The Brook at Byford
Lot 2 Nettleton Road, Byford

LOCAL STRUCTURE PLAN

Prepared for **Cedar Woods**

May 2015

DOCUMENT STATUS

		07/067	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	RC	15.10.12
			1	IF	21.11.12
			2	IF	04.12.12
			3	RC	30.01.14
			4	RC	02.10.14
			5	RC	25.05.15

ADOPTION OF AGREED STRUCTURE PLAN

CERTIFIED THAT AGREED LOT 2 NETTLETON ROAD BYFORD LOCAL STRUCTURE PLAN

WAS ADOPTED BY

RESOLUTION OF THE WESTERN AUSTRALIAN PLANNING COMMISSION ON

27 February 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~~ 16 of the ~~Western Australian Planning Commission~~ Act ~~1985~~ 2005 for that purpose, in the presence of:

Planning and Development

M Wiecka ..... Witness

16.9.2015 Date

AND BY

RESOLUTION OF THE COUNCIL OF THE SHIRE OF SERPENTINE JARRAHDALE ON

25/02/2014

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

R M Graham .....

Chief Executive Officer, Shire of Serpentine Jarrahdale

25.9.15 Date

TABLE OF MODIFICATIONS

TABLE OF MODIFICATIONS TO PART ONE AND STRUCTURE PLAN MAP

Modification No.	Description of Modification	Date Endorsed by Council	Date Endorsed by WAPC

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

THE LAND

This Local Structure Plan (LSP) is prepared in support of the development of Lot 2 Nettleton Road, Byford. Lot 2 Nettleton Road is hereafter also referred to as the 'structure plan area' or 'subject site'.

Lot 2 Nettleton Road is located immediately south-east of the Byford Town Centre, as defined by the 'Byford Town Centre Local Structure Plan' which was endorsed by the Shire of Serpentine Jarrahdale in June 2010. The north-western corner of the subject land falls within a 400m walkable catchment of the Town Centre; while the bulk of the land is within an 800m catchment. The future location of the Byford train station and rail crossing form the nucleus of the catchment.

The subject land is colloquially known as 'the Kangaroo Paddock', and much of its character can be attributed to its location east of South Western Highway at the foot of the Darling Range Regional Park. The land is located abutting existing residential areas to the east and north, which has been a key consideration for the structure plan. The north-western portion of the land has already been approved for subdivision to create 145 residential lots in accordance with the existing approved structure plan and subdivision works have recently commenced in accordance with the approvals.

PURPOSE

The purpose of this Local Structure Plan is to guide and facilitate the urbanisation of Lot 2 Nettleton Road. This Local Structure Plan 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 'Structure Plan Preparation Guidelines' (August 2012).

The LSP proposes the development of the land for 'Residential' purposes at various densities generally between R20 and R60, with the lower density lots generally abutting existing neighbouring development. A revised Concept Plan accompanies the LSP and incorporates the subdivision design approved by the Western Australian Planning Commsision for the initial stages of development in the north-western corner of the site. The revised Concept Plan reflects the current landowner's intentions for the development of the land, comprising approximately 367 lots in total.

While the predominant use will be 'Residential', a significant portion of the site will be transferred to the Crown for the purposes of 'Conservation'. This 'Conservation' area is recognised within the Shire's policy framework as a 'Local Natural Area'. A 'Multiple Use Corridor' will also be created along Beenyup Brook.

This Local Structure Plan supplants an existing structure plan prepared for the same landholding and approved by the Commission in early 2011. That structure plan is now redundant to Cedar Woods, the owner and developer of the subject land, because it proposes aged care facilities and a park home park community. Cedar Woods considers that a residential product of that type can not be sustained by the current property market. Accordingly, Cedar Woods is now seeking to develop a traditional residential lot product and this revised structure plan will facilitate this.

STRUCTURE PLAN SUMMARY TABLE

Item	Data	Section number referenced within the structure plan report
Total area covered by the structure plan	32.288 hectares	Part 2, Sect 1.2
Area of each land use proposed: • Residential • Industrial • Commercial	15.3206 hectares 0 hectares 0 hectares	Part 2, Sect 3.4
Estimated lot yield	406 lots	Part 2, Sect 3
Estimated number of dwellings	406 dwellings	Part 2, Sect 3
Estimated residential site density	12.59 dwellings per gross site hectare. 25.36 dwellings per net site hectare	Part 2, Sect 3
Estimated population	406 x 2.75* persons per dwelling = 1117 people	-
Number of high schools	0 high schools	N/A
Number of primary schools	0 primary schools	N/A
Estimated commercial floor space (for activity centres if appropriate)	0 net lettable area	N/A
Employment self sufficiency targets	Opportunity for home based employment.	N/A
Estimated number and % of public open space: • Regional open space • District open space	6 areas of POS 10-13% 0 hectares 0% 0 hectares 0%	N/A
Estimated area and number: • neighbourhood parks • local parks	0.4294 hectares 1 park 1.9873 hectares 2 parks	Part 2, Sect 3.2
Estimated number and area of natural area and biodiversity assets	5.7272 hectares 2 sites	Part 2, Sect 3.2

*Source: Western Australian Planning Commission 2010, *Outer Metropolitan Perth And Peel Sub-Regional Strategy*,WAPC, Perth Western Australia.

Page 78: "The average household size has decreased over the period 2001–2006 from 2.81 persons to 2.75 persons and by 2031 it is forecast that the average household size will have dropped markedly to 2.21 persons."

CONTENTS

FIGURES

APPENDICES

PART ONE
STATUTORY SECTION

1 STRUCTURE PLAN AREA

This Structure Plan applies to Lot 2 Nettleton Road, Byford; being the 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:

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

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

c) Appendices – Technical reports and supporting plans and maps.

3 INTERPRETATION AND RELATIONSHIP WITH THE SCHEME

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.

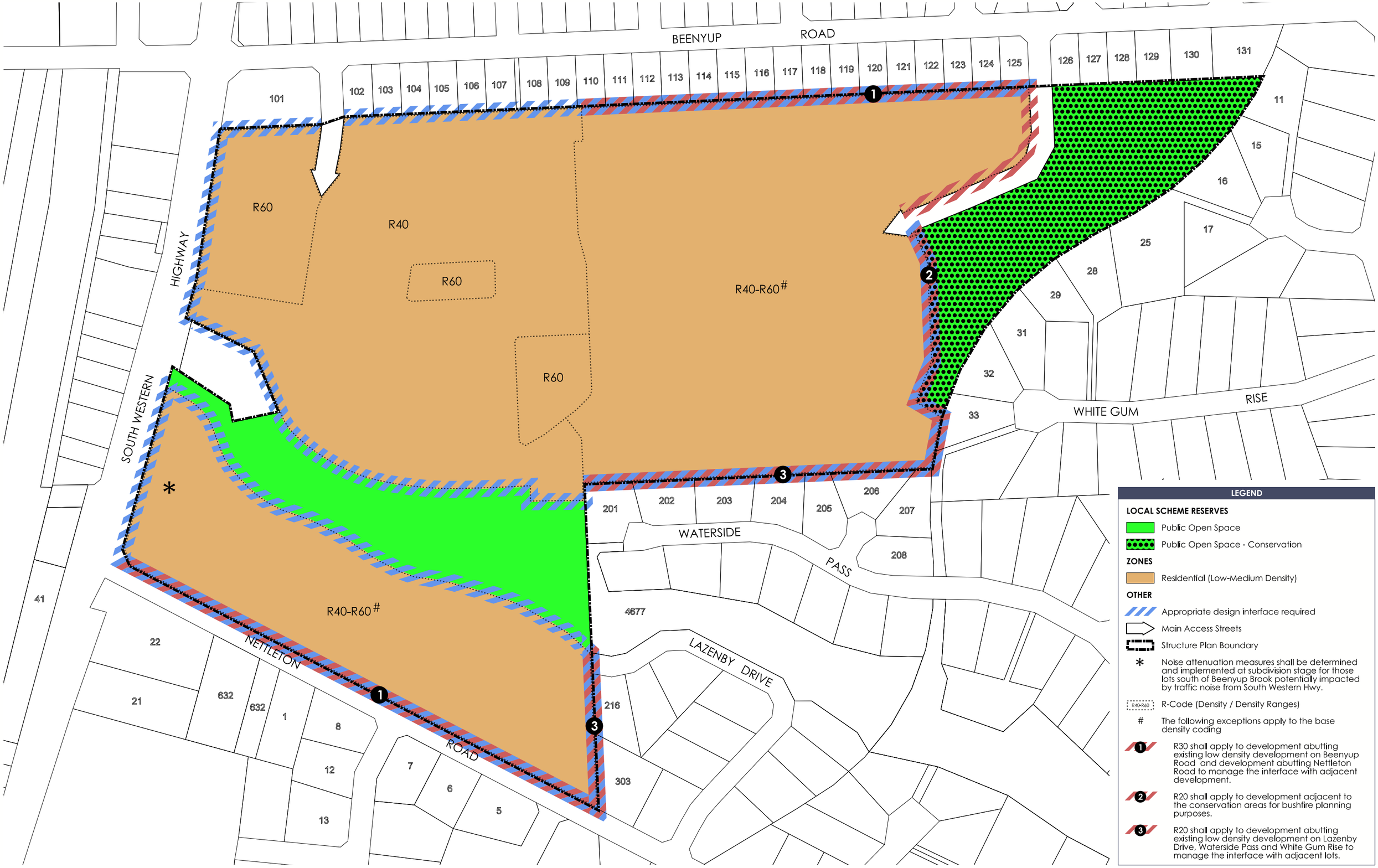
The Structure Plan map (**Plan 1**) outlines land use, zones and reserves applicable within the Structure Plan area. The zones and reserves designated under this Structure Plan apply to the land within it as if the zones and reserves were incorporated into the Scheme.

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.



LEGEND

LOCAL SCHEME RESERVES

- Public Open Space
- Public Open Space - Conservation

ZONES

- Residential (Low-Medium Density)

OTHER

- Appropriate design interface required
- Main Access Streets
- Structure Plan Boundary
- * Noise attenuation measures shall be determined and implemented at subdivision stage for those lots south of Beenyup Brook potentially impacted by traffic noise from South Western Hwy.
- R40-R60 R-Code (Density / Density Ranges)
- # The following exceptions apply to the base density coding
- 1 R30 shall apply to development abutting existing low density development on Beenyup Road and development abutting Nettleton Road to manage the interface with adjacent development.
- 2 R20 shall apply to development adjacent to the conservation areas for bushfire planning purposes.
- 3 R20 shall apply to development abutting existing low density development on Lazenby Drive, Waterside Pass and White Gum Rise to manage the interface with adjacent lots.

LOCAL STRUCTURE PLAN (PLAN 1)

Lot 2 Nettleton Road, Byford

0m 15 30 45m

s: 1:3000@A3
d: 21 May 2015
p: 07/067/031F

Taylor Burrell Barnett Town Planning and Design
187 Roberts Road Subiaco Western Australia 6008
p: (08) 9382 2911 f: (08) 9382 4586
e: admin@tbbplanning.com.au

4 OPERATION

In accordance with clause 5.18.6.1 of the Scheme, this Structure Plan shall come into operation on the date it is adopted by the Shire of Serpentine Jarrahdale after receiving notice of the approval of the proposed Structure Plan by the Commission, pursuant to clause 5.18.3.15 of the Scheme.

5 LAND USE AND SUBDIVISION

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 TARGETS

a) Objective: To provide for an minimum of 15 dwelling units per gross developable hectare within the Structure Plan area.

b) Subdivisions are to generally achieve the following:

   i) 25 dwelling units per gross developable hectare for lots within the 400m walkable catchment of the Byford Town Centre; and

   ii) 15 dwelling units per gross developable hectare for lots outside of the 400m walkable catchment of the Byford Town Centre.

5.2.2 DENSITY

a) **Plan 1** defines the residential density ranges that apply to specific areas within the Structure Plan. Lot specific residential densities, within the defined residential density ranges, are to be submitted for the eastern and southern portions of the LSP area (known as Stage 2 and 3) and assigned in accordance with a Residential Code Plan approved by the WAPC.

b) A Residential Code Plan for the eastern and southern portions of the LSP area are to be submitted at the time of subdivision to the WAPC and shall indicate the R-Code applicable to each lot within the subdivision and shall be consistent with the Structure Plan and the Residential Density Ranges identified on the LSP Map and the locational criteria contained in Clause 5.2.3.

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

d) Approval of the Residential Code Plan shall be undertaken at the time of determination of the subdivision application by the WAPC. The approved Residential 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 Code Plan will require further approval of the WAPC, with a revised Residential Code Plan submitted generally consistent with the approved plan of subdivision issued by the WAPC. The revised Residential Code Plan shall be consistent with Residential Density ranges identified on Plan 1 and the locational criteria contained in Clause 5.2.2.

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

i) *the amalgamation of lots;*

ii) *consolidation of land for "superlot" purposes to facilitate land assembly for future development;*

iii) *the purposes of facilitating the provision of access, services or infrastructure; 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 within the ranges specified in locations on Plan 1 shall be in accordance with the following criteria:

a) R30 – R60 precinct

i) A base density code of R30 shall apply.A density code of up to R60 shall generally apply in areas of high amenity, such as adjacent to public open space, as well as in areas where vehicular access via laneways is provided.

b) R40 – R60 precinct

i) A base density code of R40 shall apply.

ii) A density code of up to R60 shall generally apply in areas of high amenity, such as adjacent to public open space, as well as in areas where vehicular access via laneways is provided.

The following exceptions apply:

- A density code of R30 shall apply to development abutting existing low density development on Beenyup Road and development abuting Nettleton Road to manage interface issues with adjacent development;

- A density code of R20 shall apply to development adjacent to the conservation areas for bushfire planning purposes;

- A density code of R20 shall apply to development abutting existing low density development on Lazenby Drive, Waterside Pass and White Gum Rise to manage interface issues with these lots.

5.3 PUBLIC OPEN SPACE

A minimum of 10 per cent public open space shall be provided in accordance with the WAPC's 'Liveable Neighbourhoods'. Public open space is to be provided generally in accordance with Figure 16 and the Public Open Space Schedule contained in 3.2 of Section 2 of this report. As subdivision progresses and the estate is delivered, the POS schedule will be reconciled to ensure ongoing accuracy, and submitted at the time of subdivision for determination by the WAPC, upon the advice of the Shire of Serpentine Jarrahdale. In accordance with Liveable Neighbourhoods (Element 4 – Public Parkland), the required 10 per cent public open space contribution for the Structure Plan area will comprise a maximum 2 per cent restricted open space, and a minimum 8 per cent unrestricted open space.

POS Site 5 comprises the Multiple Use Corridor (including Beenyup Brook). The 1 in 100 year flood extent of the Brook shall not form part of the POS contribution, but shall be included as a deduction to the gross subdivisbale area. The remaining area outside of the 1 in 100 year flood extend shall be credited as unrestricted public open space, and will contribute toward the minimum 10 per cent public open space contribution for the Structure Plan area, in accordance with Liveable Neighbourhoods (Element 4 – Public Parkland).

POS Area 6 shall function as an area for conservation of natural vegetation (local bushland) and, accordingly, be classified 'Restricted Use' and contribute no more than 2 per cent of the minimum 10 per cent public open space contribution for the Structure Plan area, with the excess contribution deducted from the gross subdivisible area, in accordance with Liveable Neighbourhoods (Element 4 – Public Parkland).

5.4 BUSHLAND/CONSERVATION AREA

Approximately 3 hectares of vegetated land is to be retained in the northeast corner of the site. A letter dated 17 September 2013 has been prepared by PGV Environmental and provided to the Shire outlines the management strategies to support the Conservation Boundary. The letter details the immediate, medium and long term actions required to enhance the site, as agreed through consultation with the Shire's Environmental and Sustainability Services department. The full letter is contained as **Appendix 3.** Immediate actions include weed management and seed collection. In the medium term once the boundary of the Bushland Area is determined through the LSP approval process, the developer will fence the site, establish firebreaks and commence rehabilitation in Degraded Areas. In the long term prior to handover, the amenity of the site will be enhanced by ensuring future amenities can be installed and by establishing a walking path. The Bushland Management Plan is discussed further in Part 2, Section 3.3.4 – Bushland Management Plan.

5.5 BUSHFIRE MANAGEMENT

Land within 100 metres of the Woodland vegetation in the Conservation Area, as indicated on the LSP Map (**Figure 1**) is declared a 'Bushfire Prone Area'.

Notwithstanding any statement to the contrary within the *Australian Standard – Construction of Buildings in Bushfire Prone Areas* (AS3959-2009) (or equivalent), any Class 1, 2, or 3 building or Class 10a building or deck associated with a Class 1, 2, or 3 building to be erected on residential lots within the 'Bushfire Prone Area' as declared in this LSP shall comply with the requirements of *AS3959-2009* (or equivalent).

The WAPC, on the advice of the Shire of Serpentine-Jarrahdale and/or the Fire and Emergency Service Authority (FESA), may require as a condition of subdivision approval the preparation, approval and implementation of a Bushfire Management Plan to the specifications of the Shire and/or FESA.

5.6 CONDITIONS OF SUBDIVISION APPROVAL

a) Management Plans will be required as conditions of Subdivision approval; with the plans being implemented as part of subdivision delivery. For compliance purposes it is recommended that the requirement for the preparation of management plans is reflected on future subdivision approvals as applicable. Unless otherwise negotiated between the proponent and the Shire, clearance will not be achieved without the necessary plans being in place. The following conditions may be recommended, as applicable, requiring the preparation and/or implementation of the following strategies including, but not limited to:

   i) Noise Management Strategy (Main Roads Western Australia and Shire of Serpentine Jarrahdale);
   ii) Construction Management Plan (Shire of Serpentine Jarrahdale);
   iii) Urban Water Management Plan (Department of Water and Shire of Serpentine Jarrahdale);
   iv) Flora and Vegetation Management Plan (Shire of Serpentine Jarrahdale);
   v) Fauna Management Plan (Shire of Serpentine Jarrahdale);
   vi) Aboriginal Heritage Management Plan;
   vii) Landscape Master Plan (Shire of Serpentine Jarrahdale);
   viii) POS Management Plan (Shire of Serpentine Jarrahdale); and
   ix) Bushland Management Plan (Shire of Serpentine Jarrahdale).

   Depending on the nature of the subdivision application some of the above listed strategies may need to be prepared and submitted to inform the preparation and assessment of a subdivision application, at the discretion of the WAPC. In this regard, the applicant is encouraged to liaise with the WAPC and Shire to seek advice as to whether any strategies should be submitted with a subdivision application. The Shire may liaise with the WAPC where it is considered that additional strategies may be needed to inform its assessment of a subdivision application.

b) 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 including, but not limited to:

   i) Foreshore Management Plan;

ii) Local Water Management Strategy;
ii) Fire Management Plan;and
iii) Vegetation Assessment in accordance with Local Biodiversity Strategy.

5.7 NOISE ATTENUATION

The requirement for a noise impact assessment which outlines remediation measures and/or notifications on title are to be provided and addressed at the time of lodging a subdivision application for the land south of Beenyup Brook, having regard to State Planning Policy 5.4 'Road and Rail Transport Noise and Freight Considerations in Land Use Planning.

6 DEVELOPMENT

6.1 DETAILED AREA PLANS

Detailed Area Plans (now referred to by the WAPC as Local Development Plans) are to be prepared in accordance with clause 5.18.5 of the Scheme, prior to any subdivision and/or development of:

- Lots smaller than 260m^2;
- Areas where variations to open space, site coverage and setbacks are required to facilitate target densities;
- Lots with dual frontage (including laneway lots);
- Lots adjacent to POS areas;
- Lots adjacent to South Western Highway;
- Lots adjacent to existing development adjoining the LSP area;
- Narrow lots that require special considerations to be set; and
- Lots affected by noise and requiring noise attenuation pursuant to the Environmental Noise (Industry) Assessment report and the Transport Noise Assessment Report.

PART TWO
EXPLANATORY INFORMATION

1 PLANNING BACKGROUND

1.1 INTRODUCTION AND PURPOSE

The purpose of this Local Structure Plan is to guide and facilitate the urbanisation of Lot 2 Nettleton Road. This Local Structure Plan 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 'Structure Plan Preparation Guidelines' (August 2012)

This Local Structure Plan supplants an existing structure plan prepared for the same landholding and approved by the Commission in early 2011. The north-western portion of the land has already been approved for subdivision to create 145 residential lots in accordance with the existing approved structure plan and subdivision works have recently commenced in accordance with the approvals.

The approved structure plan is redundant to Cedar Woods, the owner and developer of the subject land, because it proposes the development of the site exclusively for aged care facilities and park-home community. Cedar Woods considers that a residential product of that type can not be sustained by the current property market. Accordingly Cedar Woods is now seeking to develop a traditional residential lot product and a new structure plan is required to facilitate this.

This LSP proposes the development of the land for 'Residential' purposes generally to a density of between R20-R60. Small pockets of lesser density are also proposed; these serve as an interface with pre-existing development on the perimeter of the subject site.

While the predominant use proposed by the Structure Plan is 'Residential', a significant portion of the site will be transferred to the Crown for the purposes of 'Conservation'. This 'Conservation' area is recognised within the Shire's policy framework as a 'Local Natural Area'. A 'Multiple Use Corridor' will also be created along Beenyup Brook.

1.2 LAND DESCRIPTION

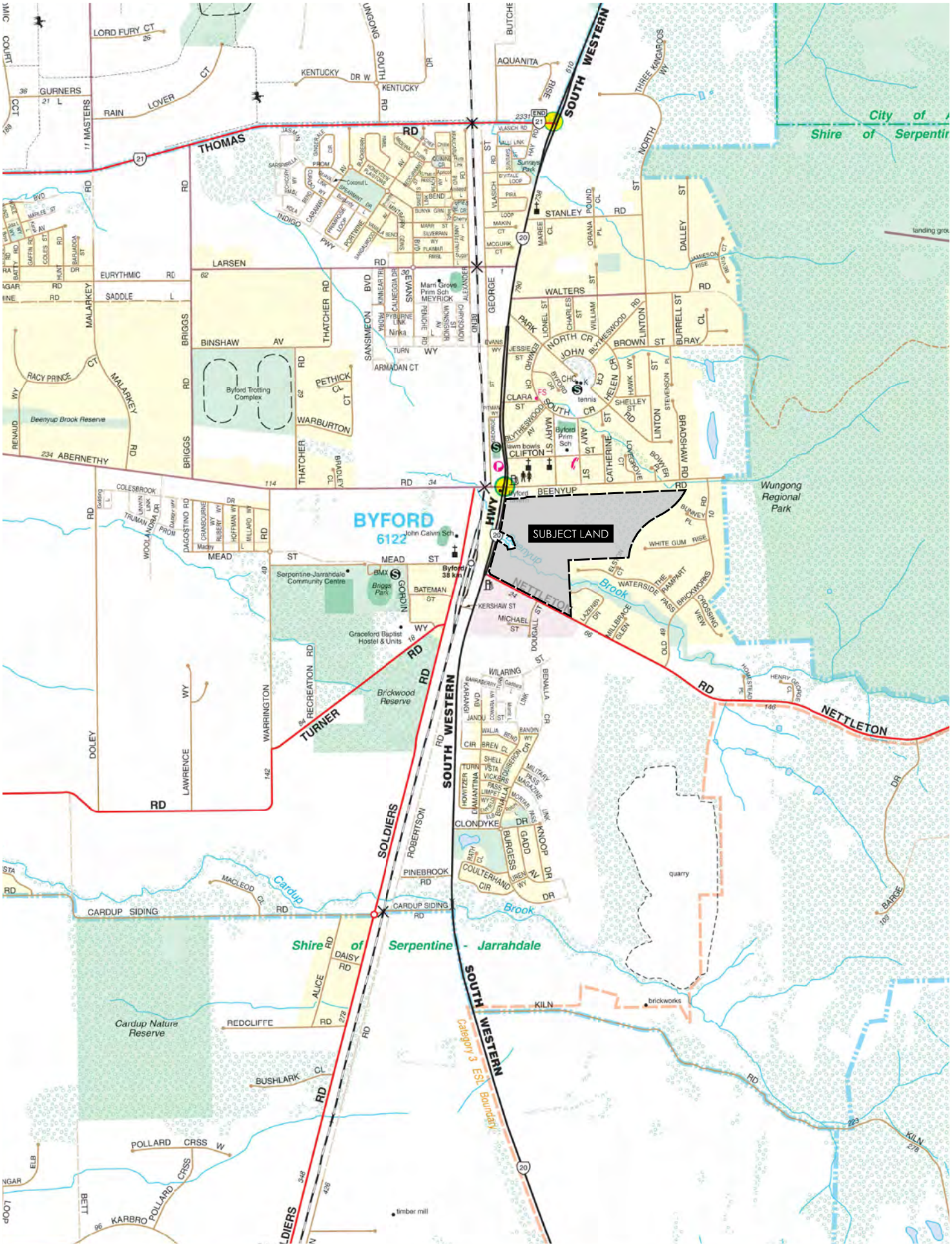
1.2.1 LOCATION

As already noted, the LSP covers a single landholding, being Lot 2 Nettleton Road, Byford. The site is situated within the south east metropolitan corridor within the Shire of Serpentine Jarrahdale. Refer to **Figure 1 – Location Plan**.

Lot 2 is presently only accessible from Nettleton Road, though the lot does have significant frontage to South Western Highway, along its western boundary. An unconstructed road reserve will ultimately connect the property with Beenyup Road to the north.

1.2.2 AREA AND LAND USE

Lot 2 comprises 32.288 hectares of vacant, disused pasture land.



LOCATION PLAN
Lot 2 Nettleton Road, Byford

figure 01

Land to the north, east and south-east of Lot 2 is characterised by low density residential development, archetypal of 1960/1970's Australia. This 'residential fabric' is really only punctuated by changes in building typology, indicating more recent subdivision activity.

Some service commercial is located to the south, including a service station on the intersection of Nettleton Road and Southwest Highway, a flour mill to the south of the Nettleton Road and Hungry Jacks approved use development at the intersection of South Western Highway and Beenyup Road. Existing and planned retail and commercial land uses are situated west of South Western Highway. Of particular significance is the Byford Town Centre, immediately north-west of the site. More intense development will likely be sought around the Byford Town Centre by the Shire as the Town Centre evolves.

Further analysis of contextual issues is illustrated in **Figure 2 – Local Context.**

1.2.3 LEGAL DESCRIPTION AND OWNERSHIP

The land the subject of the LSP comprises Lot 2 (Vol: 2004/ Fol: 85) Nettleton Road, Byford.

The Certificate of Title is attached as **Appendix 2.**

The land is owned by a single entity, being Daleford Properties Pty Ltd (for Cedar Woods).

1.3 PLANNING FRAMEWORK

1.3.1 ZONING AND RESERVATIONS

METROPOLITAN REGION SCHEME

The land is zoned 'Urban' under the Metropolitan Region Scheme (MRS). Refer **Figure 3 – MRS Extract.**

SHIRE OF SERPENTINE JARRAHDALE TOWN PLANNING SCHEME NO. 2

The land is zoned 'Development' under the Shire of Serpentine Jarrahdale Town Planning Scheme No. 2 (TPS 2); refer **Figure 4 – TPS Extract.**

1.3.2 REGIONAL AND SUB-REGIONAL STRUCTURE PLAN

In accordance with Town Planning Scheme No.2, the Shire of Serpentine Jarrahdale commissioned Taylor Burrell Barnett and Kinhill Engineers to prepare a District Structure Plan for the land fringing the Byford Townsite in late 1999. The Byford District Structure Plan or Byford Structure Plan (BSP) as it is now (refer **Figure 5**), was prepared over a number of years and ultimately approved in August 2005.

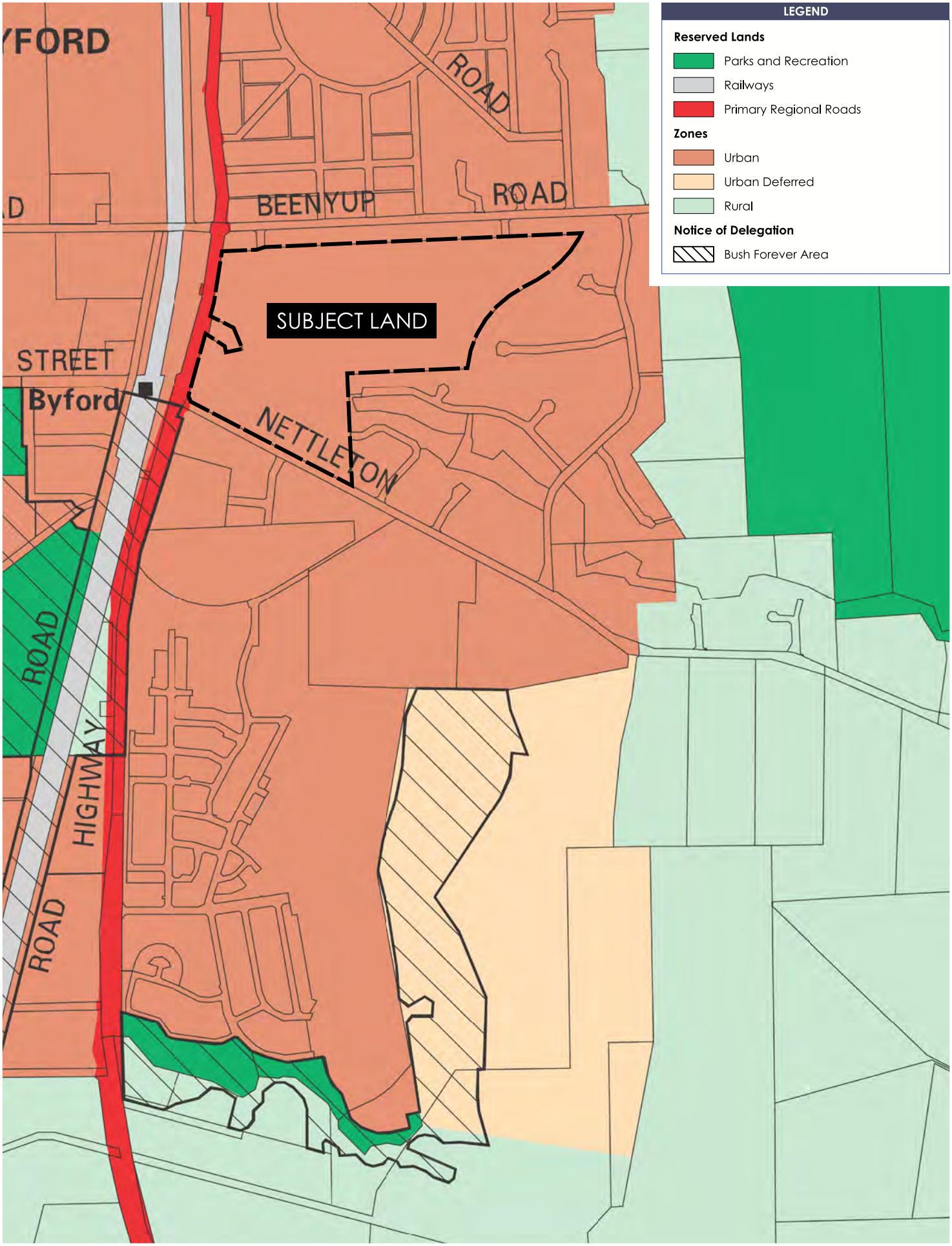
Council undertook a review of the approved BSP in 2006, however this review and a new design was never endorsed or adopted by Council. In 2007, Council again decided to review the 2005 Byford Structure Plan and in February 2007, it formally adopted modifications to the plan.

LOCAL CONTEXT
Lot 2 Nettleton Road, Byford

0m 20 40 60m
s: 1:4500@A3
d: 29 Sept 2012
p: 07/067/017

TAYLOR BURRELL BARNETT

figure **02**



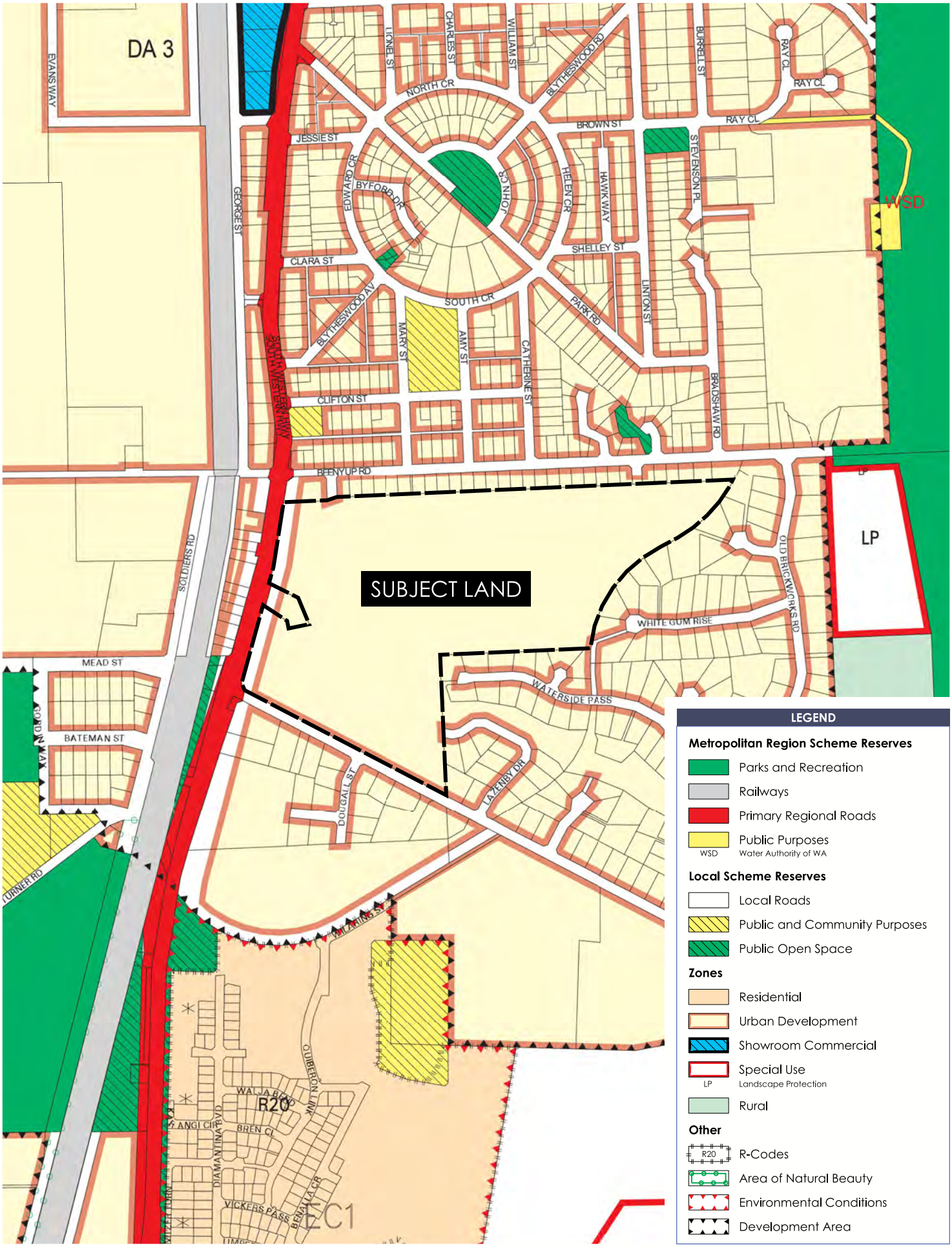
METROPOLITAN REGIONAL SCHEME ZONING

Lot 2 Nettleton Road, Byford

0m 50 100 150m

s: 1:12500@A4
d: 27 Sept 2012
p: 07/067/018

figure 03



LEGEND

Metropolitan Region Scheme Reserves

- Parks and Recreation
- Railways
- Primary Regional Roads
- Public Purposes
  - WSD — Water Authority of WA

Local Scheme Reserves

- Local Roads
- Public and Community Purposes
- Public Open Space

Zones

- Residential
- Urban Development
- Showroom Commercial
- Special Use
  - LP — Landscape Protection
- Rural

Other

- R20 — R-Codes
- Area of Natural Beauty
- Environmental Conditions
- Development Area

SHIRE OF SERPENTINE-JARRAHDALE TPS No.2 ZONING

Lot 2 Nettleton Road, Byford

N

0m 50 100 150m

s: 1:10000@A4
d: 27 Sept 2012
p: 07/067/019

figure 04

Generally the BSP promotes the development of Lot 2 for residential purposes. More specific land use designations (are illustrated in **Figure 5 – Byford Structure Plan** and) include:

- residential densities of R40-R60 within a 400m walkable catchment of the Byford Town Centre;
- a residential density of R20 within an 800m walkable catchment of the Byford Town Centre;
- a proposed local park of approximately 3000m^2;
- a proposed neighbourhood park of approximately 4000m^2 ;
- a 'Multiple Use Corridor', also designated as an 'Area of Landscape Sensitivity' and inclusive of a 'Drainage Basin'; and
- an indicative road layout that includes a north-south connection across Beenyup Brook.

This proposed Local Structure Plan reflects the land use configuration promoted by the BSP. The residential densities also accord with the BSP, albeit the 400m catchment of the town centre has now been more accurately defined on the proposed LSP and Concept Plan (refer **Figure 15**).

There is, however, one proposed departure from the BSP and this relates to the road crossing over Beenyup Brook. Whilst the BSP shows a road connection over what is otherwise described as an 'Area of Landscape Sensitivity', Cedar Woods will seek the Shire's support to exclude this road connection. A traffic report was prepared to inform and support this LSP and in that report Riley Traffic Consulting noted that the road connection was not considered necessary from a demand or safety/security perspective. Emergency access across the brook may still be required for fire fighting purposes and will be addressed in the Fire Management Plan.

In regards to POS, whilst not specifically in the location depicted on the BSP, a local park of approximately 3000m^2 and a neighbourhood park of approximately 8000m^2 have been provided for in the Concept Plan in recognition of the BSP.

1.3.3 SURROUNDING LOCAL STRUCTURE PLANNING

GLADES LOCAL STRUCTURE PLAN

The Glades, Byford is the largest Master Planned community in the south-east corridor of the Perth metropolitan area. The final approval of the Glades Local Structure Plan was given in 2011.

The design philosophy for the project was to celebrate the existing natural environment and cultural heritage of Byford and to provide a future urban form that encourages pedestrian movement and social interaction. With approximately 3,300 new dwellings to be developed, along with 4,500m^2 of retail and 2,500m^2 of non-retail commercial floorspace, the planning and development of the Glades Estate has been notably influential on subsequent development within Byford.

