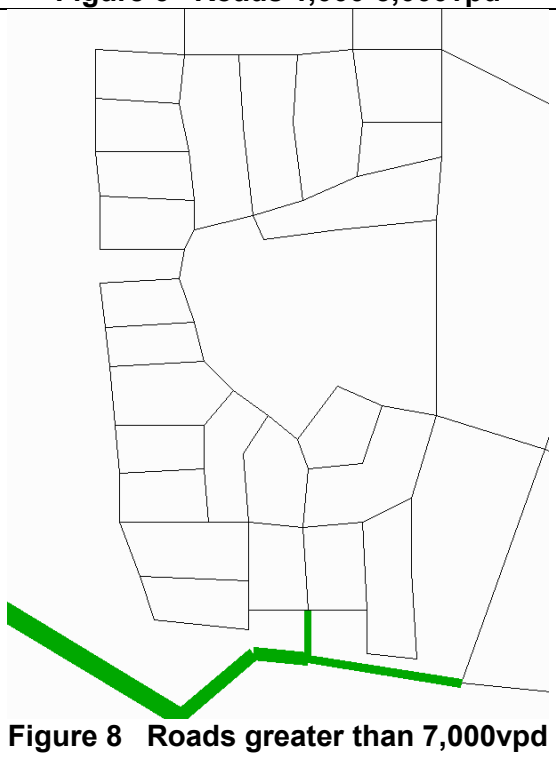


Figure 8 Roads greater than 7,000vpd

The forecast traffic flows provide a basis to develop an internal road hierarchy. Table 5 reproduces the advice on road types recommended by *Liveable Neighbourhoods.*

Table 5 *Liveable Neighbourhoods* Road Hierarchy

Indicative Daily Traffic Flow*	**Designation**	**Street Characteristics**
< 1,000 vpd	Access Street	Narrower access streets (5.5 to 6m) may be appropriate in locations further away from centres and activity where traffic flows are less than 1,000 vpd and a low on-street parking demand exists.
1,000 vpd to 3,000 vpd	Higher Order Access Street	Wider access streets (7 to 7.5m) cater for higher traffic volumes and are located closer to neighbourhood centres.
3,000 vpd to 7,000 vpd	Neighbourhood Connectors	Generally 2-lane undivided. These are 'special' streets and their design needs to have regard to context, function and adjacent land uses.
7,000 vpd to 20,000 vpd	District Distributor Type B	Typically will have 1 clear lane of travel in each direction and a parking / manoeuvring lane.
15,000 vpd to 35,000 vpd	District Distributor Type A	Typically have service roads and development frontage with ample on-street parking to support a mixture of land uses. Direct vehicle access from adjoining property should be limited where no service roads are provided.

* Function of streets needs to be considered as well as traffic volume.

The road hierarchy considers those streets that have a connective function and assigns an appropriate classification based on volume and continuity of movement.

Figure 9 shows the suggested road hierarchy for Lot 50 Mundijong.

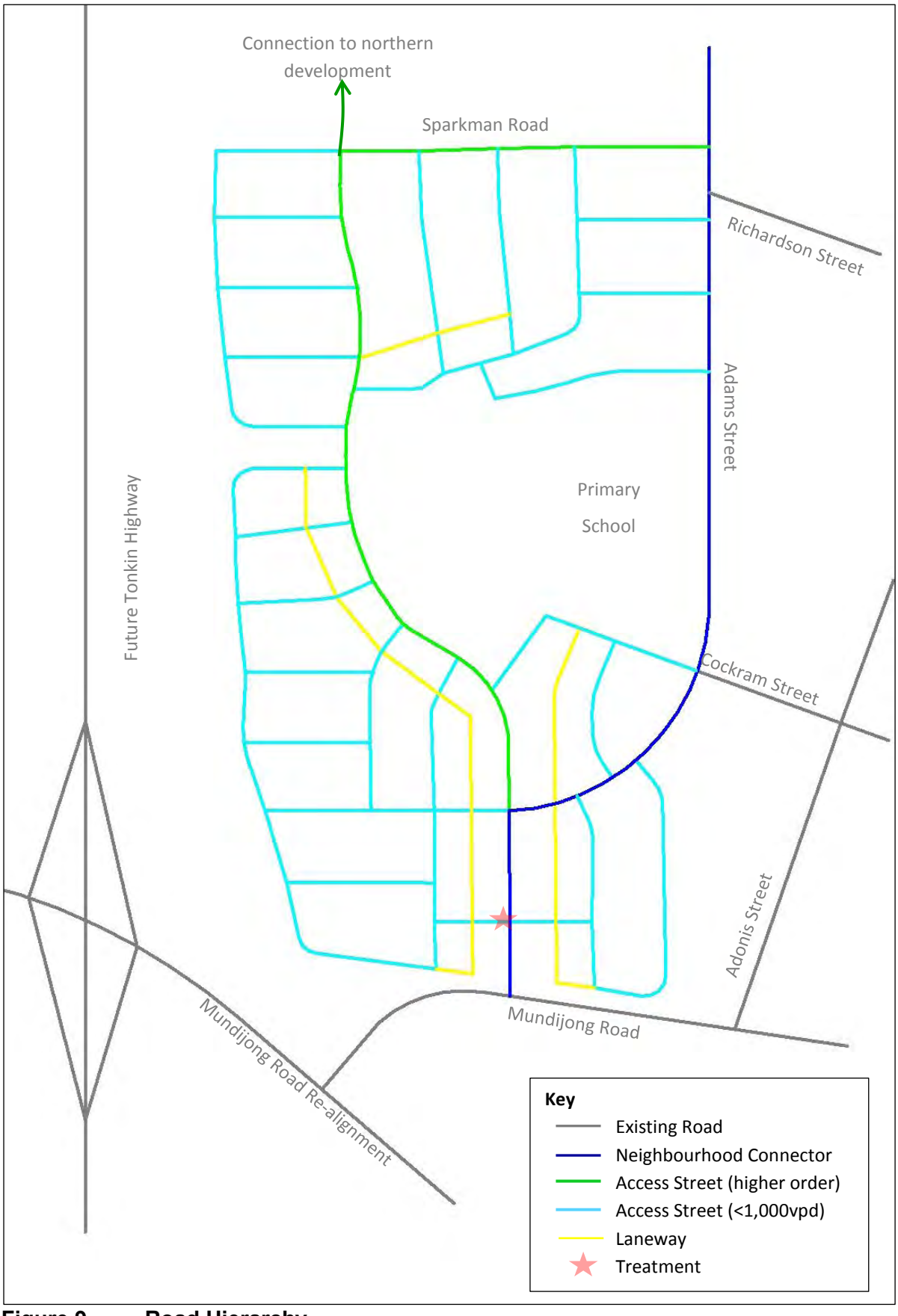


Figure 9 Road Hierarchy

The following section provides guidance on the suggested hierarchy with regard to reserves and cross-sections. The cross-sections indicated are the minimum widths recommended for the various street types. The philosophy of providing constrained streets is to encourage a slower speed environment. However, wider reservation widths may be used to suit the character of the development and increase the opportunity for landscaping and frontage activity.

Neighbourhood Connectors

Liveable Neighbourhoods provides the following comment on neighbourhood connectors:

> *Neighbourhood connectors link neighbourhoods and towns, are carefully designed to calm traffic, limit noise and facilitate pedestrian use. They have frequent local street connections. They should not attract substantial long distance through traffic, but provide for safe and convenient local travel to and from arterial routes, usually at signal controlled intersections.*

Roads shown blue in Figure 9 are considered as neighbourhood connectors as they provide the primary access to the structure plan area. Daily traffic flows on these roads are well within the 7,000 vehicles per day recommended. These streets can be provided with a standard 7.2m carriageway, which is suited to bus movements. A footpath to both sides of the street is required, although one side may be designated as a shared path. Figure 10 shows a suitable cross-section with localised widening at intersections.

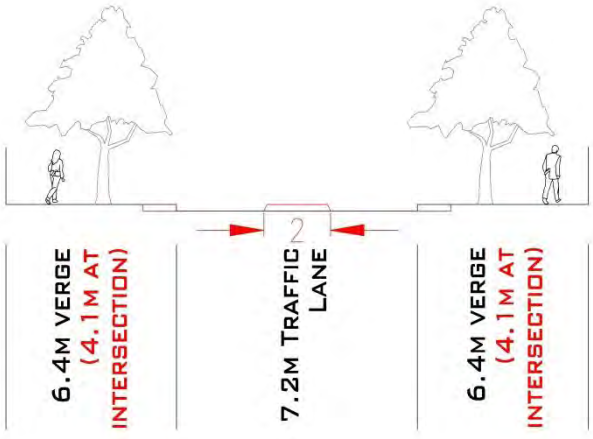


Figure 10 20m Road Reserve

At intersections, median islands of 2.0m width would be desirable to provide safer pedestrian crossing points and to highlight the intersection. A residual verge width of 4.1m will occur where such medians are provided.

A minimum 20.0m cross-section is recommended for neighbourhood connectors

Access Streets

Access streets are the main residential streets within the development and provide direct lot access. A typical access street would be provided with a 6.0m to 7.0m carriageway depending on bus routes and Local Government requirements. It is recommended however, that the minimum carriageway width be provided to encourage a slower speed environment. Unfortunately many streets with 7.0m+ carriageways and low density lots frequently experience traffic speeds well in excess of the posted 50kph limit. A reduced carriageway width will assist in achieving a more appropriate 40kph typical travel speed.

Higher Order Access Streets

Access streets carrying between 1,000vpd to 3,000vpd are considered to be higher order access streets and a slightly wider road reservation is suitable. Figure 11 shows a typical cross-section for a 16.0m wide road reservation providing a 6.0m carriageway and two 5.0m verges.

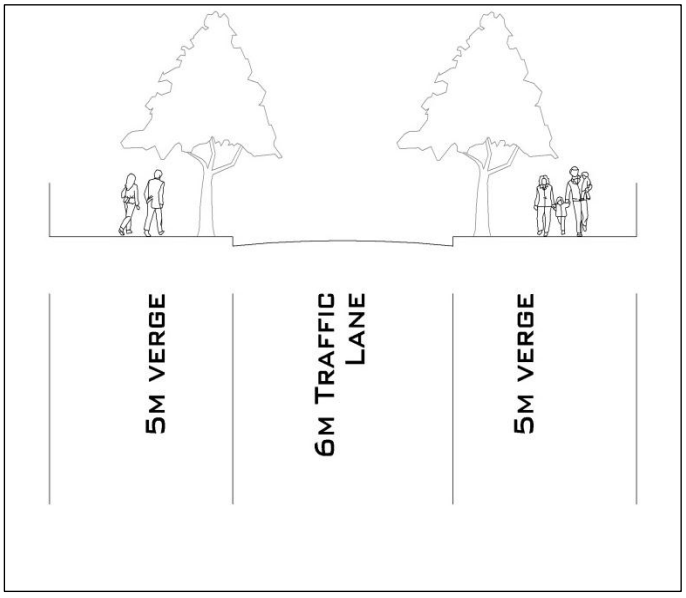


Figure 11 16m Road Reserve

Liveable Neighbourhoods suggests that these streets would be considered as "typical residential streets" (LN notation as access street C) and a carriageway width of 7.0 metres within a 15.4m – 16.0m road reservation is appropriate. However, the 7.0m wide carriageway is not supported in residential areas as it will tend to encourage a higher traffic speed. A 6.0m carriageway is preferred to encourage a 40kph target speed. A wider carriageway is only recommended where buses or large vehicles are expected.

Photograph 8 16m Road Reserve

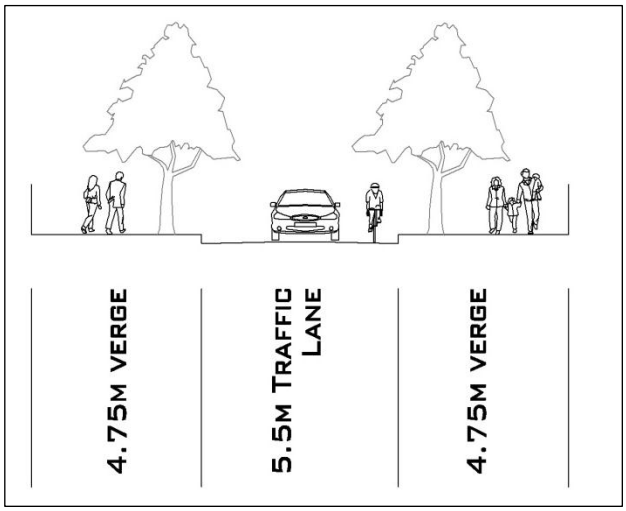
In higher density areas, the provision of parking embayments is a preferred treatment, rather than an increased carriageway width. Photograph 8 shows a typical residential street with a 6.0m carriageway.

It should be noted that from a road network capacity basis, a 6m wide carriageway could accommodate two-way traffic flows up to 1,100 vehicles per hour (indicatively 11,000vpd), but as a residential street should be restricted to less than 3,000vpd to maintain appropriate residential amenity. A wider carriageway is not required from a traffic movement perspective.

A minimum 16.0m cross-section is recommended for higher order access streets.

Lower Order Access Streets

Where daily traffic volumes are shown to be less than 1,000 vehicles per day, *Liveable Neighbourhoods* suggests that a reduced road reservation is acceptable. A carriageway width of 5.0m to 5.6m is suggested within a 14.2m road reservation. Figure 12 shows a typical cross-section of a lower order access street with a 5.5m wide carriageway in a 15.0m road reservation. The road reservation can accommodate parking embayments.



A minimum 15.0m cross-section is recommended for lower order access streets

Figure 12 15m Road Reserve

Boulevards

The development of local streets as boulevards adds opportunity for landscaping and reduces the visual level of blacktop. The use of divided carriageways with median treatments requires that a minimum road width of 4.1m is provided to conform to Austroads. Commonly, boulevards are provided with a carriageway width of 4.5m, often designated as a 3.0m traffic lane and a 1.5m cycle lane. Photograph 9 shows a 4.5m wide carriageway boulevard without cycle lanes and indicates that ample width exists (using 4.5m) to pass a stationary

Photograph 9 4.5m Carriageway Boulevard

vehicle in the event of a breakdown. Figure 13 shows a boulevard cross section with a 5.0m carriageway that includes cycle lanes. It should be noted that *Liveable Neighbourhoods* suggests a road reservation of 24.4 metres for boulevards where on-street parking is to be provided. It is recommended that a check be made on frontage activity before applying a boulevard road reservation of 22 metres.

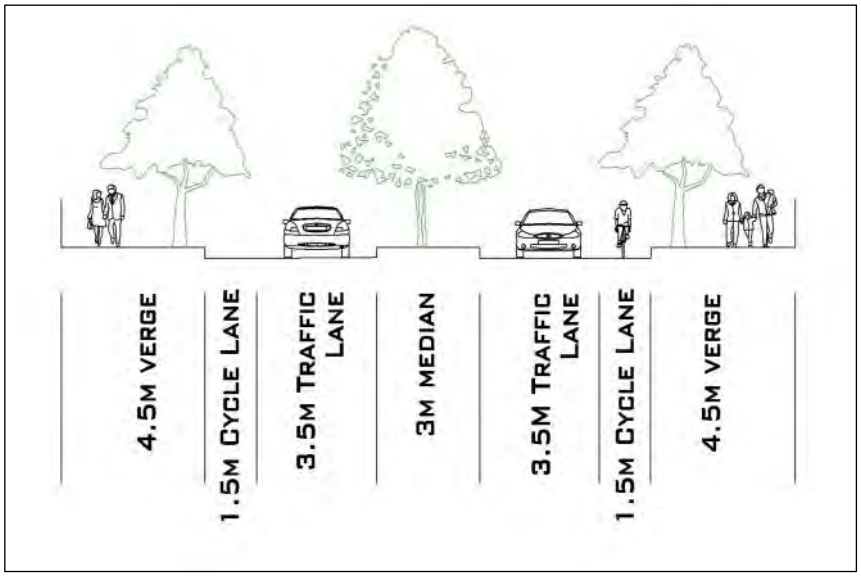


Figure 13 Boulevard Treatment 22m Road Reserve

6.4 Roads Adjacent to Open Space

Where the road reservation abuts POS, bushland, golf courses etc, there is limited need to provide a verge. The verge may be reduced where parking and/or services are not required and should be considered at the time of subdivision. A minimum verge of 1.0m is advised by current road planning standards to accommodate street furniture. Footpaths do not need to be adjacent to the road where POS is provided, but must be provided in a safe and appropriate manner. Figure 14 shows an example of a reduced road reservation adjacent to open space.

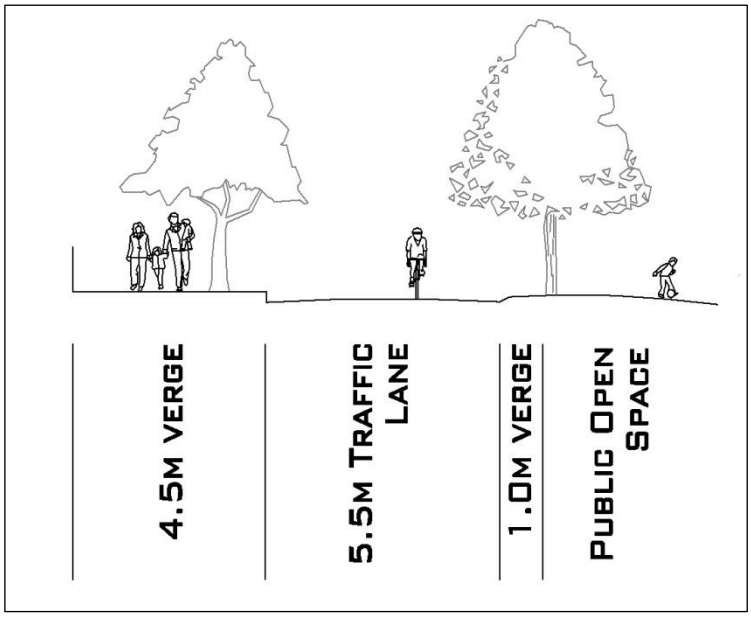


Figure 14 Roads Adjacent to POS

6.6 Four-way Intersections

Within the structure plan area daily traffic volumes are shown to be low and the use of four-way intersections is appropriate. Figure 15 shows an extract from Liveable Neighbourhoods on the preferred treatment of four-way intersections.

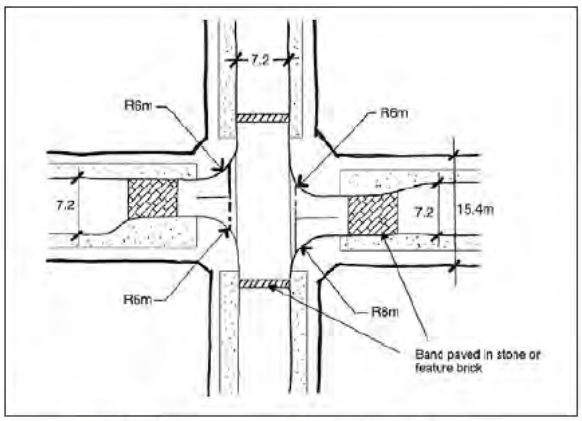


Figure 29A: Access street to access street with-four way and stagger.

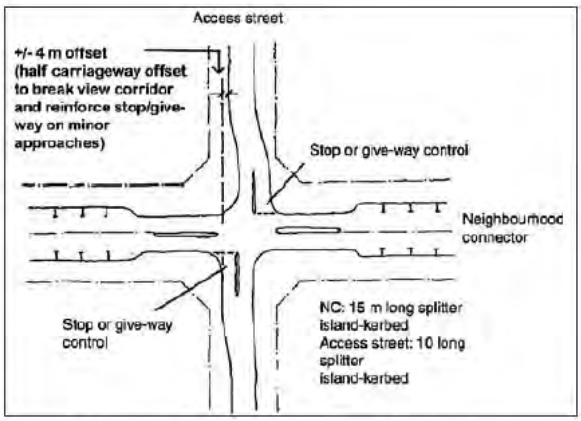


Figure 31: Left-right minor offset four-way on neighbourhood connector (derived from Austroads Guide to traffic engineering, Part 5 Intersections, Figure 5-8).

Figure 15 Liveable Neighbourhoods Four-way Intersections

Liveable Neighbourhoods suggests that four-way intersections are an appropriate treatment at the meeting of two access streets and where daily flows through the intersection are less than 2,000vpd. Approach legs should be limited to a maximum length of 160 metres with some form of speed reducing feature where the length is greater than 80 metres.

Access streets meeting neighbourhood connectors and some arterial streets are considered acceptable, but will generally require a treatment as indicated in Figure 15. In these instances *Liveable Neighbourhoods* would require a maximum of 4,000vpd passing through the intersection with a maximum combined flow of 1,000vpd on the minor legs.

Introducing four-way priority intersections on arterial streets is not recommended.

Figure 16 shows the location of four-way intersections within Lot 50 Mundijong Road and these are discussed below.

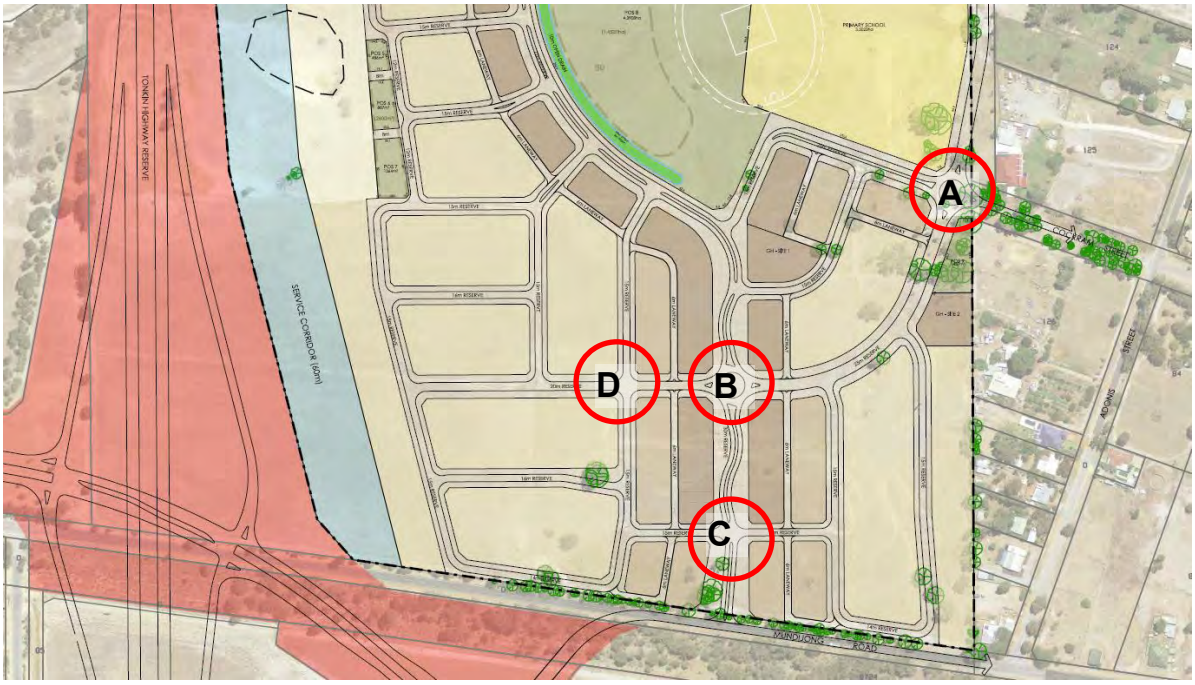


Figure 16 Four-way Intersections

A The intersection of Cockram Street / Adams Street has a forecast volume of about 2,000vpd on Cockram Street and about 3,000vpd on Adams Street. It is recommended that a roundabout be provided to control this intersection.

B The termination of Adams Street with the Lot 50 Access Road. It is expected that high turning demands will occur at this intersection and a roundabout will be required.

C Lot 50 Access Road is forecast to carry about 10,000vpd and a four-way priority controlled intersection is not acceptable. This street is expected to be developed as an entry statement boulevard and thus the side roads can be restricted to left-in / left-out movements only.

D Intersection D is a local internal road intersection with a forecast traffic demand of about 1,500vpd. North-south crossing movement will be very low and priority should be provided to the east-west movement. The intersection accords with the principles of *Liveable Neighbourhoods*.

All streets within Lot 50 are of relatively short lengths and high traffic speeds would not be expected. Further, the narrower carriageway widths proposed in low traffic residential streets will assist in reducing the attraction for speeding making a safer environment for local children.

No specific traffic management features are considered to be required within Lot 50 Mundijong.

Local Intersection Design

To reduce the opportunity for speeding it is recommended that corner radii advised by *Liveable Neighbourhoods* be used within the subdivision. The recommended radii are:

- 6.0 metres - access street / access street intersections
- 9.0 metres - access street / neighbourhood connector

Where larger vehicles are expected, such as buses accessing the school, larger radii may be required and should be considered at subdivision stage. It should be noted that adjacent to the proposed school, the minimum 6.0m radii is preferable to ensure side road traffic enters the major road at 90^0 to improve visibility to pedestrians. The tighter radii will also ensure traffic cannot enter or depart the side road at speed.

7.0 PEDESTRIANS, CYCLISTS AND PUBLIC TRANSPORT

The structure plan provides for a primary school which is within a pleasant walking distance for the majority of households. Adjacent to the school and on identified walking routes, it is desirable to provide a footpath to both sides of the street.

Current planning guidelines suggest that all streets should be provided with a footpath where ever possible. Where traffic flows exceed 1,000 vehicles per day, a footpath to both sides of the road should be provided. Figure 17 shows those streets where a footpath is required to both sides.

Cycling

Cycling would be safe on the majority of local streets where traffic flows are less than 1,000 vehicles per day. On the neighbourhood connectors shared paths should be provided to provide a safe alternative to on-road cycling. A principal shared path is indicated in the district structure plan adjacent to the future Tonkin Highway. It is desirable to provide linkages to this path, although the future service corridor may preclude such access.

Public Transport

Mundijong already has a rail station on the Perth to Bunbury line, the Australind service, which does stop. However, this is a twice a day service with scheduled departure times that make commuting to Perth CBD awkward.