The subject land, located to the east of the Glades, will benefit from the amenity provided by its proximity to the revitalized Byford Town Centre, as well as other planned community facilities such as a private K-12 school and a public primary school.

NOTES

1. AT SUCH TIME AS ANY LAND, CURRENTLY DESIGNATED FOR NON-RESIDENTIAL USES (INCLUDING RURAL -RESIDENTIAL OR RURAL-LIVING PURPOSES) IS SUBDIVIDED FOR RESIDENTIAL PURPOSES, THERE WILL BE AN EXPECTATION OF A STANDARD CONTRIBUTION TOWARDS PUBLIC OPEN SPACE AND OTHER INFRASTRUCTURE.
2. EQUESTRIAN USE WITHIN RURAL RESIDENTIAL BUFFERLIMITED TO ONE HORSE PER LOT STABLED AT THE REAR OF THE LOT ADJACENT TO THE BRIDLE PATH. NO CONNECTION BETWEEN BRIDLE PATH AND PUBLIC ROAD.
3. INTERSECTION TREATMENT OF NEW TOWN CENTRE DISTRICT DISTRIBUTOR INTEGRATOR 'B' ROAD AND LARSEN ROAD TO BE REVIEWED AS PART OF FURTHER DETAILED STRUCTURE PLANNING
4. CARDUP BROOK FORESHORE RESERVE: NOMINAL WIDTH 30 METRES.FINAL WIDTH SUBJECT TO DETAILED INVESTIGATION. LAND TO BE CEDED FREE OF COST UPON SUBDIVISION. IN ACCORDANCE WITH WESTERN AUSTRALIAN PLANNING COMMISSON SUBDIVISION POLICY.
5. RURAL RESIDENTIAL NO HORSES PERMITTED DUE TO PROXIMITY TO WATERWAY.
6. THOMAS ROAD, ABERNETHY ROAD AND ORTON ROAD TO BE WIDENED TO ACCOMMODATE STORMWATER. REFER BYFORD URBAN STORMWATER MANAGEMENT STRATEGY. PLAN TO REQUIRE THE FINAL WIDTH OF ABERNETHY ROAD TO BE 40 METRES UNLESS OTHERWISE DETERMINED AT THE LOCAL STRUCTURE PLAN STAGE.
7. POSSIBLE ALTERNATE LOCATION FOR FUTURE RAILWAY STATION BASED ON RECOMMENDATIONS OF THE TOWNSCAPE STUDY.
8. APPROX. LOCATION OF SEWER PUMP STATION AND 150m BUFFER.
9. THE BYFORD STRUCTURE PLAN PROVIDES 8.6% PUBLIC OPEN SPACE. THE BALANCE 1.4% PUBLIC OPEN SPACE WILL BE REQUIRED TO BE IDENTIFIED IN FURTHER DETAILED STRUCTURE PLANNING AND TO BE GIVEN UP AT THE TIME OF SUBDIVISION.
10. PROSPECTIVE PURCHASERS OF ALL NEW RESIDENTIAL LOTS CREATED WITHIN 200 METRES OF ANY LOT CONTAINED WITHIN THE BYFORD TROTTING COMPLEX WILL BE REQUIRED TO BE NOTIFIED THAT THEY ARE WITHIN PROXIMITY OF THE TROTTING COMPLEX AND ASSOCIATED LAND USES.
11. ANY DETAILED STRUCTURE PLANS FOR THE LAND ABUTTING THE SOUTH SIDE OF ABERNETHY ROAD SHOULD INCLUDE MEASURES TO PROVIDE FOR AN ADDITIONAL BUFFER BETWEEN ABERNETHY ROAD AND THE RURAL LAND ON THE NORTH SIDE OF ABERNETHY ROAD. SUCH MEASURES COULD INCLUDE, BUT ARE NOT LIMITED TO, THE ORIENTATION OF LOTS, LOCATION OF LOCAL PUBLIC OPEN SPACE AND ATTENTION TO THE LOCAL ROAD SYSTEM.
12. THE FUTURE CONSTRUCTION OF ABERNETHY ROAD SHOULD INCLUDE MEASURES TO PROVIDE AN AMENITY BUFFER TO THE RESIDENTIAL LAND USES ON THE SOUTH SIDE OF ABERNETHY ROAD. SUCH MEASURES COULD INCLUDE DENSE LANDSCAPING, APPROPRIATE FENCING OR BUNDING. ABERNETHY ROAD / TONKIN HIGHWAY MAY INTERACT BY MEANS OF A GRADE SEPARATION.
13. NOTWITHSTANDING LAND HAVING A CLASSIFICATION OF RESIDENTIAL (R20) WHERE SUCH LAND ABUTS LAND CLASSIFIED RURAL RESIDENTIAL, AN APPROPRIATE (LOWER) INTERFACE DENSITY OF DEVELOPMENT MAY BE REQUIRED TO BE IMPLEMENTED.
14. THE BYFORD STRUCTURE PLAN IS NOT RESPONSIBLE FOR THE ACQUISITION OF LOT 48 TURNER ROAD (BUSH FOREVER SITE) AND THAT THIS MATTER IS TO BE ADDRESSED SEPARATELY BY THE WESTERN AUSTRALIAN PLANNING COMMISSION.
15. FURTHER CONSIDERATION FOR THE RETENTION OF THE HOMESTEAD BUILDING WILL BE REQUIRED DURING DETAILED STRUCTURE PLANNING INCLUDING CONSULTATION WITH DET (IF REQUIRED) AND FURTHER DETAIL AS TO THE PROPOSED FUNCTION AND SUITABILITY OF THE BUILDING FOR COMMUNITY PURPOSES.
16. EXACT LOCATION OF THE PRIMARY SCHOOL WITHIN LOT 7 BRIGGS ROAD IS TO BE DETERMINED AT THE LOCAL STRUCTURE PLAN STAGE
17. TOWN CENTRE REQUIRES THE PREPARATION AND COMPLETION OF A LOCAL STRUCTURE PLAN, COMPLETE WITH DETAILED AREA PLANS AND DESIGN GUIDELINES. LOCAL STUCTURE PLAN IS TO INCLUDE AN INVESTIGATION INTO INCREASED RESIDENTIAL DENSITIES WITHIN THE 800 METRE WALKABLE CATCHMENT AND ITS RELATIONSHIP WITH TRANSIT ORIENTED URBAN DESIGN. THE LOCATION, NATURE, ROLE, RELATIONSHIP AND DISTRIBUTION OF DIFFERENT ACTIVITIES WITHIN THE TOWN CENTRE INCLUDING 800 METRE WALKABLE CATCHMENT AREA. ANY CHANGE TO RESIDENTIAL DENSITIES OR USES WITHIN THE 800 METRE WALKABLE CATCHMENT OF THE TOWN CENTRE WILL BE SUBJECT TO A SEPARATE MODIFICATION TO THE BSP 2005 AND COMMUNITY CONSULTATION.
18. THE EXISTING WATERWAY WILL BE SUBJECT TOWATER SENSATIVE URBAN DESIGN PRINCIPLES AT THE DETAILED ENGINEERING DESIGN STAGE. THE SPECIFIC WIDTH OF THE WATER WAY WILL BE DETERMINED AT THE LOCAL STRUCTURE PLAN STAGE.
19. THE HIGH SCHOOL SITE WILL BE A PROMINENT LANDMARK SITE. FURTHER INVESTIGATIONS ARE REQUIRED TO DETERMINE THE POSSIBILITY OF CO-LOCATING THE SCHOOL SITE WITH OTHER COMMUNITY FACILITIES. THE FACILITIES SHOULD BE LOCATED IN THE NORTH-EAST CORNER OF THE SCHOOL SITE ALONG ABERNETHY ROAD. DESIGN GUIDELINES ARE TO BE PREPARED FOR THE COMMUNITY PURPOSES SITE AS PART OF THE LOCAL STRUCTURE PLAN FOR THE TOWN CENTRE.
20. LOCAL STRUCTURE PLANS FOR PORTIONS OF THE DOLEY ROAD/WARRINGTON ROAD PRECINCT, ARE TO BE PREPARED AS DETERMINED BY THE SHIRE. THE LOCAL STRUCTURE PLAN SUBMITTED FOR THE AREA ADJACENT TO THE WESTERN EDGE OF THE BRICKWOOD RESERVE IS TO SHOW A ROAD RESERVE ADJACENT TO BRICKWOOD RESERVE SEPARATING IT FROM THE RESIDENTIAL AREA. THE LOCAL STRUCTURE PLAN SHALL ALSO INCLUDE A PUBLIC OPEN SPACE LINK BETWEEN BRICKWOOD RESERVE AND THE MULTIPLE USE CORRIDOR ON TURNER ROAD. THE LOCATION OF DRAINAGE WITHIN DOLEY ROAD/WARRINGTON ROAD PRECINCT IS INDICATIVE ONLY AND WILL BE REFINED AT THE LOCAL STRUCTURE PLAN STAGE. THE FINAL LOCATION OF THE PRIMARY SCHOOL MAY BE SUBJECT TO CHANGE AND ITS LOCATION IS TO BE DETERMINED IN CONSULATION WITH THE DET DURING DETAILED STRUCTURE PLANNING.
21. RESIDENTIAL DENSITY LIMITED TO R30 IN ACCORDANCE WITH THE BYFORD TOWNSITE DETAILED AREA PLAN.
22. THERE IS A POTENTIAL FOR A RAIL CROSSING LINKING MEAD STREET AND SOUTH WESTERN HIGHWAY. HOWEVER, THIS IS A LONG TERM OPTION AND SUBJECT TO CONSOLTATION WITH THE PUBLIC TRANSPORT AUTHORITY.
23. DETAILED STRUCTURE PLANNING WILL BE REQUIRED TO DETERMINE THE FINAL LOCATION OF THE PRIMARY SCHOOL (IN CONSULTATION WITH DET) AND THE CORRESPONDING LOCATION OF THE RURAL RESIDENTIAL ZONE.
24. THE FINAL LOCATION AND DETAILED DESIGN OF THE INTERSECTION IS TO BE DETERMINED THROUGH FUTHER DETAILED PLANNING.
25. FURTHER REVIEW OF NOISE ATTENUATION REQUIREMENTS AND OPTIONS FOR LAND ADJACENT TO TONKIN HIGHWAY IS REQUIRED DURING STRUCTURE PLANNING.
26. LAND ADJACENT TO TONKIN HIGHWAY, SOUTH OF ABERNETHY ROAD TO ORTON ROAD MAY BE REQUIRED FOR A POSSIBLE FUTURE WATER CORPORATION SERVICE CORRIDOR.
27. ADDITIONAL DRAINAGE MAY BE REQUIRED, TO BE DETERMINED THROUGH DETAILED STUCTURE PLANNING (INCLUDING PREPARATION AND FINALISATION OF A DRAINAGE AND NUTRIENT MANAGEMENT PLAN).
28. THE FINAL ALIGNMENT OF THE TOWN CENTRE DISTRIBUTOR ROAD THROUGH LOT 1 ABERNETHY ROAD WILL BE DETERMINED DURING DETAILED STRUCTURE PLANNING.
29. FINAL LOCATION OF THE PRIMARY SCHOOL NORTH OF ORTON ROAD AND WEST OF DOLEY ROAD IS TO BE DETERMINED IN CONSULTATION WITH THE DEPARTMENT OF EDUCATION AND TRAINING DURING DETAILED STRUCTURE PLANNING FOR THE AREA.

GENERAL NOTES:

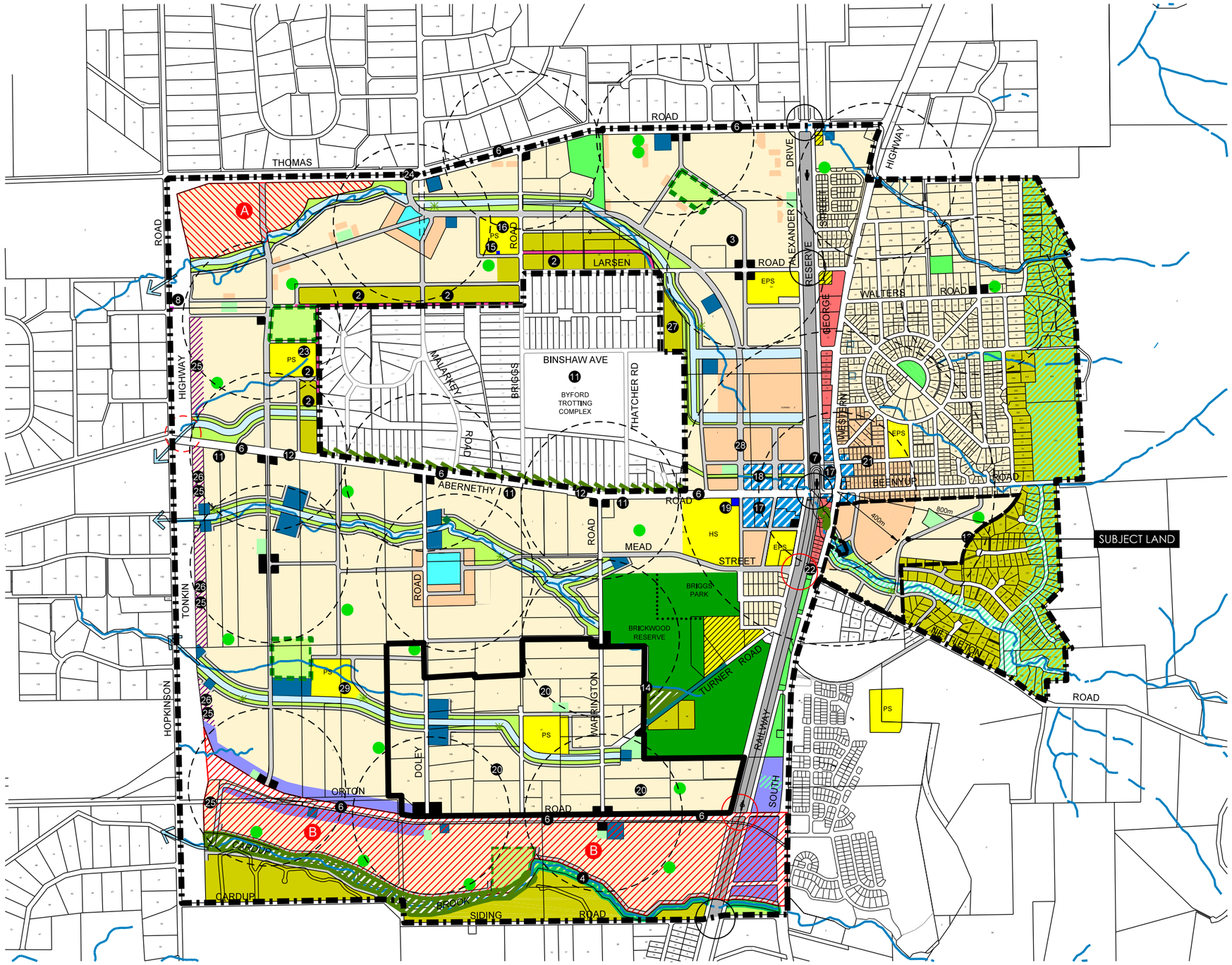
THE PREPARATION AND IMPLEMENTATION OF A BICYCLE AND PEDESTRIAN PLAN FOR EACH LOCAL STRUCTURE PLAN IN ACCORDANCE WITH THE SHIRES'S BICYCLE AND PEDESTRIAN MASTER PLAN IS REQUIRED.

LOCAL STRUCTURE PLANS TO BE PREPARED, APPROVED AND ADOPTED ACROSS THE ENTIRE DEVELOPMENT AREA.

DETAILED AREA PLANS WILL BE REQUIRED FOR LAND ABUTTING MAJOR DISTRIBUTOR ROADS, PUBLIC OPEN SPACE RESERVES, MULTIPLE USE CORRIDORS AND ARTERIAL ROADS TO ENSURE THE BUILT FORM REFLECTS THE RURAL CHARACTER OF THE AREA.

LEGEND

- STRUCTURE PLAN AREA
- DOLEY/WARRINGTON ROAD PRECINCT BOUNDARY
- RURAL RESIDENTIAL
- RESIDENTIAL (R20)
- RESIDENTIAL (R30-60)
- LAND SUBJECT TO FURTHER STUDY, SEE NOTES 25 & 26 WHERE APPLICABLE
- TOWN CENTRE (TOWN CENTRE SUBJECT TO LOCAL STRUCTURE PLAN AND DETAILED AREA PLAN AND DESIGN GUIDELINES)
- NEIGHBOURHOOD CENTRE
- HIGHWAY COMMERCIAL
- COMMUNITY PURPOSE
- NEIGHBOURHOOD NODE
- SCHOOLS
  - EPS - Existing Primary School
  - PS - Primary School
  - HS - High School
- MIXED BUSINESS
- MULTIPLE USE CORRIDOR (MUC)
- WATERWAY
- DRAINAGE BASIN INDICATIVE LOCATION
- FUTURE ROADS
- EXISITNG MRS REGIONAL PARKS AND RECREATION RESERVE
- EXISTING LOCAL PUBLIC OPEN SPACE
- PROPOSED LOCAL PARK (Approx.3000m²)
- PROPOSED LOCAL PARK WITHIN MUC
- PROPOSED NEIGHBOURHOOD PARK (Approx. 4000m²)
- PROPOSED NEIGHBOURHOOD PARK WITHIN MUC
- DISTRICT RECREATION (Approx. 4ha)
- CONSERVATION
- FORESHORE RESERVE
- PUBLIC PURPOSES
- BUFFER BETWEEN TROTTING COMPLEX EQUESTRIAN RELATED ACTIVITIES AND RESIDENTIAL AREA INCLUDED WITHIN EXISTING LOTS
- AREA OF LANDSCAPE SENSITIVITY
- DRAINAGE DIRECTION FLOW
- UNCONSTRUCTED ROAD / BRIDLE PATH
- TURNER ROAD - POSSIBLE CLOSURE SUBJECT TO FURTHER INVESTIGATIONS BY COUNCIL
- RAILWAY CROSSINGS
- POTENTIAL RAIL CROSSING SUBJECT TO FURTHER INVESTIGATIONS
- POSSIBLE FUTURE GRADE SEPERATED CROSSING
- POSSIBLE FUTURE RAILWAY STATION
- A — LAND SUBJECT TO FURTHER STUDY TO ADDRESS THE REQUIREMENTS FOR DRAINAGE AND DETAILED STRUCTURE PLANNING. CONSIDERATION TO BE GIVEN TO THE PREFERRED ALIGNMENT OF THE TONKIN HIGHWAY PRIMARY REGIONAL ROAD RESERVATION.
- B — LAND SUBJECT TO FURTHER STUDY - PLANNING TO BE FINALISED SUBJECT TO RESOLUTION OF ALIGNMENT OF ORTON ROAD



BYFORD DISTRICT STRUCTURE PLAN
Lot 2 Nettleton Road, Byford

0m 100 200 300m

s: 1:22000@A3
d: 2 Oct 2012
p: 07/067/020

figure 05

MUNDIJONG WHITBY DISTRICT STRUCTURE PLAN (MAY 2010)

In August 2011 the Shire adopted the Mundijong-Whitby District Structure Plan (DSP). 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. The DSP comprises several precincts, selected based on various criteria intended to enable efficient and coordinated development to be progressed. The subject land is outside the Mundijong-Whitby DSP area and whilst the structure, vision and objectives identified for this region will be respected, they are not required to be followed in the preparation of this LSP.

BYFORD TOWN CENTRE LSP

In June 2010 Council approved the Byford Town Centre Local Structure Plan. The purpose of the LSP was to establish the broad structure, layout, appropriate land uses and key infrastructure networks required for the expansion of the Byford Town Centre into a District Centre, as identified in the Byford District Structure Plan. The LSP is to be read in conjunction with the Design Gudielines (Local Planning Policy 31) and Town Centre Strategy, dealing with treatment of the public realm and its interface with development sites.

The Byford Town Centre LSP is currently being updated by the Shire based on agreed modifications requested by the WAPC, and is due to be finalised in early 2014.

1.4 PLANNING STRATEGIES

1.4.1 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, with the aim of achieving a connected city pattern of growth by promoting a better balance between greenfields and infill development.

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

1.4.2 OUTER METROPOLITAN PERTH AND PEEL SUB-REGIONAL STRATEGY

The draft Outer Metropolitan Perth and Peel Sub-Regional Strategy (OMPPSRS) plans for the subject site and the wider 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 as 'Urban Zone Undeveloped'.

Potential dwelling yields identified 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 zoned 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. In relation to Byford, the OMPPSRS states that the BSP has identified growth capacity for a future population, which is anticipated to be sufficient to accommodate demand beyond 2031, including and exceeded by the residential development proposed within this LSP.

1.5 POLICIES

1.5.1 WESTERN AUSTRALIAN PLANNING COMMISSION – DEVELOPMENT CONTROL (DC) POLICIES

This Local Structure Plan has been prepared with regard to the WAPC's suite of Development Control Policies (as applicable) and in accordance with the WAPC's operational policy 'Liveable Neighbourhoods' (January 2009, update 02).

Some of the more salient policy requirements are considered below.

DEVELOPMENT CONTROL POLICY NO 2.3 - PUBLIC OPEN SPACE IN RESIDENTIAL AREAS

DC Policy 23 sets out the requirement for all residential subdivisions to provide 10% of its gross subdivisible area as public open space. This LSP complies with the Commission's requirements and a schedule detailing the open space provision is included in this report.

DC Policy 23 confirms that at subdivision stage the Commission may also require the ceding of a foreshore reserve where the proposal abuts a creek line or other water course. In this case the Beenyup Brook traverses the site and a Multiple Use Corridor has been proposed to protect the water course and foreshore environs.

The proposed foreshore reserve will be deducted from the gross subdivisible area and will be in addition to any land required for open space.

1.5.2 WESTERN AUSTRALIAN PLANNING COMMISSION – STATE PLANNING POLICIES (SPP)

STATE PLANNING POLICY 2 - ENVIRONMENT AND NATURAL RESOURCES POLICY

The LSP has been supported by a full range of environmental reporting relating to water management, vegetation, fauna, the Beenyup Brook and landscape. The land is identified as capable and suitable for the subdivision and development form proposed.

As practicable, remnant vegetation will be retained and incorporated in the development. It is also utilised to buffer the development from surrounding land holdings. The Beenyup Brook and its foreshore will be ceded in a recreation reserve, restored and enhanced.

STATE PLANNING POLICY 2.8 - BUSHLAND POLICY FOR THE PERTH METROPOLITAN REGION

Approximately 3 hectares of vegetated land is to be retained in the northeast corner of the site. The future of this land shall be as per a Bushland Management Plan to be prepared by the project environmental consultant. This is in accordance with SPP 2.8 which states that proposals should have regard to the protection of significant local bushland sites recommended for protection and management. The Shire has been provided with a letter detailing the developers commitments to rehabilitate the bushland area, including immediate action as well as the ultimate management plan and agreed standard or quality of rehabilitation.

STATE PLANNING POLICY 3 - URBAN GROWTH AND SETTLEMENT

The LSP proposes the provision of a variety of housing and open space across the site. The site's close proximity to the Byford Town Centre ensures access to jobs and employment, and builds on the existing local economy. The LSP has been designed and prepared in accordance with SPP 3 Urban Growth and Settlement.

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. The Developer will also have regard to the Shire's Byford Development Contribution Arrangement

STATE PLANNING POLICY 4.1 - STATE INDUSTRIAL BUFFER POLICY

The WAPC's draft SPP 4.1 State Industrial Buffer (Amended) Policy aims to avoid conflict between industry and sensitive land uses. The policy applies to the LSP which proposes sensitive land uses in proximity to existing industrial areas. Proposals which satisfy the recommended buffer distances in the EPA's Guidance Statement 3 – Separation Distances between Industrial and Sensitive Land Uses are deemed to comply with the Policy. The Guidance Statement recommends a 300-500 metre buffer distance between flour mill industrial activity and sensitive land uses, depending on the size of the mill.

The actual buffer distance, and consequent need for noise mitigation, is explored further in the Environmental Noise Assessment prepared in support of the subdivision of land south of Beenyup Brook, as detailed in Section 2.7 – Industrial Noise.

STATE PLANNING POLICY 5.4 - ROAD AND RAIL TRANSPORT NOISE AND FREIGHT CONSIDERATIONS IN LAND USE PLANNING

The aim of SPP 5.4 is to promote a system in which sustainable land use and transport are mutually compatible. The key objective of the Policy relating to this LSP is to protect people from unreasonable noise levels of transport noise by establishing a standardised set of criteria to be used in the assessment of proposals.

Lot 2 abuts South Western Highway, listed in SPP 5.4 as a primary freight road under Main Roads jurisdiction. The LSP recognises and plan for the attenuation of noise for future noise sensitive development within the LSP area.

1.5.3 SHIRE OF SERPENTINE JARRAHDALE - ADOPTED LOCAL PLANNING POLICIES

This Local Structure Plan has been prepared having due regard to the Shire of Serpentine Jarrahdale's suite of local planning policies (LPP). Specific reference is made to the following policies, which were found to be applicable to the proposal at hand:

- LPP 17 Residential and Incidental Development
- LPP 19 Byford Development Requirements
- LPP 21 Management Plans
- LPP 22 Water Sensitive Urban Design
- LPP 26 Biodiversity Planning
- LPP 40 Detailed Area Plans
- LPP 43 Natural Hazards and Disasters
- LPP 57 Housing Diversity
- LPP 60 Public Open Space
- LPP 61 Structure Plans
- LPP 67 Landscape and Vegetation
- LPP 68 Sustainability Assessment
- LPP 24 (Revised Draft) Designing Out Crime
- LPP 62 (Draft) Urban Water Management

LIVEABLE NEIGHBOURHOODS

Liveable Neighbourhoods is the Western Australian Planning Commission's primary policy with respect to subdivision design and layout.

ELEMENT 1 – COMMUNITY DESIGN

The LSP will provide residential development in close proximity to a Town Centre. The sites will also have strong connections (both pedestrian and vehicular) with the surrounding area.

The development will provide a safe and convenient housing environment that presents a diverse mix of lot product which meets the needs of the future and established community.

ELEMENT 2 – MOVEMENT NETWORK

The characteristics of streets within the LSP area will be designed to be suitable to their function. The majority of streets within the LSP area are proposed as Access Streets (Local Roads) with a typical width of 15m or less when abutting POS. Laneways, typically 6m wide, will be provided to access garages at the rear of smaller lots. Pedestrian and cycle movement will be encouraged throughout the estate through the provision of footpaths, shared paths and adequate street lighting.

ELEMENT 3 – LOT LAYOUT

The lot orientation specifically responds to the local topography, amenity locations and solar benefits for passive climatic responsiveness for dwellings. A range of dwelling site sizes will be provided that will suit the household needs of residents. It will add to the housing diversity and choice of Byford given its specific locality.

ELEMENT 4 – PUBLIC PARKLAND

Public Open Space within the LSP area is comprised of a Multiple Use Corridor, Conservation Area and Public Open Space. The required 10% POS contribution has been achieved and credits calculated as per the requirements of LN (table provided in Section 5.3 of Part 1). A range of parks and open space areas have been provided to allow for a number of differing community functions. Visual surveillance of parks is encouraged throughout the estate, with buildings oriented toward parks, and perimeter streets are provided around all areas of open space.

ELEMENT 5 – URBAN WATER MANAGEMENT

The proposed street network within the subject site will minimise disturbance to existing landform and to retain natural features (the Beenyup Brook and remnant vegetation where specified). The creation of a Foreshore Reserve to be developed and managed in accordance with a Foreshore Management Plan will protect this habitat from adverse development impacts. The Foreshore Reserve shall be ceded without contributing to Public Open Space obligations (i.e. it will be treated as a deduction).

ELEMENT 6 – UTILITIES

Servicing of the site has been addressed in Section 3.9 of Part 2, including the provision of reticulated water, sewerage and power.

ELEMENT 7 – ACTIVITY CENTRES AND EMPLOYMENT

The LSP provides for residential development only, however the site is in close proximity to the Byford Town Centre, with a majority of the lots within a 5 or 10 minute walkable catchment from the centre. The sites proximity to the Byford Town Centre is further justification for the proposed medium density residential development in the north east area of the LSP.

ELEMENT 8 – SCHOOLS

The LSP falls within the catchment area for the Byford Primary School, north of Beenyup Road. The LSP is within a walkable catchment to the primary school.

LOCAL PLANNING POLICY 8 LANDSCAPE PROTECTION POLICY

The subject site is located wholly within the Shire's Landscape Protection Policy Area (refer **Figure 6**). In order to illustrate the development's compliance with this policy, a Landscape Management Plan was originally prepared by McNally Newton Landscape Architects (MNLA) and submitted with the existing (now redundant) LSP. The Management Plan (now updated in the context of this revised LSP) provides a description of the land and its setting, and identifies the characteristics of the development and how they would comply with the overall objectives of the policy as follows:

- To preserve the amenity deriving from the scenic value of the Darling Scarp.
- To maintain the integrity of landscapes within the Landscape Protection Area.
- To protect and enhance the landscape, scenic and townscape values through control over design, building materials and citing of development and land uses rather than prohibition of development and land use as such.
- To maintain the integrity of landscapes in the line of sight view corridor along identified scenic routes in the Shire, including but not limited to Southwest Highway, Nettleton Road and natural water courses.
- To provide developers and landowners with a statement describing the requirements for the subdivision and development within the Landscape Protection Area.

In order to achieve these objectives it is a requirement that all proposals within the Landscape Protection Policy area receive development approval from Council.

The updated Landscape Management Plan will:

- Incorporate the Design Guidelines for the Estate, which form part of the conditions of sale of the lots and assist with providing landowners with the requirements for development in the Landscape Protection Policy area, inlcuidng control over building materials, colours and finishes;
- Reference the landscaping and management requirements for the multiple use corridor (incorporating the brook) and the local bushland retention area, and;
- Outline the plant species to be used in all landscaping, including street trees, revegation in the bushland and brook foreshore, as well all plantings in the open space areas (local and neighbourhood parks).

Although more applicable to the development application stage, the policy considerations relevant to the LSP proposal are outlined in **Table 1**.

TABLE 1: COMPARISON OF LSP TO LANDSCAPE PROTECTION POLICY AREA CONSIDERATIONS

CONSIDERATION	LSP	COMMENT
General		
The visual intrusiveness of the development within the 'seen area'	✓	The primary view impact is to South West Highway and looking from the Scarp down onto the site. To manage this impact appropriate landscaping treatments will be employed, and will be detailed in the Landscape Master Plan. Development will be sensitive to the Byford landscape while including a level of innovation and style reflective of a Town Centre location.
The landscape values of the area	✓	The Landscape Management Plan identifies the landscape values of the area and identifies a suite of responses to maintain these values including protection of remnant vegetation where possible, revegetation where possible and careful selection of colours and materials.
Community attitudes to the proposed development	✓	Advertising of the LSP will allow the community the opportunity to voice their attitudes on the revised LSP. However, the lodgement of the former LSP was preceded by detailed community consultation with surrounding landowners, the Shire and resident groups. A general level of support for the proposals was received at that time.
The colour schemes and materials of the proposed development	✓	The colours and materials will strike an appropriate balance between innovation, site and climate responsiveness, and sensitivity to landscape. Colours and materials have been addressed in the Design Guidelines for the site.
The preservation and enhancement of the natural features and vegetation of the area	✓	The Beenyup Brook and its foreshore will be ceded as a reserve and will be rehabilitated, adding to the landscape attributes of the area. As far as possible remnant vegetation will be incorporated into the design.
Development shall not be permitted on ridge lines or visually exposed areas or in areas having a generalised slope of greater than 25%.	✓	The site is generally sloping from east to west.
Rezoning and Subdivision Guidelines		
Rezoning and subdivision won't be supported where it results in an undesirable density of development visible from the South West Highway	✓	The residential densities proposed by this LSP do not exceed the density shown on the former (approved) LSP. Densities are proposed in the context of striking an appropriate balance between the need for higher densities of development in proximity to the Byford Town Centre to maximise opportunities for access to the facilities offered and providing for suitable interfaces with surrounding development.
A Landscape Management Plan must accompany any application	✓	A Landscape Management Plan is currently being updated in support of the revised LSP.
Tree Preservation		
Increase by retaining trees and sensitive location of development,	✓	Remnant vegetation will be protected as far as practicable through siting of POS and the provision of a Local Natural Area

CONSIDERATION	LSP	COMMENT
additional tree planting as part of all developments, encourage landowners to protect the landscape		in the north-east of the site.Trees identified as worthy of retention in the Tree Assessment Report prepared by Paperbark Technologies (May 2013) have been retained in POS and the Foreshore Reserve, where possible. The subdivision design to the north of the brook, in particular, has been modified to respond to the desire to preserve some existing trees which were recently reassessed by an Arborist and considered worthy of retention. In this regard, the curved road has been moved further north, setback from the MUC to ensure the trees are bnot impacted by subdivision works.
Fire Control		
The likely bushfire threat affecting the site and what measures are in place/ proposed to manage fuel load	✓	As detailed in the Fire Management Plan.
Compliance with performance criteria of Planning for Bushfire Protection and Australian Standards or Council policy	✓	As detailed in the Fire Management Plan.
The effects of fire protection measures on the amenity of the locality, landscape values, loss of significant remnant vegetation, and susceptibility to instability and erosion arising from loss of vegetation	✓	The majority of the site is cleared. Some further clearing of remnant vegetation would be required to accommodate residential development regardless of the need for fire protection. A 3 hectare conservation area accommodates remnant vegetation and a management plan will address the need to preserve the integrity of the vegetation and manage the fire risk through reduction in fuel load and setbacks from residences. The road to the north of the Beenyup Brook has been specifically aligned to ensure an existing stand of trees worthy of retention could be retained in the Beenyup Brook Foreshore Reserve, as retention of the trees within the road reserve could not be guaranteed. The careful planning and design of roads surrounding these retention areas will ensure they do not pose a fire hazard. Additional opportunities for retention of vegetation within POS and road reserves will also be considered at the detailed design stage.
The availability of an adequate fire service and water supplies including access and egress	✓	As detailed in the Fire Management Plan.
The WAPC's Policy DC 3.7 – Fire Planning	✓	As detailed in the Fire Management Plan.

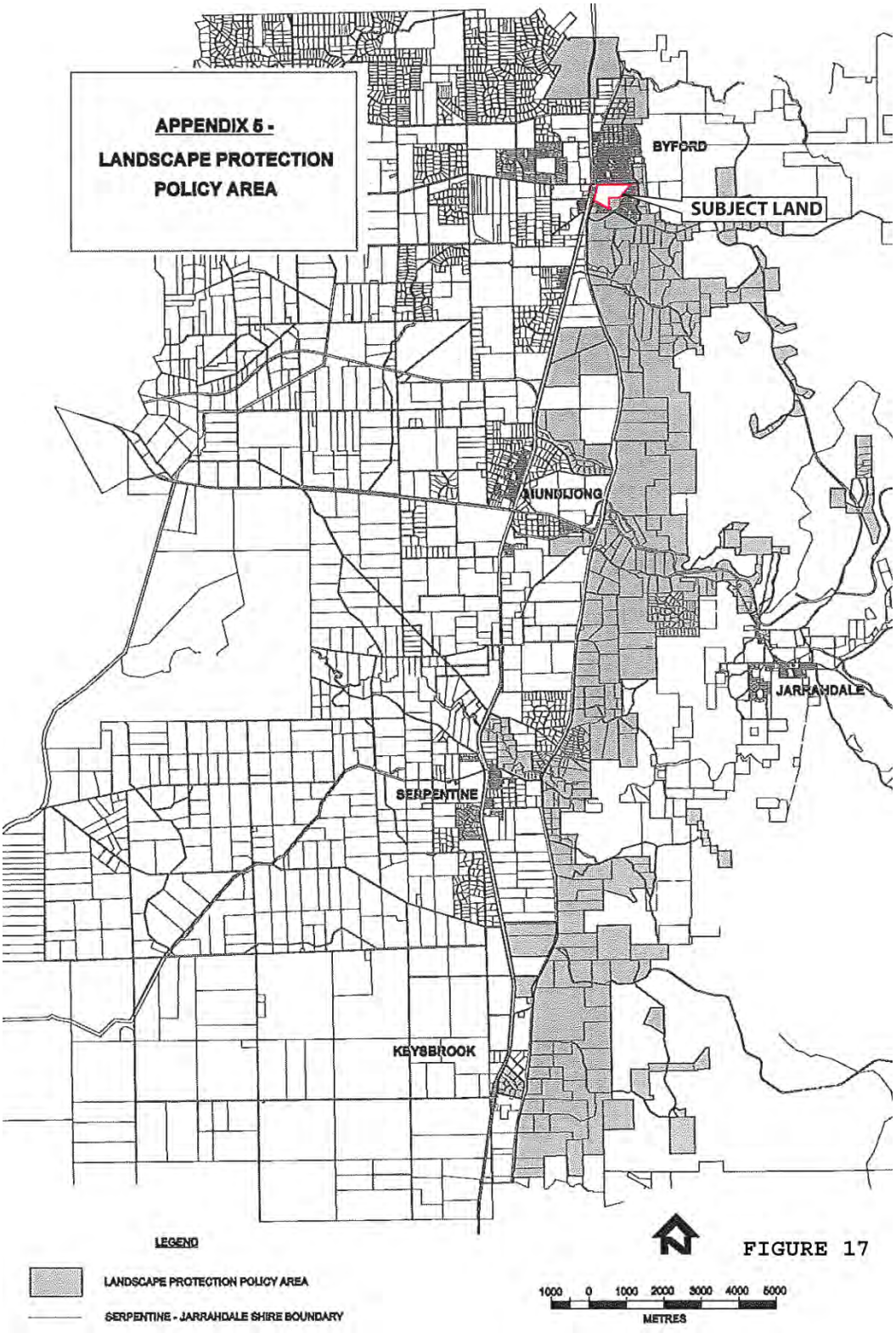


Figure 6: Policy Boundary – LPP No. 8 – Landscape Protection Policy

BYFORD TOWNSITE DETAILED AREA PLAN

The Byford Townsite Detailed Area Plan (DAP) was prepared in 2004. While the DAP provides some framework and general principles for the subdivision and development of the land, it has largely been superseded by the District Structure Plan, which allows for R30/R60 development, and a subsequent LSP approved by Council for the site.

The land is situated within the Character Area F – Nettleton North. Nettleton North is defined as being 'well placed' for subdivision. The DAP recognises the general physical attributes of the land being its cleared nature, gentle grade and the presence of the Beenyup Brook.

The DAP contains a number of subdivision guidelines. With respect to density for instance, the DAP provides for R30 development within 400 m of the Beenyup Road/South West Highway intersection and R20 development across the majority of the remainder of the site. Where the site abuts Rural Residential subdivision, densities of R5 and R10 are indicated. The LSP is consistent with the residential density principles of the Byford Townsite DAP by seeking to provide increased densities of development in proximity to the Byford Town Centre, whilst concurrently ensuring an appropriate interface with surrounding development.

The DAP also promotes solar lot orientation. New roads should be aligned within 20 degrees of either north-south or east-west. All lots should have at least 1 axis aligned according to these parameters.

Principle road connections and Public Open Space should be per **Figure 16.** The DAP identifies a north-south road-link through the property. This has been reviewed by Riley Consulting, which has advised that the link would not be required from a demand or safety/security perspective.

An open space area to retain trees is designated on the plan. After consultation with the Shire, an area of open space is designated in the NE corner of the property.

A matrix comparing the proposed subdivision and development outcomes facilitated by this LSP against DAP outcomes is provided at **Table 2** along with a justification for any departures proposed. The matrix demonstrates that, overall, the proposal would implement (or at least provide for the implementation in future stages) the significant majority of outcomes anticipated by the DAP and that where departures are proposed, they are minor and based on sound planning principles.

TABLE 2: LOCAL STRUCTURE PLAN AND BYFORD TOWNSITE DETAILED AREA PLAN COMPARISON

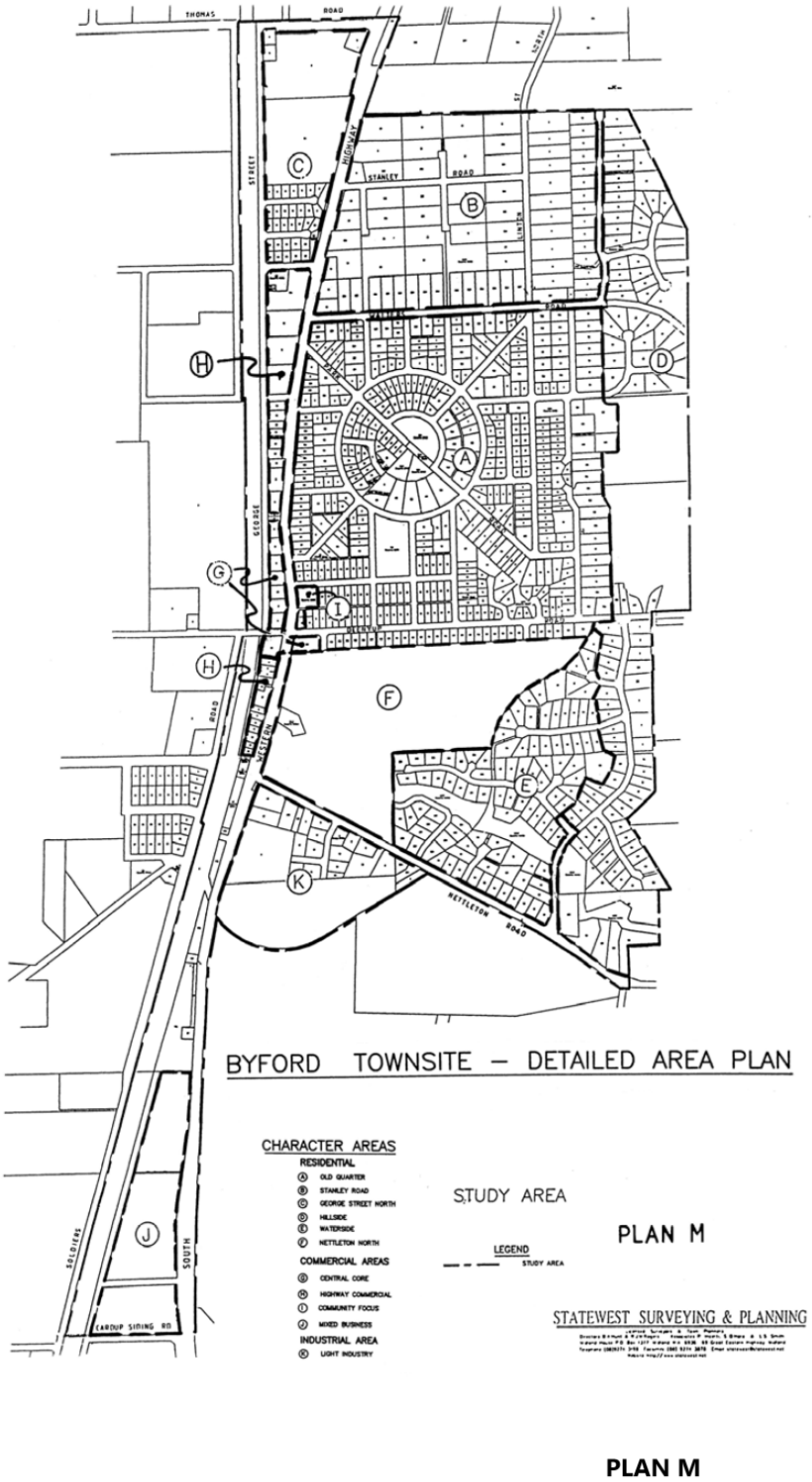
DETAILED AREA PLAN ELEMENT	LSP	COMMENT
Battle axe lots not supported unless used to provide access to lots fronting the highway or POS.	X	There are two battle axe lots proposed and are required to gain access to lots at the head two of the cul-de-sacs. One of the proposed battle axe lots will front POS 1. As an alternative, to the battleaxe configuration, a small road extension can be provided, as was previoulsy proposed, however the Shire's engineer has advised that this is not preferred as it would pose problems with access by rubbish trucks and require bin pads to be located directly in front of neighbouring lots.
Any fencing to the South West Highway and to open space is not to	X	Standard 1.8m high boundary walls are proposed for lots adjacent to South West Highway, as recommended in the Transport Noise

DETAILED AREA PLAN ELEMENT	LSP	COMMENT
exceed 1.2 m.		Assessment. This matter will be dealt with at the detailed design stage through detailed area plans, subdivision and development applications.
No driveway access onto South West Highway.	✓	No driveway access is proposed.
Landscaping to be provided between subdivision and South West Highway.	✓	A widened road reserve (18m) will be provided in order to accommodate landscaping to screen traffic from view and assist in mitigating noise, the details of which will be confirmed at the detailed landscape design stage.
R20 densities implemented south of the Beenyup Brook.	✓	Densities south of Beenyup Brook are proposed to range from R20-R40 in accordance with the Locational Criteria outlined in Part 1, Section 5.2.3.
Service Road with landscape buffer to Nettleton Road.	✓	While a service road isn't required for the development, a landscape buffer is provided allowing the protection of mature trees as far as possible.
Open space located to maximise tree retention.	✓	While not per the open space locations of the DAP, tree retention across the site has been informed by specific and detailed arbor and floristic survey. It has resulted in a road and open space network that maximises tree retention.
Transition R5 and R10 to adjoining Rural Residential subdivision.	X	A base low density code of R20 shall apply abutting existing low density development on Lazenby Drive, Waterside Pass, White Gum Rise and Beenyup Road. Interface development shall be sensitive to existing rural-residential development. Larger lot sizes (up to R5) would not represent an efficient use of land nor provie a better outcome. An R5 lot was originally proposed abutting Lot 303 on Nettleton Rd, however, following a detailed site assessment, it was revealed that the neighbouring lot was not being used for low density residential (Rural Residential) purposes and instead was being used for commercial purposes, with large setbacks to Lot 2. Accordingly, R5 density was not considered necessary and R10-R20 density was considered to have the same desired effect of providing a suitable interface to the existing development.
R20/30 densities north of Beenyup Brook.	X	An equivalent average density of approximately R30 is achieved north of the Beenyup Brook. The household types catered for by this LSP require smaller dwelling and 'lot' sizes thereby allowing for a greater density. This is supported by the land's proximity to the Town Centre.
Road connections and layout per the DAP.	X	South of the Beenyup Brook the road layout is essentially per the DAP. Emergency access across the Brook for fire fighting purposes will be provided, as well as informal pedestrian access. No road connection or formal pedestrian access is proposed. The bulk of vehicle movements would gravitate to the Highway then northwards to the Town Centre. This is catered for by the existing street network and, in the case of the pedestrians, the Beenyup Brook reserve.

DETAILED AREA PLAN ELEMENT	LSP	COMMENT
		A road isn't proposed south of existing lots fronting Beenyup Road. A road in this location would likely become a poor street environment, potentially bounded by solid fencing to the south and various standards of fencing and rear yard to the north. Lots fronting Beenyup Road could still subdivide albeit in a battleaxe arrangement.
Building setbacks – shall confirm with an R20 code unless specified otherwise.	✓	Building setbacks will be as per the applicable code with any variations specified in a Detailed Area Plan.
Dwelling Placement and Orientation – all dwellings shall front the street to maximise casual surveillance of the street or open space. At least 1 habitable room to face the street and to be on cardinal access for solar access. Living areas to be on northern side.	✓	Noted. This matter will be dealt with at the detailed design stage through detailed area plans and development applications. In this regard, a draft DAP has alreday been submitted for consideration by the Shire for the initial stage of subdivision.
Building Materials and Colours – recommended walls of masonry construction, either rendered or un-rendered or weatherboard or fibro cement look weatherboards. Also colours that take inspiration from the local soils and vegetation. Walls of custom orb steel sheeting or concrete tilt up panels not supported. Colours that are garish and sharply contrasting with neighbouring dwellings not supported. Roofing of zincalume or white or off white powder coated metal not supported unless demonstrated that glare is not an issue.	✓	This may be implemented at development and/or building permit stage. The Design Guidelines for the site will assist in achieving the desired outcome.
Corner sites – new dwellings on a corner must provide a frontage to both streets. Achieved by feature windows, wrap around verandas, arch detailing to reduce visual impact. No blank building facades facing either street.	✓	Noted – this matter will be dealt with at the detailed design stage through detailed area plans and development applications.
Fences – new front fencing not encouraged. No fences over 1.2 m. Acceptable fencing includes open or closed timber pickets in keeping with the period of the house, brick in keeping with the period of the house, hedges, colours that compliment the house. Unacceptable fence types includes steel, swimming pool surround type, corrugated fibro cement, colours that	✓	Noted – this matter will be dealt with at the detailed design stage through detailed area plans, development applications and design guidelines.

DETAILED AREA PLAN ELEMENT	LSP	COMMENT
are dark, garish and conflict with the dwelling, brush fencing, limestone.		
Boundary fences behind front setback line shouldn't exceed 1.8 m.	✓	This may be implemented at development and/or building permit stage.
Garages/Carports – Ensure garage doesn't become dominant in order to maintain open character of streets and passive surveillance. Constructed from same or similar materials as the dwelling. Garages not to be in front of the building of the setback – unless open on all sides except where it abuts the dwelling, no other available or accessible location and no existing carport/garage. They must be visible from the street and be no wider than 6 m. If rear or side access available then it must be utilised for access. Crossovers shall be maximum width of 4.5 m.	✓	Noted – this matter will be dealt with at the detailed design stage through detailed area plans, development applications and design guidelines.
Servicing – Bin storage, clothes drying areas, air conditioning units, water heating systems and other plant or equipment to be located so not visible from the street. Noisy plant and equipment shall be located and insulated to minimise impact on neighbouring properties.	✓	This may be implemented at development and/or building permit stage. Preferred fence types may be specified in design guidelines and within LDP provisions. The R-Codes and LDP's will also address these issues if necessary.
Solar hot water system panels are acceptable to the street front facing north.	✓	Noted.
Environmentally sensitive design – The Shire is committed to achieving environmentally sensitive development through sustainable building and design (water and energy efficiency, waste management) in subdivision design and development. Score sheet to be completed and submitted with each application for a new dwelling.	✓	Noted.
Thermal mass internal wall or concrete floor with access to northern sun is encouraged.	✓	Noted.
Non-glare materials.	✓	Noted – this matter will be dealt with at the detailed design stage through development applications and design guidelines.
All northern glazed areas to be shaded by eaves, awning or permanent shade device extending between .4 and .7	✓	This can be addressed at detailed design/approval stages.

DETAILED AREA PLAN ELEMENT	LSP	COMMENT
times the height of the glazed area.		
Design dwellings to maximise cross ventilation and insulation shall be provided.	✓	This can be addressed at detailed design/approval stages.
Water heating systems with 4-5 star energy rating is encouraged	✓	This can be addressed at detailed design/approval stages.
Rainwater storage tanks encouraged – minimum size of 1000 litres	✓	This can be addressed at detailed design/approval stages.
Re-use of grey water on gardens	✓	This can be encouraged at detailed design/approval stages.
Stormwater – Subdivision to conform with BDWP. This requires developers to achieve particular design objectives relating to water quality and quantity.	✓	A Local Water Management Strategy has been prepared to ensure compliance with the relevant objectives.
Sub soil drainage – where not present it shall be installed as a condition of building license.	✓	Drainage strategies are described in detail in the Local Water Management Strategy and Servicing Report with additional detail provided in the Urban Water Management Plan.
Water Sensitive Design – Local measures to reduce water export such as reduction in paved areas and installation of rain tanks encouraged.	✓	This can be secured through appropriate development and/or building approval conditions.
Landscaping – water wise and water efficient design principles.	✓	To be secured via detailed landscaping design.
Paving – where paths are necessary, wide concrete paths are most appropriate. Interruptions by crossovers should be minimised. Paths should be constructed at the back of kerb. Appropriate intersection treatments (coloured paving, ramps etc) may be required.	✓	As required, pathways in the public street network can be designed to this standard.
Walls & Structures – Limestone is inappropriate. Materials consistent with the natural environment of the locality are appropriate.	✓	To be secured via detailed landscaping design.
Street Trees – Planted at a rate of 10 per 100 metres. Type of street trees to be determined by Council & to be cognisant of above and underground services.	✓	To be secured via detailed landscaping design and may be dealt with through appropriate subdivision conditions.
Road reserves – new reserves to be 20 metres wide to enable tree planting and allowing for drainage.	X	The road reserves proposed are appropriate for the type of subdivision proposed and to accommodate a full range of services and landscaping. Reserves will tie in with existing roads, noting the 18 m width of Lazenby Drive.



PLAN M

R2 To ensure environmentally responsive housing is constructed.

Figure 7: Byford Townsite DAP

SCHEME AMENDMENT 167 – REVISED SCHEME PROVISIONS FOR DEVELOPMENT CONTRIBUTION ARRANGEMENTS

The Shire's Amendment 167 updates 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 and community infrastructure. 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 developer acknowledges its obligations in regard to development contributions, and understands that subdivision approvals will attract a condition requiring appropriate arrangements to be made in negotiation with the Shire of Serpentine Jarrahdale.

1.6 OTHER APPROVALS AND DECISIONS

PLANNING APPROVALS

A previously approved structure plan exists over the subject land, however significant changes have required the preparation of an updated structure plan. A superlot subdivision approval has been received for the creation of 3 lots within the subject site, and an existing subdivision approval has been received for Stage 1 of the subject site for the development of 145 lots, and is predominantly confined to the area already zoned residential under the existing approved LSP.

ABORIGINAL HERITAGE ACT 1972

The Minister for Indigenous Affairs granted consent to develop Lot 2 Nettleton Road in accordance with section 18 (3) of the Aboriginal Heritage Act in July 2008. The consent was based on the land uses shown on the previous structure plan, which were described in the section 18 clearance request as 'residential development' comprising 71 residential lots, 284 lifestyle village lots; and 220 seniors' lifestyle lots'.

Given that the development contemplated by this structure plan is 'residential' (albeit for a different lot product and yield) the Minister's consent is construed to still apply. Further advice will be sought in this regard as assessment of the structure plan progresses. In the meantime the developer is aware of its obligations under the Aboriginal Heritage Act.

2 SITE CONDITIONS AND CONSTRAINTS

2.1 EXISTING LAND USE

The subject site comprises vacant, discussed, pasture land. Past grazing activity has resulted in the loss of much of the site's vegetation. Within the vegetated areas that remain, the vegetation is generally limited in its understorey.

The site is bound to the north, east, and south east by low density residential development. Lot sizes appear to akin to an R5 density. Integration with the existing residential land use will be straightforward, as this Local Structure Plan also contemplates a residential use. Integration will be aided by locating lower density lot product towards the perimeter of Lot 2 and by matching levels where possible as part of the earthworks design.

Land immediately south of the subject site, (across Nettleton Road) is zoned 'Urban Development' in accordance with the Shire's Scheme. This land is however developed for what might be described as service commercial or light industrial purposes. The existence of this non-residential activity could give rise to potential (but not insurmountable) land use conflict. This might relate to noise, light and odour spill. Rather than prohibit development, this potential conflict will be managed by the developers of lot 2.

The western boundary of the subject site is delineated by the South Western Highway. Further west, across the Highway, land is reserved and developed for passenger rail infrastructure. Together the Highway and railway reserve form a north-south transport corridor but beyond this again the land is zoned for the purposes of 'Urban Development'.

The 'transport corridor' mentioned above will serve to enhance the site from an accessibility perspective; however the developer is also cognisant of the need to limit potential noise impacts generated by rail and, more particularly, vehicle traffic. The developer is committed to upholding the recommendations of the 'Environmental Protection (Noise) Regulations 1997' and 'Statement of Planning Policy 5.4 Road and Rail Transport Noise and Freight Consideration in Land Use Planning'. The site is also impacted by noise generated by the Byford Flour Mill located South of Nettleton Road. In this regard an acoustic report has already been prepared and the recommendations of that report have informed the formulation of this Local Structure Plan (refer to **Appendix 4**– Transport Noise Assessment, and **Appendix 5** – Environmental Noise Assessment). A summary of noise mitigation measures is outlined further in Section 2.7 to follow. The north-western corner of the development site abuts the 'Byford Town Centre', as defined by the draft 'Byford Town Centre Local Structure Plan' (BTCLSP). More specifically, the subject site shares a common boundary with Lot 101 Beenyup Road. Lot 1 is designated for the purposes of 'Town Centre (Retail Core)' under the BTCLSP.

It is recognised that the approved Hungry Jacks restaurant (located on Lot 101 Beenyup Road, immediately north west of the subject site) gives rise to the potential for land use conflict. This is in relation to potential loss or privacy for residential properties; noise and odour emissions; disruption caused by vehicular traffic; and possible anti-social behaviour.

The primary design response to this interface issue has been to maximise the separation between the two uses. The first step in achieving this separation has been to reorientate lots 1 through 27 along a north-south axis. The simple act of reorientation has facilitated the introduction of a laneway (Laneway 1) and a small area of landscaping as an interface between Hungry Jacks and residential properties.

The above information seeks to illustrate the broad land use context within which Lot 2 exists. For further understanding of the sites position relative to surrounding land use, and indeed the opportunities and issues of the landholdings, please refer to '**Figure 8** – Opportunities and Issues'.

2.2 BIODIVERSITY AND NATURAL AREA ASSETS

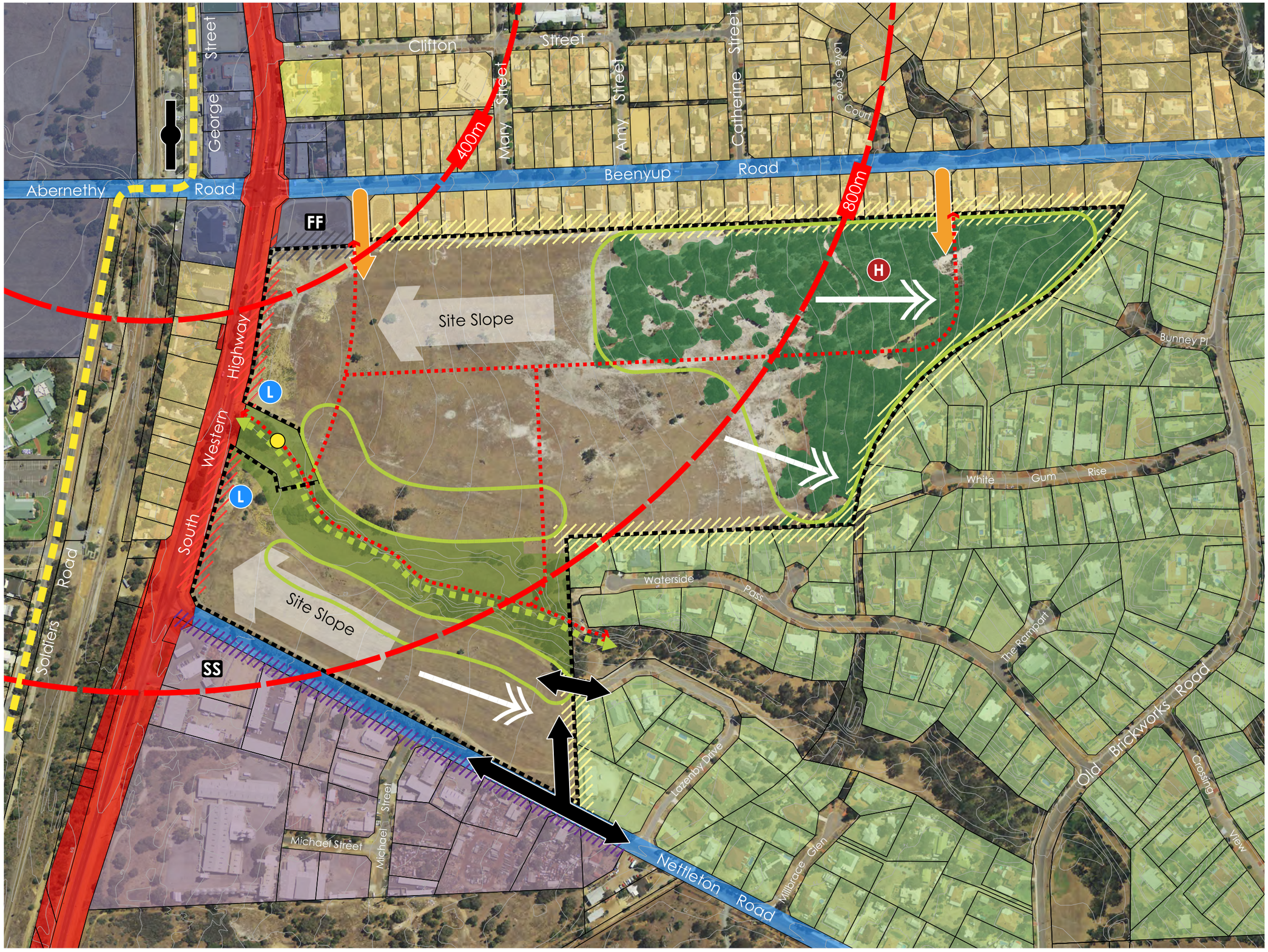
BIODIVERSITY

A significant amount of environmental reporting was undertaken in the formulation of the previous (now supplanted) structure plan. As much of that reporting presented baseline data relating to site condition; Cedar Woods has determined that it will utilise the existing environmental work in the preparation of this Local Structure Plan.

It has been advised by the project environmental consultant that the investigations would still be applicable and that a Black Cockatoo habitat assessment would be the only additional work required. The resulting Fauna Report and the Dust Management Plan would need to be updated to incorporate either the additional information or be in accordance with more recent advances in government policy/guidelines. Cedar Woods was also advised that the reports relating to vegetation type and condition in particular were not yet 5 years old and so, in terms of industry practice, could be regarded as 'current'.

The following information has been provided by the project's previous environmental consultant, ENV Australia, in April 2012:

> *"…ENV Australia (ENV) has been commissioned to review the existing environmental reports previously prepared for the site to –*
>
> 1. *update the reports to reflect the revised 'Preliminary Overall Subdivision Concept' (TBB, February, 2012), as required; and*
> 2. *provide feedback on the updating of reports to fulfil the current requirements of the environmental agencies.*
>
> *The reports ENV has previously prepared include:*
>
> - *Flora and Vegetation (November 2007);*
> - *Fauna Survey (December 2007);*
> - *Dust Management Plan (January 2009);*
> - *Foreshore Management Plan (June 2008); and*
> - *Remnant Vegetation Assessment & Biodiversity Strategy (September 2009).*



LEGEND

- Extent of Structure Plan
- Byford Town Centre
- Existing Community Purpose site
- Existing single residential
- Existing Large lot/lifestyle single residential
- Existing Service Commercial and Light Industrial landuses
- Identified Aboriginal Heritage Site (to be retained)
- Potential Multiple Use Corridor extension
- Public bus route
- Existing train station
- SS Existing Caltex station
- FF Proposed Fast Food or Other Commercial
- Primary Distributor Road
- Local Distributor road
- Existing vegetation
- Interface with Single Residential to be considered
- Interface with Service Commercial and Light Industrial land uses to be considered
- Interface with South Western Highway to be considered
- Interface with Fast Food / Commercial
- Potential for road connections
- Emergency access/egress potential
- Existing road reserve opportunities for road carriageways/entry roads
- Site Slope Topographic site slope (high to low)
- L Low point
- H High point
- Potential for walk trail network
- Land areas with high amenity input
- Walkable catchment from Byford Town Centre
- Strong viewscape to scarp

OPPORTUNITIES AND ISSUES PLAN

Lot 2 Nettleton Road, Byford

0m 20 40 60m

s: 1:4000@A3
d: 4 Oct 2012
p: 07/067/029

figure 08

It is considered that the revised 'Preliminary Overall Subdivision Concept' in itself does not warrant a revision to the above documents. However, the Dust Management Plan will require updating in line with current DEC guidelines and the Fauna Survey will need to address potential for Black Cockatoo habitat. In addition, the Foreshore Management Plan may need to address mosquito management, as the issue has attracted increasing attention in more recent times.

FLORA AND VEGETATION REPORT

The current 'Preliminary Overall Subdivision Concept' is considered to better protect the native vegetation present in the north eastern corner of the site (due to the revised design incorporating protection of more vegetation in public open space areas). *The botanical investigations undertaken as part of the 2009 Vegetation Assessment and Biodiversity Strategy are considered satisfactory under current legislation, and thus this report does not need to be updated.*

It is worth noting that the Natural Areas Assessment templates completed in 2008 do not list the presence of the Threatened Ecological Community (TEC) SCP 20b 'Banksia attenuata and Eucalyptus marginata woodlands'. However, the overall viability score of the remnant would not be changed as a result of the presence of the TEC. Also, a Department of Environment & Conservation (DEC) Naturemap search was conducted as part of the current scope of work and this indicated that no Declared Rare or Priority Flora (DRF) have been recorded in the study area since the initial 2007 survey. Therefore, an additional DEC database search for DRF will not be required, which negates the need to update the botanical reports.

FAUNA REPORT

Given the recent advances in the management of Black Cockatoo species, further emphasis is now given to the protection of these species. As such, ENV recommends a targeted Black Cockatoo habitat survey be undertaken as the amended design 'Preliminary Overall Subdivision Concept' requires the clearing of native vegetation which is considered potential Black Cockatoo habitat. The results of the survey, and the subsequent management recommendations, can either be updated into the fauna report or a separate amendment can be attached to the report.

In addition, the conservation significance system outlined in the 2007 report is no longer used and the most recent classification system will need to be adopted.

DUST MANAGEMENT PLAN

The Dust Management Plan needs to be updated to reflect the expanded subject area and to include the more rigorous requirements of the new DEC Guidelines for managing the impacts of dust and associated contaminants from land development sites, contaminated sites remediation and other related activities (released in March 2011). Specifically, further detail is required on aspects relating to the proposed works and the associated impacts, including the preparation of an 'Aspects and Impacts Analysis' and a 'Site Risk Assessment'.

The development of a Dust Monitoring Program, in line with findings of the Risk Assessment, will also be required under the new guidelines, and will need to include:

- *Outlining the purpose of the program;*

- *Developing performance criteria;*
- *Determining the number and location of monitoring stations;*
- *Outlining the QA/QC requirements;*
- *Detailing the outcomes of stakeholder consultation;*
- *Prescribing roles and responsibilities of various organisations;*
- *Prescribing complaints management procedures; and*
- *Reporting requirements to regulators.*

FORESHORE MANAGEMENT PLAN

We have concluded that the Foreshore Management Plan does not need to be amended. We understand that the previously determined foreshore reserve remains unchanged. Also the methodology for calculating a suitable foreshore reserve has not changed markedly since the Foreshore Management Plan was written. We note, however, that a Mosquito Management Plan may be requested but this could be provided as either an addendum to the report or in a separate letter.

In regards to the Fauna Survey (December 2007) and Dust Management Plan (January 2009), these reports will require updating to bring them in line with current legislation and government agency requirements."

In light of the above, the following sections have been taken from the previous Structure Plan dated 2011.

SHIRE OF SERPENTINE JARRAHDALE - LOCAL BIODIVERSITY STRATEGY

The Shire of Serpentine Jarrahdale adopted a 'Local Biodiversity Strategy' in late 2008. During formulation of the Strategy the Shire released a 'Local Biodiversity Discussion Paper' for the purposes of engaging the community and stakeholders. After receiving public comment the 'Discussion Paper' was finalised as the 'Local Biodiversity Strategy'.

The Shire prepared the 'Local Biodiversity Strategy' in order to provide mechanisms for greater local protection of natural areas and a higher standard of local management of plants and animals (biodiversity). The discussion paper (which preceded the Strategy) focused on natural areas outside those areas already protected by the State and Commonwealth Governments. These are generally areas on private lands and local reserves. Draft targets for the protection of specific types of natural areas have been proposed to provide the greatest chance of conserving biodiversity. Much of the Discussion Paper relates to how the Shire will develop in the future and efforts to protect natural areas as part of development planning.

The Paper requires an ecological assessment of any Potential Natural Area in accordance with its Natural Area Initial Assessment Template. This has been undertaken by PGV, and is detailed in a letter prepared by PGV Environmental dated 26 August 2013, provided as **Appendix 6** – Retained Vegetation Advice. The advice provided by PGV is further to the flora and vegetation survey of Lot 2 undertaken by ENV in 2007. In conclusion, PGV's comparison of the two different 3ha retained vegetation configurations indicated that there was very little difference in the conservation values protected in each configuration or in the viability of the areas as conservation reserves. This advice has been received and supported by the Shire's officers.

The ENV Assessment confirms that a vegetated portion of the Lot 2 can be described as a Local Natural Area for the purposes of the Biodiversity Strategy and the assessment of development proposals. The Assessment identifies a range of measures to be employed through the LSP and associated stages that satisfy the goals and targets of the Biodiversity Discussion Paper. They are outlined below.

VEGETATION

ENV Australia has undertaken two studies in relation to existing vegetation; these are entitled an '*Assessment of Remnant Vegetation*' and a general '*Flora and Vegetation Report*'.

Plans taken from these reports that illustrate vegetation type and condition are provided at **Figures 9 and 10** respectively.

The '*Assessment of Remnant Vegetation*' was undertaken for that portion of Lot 2 that was designated as '*Potentially Locally Significant Natural Area*' in accordance with the Shire's Local Biodiversity Strategy Discussion Paper. The 'Assessment' was supported by a database search (*Declared Rare or Priority Flora and Threatened of Priority Ecological Communities*), a tree survey, and three field surveys; two by ENV and one by the Department of Environment and Conservation.

ENV's '*Assessment of Remnant Vegetation*' confirms that the remnant vegetation qualifies as a 'Natural Area' on the grounds that it is 'Forrestfield Complex' and potentially a 'Threatened Ecological Community'.

The report also confirms that the area proposed for retention is viable with management and retains understorey/connectivity. Ultimately the area will be revegetated to achieve a 'very good' classification across the vegetated area and will be fenced with a single, informal walk trail utilised to minimise access/disturbance.

ENV concludes that:

> *The character of the vegetation community will be retained within the development proposal and managed appropriately. The landscaping aspect of the development will, in some part, mitigate for the loss of trees that were structurally unsound. The thinning of some areas will also assist in the growth of some of the light suppressed trees. The revegetation and retention of trees from the Natural Area to the southwest and western areas will provide connectivity with Beenyup Brook and also create vegetated areas within the presently cleared land on the north western side.*

BEENYUP ROAD

SOUTH WESTERN HIGHWAY

Brickworks Road

White Gum Rise

Waterside Pass

Beenyup Brook

NETTLETON ROAD

LOT 2

CcEmHh

ErTlJp

N

metres

0 30 60 90 120 150

SCALE 1 : 3 000 @ A3

LEGEND

Subject Land Boundary

VEGETATION TYPE

CcEmHh Woodland of *Corymbia calophylla* and *Eucalyptus marginata* over *Hibbertia hypericoides, Mesomelaena tetragona* and *Desmocladus flexuosa*

ErTlJp Open Woodland of *Eucalyptus rudis* over *Taxondria linearifolis, Watsonia meriana* var. *bubillifera* and *Oxcelis pescapre*.

VEGETATION TYPE (SOURCE ENV)

Lot 2 Nettleton Road, Byford

0m 15 30 45m

s: 1:3000@A3
d: 02 Oct 2012
p: 07/067/021

TAYLOR BURRELL BARNETT

figure 09

VEGETATION CONDITION (SOURCE ENV)
Lot 2 Nettleton Road, Byford

0m 15 30 45m
s: 1:3000@A3
d: 02 Oct 2012
p: 07/067/022

figure 10

In addition to the work carried out by ENV, two separate assessments have been carried out in relation to the trees on site, in order to inform the retention of mature tree stock. The initial assessment was carried out by the project surveyor in late-2007 to identify all trees on site with a diameter in excess of 300mm.

This was followed by a finer grain assessment of the trees on site by arboricultural specialist, Mr Charles Alduous-Ball, who walked the site with Taylor Burrell Barnett and examined individual tree specimens in detail. His reporting is appended to both the Landscape Management Plan and the ENV Floristic Survey.

These assessments confirmed those trees worthy of retention through the iterative design of the development and as recommend in the ENV report.

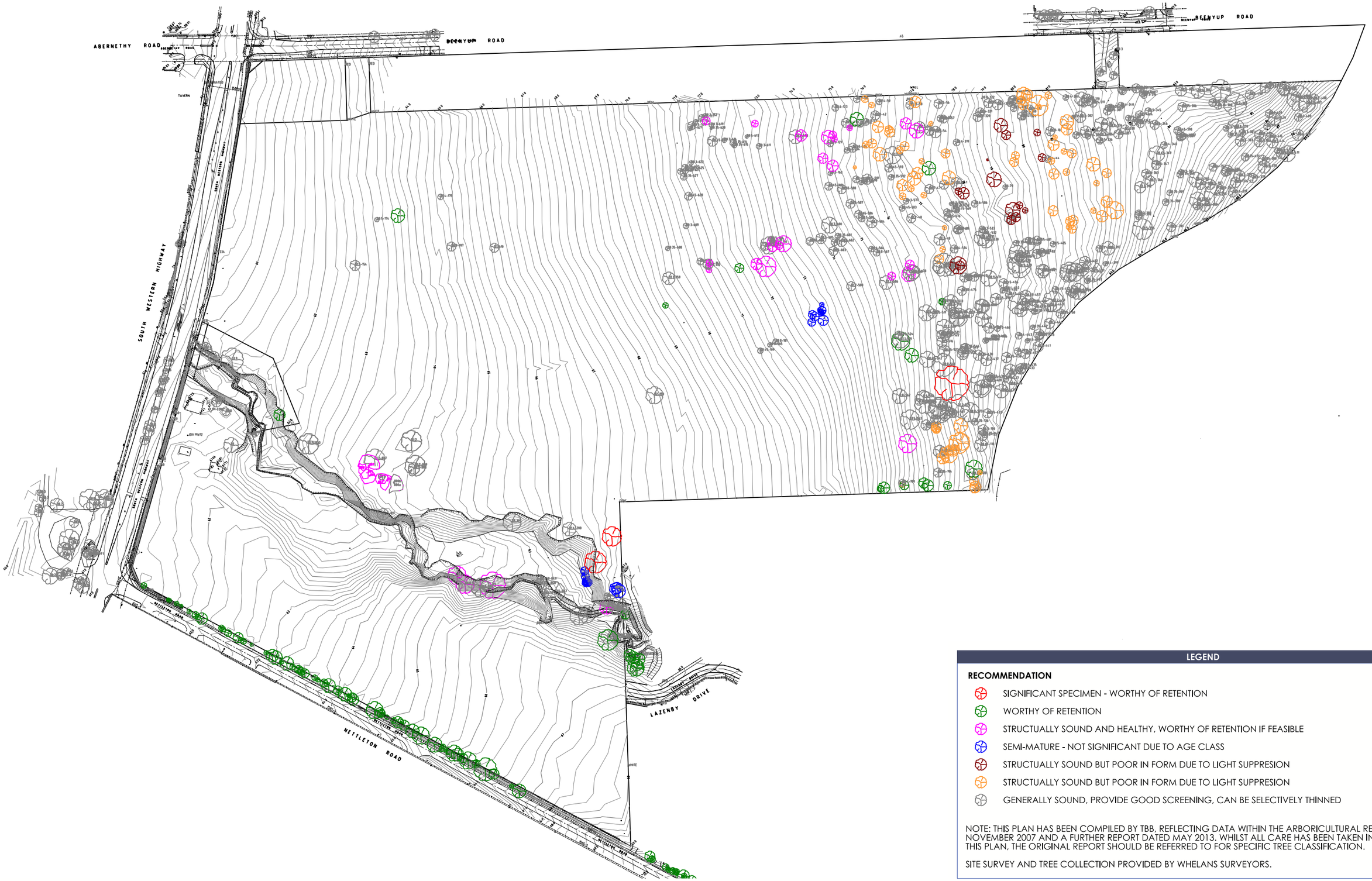
A further Tree Assessment has since been undertaken by Paperbark Technologies Pty Ltd Arboricultural Consultants (refer to **Appendix 7 –** Tree Assessment), to assess the current health and condition of the trees, as it has been some time since they have been previously inspected. This assessment was focussed on 8 trees within Lot 2 which may be affected by the installation of a new road on the northern side of the trees (north of Beenyup Brook). It was found that 2 of the trees require removal due to poor structural condition with major decay and deadwood, and that the remainder of the trees can be retained once remedial tree surgery works are carried out. The trees identified for potential retention are illustrated at **Figure 11.**

While the design outcomes proposed for Lot 2 are discussed in detail in this report, the manner in which tree retention is achieved through sensitive design may be summarised as follows:

- The provision of a sizeable portion of remnant vegetation in the north-east of the site;
- Avoiding excess earth working in well-treed areas;
- The siting of open space within the development to coincide with the location of trees worthy of retention;
- An internal road layout sympathetic to the retention of trees across the site; and
- The creation of a vegetated landscape buffer along the eastern edges of the site.