Armadale is about 21 kilometres to the north of Mundijong, where the metro rail line service to the CBD currently terminates. There is discussion of the service being extended to Byford, although this is a very long term proposal. The Perth – Mandurah line can be accessed at Wellard, Rockingham and Safety Bay. These stations are probably closer than Armadale to the north and have been developed as park and ride stations. It can be expected that commuters to Perth will be split 60/40 to the Perth – Mandurah line.

There are 2 bus services passing through the locality, routes 252 and 253. The services connect to Armadale railway station. The district structure plan sets out to provide a bus route along Taylor Road / Adams Street that would terminate to the north side of Mundijong Road. Figure 18 shows the proposed bus route and the 400 metre walkable catchment. Figure 18 shows that the majority of Lot 50 is within easy walk of the future bus service.

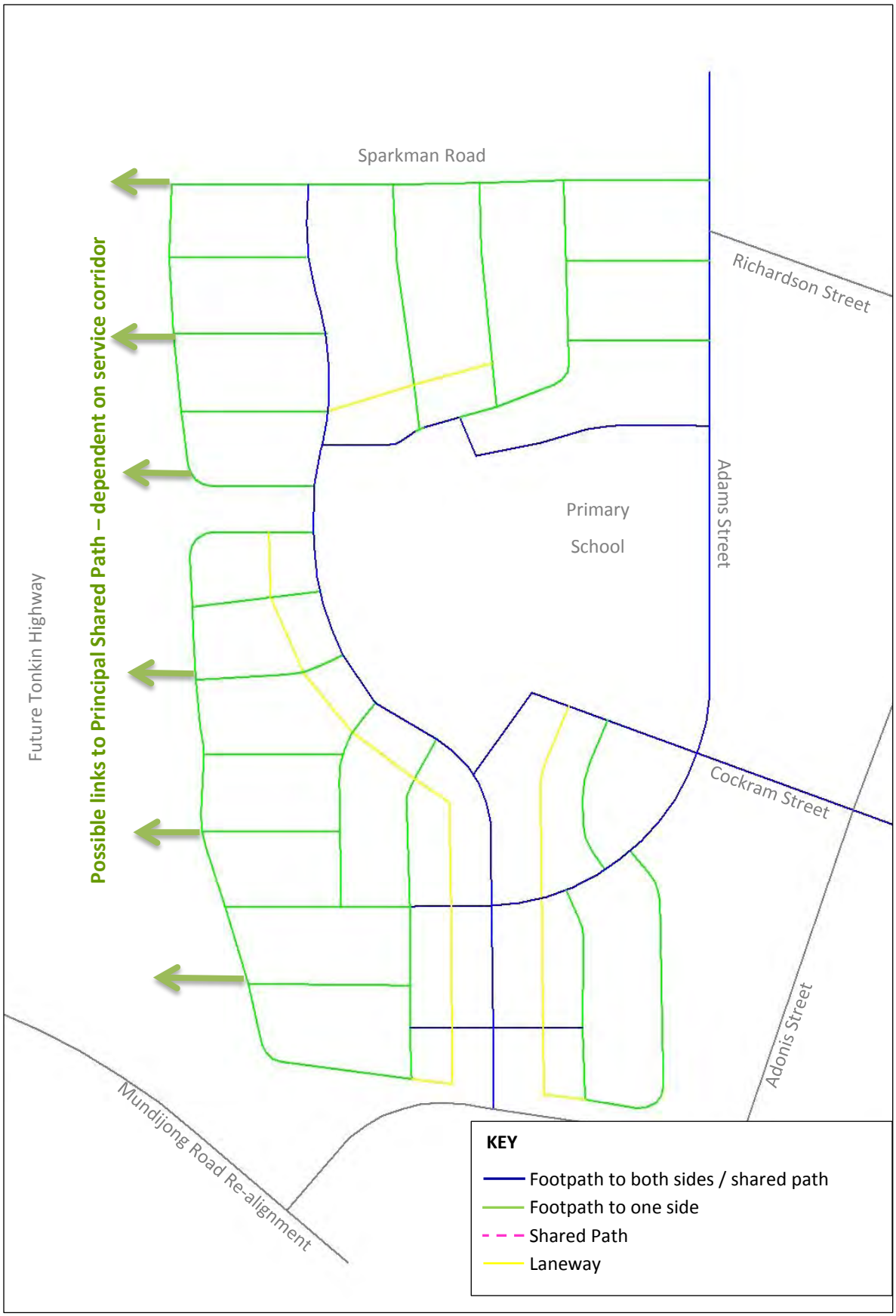
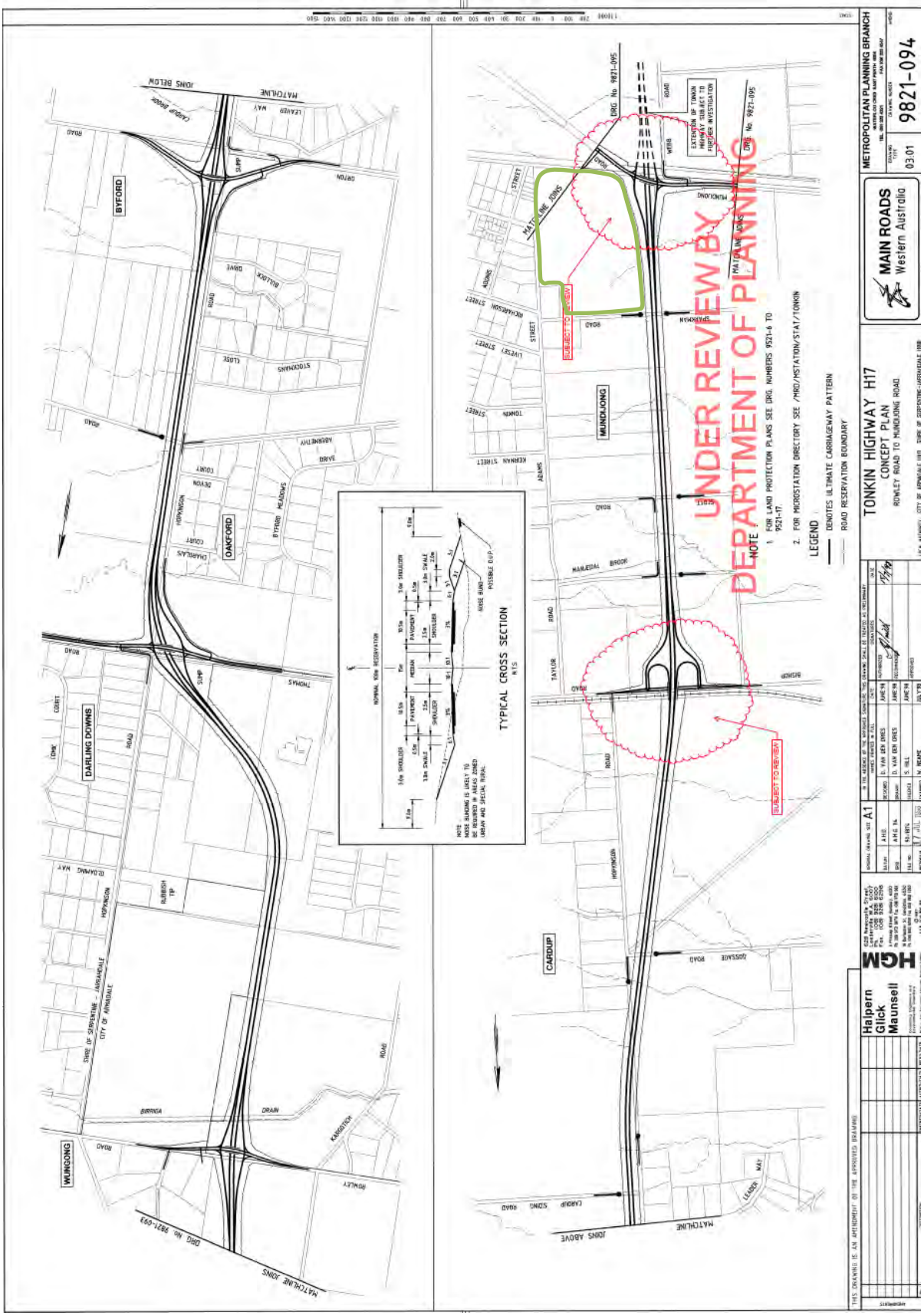


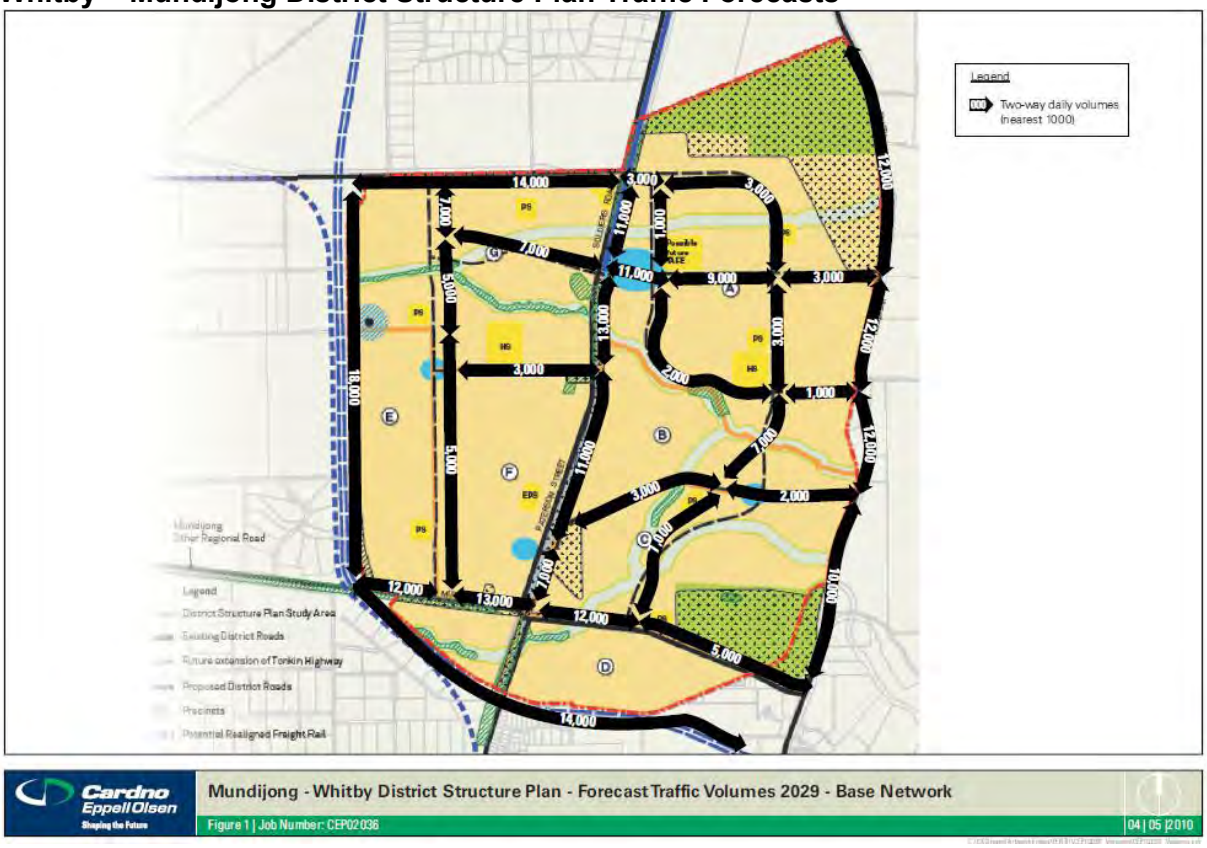
Figure 17 Footpaths and Cycle Paths

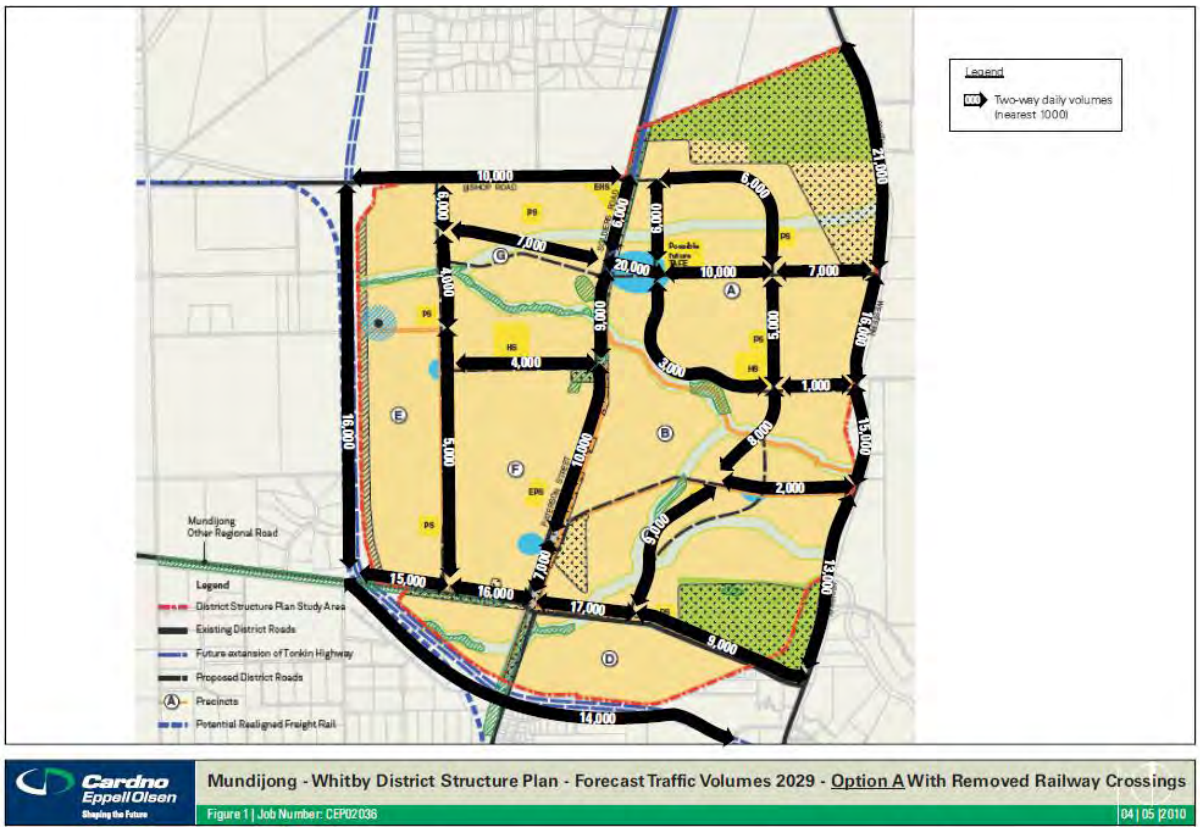
Figure 18 Roads for Future Bus Services

APPENDIX A
Tonkin Highway Concept Plan

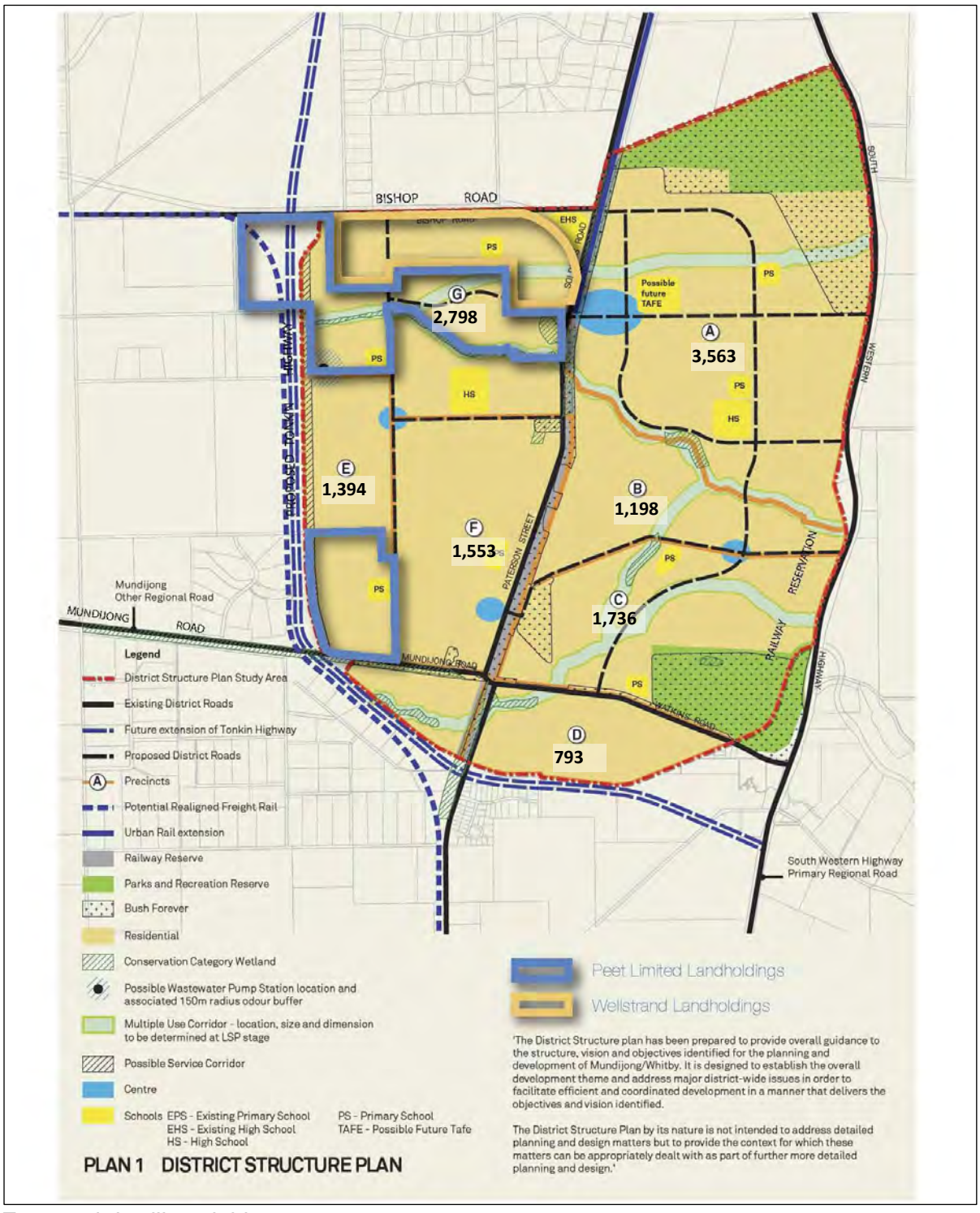


APPENDIX B
Whitby – Mundijong District Structure Plan Traffic Forecasts



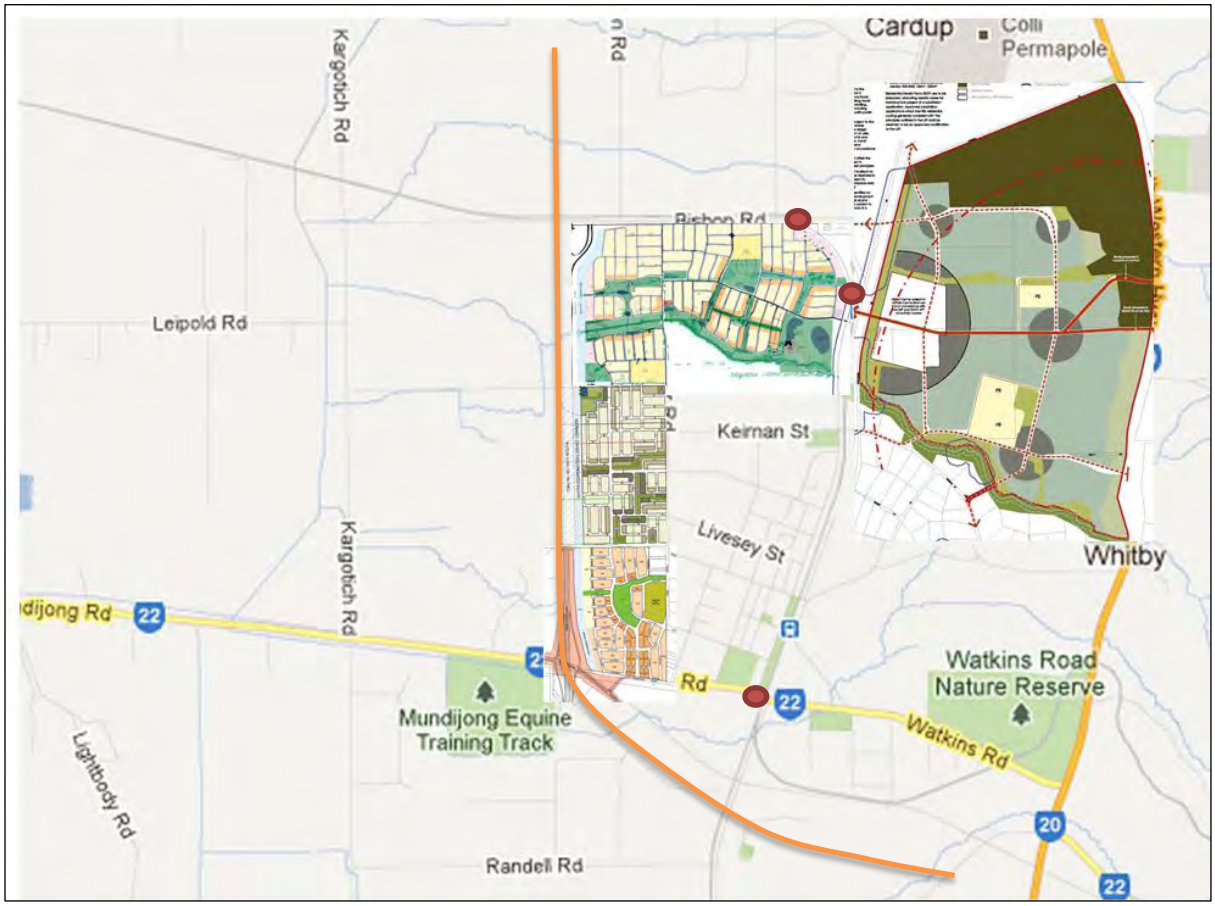


APPENDIX C
Whitby - Mundijong District Structure Plan



Expected dwelling yields

APPENDIX D
Traffic Model Area



Mundijong Modelled area and Rail Crossings

APPENDIX E

Table 1 Levels of Service by Road Type

LOS	Single Carriageway[1]	2-Lane Boulevard[2]	Dual Carriageway (4-Lanes)[3]	Dual Carriageway (4-lane Clearway)[3]
Road Type	**1**	**2**	**3**	**4**
A	2,400vpd	2,600vpd	24,000vpd	27,000vpd
B	4,800vpd	5,300vpd	28,000vpd	31,500vpd
C	7,900vpd	8,700vpd	32,000vpd	36,000vpd
D	13,500vpd	15,000vpd	36,000vpd	40,500vpd
E	22,900vpd	25,200vpd[4]	40,000vpd	45,000vpd
F	>22,900vpd	>25,200vpd[4]	>40,000vpd	>45,000vpd

[1] Based on Table 3.9 Austroads - Guide to Traffic Engineering Practice Part 2
[2] Based on single carriageway +10% (supported by Table 3.1 Austroads - Guide to Traffic Engineering Practice Part 3) – Boulevard or division by medians.
[3] Based on RRR Table 3.5 - mid-block service flow rates (SF.) for urban arterial roads with interrupted flow. Using 60/40 peak split.
[4] Note James Street Guildford passes 28,000vpd.

APPENDIX F

Lot 50 Access to Mundijong Road

Lot 50 - Mundijong Road Give Way -Interim Years AM Peak
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
East: Mundijong Road east											
5	T	241	3.0	0.126	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
6	R	65	3.0	0.052	8.8	LOS A	0.3	1.9	0.26	0.62	47.9
Approach		306	3.0	0.126	1.9	LOS A	0.3	1.9	0.05	0.13	56.9
North: Lot 50 Access											
7	L	151	3.0	0.143	8.9	LOS A	0.7	5.0	0.25	0.64	47.8
9	R	108	3.0	0.233	14.2	LOS A	1.2	8.4	0.59	0.86	43.2
Approach		259	3.0	0.233	11.1	LOS A	1.2	8.4	0.39	0.73	45.8
West: Mundijong Road west											
10	L	44	3.0	0.079	8.3	LOS A	0.0	0.0	0.00	0.91	49.0
11	T	104	3.0	0.079	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		148	3.0	0.079	2.5	LOS A	0.0	0.0	0.00	0.27	56.2
All Vehicles		714	3.0	0.233	5.3	NA	1.2	8.4	0.17	0.38	52.2

Lot 50 - Mundijong Road Give Way -Interim Years PM Peak
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
East: Mundijong Road east											
5	T	104	3.0	0.054	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
6	R	151	3.0	0.151	9.9	LOS A	0.8	5.5	0.44	0.71	47.1
Approach		255	3.0	0.151	5.9	LOS A	0.8	5.5	0.26	0.42	51.6
North: Lot 50 Access											
7	L	65	3.0	0.075	9.9	LOS A	0.3	2.4	0.39	0.69	47.2
9	R	44	3.0	0.116	15.8	LOS B	0.5	3.8	0.61	0.87	41.9
Approach		109	3.0	0.116	12.3	LOS B	0.5	3.8	0.47	0.76	44.9
West: Mundijong Road west											
10	L	108	3.0	0.186	8.3	LOS A	0.0	0.0	0.00	0.91	49.0
11	T	241	3.0	0.186	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		349	3.0	0.186	2.6	LOS A	0.0	0.0	0.00	0.28	56.1
All Vehicles		714	3.0	0.186	5.2	NA	0.8	5.5	0.17	0.41	52.5

APPENDIX G

Lot 50 Access to Mundijong Road with Full Development of DSP

Lot 50 - Mundijong Road Roundabout - full development AM Peak
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
East: Mundijong Road east											
5	T	758	3.0	0.984	48.0	LOS D	38.8	285.3	1.00	1.91	25.9
6	R	51	48.0	0.991	55.9	LOS D	38.8	285.3	1.00	1.86	25.7
Approach		808	5.8	0.984	48.5	LOS D	38.8	285.3	1.00	1.91	25.9
North: Lot 50 Access											
7	L	72	3.0	0.645	12.0	LOS A	8.6	61.9	0.88	0.93	44.2
9	R	537	3.0	0.644	17.9	LOS B	8.6	61.9	0.88	0.96	41.4
Approach		608	3.0	0.645	17.2	LOS B	8.6	61.9	0.88	0.96	41.7
West: Mundijong Road west											
10	L	282	3.0	0.524	5.9	LOS A	6.8	49.2	0.41	0.48	49.9
11	T	505	3.0	0.525	4.6	LOS A	6.8	49.2	0.41	0.40	50.4
Approach		787	3.0	0.525	5.1	LOS A	6.8	49.2	0.41	0.43	50.2
All Vehicles		2204	4.0	0.984	24.3	LOS B	38.8	285.3	0.76	1.12	35.9

Lot 50 - Mundijong Road Roundabout - full development PM Peak
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue Vehicles	95% Back of Queue Distance	Prop. Queued	Effective Stop Rate	Average Speed
		veh/h	%	v/c	sec		veh	m		per veh	km/h
East: Mundijong Road east											
5	T	505	3.0	0.509	6.1	LOS A	5.5	39.8	0.71	0.57	48.1
6	R	72	3.0	0.508	13.3	LOS A	5.5	39.8	0.71	0.80	46.3
Approach		577	3.0	0.509	7.0	LOS A	5.5	39.8	0.71	0.60	47.9
North: Lot 50 Access											
7	L	51	3.0	0.481	12.4	LOS A	5.2	37.2	0.95	0.95	43.8
9	R	276	3.0	0.480	18.3	LOS B	5.2	37.2	0.95	0.97	41.2
Approach		326	3.0	0.480	17.4	LOS B	5.2	37.2	0.95	0.97	41.5
West: Mundijong Road west											
10	L	537	3.0	0.838	6.5	LOS A	20.1	144.2	0.71	0.47	48.0
11	T	758	3.0	0.838	5.3	LOS A	20.1	144.2	0.71	0.44	48.0
Approach		1295	3.0	0.838	5.8	LOS A	20.1	144.2	0.71	0.45	48.0
All Vehicles		2198	3.0	0.838	7.9	LOS A	20.1	144.2	0.75	0.57	46.8

APPENDIX 8
LOCAL WATER MANAGEMENT STRATEGY

wave international

DETERMINE • DESIGN • DELIVER



MUNDIJONG PRECINCT E2

Local Water Management Strategy

Peet Limited

Rev B – February 2013

engineering project management environment

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Project Brief

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDICES

LIST OF FIGURES

1 INTRODUCTION

1.1 Background

Peet Limited has engaged Wave International to prepare a local water management strategy (LWMS) for a 55ha landholding within the Mundijong/Whitby District Structure Plan area. The site is approximately 40km south-east of the Perth CBD, and 2km south/west of the Mundijong Town Centre.