In addition to these design elements, the arboriculture specialist has recommended the implementation of a number of management measures as the project progresses to maximise the likely survival of retained trees. These measures may be required as conditions of subdivision approval, and are summarised as follows:

- The implementation of suitable protection measures to reduce detrimental damage by heavy machinery during earth-working;
- As far as practicable, underground services to be constructed a suitable distance from trees to avoid excessive root plate reduction; and
- As far as practicable, soils levels not to be drastically reduced or increased within the root plate zone of trees identified for retention.



LEGEND

RECOMMENDATION	CONDITION
SIGNIFICANT SPECIMEN - WORTHY OF RETENTION	SOUND
WORTHY OF RETENTION	SOUND
STRUCTUALLY SOUND AND HEALTHY, WORTHY OF RETENTION IF FEASIBLE	SOUND
SEMI-MATURE - NOT SIGNIFICANT DUE TO AGE CLASS	SOUND
STRUCTUALLY SOUND BUT POOR IN FORM DUE TO LIGHT SUPPRESION	SOUND
STRUCTUALLY SOUND BUT POOR IN FORM DUE TO LIGHT SUPPRESION	FAIR TO SOUND
GENERALLY SOUND, PROVIDE GOOD SCREENING, CAN BE SELECTIVELY THINNED	FAIR TO SOUND

NOTE: THIS PLAN HAS BEEN COMPILED BY TBB, REFLECTING DATA WITHIN THE ARBORICULTURAL REPORT OF NOVEMBER 2007 AND A FURTHER REPORT DATED MAY 2013. WHILST ALL CARE HAS BEEN TAKEN IN PREPARING THIS PLAN, THE ORIGINAL REPORT SHOULD BE REFERRED TO FOR SPECIFIC TREE CLASSIFICATION.

SITE SURVEY AND TREE COLLECTION PROVIDED BY WHELANS SURVEYORS.

TREE SURVEY PLAN
Lot 2 Nettleton Road, Byford

0m 15 30 45m

s: 1:3000@A3
d: 30 Jan 2014
p: 07/067/023A

figure 11

Fundamental to the Local Structure Plan is the identification of a Conservation Area within the eastern most extent of the lot. Prior to detailed subdivision design, the Conservation Area is estimated to be a little in excess of 3 hectares.

The extent and morphology of the proposed Conservation Area has been determined by Taylor Burrell Barnett in response to reporting undertaken by ENV Australia in the period 2008-2009. Specifically ENV carried out desktop research and field survey work to determine whether any part of the subject lot was a 'Local Natural Area' in accordance with the definition given in the Shire of Serpentine Jarrahdale's 'Local Biodiversity Strategy'. ENV determined that the vegetation in eastern most part of the site could diagnostically constitute a 'Local Natural Area' hence approximately 3 hectares of land is set aside for conservation purposes under this LSP.

As the LSP is implemented the Conservation area will, through the process of subdivision, be ceded with the Shire of Serpentine Jarrahdale as a Reserve under Town Planning Scheme No.2.

2.3 LANDFORM AND SOILS

LANDFORM

The site is comparatively featureless being flat and low-lying in nature.

The only landform element of particular note is the Beenyup Brook, which traverses the site along an east-west axis. The Brook foreshore is steep and deeply incised in places and is partially vegetated.

SOILS AND GEOTECHNICAL

The geotechnical attributes of the land have been assessed by Coffey Geotechnics and the resultant report is attached as **Appendix 8.**

The Geotechnical Report identified, by way of on-site testing, the following typical soil profile across the site:

TABLE 3: TYPICAL SUBSURFACE SOIL PROFILE

Unit	Typical Depth to Top of Layer	Typical Layer Thickness	Description/Remarks
1	0m	0-0.1m	Sand, loose sandy, fine to medium grained, grey to dark grey, trace of fines and root fibres.
2	0.1m	0-0.5m	Sand, fine to medium grained, off white, with some gravel, trace of fines and tree roots.
3	0.3-0.5m	0-0.7m	Clayey Gravel/Clayey Sand, fine to medium grained, off white, low plasticity, trace of tree roots.
4	0.2-1.0m	>1.2m	Clayey Gravel, fine to medium grained, brown mottled grey, low plasticity.

The Geotechnical Report concludes that the site's surface is covered with a layer of sandy topsoil, approximately 100mm thick. Underneath are sandy, gravely sand and clayey sand layers. The soil profile is gently sloping (approximately 3% grade) though it is steeper in eastern portions of the site and in areas adjacent to the Beenyup Brook.

Based on the above information a site classification of *M* (moderately clay or silt sites, which can experience moderate ground movement from moisture changes) is considered to be appropriate to the site though this may be upgraded to *S* Class (slight reactive clay sites with only slight ground movement) through an appropriate level of fill.

The Geotechnical Report provides a range of recommendations with respect to the application of fill and the protection of footings, pavement and road construction, which will be reflected in more detailed design and construction phases of the project.

Environmental advice provided by ERM to Coffey Geotechnics indicated that based on the land use history of the site, it was unlikely that any site contamination would be present. No further work is therefore proposed in relation to this issue at this time.

ACID SULPHATE SOILS

Regional Acid Sulphate Soil (ASS) mapping from Planning Bulletin No 64 (WAPC, 2003) identifies the site as having low to moderate risk of ASS occurring at depths greater than 3m from the surface. No further work is therefore proposed in relation to this issue at this time.

TOPOGRAPHY

Lot 2 Nettleton Road is located close to the base of the Darling Scarp.

The site slopes from 89m AHD at its noth eastern boundary to 60m AHD at its western boundary. A Topography Plan is provided at **Figure 12.**

The main topographical feature is the Beenyup Brook. There are significant topographical variations along the Brook (up to 3m) and the northern bank is particularly steep in some areas. The creekline channel is an average width of 2m and expands up to 5m at its widest point.

2.4 GROUNDWATER AND SURFACE WATER

PRE-DEVELOPMENT HYDROLOGY

Beenyup Brook flows through the middle of the site in a westerly direction. Beenyup Brook is considered ephemeral with flow occurring during winter and spring.

The majority of the overland surface water flow from the site drains to Beenyup Brook, except for the north eastern corner which drains towards a small drain alongside Beenyup Road.

A shallow table drain runs along the south side of the site alongside Nettleton Road, flowing in a westerly direction towards South Western Highway before discharging to Beenyup Brook.

TOPOGRAPHY PLAN (SOURCE MNLA)
Lot 2 Nettleton Road, Byford

0m 15 30 45m
s: 1:3000@A3
d: 02 Oct 2012
p: 07/067/024

figure 12

On the southern side of the site adjacent to Waterside Pass a cut-off drain is present which drains a portion of the adjacent residential development, ultimately discharging into Beenyup Brook. This cut off drain is located within the adjacent properties and does not enter the site.

With respect to groundwater levels, groundwater monitoring was conducted for 16 bores within the site over 2 winters. Based on this data and nearby long term DoW bores, the average annual maximum groundwater level (AAMGL) across the site ranges from 61.1mAHD along the western edge of the site to 82.4 mAHD in the elevated eastern area. Depth to groundwater ranges from ponding at surface to 5.1m below existing natural surface.

The western side of the site is classified as a multiple use palusplain. No Environmental Protection Policy (EPP) Lakes or conservation category wetlands are located within the site.

SURFACE WATER QUALITY

Surface water quality for Beenyup Brook was monitored by JDA Consultant Hydologists monthly between October 2007 and August 2008. In summary (JDA 2009):

- The average concentrations of TN (0.82 mg/L) and TP (0.015 mg/L) measured within the site was comparable to the upstream results reported in the BDWMP, and was below ANZECC guidelines.
- Site average pH was recorded as 6.5 which is neutral to slightly acidic.
- Mean electrical conductivity for the site was above ANZECC guidelines at 0.52 mS/cm but under the typical value for urban stormwater quality on the Swan Coastal Plain.

GROUNDWATER QUALITY

Groundwater quality sampling of the superficial aquifer was done by JDA monthly from October 2007 to September 2008 for monitoring bores MW1 to MW13 and from March 2008 to September 2008 for monitoring bores MW14-MW-16. In summary (JDA 2009):

- Groundwater samples across the site ranged in pH from 4.5 to 6, with a mean of 5.3. These values are slightly below the ANZECC guideline of 6.5-8 and are slightly acidic.
- Mean conductivity for the site was 1.93 mS/cm, which is above the ANZECC guideline of 0.12-0.3 mS/cm.
- TN across the site (taken as average values for each bore) ranged from 0.2 to 13.1 mg/L with an average of 2.0 mg/L. Whilst this average is above the ANZECC guideline of 1.2 mg/L, it is below the expected post development stormwater concentration of 1.1 mg/L for typcial urban stormwater quality on the Swan Coastal Plain.
- TP levels were generally below 0.1 mg/L with the site average being 0.04 mg/L. The majority of samples were below the expected value of 0.21 mg/L for typical urban stormwater quality on the Swan Coastal Plain.

LOCAL WATER MANAGEMENT STRATEGY

Stormwater and groundwater management is proposed to be undertaken consistent with DoW water sensitive urban design practices. The system will consist of pipes to convey road runoff to ephemeral water storage areas, with biofiltration used to provide water quality treatment for the proposed development prior to discharging to the receiving environment.

Key elements of the system which are reflected in the structure plan include:

- Maintenance of existing surface water flow paths and catchments.
- Restoration of Beenyup Brook.
- Application of multiple use characteristics through integration of stormwater management with POS areaas and the waterway buffer .
- Use of higher density urban residential zonings to reduce landscape nutrient input.

Imported fill and subsoil drainage will be used to achieve the necessary clearance above a controlled groundwater level (CGL) established at the AAMGL.

2.5 BUSHFIRE HAZARD

A detailed Fire Management Plan has been prepared by consultating group Bushfire Safety (refer to **Appendix 9**). The report is quite detailed and contains a series of recommendations regarding separation distances, minimizing fuel loads on site, and management of fuel loads into the future. The fundamental recommendations of the report will inform developer commitments and the landscape reponse.

1. The Fire Management Plan is an important document that should be taken into consideration by all parties participating in future subdivision and development of the lot 2. For ease of reference however the most salient recommendations to come out of the plan include the following:All proposed building envelopes/sites have a minimum 20 metre Building Protection Zone and fall within acceptable levels of risk. Maximum predicted BAL is BAL-12.5.

2. The Conservation Reserve will be actively managed to maintain fuel load standards consistent with Hazard Separation Zone standards (i.e. 6 tonnes per hectare) by regime of fuel reduction burning, perimeter access is provided for fire prevention and suppression activities.

3. Beenyup Brook corridor will be revegetated to comply with the 'Low threat' definition under the Australian Standard (AS3959-2009) - Construction of Buildings in Bushfire-Prone Areas. This is consistent with the Foreshore Management Plan, which states that native vegetation will be retained in the Landscape Areas where possible, however some trees may be removed or lopped for fire or safety reasons.

4. Vast majority of dwellings will be > 100 metres from 'classified' vegetation.

5. Lots requiring compliance with AS3959 are indicated on the Local Structure Plan (**Plan 1**), including those within 100 metres of the open forest vegetation adjacent the southwest corner of the site, and the woodland vegetation to the east of the site, south of Beenyup Brook.

6. Access and egress for residents and emergency services comply with minimum standards.

7. Water supply complies with minimum standards.

8. Emergency access across the Brook for fire fighting purposes will be provided.

2.6 HERITAGE

The subject land does not accommodate any site or building identified for protection in the Local Municipal Heritage Inventory or other heritage register.

ABORIGINAL HERITAGE ACT 1972

In July 2007 Ethnosciences carried out a desktop assessment of Lot 2 and preliminary ethnographic consultation.

Ethnosciences had previously carried out an archaeological reconnaissance of the land in November 2006 for another client. This resulted in the identification of three artefact scatters and one isolated artefact. A more detailed archaeological survey was undertaken by Tempus Archaeology in September 2007.

The archaeological survey relocated the three previously recorded archaeological sites and the isolated find. An additional sixteen flaked stone artefacts were also found, eleven of which were provisionally grouped into three new archaeological loci with the balance classified as isolated finds. Refer to **Figure 13**.

The ethnographic survey was undertaken in July and November 2007 and involved representatives of four key Aboriginal groups who have associations with and knowledge of Aboriginal heritage values of the survey area. The purpose of the ethnographic survey was to identify any previously unreported ethnographic sites and to seek the views of the Aboriginal community with regards to the archaeological findings outlined above and the proposed development in general. That consultation identified the Beenyup Brook as both an ethnographic site and as having spiritual significance. It is not, however, an 'Aboriginal Site' as defined by the Aboriginal Heritage Act 1972. The ethnographic report is also attached to this report as **Appendix 10.**

As an outcome of the consultation the Aboriginal communities sought the protection of Beenyup Brook and the associated flora and fauna of its foreshore. In order to achieve this, a foreshore buffer width was discussed along with a range of other specific management measures relating to stormwater and weed management for example. These matters are addressed in ENV Australia's Foreshore Management Plan.

Abernethy Road

Beenyup Road

South Western Highway

White Gum Rise

Waterside Pass

The Rampart

Old Brickworks Road

Nettleton Road

Lazenby Drive

LEGEND

- Site section 18 clearance obtained
- Site to be retained

INDIGENOUS HERITAGE LOCATIONS

Lot 2 Nettleton Road, Byford

0m 15 30 45m

s: 1:3000@A3
d: 02 Oct 2012
p: 07/067/025

figure 13

In response to the reporting undertaken, the Minister for Indigenous Affairs granted consent to develop the land in accordance with section 18 (3) of the Aboriginal Heritage Act in July 2008. The consent was based on the land uses shown on the previous structure plan, which were described in the section 18 clearance request as 'residential development' comprising 71 residential lots, 284 lifestyle village lots; and 220 seniors 'lifestyle lots'.

Given that the development contemplated by this structure plan is 'residential' (albeit for a different lot product and yield) the Minister's consent is construed to still apply. Further advice will be sought in this regard as assessment of the structure plan progresses. In the meantime the developer is aware of its obligations under the Aboriginal Heritage Act.

2.7 FORESHORES

A Multiple Use Corridor (Beenyup Brook and its foreshore) runs east-west through the site. A Foreshore Management Plan (FMP) has been prepared and is contained in **Appendix 11**, and it is intended that the FMP will be approved as part of the LSP. As part of the FMP a foreshore assessment was undertaken for that portion of the Beenyup Brook within Lot 2 Nettleton Road.

The foreshore area as defined by ENV is illustrated at **Figure 14.**

The FMP identifies that the foreshore of the Brook has been largely cleared for grazing. The vegetation within the Brook's channel should be classified as 'degraded.' Riverine and wetland vegetation was limited to, at most, within 15 metres of the Brook.

The foreshore has been kept at least 55 metres wide adjacent to the South West Highway in accordance with the BDWMP – Byford Townsite Briefing Paper.

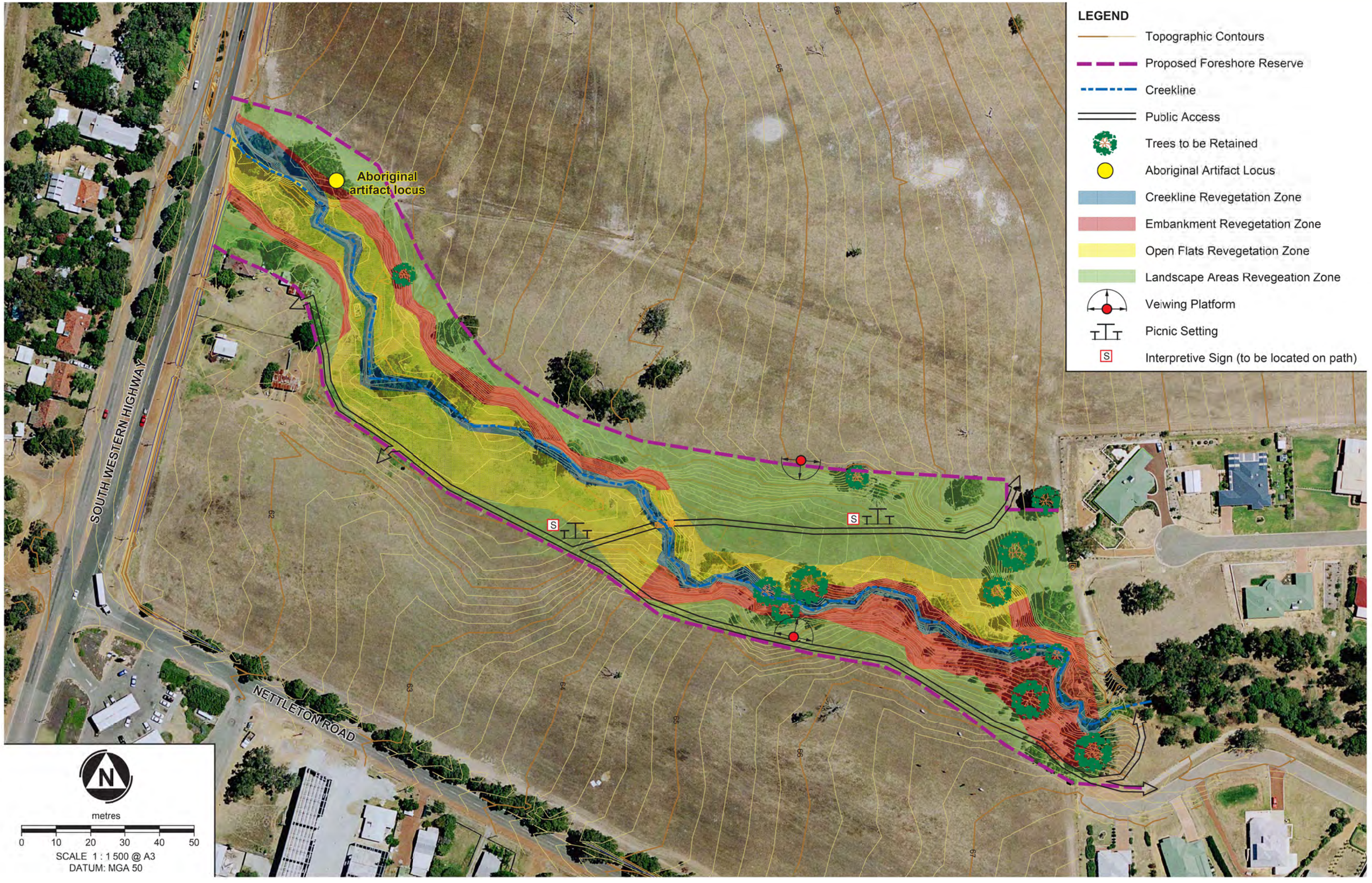
The soil associated with the Brook is prone to erosion and this is illustrated by the nature of the Creek's banks, which are deeply incised and steep in places. This is particularly so on the western portion of the northern bank and the eastern half of the southern bank. The foreshore area in this section is narrow as a result.

The eastern portion of the northern foreshore comprises a steep bank abutting the channel and a gentle bank approximately 40 metres from the channel. The foreshore reserve in this area spans 85 metres.

There is an area on the southern side of the Brook where the topography is relatively low lying and, ENV believes, seasonally inundated. This area forms part of the foreshore reserve.

There are two places where the foreshore reserve is proposed to be less than the default 30 metres from the centreline – in areas corresponding with very steep banks. These narrower widths are compensated for through greater foreshore areas on the corresponding and opposite banks, ensuring that a total foreshore reserve width of between 55m and 85m is achieved..

With respect to land use, the land either side of the Brook is cleared and has a vegetation condition of 'completely degraded.' The FMP provides for appropriate levels of landscaping and rehabilitation with residential development located beyond the foreshore reserve.



FORESHORE MANAGEMENT PLAN (SOURCE ENV)
Lot 2 Nettleton Road, Byford

0m 10 20m
s: 1:1500@A3
d: 02 Oct 2012
p: 07/067/026

figure 14

An archaeological survey identified artefacts adjacent to the Brook. This site is included within the foreshore reserve and will be protected from development.

2.8 CONTEXT AND OTHER LAND USE CONSTRAINTS

FAUNA

In accordance with the Environmental Protection Authority's Guidance Statement No. 56, ENV Australia was commissioned to undertake a Level One Fauna Assessment of the land.

ENV concludes that by reason of the largely cleared nature of the site, most has little to no habitat value. The Beenyup Brook is not curentlly regarded as a major ecological linkage due to its degraded state.

In addition, because of the nature of development surrounding the site, fauna movement is likely to be generally limited to aerial species (with the exception of kangaroos, which will be discussed further). At this stage, a focused survey to establish the presence of potential Black Cockatoo habitat has not been undertaken. The fauna survey was conducted prior to the emphasis on Black Cockatoo species as a conservation significant species. If considered necessary, this can be undertaken at subdivision stage.

In saying this, much of the native vegetation in the northeastern corner of the site is being retained, and certainly most of the vegetation in 'Good' condition will be retained post-development.

The habitats on site are likely to be of most significance to birds, which may utilise the site for foraging purposes. They are unlikely to be reliant on the site as alternative suitable foraging habitat exists close by. Bird species include Black Cockatoos, which have been observed feeding within marri trees on the site (associated with an 'alluvial plain' habitat). However, in the event of this habitat being disturbed (as is proposed) a cockatoo survey is recommended.

Fauna of conservation value with 'sedentary habits' or 'small home ranges' (ENV, 2007) are not expected to be presented in sustainable numbers due to the limited extent of habitat available and the limited connectivity to other bushland areas.

ENV concludes that the development is unlikely to have a significant impact on any regionally widespread fauna in the locality.

The report outlines a number of management measures for the site as follows:

- In the event that the alluvial plain habitat is proposed to be cleared, a cockatoo survey will be undertaken to assess the site's significance against the requirements of the *Environmental Protection and Biodiversity Conservation Act 1999* and the *Wildlife Conservation Act 1950*. As approximately 3ha of remnant vegetation is to be retained, a survey has not been considered critical to date.
- Any bird's nests present on site are inspected for the presence of eggs prior to clearing.
- If possible the proposed development is positioned over areas already cleared to minimise disturbance to habitats present on site.

- Retain as many trees as possible on site.
- Personnel involved with the project receive a copy of this report to ensure familiarisation with the potential impacts on fauna and habitats present on site.

Cedar Woods is committed to implementing each of the recommendations. The manner in which the design results in the retention of as many trees as practicable and the location of development over cleared areas are outlined in ensuing sections of this report.

KANGAROOS

Anecdotally it is understood that a significant kangaroo population inhabits the site. The ongoing wellbeing of this population will need to be considered as development proceeds. As an interim step appropriate fencing will be erected to ensure separation between the kangaroo population and the development front; this is especially important during earth working and construction where such activities could cause significant distress and erratic behaviours in the animals.

A Fauna Management Plan has been endorsed by the Shire and the Department of Parks and Wildlife and provides for kangaroos to egress freely, and an information sheet in relation to the kangaroos has been dispersed to nearby residents. The full report is contained in **Appendix 12.** Management actions are summarised as follows:

1. Management of Kangaroo Population
2. Relocation
3. Tranquilising and Relocation
4. Communication
5. Monitoring
6. Reporting

The actions for Kangaroo Management will be monitored for effectiveness and modified as necessary.

NOISE

Lloyd George was engaged to undertake studies of the current and anticipated future noise levels resulting from road traffic (from the adjoining South West Highway) and a nearby industrial use. The associated reports are provided as technical appendices and summarised in the following sections.

ROAD TRAFFIC NOISE

Houses within noise affected areas as identified in the Transport Noise Assessment will be managed through a combination of noise bund adjacent to the Highway and 'Quiet House' design principles that may include laminated glazing; closed eaves; and mechanical ventilation. Lots requiring measures to mitigate noise generated from the Highway are summarised in **Table 4** below. Such measures are the responsibility of the developer, and can be negotiated and implemented at subdivision stage. It is acknowledged that subdivision approvals will impose conditions requiring the preparation of DAPs for noise affected lots, which will be approved and administered by the Shire. In this regard, a draft DAP has already been submitted to the Shire for approval for the existing approved subdivision area.

TABLE 4: SUMMARY OF TRANSPORT NOISE MITIGATION MEASURES

Affected Lots	Mitigation Measure
Lots 1, 19-22	• Noise insulation package B is recommended to be implemented to meet the indoor noise standards for residential developments in areas where noise levels exceed the limit by no more than 3dB. • Altnerative constructions may be acceptable if supported by a report undertaken by a suitable qualified acoustical consultant once the lots specific building plans are available. • One outdoor area will need to be provided that is shielded from the road.
Lots 2-5, 15-18, 23-27, 44-45, 54-58	• Noise insulation package A is recommended to be implemented to meet the indoor noise standards for residential developments in areas where noise levels exceed the noise target but are within the limit. • Altnerative constructions may be acceptable if supported by a report undertaken by a suitable qualified acoustical consultant once the lots specific building plans are available.
Lots 1-5, 15-27, 44-45, 54-58	• Notifications on lot titles are required.
Lots with double storey construction	• Specialist advice but be sought.

INDUSTRIAL NOISE

The site is impacted by industrial noise generated by the Byford Flour Mill located South of Nettleton Road. As outlined in the Environmental Noise Assessment Report, the onus of complying with the prescribed standards of the *Environmental Protection (Noise) Regulations 1997* is on the noise emitter. It is recommended that the Mill be notificed of it's noise exceedances and undertake investigations to determine the source of the noises and undertake noise control.

It is understood that the petrol filling station plays music during the night and this also exceeds noise standards. By way of response it is recommended that the petrol filling station be advised by the developer that once residences are occupied, playing of external music during the night is unacceptable.

3 LAND USE AND SUBDIVISION REQUIREMENTS

3.1 LAND USE

The proposed Local Structure Plan seeks to facilitate development of Lot 2 for residential purposes whilst retaining specific tracts of land that boast land form and vegetation types representative of the locality.

Given the close proximity of the Byford Town Centre (and the desire for non-residential land uses to be consolidated within this activity centre), there are no non-residential land uses contemplated within the LSP area.

Precise lot yields can only be accurately determined as detailed design progresses. The Concept Plan **(Figure 15)** and predicted lot yield analysis do illustrate however, how the proposal will provide for a diversity of housing types, adding to housing choice in the locality.

3.2 OPEN SPACE

RETENTION OF REMNANT VEGETATION

Remnant vegetation can lend character to a geographic area and provide a link with the past. Given its importance within an urbanised environment (for the purposes of development respite, way-finding and sense of place) remnant vegetation needs to be actively managed to retain its condition. This in turn serves to protect aesthetic, cultural, and ecological values of the site.

ENV Australia has undertaken a survey of the remnant vegetation at Lot 2 and in so doing has established a record of the intrinsic values that need to be protected. The protection of the remnant vegetation from detrimental impacts, such as fire, weeds, rubbish and avoidable disturbance is fundamental to the survival of the remnant vegetation. To guide the protection strategies a detailed management plan will need to be formulated addressing, amongst other things, fencing, replanting, management of pest animals and the interface with surrounding residential land uses.

The development of the best management plan to protect a remnant vegetation community can be easily eroded by poor implementation or implementation by an inappropriate organisation or agency. To this end, it is considered that the management of remnant vegetation should be undertaken by Government agencies, such as, the Department of Environment and Conservation whose core functions relate to preservation and maintenance of the natural environment. Accordingly the management of the remnant vegetation by a land developer, who may not have expertise or a background in managing such important vegetation communities may, ultimately result in the loss or degradation of the remnant vegetation.

PUBLIC OPEN SPACE

The Structure Plan provides for a total of 85,599m^2 of open space which includes areas for conservation purposes and foreshore management. Open space, irrespective of its core purpose, is distributed across the site for maximum accessibility and equity. A further objective in the siting of open space has been to maximise vegetation retention.

ABERNETHY ROAD

BEENYUP ROAD

SOUTH WESTERN HIGHWAY

400m radius

Beenyup Brook

NETTLETON ROAD

LAZENBY DRIVE

LEGEND

- Residential (traditional and cottage)
- Residential (laneway)
- Public Open Space (with key pedestrian connectivity)
- Intergrated Drainage Swale
- Conservation Land Area
- Existing Trees identified with potential for retention (subject to detailed design)
- Walkable Catchment to Byford Town Centre
- Structure Plan Boundary

NOTES

1. Rehabilitation and enhancement to Beenyup Brook.
2. Interface development to be sensitive to existing development.
3. Potential emergency access/egress.
4. Vegetation protection zone for conservation (land area approx 3ha).
5. Laneway lot product oriented to key amenity.
6. Investigate potential to maintain established trees as mitigation to adjoinging land uses.

CONCEPT PLAN
Lot 2 Nettleton Road, Byford

0m 15 30 45m

s: 1:3000@A3
d: 04 Oct 2013
p: 07/067/015C

figure 15

The distribution and location of open space has been influenced by:

- Geo-heritage/landform;
- Local ecology (including waterways and significant vegetation);
- The desire for landscape connectivity/linkages extending across the site in strategic locations;
- An appropriate balance between active and passive open space requirements;
- The need for an appropriate level of buffering between existing adjacent development and residential areas;
- Walkability/access to open space areas; and
- Drainage requirements.

The overall principles for the open space areas include:

- Provide connections to the wider open space network and walk trails from areas of proposed residential development;
- Expression of the Beenyup Brook as a major place-defining element;
- Provide landmark elements and relationships that assist in orientation and legibility;
- Integrate urban water drainage to create passively irrigated open spaces; and
- Provide diverse space from highly naturalistic to more formal urban spaces.

As previously described, conservation of representative landscape types present at the site will contribute to the sense of place of the development. The proposed use of native plant species in the POS will also contribute to this and reduce the need for future irrigation.

A strongly linked open space network of passive and active recreation spaces will be provided to facilitate community use as:

- Informal kick-about areas;
- Picnic areas;
- Play areas;
- Walking trails; and
- Beenyup Brook access.

The open space features of the Structure Plan are outlined in **Figure 16** and detailed below.

Conservation areas (restricted and unrestricted): Associated with the retained endemic vegetation to the north east of the site and the land area adjoining the Beenyup Brook, these areas are instrumental in the character of this area both before and following urban development. The defined shape and area of these identified sites have been determined following considerable evaluation of the Master Plan.

Active and Passive Open Space Areas (unrestricted): Public open space areas shall incorporate features and facilities to encourage residential growth and provide amenities to residents and visitors alike. The open space network will consist of:

- Neighbourhood Parks – ranging in size from 3,000 m² to 8,000m² and provide a mix of active and passive recreation opportunities and is likely to also include a drainage function.

ABERNETHY ROAD

BEENYUP ROAD

400m radius

SOUTH WESTERN HIGHWAY

1

2

3

4

5

6

Beenyup Brook

LAZENBY DRIVE

NETTLETON ROAD

LEGEND

- Potential Multiple Use Corridor extent (deduction)
- Potential Conservation Area extent (deduction)
- Public Open Space and Drainage
- 3 POS identification number

PUBLIC OPEN SPACE PROVISION

Lot 2 Nettleton Road, Byford

0m 15 30 45m

s: 1:3000@A3
d: 15 Nov 2013
p: 07/067/027B

figure 16

- Local Parks up to 3,000 m^2 – smaller more intimate passive spaces that may also provide active areas.
- Key public realm connections (uncredited) to form important connections and site permeability.
- Walk Trails – continuous walk trails have been designed to facilitate movement throughout the estate, and connect importantly to both the Byford Town Centre and adjoining established linear open space to the east.

The breakdown of restricted and unrestricted public open space provision across the site is detailed in **Table 5** below, prepared in accordance with *Liveable Neighbourhoods* (Element 4 – Public Parkland). As it stands, the site provides for approximately 13 per cent public open space contribution, in excess of the required 10 per cent contribution. However, as subdivision progresses and the estate is delivered, the POS schedule will be reconciled to ensure ongoing accuracy, and submitted at the time of subdivision for determination by the WAPC, upon the advice of the Shire of Serpentine Jarrahdale.

TABLE 5 – PUBLIC OPEN SPACE SCHEDULE

PUBLIC OPEN SPACE SCHEDULE (for Revised Plan 07/067/035D)		
Public open space schedule applies to structure plans and subdivisions	**Total**	
Site Area		**32.2880**
Less		
Excess restricted POS (Conservation Area - less allowable contribution)	2.9964	
Beenyup Brook MUC 1:100yr flood extent	1.5000	
Total	**4.4964**	
Net Site Area		**27.8148**
Deductions		
Primary School	0	
Town Centres and commercial	0	
Dedicated drainage reserve (1:1)	0.4060	
Other approved contingencies	0	
Gross Subdivisible Area		**27.3856**
Public Open Space @ 10%		**2.7386**
Public Open Space Contribution		
May comprise:		
minimum 80 per cent unrestricted public open space		2.1908
maximum 20 per cent restricted open space		0.5477

PUBLIC OPEN SPACE SCHEDULE (for Revised Plan 07/067/035D)		
		2.7386
Unrestricted public open space sites		
POS 1	1.0286	
POS 2	0.3190	
POS 3	0.3304	
POS 4	0.1130	
MUC (less 1 in 100 year ARI Flood Extent)	1.1991	
TOTAL		**2.9901**
Restricted use public open space sites		
Total restricted public open space contribution		
Component of Conservation Area (Local bushland)	0.0317	
Drainage component of POS Areas (1:5yr ARI)	0.5160	
Total restricted use public open space (max 20% of POS contribution)		0.5477
Public Open Space Provision		**3.5378**
Percentage of Public Open Space Provided		12.9185

3.3 LANDSCAPING

3.3.1 LANDSCAPE MANAGEMENT PLAN AND REVEGETATION

A Landscape Management Plan has already been prepared to support the previously approved Structure Plan for the site and is currently being updated by Plan E to reflect the latest development intentions, albeit the principles have not changed. The previous report is included as **Appendix 13**. It describes the landscape context of Lot 2 Nettleton Road and the associated landscaping responses, including where revegetation and in-filling will take place. Revegetation shall comprise native species and will reintroduce such species to currently cleared areas of the lot. The updated management plan will be finalised prior to subdivision.

3.3.2 VISUAL INTERFACE

The development area has an outward visual interface with South West Highway, Nettleton Road and existing private property. The Darling Scarp vista and views to the west will be protected and enhanced through the use of native planting. The interface with Nettleton Road and industrial land to the south, as well as the private rural-residential property to the east of the site will be softened by the retention of trees that are in good condition, a large extent of remnant bushland as well as additional planting.

These measures will soften the impact of the proposed development to the surrounding areas as well as enhance security and amenity between the existing private property and the site. Within the site itself, views from east to west which overlook the Beenyup Brook out to the Byford district will be maintained through the orientation of local roads and open space.

It is acknowledged that an appropriate design interface will likely be required between Lot 2 and the residential properties located on the southern side of Beenyup Road. Clearance from the ground water table is an insurmountable development constraint that will dictate the minimum finished level achieved across Lot 2 and thus the level difference between Lot 2 and neighbourhing properties to the north.

The potential visual interface conflict with the approved fast food outlet to the northwest has been mitigated through the reorientation of lots and introduction of a laneway and a small area of landscaping (as detailed in Section 2).

3.3.3 LANDSCAPE

Various characteristics stood out as being dominant or important within the local area:

- Retention of significant vegetation, in particular the *Corymbia calophylla* and *Eucalyptus marginata,* which are present in streetscapes, road verges, open spaces and in conservation areas.
- The utilisation of endemic and native species as decorative vegetation, in manicured planting beds and as revegetation, in conservation areas.
- Laterite gravel and rock work also featured prominently within the local area again as decorative features in planting beds and in a regenerative fashion stabilising creek beds and edging water bodies.
- The local area also showed a pattern of using recycled materials and earth colours for public facilities such as seating, fencing, or landscaping borders and this enhances other characteristics of the area.
- Also of significance and importance to the area is the Darling Scarp. It functions as a scenic backdrop and provides an amenity that in some areas remains in its natural state.

3.3.4 THE RETENTION OF REMNANT VEGETATION

The LSP provides for the retention of approximately 3 hectares of vegetation to ensure viability (with management), the retention of understorey and linear connectivity between the Foreshore and Scarp.

The configuration of the retained vegetation (Local Natural Area) differs slightly from that proposed as part of the previous LSP. The justification for the modified configuration is detailed in a letter dated 26 August 2013 prepared by PGV Environmental and provided to the Shire, contained in **Appendix 6**. A comparative assessment of the two configurations has been undertaken and it was determined that, in terms of the conservation values, there is very little difference between the two configurations. The retained vegetation is not a Threatened or Priority Ecological Community and is classified as Good on the vegetation condition scale. The area protects fauna values on the site with the retention of Marri and Jarrah trees for Black Cockatoo habitat. Landscape Management Plan and Revegetation

3.3.5 LANDSCAPE MANAGEMENT PLAN AND REVEGETATION

The Landscape Management Plan currently being prepared by Plan E in support of the updated LSP identifies where revegetation and in-filling will take place. Revegetation shall comprise native species and will re-introduce such species to currently cleared areas of the Lot.

3.3.6 BUSHLAND MANAGEMENT PLAN

A Bushland Management Plan is to be prepared and approved prior to the commencement of works and be implemented through the progression of the project. The Plan is to include strategies for:

- Fire management;
- Weed management (by a Shire approved consultant);
- Secure tenure;
- Preventing illegal 'dumping';
- Controlling edge effects (public access, trampling, etc);
- Fauna, in particular kangaroos and the potential for them to overpopulate the site;
- Appropriate interface treatments; and
- Revegetation of any degraded areas.

3.3.7 MULTIPLE USE CORRIDOR

A Multiple Use Corridor (the Beenyup Brook and its foreshore) runs east-west through the site. The ceding and rehabilitation of the foreshore area will enhance the Brook as an ecological linkage.

The landowner is aware of its obligations under the Aboriginal Heritage Act 1972 in the event of additional artefacts being uncovered during construction phases.

3.3.8 INTEGRATION WITH THE SURROUNDING AREA

The opportunities to integrate with the surrounding area are dictated by the surrounding lot and road pattern.

The LSP utilises existing road connection points to Beenyup Road and to Lazenby Drive. It also respects that no vehicular access is permitted (except in emergency situations) to South West Highway.

The site backs onto existing rural residential lots to the east and residential lots to the north.

The form of development facilitated by this proposal would effectively balance the need to provide population density in proximity to the Byford Town Centre with the need to limit impacts on adjacent lower density residential development coupled with a respect for the existing vegetation on site.

In this regard a vegetated landscape buffer incorporating remnant vegetation will, along with approximately 3 ha of remnant vegetation in the NE portion of the site, be utilised to screen adjacent Rural Residential holdings from the development. Built form will also be of a vernacular sensitive to the Byford locality.

The recreation reserve and landscaping measures will create a strong east-west link through the development site to and from the Town Centre.

Development abutting those residential lots fronting Beenyup Road would have the impact of allowing those landowners who wish to subdivide to do so in a battleaxe form. Those landowners who do not wish to subdivide would not be compelled to do so and nor would their amenity be diminished through the creation of new residential lots along their rear boundary. The developer is aware of the interface issue with existing properties along this boundary, and this will be dealt with at the subdivision stage.

Any potential land use conflict with the future development of a Hungry Jacks restaurant on the abutting Lot 101 has been dealt with through effective design responses as detailed in Section 2.

3.3.9 DESIGN & TREATMENT OF LANDSCAPE & OPEN SPACE

The Landscape Management Plan outlines the range of measures that will be employed in future (detailed design) phases to ensure an appropriate and sensitive landscaping approach. These measures include:

- The retention of existing vegetation as far as practicable;
- The use of endemic and native plant species;
- Utilisation of laterite gravel and rock work;
- Use of recycled elements and earth coloured materials; and
- Enhancement and utilisation of the backdrop provided by the Darling Scarp.

The Plan also provides detail on the manner in which earthworking would be managed and its impact on landscape, the means to control erosion, and the treatment of the Beenyup Brook with respect to revegetation, bank stabilisation and the creation of riffle pools. Details on the landscaping of drainage basins are also provided. Each of these elements will utilise the various landscaping measures outlined above.

The siting and design of development including road layout and the use of appropriate colours and materials will form a suite of planning controls to ensure appropriate landscaping outcomes.

LANDSCAPE DESIGN/PUBLIC OPEN SPACE STRATEGY

The overall Landscape Strategy is to provide a cohesive series of Public Open Spaces that are connected both physically and in character, as reflected in the Landscape Masterplan included as **Appendix 14.**

- Native vegetation and existing landform shall be retained where possible and have informed the design process.
- The POS areas shall cater for a variety of passive and active uses to suit a range of users and to cater to a broad demographic.
- An emphasis has been created on ease of access throughout the site and into surrounding areas for bikes and pedestrians.
- Materials, landform and planting shall reflect the natural environment of Serpentine-Jarradale to create a unique sense of place.

This section of the report describes the basic principles of the overall Public Open Space (POS) strategy for Lot 2, Nettleton Road, Byford. The proposed residential subdivision is to be developed around a range of open space opportunities. The site has 4 key POS typologies which have informed the development of character precincts which include:

- Multiple Use Corridors which focus on the retention of vegetation, informal and passive recreation.
- Neighbourhood Parks which cater for civic uses
- Local Parks which cater for active recreation and small gatherings
- Conservation Area which is a protected area with restricted access.

It is envisaged that no resident will be more than approximately 400m away from an open space area.

LANDSCAPE DESIGN/PUBLIC OPEN SPACE PRINCIPLES

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. The distribution of POS over the whole site has been informed by site elements including existing vegetation, topography and existing creek line. This optimises the public open space linkages throughout the master plan.

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 specifically along Beenyup Brook and in the Conservation Area will assist in establishing the site's Sense of Place, which will be reinforced through the landscape materials palette.

MATERIAL 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 are aesthetically pleasing while responding to the surrounding natural environment, incorporating water sensitive design species while creating view shafts to develop community value.

PLANTING PALETTE

Planting details will be provided as part of the Landscape Master Plan and Landscape Managemet Plan. The planting palette will address biodiversity by providing for predominantly local species. Specific consideration will be given to the Beenyup Brook and bushland conservation area.

MULTIPLE USE CORRIDOR

Three major Public Open Space (POS 1,4 & 5) areas have been designated to include the site's regional drainage path (Beenyup Brook) whilst also designed to accept major and minor stormwater drainage events from the development in an attractive landscape setting. Ranging in size between 2000 m^2 to 1.58 hectares, these open space areas will contain swales and stormwater storage areas 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.

To facilitate multiple uses, it is proposed 1:1 year and 1:5 year stormwater events will be contained within landscaped drainage swales within the POS and the 1:100 year stormwater event contained within adjacent landscaped stormwater storage areas.

The landscaped stormwater storage areas will also form an integral component of the overall drainage strategy. As such their design will be undertaken to minimise erosion and sedimentation of the site and its surrounds. The use of rock spalling will be required to all drainage out flow points where water flow rates are at their highest to minimise erosion.

Vegetation and rock work will also be installed to assist in reducing water velocity and to stabilise the subgrade.

Sediment from the surrounding development area will be deposited within drainage storage areas to ensure this does not flow directly into the adjacent Beenyup Brook and downstream water bodies. Drainage areas will also filter nutrients and pollutants from stormwater flows prior to release to the receiving environment.

Taking into consideration the Fire Management Plan's recommendations Beenyup Brook will typically be re-vegetated 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. Occasionally 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 1:5 year stormwater flood levels. The 1:5 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 sparse remnant native vegetation on a large portion of the MUC area within the proposed development area. The existing vegetation over the site has been highly modified through previous farming and land use practices. Existing 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:

- Block work 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 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.

NEIGHBOURHOOD PARKS

There are two neighbourhood parks strategically placed within Lot 2. Neighbourhood Parks are those open space areas which are larger in area than local parks, being approximately 3000 m^2 to 8000 m^2 in size. Generally, neighbourhood parks are a destination along the linear public open space network, linked to the adjoining residential street and to the linear open space network through paths, providing ease of access and legibility.

The landscape treatment of these spaces will be informal, characterised by revegetation and native parkland plantings to encourage passive recreation uses. However, within these parks there will be some areas of localised turf, to cater for informal active recreation. Some of the neighbourhood parks may contain an area of retained remnant vegetation.

As with the local parks, drainage areas may be catered for within the neighbourhood parks. Where these are included, the drainage areas will be landscaped, for both recreation and amenity functions. Avenues of trees and minimal shrub planting are preferred. Planted species will be a mix of natives and some exotic species at high impact points.

These POS 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 parks 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. In both cases the western boundary will be defined by a swale with drifts of native plantings.

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 Water wise principles.

Through the development of landscaped areas and its associated facilities will be the provision for picnic settings and informal gathering spaces.

The location of shelters, seating, possible BBQ's and shade trees will delineate the predominant passive from the community activation space within the POS. Positioning of all facilities within the large park will maximise available views towards the Darling Range wherever possible.

These Neighbourhood Parks will be required to accept some stormwater runoff from the surrounding development area.

LOCAL PARK

Ssmall to medium sized POS areas, will also be provided within the development. These parks shall incorporate elements of all the items outlined previously, with the exception of larger informal recreation / kick about areas and communal features such as BBQ's. These Pocket Park is 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.

CONSERVATION AREA

The conservation area and adjacent interface shall also consist of passive recreation opportunities through walk trails in and adjacent conservation areas. Supplement planting to the conservation area shall limit direct public access and where possible an informal dual use path system shall extend along the length of the conservation area to increase protection for the existing vegetation from turf and weed encroachment.

Pedestrian path linkages shall restrict movement throughout the park and minimise any intrusion into the existing vegetation. Possibilities will exist for interpretive signage to be located along footpaths and boardwalks informing the community of the importance of the local flora and fauna. Proposed planting shall take into consideration the recommendations of the Fire Management Report and comply with the proposed Hazard Separation Zones. Proposed plant species shall be water wise, native species or a nominated FESA fire retardant species.

The Dual use and pedestrian path systems shall be designed to allow vehicular crossing and access points for maintenance purposes. The POS fronting the central conservation area offers a range of passive recreation and community facilities including settings for picnics and informal gatherings. The Conservation area shall be composed of 95% retained vegetation, 5% native planting with no planned irrigation.

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 allocated however will be submitted to the Jarrahdale Serpentine Shire for approval with the landscape and irrigation documentation package. They will 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 adjacent to South West Highway, Nettleton Road and along Beenyup Brook will enhance the project's landscape theme. The trees will serve an important visual buffer and amenity function in reinforcing the rural character of Byford.

DRAINAGE TREATMENTS ADJACENT TO POS

All stormwater from the development will be directed into a system of drainage swales and bio-retention areas constructed along the edges of the POS. These areas will be sized to treat the flows from the 1 in 1 yr event in accordance with the principles of the Department of Water, Stormwater Management Manual for Western Australia.

Storm events in excess of the 1 in 1 year will be directed into adjacent larger stormwater storage areas for attenuation prior to diacharge to the receiving environment

A portion of the treated stormwater may also be harnessed for beneficial uses elsewhere on site.

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.

Reduced irrigation design methods include reduction in areas of turf, avoidance of species which require extensive irrigation and the design of irrigation systems for efficiency (to be detailed at subdivision stage).

The planting design of all Streetscape and Public Open Space areas will consist of predominantly endemic native species. Planting design is proposed to include a water sensitive design approach and will also seek to reduce irrigation rates over the long term to planting areas to promote a longer term water saving strategy for the development.

Hydro zoning will also provide a supplementary design principle whereby groups of plants with similar irrigation demand needs will be grouped together. This will facilitate irrigation efficiencies that can be made across the scheme.

Stormwater swales and storage areas are proposed to be in the main non-irrigated and will be planted with native sedges and rushes to facilitate with the drainage engineering required for the site.

Irrigation, when necessary, shall aim to incorporate elements of subsurface, drip and trickle water application methods, with water application based on seasonal need and a reduced number of areas under surface spray water application. As described above, water-wise principles will be employed to meet the Department of Water guidelines that groundwater allocation be no more than 7,500 kilolitres/hectare/annum.

WATER WISE PLANTING

In line with the overall principle to reduce irrigation water demands it is proposed that native species will be the predominant planting type to minimise irrigation requirements. Soil conditioning will be employed to reduce leaching and increase soil moisture holding capacity. All garden beds will be mulched to reduce water loss through evaporation.

MAINTENANCE MINIMISATION

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.

The reduction of turf areas and use of native species will minimise the maintenance required throughout Lot 2 Nettleton Road, Byford.

In conjunction with the detail design of public open space and verge areas to be ultimately vested and controlled by the Council, a maintenance minimisation review is undertaken by the design consultant team to best reduce likely future maintenance costs at the time of subdivision detailed design. This process may typically include:

- review of all materials to ensure fit for purpose and lifespan
- review of corners, edges and trim to ensure definition of maintainable edges
- review of the volume of planting and turf areas
- review of plant and turf species and their specific growth habits and requirements
- water quality design review of open water bodies and water courses
- water monitoring of groundwater quality and levels, lakes, wetlands and overflows
- review of irrigation materials and standards to ensure best practice
- implementation of sustainability and water wise principles to enable the reduction of ongoing costs through removal of some short term landscape establishment assets
- review of all structural design to ensure fitness for purpose and lifespan

3.4 RESIDENTIAL

The development proposed by the LSP will provide residential dwellings within a walkable catchment to an established Town Centre. The connectivity requirements for a robust neighbourhood have been embedded in the design in terms of pedestrian and vehicular permeability with the Byford activity centre and with the surrounding established residential area. Relationships with an existing walk trail network have been instrumental in defining the character and structure of the proposed LSP design.

The development will provide a safe and convenient housing environment with a diverse mix of lot product aimed at meeting the needs of the established and future community of Byford. Lot sizes and types have been mixed throughout the estate locating a diverse demographic in proximity to a wide variety of amenity.

The lot design responds to the local topography, amenity locations and solar benefits for passive climatic responsiveness for dwellings.

Lot 2 experiences a number of constraints based on neighbouring land uses; added to which a significant proportion of the site is undevelopable (owing to the Local Natural Area and Beenyup Brook). The various interface requirements, including those within the site, has required the use of more compatible lower densities (larger lots), wider road reserves and retention of vegetation where possible to mitigate impacts both on and off-site in certain areas. In doing so, a dwelling yield of approximately 14 dwellings per hectare has been able to be achieved, which is close to the target density of 15 dwellings per hectare.

The reduction in lot yield from the existing approved LSP for Lot 2 is due to the change in land use from aged accommodation (which is typically more dense) to a traditional residential lot product. Despite the consequent reduction in dwelling yield, the overall population is estimated to increased across the site.

DESIGN PRINCIPLES

The site offers unique views to the east of the Scarp. These are impressive, and serve as a constant reminder of the sites proximity to nature reserves and open space. This natural character has been embedded in the LSP through its respect of original site characteristics and retention of expansive areas for the benefits of the community and the natural environment at large.

These retained naturally vegetated sites are interlinked with pedestrian and vehicular networks along with additional open space elements to provide an estate with a clearly themed natural focus. Key road entries have been aligned to celebrate these elements and expose the road users to the sites benefits and lifestyle uplift.

The proximity of the Byford town centre and natural amenity both serve to justify the residential density proposed on the structure plan. A diverse variety of housing has purposely been offered in proximity to these locations to broaden the opportunities for a wide populous.

The road network oriented to the Beenyup Brook offers strong public view corridors for all residents, drawing this foreshore landscape element into the residential component of the site and offering direct accessibility for pedestrian movement.

LOT LAYOUT

A wide variety of lot sizes has been offered to provide a mixture of living opportunities in proximity to the Town Centre. Moderate sized lots have generally been located with visual connectivity to landscape relief offered by public open space elements. This level of proximity also offers the benefits of accessibility for the purposes of recreation for family inhabitants of these moderate sized dwellings.

The majority of moderate sized lots are located within 400m walkable catchment of the Town Centre, however due to the high permeability of the pedestrian network, additional moderate sized lots are located outside of the 400m catchment (approximately 800m2) and in proximity of open space amenity.

All such lots are purposely oriented north/south to maximise their potential for climatic efficient design with limited shadowing impact of east/west oriented narrow lots. The north south road design however prioritises solar amenity for the standard lot product on a east/west access.

The topography of the site has supported the design imperatives highlighted above with minimal impact on the private and public realm, although retaining wall structures will be required to lots in order to maintain this predominant north/south road orientation.

3.5 MOVEMENT NETWORKS

A Traffic Impact Assessment has been undertaken by Riley Consulting Traffic Engineers. The technical report has been included as **Appendix 15.** Incuded as **Figure 17** is a Movement Network Plan summarising the findings of the traffic assessment.

Lot 2 will yield an estimated 367 dwellings once fully developed. The traffic generation of residential lots in Byford has been previously assessed at 7 trips per dwelling (in associated traffic forecast modelling) and thus the development could be expected to generate (366 x 7) 2,562 trips per day. The site is expected to generate 2,562 trips per day. During the peak hours between 8% and 10% of the daily flow can be expected from the residential land uses. Assuming 10% it can be expected that during peak periods to development will generate 256 vehicle movements. The split is expected to be 70% in the peak direction. The traffic generation of the proposed development is shown to be about 3,109 vehicles per day based on the maximum yield of the site.

REGIONAL ROADS

The South West Highway is a primary regional road and it provides a regional link between Armadale (where it joins Albany Highway), Perth and Walpole (where it joins the South Coast Highway to Albany). The South Western Highway is generally constructed as a single carriageway two-lane road, except through Byford, where a four-lane divided carriageway has been provided. Traffic speeds are limited to 90kph approaching the town and 50-60kph through the town. It is expected that the extension of the Tonkin Highway beyond Thomas Road will provide an alternative route for regional traffic and trucks. Significant traffic decreases can be expected when the Tonkin Highway is extended. The intersection of South Western Highway/Abernethy Road is controlled by traffic signals that were installed in January 2009.

ABERNETHY ROAD

BEENYUP ROAD

400m radius

SOUTH WESTERN HIGHWAY

Beenyup Brook

NETTLETON ROAD

LAZENBY DRIVE

LEGEND

- Primary Distributor Road
- District Distributor Road
- Local Distributor Road (Neighbourhood Connector B)
- Access Street (Local Road)
  - typically 15m wide or less when abutting POS
- Laneways
  - typically 6m
- No Direct Vehicle Access Permitted to South West Highway
- Priority Pedestrian Path Alignment
- Four way traffic signal controlled intersection (existing)
- Three way priority controlled intersection (existing)

MOVEMENT NETWORK
Lot 2 Nettleton Road, Byford

0m 15 30 45m

s: 1:3000@A3
d: 15 Nov 2013
p: 07/067/028C

figure 17

THE SOUTH WESTERN HIGHWAY

The South Western Highway adjacent to the site is constructed as a four-lane divided road with limited access. The current daily volume of 12,140vpd would provide Level of Service A. The increase in traffic as a result of the proposed structure plan development varies from 1,128vpd to 948vpd and would also provide Level of Service A. Further north, the highway reduces to a single carriageway road and the current volume of 12,1404vpd will provide Level of Service D. The forecast increase resulting from the structure plan development will retain Level of Service D and can be considered to have no detrimental impact to the current operation of the highway.

Studies have also been carried out for the main intersections between the South Western Highway and the proposed structure plan development.

At the junction of the South Western Highway and Beenyup Road, the analysis indicates that the development traffic forecast to use the intersection during the morning peak period is unlikely to affect current Levels of Service. Level of Service C is indicated as the lowest approach level, with Level of Service D likely to be experienced by traffic turning right from Beenyup Road. It is considered that the intersection will continue to operate in an acceptable manner. The intersection of South Western Highway / Beenyup Road will operate with good Levels of Service

The junction of the South Western Highway / Nettleton Road intersection is a three-way priority controlled intersection. Nettleton Road is required to yield to traffic on the South Western Highway. There is a narrow median on the highway to the south, widening to provide a divided carriageway north of Nettleton Road. The analysis indicates that the proposed development can be expected to operate with Level of Service C on Nettleton Road. This is good operation on a highway and indicates that the proposed development will have no significant impact.

In the longer term (2022) the intersection of South Western Highway with Nettleton Road is shown to experience level of Service F with a V/C of 0.97 (at practical capacity) and a delay of 111 seconds. However, by 2021 it would be expected that the Tonkin Highway will be completed and traffic demands on South Western Highway significantly lower than forecast.

LOCAL ROADS

BEENYUP ROAD

Beenyup Road is classified as a local distributor road in the MRWA Functional Road Hierarchy. Beenyup Road is constructed as a single carriageway road with residential property to the northern side taking direct access. Current traffic data is not available, but historical data from the Shire of Serpentine – Jarrahdale indicates traffic flows of about 1,142 AADT. As there is limited opportunity for development off Beenyup Road, the traffic flows shown above are not expected to have increased.

Beenyup Road is more residential in nature, but is classified as a local distributor road. The forecast traffic increases can be expected to have no impact to the east of the subject land. To the east of the South Western Highway, a flow of 2,075vpd can be expected to the access into the site. There are approximately 3 to 4 existing houses that would be affected by this increase in traffic movements. Further east the daily volume reduces to about 2,018vpd.

Reference to Liveable Neighbourhoods indicates that residential access streets should provide for traffic flows less than 3,000vpd. Based on an existing daily flow of about 1,142 vehicles, the expected increases can be seen to result in about 2,075vpd adjacent to the South Western Highway and 2,018vpd further east. It can be seen therefore, that the proposed structure plan development would not result in Beenyup Road operating in a manner contrary to current planning guidelines. The proposed development will not result in Beenyup Road operating in a manner contrary to current planning guidelines.

NETTLETON ROAD

Nettleton Road is classified as a district distributor type A road in the Main Roads Functional Road Hierarchy between the South Western Highway and Brickworks Road. Beyond Brickworks Road it is classified as a district distributor type B road. Nettleton Road is constructed as a single carriageway road and traffic data provided by the Shire of Serpentine – Jarrahdale indicates a flow of 1,542vpd (2006) west of Brickworks Road. Site inspection during the morning peak hour indicates a flow of about 170 vehicles which is within the expected range.

The MRWA Functional Road Hierarchy expects a daily flow greater than 8,000vpd. The structure plan development is shown to result in a daily flow of about 2,509vpd, which is well below the expected flow. As a road passing through a light industrial area, the forecast traffic increase will have minimal impact. Current volumes would provide Level of Service A. The increase as a result of the proposed structure plan development will provide Level of Service B, which is considered to be very good. Nettleton Road is expected to operate with Level of Service B.

Abernethy Road which is classified in the MRWA Functional Road Hierarchy as a district distributor type A road between the South Western Highway and Soldiers Road. West of Soldiers Road it is classified as a local distributor road. It is constructed as a rural road with a standard 7.2m (approximate) road pavement between Soldiers Road and Hopkinson Road. East of Soldiers Road a slightly wider carriageway has been constructed to provide additional capacity at its intersection with the South Western Highway. East of Soldiers Road there is a level crossing. Traffic data supplied by MRWA indicates a daily flow of 4,297 vehicles per day (2007) equally split eastbound/westbound to the east of Soldiers Road. Structure planning in the local area indicates a forecast increase to about 5,500vpd on Abernethy Road to the west of the South Western Highway. The expected traffic increases are as a result of local residential development and traffic attracted to the proposed shopping centre.

ACCESS ARRANGEMENTS

The location of the site will require that access to the regional road network is taken from the South Western Highway to head north or south. The distribution of traffic from new dwellings in the locality can be expected to be similar to current movements at Beenyup Road which shows 37% of traffic attracted to the north, 19% of traffic attracted to Abernethy Road and 44% of traffic attracted to the south.

There are two intersections proposed with Nettleton Road. The forecast traffic movements on Nettleton Road would be 200 vehicles on the major road with a minor road flow of about 20 vehicles. Access to Nettleton Road will operate with uninterrupted flow conditions.

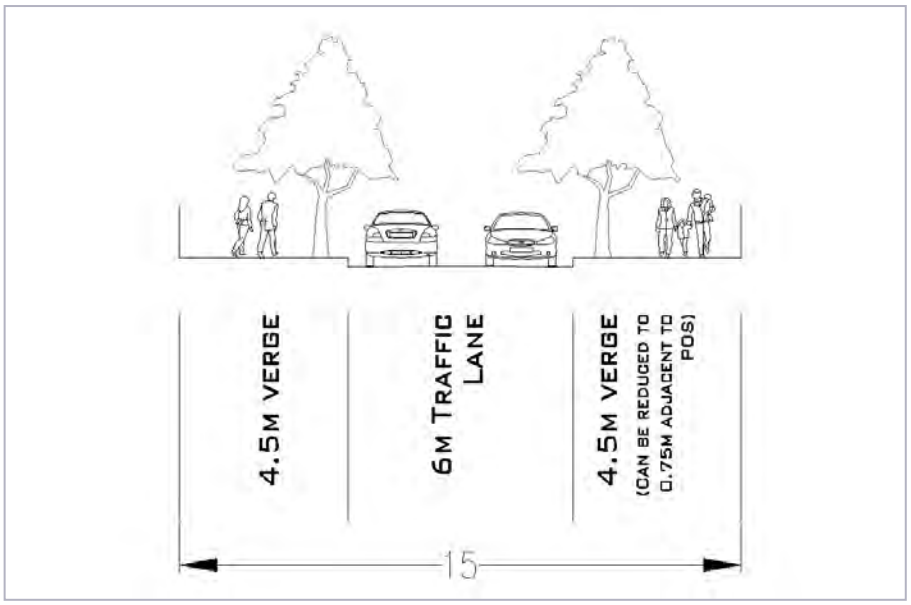
There are two intersections proposed with Beenyup Road. The accesses to Beenyup Road are forecast to attract 1,197 vpd to the west and 879vpd to the east. The accesses to Beenyup Road will operate with uninterrupted flow conditions. The peak period turning movements may well exceed the level indicated by Austroads for the provision of right turning lanes. However, the opposing traffic movement is very low and is highly unlikely to result in turning traffic causing significant interruption to the through movement. A right turn lane for the site access is not therefore considered to be warranted.

INTERNAL VEHICULAR ROAD NETWORK

The internal roads within the structure plan will generally cater for less than 500 vehicles per day. At access locations a higher flow will occur up to 1,200vpd. The forecast traffic movements provide for quiet residential streets and a reduce road reservation would be recommended to limit traffic speeds and provide a good residential environment.

Liveable Neighbourhoods suggests that residential streets with about 1,000vpd can be considered as access streets and a 14.2m wide road reservation is suited. A 6m road pavement allows ample room for two-way traffic and would permit the occasional parking of a vehicle on the street. The cross-section below shows a typical structure plan access street with a 15.0 metre wide road reservation with a 6.0 metre road pavement consistent with Liveable Neighbourhoods standards. A wider road would not be required in this area, especially where on-street parking is unlikely.

Where parking is required, it will be provided in accordance with local government town planning scheme requirements and the RD-codes.



WALKING AND CYCLING

The subject site is located close to Byford town centre. A footpath is provided to the north side of Beenyup Road. Traffic signals have been introduced on the South Western Highway at Abernethy Road/Beenyup Road, a pedestrian facility is provided. It is recommended that between the subject site access and South Western Highway a 2.0 metre wide footpath be provided.

Access to public transport in the form of buses and trains to Perth and the South West region circulate through Byford Town Centre. As stated above, access to Byford Centre will be via the eastern side of South Western Highway and the pedestrian footpath from the structure plan entrance along Beenyup Road.

The Shire's Bicycle and Shared Path Plan (July 2012) indicates that the Byford Town Centre has a path network along both sides of South Western Highway with a wide brick paved path on the western side, north of Abernethy/Beenyup Road, adjacent to shops and sporting facilities.

Pedestrian and shared paths proposed as part of the LSP will link into the surrounding network within Byford, particularly existing trails located within the Darling Scarp. Consideration has been given to the Shire's Local Planning Policy No. 9 – Multiple use Trails.

The Transport Assessment recognises that the Byford Town Centre currently presents a relatively poor pedestrian and cycle area. However, as the Town Centre is developed, there will be a greater demand for pedestrian/cycle friendly environments. The injection of residents to the locality stemming from this LSP would further increase this demand. All internal streets carry low traffic volumes and cycling on internal streets would be considered safe and appropriate. Footpaths will be provided within the site on certain streets, as detailed in **Appendix 16** – Traffic Impact Assessment.

PUBLIC TRANSPORT

The following local bus routes are operated by Transperth in Byford:

- 251 – Armadale Station-Byford via South Western Highway
- 252 – Armadale Station-Mundijong via Byford
- 253 – Armadale Station-Jarrahdale via Byford and Mundijong
- 254 – Armadale Station-Byford via Kardan Boulevard

These routes generally have an hourly frequency (more frequent during peak times), and bus stops are provided on South Western Highway near the Nettleton Road intersection, within a walkable catchment from the site. A regular train service is provided from Armadale rail station to Perth and the metropolitan area. A rail service is provided from Byford station to Perth and Bunbury. The service operates twice a day in each direction and ticket bookings are required.

We understand, from meetings with Council, that it is promoting the upgrading of the Byford Rail Station to accommodate a regular passenger rail service, bolstering land use and density within the Centre. Providing opportunity for a large number of residents to locate within a short walking distance of the rail station could be expected to lend support to the Shire's negotiations in this regard.

The Byford Town Centre is within an 800m walk for much of the structure Plan area. The town centre is set to be developed to provide a commercial and social hub to the locality and in the long term a rail station may be developed within the town centre. Pedestrian access to the Centre is therefore an important consideration. A 2.0m footpath should be provided between South Western Highway and the entrance to the Structure Plan area to the north side of Beenyup Road. A footpath should also be provided to at least one side of all the internal access roads.

It is unlikely that the cycling environment along the South western Highway will be attractive to cyclists. However in the longer term as the Structure plan area reaches ultimate completion and more facilities are developed in the Byford Town Centre that people may wish to cycle from the structure plan area to Byford. Therefore in the longer term cycle facilities at the South Western Highway traffic signals may be desirable.

The injection of some 900-1000 residents into the locality will increase the demand for public transport access. It is understood that the Public Transport Authority (PTA) has proposed a number of bus transport routes for the Byford area.

3.6 WATER MANAGEMENT

Hyd2o (consulting hydrologists) have prepared a Local Water Management Strategy (LWMS) addendum report in support of this local structure plan (refer to **Appendix 15**). The document is submitted as a minor revision to the previously approved 2009 Local Water Management Strategy prepared by JDA Consultant Hydrologists. Stormwater modelling has been updated to reflect the revised structure plan and inform land take requirements for drainage purposes.

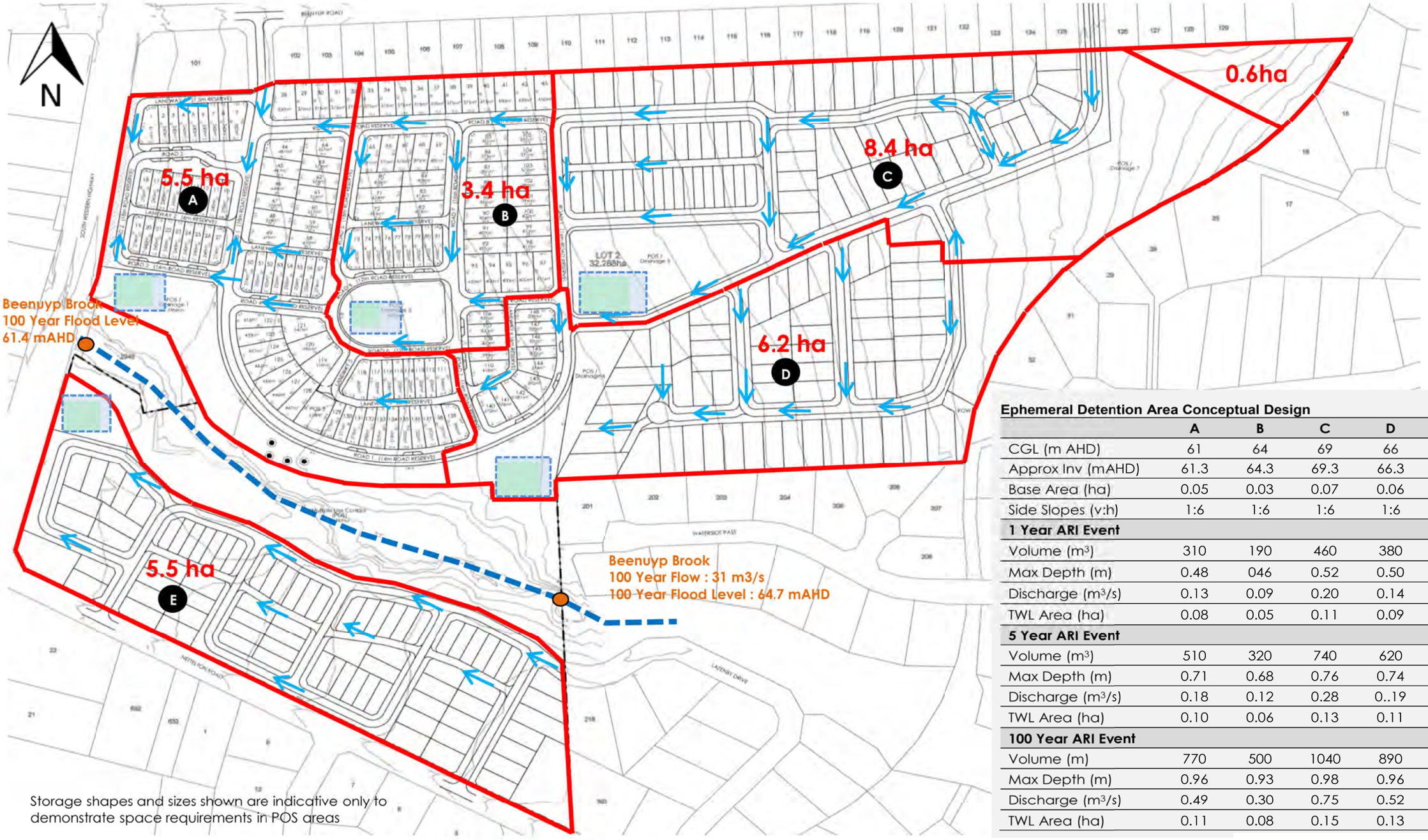
The development of the structure plan and LWMS for the site has been informed by an understanding of its key hydrological considerations. The site is characterised by a high water table in its western area, predominantly gravelly sandy clay of low infiltratiion capacity, and a regional watercourse (Beenyup Brook) through the centre of the site which requires due consideration in terms of regional flood management. The site contains an area of remnant bushland to the east which will be retained post development, and foreshore areas of Beenyup which will be restored and rehabilitated.

The site is considered typical of development sites along the base of the Darling Scarp.

The LWMS and its addendum has been prepared in accordance with the principles, objectives and key criteria of Better Urban Water Management (BUWM) (Western Australian Planning Commission, 2008). Implementation of the strategy will be undertaken in accordance with BUWM through the development and implementation of urban water management plans for individual stages of development within the site.

A copy of the original LWMS should be read in conjunction with this Structure Plan, and to which Hyd2o's LWMS addendum is attached.

A conceptual drainage plan has been prepared and is included as **Figure 18**. A summary of the overall strategy for the site based on JDA(2009) and the revised stormwater modelling presented in the LWMS addendum report is detailed in the following table.



Ephemeral Detention Area Conceptual Design

	A	B	C	D	E
CGL (m AHD)	61	64	69	66	61
Approx Inv (mAHD)	61.3	64.3	69.3	66.3	61.3
Base Area (ha)	0.05	0.03	0.07	0.06	0.06
Side Slopes (v:h)	1:6	1:6	1:6	1:6	1:6
1 Year ARI Event					
Volume (m^3)	310	190	460	380	360
Max Depth (m)	0.48	046	0.52	0.50	0.48
Discharge (m^3/s)	0.13	0.09	0.20	0.14	0.13
TWL Area (ha)	0.08	0.05	0.11	0.09	0.09
5 Year ARI Event					
Volume (m^3)	510	320	740	620	600
Max Depth (m)	0.71	0.68	0.76	0.74	0.72
Discharge (m^3/s)	0.18	0.12	0.28	0..19	0.19
TWL Area (ha)	0.10	0.06	0.13	0.11	0.11
100 Year ARI Event					
Volume (m)	770	500	1040	890	890
Max Depth (m)	0.96	0.93	0.98	0.96	0.96
Discharge (m^3/s)	0.49	0.30	0.75	0.52	0.51
TWL Area (ha)	0.11	0.08	0.15	0.13	0.13

LEGEND

- Post Development Catchment Boundaries
- Flow Direction (piped to 5 year, overland within road Reserve >5 year ARI)
- 1 Year ARI/Bioretention Area
- 100 Year ARI Storage Area

LOCAL WATER MANAGEMENT STRATEGY - PRELIMINARY DRAINAGE PLAN (SOURCE HYD2O)

Lot 2 Nettleton Road, Byford

0m 15 30 45m

s: 1:3000@A3
d: 15 Nov 2012
p: 07/067/032

figure 18

TABLE 6 – SUMMARY OF LWMS

Local Water Management Strategy Summary Strategy Elements	LWMS Method & Approach
Water Use Sustainability	
Water Efficiency	• Use of small lots to reduce ex house use • 5 Star building standards (water efficient fixtures and fittings) • Use of dry planted species in the Beenyup Brook foreshore reserve
Water Supply	• Lots : Water Corporation IWSS and rainwater tanks • POS : Irrigation Source and POS treatments to be determined and refined at UWMP Stage • Foreshore Reserve : No long term irrigation proposed
Wastewater	• Water Corporation reticulated sewerage.
Stormwater	
Flood Protection	• Provision of 1 in 100 year storage areas for local stormwater • Estimated total storage volume : 4090 m3 • Estimated total storage area : 0.60 ha • Establish minimum habitable floor levels at 0.5m above the 100 yearARI flood levels. • Provide safe passage for 1 in 100 year storm event in Beenyup Brook • Provide flow paths for overland flows within the development area which exceed the capacity of piped drainage.
Serviceability	• Piped drainage system sized to convey 5 year event • Provision of 1 in 5 year storage areas for local stormwater • Estimated total storage volume : 2790 m3 • Estimated total storage area : 0.51 ha
Ecological Protection	• Remediation and protection of the Beenyup Brook foreshore reserve • Bioretention established as 2% of equivalent impervious area • Provision of 1 in 1 year storage areas for local stormwater • Estimated total storage volume : 1700 m3 • Estimated total storage area : 0.42 ha • Non structural control commitment, details at UWMP stage
Groundwater	
Fill & Subsoil Drainage	• CGL established at the average annual maximum groundwater level (AAMGL) • Imported sand fill to provide required clearance above the CGL • Subsoil drainage located within road reserves across the site to control post development groundwater rise, and groundwater rise above the CGL in wet years.
ASS & Contamination	• Acid Sulphate Soils to be investigated as a separate process (if required) and reported in UWMP

3.7 EDUCATION FACILITIES

The Department of Education and Training has advised (by email correspondence dated 17 October 2012) that this development would fall within the catchment area for the Byford Primary School and that there would be no requirement for school site contributions. Byford Primary School is located north of Lot 2 along Clifton Street, and is within a walkable catchment from the site. The proposed Primary Pedestrian Path through the site will link into Beenyup Road and provide access to the primary school. The site is also located in close proximity to Byford Kindergarten, Marri Grove Primary School, John Calvin School and Byford Secondary College.

3.8 ACTIVITY CENTRE AND EMPLOYMENT

With the exception of public open space, lot 2 shall be developed exclusively for residential purposes.

Given the close proximity of the Byford Town Centre and Armadale Strategic Metropolitan Centre (categorised as 'District Centre' and 'Strategic Metropolitan Centre' respectively), there is no requirement for retail or commercial uses to be introduced with the development of lot 2.

All daily convenience and comparison shopping needs will be fulfilled by the existing centres. It is considered that any effort to establish new retail and commercial function within Byford would serve to undermine the existing and already planned offer.

3.9 INFRASTRUCTURE COORDINATION, SERVICING AND STAGING

EARTHWORKS/FINISHED LEVELS/RETAINING WALLS

The Armadale Sheet of the 1:50,000 Environmental Geology series maps indicates that the site is underlain by gravelly sandy clay of colluvial origin to the west and gravelly clayey sand of colluvial origin to the east.

A geotechnical investigation was completed by Coffey Geotechnics in April 2008. This report confirmed that the ground conditions are generally represented by a sand layer overlaying clayey gravel/clayey sand.

In order to generate a 'Class S' Site Classification (Australian Standards AS2870 – Residential Slabs and Footings), a sand depth of 1.0m or greater is required to the clayey/gravelly layer. Based on this information, some importation of clean fill will be required to ensure Class S Classification is achieved. The western portion of the Site becomes saturated in winter months and deeper fill may be required to ensure adequate separation to groundwater.