The Mundijong/Whitby District Structure Plan (DSP) was adopted by the Shire of Serpentine Jarrahdale (SJ Shire) in August 2011 to control the development of over 1400ha of mostly rural land within the SJ Shire for urban development.

This LWMS will address water management issues over the proposed local structure plan (LSP) area, which forms sub-precinct E2 of the Mundijong/Whitby DSP area. The LSP area (the site) covers Lot 50 Cockram St and Lot 119 Sparkman Road, and is expected to yield approximately 500 residential lots and a primary school when fully developed. The site is located on Mundijong Road, and is bounded by Mundijong Road, Adams Road, Sparkman Road and the future Tonkin Highway reserve. The location of the site in relation to surrounding areas is shown in Figure 1.1, while the proposed LSP layout is included as Figure 1.2.

The site has historically been used for stock grazing and is almost entirely cleared, with natural surface levels falling from east to west across the site at a grade of approximately 0.8%. Existing ground levels range from 30mAHD along the eastern boundary to 26mAHD in the west, and soil conditions generally comprise sand of varying depths overlying the clays of the Guildford formation.

Lot 50 Cockram Street falls within the area covered by the Mundijong Whitby DSP District Water Management Strategy (DWMS), which was prepared by GHD in 2010.The DWMS addresses broad-scale stormwater management measures over an 1800ha area which extends from the future Tonkin Highway reserve to South Western Highway.

The DWMS identified two drainage flow paths which cross the site from east to west, although both are very shallow and not well-defined. These drainage paths convey flow from a small catchment to the east of Precinct E2 across the site towards a drainage reserve immediately west of the future Tonkin Highway reserve. Section 2.5 details the pre-development surface water conditions across the LSP area.

1.2 Proposed development

The Mundijong/Whitby DSP was produced to guide urban development over previously rural land across Mundijong & Whitby, which was broken down into seven precincts (Precincts A-G). An amendment to the DSP in April 2012 further delineated two of the precincts (E & G) into sub-precincts (E1, E2 and G1, G2). An LSP has been prepared to address the proposed development of Sub-precinct E2, and this LWMS is a key supporting document of the LSP.

The development of the LSP area is expected to yield approximately 500 residential lots, with a primary school and associated sporting oval on the eastern side of the site.

1.3 Design principles and objectives

The DWMS set out several design principles and objectives for water conservation, stormwater management and groundwater management within the Mundijong/Whitby DSP area. These design objectives and criteria are summarised in the table below:

Table 1.1 - DWMS design objectives

Category	Design objectives	Strategies	Design criteria
Protection of environmental assets	• Minimise changes to hydrology to prevent impacts on watercourses & wetlands • Manage & restore watercourses & wetlands • Assess & manage impacts on native flora & fauna • Assess & manage impacts on sites of indigenous significance		
Urban water use	• Ensure the efficient use of all water resources in the newly-developing urban form & aim to achieve highest value use for fit-for-purpose water. • Maintain opportunities for future generations by using water more	Potable water: • Adopt drinking water targets. • Use only water efficient fixtures & fittings. • Ensure that landscaping & irrigation use water	• Consumption target of 100 kL/person/year (40-60 kL/person/year of scheme water). • Meet 5-star Plus provisions for all new dwellings. • Promote the use of native plants. All parts of POS except turfed areas are to contain only native plants. Alternative non-local plants may be considered where passive solar exposure is required. • The use on on-site rainwater tanks is to be promoted to achieve water

Category	Design objectives	Strategies	Design criteria
	efficiently. This is best achieved by combining several approaches such as raising community awareness, regulation, market mechanisms to facilitate recognition of the true value of water and financial incentives/ assistance to facilitate change.	efficiently. Fit-for-purpose water: • Ensure that non-potable water supply systems deliver a net benefit to the community. • Ensure that non-potable water supply systems are designed as part of an integrated water supply.	consumption targets whilst also having the ability to fully or partially meet on-site retention requirements.
Stormwater management	• Protection of wetlands & waterways from the impacts of urban runoff. • Protection of infrastructure and assets from flooding and inundation.	• Minimise changes in hydrology to prevent impacts on receiving environments: • 1yr1hr ARI post-development discharge volume and peak flow rates shall be maintained relative to pre-development conditions at subcatchment outlets. Where there are identified impacts on significant ecosystems, maintain or restore desirable environmental flows and/or hydrological cycles	• Retain 1yr 1hr ARI event at-source via soakage or storage devices. • Post-development critical 1yr peak flow and volume & 100yr ARI peak flow to be consistent with pre-development flows at the discharge point from all subdivisions, at discharge points from each structure plan & at discharge points from each subcatchment. • Flows from developed areas to be attenuated via flood detention storage areas incorporated into POS and located outside defined floodways. • Post-development flows for all ARI events to be discharged at flow rates which are consistent with pre-development flow rates for those same events. • Floodways shown in DWMS Figure A11 are not to be developed or obstructed in any way.

Category	Design objectives	Strategies	Design criteria
		as approved by the DoW. • Implement BMPs that promote on-site retention of events up to 1yr 1hr ARI. • Manage surface water flows from major events to protect infrastructure an assets. • Uphold environmental values of downstream waterways within and surrounding the study area.	• Development outside the floodway should ensure finished flood levels are a minimum of 0.5m above the 100yr ARI flood level in streamlines and basins, and 0.3m above the 100yr ARI flood level for other drainage paths (eg road reserves). • Existing cross-sectional areas of waterways to be maintained. • POS and retention basins should operate as dry basins with minimum 0.3m separation between invert and CGL. • Defined major arterial roads to remain passable in the 100yr ARI storm event. • Minor roads to remain passable in the 5yr ARI event • Emergency evacuation areas to be at least 2m above 100yr ARI flood level. • Water quality treatment systems and WSUD structures to be designed in accordance with the Stormwater Management Manual and Australian Runoff Quality.
Surface water quality	• Uphold environmental values of downstream waterways within and surrounding the study area.		• Non-structural measures to reduce applied nutrient loads. • On-site retention of 1yr 1hr ARI event. • Use of bioretention structures. • The following water quality targets are to be achieved as compared to a development that does not actively manage water quality: • 80% reduction in TSS

Category	Design objectives	Strategies	Design criteria
			• 60% reduction in TP • 45% reduction in TN • 70% reduction in gross pollutants. • If no water quality modelling is done, the following are to be achieved: • Retain 1yr 1hr ARI event from connected impervious areas at-source. • Maintain critical pre-development 1yr ARI peak flows and volumes. • Size bioretention systems to be 2% of connected impervious area. • Soil amendment should include a 300mm deep layer of material to reduce nutrient export (PRI>10) across at least 10% of the site including all landscaped POS and drainage structures. • Swales and bioretention/infiltration systems to have sufficient clearance from groundwater to ensure that they do not remain permanently wet.
Groundwater management	• Protect infrastructure & assets from flooding by high seasonal groundwater levels, perching and/or soil moisture. Protection of groundwater dependent ecosystems from the impacts of urban runoff.	• Manage groundwater levels to protect infrastructure & assets. • Maintain groundwater regimes for the protection of groundwater dependent ecosystems.	• Where a perched water table exists or the predicted maximum groundwater level is within 1.2m of natural surface, clean fill and/or subsoil drainage is required to ensure adequate separation to finished levels. Subsoil drains to be installed at or above approved CGL. • Bioretention system & drainage inverts to be at or above approved CGL, although existing inverts below this level may remain.

Category	Design objectives	Strategies	Design criteria

	• Managing & minimising changes in groundwater level & groundwater quality following development/redevelopment.	• Manage the shallow aquifer to protect the value of groundwater resources.	• Subsoil drains to be at or above CGL.
			• Subsoil drains to have free-draining outlets.
			• Finished lot levels to be at least 0.8m above the phreatic line (ie the mounding between parallel subsoil drains).
			• Clean fill imported on the site for WSUD elements is to incorporate a band of material that will reduce phosphorous export via soil leaching, whilst also meeting soil permeability & soil compaction criteria specified by the local government authority.
			• Where development is associated with any new or existing waterway or open drain that intersects the shallow water table, and that may discharge pollutants from the shallow groundwater to receiving environments, the following interim targets will be adopted (as compared to a site that does not actively manage water quality):
			  • 60% reduction in TP
			  • 45% reduction in TN.
			• Where development is associated with an ecosystem that is dependent of a particular hydrologic regime for survival, the water quality discharged to the groundwater must be in accordance with the requirements of the DEC.

2 PRE-DEVELOPMENT ENVIRONMENT

The subject area is 55ha in area and is well located, at the intersection of Mundijong Road and the future Tonkin Highway extension. The following sections include information on existing (pre-development) site conditions and summaries of the various studies and site investigations that have been completed to support this LWMS and LSP.

The site is almost entirely cleared, except for a few scattered trees and an area of vegetation in the north-western corner of the site. A house and farm buildings are located on Lot 119, in the north-eastern corner of the precinct. Figure 2.1 shows a recent aerial photo of the LSP site and surrounding area.

2.1 Topography

The site is relatively flat, sloping at a grade of approximately 0.5% from east to west. Levels fall from 30mAHD along the eastern end of the site to 26mAHD along the site's western boundary. Existing surface contours are shown in Figure 2.1.

2.2 Geotechnical conditions and acid sulfate soils

A geotechnical site investigation was carried out by Galt Geotechnics in 2011, which found that soil conditions across the site generally comprised Clayey Sand (SC), Sand (SP) and Ferricrete Gravel (GC). The site stratigraphy is quite variable both laterally and vertically. The average depth of the sand layer is 0.9m at the north-western region of the study area, increasing to 1.8m in the southern boundary of the study area. Figure 2.2 shows the test pit locations and contours of the underlying clay levels, while Figure 2.3 shows the depth from natural surface to the underlying clays. A copy of the bore logs from the geotechnical investigation is included as Appendix A.

A review of the Department of Environment & Conservation's (DEC) risk mapping for acid sulfate soils (ASS) showed that the entire site is classified as "Class 2 – Moderate to low risk of ASS occurring within 3m of natural surface". According to the Galt Geotechnics report, there is low likelihood of actual ASS or potential ASS at the site, based on the field testing that was carried out during the geotechnical investigation.

2.3 Wetlands and Bush Forever sites

The majority of the site is classified as a Multiple Use Wetland (MUW) under the Department of Environment & Conservation's Geomorphic Wetland mapping dataset (UFI 15785 – Palusplain Multiple Use). The Mundijong Road reserve along the southern boundary is classified as a Conservation Category Wetland (CCW) (UFI 14817 – Palusplain Conservation) and a Bush Forever site (Bush Forever site 360). Wetland mapping for the LSP area is included in Figure 2.4.

2.4 Groundwater

Groundwater flows from east to west across the region, generally following the topography. The Perth Groundwater Atlas (DoW, online) shows a snapshot of groundwater levels as measured in May 2003 (which are an indication of low groundwater levels); showing groundwater levels at the site ranging from 27mAHD in the east to 23mAHD in the west.

2.4.1 Pre-development groundwater levels

Site-specific groundwater monitoring was carried out by Brown Geotechnical & Environmental and Emerson Stewart between September 2008 and August 2011 to gain an understanding of pre-development groundwater levels and water quality across the LSP area. The monitoring showed that groundwater levels were at their highest in September 2009, when depth to groundwater ranged from at-surface to 700mm below natural surface.

Groundwater across this area tends to perch on the underlying clayey soils, causing large fluctuations of up to 2.5m between high and low groundwater levels. In areas of the site where the depth to the underlying clay materials is low, typical peak groundwater levels are very shallow (within 100mm of existing surface). Parts of the site with a greater depth of sand over the underlying clays have a slightly larger natural separation between existing surface and peak groundwater levels (up to 800mm).

A comparison of the pre-development monitoring data to nearby long-term DoW monitoring bores showed that the maximum groundwater levels measured in September 2009 were close to the long-term (25-year) average maximum levels. Using the long-term DoW data, the site groundwater levels have been calibrated to estimate a typical winter perched water level (refer Appendix B). Figure 2.5 shows the groundwater monitoring bore locations and the pre-development perched water level contours, and Figure 2.6 shows the depth from natural surface to typical winter water levels.

A combination of fill and subsoil drainage will be required in the areas where groundwater is close to the natural surface – Section 4 contains details of how groundwater will be managed across the proposed development.

DWMS groundwater modelling

The Mundjiong Whitby DWMS (GHD, 2010) included details of groundwater modelling completed over the entire district structure plan area. Figure A.8 of the DWMS shows that GHD's estimated groundwater levels fall from 32-33mAHD at the eastern edge of Precinct E2 to 27mAHD at the western edge of Precinct E2. These modelled levels are several metres above existing surface level, and are not considered to be an accurate representation of actual groundwater behaviour at this site.

The groundwater design criteria outlined in this LWMS has been determined for Precinct E2 based on the site-specific groundwater monitoring data described above.

2.4.2 Pre-development groundwater quality

Groundwater quality monitoring at the site was assessed on a quarterly basis by Brown Geotechnical & Environmental and Emerson Stewart between September 2008 and August 2011 using 6 bores distributed across the study site. Bore locations are shown in Figure 2.5. Samples were analysed for physical parameters and nutrients. A summary of average groundwater quality results is shown in Table 2.1 below.

Table 2.1 - Average pre-development water quality

	pH (Field)	EC (field)	Dissolved Oxygen	Phosphorus	Total Nitrogen	Ammonium	Iron
		uS/cm	mg/L	mg/L	mg/L	mg/L	mg/L
Guideline values	6.5 - 8	1200 - 3000		0.07	1.2	0.08	
MB01	5.7	741	0.9	0.69	3.71	0.14	20.8
MB02	5.9	642	0.6	0.29	1.56	0.12	7.1
MB03	6.1	1697	0.8	0.34	2.10	0.43	45.1
MB04	6.3	8657	0.8	0.03	9.84	0.62	8.3
MB05	6.5	876	1.0	0.03	11.91	0.28	6.4
MB06	6.4	4245	1.6	0.18	21.64	0.09	24.2
Mean	6.2	2810	0.95	0.26	8.46	0.28	18.65
Count	6	6	6	6	6	6	6
Std Dev	0.31	3169	0.35	0.25	7.72	0.21	15.0

The range of the Phosphorous concentration values across the northern half of study site is between 0.03 mg/L at MB04 & MB05 and a high of 0.69 mg/L at MB01. Phosphorous concentrations across the site are generally low and within guideline values.

The Nitrogen (Total) (TN) has a mean value of 8.46 mg/L and a min/max range of 20 mg/L which indicates significant difference in values across the study site. The highest concentrations were observed around the south-east bore locations of MB06. The samples taken on 17 September 2009 and 14 December 2009 showed particularly high concentrations of Total Nitrogen, but the samples taken in all other monitoring events was similar to the other bores across the site.

Average pH values are around 6, which indicates that overall the site does not represent significant risk to down-gradient ecosystems.

Results of the groundwater quality monitoring are contained in Appendix B

2.5 Surface water

Surface runoff from the site is via overland flow from east to west, following the natural topography. There are some very shallow farm drains (approx 0.2 - 0.5m deep) across the site, which direct stormwater runoff towards the western side of the site. The main flow path through the site becomes more pronounced near the site's western border, and this existing waterway discharges to a Water Corporation main drain at Kargotich Road, approximately 1.5km west of the site.

Another Water Corporation main drain is present along the southern side of Mundijong Road. This drain also flows towards the west, but runoff from Precinct E2 doesn't fall within the catchment of this drain, with the exception of a small area to the east of the site, which flows across the south-eastern corner of Lot 50.

The Mundijong-Whitby DWMS (GHD, 2010) identified two flow paths which take runoff from upstream catchments east of Adams St through the site. The DWMS estimated the combined flow through the Precinct E2 site from upstream catchments to be approximately $12m^3/s$ under pre-development conditions (for the critical 100yr ARI event). 2-dimensional pre-development surface water model of the surrounding catchment was developed to confirm the estimated flow rates and flow paths outlined in the DWMS. The results of this modelling are outlined in Section 2.5.1 below.

2.5.1 Pre-development surface water modelling

Surface runoff from a 390ha catchment discharges through Lot 50 Cockram Street and Lot 7 Adams Street. Due to the relatively flat nature of the site and very shallow existing drains, there is significant interaction between flow paths throughout the catchment which makes the calculation of pre-development flow rates particularly complex.

A 2-dimensional surface water model was developed using XP Storm's 2D module, which has the ability to model floodplains and areas with poorly-defined flow paths with greater accuracy than a traditional 1-dimensional model. The model was developed to clarify pre-development flow rates from the overall catchment and to better delineate the flow paths through the catchment, as the existing drains are very shallow and not well defined. The extent of the upstream catchment was determined using LiDAR topographical data obtained from the Department of Water, and was generally consistent with the catchments shown in the Mundijong/Whitby DWMS.

The 2D modelling showed that pre-development flows entering Precincts E1 & E2 are concentrated into four main flow paths:

- Lot 9003 Adam St, between Kiernan St and Tonkin St
- Lot 7 Adams St, north of Livesey St
- Lot 119 Sparkman Rd, near Richardson St
- Lot 50 Cockram St, between Mundijong Road and Cockram St.

Figure 2.7 shows the extent of the upstream surface water catchment, and the main flow paths and peak pre-development flow rates from the overall catchment, while the parameters used in the 2D modelling are detailed in Appendix C. Table 2.2 below summarises the pre-development flow rates at critical locations across the catchment for the peak 5-year and 100-year ARI events.

Table 2.2 - Peak pre-development runoff rates

Flow location	5yr ARI peak flow	100yr ARI peak flow
A Lot 9003 Adams St - near Tonkin St	1.2 m^3/s	2.9 m^3/s
B Lot 7 Adams St - near Livesey St	0.8 m^3/s	1.9 m^3/s
C Lot 7 Adams St	1.8 m^3/s	4.6 m^3/s
D1 Lot 50 Cockram St - at Sparkman Rd	1.2 m^3/s	2.1 m^3/s
D2 Lot 50 Cockram St - south of Sparkman Rd	1.1 m^3/s	3.3 m^3/s
E1 Lot 119 Sparkman Rd - north-western corner	0.5 m^3/s	1.4 m^3/s
E2 Lot 119 Sparkman Rd - south-western corner	1.5 m^3/s	3.2 m^3/s
F Lot 50 Cockram St – western boundary (main drainage outlet)	3.6 m^3/s	7.2 m^3/s
G1 Lot 50 Cockram St – eastern boundary, between Mundijong Rd & Cockram St	1.0 m^3/s	2.5 m^3/s
G2 Lot 50 Cockram St – south-eastern corner, near Mundijong Rd	0.4 m^3/s	0.9 m^3/s
H Lot 50 Cockram St – south-western corner	0.5 m^3/s	1.8 m^3/s

The pre-development modelling results show the runoff that is generated within the Precinct E2 catchment, and these flow rates will be the allowable post-development flow rates from the development of the LSP area. Basins within the POS areas will be sized to attenuate post-development flows to these pre-development levels (to be determined for each subcatchment on a pro-rata area basis).

Table 2.3 - Allowable flow rates from Precinct E2

	5yr ARI peak flow	100yr ARI peak flow
Peak allowable flow rate from Precinct E2	1.0 m^3/s	2.1 m^3/s

3 WATER CONSERVATION

The DWMS identified two key objectives for water use and conservation in the Mundijong/Whitby DSP area:

- Ensure the efficient use of all water resources in the newly-developing urban form and aim to achieve highest value use of fit-for-purpose water.
- Maintain opportunities for future generations by using water more efficiently.

This development will be designed to minimise potable water use, and to ensure fit-for-purpose water use. "Fit-for-purpose" refers to the use of water that is of a suitable quality for the intended use. The use of high-quality drinking water for garden irrigation, for example, is not a fit-for-purpose use and lower-quality water (e.g. rainwater, groundwater etc) would be more suitable for this purpose.

The DWMS identified the following design criteria that should be considered for developments within the DSP area to achieve the water use objectives.

- Achieve a water consumption target of 100kL/person/year, of which only 40-60kL/person/year should be from potable water.
- Meet the State Government's '5-Star Plus' provisions for all new dwellings.
- Promote the use of native plants throughout the development. Non-turfed areas in POS to contain only native plants.
- Promote the use of on-site rainwater tanks to achieve water consumption targets.

Future urban water management plans (UWMPs) for the precinct will outline the specific water conservation measures that will be taken to ensure that the consumption targets are achieved.

3.1 Potable water supply

Potable water will be supplied from the Water Corporation's reticulated water supply.

The total water consumption target of 100kL/person/year is generally achieved through the use of waterwise fittings and appliances inside the house, along with planting water efficient gardens with minimal lawn areas and native, low-water-use plants. Future UWMPs will include a detailed water consumption estimate to show that the development can achieve the water consumption targets.

To achieve the potable water consumption target of 40-60kL/person/year, all water use outside the house (i.e. outdoor taps and irrigation) would need to be from non-potable sources like groundwater, rainwater or recycled water.

Appendix C contains an estimate of water consumption for the LSP area, based on the current estimate densities and approximate lot yield.

3.1.1 Water efficient appliances

Potable water use will be minimised throughout the LSP area by ensuring that new dwellings install water efficient appliances and fittings that comply with the State Government's 5 Star Plus program.

The requirements of the 5 Star Plus program have been incorporated into the Building Code of Australia to ensure that all new houses install water and energy efficient hot water systems, taps and toilets, and swimming pool covers.

In addition to these regulatory requirements, the developer will encourage lot purchasers to install water efficient appliances (e.g. washing machines) to further reduce potable water use.

3.2 Non-potable water supply

An important part of water sustainability is fit-for-purpose water use, or the use of alternative water sources for applications where drinking-quality water is not necessary (e.g. toilet flushing, garden watering).

The State Water Plan (Government of Western Australia, 2007) identified a potable water consumption target of 40-60 kL/person/year. This target can only by achieved if all outdoor water use is supplied by non-potable sources, and the widespread implementation of non-potable water schemes is most successful when installed with the construction of subdivision works. A non-potable water supply (third pipe) system would allow the use of alternative water sources throughout the development and would greatly reduce consumption of potable water.

The widespread implementation of non-potable water schemes is most successful when installed with the construction of subdivision works. A reticulated non-potable water supply (third pipe) system would allow the use of alternative water sources throughout the development and would greatly reduce consumption of potable water.

The Shire of Serpentine Jarrahdale is investigating potential alternative water sources that could be used for a third-pipe scheme throughout the greater Mundijong area. The developer will continue to liaise with the Shire as the development process continues, with a view to implementing a reticulated third-pipe system should an alternative water source be available at the time of development. The road reserves within the development are wide enough to accommodate a third pipe network within the verges, should an alternative water source be available at the time of subdivision.

3.2.1 POS irrigation

Public open space is expected to be irrigated using groundwater from the superficial aquifer. The site falls within the Serpentine Groundwater Area, and the Byford 3 Groundwater Subarea. According to the Department of Water (September 2012), there is water available in the superficial aquifer, and a groundwater licence application is currently being assessed by the DoW with the licence expected to be issued in March 2013.

The groundwater licence application is for approximately 44 kL/yr, to irrigate 5.6 ha of POS and streetscapes. The primary school site has not been included in the application, and the DET will be responsible to secure a groundwater allocation for the primary school area. When the groundwater licence is approved, exploratory drilling will be undertaken to determine the possible yield in the proposed bore locations.

4 GROUNDWATER MANAGEMENT

4.1 Groundwater levels & subsoil drainage

The design of the development will need to achieve sufficient separation between finished lot levels and post-development perched groundwater levels. This will be achieved via a combination of subsoil drainage and imported sand fill.