It is generally intended to grade the site to create level lots, while maintaining the general landform of the development. Due to the slope of the Site it will be necessary in places to construct retaining walls. Earthworks levels will match as close as is practicable to the surrounding interface with existing properties, Beenyup Brook, South Western Highway and the 'Conservation' area.

SEWERAGE

To the north of the site there is an existing dormant sewer main in Waterside Pass and an existing main at the intersection of George Street and Abernethy Road.

To the south of the site there is an existing dormant sewer in Lazenby Drive, an existing system at the intersection of Nettleton Road and South Western Highway and an existing Access Chamber approximately 50 metres north of Nettleton Road.

The portion of the site north of Beenyup Brook will be serviced by reticulated sewerage via the construction of a DN300 main through Lot 2 from the existing dormant sewer main in Waterside Pass, connecting to the existing main at the intersection of George Street and Abernethy Road.

The portion of the site south of Beenyup Brook will be serviced by reticulated sewerage via a DN225 main from the existing dormant sewer in Lazenby Drive, connecting to the existing system at the intersection of Nettleton Road and South Western Highway or to an existing Access Chamber approximately 50 metres north of Nettleton Road. In addition a section of DN225 will be required to be constructed between the existing main in South Western Highway to the intersection of Mead Street and Gordin Way.

WATER SUPPLY

Water Corporation has advised that there is an existing DN600 main along the South Western Highway and DN100 in Beenyup Road, an existing DN150 in Nettleton Road and an existing DN200 main in Bradshaw Road.

Connections for the site below RL70m AHD will be from the existing DN600 main along the South Western Highway and DN100 in Beenyup Road. A DN200 main will be constructed through the land parcel from South Western Highway to the existing DN150 in Nettleton Road, crossing Beenyup Brook, allowing servicing of land north and south of Beenyup Brook.

Land above RL70m AHD will be required to connect into the Byford High Level mains. This will require a DN200 connection to the existing DN200 main in Bradshaw Road. This connection will be required to come down the Beenyup Road reserve with two connections provided for internal reticulation.

ELECTRICITY

The Western Power database of existing power services (DFIS) shows that there is currently high voltage (HV) and low voltage (LV) infrastructure in the South Western Highways road reserve. The capacity of the existing electricity network will be confirmed when the development formally proceeds and a Design Information Package is received from Western Power.

TELECOMMUNICATIONS

Byford is within the National Broadband Network (NBNCo) fibre footprint. As the proposed development will realise over 100 dwellings it will qualify for NBN installation at the time of civil construction subject to the initial 100 lots being developed within a 3 year timeframe. Provision of or upgrading of telecommunications infrastructure to service the site is subject to review by NBNCo at the time the development proceeds.

GAS

100mm PVC medium pressure gas mains exist in Beenyup and Nettleton Roads. Atco Gas have advised the site can be serviced by these mains. Servicing requirements are subject to review by Atco Gas at the time the development proceeds.

STAGING

Cedar Woods is likely to develop the site over a period of not less than 7 years. Stage 1 has commenced in the north-western corner of the lot. The development front will then generally proceed south, south east, and then across Beenyup Brook.

It is possible that development may commence early along Nettleton Road, hence the development front may move simultaneously from the north and south, inward towards Beenyup Brook.

The implementation of an approved Bushland Management Plan (Contained as **Appendix 3**) for the Local Natural Area is required prior to the commencement of works.

3.10 DEVELOPER CONTRIBUTION ARRANGEMENTS

As noted earlier in this Local Structure Plan, Cedar Woods is aware of its obligations in respect of the Byford Developer Contribution Arrangement.

Lot 2 Nettleton Rd, Byford

Local Water Management Strategy

ADDENDUM

November 2013

Client: Cedar Woods

Contents

APPENDICES

TABLES

FIGURES

Disclaimer

This document is published in accordance with and subject to an agreement between Hyd2o and the Client for whom it has been prepared, and is restricted to those issues that have been raised by the Client in its engagement of Hyd2o. It has been prepared using the skill and care ordinarily exercised by hydrologists in the preparation of such documents.

Hyd2o recognise site conditions change and contain varying degrees of non-uniformity that cannot be fully defined by field investigation. Measurements and values obtained from sampling and testing in this document are indicative within a limited timeframe, and unless otherwise specified, should not be accepted as conditions on site beyond that timeframe.

Any person or organisation that relies on or uses the document for purposes or reasons other than those agreed by Hyd2o and the Client does so entirely at their own risk. Hyd2o denies all liability in tort, contract or otherwise for any loss, damage or injury of any kind whatsoever (whether in negligence or otherwise) that may be suffered as a consequence of relying on this document for any purpose other than that agreed with the Client.

Executive Summary

This Local Water Management Strategy (LWMS) Addendum has been prepared by Hyd2o on behalf of Cedar Woods in support of a preparation of a revised local structure plan for Lot 2 Nettleton Road Byford (herein referred to as the site).

This document is submitted as a minor revision of the previously approved 2009 Local Water Management Strategy for the site prepared by JDA Consultant Hydrologists, with stormwater modelling updated to reflect the revised structure plan and inform land take requirements for drainage purposes.

The development of the structure plan and LWMS for the site has been informed by an understanding of key hydrological considerations for the site. The site is characterised by a high water table in its western area, predominantly gravelly sandy clay of low infiltrative capacity, and a regional watercourse (Beenyup Brook) though the centre of the site which requires due consideration in terms of regional flood management. The site contains a remnant area of bushland to the east which will be retained post development, and foreshore areas of Beenyup which will be restored and rehabilitated.

The site is considered typical of development sites along the base of the Darling Scarp.

This LWMS addendum has been prepared in accordance with the principles, objectives and key criteria of *Better Urban Water Management* (BUWM) (Western Australian Planning Commission, 2008). Implementation of the strategy will be undertaken in accordance with BUWM through the development and implementation of urban water management plans for individual stages of development within the site.

A summary of the overall local water management strategy for the site based on JDA(2009) and the revised stormwater modelling presented in this report is detailed in the following table.

Local Water Management Strategy Summary

Strategy Elements	LWMS Method & Approach
Water Use Sustainability	
Water Efficiency	• Use of small lots to reduce ex house use • 5 Star building standards (water efficient fixtures and fittings) • Use of dry planted species in the Beenyup Brook foreshore reserve
Water Supply	• Lots : Water Corporation IWSS and rainwater tanks • POS : Irrigation Source and POS treatments to be determined and refined at UWMP Stage • Foreshore Reserve : No long term irrigation proposed
Wastewater	• Water Corporation reticulated sewerage
Stormwater	
Flood Protection	• Provision of 1 in 100 year storage areas for local stormwater • Estimated total storage volume : 4890 m^3 (inclusive of 1&5 year) • Estimated total storage area : 1.04 ha • Establish minimum habitable floor levels at 0.5m above the 100 yearARI flood levels. • Provide safe passage for 1 in 100 year storm event in Beenyup Brook • Provide flow paths for overland flows within the development area which exceed the capacity of piped drainage.
Serviceability	• Piped drainage system sized to convey 5 year event • Provision of 1 in 5 year storage areas for local stormwater • Estimated total storage volume : 3050 m^3 (inclusive of 1 year) • Estimated total storage area : 0.93 ha
Ecological Protection	• Remediation and protection of the Beenyup Brook foreshore reserve • Bioretention established as 2% of equivalent impervious area • Provision of 1 in 1 year storage areas for local stormwater • Estimated total storage volume : 1710 m^3 • Estimated total storage area : 0.41 ha • Non structural control commitment, details at UWMP stage
Groundwater	
Fill & Subsoil Drainage	• CGL established at the average annual maximum groundwater level (AAMGL) • Imported sand fill to provide required clearance above the CGL • Subsoil drainage located within road reserves across the site to control post development groundwater rise, and groundwater rise above the CGL in wet years.
ASS & Contamination	▪ Acid Sulphate Soils to be investigated as a separate process (if required) and reported in UWMP

1. Introduction

This local water management strategy (LWMS) addendum has been prepared by Hyd2o on behalf of Cedar Woods to support the development of a revised local structure plan for Lot 2 Nettleton Road Byford (herein referred to as the site).

The site is approximately 32 ha and located approximately 35km south east of the Perth central business district within the suburb of Byford and the Shire of Serpentine Jarrahdale (Figure 1).

This addendum does not seek to reproduce all information previously provided in the approved JDA(2009) LWMS and therefore should be read in conjunction with that document. This document is submitted as a minor revision of the previously approved 2009 Local Water Management Strategy for the site prepared by JDA Consultant Hydrologists, with stormwater modelling updated to reflect the revised structure plan and inform land take requirements for drainage purposes

This document has been prepared in accordance with the principles and objectives of Better Urban Water Management (Western Australian Planning Commission, 2008) and advice of the Department of Water and Shire of Serpentine Jarrahdale.

This LWMS addendum uses the following key documents to guide its development :

- Byford Townsite Drainage and Water Management Plan (BDWMP) (Department of Water, 2008)
- Lot 2 Nettleton Road, Byford, Local Water Management Strategy (JDA, 2009)
- Shire of Serpentine Jarrahdale Local Planning Policy 22: Water Sensitive Urban Design (Shire of Serpentine Jarrahdale, 2009)
- Better Urban Water Management (WAPC, 2008)
- Peel Harvey WSUD Local Planning Policy (Peel Development Commission, 2006)
- Stormwater Management Manual for WA (Department of Water, 2007)
- Decision Process for Stormwater Management in WA (Department of Water, 2009)
- Engineering Standards for Subdivisional Development (Shire of Serpentine Jarrahdale, 2010)

2. Proposed Development

The revised structure plan for the site is shown in Figure 2. The previous structure plan for the site is contained as an inset to Figure 2 for comparative purposes.

Consideration of the predevelopment environment of the site and existing constraints has guided the development of this plan. The site will be comprised of predominately urban residential development with lot sizes ranging from a minimum of approximately 240 m^2 in the western area adjacent to South Western Highway to typically 600-700 m^2 sized lots in the eastern area of the site.

Landscaped POS areas are distributed and will be designed with multiple use characteristics to provide treatment and attenuation of stormwater.

The proposed development will retain 3ha of remnant vegetation in the north eastern corner of the site and include a foreshore reserve surrounding Beenyup Brook.

3. Pre-Development Environment

A brief description of the predevelopment environment of the site is provided below. A more detailed description of the predevelopment environment for the site and associated monitoring data is contained in JDA (2009).

3.1 Site Conditions

The 32 ha site is approximately 35 km south-east of Perth CBD. The site is bounded by Beenyup Road to the north, Nettleton Road to the south and South Western Hwy to the west. The site is predominately pasture, with native vegetation in the eastern corner.

Elevation of the site increases toward the east from 61 to 89 mAHD (Figure 3). The site is traversed by Beenyup Brook, which flows from east to west through the centre of the site.

3.2 Geotechnical

Environmental geology mapping shows the site to be predominantly comprised of gravelly sandy clay made up of rounded gravel of colluvial origin (Figure 4). Based on Coffey Geotechnics (2008), the sub surface profile is described as follows :

- SAND (Topsoil)- 0 to 0.1m loose fine to medium grained
- SAND- 0 to 0.5m thick, fine to medium grained
- CLAYEY GRAVEL/CLAYEY SAND- 0 to 0.7m thick, fine to medium grained
- CLAYEY GRAVEL- >1.2m thick, fine to medium grained, low plasticity

Due to the presence of clays on the site at shallow depth, opportunities for infiltration are considered likely to be limited.

With respect to ASS (Figure 4), there is low to moderate risk of ASS occurring at depths greater than 3m from the surface (WAPC 2003) in areas west of the site, however no known risk of ASS within the site. The site is not listed on the Department of Environment and Conservation's of Western Australia Contaminated Sites Register.

3.3 Wetlands

The western side of the site is classified as a multiple use palusplain in the Department of Environment and Conservation (DoEC) Geomorphic Wetlands of the Swan Coastal Plain mapping (Figure 5). No Environmental Protection Policy (EPP) or Conservation category wetlands are located within the site.

3.4 Surface Water

3.4.1 Existing Surface Drainage

The existing surface water drainage network for the site is shown in Figure 6. Beenyup Brook flows through the middle of the site in a westerly direction and has a catchment area of approximately 14.5 km^2 upstream of the site. Beenyup Brook is ephemeral with flow occurring during winter and spring.

The majority of the site drains to Beenyup Brook, except for the north eastern corner which drains towards a small drain alongside Beenyup Road.

On the southern side of the site adjacent to Waterside Pass a cut-off drain is present which diverts the flow from a portion of the adjacent residential development ultimately discharging into Beenyup Brook. This cut off drain is located within the adjacent properties and does not enter the site.

3.4.2 Peak Flow Estimates

Peak flow rates for the site and Beenyup Brook are provided in the BDWMP (DoW, 2009). The BDWMP (DoW, 2009) provides an estimated predevelopment flow rate from the site of 0.93m^3/s for a 1 in 5 year ARI event and 2.47m^3/s for a 1 in 100 year ARI event, which defines the allowable post development discharges from the site. This equates to allowable pro rate flow rates from the site of 32 l/s/ha and 86 l/s/ha for the 5 and 100 year ARI storm events respectively.

For Beenyup Brook, the BDWMP provides peak flow estimates at South Western Hwy immediately downstream of the site of 8 m^3/s and 31 m^3/s for the 1 in 5 year and 100 year ARI event respectively. The BDWMP reports 100 year ARI flood levels for Beenyup Brook of 61.4 mAHD adjacent to South Western Highway increasing to 64.7mAHD at the upstream boundary of the site.

Hyd2o HECRAS hydraulic modelling of the flood extent of Beenyup Brook for the 1, 5, and 100 year ARI events is contained as Appendix B.

3.4.3 Surface Water Quality

Predevelopment surface water quality monitoring was completed by JDA in 2008. The concentrations of TN and TP measured for Beenyup Brook were comparable to the upstream results reported in the BDWMP, and were below ANZECC guidelines (JDA 2009). Water quality in Beenyup Brook did not appear to deteriorate as it passed through the site.

3.5 Groundwater

3.5.1 Groundwater Levels

A total of 16 groundwater monitoring bores were installed at the site by JDA between 2007 and 2008 (JDA, 2009) and monitored over 2 winters. The estimated average annual maximum groundwater level (AAMGL) is shown in Figure 7.

The AAMGL across the site ranges from 61.1 mAHD along the western edge of the site to 82.4 mAHD in the elevated eastern area, indicating the depth to groundwater ranges from 0 m (at surface) to 5.1m below existing natural surface. To complement this data, Hyd2o undertook a further groundwater level reading across the site on 12 September 2012. This data is shown in relation to the previously calculated AAMGL in Appendix A.

3.5.2 Groundwater Quality

The average TN across the site for the groundwater monitoring period was 2.0 mg/L. This average is above the ANZECC guideline of 1.2 mg/L, however it is below the expected post development stormwater concentration of 1.1 mg/L for typical urban stormwater quality on the Swan Coastal Plain.

TP levels were generally below 0.1 mg/L with the site average being 0.04 mg/L. The majority of samples were below the expected value of 0.21 mg/L for typical urban stormwater quality on the Swan Coastal Plain.

4. Design Criteria

Key design criteria for the site have not changed since approval of the JDA(2009) LWMS.

These criteria are summarised in Table 1, based on the key reference documents previously detailed in Section 1.2.

These design criteria are used in this addendum to inform the revised stormwater modelling for the site.

Table 1: Design Criteria

Strategy Elements	Criteria
Water Use Sustainability	
Water Efficiency	▪ Reduce consumptive use through adoption of waterwise practices.
Water Supply	▪ Develop "fit for purpose" water supply strategy, and minimise potable water use where drinking quality water is not essential.
Wastewater	▪ Provide a wastewater system which meets agency requirements.
Stormwater	
Flood Protection	▪ Provision of 1 in 100 year storage areas for local stormwater ▪ Establish minimum habitable floor levels at 0.5m above the 100 yearARI flood levels. ▪ Provide safe passage for 1 in 100 year storm event in Beenyup Brook ▪ Provide flow paths for overland flows within the development area which exceed the capacity of piped drainage.
Serviceability	▪ Provision of 1 in 5 year storage areas for local stormwater. ▪ Road drainage system to be designed so that roads will be passable in the 1 in 5 year ARI event.
Ecological Protection	▪ Remediation and protection of the Beenyup Brook foreshore reserve ▪ 1 in 1 year 1 hour storm event to be retained on site (where possible). ▪ Bioretention areas established at 2% of connected impervious areas. ▪ Establishment of storage invert levels at or above the seasonal maximum groundwater levels. ▪ Implement non-structural controls.
Groundwater	
Fill Requirement & Subsoil Drainage	▪ Provide subsoil drainage if/where required to control any post development groundwater rise. ▪ Establish development levels with acceptable clearance above groundwater levels via fill importation.

5. Water Use Sustainability Initiatives

Water use sustainability initiatives have not changed since approval of the LWMS (JDA, 2009).

Recommended water use efficiency measures are consistent with the Water Corporation's 'Waterwise' land development and include:

- Use of small lots to reduce garden (ex-house) use
- Promotion of use of waterwise practices including water efficient fixtures and fitting (taps, showerheads, toilets and appliances, rainwater tanks, waterwise landscaping)
- Use of native plants in POS areas
- All houses to be built to 5 star building standards
- Remediation and protection of the Beenyup Brook foreshore area, including the use of dry planted species in the foreshore area

Landscape design will be based on 'Waterwise' principles and detail the planting of native shrubs and trees indigenous to the local region. It is envisaged that no long term reticulation of the foreshore reserve will be required.

Agreed water conservation measures and locations will be detailed at the UWMP stage.

With respect to water supply, the Water Corporation's Integrated Water Supply System (IWSS) will supply potable water to the future homes on the site.

With respect to non potable supply for POS irrigation, JDA (2009) reported that abstraction of superficial aquifer groundwater was considered unlikely to be possible due to the presence of Guilford clay, even though allocation was available. Based on DoW's online Water Register, groundwater in the vicinity of the site is also available in the Fractured Rock Aquifer and Cattamarra Coal Measures. However, advice from DoW reported in JDA (2009) indicates there is no clear presence of a confined aquifer beneath the site due to its proximity to the Darling Scarp.

Sources for POS irrigation will be required to be further investigated and reported at UWMP stage, and will ultimately affect the final selected treatments and plantings for POS areas.

Wastewater will be deep sewerage (reticulated) with management by Water Corporation.

6. Stormwater Management Strategy

Changes to the local structure plan have resulted in changes in area requirements for management of stormwater compared to the LWMS (JDA,2009) and this revised modelling is discussed in the following Chapter.

Stormwater management will be undertaken consistent with DoW water sensitive urban design practices. Due to site infiltration constraints, the system will consist of pipes to convey road runoff to ephemeral water storage areas, with biofiltration to provide water quality treatment for the proposed development prior to discharging to the receiving environment.

6.1 Stormwater Modelling

Storage areas outlined in the current approved LWMS (JDA, 2009) were designed using XP-Storm. Hyd2o has used the same model to determine storage requirements on the basis of the revised structure plan.

XP-Storm is used to determine conceptual flood storage requirements, and provide an assessment of the local structure plan area required for drainage purposes at a level of detail consistent with the requirements for an LWMS.

Key stormwater modelling parameters including runoff coefficients are shown in Table 2.

Five storage areas have been modelled based on the revised local structure plan. These storage areas are based on catchments derived from mapping of the area by Hyd2o.

Catchment areas are shown in Figure 8.

The following key parameters informed the establishment of the model:

- A runoff of 70% from residential areas, 60% from POS, 90% from road and road reserves, and 20% from the bush conservation area. These rates assume lot connections will be required rather than soakwells at lot scale.
- Allowable post development design flows for the site were calculated based on allowable catchment discharges provided in the BDWMP (DoW, 2009). The allowable pro-rate flow rates for individual catchments are shown in Table 2 for 5 and 100 year ARI events. As previously detailed in Section 3.4, The BDWMP (DoW,2009) specifies an allowable pro rate flow rate for the catchment of 32 l/s/ha and 86 l/s/ha for the 5 and 100 year ARI storm events respectively.

XP-Storm uses design rainfall methods based on the methodology in Australian Rainfall and Rainfall & Runoff (AR&R) (Institution of Engineers, Australia 2000) and determined using the Bureau of Meteorology Computerised IFD Rainfall System (CDIRS). The rainfall temporal pattern was assumed to be spatially uniform across the catchment.

Storm durations modelled ranged from 1 hour to 72 hours, with the critical duration storm event determined to define storage requirements.

6.2 Flood Protection (100 year)

6.2.1 Regional Watercourse

Regional flood modelling of Beenyup Brook was provided in the BDWMP (DoW, 2008) and discussed in JDA(2008). These documents provided 100 year flood levels within the brook and delineated indicative floodways. This information is still current and has not been updated as a result of this Addendum.

As previously detailed in Section 3.4.2, the modelling provided a 100 Year ARI flood level for Beenyup Brook of 61.4 mAHD adjacent to South Western Highway increasing to 64.7mAHD at the upstream boundary of the site.

Hyd2o HECRAS hydraulic modelling of the flood extent of Beenyup Brook adjacent to the site for the 1, 5, and 100 year ARI events is contained as Appendix B.

The Beenyup Brook foreshore reserve delineated in Figure 2 has a minimum width of 50m and extends to in excess of 100m in the site. This exceeds the indicative 40m width requirement provided in the BDWMP (DoW,2008).

Post development, the floodway will be contained within the Beenyup Brook foreshore reserve, with the minimum habitable floor level for areas adjacent to Beenyup Brook set 0.5 m above the 100 Year ARI flood level, consistent with DoW flood protection requirements.

6.2.2 Local Stormwater

Modelled flood protection storage volumes, areas and flood rises for the 100 year ARI event are detailed in Table 2 and Figure 8.

Note that modelling for catchments A, B, and D have been performed at a UWMP level of detail based on the availability of detailed engineering plans at the time of modelling for these areas.

The total detention area required for the 100 year ARI event is approximately 1.04 ha or 3.5% of the total development area (excluding Beenyup Brook foreshore reserve).

The total storage volume required for a 100 year event is estimated as 4890 m^3 (inclusive of 1 and 5 year event volumes).

The final ephemeral detention area configuration, landscaping, and engineering detail will be documented in the UWMP for each stage of development, based on final earthworks, drainage and road design levels for the development area.

The detailed design process will likely result in minor refinements to the storage parameters outlined in this report, and the UWMP process will allow for stormwater modelling to be updated accordingly.

Storage inverts have been established 0.3m above the controlled groundwater level (CGL) for the site established as the AAMGL (Chapter 7). Given the groundwater gradient across the site, subsoil is likely to be required in stormwater storage areas to provide a controlled groundwater level below the storage invert.

Any changes to the final design inverts presented in this report will be determined in consultation with DoW and the Shire of Serpentine Jarrahdale at subdivision stage and reported in a UWMP.

In compliance with DoW requirements, the minimum habitable building floor levels will be set at a 0.5m clearance above estimated 100 year ARI flood levels.

6.3 Serviceability (5 year)

Table 2 and Figure 8 detail the modelled storage volumes, areas, flood rises and inverts for the 5 year ARI design event. This provides the extent of the area required for stormwater serviceability requirements.

Assuming 1 year bioretention areas as separate to 5 and 100 year areas, the total storage area required for up to the 5 year ARI event is approximately 0.93 ha or 3.1% of the total development area (excluding Beenyup Brook foreshore reserve).

A total storage volume of 3050m^3 is estimated as required across the five catchments, inclusive of 1 and 5 year storage volumes.

6.4 Ecological Protection (1 year)

Storm volumes for ecological protection based on the 1 hour 1 year ARI event are provided in Table 2 and Figure 8 to provide a guide for storage requirements and areas for water quality treatment consistent with DoW requirements (DoW, 2009).

Note that 1 year areas have been modelled as separate areas consistent with Shire of Serpentine Jarrahdale advice (Craig Wansborough, per comm)

With respect to biofiltration, based on DoW criteria, the area required for bioretention will be approximately 0.4 ha, sized as 2% of the connected equivalent impervious area.

This is effectively similar to the area required to attenuate the 1 hour 1 year ARI event (Table 2). The 1 year ARI areas shown in Table 2 therefore effectively represent the areas required to be vegetated for water quality treatment.

The UWMP will contain further detail of biofiltration areas.

Table 2: Ephemeral Detention Area Conceptual Design

Site Characteristics		A	B	C	D	E	Totals
Residential (ha)	70%	3.6	0.5	3.6	4.5	3.4	15.6
POS (ha)	60%	1.1	0.4	0.9	0.4	0.2	3.0
Road Reserve (ha)	90%	2.8	0.2	1.8	1.9	1.8	8.5
Bush (ha)	20%	0.0	0.0	1.8	0.7	0.0	2.5
Total Area (ha)		7.5	1.1	8.1	7.5	5.4	29.6
Equiv Imp Area (ha)		5.7	0.8	5.0	5.2	4.1	20.8
Allowable Discharge							
5 Year (m^3/s)		0.17	0.12	0.27	0.19	0.17	0.93
100 year (m^3/s)		0.46	0.34	0.73	0.51	0.46	2.49
Storage Design Parameters							
CGL (m AHD)		61	64	69	66	61	-
Storage Invert (mAHD)		61.3	64.3	69.3	66.3	61.3	-
Bioretention Area (1 Year 1 Hr) [1]							
Base Area (m^2)		690	50	1200	550	680	3170
Side Slopes (v:h)		1:4	1:4	1:0	1:4	1:0	-
Max Depth (m)		0.46	0.81	0.45	0.46	0.50	-
TWL Area (m^2)		1150	190	1200	840	680	4060
Volume (m^3)		420	90	540	320	340	1710
Nominal Outlet Dia (mm)		375	100	300	400	300	-
Discharge (m^3/s)		0.22	0.01	0.12	0.27	0.13	0.75
Separate Flood Storage Area (5 and 100 Year) [2,3]							
Side Slopes (v:h)		1:4	1:4	1:6	1:4	1:6	-
Base Area (m^2)		2270	140	300	1100	250	4060
Nominal Outlet Dia (mm) [4,5]		250	100	200	525	200	-
Spillway [4,5]		no	no	yes	no	yes	-
5 Year ARI Event							
Volume (m^3)		430	80	350	210	270	1340
Max Depth (m)		0.18	0.42	0.73	0.18	0.67	-
Discharge (m^3/s) [6]		0.26	0.02	0.20	0.37	0.19	1.00
TWL Area (m^2)		2480	230	680	1200	570	5160
Critical Storm (hr)		12	6	12	12	12	-
100 Year ARI Event							
Volume (m^3)		1160	180	720	510	610	3180
Max Depth (m)		0.46	0.78	1.18	0.42	1.15	-
Discharge (m^3/s) [6]		0.30	0.03	0.60	0.79	0.47	2.09
TWL Area (m^2)		2780	330	990	1340	880	6320
Critical Storm (hr)		1	1	1	1	1	-

1. Bioretention area modelled as separate to flood storage area.
2. Flows in excess of 1 in 1 year 1 hour event bypass bioretention to flood storage area.
3. Flood storage area inverts modelled as the same as bioretention inverts
4. Catchments A, B, and D modelled at UWMP level of detail. 5 and 100 year discharges are via a low level outlet only. Nominally modelled at 10m length with diameter as shown. Size and length subject to engineering design.
5. Catchments C and E modelled with 5 year discharge via low level outlet, 100 year discharge via spillway at 1.05m depth, modelled as 4m wide broad crested. Outlet structures and sizes to be refined at UWMP stage.
6. Discharge shown for 5 and 100 year events above are total outflow inclusive of outflow from bioretention area

7. Groundwater Management Strategy

A brief description of the groundwater management strategy is provided below. The approach of using subsoil set at the CGL and fill is consistent with that previously detailed in the approved LWMS (JDA, 2009).

7.1 Fill and Subsoil Drainage

Imported fill and subsoil drainage will be used within the development area to :

- achieve the necessary clearance above groundwater for development
- protect against post development groundwater rise due to land use changes and also protect against groundwater levels during wet years.

The controlled groundwater level (CGL), for the site has been established as the AAMGL. All subsoil drainage will be established at or above this level.

In stormwater storage areas, due to the groundwater gradient across the site, subsoil is likely to be required to provide a controlled groundwater level below the storage invert.

The final requirement for finished lot levels and fill will be detailed in individual UWMP's which will be produced following approval of the LWMS addendum.

7.2 Acid Sulphate Soils

Management of acid sulphate soils (ASS) will be addressed by a separate study to this LWMS, and details regarding the outcomes of any ASS studies required will be included as part of the UWMP process.

All assessment and management of ASS will be conducted in accordance with the Acid Sulphate Soil Guideline Series Identification and Investigation of Acid Sulphate Soils (DoE, 2004).

8. Urban Water Management Plans

Consistent with processes defined in WAPC (2008), Urban Water Management Plans (UWMP's) will be developed and submitted to support individual subdivision applications within the site.

UWMP's will address:

- Demonstrated compliance with LWMS criteria and objectives to the satisfaction of the Shire of Serpentine Jarrahdale and DoW.
- Agreed/approved measures to achieve water conservation and efficiencies of water use.
- Detailed stormwater management design including refining stormwater modelling detailed in the LWMS.
- Management of groundwater levels including proposed fill levels and any subsoil drainage inverts (if/where required).
- Specific structural and non-structural BMPs and treatment trains to be implemented including their function, location, maintenance requirements, and agreed on going management arrangements.
- Management of subdivisional works.
- Implementation plan including roles, responsibilities, funding and maintenance arrangements.
- Specific monitoring and reporting to be undertaken consistent with the monitoring program defined in the LWMS.
- Contingency plans (where necessary).

More detail on stormwater storage integration will be provided during the development of UWMP's, including refinement of stormwater modelling (if required), preparation of landscape plans (species selection and treatments), and detailed engineering design drawings.

Preparation of UWMP's will be the developer's responsibility.

9. Monitoring

The following monitoring program summarises details contained in JDA(2009) with some revision of monitoring locations to address structure plan changes.

9.1 Pre Development

The site has been subject to a comprehensive pre development water quality monitoring program. No additional pre development monitoring is envisaged to be required for the site for agency approval purposes.

Some additional monitoring data may be collected as/if required to inform engineering design.

9.2 Post Development

The JDA LWMS proposed that the post development monitoring program operate over a period of 3 years. Annual monitoring reports are the responsibility of the developer to prepare and will be submitted to the DoW and Shire of Serpentine Jarrahdale for review.

Table 3 summarises the post development monitoring program consistent with the previous approved program detailed in (JDA, 2009).

Table 3: Post Development Monitoring Program

Monitoring	Parameter	Location	Method	Frequency and Timing
Groundwater	Water Level (m AHD)	12 locations corresponding with pre development monitoring sites (Figure 10)	Electrical depth probe or similar	Monthly over 3 years
	pH, EC Nutrients Heavy Metals		Pumped bore sample	Quarterly over 3 years
Surface Water	Water Level (m AHD)	Upstream boundary on Beenyup Brook	Data logger on Beenyup Brook	3 years, samples taken monthly while flowing
	pH, EC, TSS Nutrients Heavy Metals		Collected grab samples	
Stormwater	pH, EC, TSS Nutrients Heavy Metals	5 locations (ephemeral detention area outlets) (Figure 10)	Collected grab samples	3 years, samples taken monthly while flowing

10. Implementation

Table 4 details the roles, responsibilities and funding to implement the LWMS for this site. This has been revised from the approved LWMS (JDA,2009) in accordance with the proposed structure plan.

Monitoring outcomes will be used in a continual improvement capacity to review the implemented WSUD within the site and inform the planning and design approaches for subsequent stages of development.

Any modification required to the LWMS would be identified through the review process of monitoring data and would require the agreement of all parties (DoW, Shire of Serpentine Jarrahdale, and developer).

Operation and maintenance of the stormwater management system will initially be the developer's responsibility, ultimately reverting to the Shire following handover.

Details of maintenance responsibilities will be further outlined at the UWMP stage. The schedule for maintenance works will be consistent with typical requirements of the Shire of Serpentine Jarrahdale.

Table 4: Implementation Responsibilities

		Responsibility & Funding	
LWMS Section	**Implementation Action**	**Developer**	**SSJ and DoW**
Urban Water Management Plan			
8	Preparation of a UWMP	☑	
8	Review & Approval of a UWMP		☑
Monitoring Program			
9	Post Development Monitoring Program	☑	
Stormwater System			
-	Construction of system	☑	
	Operation & Maintenance		
-	a) Prior to Handover	☑	
	b) Following Handover		☑

11. References

Australian and New Zealand Environment and Conservation Council (ANZECC) (2000) National Water Quality Management Strategy: Australian and New Zealand Guidelines for Fresh and Marine Water Quality, October 2000.

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Western Australian Planning Commission (2003). Planning Bulleting No. 64: Acid Sulphate Soils. Western Australian Planning Commission, November 2003.