Existing groundwater levels are shallow, with some seasonal inundation occurring in low-lying areas of the site. During winter months, groundwater perches on the underlying clays, with the maximum measured water levels (in September 2009) within 0.8m of existing ground level. Water levels in late 2009 were representative of typical winter peak levels, and a calculation of typical winter perched water levels is included in Section 2.4.1.

The DWMS proposed controlled groundwater levels (CGLs) across the entire DSP area; however the levels shown are several metres above existing ground level in Precinct E2, and as such are not considered to be applicable to this LSP area.

We propose that the following criteria should apply to setting a localised CGL for Precinct E2 – which would set the minimum level for subsoil drainage or open drainage inverts:

- In areas near groundwater dependant ecosystems (eg CCWs), CGL should be equivalent to the pre-development perched winter water levels. The design of the subsoil drainage system will need to show that no drawdown of pre-development perched water levels will occur within wetlands or their buffers.
- In all other areas, the level of the underlying clay material will dictate minimum drainage and subsoil drainage invert levels. Some localised shaping of the clay may be undertaken, to ensure ponding of perched water in localised low points is avoided. Open drains and bioretention areas should be designed to ensure that baseflow during winter months is contained within defined areas that will be planted with sedges and appropriate plant species.
- Subsoil drainage invert levels at the outfall locations should be at least 0.6m above the invert of the closest open drain, to ensure sufficient separation above baseflow levels. Subsoil drains should discharge to bioretention treatment areas.

4.1.1 Subsoil drainage network

A combination of imported sand fill and subsoil drainage will be used to ensure adequate separation between finished lot levels and perched water levels, and to alleviate the perching of infiltrated rainwater on the impermeable clay soils & ferricrete across the site. Finished lot levels are to be a minimum of 1.5m above subsoil drainage inverts, or 1.8m above the underlying clay surface – whichever is higher.

Minimum subsoil drainage levels will be dictated by several factors – the level of the clay & ferricrete material present across the site; the invert level of the open drainage swales at subsoil outfall locations; and in the upstream reaches of the subsoil drainage network the invert levels will be governed by minimum pipe grades.

The underlying clay & ferricrete material will be shaped towards the proposed open drains through POS corridors in localised areas, with the invert of the open drains to be no lower than the graded clay surface. Subsoil drains will be installed to alleviate the perching of infiltrated rainfall that occurs during winter months, with outfalls to be at least 0.6m above open drain inverts to ensure sufficient freeboard above winter baseflow levels. Subsoil drainage inverts must be above the clay surface in all locations to allow the drains to operate effectively.

The detailed design of the subsoil drainage network will need to ensure that subsoil drains at the southern end of the site, near Mundijong Road, will be at or above typical pre-development perched water levels, to ensure that water levels in the CCW along Mundijong Road are not affected by the development.

4.2 Groundwater quality

Groundwater quality will primarily be managed through the landscaping design, with the design to include plants that required low fertiliser use to reduce the amount of nutrients leaching into the groundwater. A similar approach will be taken with the landscaping packages offered to residents, which will include information on minimising fertiliser use.

The perched groundwater that is intercepted by subsoil drains during winter months will be treated in bioretention swales at the drainage outfalls, which will be located in POS areas and will be designed with appropriate soil media and plant species to retain and treat the discharge from subsoil drains.

5 SURFACE WATER MANAGEMENT

The Mundijong/Whitby DWMP identified the following key strategies for the management of stormwater in the DSP area:

- Minimise changes in hydrology to prevent impacts on receiving environments (by managing post-development runoff to pre-development flow rates, and promoting on-site retention of the 1yr 1hr ARI storm event)
- Manage surface water flows from major events to protect infrastructure and assets
- Uphold environmental values of downstream waterways within and surrounding the study area.

The surface water strategy for the site is to generally maintain the pre-development flow paths, which follow the site's natural topography. Storage basins and swales will be integrated into the public open space to attenuate post-development runoff and ensure that runoff discharging from the site is within pre-development flow rates, to protect downstream landholdings from flooding.

The open drains that convey flow from upstream catchments – and from the basins within the site – to downstream waterways have been sized with a trapezoidal shape. The drains have a 3m wide base, with 1:6 side slopes, and the 100yr flood depth in these drainage swales is between 0.5m and 1.2m. The drainage swales will be landscaped to appear as a natural, landscaped living stream.

Main detention storage areas for 5yr and 100yr ARI events should be designed with their invert level 0.6m above the invert of the adjacent open drain. This will allow room for localised subsoil drainage beneath the main basins, to encourage infiltration and avoid extended waterlogging of the basin areas during periods of high groundwater.

5.1 Stormwater modelling

5.1.1 Local drainage management

Road runoff from events up to 1yr ARI will be directed into the bioretention swales in POS areas for on-site retention. Residential lots are expected to retain runoff from roof and hardstand areas in soakwells within the lot.

Inflows from the upstream catchment to the east of Precinct E2 have been allowed for in the design of the open drainage swales through Precinct E2.

JDA Consultant Hydrologists has prepared an LWMS to address water management for Precinct E1 (immediately north of Precinct E2), which proposes to discharge flow from the Precinct E1 LSP area along the Sparkman Road reserve, without discharging into Precinct E2. This flow would be piped for up to the 5yr ARI event, and conveyed by overland flow for major storm events.

Runoff within Precinct E2 will be managed by collecting road runoff in a piped drainage network, which will discharge to flood storage basins in the POS areas. These basins will act to attenuate the runoff to pre-development levels and will discharge to the open drains which replicate, as closely as practicable, the pre-development flow paths through POS corridors.

Table 5.1 below shows the required storage areas for the 1yr 1hr ARI and critical 5yr and 100yr ARI storm events to attenuate post-development runoff to allowable (pre-development) levels. Parameters used in the stormwater modelling to size the storage areas are included in Appendix C.

Table 5.1 - Required storage volumes for critical storm events

Basin ref	1yr 1hr ARI bioretention area	5yr ARI flooded area	100yr ARI flooded area
1	370 m^2	1,000 m^2	1,300 m^2
2	540 m^2	1,000 m^2	1,300 m^2
3	1,050 m^2	1,800 m^2	2,300 m^2
4	480 m^2	1,600 m^2	1,900 m^2
5	930 m^2	2,600 m^2	3,100 m^2
6	820 m^2	3,100 m^2	3,900 m^2
7	1,710 m^2	3,400 m^2	3,900 m^2
8	550 m^2	1,000 m^2	2,100 m^2

5.1.2 Major flood management

Earthworks design through Precinct E2 will ensure that roads grade towards the POS areas, with finished floor levels required to achieve a minimum of 0.3m above 100yr flood levels in all parts of the catchment (0.5m above 100yr flood levels in basins and open drains).

The outlets from the flood storage basins, and culverts at road crossings, will be sized to ensure that post-development flows at the downstream (western) end of the site are within pre-development levels. Figure 5.1 shows the required storage areas for the critical 100yr ARI storm event to attenuate post-development runoff to allowable levels.

Figure 5.2 shows the expected 5yr & 100yr ARI flood width and depths in the open drains through the POS corridors.

5.1.3 Diversion of upstream flows

The location of the drainage connection for upstream catchments at the southern end of the LSP area does not align with the pre-development inflow location. Under pre-development conditions, runoff from the southern part of the catchment enters the site between Cockram Street and Mundijong Road (noted as Locations G1 and G2 on Figure 2.7).

The main flow path (G1) will be intercepted where it crosses Cockram Street and piped to the MUC south of the proposed primary school.

A small flow path (G2) takes overflow from the flow path at G1, crosses the south-east corner of the LSP area and discharges to the existing open drain on the southern side of Mundijong Road. This overflow path will be diverted via piped drainage along Adonis Street when the south-eastern corner of the LSP area is developed.

5.2 Surface water quality

Surface water quality will be managed via the bioretention treatment swales within each POS area. Stormwater runoff will be directed into these areas, which will be constructed with amended soil and planted with appropriate plant species to maximise nutrient uptake from the stormwater runoff.

The provision of landscaping packages to lot purchasers will ensure that appropriate native species that require minimal fertiliser use are planted, and educational material will be provided to landowners about appropriate fertiliser use, to minimise the amount of fertiliser wash-off from gardens into the stormwater drainage network.

5.3 Wetlands & waterways

There are no significant wetlands or water-dependant ecosystems within Precinct E2, but there is a CCW to the south of the site, alongside Mundijong Road. No stormwater flow from the development will discharge to this wetland area, and subsoil drainage in the vicinity of the wetland area will be designed with invert levels are at or above typical winter perched water levels to ensure that water levels in this wetland area are not impacted by the development.

6 MONITORING AND IMPLEMENTATION

6.1 Monitoring program

The proposed monitoring program for the LSP area is outlined in Table 6.1 below, and indicative monitoring locations are shown in Figure 6.1. The monitoring locations are shown in areas of POS, and are subject to change as the planning process progresses and the subdivision layout evolves.

Table 6.1 - Monitoring program

Responsible agency	Monitoring program	Requirements	Duration & frequency
Developer	Pre-development groundwater monitoring	GW levels & nutrients (pH, EC, TN, FRP, TKN, ammonia, TP, heavy metals).	Minimum period of 18 months (including 2 winters), preferably 3 years. Monthly water levels, quarterly water quality.
	Post-development groundwater monitoring	GW levels & nutrients (pH, EC, TN, FRP, TKN, ammonia, TP, heavy metals).	Period of 2 years post-development (including at least 1 year following completion of 80% of the development. Monthly water levels, quarterly water quality.
	Post-development surface water monitoring	Flows, water levels & nutrients (pH, EC, TN, FRP, TKN, ammonia, TP, heavy metals)	Period of 2 years post-development (including at least 1 year following completion of 80% of the development. Levels and water quality as appropriate during winter periods.
SJ Shire - with funding from developer contribution scheme	Post-development groundwater & surface water monitoring	Monitor local superficial groundwater levels, water quality and flows within development & wetlands, behavioural patterns with respect to non-structural measures for water quality management.	After developer-funding monitoring program is complete.
DoW	Regional groundwater & surface water monitoring	Monitor regional surface water flows & quality, confined aquifer& regional groundwater levels & quality, groundwater abstraction, efficacy of BMPs, performance of new drainage systems.	Ongoing

Responsible agency	Monitoring program	Requirements	Duration & frequency
DEC	Environmental asset monitoring	Evaluate health of significant environmental assets.	Ongoing

6.2 Trigger values and contingency actions

6.2.1 Groundwater quality targets

Groundwater quality targets for the LSP area have been determined (Table 6.2 below). Target values are set with regard to the baseline quality data and the potential to improve the groundwater quality at the site. Targets are the mean plus one standard deviation and are considered to be met if the mean of all the post development bores is within the target range.

Table 6.2 - Post-development groundwater quality targets

Analyte	Groundwater quality target
pH	> 5.9
Electrical conductivity	< 5900 µS/cm
Dissolved oxygen	< 1.3 mg/L
Phosphorous	< 0.5 mg/L
Total Nitrogen	< 15.7 mg/L
Ammonium	< 1.0 mg/L
Iron (mg/L)	< 33.7 mg/L

6.2.2 Contingency actions

If post-development monitoring finds that water quality-related objectives are not being met, the developer and Shire would undertake the following procedures:

- Ensure that the development has fully complied with development conditions relating to water quality management (i.e. installation and operation of BMPs). If such BMPs have not been designed and installed as approved, then the developer would do so or council would be entitled to take regulatory action for a breach of development conditions.

- Investigate opportunities to apply additional non-structural BMPs to the study area (e.g. educational programs, street sweeping, nutrient management plans, alteration of maintenance regimes, soil amendment, local rainwater tank rebate scheme etc). Funding for such additional measures would typically be covered by the local government authority.

These contingency actions will depend on the specific BMPs that are implemented in the development, and will be confirmed as part of future UWMPs within the LSP area.

6.3 Implementation

Table 12 of the Mundijong/Whitby DWMS includes an extensive list of actions & responsibilities for the implementation of the measures outlined in the DWMS.

6.4 Matters to be addressed in future UWMPs

Future urban water management plans for developments in the Precinct E2 area will include more detailed information on the design of the following infrastructure:

- Stormwater retention/detention basin sizes, depths & configurations, including details of bioretention areas.
- Subsoil drainage layouts & invert levels.
- Minimum earthworks levels to achieve drainage design objectives.
- Proposed cross-sections for open drains through the site.
- Confirmation that the final stormwater drainage design achieves the objectives of this LWMS – particularly that post-development flow rates remain within pre-development levels.
- Details of the specific water-conservation measures that will be applied at the site (including any proposed non-potable water supply).
- POS landscaping concept plan, and confirmation that a water source for POS irrigation has been secured.

7 REFERENCES

Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ & ANZECC) (2000), *National Water Quality Management Strategy Australian Guidelines for Urban Stormwater Management*

Cardno (2011), *Whitby, Various Lots - Local Water Management Strategy*

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Engineers Australia (2001), *Australian Rainfall & Runoff, A Guide to Flood Estimation*

Galt Geotechnics (2011), *Geotechnical Study - Proposed Residential Development Lot 46 Mundijong Road, Mundijong*

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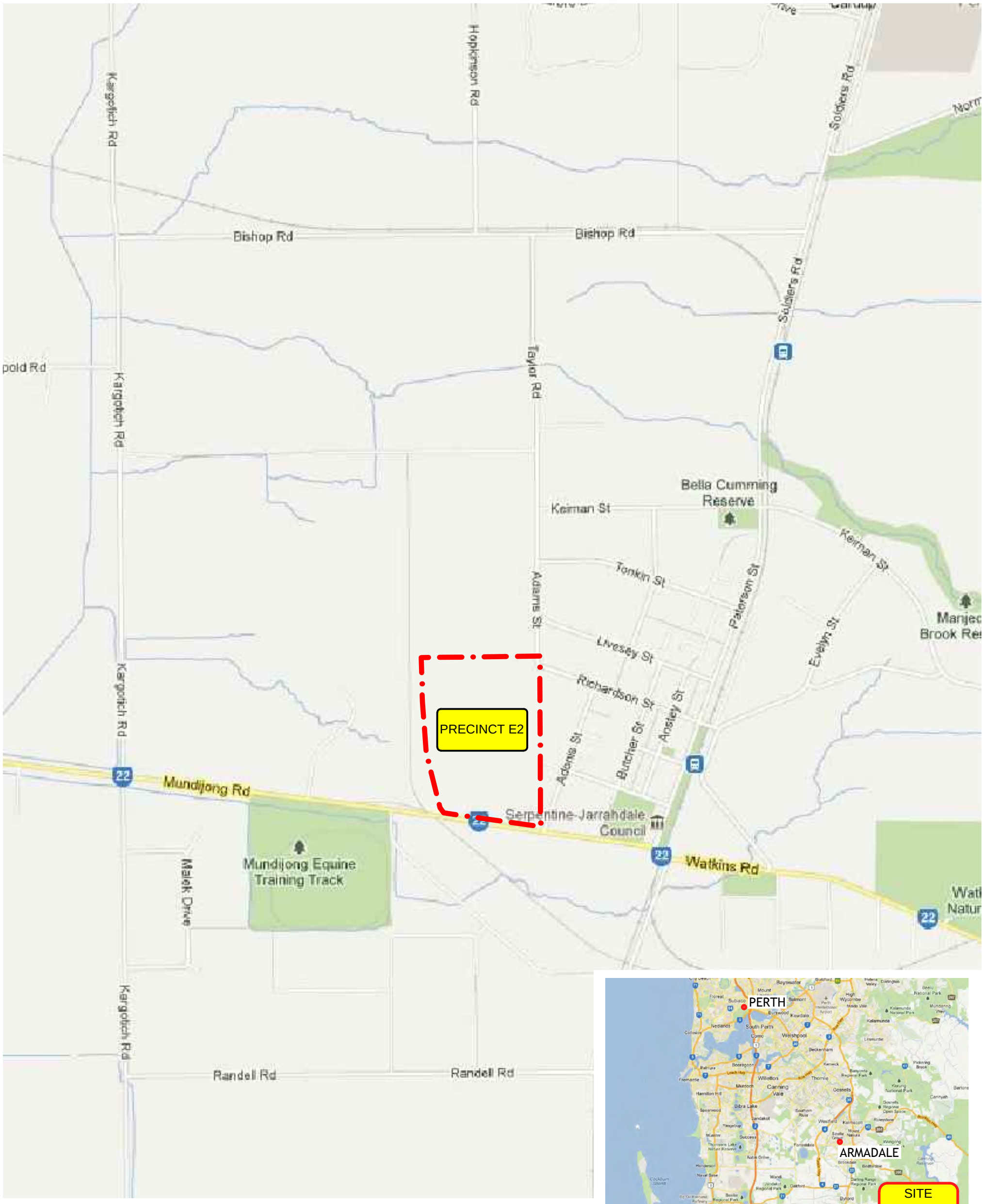
Shire of Serpentine Jarrahdale (2010), *Mundijong/Whitby District Structure Plan*

Western Australian Planning Commission (2008), *Better Urban Water Management*



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MUNDIJONG PRECINCT E2 LWMS

SITE LOCALITY PLAN

Job Number	2681-22
Revision	A
Date	OCTOBER 2012

FIGURE 1.1

Q:\1550 PEET\F\2681\22\600\640 Sketches\2681-22-SK-01-01.dwg - anthony iddon - 29/10/2012 2:19:45 PM

SPARKMAN RD

RICHARDSON

FUTURE TONKIN HIGHWAY

SERVICE CORRIDOR

PRIMARY SCHOOL

ADAMS ST

ADONIS

COCKRAM ST

ST

ADONIS

MUNDIJONG RD

80 40 0 80 160 240 Metres

SCALE 1 : 4000

LEGEND

- LSP BOUNDARY
- PUBLIC OPEN SPACE
- PRIMARY SCHOOL
- WATER CORPORATION SERVICE CORRIDOR

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MUNDIJONG PRECINCT E2 LWMS

LOCAL STRUCTURE PLAN LAYOUT

Job Number	2681-22
Revision	A
Date	OCTOBER 2012

FIGURE 1.2

Q:\1550 PEET\F\2681\22\600\640 Sketches\2681-22-SK-01-02.dwg - anthony iddon - 29/10/2012

LEGEND

LWMS BOUNDARY

26.5 PREDEVELOPMENT GROUND CONTOURS (0.5m INTERVAL)

80 40 0 80 160 240 Metres

SCALE 1 : 4000

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MUNDIJONG PRECINCT E2 LWMS

EXISTING CONTOURS AND AERIAL PHOTO

Job Number	2681-22
Revision	A
Date	OCTOBER 2012

FIGURE 2.1

SPARKMAN RD

RICHARDSON

FUTURE TONKIN HIGHWAY

ADAMS ST

ADONIS ST

COCKRAM ST

MUNDIJONG RD

TP01 TP02 TP03 TP04 TP05 TP06 TP07 TP08 TP09 TP10 TP11 TP12 TP13 TP14 TP15 TP16 TP17 TP18 TP19 TP20 TP21 TP22 TP23 TP24 TP25

26.0 27.0 28.0 25.0

LEGEND

- LWMS BOUNDARY
- EXISTING CLAY CONTOURS (0.2m INTERVAL)
- 27.0 EXISTING CLAY CONTOURS (1.0m INTERVAL)
- TP16 GEOTECH TEST LOCATION

80 40 0 80 160 240 Metres

SCALE 1 : 4000

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MUNDIJONG PRECINCT E2 LWMS

GEOTECHNICAL TEST PIT LOCATIONS & CLAY CONTOURS

Job Number 2681-22
Revision A
Date OCTOBER 2012

FIGURE 2.2

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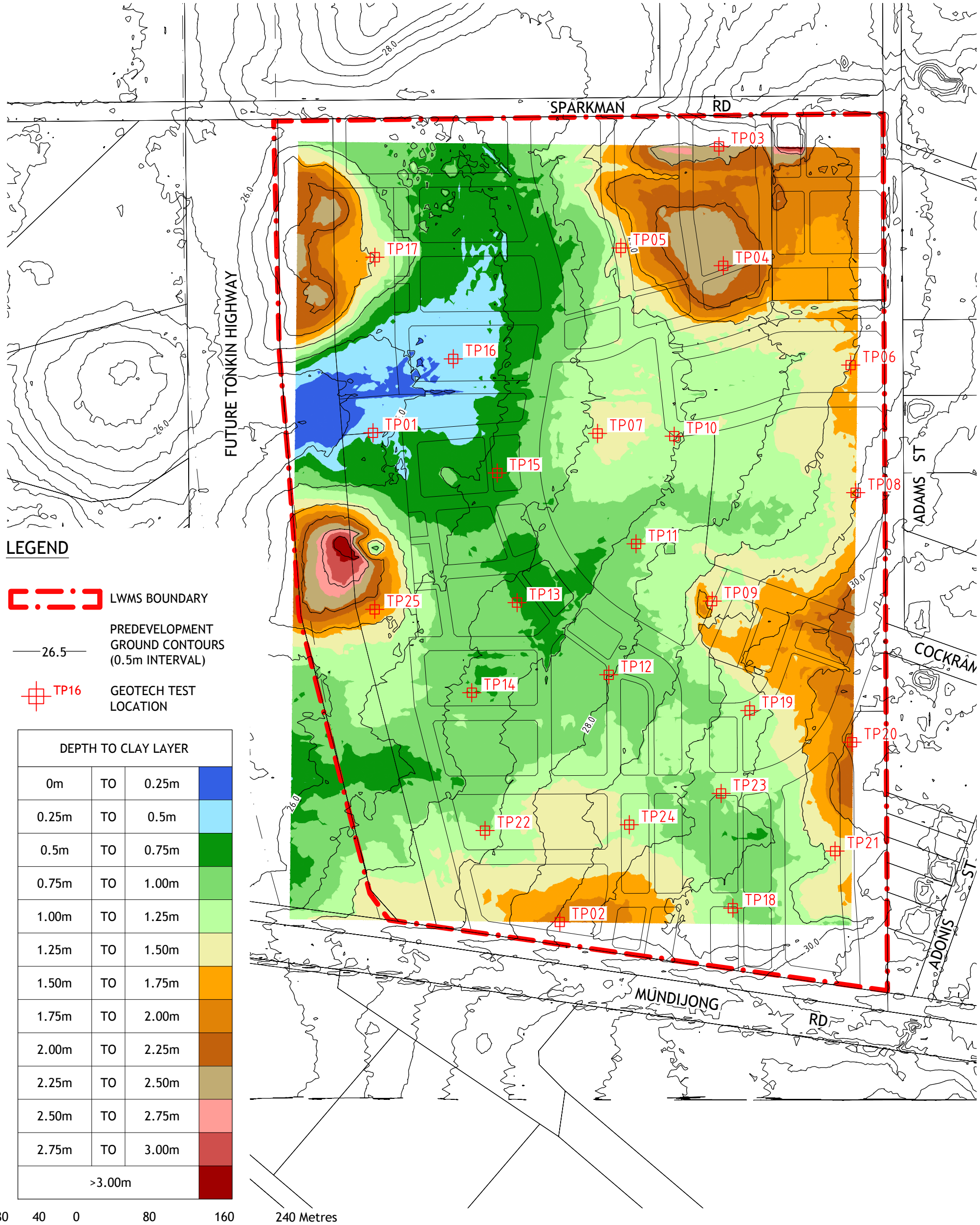

LEGEND

LWMS BOUNDARY

26.5 — PREDEVELOPMENT GROUND CONTOURS (0.5m INTERVAL)

TP16 — GEOTECH TEST LOCATION

DEPTH TO CLAY LAYER		
0m	TO	0.25m
0.25m	TO	0.5m
0.5m	TO	0.75m
0.75m	TO	1.00m
1.00m	TO	1.25m
1.25m	TO	1.50m
1.50m	TO	1.75m
1.75m	TO	2.00m
2.00m	TO	2.25m
2.25m	TO	2.50m
2.50m	TO	2.75m
2.75m	TO	3.00m
>3.00m		

80 40 0 80 160 240 Metres

SCALE 1 : 4000

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DEPTH TO CLAY LAYER

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Date OCTOBER 2012

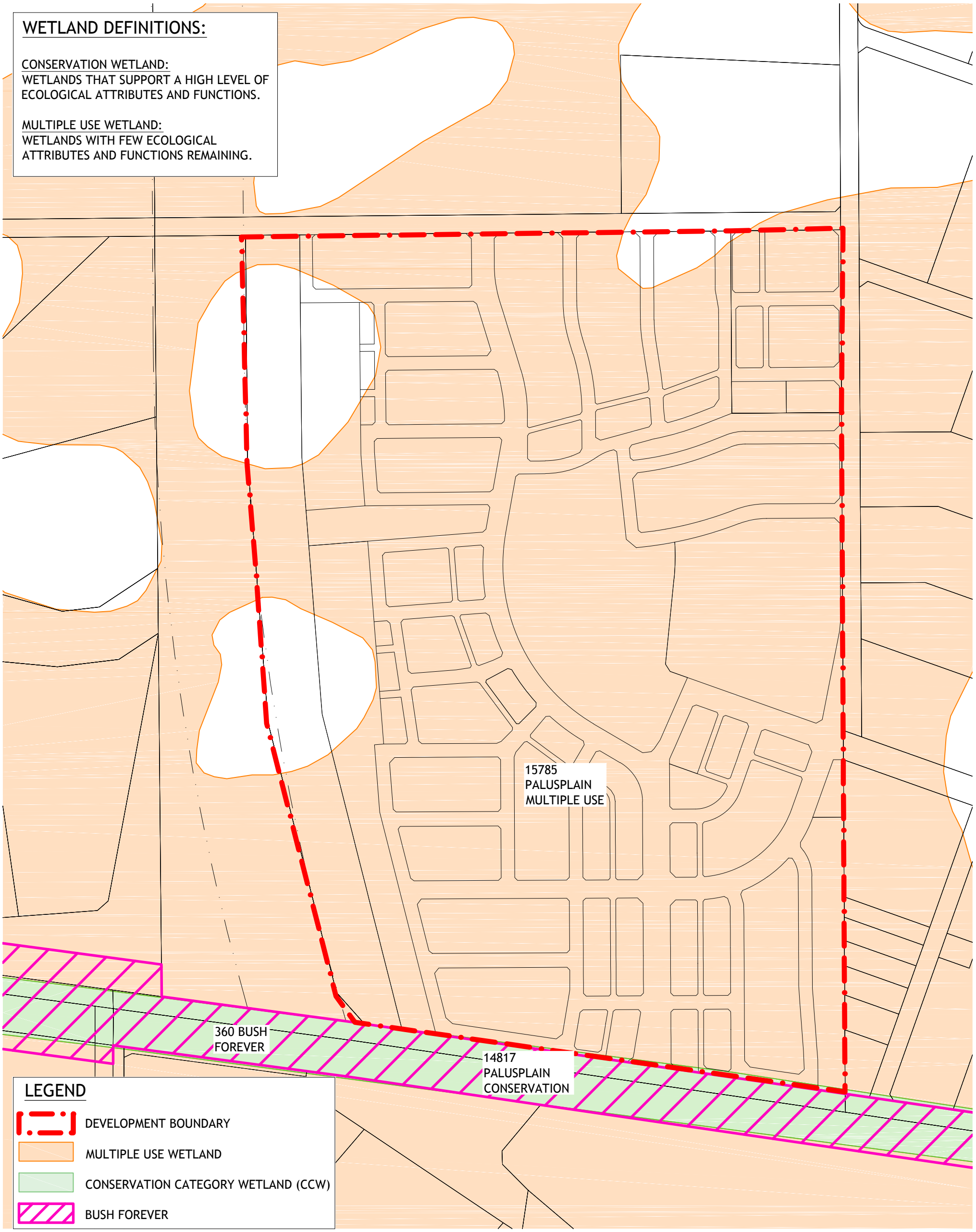
FIGURE 2.3

Q:\1550 PEET\F\2681\22\600\640 Sketches\2681-22-SK-02-03.dwg - anthony iddon - 29/10/2012

WETLAND DEFINITIONS:

CONSERVATION WETLAND:
WETLANDS THAT SUPPORT A HIGH LEVEL OF ECOLOGICAL ATTRIBUTES AND FUNCTIONS.

MULTIPLE USE WETLAND:
WETLANDS WITH FEW ECOLOGICAL ATTRIBUTES AND FUNCTIONS REMAINING.



80 40 0 80 160 240 Metres

SCALE 1 : 4000

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DEC WETLAND MAPPING

Job Number	2681-22
Revision	A
Date	OCTOBER 2012

FIGURE 2.4

SPARKMAN RD

RICHARDSON

FUTURE TONKIN HIGHWAY

ADAMS ST

ADONIS

COCKRAM ST

MUNDIJONG RD

MB01

MB02

MB03

MB04

MB05

MB06

26.0

27.0

28.0

29.0

LEGEND

- LWMS BOUNDARY
- PERCHED WATER CONTOURS (0.2m INTERVAL)
- 27.0 PERCHED WATER CONTOURS (1.0m INTERVAL)
- MB04 MONITORING BORE LOCATION

80 40 0 80 160 240 Metres

SCALE 1 : 4000

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Revision A
Date OCTOBER 2012

MONITORING BORE LOCATIONS & PRE-DEVELOPMENT WINTER PERCHED WATER LEVELS

FIGURE 2.5

Q:\1550 PEET\F\2681\22\600\640 Sketches\2681-22-SK-02-05.dwg - anthony iddon - 29/10/2012

SPARKMAN RD

FUTURE TONKIN HIGHWAY

RICHARDSON

ADAMS ST

ADONIS ST

COCKRAM ST

MUNDIJONG RD

LEGEND

LWMS BOUNDARY

DEPTH TO GROUNDWATER		
SURFACE PONDING		
0m	TO	0.2m
0.2m	TO	0.4m
0.4m	TO	0.6m
0.6m	TO	0.8m
0.8m	TO	1.0m
1.0m	TO	1.2m
1.2m	TO	1.5m
>1.5m		

80 40 0 80 160 240 Metres

SCALE 1 : 4000

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DEPTH TO PRE-DEVELOPMENT
PERCHED WINTER WATER LEVELS

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Revision A
Date OCTOBER 2012

FIGURE 2.6

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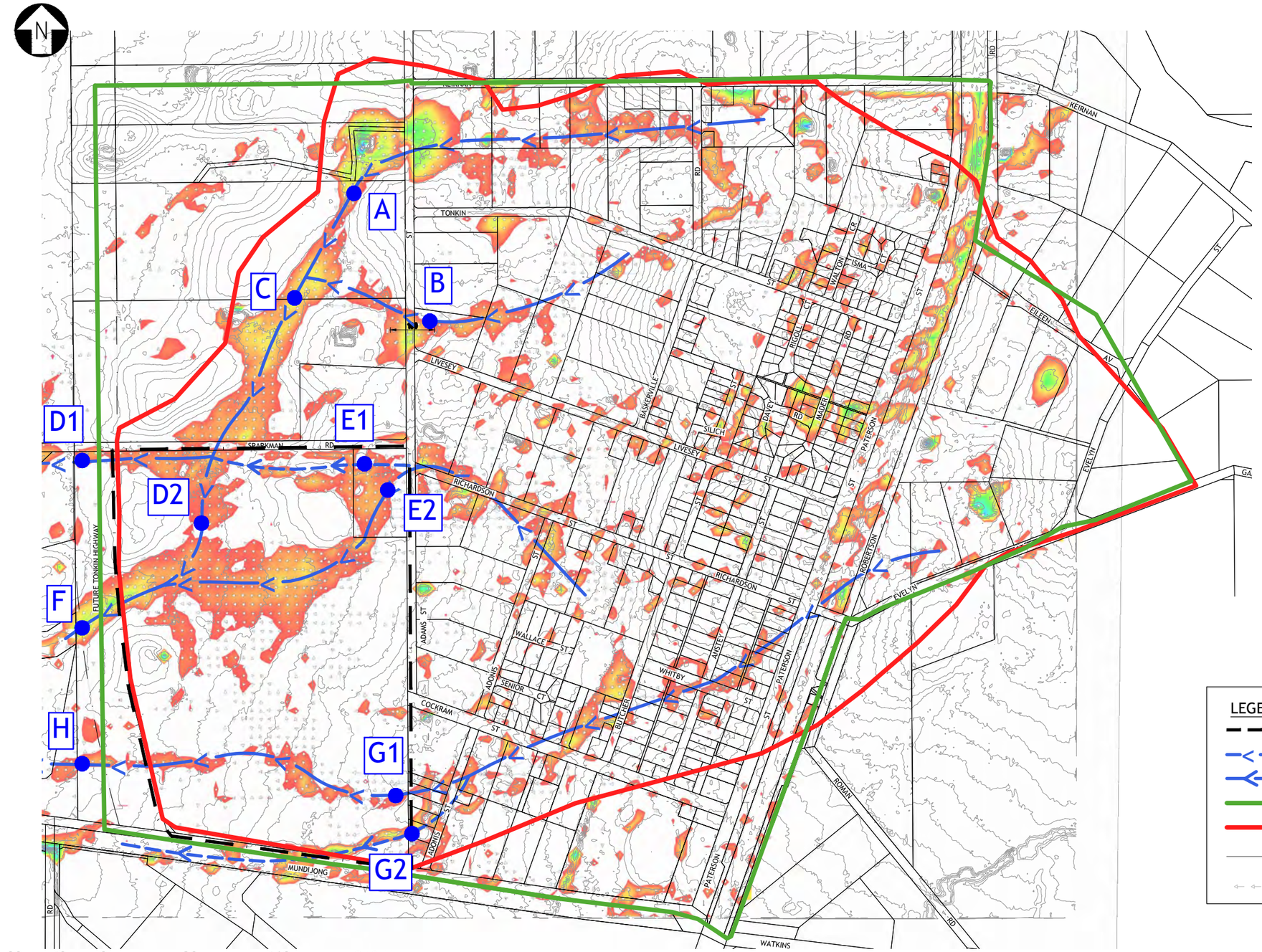

SCALE 1 : 4000

100YR ARI DEPTH OF INUNDATION

- 1.000m
- 0.900m
- 0.800m
- 0.700m
- 0.600m
- 0.500m
- 0.400m
- 0.300m
- 0.200m
- 0.100m

LOCATION	5yr Q (m^3)	100yr Q (m^3)
A	1.2	2.9
B	0.8	1.9
C	1.8	4.6
D1	1.2	2.1
D2	1.1	3.3
E1	0.5	1.4
E2	1.5	3.2
F	3.6	7.2
G1	1.0	2.5
G2	0.4	0.9
H	0.5	1.8

LEGEND

- DEVELOPMENT BOUNDARY
- PRE-DEVELOPMENT FLOW PATH
- OVERLAND FLOW PATH FOR MAJOR STORM EVENTS
- CATCHMENT BOUNDARY (GHD DWMS)
- CATCHMENT BOUNDARY (2D MODELLING)
- PREDEVELOPMENT GROUND CONTOUR (0.5m INTERVAL)
- DIRECTION OF FLOW

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PRE-DEVELOPMENT SURFACE FLOW PATHS

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FIGURE 2.7

Q:\1550 PEET\F\2681\22\600\640 Sketches\2681-22-SK-02-07.dwg - anthony iddon - 29/10/2012

BASIN INFORMATION

BASIN NUMBER	BASIN OUTLET SIZE (mm)	INVERT LEVEL (mAHD)	1YR AREA (m^2)	5YR AREA (m^2)	5YR TWL (mAHD)	100YR AREA (m^2)	100YR TWL (mAHD)
1	300	26.0	370	1000	26.8	1300	26.9
2	225	25.9	540	1000	26.8	1300	26.8
3	525	26.0	1050	1800	26.8	2300	26.9
4	225	26.8	480	1600	27.7	1900	27.7
5	225	27.1	930	2600	28.0	3100	28.0
6	225	26.8	820	3100	27.7	3900	27.8
7	375	28.0	1710	3400	28.8	3900	28.8
8	225	27.3	550	1000	28.3	2100	28.3

80 40 0 80 160 240 Metres

SCALE 1 : 4000

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N

PEET LIMITED
MUNDIJONG PRECINCT E2 LWMS

POST DEVELOPMENT
DRAINAGE MANAGEMENT

Job Number	2681-22
Revision	C
Date	MARCH 2013

FIGURE 5.1

Q:\1550 PEET\C\2681\22\600\640 Sketches\2681-22-SK-05-01.dwg - anthony iddon - 22/03/2013

	FLOOD DEPTH (m)	FLOOD WIDTH (m)
5 YEAR	0.7	12
100 YEAR	1.2	18

	FLOOD DEPTH (m)	FLOOD WIDTH (m)
5 YEAR	0.4	9
100 YEAR	0.7	13

	FLOOD DEPTH (m)	FLOOD WIDTH (m)
5 YEAR	0.6	11
100 YEAR	0.9	15

	FLOOD DEPTH (m)	FLOOD WIDTH (m)
5 YEAR	0.5	10
100 YEAR	0.9	15

	FLOOD DEPTH (m)	FLOOD WIDTH (m)
5 YEAR	0.6	11
100 YEAR	1.1	17

	FLOOD DEPTH (m)	FLOOD WIDTH (m)
5 YEAR	0.7	12
100 YEAR	1.2	18

	FLOOD DEPTH (m)	FLOOD WIDTH (m)
5 YEAR	0.3	8
100 YEAR	0.5	10

LEGEND

DEVELOPMENT BOUNDARY

PUBLIC OPEN SPACE

OPEN DRAINAGE SWALE

80 40 0 80 160 240 Metres

SCALE 1 : 4000

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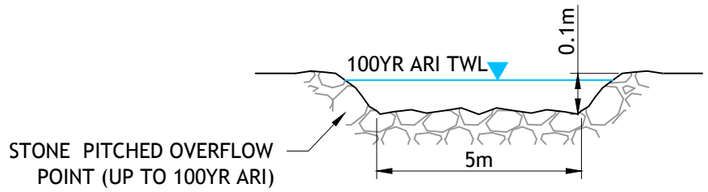
PEET LIMITED
MUNDIJONG PRECINCT E2 LWMS

DRAINAGE SWALE
FLOOD DEPTHS AND WIDTHS

Job Number 2681-22
Revision B
Date FEBRUARY 2013

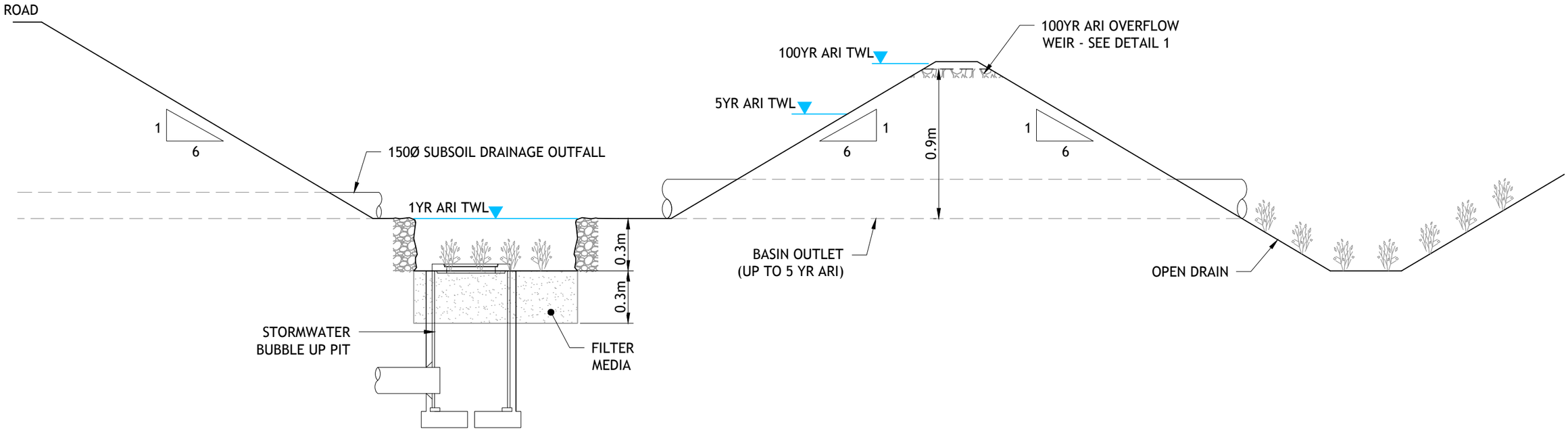
FIGURE 5.2

Q:\1550 PEET\C\2681\22\600\640 Sketches\2681-22-SK-05-02.dwg - anthony iddon - 13/02/2013



DETAIL 1

NOT TO SCALE



CROSS SECTION - BASIN ARRANGEMENT

NOT TO SCALE

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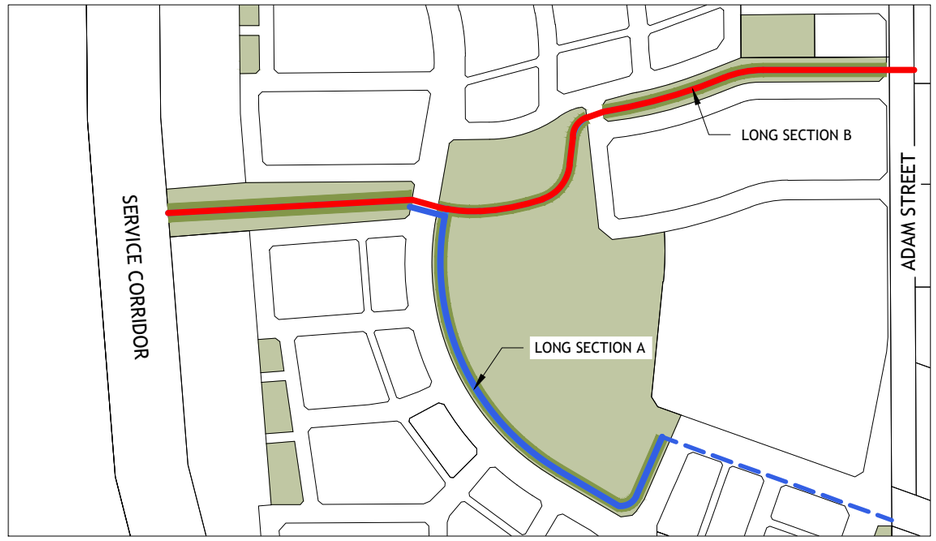
PEET LIMITED
MUNDIJONG PRECINCT E2 LWMS

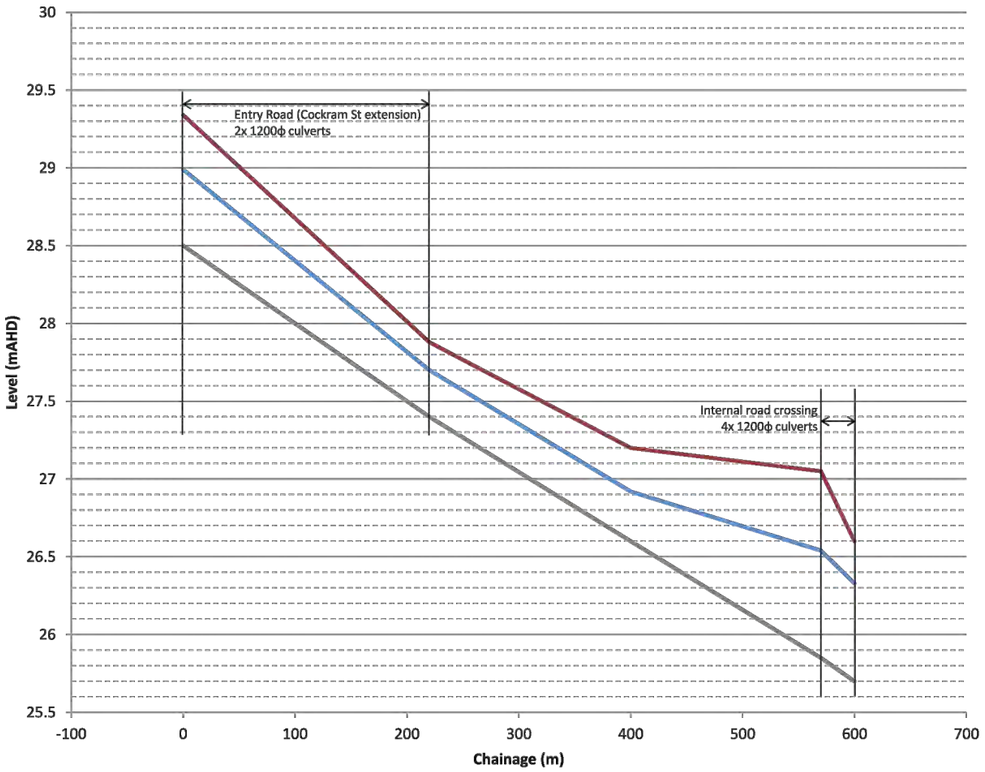
BASIN OUTLET CONFIGURATION

Job Number	2681-22
Revision	A
Date	FEBRUARY 2013

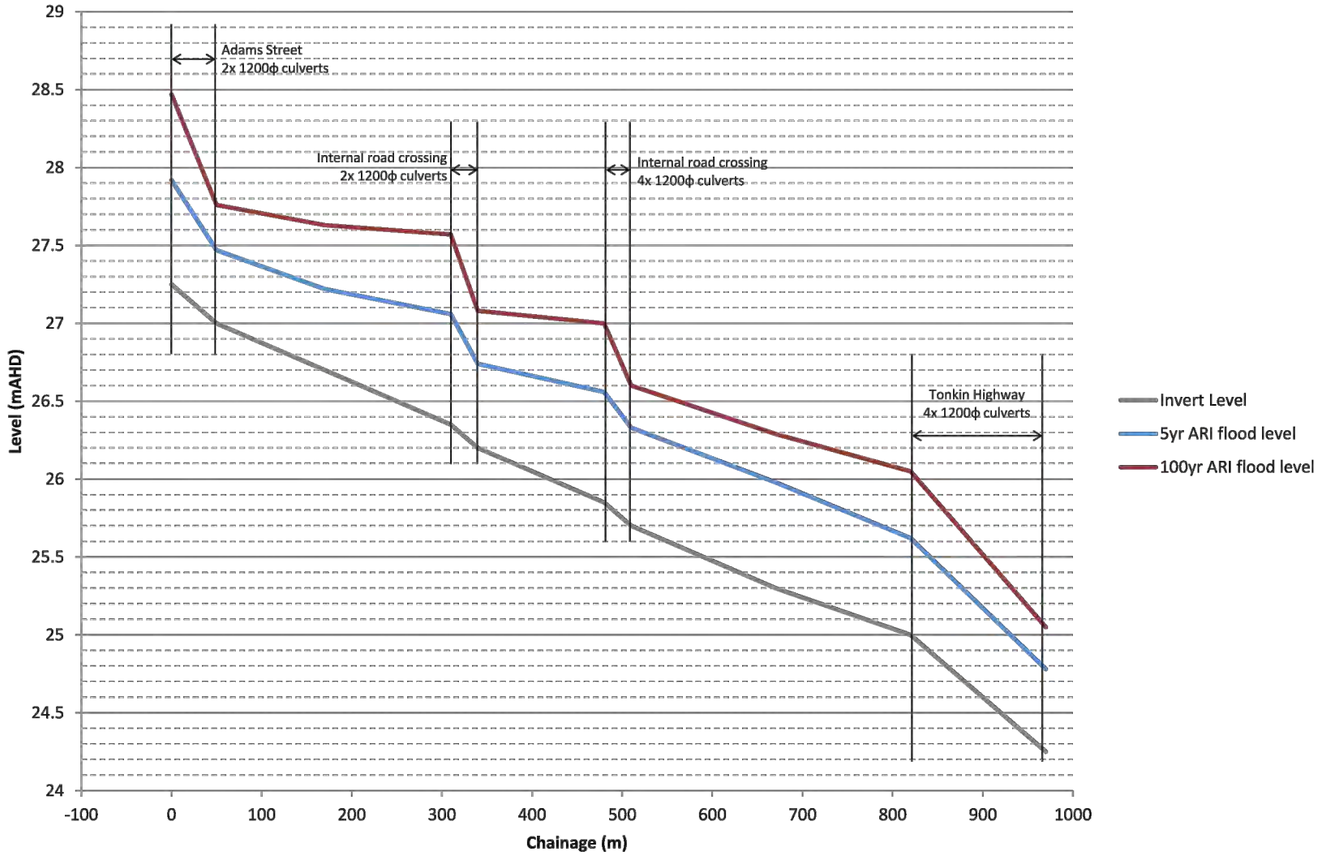
FIGURE 5.3



DRAINAGE PLAN
SCALE 1:4000



LONG SECTION A



LONG SECTION B

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PEET LIMITED
MUNDIJONG PRECINCT E2 LWMS

INDICATIVE OPEN DRAIN LONG SECTIONS

Job Number	2681-22
Revision	A
Date	FEBRUARY 2013

FIGURE 5.4

Q:\1550 PEET\C\2681\22\600\640 Sketches\2681-22-SK-05-04.dwg - anthony iddon - 13/02/2013

SPARKMAN RD

RICHARDSON

FUTURE TONKIN HIGHWAY

ADAMS ST

ADONIS

COCKRAM ST

MUNDIJONG RD

MB01

MB02

MB03

MB04

MB05

LEGEND

LWMS BOUNDARY

PUBLIC OPEN SPACE AREA

MB04 POST DEVELOPMENT MONITORING BORE LOCATION

80 40 0 80 160 240 Metres

SCALE 1 : 4000

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PEET LIMITED
MUNDIJONG PRECINCT E2 LWMS

INDICATIVE POST-DEVELOPMENT MONITORING BORE LOCATIONS

Job Number 2681-22
Revision A
Date FEBRUARY 2013

FIGURE 6.1

Q:\1550 PEET\C\2681\22\600\640 Sketches\2681-22-SK-06-01.dwg - anthony iddon - 13/02/2013

APPENDIX A – Geotechnical bore logs

EXPLANATORY NOTES TO BE READ WITH BOREHOLE AND TEST PIT REPORTS

Galt GEOTECHNICS

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)
		BOULDERS and/or COBBLES
	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
	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	

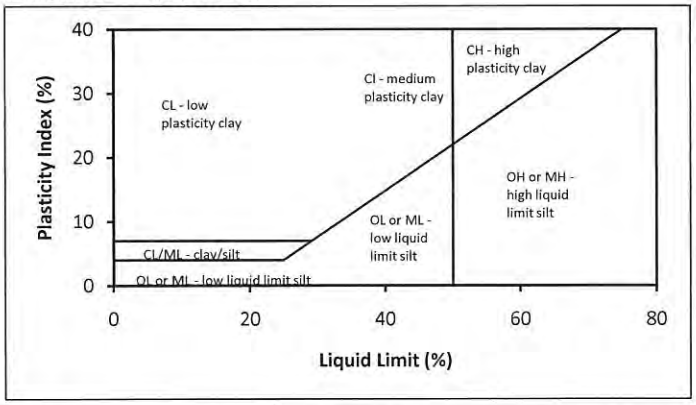
SOIL CLASSIFICATION AND INFERRED STRATIGRAPHY

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.

REPORT OF TEST PIT **TP01**

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC — Logged Date: 04/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403139	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426624	TP Width (m): 0.6 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE				SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt, abundant rootlets	M-W	L-MD		0.0
0.2						As above, pale brown, with some low plasticity clay fines, no rootlets				0.2
0.4					SC	Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, grey-white and yellow-brown, 20-30% low to medium plasticity clay fines				0.4
0.6	M				GP	GRAVEL: Fine to coarse grained ferricrete gravel, with 10% medium plasticity Sandy CLAY				0.6
0.8										0.8
1.0										1.0
1.2	E		Disturbed Sample SA01-1		CH	Sandy CLAY/Clayey SAND: High plasticity, pale grey and yellow-brown, 40-60% sand		St		1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0	M-H								Moderate to well cemented ferricrete in places from 2.0 m depth.	2.0
2.2										2.2
2.4		▶			SP	SAND: Medium to coarse grained, sub-rounded to sub-angular, white, some low to medium plasticity clay fines	W	MD		2.4
2.6										2.6
2.8										2.8

End of test pit at 2.5 m.
Target depth.
Water inflow at base of pit (2.5 m).