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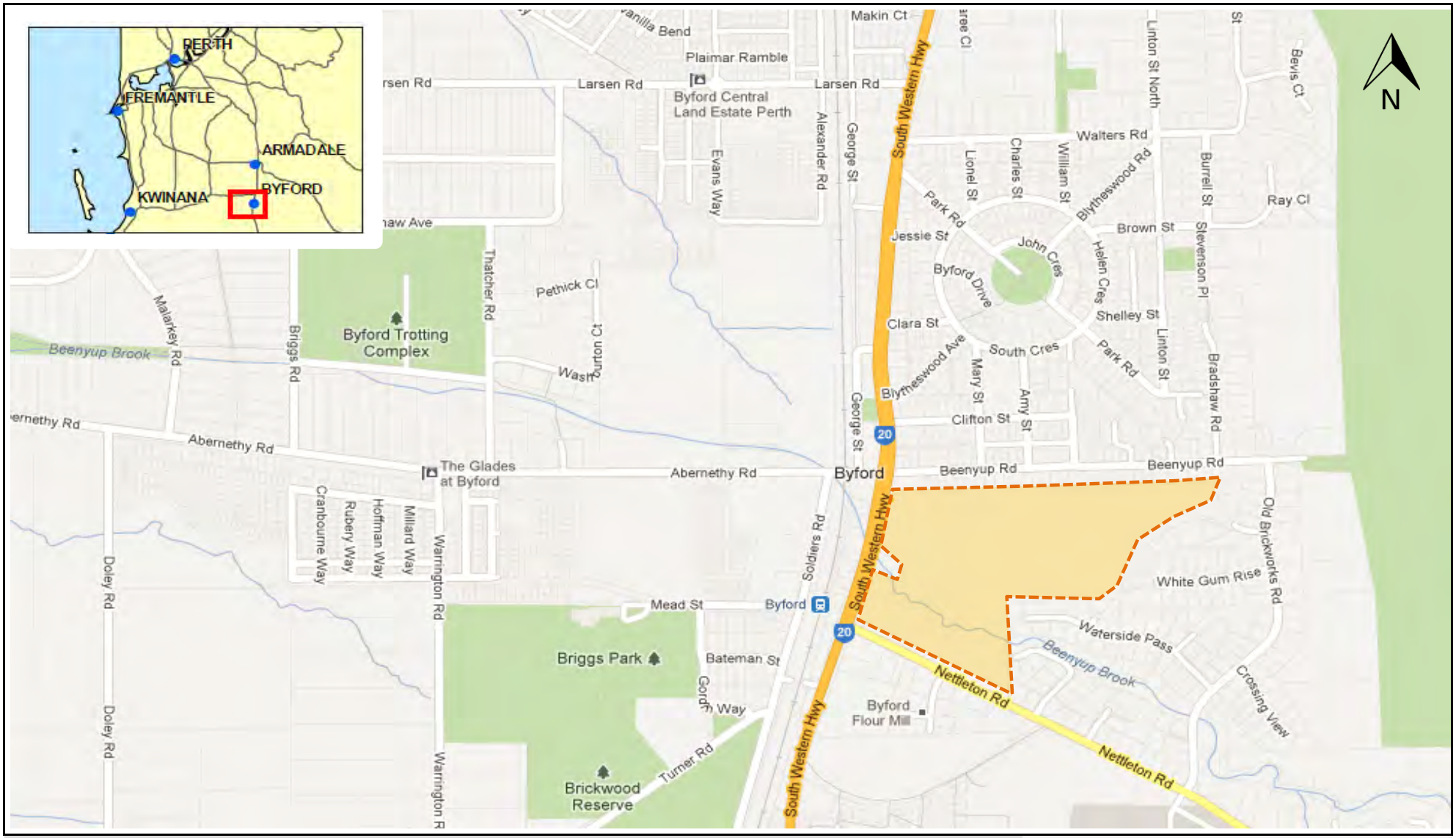
FIGURES

Date :11/10/2012 Job No H12058



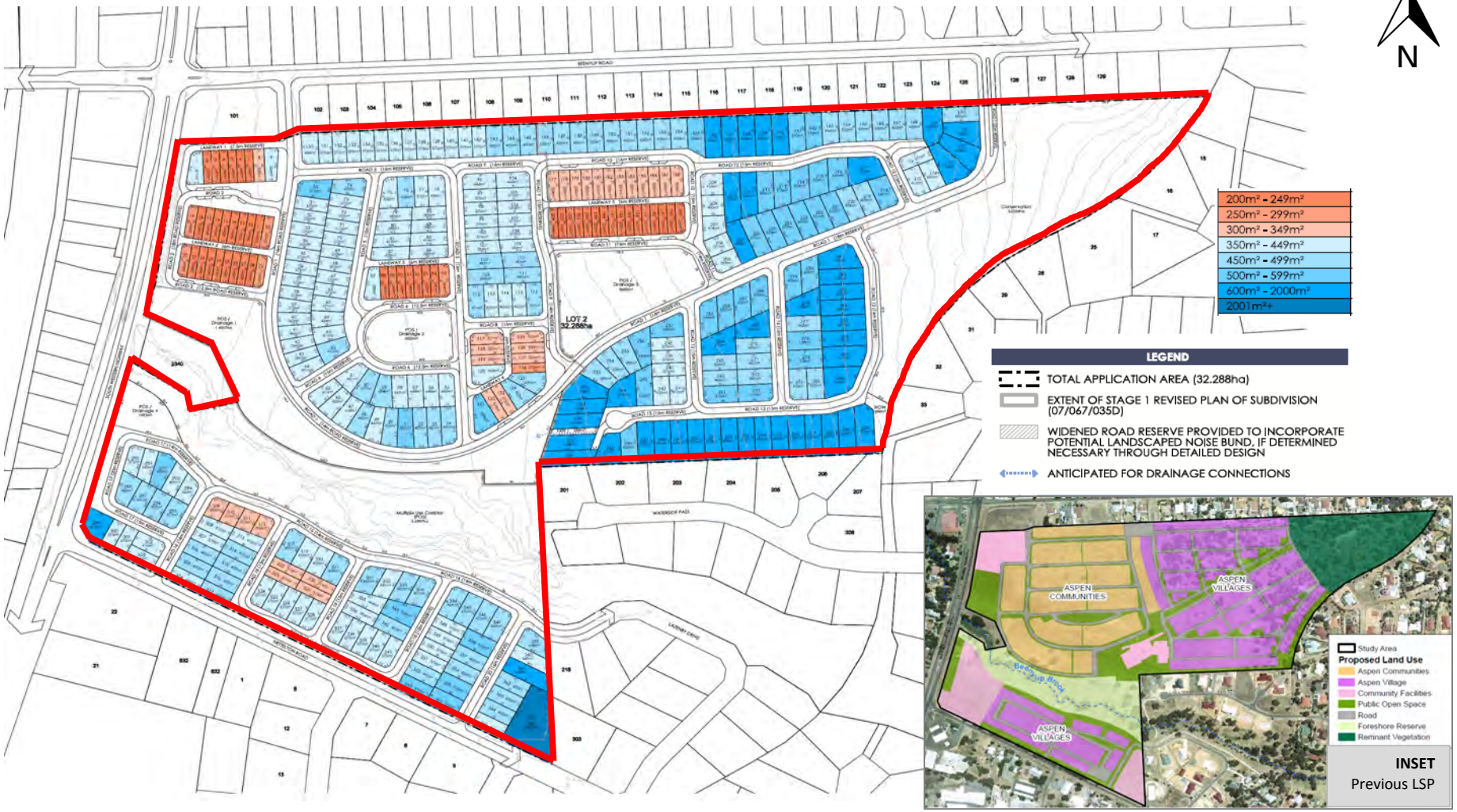
hyd2o

Lot 2 Nettleton Road Byford LWMS Addendum

Site Context Plan

Figure 1

Date : 3/7/2013 Job No H13010



Source: Taylor Burrell Barnett 2013., JDA(2009)

Site Boundary

0m 60m 120m 180m 240m

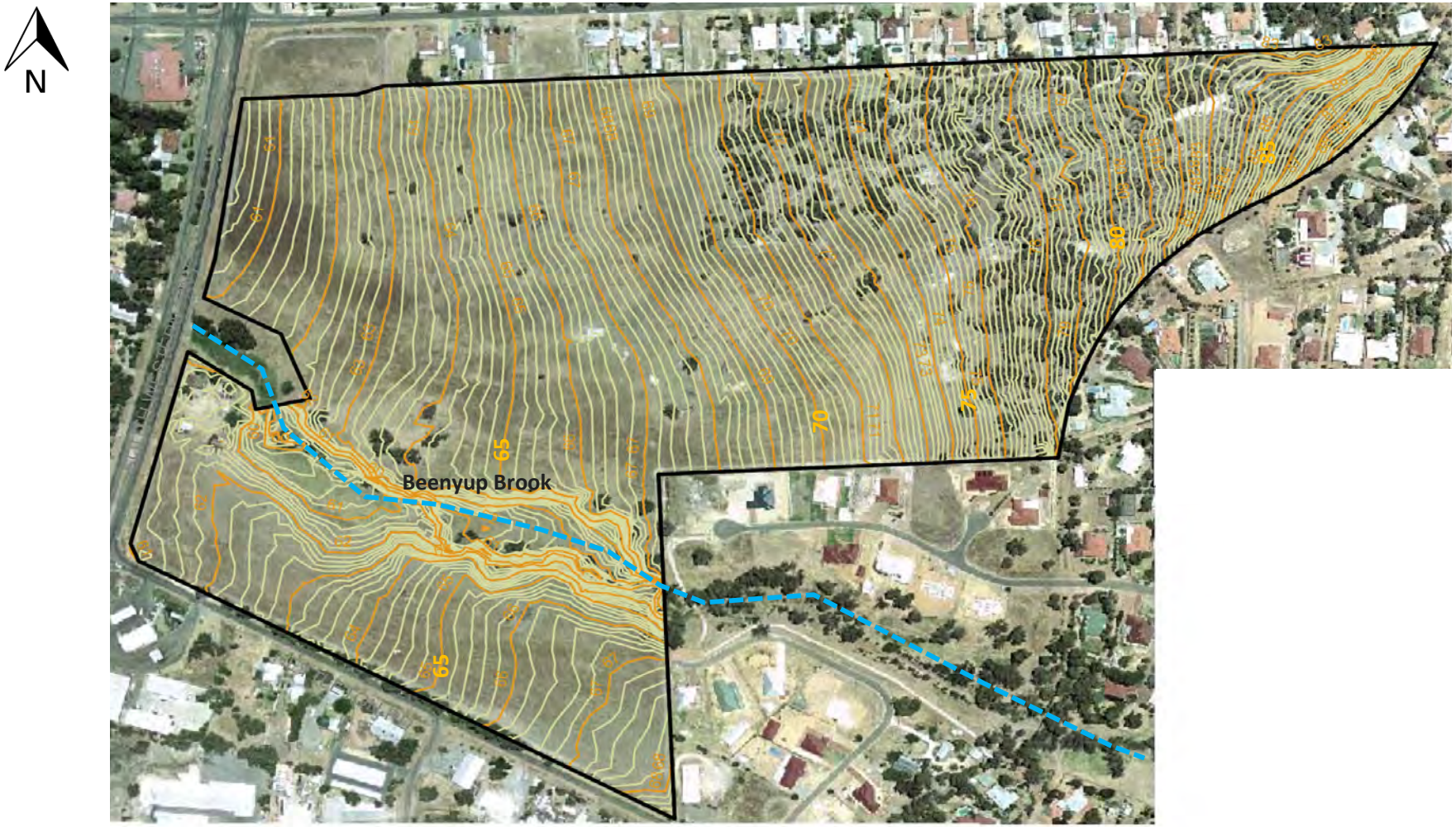
hyd2o

Lot 2 Nettleton Rd Byford LWMS Addendum

Revised Local Structure Plan

Figure 2

Date : 05/10/2012 Job No H12058



Source: JDA (2009)

Site Boundary

1m Topographic Contour

0.2m Topographic Contour

0m 100m 200m 300m

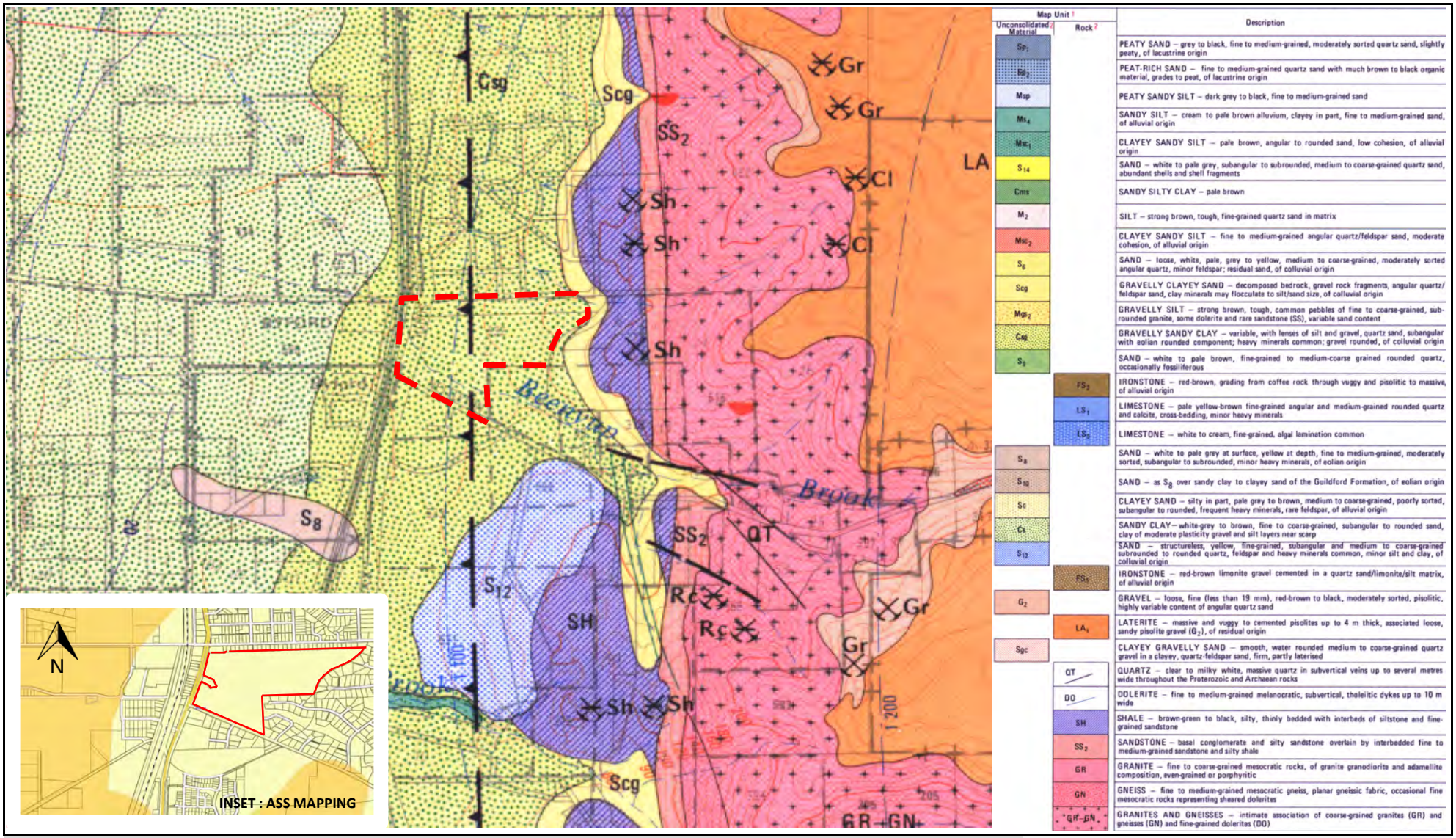
hyd2o

Lot 2 Nettleton Rd Byford LWMS Addendum

Site Condition Plan

Figure 3

Date :25/09/2012 Job No H12058



Site Boundary

Class 2: Moderate to low risk of ASS occuring within 3m of natural soil surface but high to moderate risk of ASS beyond 3m of natural soil surface

No known ASS risk

0m 500m 1000m 1500m

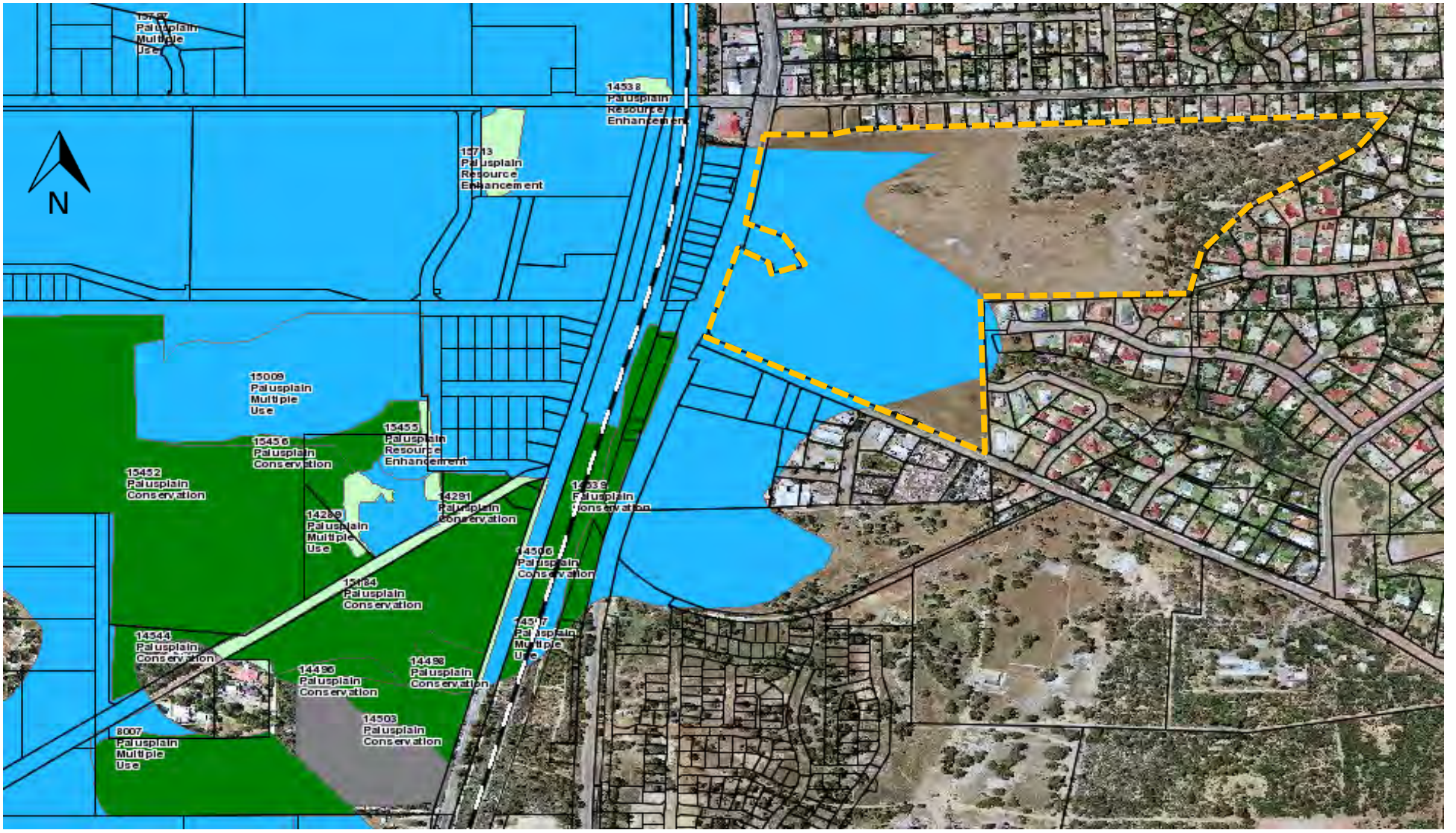
hyd2o

Lot 2 Nettleton Road Byford LWMS Addendum

Geotechnical Plan

Figure 4

Date : 08/10/2012 Job No H12058



Source: WA Atlas, Landgate 2012

Multiple Use

Resource Enhancement

Conservation Category

Site Boundary

0m 100m 200m 300m 400m

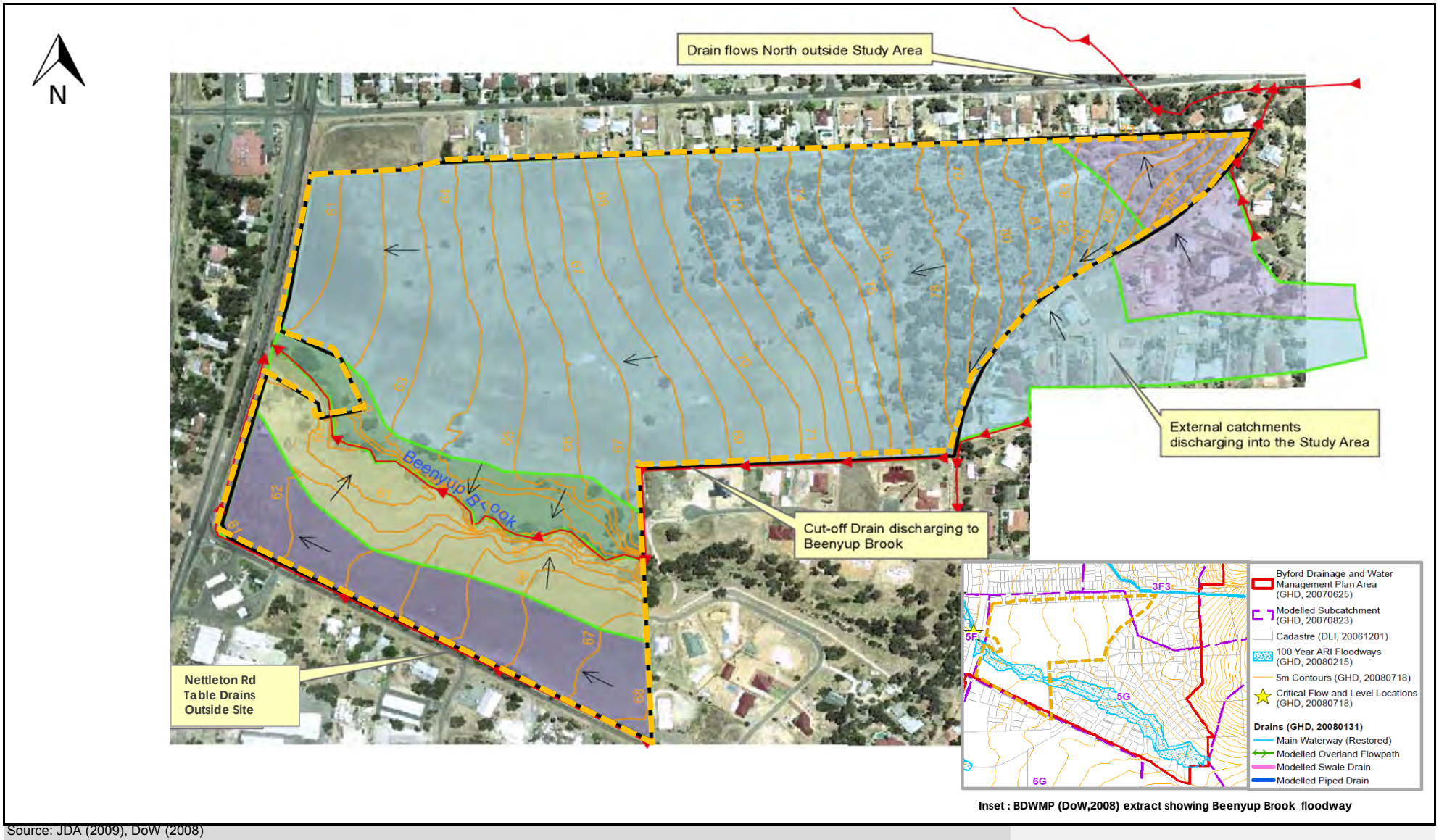
hyd$_2$o

Lot 2 Nettleton Rd Byford LWMS Addendum

Wetland Plan

Figure 5

Date : 5/10/2012 Job No H12058



Inset : BDWMP (DoW,2008) extract showing Beenyup Brook floodway

Source: JDA (2009), DoW (2008)

- Site Boundary
- Flow Direction
- Existing Drainage /Watercourses
- Predevelopment Catchment Boundaries

0m 100m 200m 300m

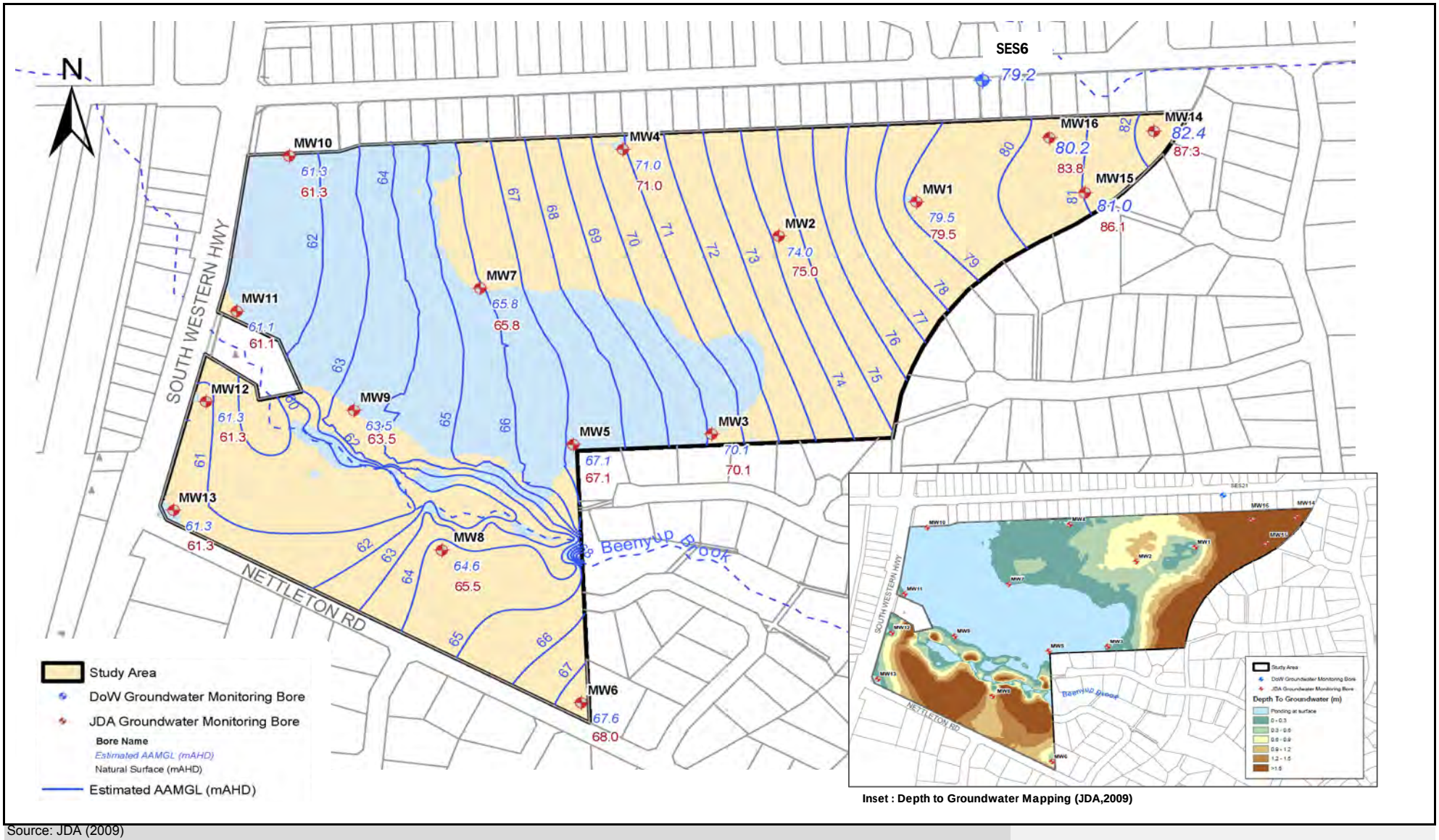
hyd$_2$o

Lot 2 Nettleton Road Byford LWMS Addendum

Surface Water Plan

Figure 6

Date : 5/10/2012 Job No H12058



Inset : Depth to Groundwater Mapping (JDA,2009)

Source: JDA (2009)

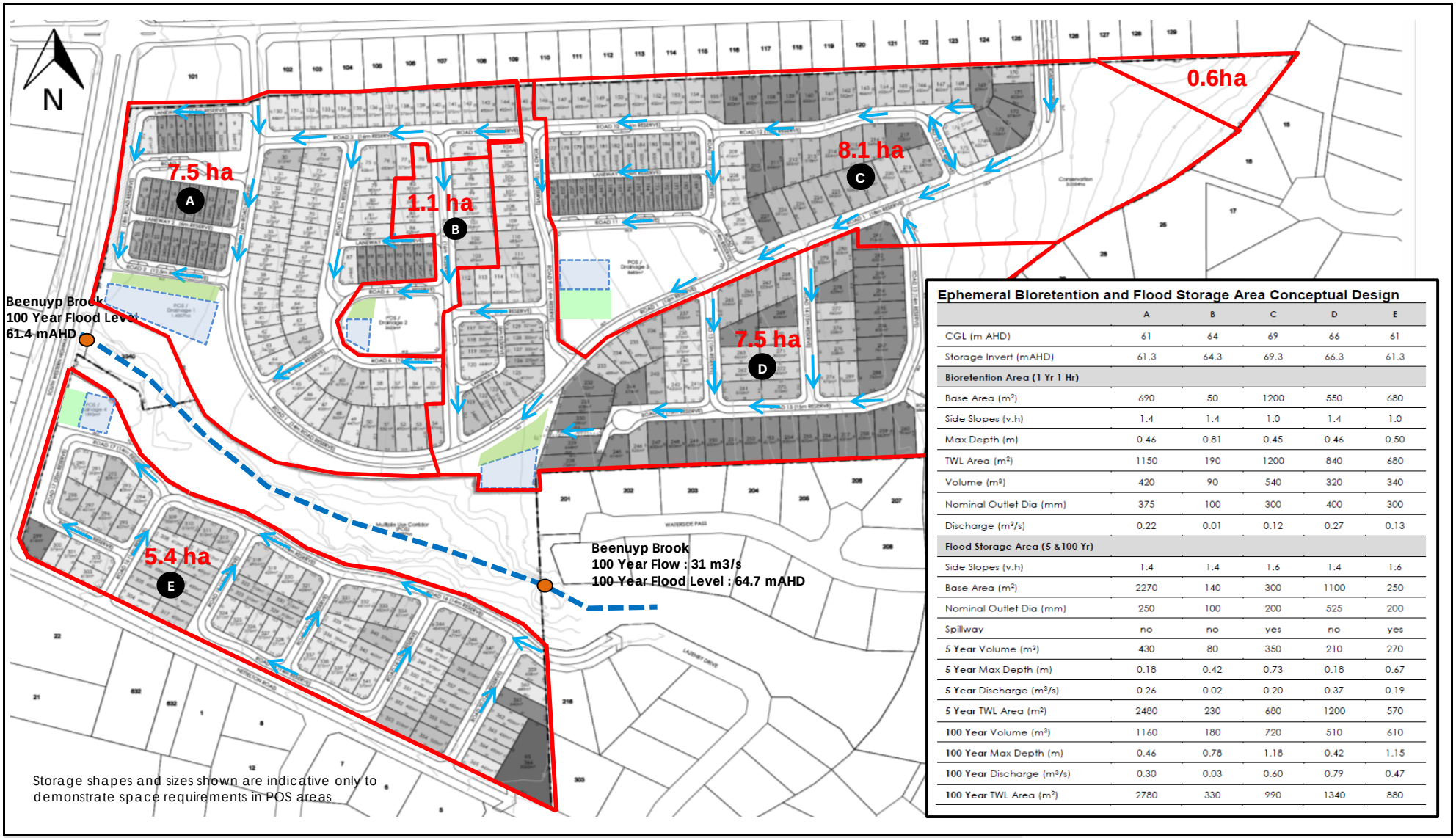
hyd2o

Lot 2 Nettleton Road Byford LWMS Addendum

Groundwater Plan

Figure 7

Date :8/11/2013 Job No H13010



Ephemeral Bioretention and Flood Storage Area Conceptual Design

	A	B	C	D	E
CGL (m AHD)	61	64	69	66	61
Storage Invert (mAHD)	61.3	64.3	69.3	66.3	61.3
Bioretention Area (1 Yr 1 Hr)					
Base Area (m^2)	690	50	1200	550	680
Side Slopes (v:h)	1:4	1:4	1:0	1:4	1:0
Max Depth (m)	0.46	0.81	0.45	0.46	0.50
TWL Area (m^2)	1150	190	1200	840	680
Volume (m^3)	420	90	540	320	340
Nominal Outlet Dia (mm)	375	100	300	400	300
Discharge (m^3/s)	0.22	0.01	0.12	0.27	0.13
Flood Storage Area (5 &100 Yr)					
Side Slopes (v:h)	1:4	1:4	1:6	1:4	1:6
Base Area (m^2)	2270	140	300	1100	250
Nominal Outlet Dia (mm)	250	100	200	525	200
Spillway	no	no	yes	no	yes
5 Year Volume (m^3)	430	80	350	210	270
5 Year Max Depth (m)	0.18	0.42	0.73	0.18	0.67
5 Year Discharge (m^3/s)	0.26	0.02	0.20	0.37	0.19
5 Year TWL Area (m^2)	2480	230	680	1200	570
100 Year Volume (m^3)	1160	180	720	510	610
100 Year Max Depth (m)	0.46	0.78	1.18	0.42	1.15
100 Year Discharge (m^3/s)	0.30	0.03	0.60	0.79	0.47
100 Year TWL Area (m^2)	2780	330	990	1340	880

Post Development Catchment Boundaries

Flow Direction (piped to 5 year, overland within road Reserve >5 year ARI)

1 Year ARI/Bioretention Area

100 Year ARI Storage Area

0m 60m 120m 180m

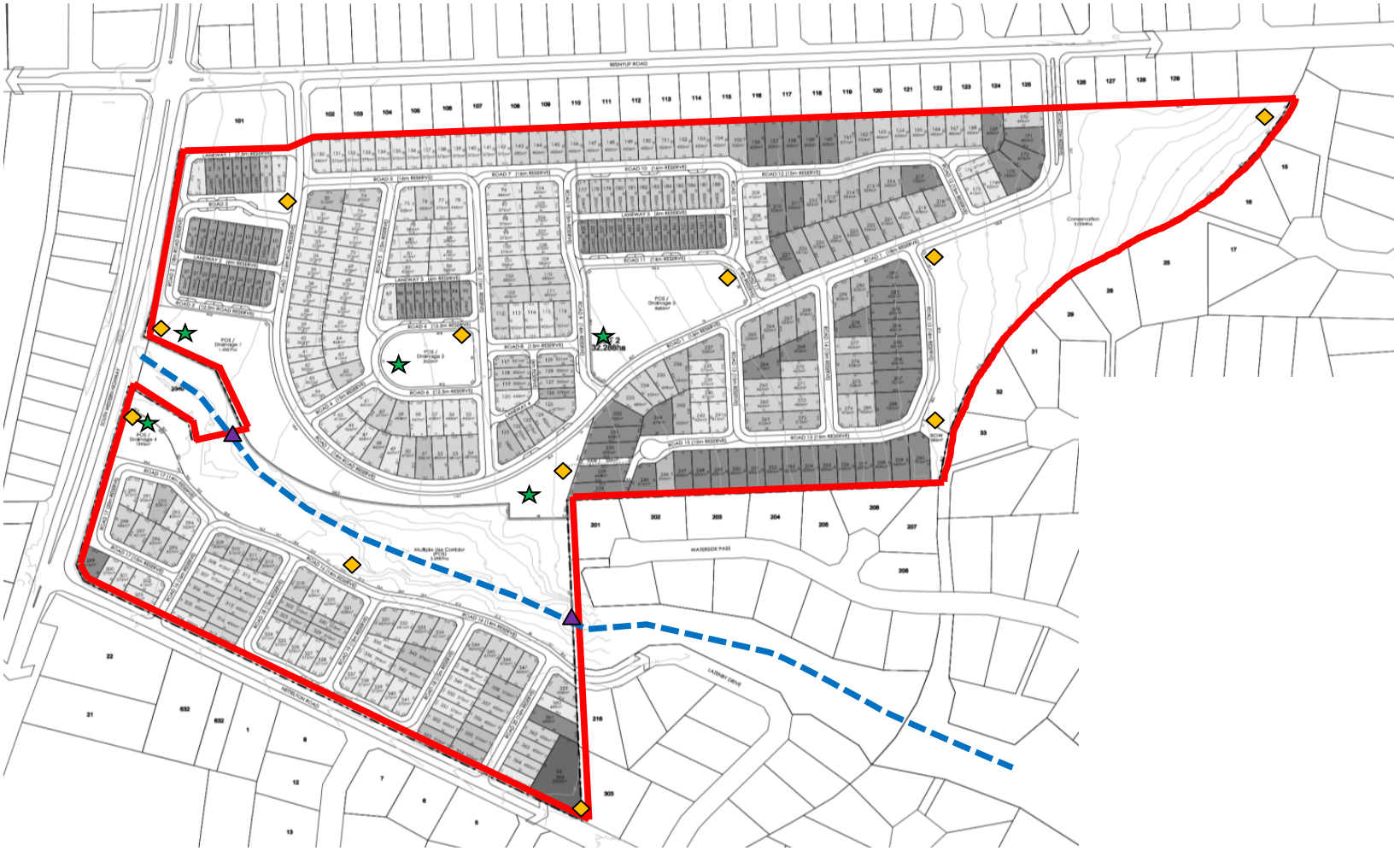
hyd$_2$o

Lot 2 Nettleton Road LWMS Addendum

1,5, & 100 Year ARI Event Plan

Figure 8

Date : 03/7/2013 Job No H13010



Source: JDA (2009)

- Site Boundary
- Stormwater Monitoring Sites
- Groundwater Monitoring Sites
- Beenyup Brook Monitoring Sites

0m 60m 120m 180m 240m

hyd$_2$o

Lot 2 Nettleton Rd Byford LWMS Addendum

Post Development Monitoring Plan

Figure 9

APPENDIX A : GROUNDWATER LEVEL MONITORING DATA SEPTEMBER 2012

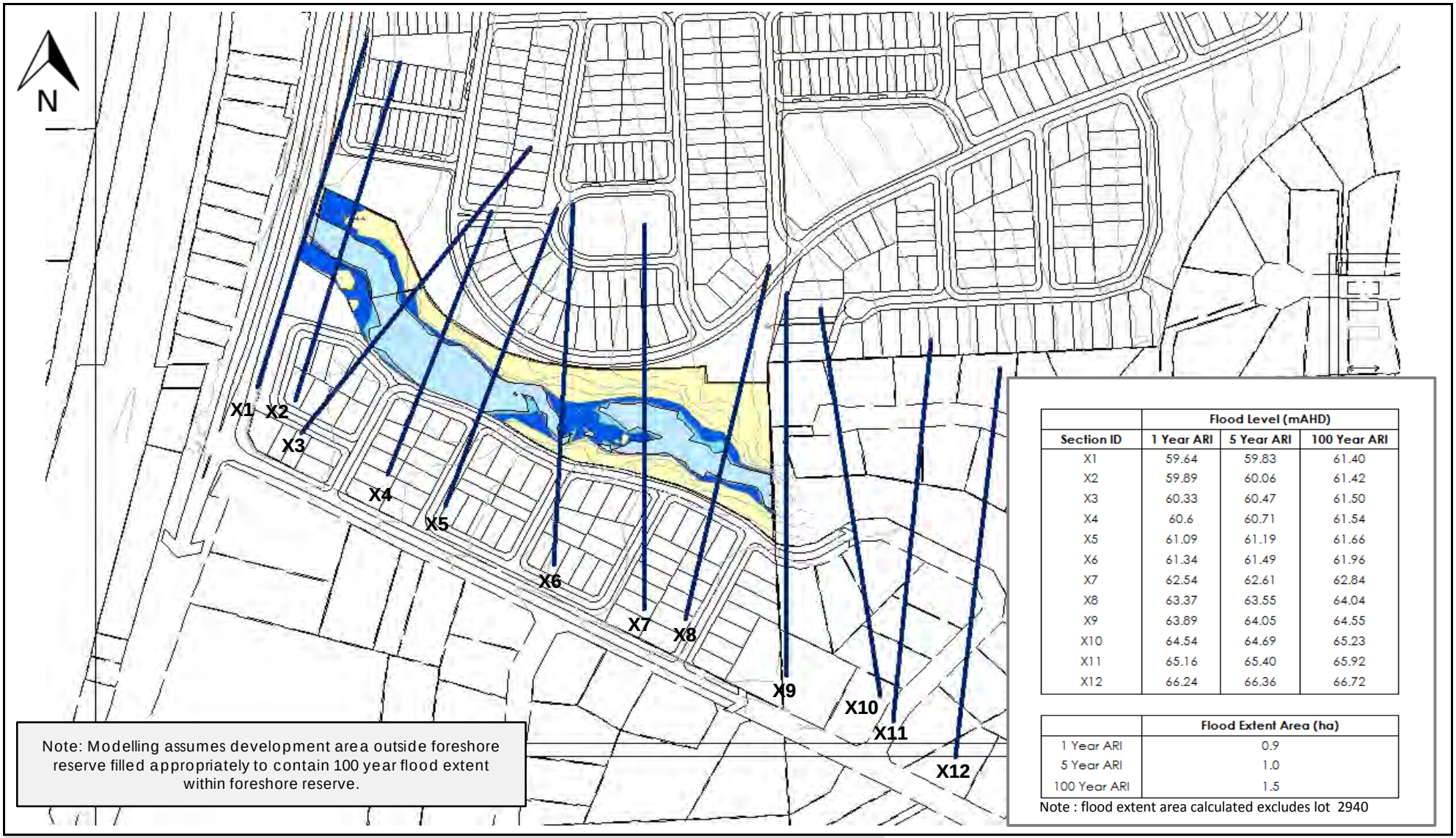
APPENDIX A

JDA(2009) Estimated Predevelopment AAMGL and Hyd2o Groundwater Levels

Locn	Location (GDA)		Natural Surface (m AHD)	Top of Casing (m AHD)	JDA (2009) AAMGL (m AHD)	Hyd2o (12/09/12)	
	Easting	Northing				mBTOC	mAHD
MW1	407264	6434440	79.46	80.16	79.46	destroyed	-
MW2	407130	6434404	75.05	75.73	74.20	4.72	71.01
MW3	407064	6434194	70.07	70.74	70.07	1.26	69.48
MW4	406978	6434194	70.94	71.59	70.94	1.67	69.92
MW5	406929	6434183	67.12	67.81	67.12	1.08	66.73
MW6	406937	6433911	68.04	68.80	67.58	1.74	67.06
MW7	406838	6434220	65.84	66.57	65.84	destroyed	-
MW8	406801	6434220	63.45	66.12	64.62	2.20	63.92
MW9	406715	64344220	63.51	64.22	63.51	1.25	62.97
MW10	406652	6434489	61.34	62.02	61.34	1.37	60.65
MW11	406601	6434324	61.06	61.79	61.06	destroyed	-
MW12	406571	6434229	61.26	61.89	61.26	1.29	60.60
MW13	406540	6434114	61.29	61.99	61.29	0.97	61.02
MW14	407496	6434515	86.70	87.27	82.39	4.73	82.54
MW15	407428	6434450	86.14	86.75	81.04	4.24	82.51
MW16	407394	6434508	83.84	84.42	80.18	4.41	80.01
BDM12	406253	6433849	-	56.07	55.99	-	-
SES21	406351	6432721	60.06	60.74	60.04	1.26	59.48
SED6	407329	6434569	81.31	81.55	78.83	2.77	78.78

APPENDIX B : BEENYUP BROOK FLOOD MODELLING

Date : 03/05/2013 Job No H13010



Section ID	Flood Level (mAHD)		
	1 Year ARI	5 Year ARI	100 Year ARI
X1	59.64	59.83	61.40
X2	59.89	60.06	61.42
X3	60.33	60.47	61.50
X4	60.6	60.71	61.54
X5	61.09	61.19	61.66
X6	61.34	61.49	61.96
X7	62.54	62.61	62.84
X8	63.37	63.55	64.04
X9	63.89	64.05	64.55
X10	64.54	64.69	65.23
X11	65.16	65.40	65.92
X12	66.24	66.36	66.72

	Flood Extent Area (ha)
1 Year ARI	0.9
5 Year ARI	1.0
100 Year ARI	1.5

Note : flood extent area calculated excludes lot 2940

Modelled Cross Sections

X1 Section ID

Wetland Foreshore Reserve

1 in 1 Year ARI Flood Extent

1 in 5 Year ARI Flood Extent

1 in 100 Year ARI Flood Extent

0m 60m 120m

hyd$_2$o

Lot 2 Nettleton Road Byford LWMS Addendum

Beenyup Brook 1, 5 and 100 Year Flood Extent

Appendix B

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CEDAR WOODS PROPERTIES LIMITED

LOT 2 NETTLETON ROAD, BYFORD

PROPOSED RESIDENTIAL DEVELOPMENT

TRAFFIC IMPACT ASSESSMENT

September 2014

Riley Consulting

PO Box Z5578

Perth WA 6831

0413 607 779 Mobile

Issued on	12 September 2014	Amendment	Date
Version	V2	V2 edited for MRWA comments	12-09-14
Reference	732		

CONTENTS

1.0 EXECUTIVE SUMMARY

Riley Consulting has been commissioned by Cedar Woods Properties Limited to assess the traffic impacts of the proposed development of Lot 2 Nettleton Road, Byford. The analysis undertaken in this report indicates the following:

- This report has been updated to reflect comments raised by MRWA in regard to the trip rate (increased for 7 per lot to 8 per lot) and the HGV content on South Western Highway. The amendments made do not affect the outcomes of this report.