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT **TP02**

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC Logged Date: 04/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403347	Checked: RP Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426097	TP Width (m): 2 TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶			SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlet	M-W	L		0.0
0.2						As above, white, no fines, no rootlets		MD		0.2
0.4										0.4
0.6						As above, brown, with weakly cemented sections		L-VL		0.6
0.8						As above, yellow-brown, no cementation, trace low plasticity clay fines	W			0.8
1.0										1.0
1.2										1.2
1.4										1.4
1.6								L-MD		1.6
1.8										1.8
2.0					SC	Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, pale grey and yellow-brown, 10-15% low to medium plasticity clay fines				2.0
2.2										2.2
2.4									Estimated depth due to hole collapse.	2.4
2.6										2.6
2.8										2.8

End of test pit at 2.5 m.
Stopped due to hole collapse.
Water inflow at approximately 1.4 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT **TP03**

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC — Logged Date: 04/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403510	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426938	TP Width (m): 0.6 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0						SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets				0.0
0.2						As above, white, no fines, no rootlets				0.2
0.4										0.4
0.6										0.6
0.8										0.8
1.0		▶								1.0
1.2	VE		ASS Samples taken at 0.5 m intervals		SP		M-W	L-MD	Hole collapse.	1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4					GP	GRAVEL: Fine to coarse grained ferricrete gravel, with Clayey SAND				2.4
2.6										2.6
2.8										2.8

End of test pit at 2.5 m.
Target depth.
Water inflow between 1.0 m and 1.5 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP04

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC — Logged Date: 04/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403516	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426809	TP Width (m): 0.6 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶			SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	M-W	VL-L		0.0
0.2						As above, pale brown, no silt, no rootlets				0.2
0.4										0.4
0.6						As above, yellow-brown, trace low plasticity clay fines	W			0.6
0.8										0.8
1.0										1.0
1.2										1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0						As above, pale grey with some ferruginised fine to medium gravel				2.0
2.2										2.2
2.4										2.4
2.6										2.6
2.8										2.8

End of test pit at 2.5 m.
Target depth. Inferred ferricrete at base.
Water inflow at 2.5 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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Galt GEOTECHNICS

REPORT OF TEST PIT — TP05

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC — Logged Date: 04/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403405	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426827	TP Width (m): 2 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶	ASS Samples taken at 0.5 m intervals		SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, trace rootlets As above, white, no fines, no rootlets	W	L		0.0
1.2			Disturbed Sample SA05-1		SC	Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, pale grey mottled yellow-brown, 15-30% medium plasticity clay fines varying with depth	M-W		Hole collapse.	1.2
2.0						End of test pit at 2.0 m. Stopped due to hole collapse. Water inflow between 1.0 m and 1.5 m.				2.0
2.8										2.8

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

GALT GEOTECHNICS PTY LTD

Galt GEOTECHNICS

REPORT OF TEST PIT TP06

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC Logged Date: 04/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403055	Checked: RP Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426703	TP Width (m): 0.6 TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶	ASS Samples taken at 0.5 m intervals		SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	W	L		0.0
0.2						As above, pale brown, no fines, no rootlets				0.2
0.4						Gravelly SAND: Medium to coarse grained, sub-rounded to sub-angular, grey-white mottled yellow-brown, 20-40% fine to coarse grained ferricrete gravel		MD	Hole collapse.	0.4
0.6										0.6
0.8										0.8
1.0	M				SC	Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, pale blue mottled yellow-brown and blue-green, ~20% medium plasticity clay fines, with 20-40% fine to coarse grained ferricrete GRAVEL increasing with depth				1.0
1.2										1.2
1.4	H				GP	GRAVEL: Fine to coarse grained ferricrete, with 20% Clayey SAND, some cobbles				1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6
2.8										2.8

End of test pit at 1.5 m.
Refusal on Ferricrete.
Water inflow at approximately 0.5 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

GALT GEOTECHNICS PTY LTD

Galt GEOTECHNICS

REPORT OF TEST PIT TP07

PROJECT DETAILS
Job Number: J1101127
Client: Wave Engineering Pty Ltd
Project: Residential Development
Location: Lot 46 Mundijong Road Mundijong

SPATIAL DETAILS
Position: See Plan
Easting (m): 403382
Northing (m): 6426626
Datum: MGA94
Surface RL (m):

DRILLING DETAILS
Logged: HWC Logged Date: 04/10/2011
Checked: RP Checked Date: 27/10/2011
TP Width (m): 2 TP Length (m):
Machine: Komatsu WB 97R Bucket: Toothed
Contractor: Erskine EM Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶			SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	W	VL-L		0.0
0.2						As above, pale brown, no fines, no rootlets				0.2
0.4										0.4
0.6										0.6
0.8										0.8
1.0										1.0
1.2										1.2
1.4										1.4
1.6					SC	Clayey SAND: Medium plasticity fines, grey-green mottled yellow-brown, medium to coarse sub-rounded to sub-angular sand, becoming sandier with depth			Estimated depth due to hole collapse.	1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6
2.8										2.8

End of test pit at 2.0 m.
Stopped due to hole collapse.
Water inflow at approximately 0.5 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP08

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC — Logged Date: 03/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403662	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426565	TP Width (m): 0.6 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶	ASS Samples taken at 0.5 m intervals		SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	M-W	L-MD	Hole collapse.	0.0
0.2						As above, white, no fines, no rootlets				0.2
0.4						As above, brown				0.4
0.6						As above, pale brown				0.6
0.8										0.8
1.0										1.0
1.2										1.2
1.4										1.4
1.6					SC	Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, grey-white mottled yellow-brown, 15% low to medium plasticity clay fines, with some 5-15 mm ferruginised nodules		MD		1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6
2.8										2.8

End of test pit at 2.0 m.
Refusal on Ferricrete.
Water inflow at approximately 0.6 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP09

PROJECT DETAILS

Job Number: J1101127
Client: Wave Engineering Pty Ltd
Project: Residential Development
Location: Lot 46 Mundijong Road Mundijong

SPATIAL DETAILS

Position: See Plan
Easting (m): 403508
Northing (m): 6426446
Datum: MGA94
Surface RL (m):

DRILLING DETAILS

Logged: HWC — Logged Date: 03/10/2011
Checked: RP — Checked Date: 27/10/2011
TP Width (m): 2 — TP Length (m):
Machine: Komatsu WB 97R — Bucket: Toothed
Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE				SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	M-W	VL		0.0
0.2						As above, white, no fines, no rootlets				0.2
0.4										0.4
0.6										0.6
0.8						As above, pale brown, trace low plasticity clay fines				0.8
1.0						As above, yellow brown, some silt fines			Estimated depth due to hole collapse.	1.0
1.2										1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6
2.8										2.8

End of test pit at 1.8 m.
Stopped due to hole collapse.
Groundwater not encountered.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP10

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC — Logged Date: 04/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403465	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426624	TP Width (m): 0.6 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶	ASS Samples taken at 0.5 m intervals Sample SA10-1		SP	SAND: Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets to 0.1 m	M-W	L-MD		0.0
0.2										0.2
0.4										0.4
0.6			Sample SA10-2		SC-CI/CH	Clayey SAND/Sandy CLAY: Medium to high plasticity fines, olive grey mottled yellow-brown, medium to coarse sub-rounded to sub-angular sand, becoming sandier with depth			Slight sulphur odour while excavating	0.6
0.8										0.8
1.0										1.0
1.2						Clayey SAND: Medium plasticity fines, blue-green mottled yellow-brown, medium to coarse sub-rounded to sub-angular sand, becoming sandier with depth				1.2
1.4										1.4
1.6										1.6
1.8					SC					1.8
2.0										2.0
2.2										2.2
2.4						End of test pit at 2.4 m. Target depth. Water inflow at 0.1 m.				2.4
2.6										2.6
2.8										2.8

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP11

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC — Logged Date: 03/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403425	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426507	TP Width (m): 0.6 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶	ASS Samples taken at 0.5 m intervals		SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	M-W	VL-L		0.0
0.2						As above, pale brown, no fines, no rootlets				0.2
0.4										0.4
0.6										0.6
0.8										0.8
1.0					SC	Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, grey-white and yellow-brown, 20-30% low to medium plasticity clay fines				1.0
1.2										1.2
1.4					GC	GRAVEL: Fine to coarse grained ferricrete, in a Clayey SAND (as above) matrix (approximately 40%)				1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6						End of test pit at 2.6 m. Target depth. Water inflow at 1.2 m.				2.6
2.8										2.8

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP12

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC — Logged Date: 03/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403397	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426365	TP Width (m): 0.6 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶			SP	SAND: Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets to 0.1 m	M-W	VL-L		0.0
0.2										0.2
0.4										0.4
0.6										0.6
0.8									Hole collapse.	0.8
1.0					SC	Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, grey-white and yellow-brown, 20-30% low to medium plasticity clay fines, some ferruginised nodules 5-15 mm in size		L-MD		1.0
1.2										1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6
2.8										2.8

End of test pit at 2.5 m.
Target depth.
Water inflow at 2.0 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP13

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC — Logged Date: 03/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403297	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426442	TP Width (m): 0.6 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0						SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets				0.0
0.2					SP	As above, pale brown, no silt, no rootlets		L		0.2
0.4										0.4
0.6		▶								0.6
0.8						Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, grey-white and yellow-brown, 20-30% low to medium plasticity clay fines				0.8
1.0	VE		Disturbed Sample SA13-2				M-W			1.0
1.2										1.2
1.4			In situ sample SA13-1		SC			MD		1.4
1.6										1.6
1.8						As above, olive grey and yellow-brown predominantly, ~30% medium plasticity clay fines				1.8
2.0										2.0
2.2										2.2
2.4	H					FERRICRETE				2.4
2.6										2.6
2.8										2.8

End of test pit at 2.5 m.
Target depth.
Water inflow at approximately 0.7 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP14

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC — Logged Date: 03/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403249	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426344	TP Width (m): 0.6 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶			SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	M-W	L-MD		0.0
0.2						As above, pale brown, no silt, no rootlets				0.2
0.4										0.4
0.6										0.6
0.8					SC	Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, grey-white and yellow-brown, ~15% low to medium plasticity clay fines, with increased clay content in parts, with some ferruginised nodules (5-15 mm in size)			Hole collapse.	0.8
1.0										1.0
1.2										1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4	H					FERRICRETE		MD		2.4
2.6										2.6
2.8										2.8

End of test pit at 2.7 m.
Target depth.
Water inflow at approximately 0.7 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP15

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC — Logged Date: 04/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403274	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426582	TP Width (m): 0.6 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE				SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	M-W	L-MD		0.0
0.2						As above, pale brown, no silt, no rootlets				0.2
0.4										0.4
0.6			Disturbed Sample SA15-1		SC	Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, grey-white mottled yellow-brown, ~20-30% medium plasticity clay fines, with fines content increasing in parts				0.6
0.8										0.8
1.0										1.0
1.2	M				GP	Sandy GRAVEL: Fine to medium grained ferricrete, brown, with ~20% medium to coarse grained sand,	W			1.2
1.4										1.4
1.6						GRAVEL: Fine to coarse grained ferricrete gravel, pale brown and olive grey, with 20% Clayey SAND/Sandy CLAY becoming well cemented				1.6
1.8	H	▶								1.8
2.0						End of test pit at 2.0 m. Refusal on Ferricrete. Water inflow at 1.8 m.				2.0
2.2										2.2
2.4										2.4
2.6										2.6
2.8										2.8

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP16

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC — Logged Date: 04/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403225	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426705	TP Width (m): 0.6 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE				SP	SAND (Topsoil): Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	M-W	L		0.0
0.2						As above, pale brown, no silt, no rootlets				0.2
0.4			Sample SA16-1		SC	Clayey SAND: Medium to coarse grained, olive grey mottled yellow-brown, 40-50% medium to high plasticity clay fines, becoming ferruginised from 0.6 m (moderately to well cemented)				0.4
0.6	H							H		0.6
0.8			In situ sample SA16-2							0.8
1.0										1.0
1.2										1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6
2.8										2.8

End of test pit at 0.7 m.
Refusal on Ferricrete.
Groundwater not encountered.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP17

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: HWC — Logged Date: 04/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403139	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426814	TP Width (m): 2 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE	▶	ASS Samples taken at 0.5 m intervals		SP	SAND: Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets to 0.1 m	W	VL-L		0.0
0.2										0.2
0.4										0.4
0.6										0.6
0.8						As above, brown, with some weakly cemented nodules (5-15 mm), trace low plasticity clay fines, no rootlets				0.8
1.0										1.0
1.2						As above, yellow-brown, no cementation				1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6
2.8										2.8

End of test pit at 2.0 m.
Stopped due to hole collapse.
Water inflow at approximately 1.0 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP18

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: RP — Logged Date: 03/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403534	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426114	TP Width (m): 0.6 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	E	▶	ASS Samples taken at 0.5 m intervals		SP	SAND: Medium to fine grained, black to 0.1 m, becoming pale grey, with some low plasticity clay fines	W	VL	Topsoil with abundant rootlets to 0.1 m.	0.0
0.8					SC	Clayey SAND: Medium to fine grained, with 20-30% medium plasticity clay fines, with frequent ferruginised nodules (can be broken with fingers)		S-F		0.8
2.0	M					As above, but generally more cemented		St		2.0
2.8						End of test pit at 2.5 m. Target depth. Water inflow at 0.4 m and 1.5 m.				2.8

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP19

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: RP — Logged Date: 03/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403550	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426328	TP Width (m): 0.6 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0					SP	SAND: Medium grained, black at top 0.1 m becoming pale greyish yellow, trace fines	W	VL		0.0
0.6		▶			SC	Clayey SAND: Medium to fine grained, with ~20% medium plasticity clay fines, grey mottled orange, with weakly ferruginised nodules		F		0.6
2.6						End of test pit at 2.6 m. Refusal on moderately cemented Ferricrete nodules. Groundwater not encountered.				2.6

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP20

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: RP — Logged Date: 03/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403661	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426295	TP Width (m): 2 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0						SAND: Medium grained, black at top becoming pale grey, trace fines			Topsoil to 0.1 m.	0.0
0.2										0.2
0.4										0.4
0.6										0.6
0.8						As above, brown becoming orange				0.8
1.0			ASS Samples taken at 0.5 m intervals		SP		W	VL		1.0
1.2										1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0										2.0
2.2										2.2
2.4										2.4
2.6										2.6
2.8										2.8
						End of test pit at 2.0 m. Stopped due to hole collapse. Groundwater not encountered.				

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

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REPORT OF TEST PIT — TP21

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: RP — Logged Date: 03/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403644	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426177	TP Width (m): 0.6 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0					SP	SAND: Medium to fine grained, dark grey becoming pale yellow-grey, with ~10% low plasticity clay fines	W	VL	Black topsoil to 0.1 m.	0.0
0.2										0.2
0.4					SC-CI/CH	Clayey SAND/Sandy CLAY: Coarse, medium and fine grained, with 40-60% medium to high plasticity fines, pale grey and orange, scattered weakly ferruginised nodules				0.4
0.6										0.6
0.8										0.8
1.0										1.0
1.2										1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0		▶								2.0
2.2					GC	Clayey GRAVEL: Medium to fine grained, moderately cemented ferricrete nodules in a matrix (40%) of Clayey SAND				2.2
2.4										2.4
2.6										2.6
2.8										2.8

End of test pit at 2.4 m.
Near refusal.
Water inflow (slow seepage) at 2.1 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

GALT GEOTECHNICS PTY LTD

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REPORT OF TEST PIT TP22

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: RP — Logged Date: 03/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403265	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426195	TP Width (m): 2 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0						SAND: Medium grained, black at top 0.1 m becoming pale yellow-grey and yellow				0.0
0.2										0.2
0.4					SP					0.4
0.6		▶								0.6
0.8										0.8
1.0						Clayey SAND: Medium grained, pale grey mottled pale orange, 20% medium plasticity fines				1.0
1.2			ASS Samples taken at 0.5 m intervals				W	L		1.2
1.4										1.4
1.6										1.6
1.8					SC					1.8
2.0						As above, with occasional well cemented ferricrete nodules				2.0
2.2										2.2
2.4										2.4
2.6										2.6
2.8										2.8
						End of test pit at 2.6 m. Collapse. General seepage below 0.6 m.				

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

GALT GEOTECHNICS PTY LTD

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REPORT OF TEST PIT TP23

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: RP — Logged Date: 03/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403520	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426238	TP Width (m): 2 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0					SP	SAND: Medium grained, layered black, pale grey and orange yellow, trace fines	W	VL	Black topsoil to 0.1 m.	0.0
0.2										0.2
0.4		▶								0.4
0.6										0.6
0.8										0.8
1.0					SC	Clayey SAND: Medium to fine grained, grey occasionally mottled yellow orange, 20% low to medium plasticity fines				1.0
1.2										1.2
1.4										1.4
1.6										1.6
1.8										1.8
2.0						As above, with ferricrete nodules towards base				2.0
2.2										2.2
2.4										2.4
2.6										2.6
2.8										2.8

End of test pit at 2.6 m.
Collapse below 0.2 m.
General seepage below 0.4 m.

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

GALT GEOTECHNICS PTY LTD

Galt GEOTECHNICS

REPORT OF TEST PIT TP24

PROJECT DETAILS	SPATIAL DETAILS	DRILLING DETAILS
Job Number: J1101127	Position: See Plan	Logged: RP — Logged Date: 03/10/2011
Client: Wave Engineering Pty Ltd	Easting (m): 403421	Checked: RP — Checked Date: 27/10/2011
Project: Residential Development	Northing (m): 6426203	TP Width (m): 2 — TP Length (m):
Location: Lot 46 Mundijong Road Mundijong	Datum: MGA94	Machine: Komatsu WB 97R — Bucket: Toothed
	Surface RL (m):	Contractor: Erskine EM — Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0					SP	SAND: Medium grained, black at top 0.1 m becoming pale grey and yellow, trace fines	W	L		0.0
0.6		▶								0.6
1.2					SC	Clayey SAND: Medium grained, grey stained orange, 20% medium to low plasticity fines				1.2
2.5						End of test pit at 2.5 m. Target depth. Continual collapse during excavation. Seepage below 0.6 m.				2.5

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

GALT GEOTECHNICS PTY LTD

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REPORT OF TEST PIT TP25

PROJECT DETAILS

Job Number: J1101127
Client: Wave Engineering Pty Ltd
Project: Residential Development
Location: Lot 46 Mundijong Road Mundijong

SPATIAL DETAILS

Position: See Plan
Easting (m): 403143
Northing (m): 6246433
Datum: MGA94
Surface RL (m):

DRILLING DETAILS

Logged: RP Logged Date: 04/10/2011
Checked: RP Checked Date: 27/10/2011
TP Width (m): 2 TP Length (m):
Machine: Komatsu WB 97R Bucket: Toothed
Contractor: Erskine EM Operator: James

DEPTH (m)	EXCAVATION RESISTANCE	GROUNDWATER	SAMPLES & FIELD TESTS	GRAPHIC LOG	USCS CLASSIFICATION	MATERIAL DESCRIPTION (Soil type, plasticity or particle characteristics, colour, secondary and minor components)	MOISTURE CONDITION	CONSISTENCY/ DENSITY	ADDITIONAL OBSERVATIONS	DEPTH (m)
0.0	VE		ASS Samples taken at 0.5 m intervals		SP	SAND: Medium to coarse grained, sub-rounded to sub-angular, dark grey, trace silt fines, abundant rootlets	M-W	L		0.0
0.2						As above, no fines, no rootlets				0.2
0.4										0.4
0.6										0.6
0.8										0.8
1.0								MD		1.0
1.2										1.2
1.4						As above, brown, with weakly cemented nodules (5-15 mm in size)				1.4
1.6						As above, white, no nodules				1.6
1.8										1.8
2.0					SC	Clayey SAND: Medium to coarse grained, sub-rounded to sub-angular, pale grey mottled yellow-brown, 10-15% low to medium plasticity clay fines, becoming ferruginised with depth				2.0
2.2										2.2
2.4										2.4
2.6										2.6
2.8										2.8
						End of test pit at 2.0 m. Stopped due to hole collapse. Groundwater not encountered.				

See Explanatory Notes and Method of Soil Description sheets for detials of abbreviations and basis of descriptions

GALT GEOTECHNICS PTY LTD

APPENDIX B – Pre-development groundwater monitoring data

	Easting	Northing	NSL (from LiDAR)
MB01	403631	6426722	28.3
MB02	403315	6426824	26.7
MB03	403018	6426687	25.5
MB04	403299	6426476	27.0
MB05	403293	6426143	27.8
MB06	403609	6426332	29.9
DoW bore T270	401401	6429300	16.7

(from DoW records)

DoW avg max GWL =	17.0
DoW reading @ 14-Oct-09 =	16.7
adjustment to Oct-09 GWLs =	0.3
DoW avg min GWL =	15.7
DoW reading @ 5-May-09 =	15.3
adjustment to Apr-09 GWLs =	0.4

typical winter (high) water levels

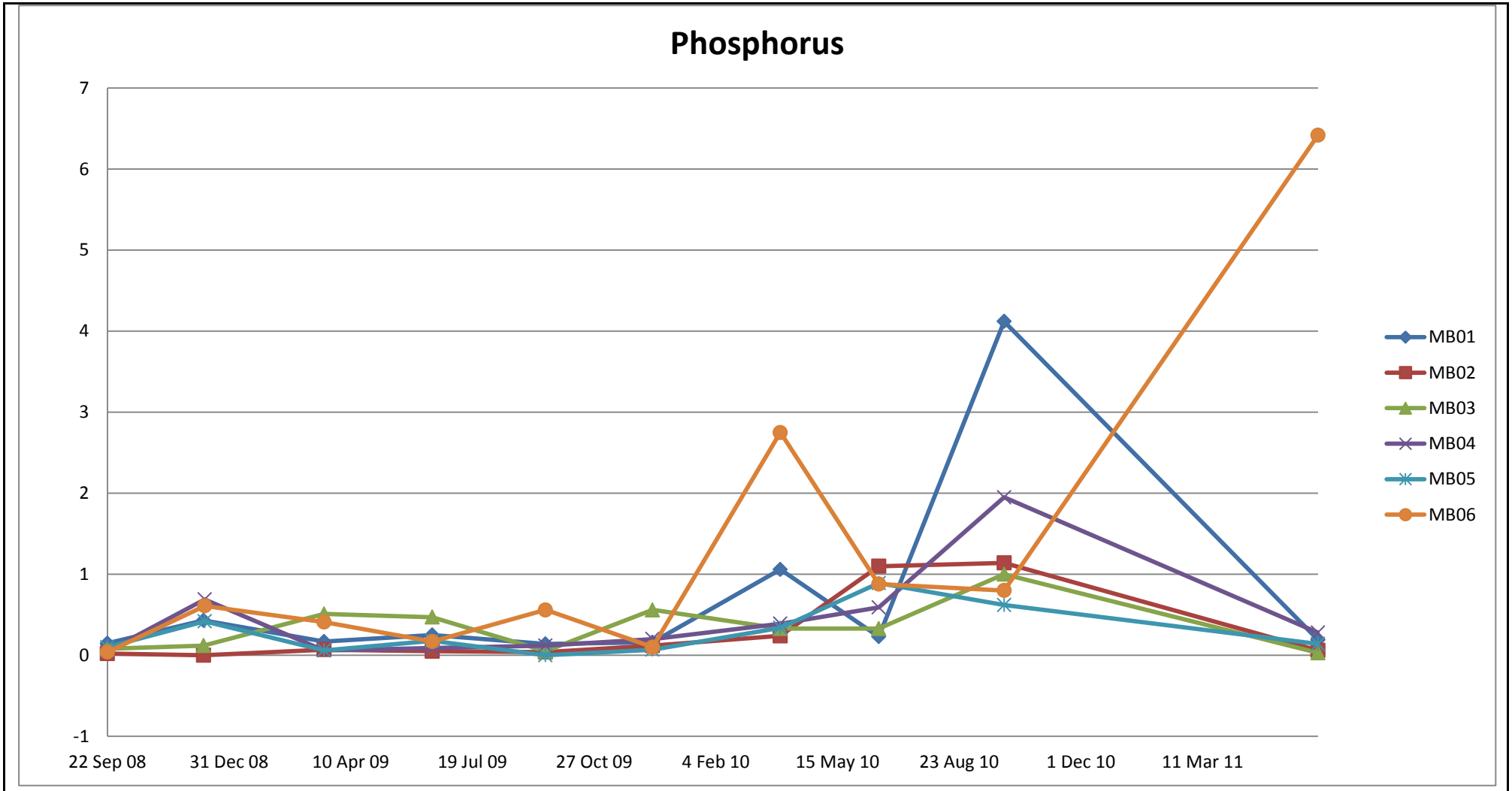
	GWL	mBGL	NSL
MB01	27.9	0.4	28.3
MB02	26.6	0.1	26.7
MB03	25.2	0.3	25.5
MB04	26.2	0.8	27
MB05	27.0	0.8	27.8
MB06	29.1	0.8	29.9
DoW bore T270	17.0	-0.3	16.7

typical summer (low) water levels

	GWL	mBGL	clay level
MB01	27.1	1.2	26.9
MB02	25.8	0.9	26.1
MB03	24.2	1.3	24.9
MB04	24.9	2.1	26.3
MB05	25.6	2.2	26.4
MB06	27.2	2.7	28.4
DoW bore T270	15.7	1.0	n/a

mAHD - corrected GWL data (= emerson stewart mAHD data MINUS casing height)

	22-Sep-08	21-Oct-08	18-Nov-08	11-Dec-08	20-Jan-09	20-Feb-09	19-Mar-09	24-Apr-09	25-May-09	16-Jun-09	15-Jul-09	14-Aug-09	17-Sep-09	09-Oct-09	18-Nov-09	14-Dec-09	19-Jan-10	23-Feb-10	29-Mar-10	18-Jun-10	26-Jul-10	24-Aug-10	29-Sep-10	14-Jun-11	18-Jul-11	15-Aug-11
MB01	27.661	27.451	27.381	27.301	27.091	26.921	26.841	26.731	26.851	26.941	27.611	27.941	27.941	27.611	27.298	27.19	27.02	26.866	26.934	27.234	27.576	27.494	27.226	27.006	27.562	27.845
MB02	26.36	26.11	26.04	25.97	25.65	25.49	25.44	25.39	25.53	25.67	26.34	26.55	26.65	26.33	26.052	25.808	25.549	25.473	25.57	25.972	26.253	26.295	25.947	25.737	26.32	26.55
MB03	24.791	24.591	24.481	24.441	24.161	24.011	23.931	23.831	23.991	24.211	24.891	25.081	25.071	24.881	24.007	24.345	24.165	24.03	24.103	24.574	24.788	24.806	24.477	24.33	24.869	25.027
MB04	25.677	25.607	25.507	25.427	25.097	24.907	24.747	24.547	24.477	24.617	26.237	26.547	26.487	25.867	26.004	25.418	25.179	24.966	24.846	25.708	26.239	26.067	25.645	25.798	26.482	26.537
MB05	26.554	26.364	26.234	26.124	25.814	25.634	25.454	25.214	25.004	25.044	26.354	27.044	27.114	26.674	26.242	26.178	26.038	25.866	25.842	25.926	26.336	26.326	26.114	25.659	26.494	26.991
MB06	28.569	28.419	28.279	29.059	27.839	27.439	27.069	26.789	26.719	26.819	28.539	29.129	29.159	28.809	28.317	28.192	27.809	27.279	27.024	27.225	28.234	28.146	27.746	26.848	28.389	29.066

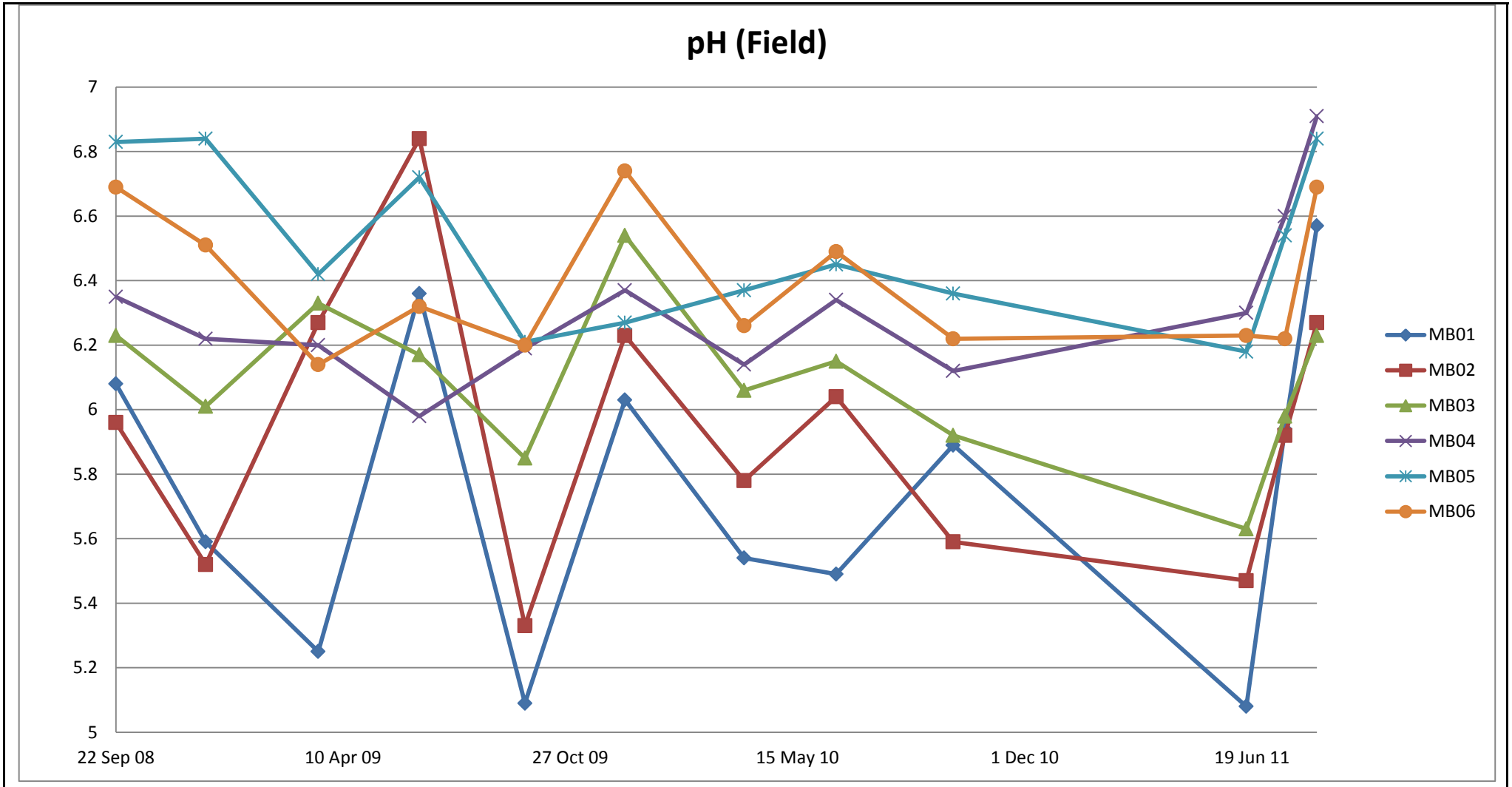


Figure

[Project_Name], Where([LChem1_Chemistry].[LocCode] In('MB01' , 'MB02' , 'MB03' , 'MB04' , 'MB05' , 'MB06'))

Date:	Drawn:
Scale: nts	Chk'd:
Original:	Rev:
File Reference:	

ESDAT



Figure

[Project_Name], Where([LChem1_Chemistry].[LocCode] In('MB01' , 'MB02' , 'MB03' , 'MB04' , 'MB05' , 'MB06'))

Date:	Drawn:
Scale: nts	Chk'd:
Original:	Rev:
File Reference:	

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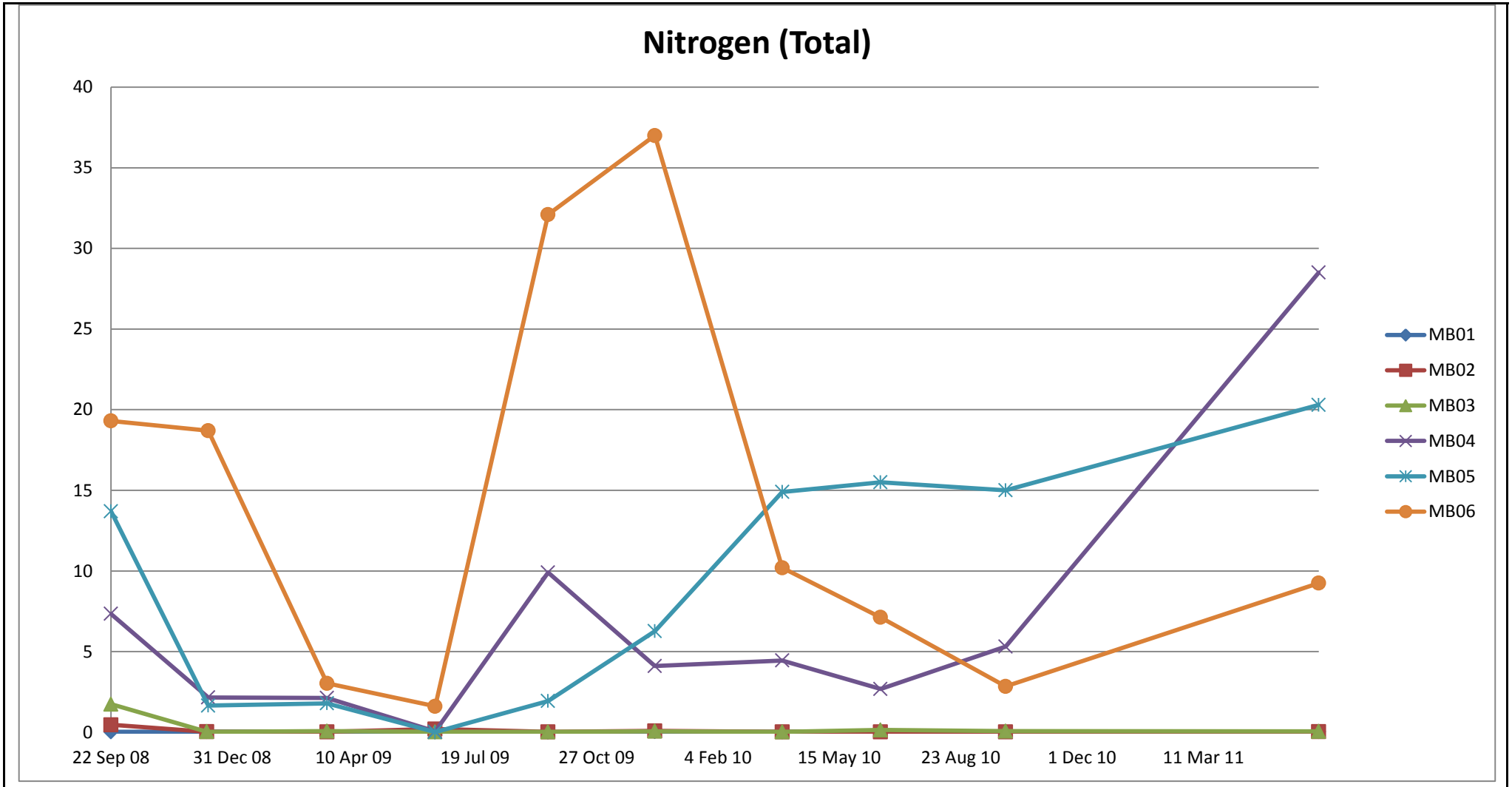

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[Project_Name], Where([LChem1_Chemistry].[LocCode] In('MB01' , 'MB02' , 'MB03' , 'MB04' , 'MB05' , 'MB06'))

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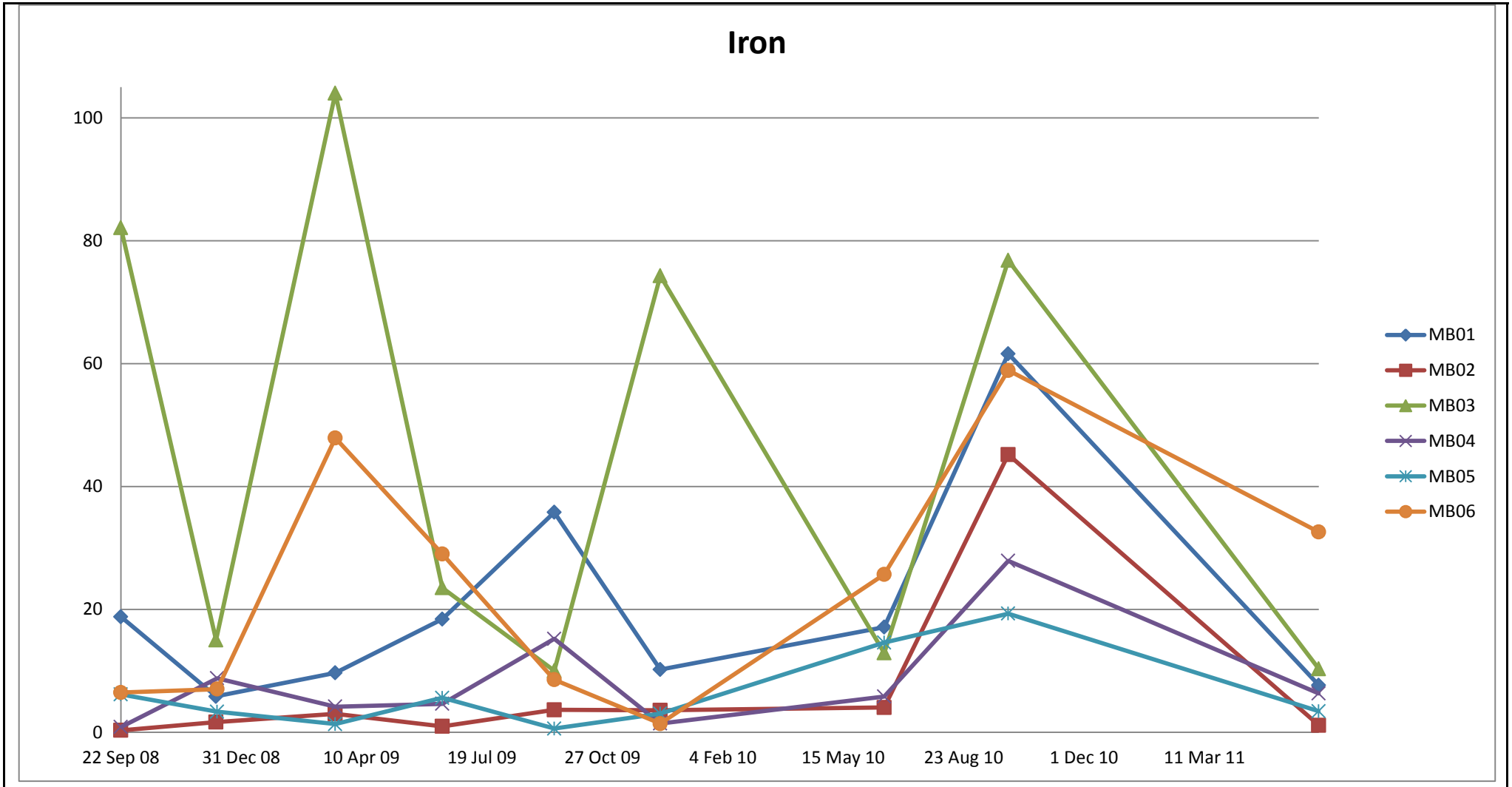

Figure

[Project_Name], Where([LChem1_Chemistry].[LocCode] In('MB01' , 'MB02' , 'MB03' , 'MB04' , 'MB05' , 'MB06'))

Date:	Drawn:
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Original:	Rev:
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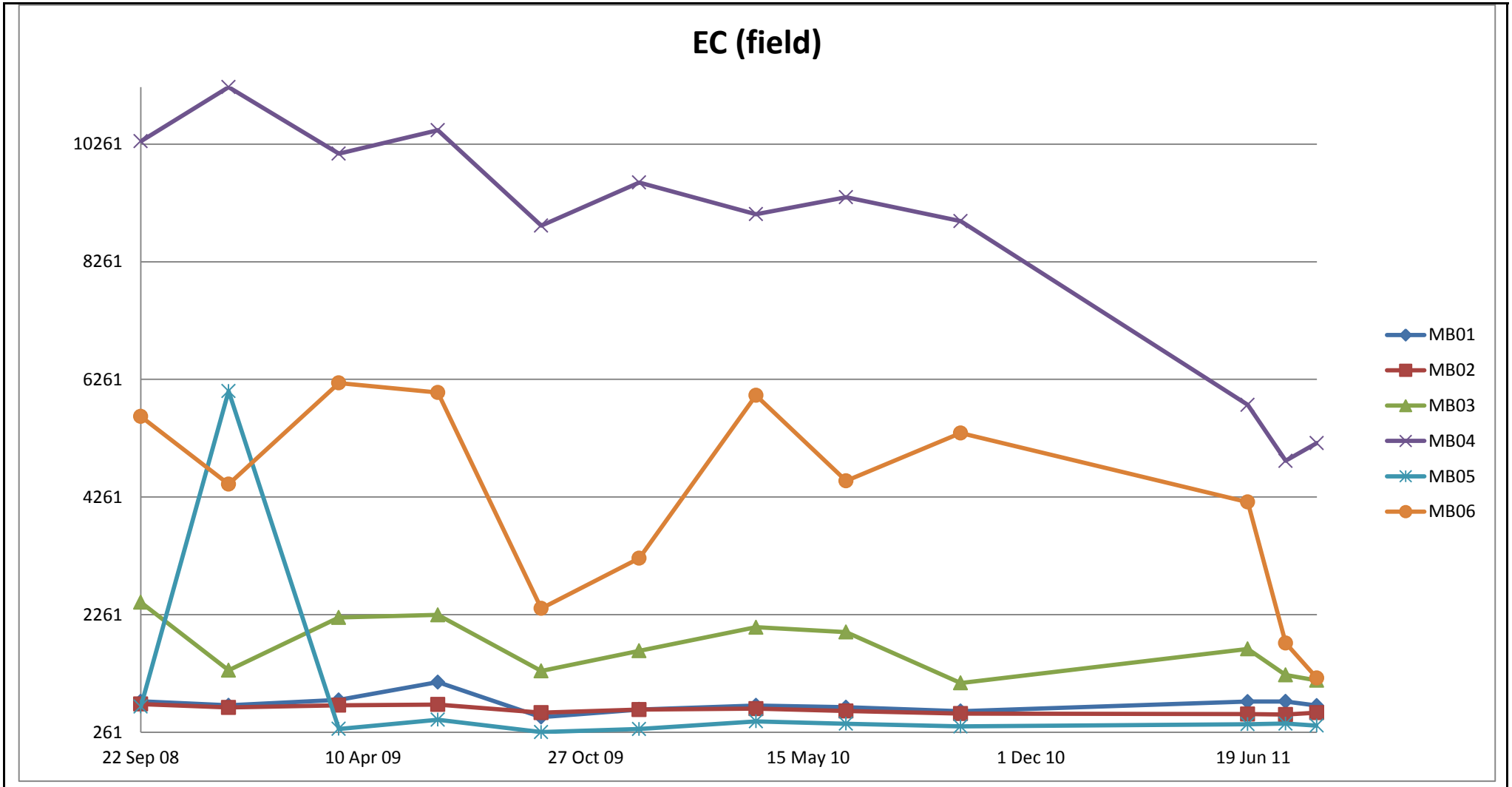

Figure

[Project_Name], Where([LChem1_Chemistry].[LocCode] In('MB01' , 'MB02' , 'MB03' , 'MB04' , 'MB05' , 'MB06'))

Date:	Drawn:
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Original:	Rev:
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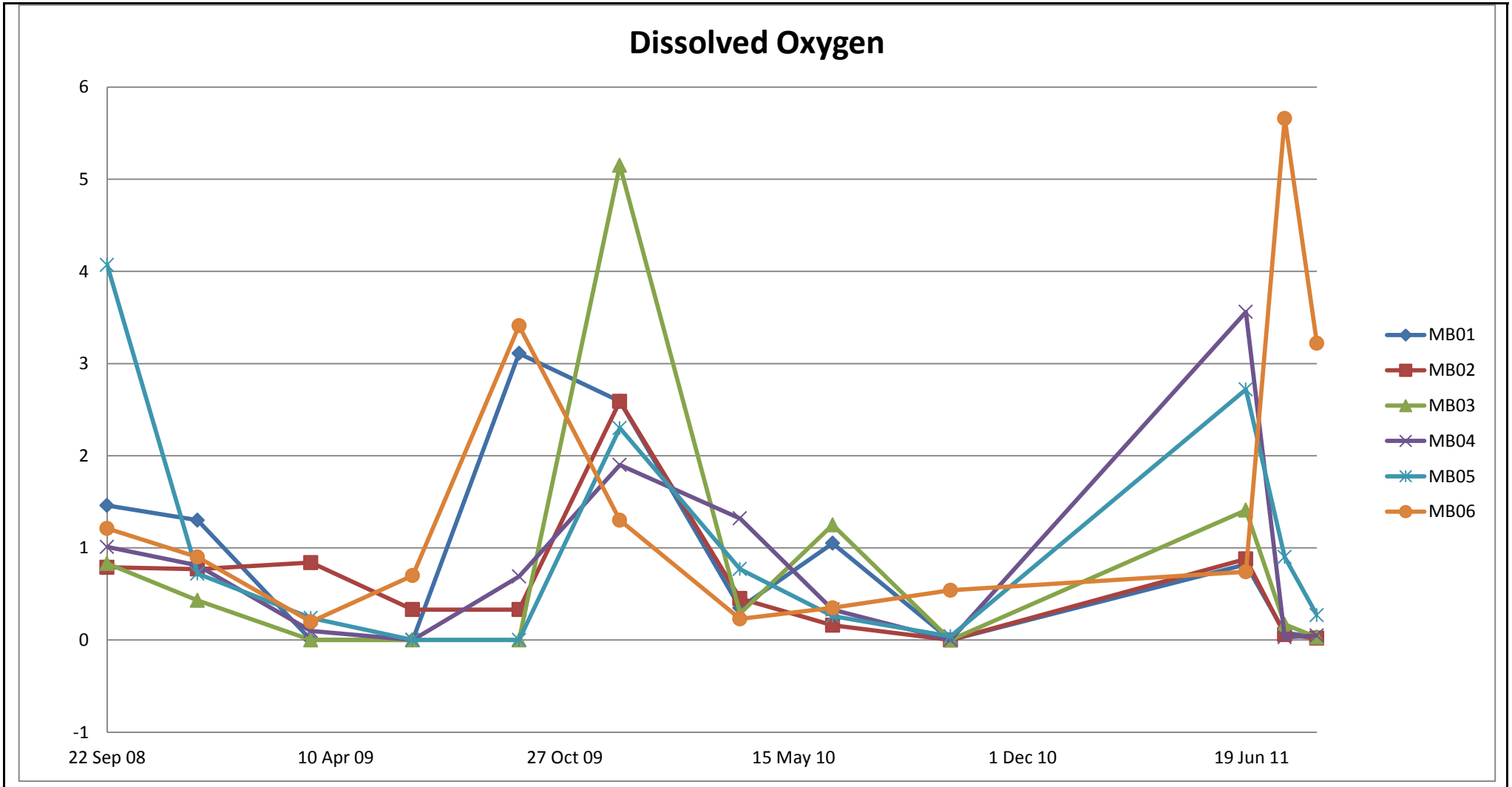

Figure

[Project_Name], Where([LChem1_Chemistry].[LocCode] In('MB01' , 'MB02' , 'MB03' , 'MB04' , 'MB05' , 'MB06'))

Date:	Drawn:
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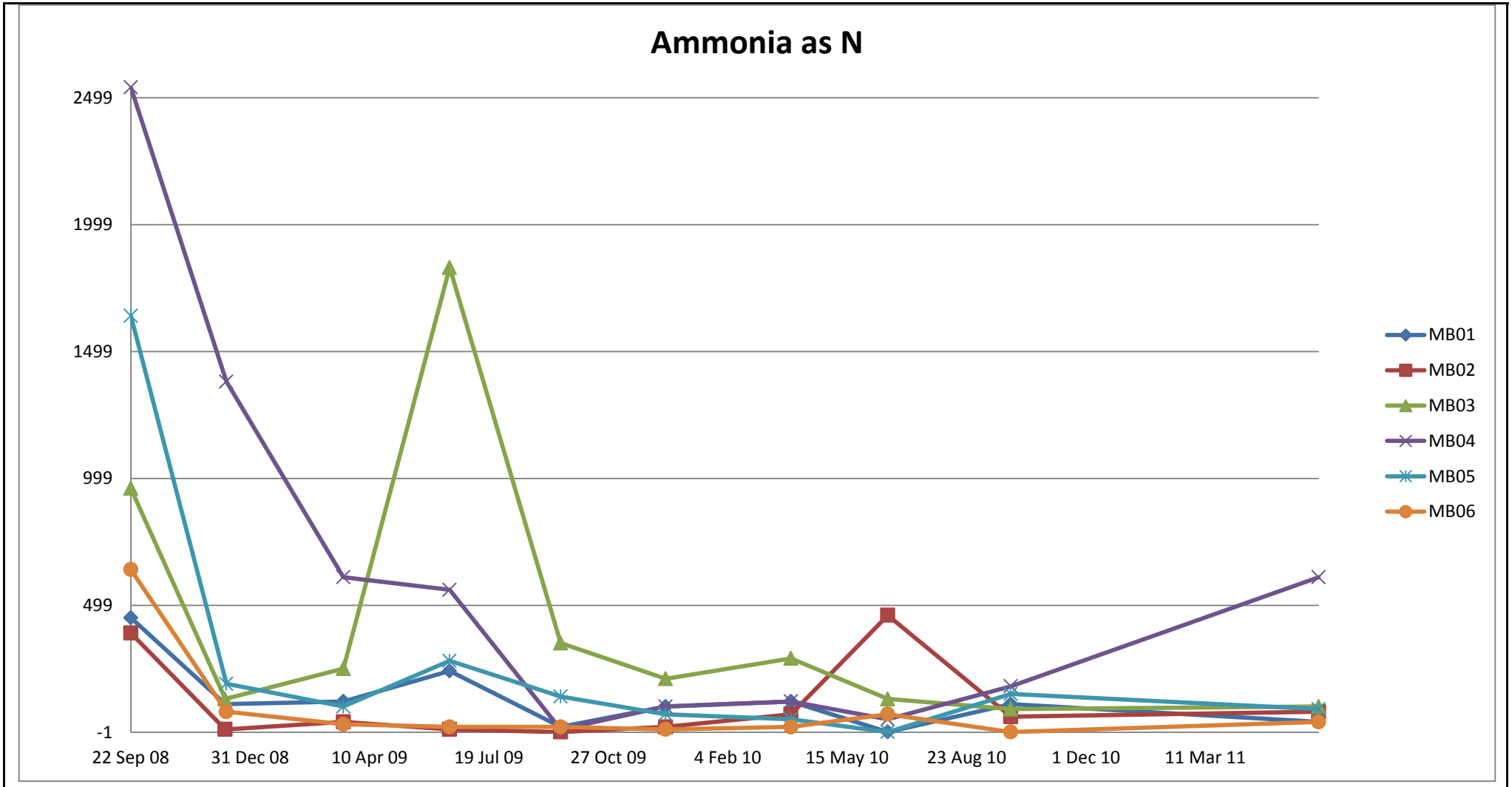


Figure

[Project_Name], Where([LChem1_Chemistry].[LocCode] In('MB01' , 'MB02' , 'MB03' , 'MB04' , 'MB05' , 'MB06'))

Date:	Drawn:
Scale: nts	Chk'd:
Original:	Rev:
File Reference:	

ESDAT

APPENDIX C – Water consumption estimates

Water Use Summary

The Water Use tool is primarily aimed at residential developments but can handle mixed developments.

Developer:	Peet LTD
Development Name:	Lot 50 Mundijong Road
Date Of Entry:	7-Feb-13
Total Area of Development (m^2):	513,817

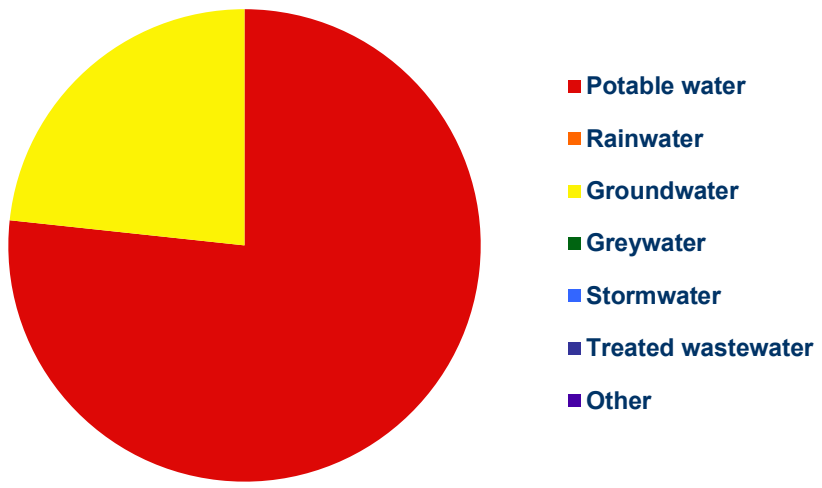
Area Totals Match

Water Demand

Help/Notes (Click)

Water demand by source type in kL/year.

Potable water[1]	151,073
Rainwater	0
Groundwater	45,897
Greywater	0
Stormwater	0
Treated wastewater	0
Other	0



Water Use

Summary in Detail (Click)

Water use for total development and by sub-section.

	Total Water[2] (kL/person/year)	Potable Water[2] (kL/person/year)	Non-Potable Water[2] (kL/person/year)	Development Consumption (kL/year)
Consumption Indicators	96	96	0	196,970

Development Summary

Click on subsection to go to page.

		Area (m^2)	Irrigation (kL/year)	Drinking[1] (kL/year)	Non-Drinking (kL/year)
1.	Residential	275,638	46,887	49,522	38,602
2.	Schools	35,022	13,448	1,568	1,045
3.	Commercial & Industrial				
4.	Public Open Spaces, Roads, Footpaths & Verges	203,157	45,897		
5.	Other				
	TOTAL	513,817	106,233	51,090	39,647

[1] All drinking water needs are met by Potable water.

[2] These consumption indicators relate to the residential segment only.

1. Residential

Please Enter Total Residential Area

Total Area (m^2): 275,638

Area Running Total (m^2): 275,638 **Area Totals Match**

Total Residential Water Use

Summary Page (Click)

Per Capita Summary

kL/Person/Year (Total)[1]	96
kL/Person/Year (Potable)	96
kL/Person/Year (in-house)[2]	55
kL/Person/Year (ex-house)	41
kL/Person/Year (Non-Potable)	0
kL/Person/Year (in-house)	0
kL/Person/Year (ex-house)	0

Per Year Summary

kL/Year (Total)[1]	135,011
kL/Year (Irrigation)	46,887
kL/Year (Drinking)	49,522
kL/Year (Non-Drinking)	38,602
kL/ha/Year (Irrigation)	1,701
kL/Year (Potable)	135,011
kL/Year (in-house)	76,840
kL/Year (ex-house)	58,171
kL/Year (Non-Potable)	0
kL/Year (in-house)	0
kL/Year (ex-house)	0

[1]Total refers to Potable & Non-Potable Water

[2]See Parameter & Assumptions for in- & ex-house definitions

Residential Information

Summary Page (Click)

Multiple residency types are possible.

Help/Notes (Click)

Household Type	Lots	Households (per Lot)	Area (m^2/Lot)	Irrigation Area (m^2/Lot)
Lifestyle/Semi Rural	18	1	1,619	194
☐ Traditional	356	1	546	137
☐ Traditional	88	1	☑ 345	86
☐ Cottage	80	1	☑ 272	68
☐ Apartment	2		2,056	452
☐				

Water Sources

Summary Page (Click)

Select possible water sources and their contribution to Irrigation or Non-Drinking water use.

Model only uses water source when check box is ticked.

Source	Select Source(s)	Source Contribution (%) Irrigation	Non-Drinking
Potable water		100	100
Rainwater*		0	0
Groundwater			
Greywater			
Stormwater			
Treated wastewater			
Other		100	
TOTAL ALTERNATE		0	0

Apply Rainwater to:
Irrigation
Non-drinking

* Rainwater proportion calculated automatically and split between Irrigation and Non-drinking

2. Schools

Please Enter Total School Area

Total Area (m^2): 35,022

Area Running Total (m^2): 35,022 **Area Totals Match**

Total Schools Water Use

Summary Page (Click)

Per Year Summary

kL/Year (Total)[1]	16,061
kL/Year (Irrigation)	13,448
kL/Year (Drinking)	1,568
kL/Year (Non-Drinking)	1,045
kL/ha/Year (Irrigation)	3,840
kL/Year (Potable)	16,061
kL/Year (Non-Potable)	0

[1]Total refers to Potable & Non-Potable Water

School Information

Summary Page (Click)

Multiple school sizes are possible.

Help/Notes (Click)

School Type	Students	Area (m^2/School)	Irrigation Area (m^2/School)
Primary School	300	35,022	14,009

Water Sources

Summary Page (Click)

Select possible water sources and their contribution to Irrigation or Non-Drinking water use.

Model only uses water source when check box is ticked.

Source	Select Source(s)	Source Contribution (%) Irrigation	Non-Drinking
Potable water	☐	100	100
Rainwater*	☐	0	0
Groundwater	☐	100	
Greywater	☐		
Stormwater	☐		
Treated wastewater	☐		
Other	☐		
TOTAL ALTERNATE		0	0

Apply Rainwater to:
☑ Irrigation
☑ Non-drinking

* Rainwater proportion calculated automatically and split between Irrigation and Non-drinking

4. POS, Roads & Verges

Please Enter Total POS, Roads & Verges Area

Total Area (m^2): 203,157

Area Running Total (m^2): 203,157 **Area Totals Match**

Total POS, Roads & Verges Water Use

Summary Page (Click)

Per Year Summary

kL/Year (Total)	45,897
kL/Year (Irrigation)	45,897
kL/Year (Drinking)	0
kL/Year (Non-Drinking)	0
kL/ha/Year (Irrigation)	2,259
kL/Year (Potable)	0
kL/Year (Non-Potable)	45,897

[1]Total refers to Potable & Non-Potable Water

POS, Roads & Verges Information

Summary Page (Click)

Help/Notes (Click)

For Active POS, please estimate the total water use by amenities.
E.g. water fountains and shower cubicles.

Public Open Space	Area (m^2)	Amenities (kL/Year)
Active	29,000	
Passive	13,714	
Bushland/Non-Irrigated Areas	13,713	
Roads & Paths	146,730	
Verges		
Street Scaping		

Water Sources

Summary Page (Click)

Select possible water sources and their contribution to Irrigation or Non-Drinking water use.
Model only uses water source when check box is ticked.

Source	Select Source(s)	Source Contribution (%) Irrigation	Non-Drinking[1]
Potable water	☐	0	100
Rainwater[2]	☑	0	0
Groundwater	☐	100	
Greywater	☐		
Stormwater	☐		
Treated wastewater	☐		
Other	☐		
TOTAL ALTERNATE		100	0

Apply Rainwater to:
Irrigation ☑
Non-drinking ☑

[1] Non-Drinking water use for POS amenities.
[2] Rainwater proportion calculated automatically and split between Irrigation and Non-drinking

APPENDIX D – Stormwater modelling parameters & results

Pre-development surface water modelling

A surface water model of the pre-development conditions of the catchment surrounding Precinct E2 was developed using the 2D module of the XP Storm stormwater modelling software. XP Storm is an urban drainage design software package capable of hydrologic and hydraulic modelling of urban catchments. The 2D module of XP Storm models 2-dimensional flow over a grid, rather than via a series of discrete nodes and links. Topographical data, rainfall information and infiltration losses & catchment roughness parameters are input into the 2D module to determine the runoff generated by the catchment and the flow paths and extent of inundation.

The following sections outline the parameters used in the pre-development modelling.

Design rainfall

The 2D module of XP Storm uses rainfall-on-grid to model stormwater runoff from the catchment. Design storm durations varied between 1 hour & 72 hours, to determine the critical duration event for both 5yr & 100yr ARI, and to size the bioretention areas for the post-development scenario. Design rainfall Intensity Frequency Duration (IFD) data was created using the Bureau of Meteorology's online IFD-generator tool.

The data used for the Mundijong site is presented in Table D.1below.

Table D.1 - IFD design data

ARI	Duration					
	Intensity (mm/hr)					
	1 hour	6 hour	12 hour	24 hour	48 hour	72 hour
1 year	17.3	-	-	-	-	-
5 year	27.2	8.7	5.6	3.6	2.3	1.7
100 year	48.1	15.0	9.7	6.3	4.1	3.1

Catchment properties

The catchment parameters for the various landuses included in the modelling are outlined in Table D.2 below.

Table D.2 - Land use & infiltration losses

Landuse	Manning's roughness	Initial loss (mm)	Continuing loss (mm/hr)
Existing roads (impervious)	0.015	1.5 mm	0 mm/hr

Landuse	Manning's roughness	Initial loss (mm)	Continuing loss (mm/hr)
Existing urban (pervious)	0.025	10 mm	4 mm/hr
Existing rural (cleared, with sandy soils)	0.05	10 mm	4 mm/hr
Existing rural (cleared, with clay soils)	0.2	5 mm	1.5 mm/hr

Peak flow rates

Table D.3 below summarises the pre-development peak flow rates at various locations across the catchment for the critical 5yr and 100yr ARI storm event. These locations are shown on Figure 2.7.

Table D.3 - Peak pre-development flow rates

Flow location	Peak flow - 5yr 48hr ARI	Peak flow - 100yr 6hr ARI
A - Lot 9003 Adams St - near Tonkin St	1.2 m^3/s	2.9 m^3/s
B - Lot 7 Adams St - near Livesey St	0.8 m^3/s	1.9 m^3/s
C - Lot 7 Adams St	1.8 m^3/s	4.6 m^3/s
D1 - Lot 50 Cockram St - at Sparkman Rd	1.2 m^3/s	2.1 m^3/s
D2 - Lot 50 Cockram St - south of Sparkman Rd	1.1 m^3/s	3.3 m^3/s
E1 - Lot 119 Sparkman Rd - north-western corner	0.5 m^3/s	1.4 m^3/s
E2 - Lot 119 Sparkman Rd - south-western corner	1.5 m^3/s	3.2 m^3/s
F - Lot 50 Cockram St – western boundary (main drainage outlet)	3.6 m^3/s	7.2 m^3/s
G1 - Lot 50 Cockram St – eastern boundary between Mundijong Rd & Cockram St	1.0 m^3/s	2.5 m^3/s
G2 - Lot 50 Cockram St – south-eastern corner, near Mundijong Rd	0.4 m^3/s	0.9 m^3/s
H - Lot 50 Cockram St – south-western corner	0.5 m^3/s	1.8 m^3/s

Post-development surface water modelling

Post-development stormwater modelling was undertaken using the 'standard' 1D module of XP Storm.

The 1D module uses a standard node & link network to model the hydrology of the urban catchment, and the hydraulic elements such as basins and piped or open drains. The following sections outline the parameters used in the design of the post-development drainage basins and open drains.

Design rainfall

Design storm durations varied between 1 hour & 72 hours, for 1yr, 5yr & 100yr ARI design storms. Design rainfall Intensity Frequency Duration (IFD) data was created using the Bureau of Meteorology's online IFD-generator tool. The data used for the Mundijong site is presented in Table D.1 above.

Catchment properties

The catchment parameters for the various landuses included in the modelling are outlined in Table D.4 & Table D.5 below.

Table D.4 - Post-development land uses

Post-development landuse	% impervious	Catchment area
Residential lots	30 %	28.0 ha
Road reserve	80 % [1]	14.7 ha
POS	5 %	6.3 ha
Schools	10 %	3.5 ha

Note 1: An impervious fraction of 80% is sufficient to allow for the full pavement width, crossovers, footpaths on both sides of the road, and approximately 25-30% of lots to have fully paved front verges.

Table D.5 - Manning's n & infiltration losses

Landuse	Manning's roughness	Initial loss (mm)	Continuing loss (mm/hr)
Impervious surfaces	0.014	1.5 mm	0 mm/hr
Pervious surfaces	0.03	15 mm	4 mm/hr

Peak allowable flow rates

The post-development modelling has allowed for flow from upstream catchments to the east of the site to pass through the Precinct E2 (at pre-development levels). Flow which overflows into Precinct E2 from the north under pre-development conditions will be conveyed to the east along Sparkman Road, as noted in the LWMS for Precinct E1 to the north of the site.

The following peak flow rates have been allowed for in the design of the post-development drainage network:

- Location E
  - 5yr ARI - Q = 2.0 m^3/s
  - 100yr ARI - Q = 4.6 m^3/s
- Location G
  - 5yr ARI - Q = 1.3 m^3/s
  - 100yr ARI - Q = 3.4 m^3/s

The pre-development modelling for the site determined that the peak allowable runoff from Precinct E2 was **1.0 m3/s** and **2.1 m3/s** for the critical 5yr & 100yr ARI events respectively. Based on these flow rates, the storage basins through the site were designed to attenuate post-development runoff to within these allowable levels. The required areas for flood attenuation in the POS areas are shown in Table D.6 below, and also in Figure 5.1.

Table D.6 - Required bioretention & flood storage areas

Basin ref	1yr 1hr ARI bioretention area	5yr ARI flooded area	100yr ARI flooded area
1	370 m^2	1,000 m^2	1,300 m^2
2	540 m^2	1,000 m^2	1,300 m^2
3	1,050 m^2	1,800 m^2	2,300 m^2
4	480 m^2	1,600 m^2	1,900 m^2
5	930 m^2	2,600 m^2	3,100 m^2
6	820 m^2	3,100 m^2	3,900 m^2
7	1,710 m^2	3,400 m^2	3,900 m^2
8	550 m^2	1,000 m^2	2,100 m^2

Table D.7 below shows the peak flow rates from each of the basins through the subdivision. These flow rates are within the allowable (pre-development) flow rates outlined in Section 2.5.1 of this LWMS.

Table D.7 - Peak post-development flow rates from flood storage areas

Basin ref	5yr ARI peak outflow	100yr ARI peak outflow
1	0.1 m^3/s	0.1 m^3/s
2	0.1 m^3/s	0.2 m^3/s
3	0.3 m^3/s	0.5 m^3/s
4	0.1 m^3/s	0.2 m^3/s
5	0.1 m^3/s	0.3 m^3/s
6	0.1 m^3/s	0.3 m^3/s
7	0.2 m^3/s	0.4 m^3/s
8	0.1 m^3/s	0.1 m^3/s
TOTAL	**1.0 m^3/s**	**2.1 m^3/s**

APPENDIX 9
INFRASTRUCTURE SERVICING REPORT

wave international

DETERMINE • DESIGN • DELIVER



Lot 50 Cockram Street, Mundijong

Infrastructure Servicing Report

Peet Ltd

August 2012

engineering project management environment

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LOT 50 COCKRAM STREET, MUNDIJONG-INFRASTRUCTURE SERVICING REPORT

Project Brief

Job Number	2681
Project	Infrastructure Servicing Report for the proposed subdivision at Lot 50 Cockram Street in Mundijong
Client	Peet Ltd
Client Contact	Clay Thomas
Client Address	Level 7, 200 St Georges Terrace PERTH, WA 6000

Document Status

Rev	Date	Description	By	Signed
A	Aug 2012	Infrastructure Servicing Report	OC	

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TABLE OF CONTENTS

1 INTRODUCTION

1.1 Background

Wave International was commissioned by Peet Ltd to prepare an infrastructure servicing report on Lot 50 Cockram Street in Mundijong. The subject land is bounded by Sparkman Road to the north, proposed Tonkin Highway to the west, Mundijong Road to the south and Adams Street to the east. The subject land is approximately 54 hectares and is shown on drawing 2681-01- SK-02 in Appendix A.

This infrastructure servicing report is prepared in support of the Local Structure Plan (LSP) submission.

1.2 Proposed Land Use

The Lot 50 Cockram Street Mundijong Development will be developed for residential purposes of standard traditional 500 to 550 sq m lots with pockets of medium density of 350 to 380 sq m lots and low density of 1500 sq m lots. Based on the preliminary concept plan by TBB, the lot yield will comprise between 472 and 507 lots depending on the options adopted.

2 SEWER

2.1 Existing Infrastructure

Currently there is no sewer reticulation network in Mundijong.

2.2 Water Corporation Planning

The Water Corporation has a long term plan to construct a permanent Type 1000 sewer pump station (Mundijong A) at Scott Road to service the whole of Mundijong. The discharge from Mundijong A will be at East Rockingham Waste Water Treatment Plant via a pressure main along the service corridor and Mundijong Road. Initially a temporary pump station will be built in Scott Road and pump northwards to an existing pump station in Byford with an approximately 20 l/s capacity available.

The availability of this 20 l/s capacity for Mundijong will be subject to ongoing monitoring and will only be available on a staged basis and will be dependent on the progressive upgrades of Byford pump station.

Water Corporation is currently undertaking a review of the sewer planning in Mundijong and it is expected that the review will be completed by November 2012.

To service Lot 50 Cockram Street, a temporary Type 40 sewer pump station can be constructed near Sparkman Road and discharge via a pressure main to the proposed temporary pump station at Scott Road.

The proposed sewer infrastructure requirements for Lot 50 Cockram Street are shown on drawing 2681-01-SK-01 in Appendix A.

3 WATER

3.1 Existing Infrastructure

The main water supply to Mundijong is currently supplied off the Serpentine Trunk Main on Summerfield Road 5.5km to the south of Mundijong Road. This water main consists of pipes of 150mm and 300mm diameters and Water Corporation is in the process of upgrading the 150mm dia. pipes to 400mm dia. pipes.

3.2 Water Corporation Planning

The long term water supply proposed for Mundijong would be a supply from the north along Soldier Road from Byford gravity tank. This proposed water distribution pipeline would vary in size from 500 to 900mm dia. Sections of the mains will be installed to allow for staging as development occurs to the north of Mundijong, but this would need to be supplied off the current network and works will be developer funded.

Water Corporation is currently undertaking a review of the water planning in Mundijong and it is expected that the review will be completed by November 2012.

However in the interim, the water supply for Lot 50 Cockram Street can be obtained from the water main at the corner of Paterson Street and Mundijong Road. It is expected that a 250mm dia. main will be laid from Paterson Road to the site.

The proposed water infrastructure requirements for Lot 50 Cockram Street are shown on drawing 2681-01-SK-01 in Appendix A.

4 ROADS AND TRAFFIC

4.1 Existing Road Infrastructure

Lot 50 Cockram Street is bounded by Sparkman Road to the north, proposed Tonkin Highway to the west, Mundijong Road to the south and Adams Street to the east.

The existing road infrastructure is described in more detail below.

- **Sparkman Road** – Sparkman Road is located to the north of the site and provides a link between Adams Street and the north of the site. Sparkman Road is not constructed.
- **Proposed Tonkin Highway** – Proposed Tonkin Highway is proposed to be located to the west of the site and there is no link between the site the Highway. The proposed Highway is separated from the site by a 60m Water Corporation service corridor.
- **Mundijong Road**– Mundijong Road is located to the south of the site and provides an east- west connection of the development area. Mundijong Road is a sealed rural road and unkerbed.
- **Adams Street**– Adams Street is located to the east of the site and provides a major link between site and the north. Adams Street is only constructed between Sparkman Road and Richardson Street.

4.2 Proposed New Road and Upgrade

Several new roads and existing road upgrading will be required to provide an acceptable level of service for the fully developed Lot 50 area and varies from existing external roads to new roads within the site.

The internal roads will be constructed as and when development occurs and will also be funded by the developer.

External roads will be constructed or upgraded when the level of service drops below the acceptable service level. The cost of upgrading / construction of the external road infrastructure will be shared between the adjoining owners. The following road infrastructure items will be required for Lot 50 area:

- **Sparkman Road** – Sparkman Road is not constructed and will be required to be constructed from the intersection with Adams Street to the Water Corporation Service Corridor. Sparkman Road may be required to be constructed to a Neighbourhood Connector B standard which is a 7.5m two lane road within a 20m road reserve. The construction of Sparkman Road will be a developer cost but cost share with adjoining owners and will be done as part of the subdivisional works or it may be done as Developer Contribution Plan.
- **Mundijong Road** – The road is currently a 7.5 m two lane rural road with a 1m shoulder and may be required to be upgraded to a four-lane divided road in a 40m road reserve. The upgrading of Mundijong Road will be a developer cost but cost share with adjoining owners and will be done as part of the subdivisional works or it may be done as Developer Contribution Plan.

- **Adams Street** – Adams Street is currently not constructed south of Richardson Street and will be required to be constructed to a Neighbourhood Connector B standard which is a 7.5m two lane road within a 22.5m road reserve. The construction of Adams Street will be a developer cost but cost share with adjoining owners and will be done as part of the subdivisional works or it may be done as Developer Contribution Plan outside the site.
- **North – South Road through the site**– the North-South Road may be required to be constructed to Integrator B standard with a 7.5m two lane road with a 2- 6 m central median within a road reserve of 25- 30 m. The construction of North-South Road through the site will be a developer cost and will be done as part of the subdivisional works.

All the above upgrading and construction of the road infrastructure have to be confirmed by a Traffic report.

The proposed road infrastructure requirements for Lot 50 Cockram Street are shown on drawing 2681-01-SK-02 in Appendix A.

5 SURFACE WATER MANAGEMENT

5.1 District and Local Water Management

Lot 50 Cockram Street falls within the area covered by the Mundijong Whitby District Structure Plan District Water Management Strategy, which was prepared by GHD (2010).The DWMS addresses broad-scale stormwater management measures over an 1800ha area which extends from the future Tonkin Highway reserve to South Western Highway.

A Local Water Management Strategy has been prepared by Wave International to further define surface water and groundwater management design concepts at Lot 50 Cockram St. The following paragraphs summarise the main outcomes of the DWMS and LWMS.

5.2 Flood Management Strategy

5.2.1 Flood Conveyance

Stormwater runoff from upstream landholdings flows via overland flow across the site from east to west. This flow, along with runoff from the Lot 50 development will be managed within the two multiple-use corridors on the site.

Stormwater will be managed to ensure that post-development flow rates are within pre-development levels and that dwellings are protected from flooding in major storm events.

5.3 Local Stormwater Management

5.3.1 Lot Runoff

Lot runoff will be managed through the use of soakwell systems to retain and infiltrate roof runoff within individual lots.

Subsoil drainage will be installed within road reserves to promote infiltration and improve the efficiency of soakwells.

Future lot owners may also opt to install rainwater tanks, which will also act to retain lot runoff on-site.

5.3.2 Road Runoff

A conventional piped network will be designed to manage road runoff, with 'leaky' side entry/gully pits located to suit appropriate spread rates and pit spacings. The level of service for the side entry/gully pits and the pipe network will be dependent on the road hierarchy.

Road runoff from minor storm events (up to 1 year ARI) will be retained and treated within bioretention systems in public open space areas to ensure water quality objectives are met.

5.3.3 Post Development Flows and Storage

To ensure that downstream landholdings are not adversely impacted by development in upstream catchments, each development must ensure that peak post-development flow rates generated by runoff from the development area do not exceed pre-development levels. This is achieved through the use of detention storage areas spread throughout the development.

Off-line storage areas will be provided within public open space to attenuate peak flows, and will discharge to open swale drains through the multiple use corridors.

6 POWER

The existing Western Power distribution infrastructure in the vicinity of the Lot 50 Cockram Street comprises of several three phase 22kV high voltage (HV) aerial feeder lines (BYF 524) from Byford Zone Substation along Taylor Road and Adams Street.

There is currently some spare capacity on the BYF 524 feeder but the actual spare capacity is not known and confirmation from Wester Power will be required. This capacity is available on a first-come first-served basis.

Western Power has plans to construct a major Zone Substation along Gossage Road in Oldbury in 2025. If the supply capacity is required before 2025 Western Power will charge the developer for the full capital costs.

Western Power's Feasibility Study for Mundijong estimates that the Headworks charges will amount to approximately $2,500 to $3,000 per lot for the initial phase of the development. Headworks refer to distribution network reinforcements outside the subdivision that are necessary in order to provide power capacity to the subdivision. All headworks extensions, removal, moving or upgrades to the network will be fully funded by the developer.

The WAPC and Western Power will most likely stipulate that the existing HV and LV aerials adjacent to the subdivision are to be undergrounded and any existing consumers affected must have their consumer mains reconnected to the underground network.

7 GAS

There are no existing ATCO Gas (formally WA Gas Networks) gas headworks infrastructure in the vicinity of Lot 50 Cockram Street area and they have no current infrastructure planning in this area.

Provision of natural gas to the site will require the construction of a headworks high pressure gas main from Nettleton Road from Byford.

8 COMMUNICATIONS

It is envisaged that Lot 50 Cockram Street development would fall under the ambit of the National Broadband Network (NBN) which requires developers to install an approved pipe and pit system as part of the development.

Network infrastructure will be installed subsequently by NBN appointed contractors at no cost to the developers.

APPENDIX A – PRELIMINARY INFRASTRUCTURE SERVICES LAYOUT

SEWER PRESSURE MAIN TO TEMPORARY PUMP STATION AT SCOTT ROAD

SPARKMAN ROAD

ADAMS STREET

PROPOSED SEWER PUMP STATION LOCATION

SERVICE CORRIDOR

PRIMARY SCHOOL

COCKRAM STREET

FUTURE TONKIN HIGHWAY

MUNDIJONG ROAD

DN250 WATER PIPE TO EXISTING MAIN AT INTERSECTION OF PATERSON STREET & MUNDIJONG ROAD

LEGEND

- SUBDIVISION AREA
- WATER MAIN
- DN250 WATER MAIN
- SEWER GRAVITY MAIN
- SEWER PRESSURE MAIN

80 40 0 80 160 240 Metres

SCALE 1 : 4000

MGA94 Z50

N

wave international
DETERMINE · DESIGN · DELIVER

PEET LIMITED
LOT 50, COCKRAM STREET, MUNDIJONG

SERVICES LAYOUT

Job Number 2681
Revision A
Date AUGUST 2012

2681-01-SK-001

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