- The proposed residential development of the subject land fits well with current surrounding land uses. The development can be expected to generate about 2,597 vehicle movements per day.

- Assessment of the forecast traffic increases shows that whilst the increases may be proportionately high, the increases are unlikely to have any significant impact on the operation of the road network. Based on current daily volumes, Levels of Service will not be affected by the proposed development.

- Assessment of the peak period of road network operation indicates that the traffic signals on the South Western Highway at Beenyup Road will not be adversely affected by the proposed development. Analysis indicates that good Levels of Service are maintained to all approaches in the future years of 2023 and 2031.

- The intersection of South Western Highway / Nettleton Road is shown to operate in an acceptable manner with current traffic demands. However, analysis of the 2023 traffic forecast indicates that upgrading of the intersection as indicated in plans provided by MRWA will be required. It is expected that development off Nettleton Road will be at a later stage and further assessment should be undertaken at the time of subdivision.

2.0 THE SITE AND SURROUNDING ROAD NETWORK

The site is located in the suburb of Byford, approximately 22 kilometres from Perth. Byford is an expanding suburb nestled along the South Western Highway. The current population is about 7,000 people, although the residential expansion of the locality will see the local population increase significantly.

The site is bounded by Beenyup Road, the South Western Highway and Nettleton Road. Figure 1 shows the location of the site in relation to the regional, district and local road network. Roads of significance to the development proposal are discussed below.

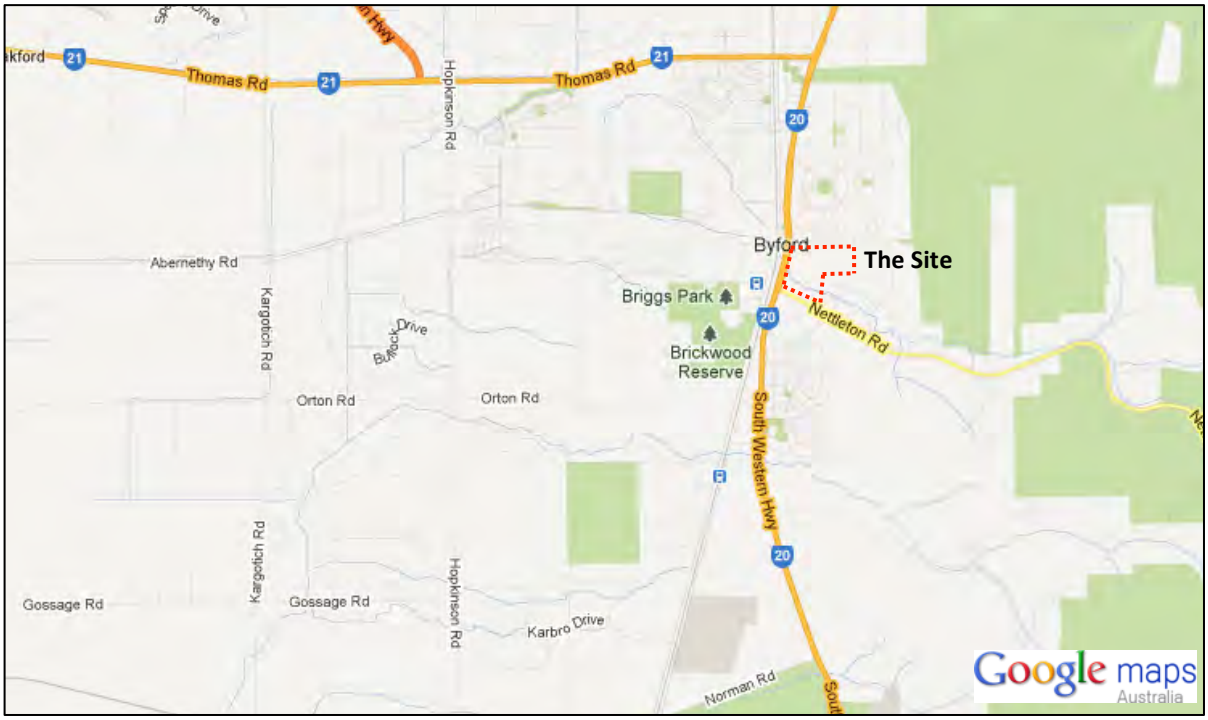


Figure 1 Site Location (land area indicative)

South Western Highway

The South Western Highway is a primary regional road under the control of Main Roads WA (MRWA). It provides a regional link between Armadale (where it joins Albany Highway), Perth and Walpole (where it joins the South Coast Highway to Albany). The South Western Highway is a primary freight route and caters for large trucks throughout the year. However, the development of the Tonkin Highway should remove the use of this route by large trucks over time. The construction of the Tonkin Highway extension is not currently in the MRWA programme.

Photograph 1 South Western Highway

The South Western Highway is generally constructed as a single carriageway two-lane road, except through Byford, where a four-lane divided carriageway has been provided. Traffic speeds are limited to 90kph approaching the town and 50-60kph through the town. Traffic data has been provided by MRWA for 2010 and is shown in Table 1. Photograph 1 shows the view looking south at Abernethy Road.

Table 1 South Western Highway Traffic Volumes

Location	Year	Daily Flow (variation)	AM	PM
South of Thomas St	2012	16,714 (104%)	1,381	1,403
	2010	14,148 (93%)	1,118	1,253
	2008	15,356 (100%)	1,205	1,295
South of Jessie St	2010	12,140	1,012	1,082
South of Pitman Way	2012	12,248	988	1,083
North of Abernethy Rd (Scats)	2013	13,850	1,057	1,130
South of Abernethy Rd (Scats)	2013	11,800	912	950
South of Nettleton Rd	2088	9,948	730	826

The intersection of South Western Highway / Abernethy Road is controlled by traffic signals that were installed in January 2009. Scats data has been provided for the traffic signals from MRWA and is noted in Table 1. It can be seen that annual growth on the Highway is very low. Analysis of the intersection operation undertaken in this report is based on the current Scats data. For the purpose of this report the traffic volume on South Western Highway used for analysis will be:

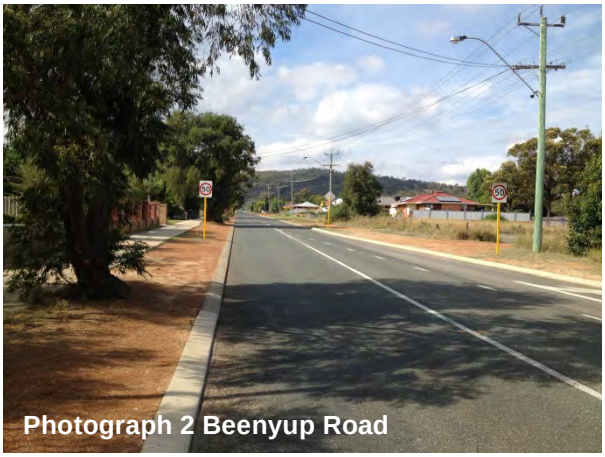
- North of Abernethy Road 13,850vpd (2013 data)
- South of Abernethy Road 11,800vpd (2013 data)
- South of Nettleton Road 10,345vpd (factored by Thomas St count data)

Vehicle classification data indicates that typically 11% of the total daily flow is truck movements on the South Western Highway. Truck traffic varies according to the season and is known to increase significantly during the grain season. As stated, it is expected that the

extension of the Tonkin Highway beyond Thomas Road will provide an alternative route for regional traffic and trucks. Significant traffic decreases can be expected when the Tonkin Highway is extended.

Beenyup Road

Beenyup Road is classified as a local distributor road in the MRWA *Functional Road Hierarchy.* The hierarchy suggests that local distributors should provide access within the cell, but discourage through traffic and have a maximum desirable traffic flow of 6,000vpd. Beenyup Road is constructed as a single carriageway road with residential property to the northern side taking direct access. Photograph 2 shows the view from the traffic signals along Beenyup Road.



Photograph 2 Beenyup Road

Current daily traffic data is not available, but Scats data from the traffic signals at South Western Highway indicates a daily flow of about 2,480 vehicles. The traffic demand of Beenyup Road will increase as a result of local development.

Nettleton Road

Nettleton Road is classified as a district distributor type A road in the MRWA *Functional Road Hierarchy* between the South Western Highway and Brickworks Road. Beyond Brickworks Road it is classified as a district distributor type B road. The road hierarchy expects traffic flows greater than 8,000vpd on district distributor type A roads. It is considered that the classification was provided to recognise the light industrial / commercial land uses in the locality. Photograph 3 shows the view looking east along Nettleton Road

Photograph 3 Nettleton Road

Nettleton Road is constructed as a single carriageway road and historical traffic data provided by the Shire of Serpentine – Jarrahdale showed a flow of 1,542vpd (2006) west of Brickworks Road. A recent site inspection during the morning peak hour indicated a flow of

about 170 vehicles (two-way) which suggests a daily flow of about 2,400vpd. It was noted that about 20% to 30% of traffic was associated with the petrol filling station.

Abernethy Road

To the west of the subject land lies Abernethy Road which is classified in the MRWA *Functional Road Hierarchy* as a district distributor type A road between the South Western Highway and Soldiers Road. West of Soldiers Road it is classified as a local distributor road. It is constructed as a rural road with a standard 7.2m (approximate) road pavement between Soldiers Road and Hopkinson Road. East of Soldiers Road a slightly wider carriageway has been constructed to provide additional capacity at its intersection with the South Western Highway. East of Soldiers Road there is a level crossing.

The Scats data indicates a daily flow of 2,946vpd approaching the traffic signals, indicating a daily volume in the order of 6,000vpd. A high proportion of the daily movement will be associated with the existing retail uses. West of the shopping centre the forecast daily flow varies from 5,000vpd to 7,000vpd with full development of land to the west.

Appendix A shows the peak hour traffic data recorded by the traffic signals at South Western Highway / Abernethy Road in April 2013. It is noted that a comparison to Scats data from June 2012 shows only minor variations.

The development site plan is shown as Figure 2 and is provided for reference only.

Figure 2 **Site Concept Plan** (refer architect for detail)

3.0 TRAFFIC GENERATION AND DISTRIBUTION

It is proposed to develop the site to provide a mixture of residential lots ranging in size. Overall the site will provide a total of 371 dwellings once fully developed.

The traffic generation of residential lots in Byford has been previously assessed at 8 trips per dwelling for structure planning purposes and thus the development could be expected to generate (371 x 8) 2,597 trips per day.

The site will generate 2,968 trips per day.

During the peak hours, between 8% and 10% of the daily flow can be expected from the residential land uses. Assuming 10% it can be expected that during peak periods the development will generate 296 vehicle movements. The split is expected to be 70% in the peak direction.

Distribution

The location of the site will require that access to the regional road network is taken from the South Western Highway to head north or south. Ultimately there may be some walking trips to the future rail station at Byford, although this is a long term prospect. Local shopping will be provided off Abernethy Road and will attract traffic movement.

The distribution of traffic from new dwellings in the locality can be expected to be similar to current movements at Beenyup Road which shows 36% of traffic attracted to the north, 25% of traffic attracted to Abernethy Road and 39% of traffic attracted to the south. It is interesting to note that current traffic movements are equally split north and south, which reflects the ABS employment data indicating just 11% of professional workers living in the suburb, suggesting Perth CBD is not a major attractor. The ABS data shows a higher level of trade and manual workers and access to key centres such as Rockingham would be easier from Mundijong Road. Figure 3 shows the anticipated traffic movements associated with the proposed uses of the site.

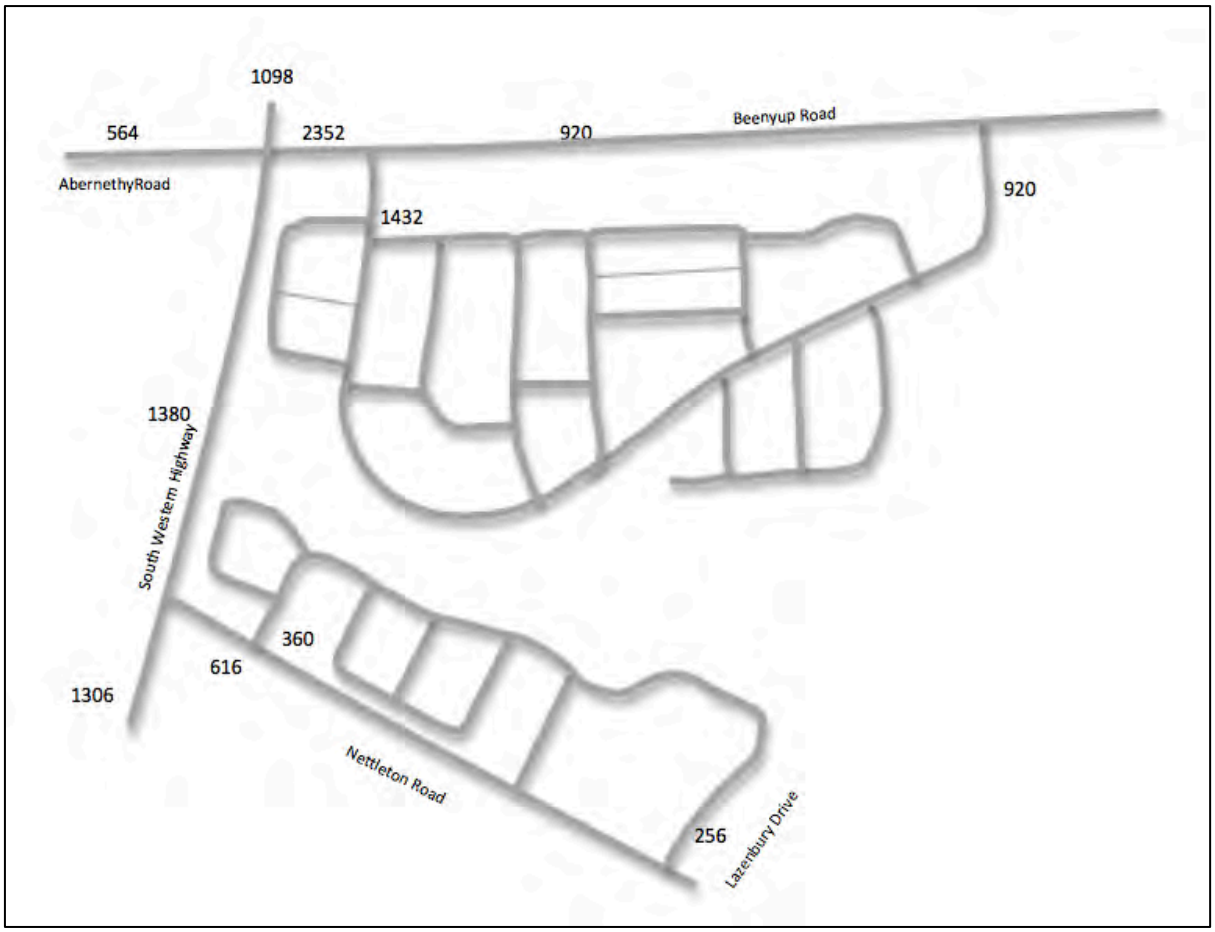


Figure 3 Forecast Traffic Increases (flows greater than 300vpd)

Appendix A shows the expected increases to the peak hour movements. During the evening peak the generation of the land uses would be expected to be reversed, but is likely to be slightly lower due to the type of local employment.

4.0 TRAFFIC IMPACTS

The traffic generation of the proposed development is shown to be about 2,597 vehicles per day based on the maximum yield of the site. Table 2 considers the forecast increases to local traffic flows. The Level of Service assessment is based on the table attached as Appendix B.

Table 2 Expected Increases to Local Road Network

Road	Volume	Capacity	Development	%	Volume	LoS
South Western Highway north	13,850	50,000	1,098	7.93%	14,948	A
South Western Highway south	10,345	50,000	1,306	12.62%	11,651	D
Abernethy Road east	4,297	15,000	564	13.12%	4,861	B
Beenyup Road	2,480	9,000	2,352	94.84%	4,832	C
Nettleton Road	2,400	9,000	616	25.67%	3,016	B

*Indicates attraction to local centre

In traffic engineering terms it is recognised that daily traffic flows can vary by +/-5% and when a development increases the daily flow within this range, it is considered to have no significant impact. Based on the derived traffic generation of the proposed land uses and the distribution assumptions used, it can be seen that the traffic generated by the development is typically greater than 5% and further assessment is required.

To consider the impact of the increased traffic, an assessment of the change to current Levels of Service is provided. Based on data contained in *Austroads* and the Ministry for Planning's *Road Reserves Review*, Table 2 shows that current Levels of Service will not change as a result of the proposed development.

The proposed development will not affect current Levels of Service.

Road Hierarchy Assessment

The impact of the proposed development upon the South Western Highway, based on current volumes, is shown not to affect Levels of Service. As a four lane divided road through the town centre, the Highway has ample capacity to cater for significant traffic increases in the region. However, south of Nettleton Road it is constructed as a single lane road and is currently operating with daily volumes greater than desirable. Based on the *Road Reserves Review* (Ministry for Planning), it is considered that 9,000vpd is the flow at which

duplication should be considered. However, duplication of the South Western Highway south of Byford should be unnecessary once the Tonkin Highway is extended.

Beenyup Road

Beenyup Road is more residential in nature, but is classified as a local distributor road. The forecast traffic increases can be expected to have no impact to the east of the subject land. However, west of the development site, traffic will build up from the two accesses. To the east of the South Western Highway, an increase of 2,480vpd will occur and will affect 3 to 4 existing houses. Further east of the primary site access, the increase would be about 920vpd and will affect 34 dwellings. The increase equates to 92 vehicles in the peak period or an additional vehicle every 40 seconds.

Beenyup Road is classified as a local distributor and is therefore suited to carry up to 6,000vpd based on the DC policy (*Liveable Neighbourhoods* suggests 7,000vpd). The proposed development will increase the daily flow to about 4,832vpd at its western end and 3,400vpd for the majority of affected residents. Whilst the increase as a result of the development may be noticeable, Beenyup Road will not operate in a manner contrary to its intended function.

The proposed development will not result in Beenyup Road operating in a manner contrary to current planning guidelines.

Nettleton Road

Nettleton Road is a district distributor type B road and provides access to a small light industrial area. The forecast traffic increases will not result in a daily flow higher than is acceptable for the road classification. As there are no residential dwellings located adjacent to the development site, the development is expected to have no significant impact.

All roads will continue to operate in the manner for which they are intended.

5.0 PEAK HOUR IMPACTS

It has been shown that the impact to the surrounding highway network throughout the day is unlikely to affect current Levels of Service. Whilst some traffic increases may be proportionately high, there would appear to be no warrants for major road upgrading as a result of the proposed development.

It is during the peak periods of development activity that the local road network may experience some impact, specifically the existing intersections of the South Western Highway at Abernethy Road / Beenyup Road and Nettleton Road. Analysis is undertaken using Sidra to determine the potential impact of the proposed development on current conditions and future conditions. To provide an appropriate comparison Sidra has been used to determine the appropriate signal green times on all assessments (note that MRWA may prefer alternative timings that favour higher speed through movements to South Western Highway).

Current Peak Hours

The South Western Highway / Beenyup Road intersection is a four-way traffic signal controlled intersection. Analysis of the traffic signals has been undertaken based on the present day traffic flows and the increases as a result of the proposed development. Table 3 shows the Sidra analysis for the current operation and Appendix C the Sidra summary. It should be noted that =cycle times have been selected by Sidra and are used for comparison purposes. MRWA regional road polices may result is different signals being used on site.

Table 3 South Western Highway / Beenyup Road – Existing Peak Periods

	AM Peak			PM Peak		
Road	Sat	Delay	LoS	Sat	Delay	LoS
SW Highway south	0.294	13s	A	0.206	14s	A
Beenyup Road	0.137	22s	B	0.094	20s	B
SW Highway north	0.392	15s	B	0.436	15s	B
Abernethy Road	0.301	22s	B	0.285	23s	B

The forecast traffic increases shown in Appendix A have been used to determine the expected operation of the intersection with the proposed development. Table 4 shows the summary of the Sidra analysis, which is attached as Appendix D.

Table 4 South Western Highway / Beenyup Road – Existing With Lot 2

	AM Peak			PM Peak		
Road	Sat	Delay	LoS	Sat	Delay	LoS
SW Highway south	0.294	13s	A	0.231	15s	B
Beenyup Road	0.294	23s	B	0.164	21s	B
SW Highway north	0.329	15s	B	0.436	15s	B
Abernethy Road	0.331	22s	B	0.349	23s	B

It can be seen that based on the current performance of the traffic signals at South Western Highway / Abernethy Road / Beenyup Road, the proposed residential development will have no significant impact to the current operation. The only impact is a slightly reduced level of service (from A to B) on the South Western Highway southern approach. This is due to a slight increase in delay modelled by Sidra.

The development of Lot 2 will have minimal impact to the operation of the traffic signals on South Western Highway.

South Western Highway / Nettleton Road

The South Western Highway / Nettleton Road intersection is a priority controlled intersection with Nettleton Road yielding to traffic on the South Western Highway. There is a narrow median on the highway to the south of Nettleton Road. To the north, the road widens to provide a divided carriageway.

Analysis of the existing intersection operation has been undertaken using Sidra, the summary is shown in Table 5. Appendix D shows the analysis.

Table 5 South Western Highway / Nettleton Road – Existing Peak Periods

	AM Peak			PM Peak		
Road	Sat	Delay	LoS	Sat	Delay	LoS
SW Highway south	0.238	0.1s	A	0.168	0.4s	A
Nettleton Road	0.474	28.3s	B	0.313	28.9s	C
SW Highway north	0.184	1.6s	A	0.309	0.8s	A

Based on the expected traffic increases shown in Appendix A, Table 6 shows the summary of the Sidra analysis. The Sidra output is included in Appendix D.

Table 6 South Western Highway / Nettleton Road – Existing With Lot 2

	AM Peak			PM Peak		
Road	Sat	Delay	LoS	Sat	Delay	LoS
SW Highway south	0.238	0.3s	A	0.168	1.0s	A
Nettleton Road	0.618	32.4s	C	0.404	31.6s	C
SW Highway north	0.184	1.8s	A	0.309	1.1s	A

The analysis indicates that the proposed development can be expected to operate with Level of Service C on Nettleton Road. This is good operation on a highway and indicates that the proposed development will have no significant detrimental impact.

The intersection of South Western Highway / Nettleton Road will operate with acceptable Levels of Service.

6.0 LONG TERM IMPACTS

The WAPC *Transport Assessment Guidelines* requires that developments consider a 10 year planning horizon to assess how the long term operation of the road network may be impacted.

As a result of the Shire of Serpentine – Jarrahdale's structure plan for the town centre, local traffic movements in the locality can be expected to increase. However, the time at which development may occur is unknown and since the global downturn in 2009, there has been a significant slowing of development in WA. The planning horizon of 2023 could see the full development of the LWP landholding and possibly all three stages of the town centre redevelopment[1]. It is unlikely that a rail station would be provided by this time and assessment of the impacts of the future rail station will need to be undertaken by PTA as the size of commuter car parking may have significant traffic impacts during peak periods.

Reference is made to MRWA website traffic data on the South Western Highway to assess the potential regional traffic growth by 2023. MRWA data indicates that the daily volume has increased from 8,860vpd in 2005 to 9,540vpd in 2009, which indicates an increase of about 2% per annum (1.9% actual). The current growth level is slightly less than the traditional expectations of 3%pa, but it is considered that actual growth since 2009 is likely to be lower. Appendix E shows the traffic forecasts for 2023.

Table 7 shows the Sidra analysis of the South Western Highway / Abernethy Road / Beenyup Road intersection with full development by 2023. Sidra outputs are attached in Appendix F.

Table 7 South Western Highway / Beenyup Road 2023

	AM Peak			PM Peak		
Road	Sat	Delay	LoS	Sat	Delay	LoS
SW Highway south	0.403	15s	B	0.466	17s	B
Beenyup Road	0.332	23s	B	0.200	21s	B
SW Highway north	0.538	17s	B	0.811	19s	B
Abernethy Road	0.482	24s	B	0.772	27s	B

[1] Stage 2 completion is more likely.

Analysis indicates that the traffic signals within Byford town centre will continue to operate with very good Levels of Service with the forecast traffic increases associated with the proposed development of Lot 2, completion of residential development to the west and completion of all three stages of the town centre.

The traffic signals will operate with very good Levels of Service in 2023.

Analysis of the intersection of South Western Highway / Nettleton Road has also been undertaken for the forecast year of 2023. The analysis is shown in Table 8 and the Sidra outputs attached in Appendix G.

Table 8 South Western Highway / Nettleton Road 2023

	AM Peak			PM Peak		
Road	Sat	Delay	LoS	Sat	Delay	LoS
SW Highway south	0.312	0.2s	A	0.320	0.6s	A
Nettleton Road	0.928	87.3s	F	1.426	511s	F
SW Highway north	0.211	1.6s	A	0.413	1.0s	A

The analysis indicates that the Nettleton Road approach will fail to operate in an acceptable manner and some form of upgrading will be required. MRWA has produced plans showing a widening for South Western Highway adjacent to the subject land with Nettleton Road provided with a full right turn lane. A median will be provided to South Western Highway to allow turning traffic to shelter. Sidra cannot model this scenario but it is a common treatment on many regional roads and caters for significant side road traffic demands.

Analysis of the MRWA intersection layout has been undertaken using Saturn, which can account for median storage and the impact of vehicles waiting in the median. The analysis indicates that the right turn from Nettleton Road would actually experience an overall delay of about 26 seconds during the PM peak (the worst affected peak period), suggesting that Level of Service B would exist.

Nettleton Road intersection requires a median on South Western Highway.

It is expected that development of land adjacent to Nettleton Road will form a later stage of development and it is recommended that the intersection be reviewed at the time of subdivision.

MRWA 2031 Impacts

MRWA requested as part of the development approval for the previous planning application that analysis be provided for 2031, which is beyond the scope set out by the WAPC. A request to MRWA for traffic forecasts for 2031 has been submitted through the Shire of Serpentine-Jarrahdale (at the request of MRWA) but at the time of preparing this report no data has been provided. Analysis for 2031 is provided assuming continuing growth at 2%pa on the South Western Highway. It has been previously assumed that all local development is complete by 2023, so the increase in traffic flows is only the through movement on the South Western Highway. Appendix H shows the derived traffic forecasts and Appendix I shows the Sidra analysis. Table 9 provides a summary.

Table 9 South Western Highway / Beenyup Road 2031

	AM Peak			PM Peak		
Road	Sat	Delay	LoS	Sat	Delay	LoS
SW Highway south	0.426	15.2s	B	0.419	17.3s	B
Beenyup Road	0.329	23.6s	B	0.196	21.3s	B
SW Highway north	0.567	16.7s	B	0.780	18.6s	B
Abernethy Road	0.470	24.3s	B	0.770	27.7s	B

Table 9 suggests that by 2031 with full development of the locality, the traffic signals at Abernethy Road should continue to operate with good Levels of Service. The analysis assumes that the Tonkin Highway has not been constructed, which suggests that South Western Highway would be duplicated to the south to allow the forecast daily volume of 16,200vpd sufficient capacity. However, it would be anticipated that traffic flows on the South Western Highway could significantly reduce with the construction of the Tonkin Highway.

7.0 ACCESS

Nettleton Road

There are two intersections proposed with Nettleton Road and it is shown in Figure 3 that the western access has the highest demand at 315vpd. During the morning peak period a total demand for 31 vehicle movements would be anticipated, split 22 departing the site and 9 entering. Appendix A shows the peak hour flow on Nettleton Road to be about 200 vehicles, although much of this traffic is associated with the existing petrol filling station. Reference to Austroads Table 4.1 from the *Guide to Traffic Engineering Practice Part 5*, reproduced below, provides guidance on the traffic flows that will provide uninterrupted flow conditions. Austroads states that where uninterrupted flow conditions exist, further analysis is not required.

Table 4.1 — Intersection Capacity - Uninterrupted Flow Conditions

Major Road Type[1]	Major Road Flow (vph)[2]	Minor Road Flow (vph)[3]
Two-lane	400	250
	500	200
	650	100
Four-lane	1000	100
	1500	50
	2000	25

Notes:

1. Major road is through road (i.e. has priority).
2. Major road design volumes include through and turning movements.
3. Minor road design volumes include through and turning volumes.

Reference to Table 4.1 above indicates that with a side road demand of 22 vehicles and a major road movement of 200 vehicles, uninterrupted flow conditions will exist. It can also be seen that significant increases can occur on Nettleton Road before analysis of the accesses would be warranted. No turn lane treatments would be considered warranted on Nettleton Road as a result of the proposed development.

Access to Nettleton Road will operate with uninterrupted flow conditions.

Beenyup Road

The accesses to Beenyup Road are forecast to attract 1,253vpd to the west and 805vpd to the east. Therefore the highest peak movement will be (125 peak hour vehicle movements split 70% out) 100 vehicles accessing Beenyup Road. Appendix A show the peak hour flow on Beenyup Road to be about 250 vehicles and reference to Table 4.1 indicates that uninterrupted flow conditions can be expected. Further analysis of the site accesses would not be required.

The accesses to Beenyup Road will operate with uninterrupted flow conditions.

It can be seen that significant increases to local traffic flow would be required to warrant further analysis of the access operation.

Turning Lane Requirements

Access to the site is taken from Beenyup Road, a street of a residential nature. Current traffic flows are low and would not be expected to increase significantly other than from the proposed development. The opposing traffic movement is very low and is highly unlikely to result in turning traffic causing significant interruption to the through movement. Long term analysis of the traffic signal operation indicates a possible queue of 35 metres. The first access is located approximately 80 metres from the signal stop line and queuing traffic would not restrict access during peak periods. A right turn lane for the site access is not therefore considered to be warranted. It is also considered that occasional turning vehicles will assist speed reduction on Beenyup Road, thereby improving safety for local residents.

Right turn lanes are not required for the site accesses.

Visibility

Nettleton Road has a posted speed limit of 60kph, which is unlikely to change. Beenyup Road should be operating with the urban 50kph limit due to its obvious residential nature. However, it is expected that 60kph is probably the assumed posted speed. A visibility of 71 metres Approach Sight Distance is required under Austroads with a desirable visibility to Safe Intersection Sight Distance of 114 metres (minimum). Photographs 2 and 3 show the views along Beenyup Road and Nettleton Road and it can be seen that the relatively straight alignment of these roads will permit visibility to Austroads standards to be achieved.

Austroads visibility for the accesses can be achieved.

8.0 INTERNAL TRAFFIC MATTERS

Figure 2 shows the site layout and Figure 3 indicates the expected daily traffic flows. It can be seen that internal roads will generally cater for less than 500 vehicles per day. At access locations a higher flow will occur up to 1,200vpd. The forecast traffic movements provide for quiet residential streets and a reduced road reservation would be recommended to limit traffic speeds and provide a good residential environment.

Liveable Neighbourhoods suggests that residential streets with about 1,000vpd can be considered as access streets and a 14.2 metre wide road reservation is suitable. A 6 metre road pavement allows ample room for two-way traffic and would permit the occasional parking of a vehicle on the street. Figure 4 shows the recommended cross-section for low traffic streets based on advice set out in *Liveable Neighbourhoods*.

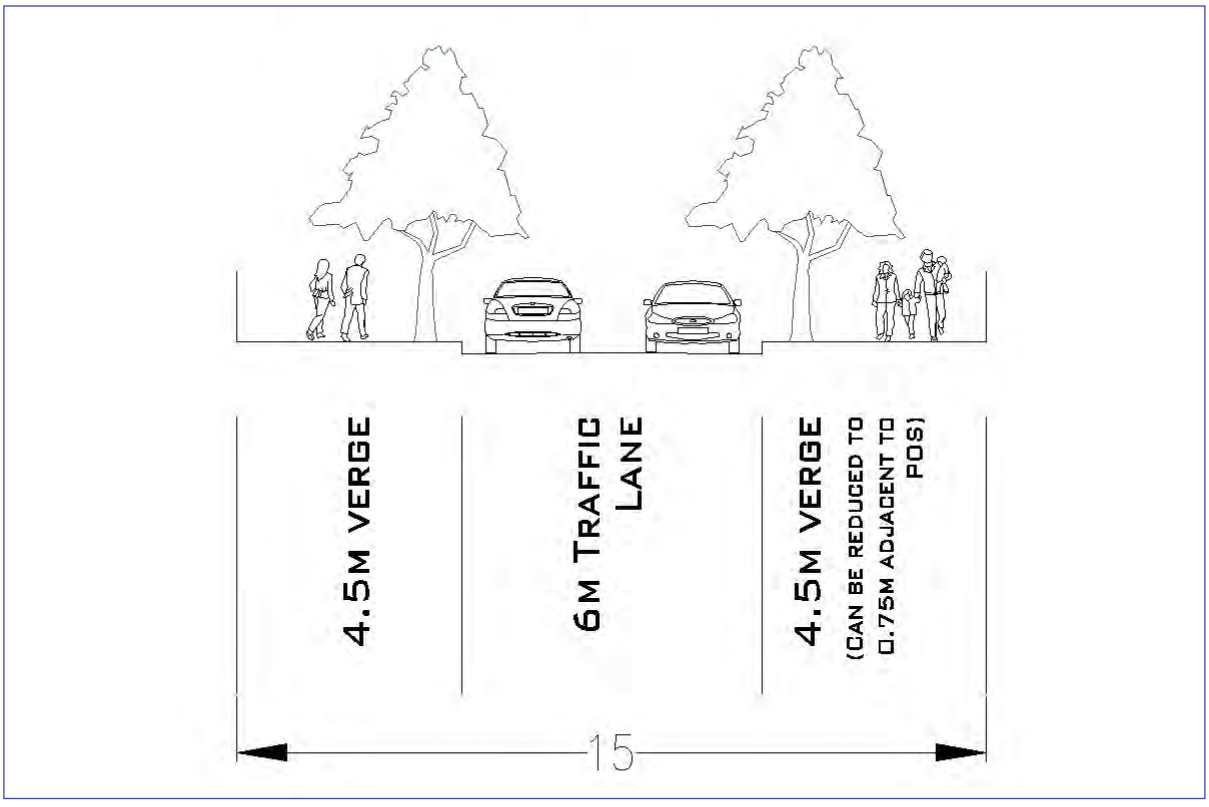


Figure 4 Suggested Road Cross-Section

The cross-section shows a typical 15.0 metre wide road reservation with a 6.0 metre road pavement. A wider road would not be required in this area as adjacent land uses are residential and on-street parking is unlikely (except for visitors). A footpath should be provided to at least one side of the road. The road reservation and cross-section are in accordance with *Liveable Neighbourhoods*.

Public Open Space

Where the road reservation abuts public open space (or any other undeveloped land in a reserve) there is limited need to provide a full width verge. The verge may be reduced where parking and/or services are not required and this should be considered at the time of subdivision. A minimum verge of 1.0 metre is suggested to accommodate street furniture.

Laneways

It is recommended that where laneways are used a width of 7.0 metres is provided. Based on Australian Standards this width will provide access to the minimum garage doorway width of 2.4 metres. A minimum laneway width of 6.0 metres, as set out by *Liveable Neighbourhoods* is acceptable, but should be provided with a design guideline addressing the minimum garage doorway width to be used.

9.0 PEDESTRIANS, CYCLISTS AND PUBLIC TRANSPORT

The subject site is located close to Byford town centre. The town centre is set to be developed to provide a commercial and social hub to the locality. In the long term a rail station may be developed within the town centre, although PTA has suggested that excessive levels of parking will be required which will detract from the walkability of the town centre. However, this is an issue that can only be addressed by the Shire.

Traffic signals have been introduced on the South Western Highway at Abernethy Road / Beenyup Road and a pedestrian facility is provided.

A footpath is provided to the north side of Beenyup Road only (in the vicinity of the subject land). It is recommended that between the subject site access and South Western Highway, a 2.0 metre wide footpath be provided.

A footpath should be provided between South Western Highway and the site entrance.

Cycling

Cycling is not expected to be very attractive due to the high speed road network in the locality and the current lack of local facilities. However, the town centre will provide cycle parking and it can be expected that for small shopping needs, local residents can cycle. In the longer term cycle facilities at the South Western Highway traffic signals may be desirable.

All internal streets carry low traffic volumes and cycling on internal streets would be considered safe and appropriate.

Public Transport

Figure 5 shows current bus services in the locality. Buses are provided to Armadale rail station where a regular train service is provided to Perth and the metropolitan area. A rail service is provided from Byford station to Perth and Bunbury. The service operates twice a day in each direction and ticket bookings are required.

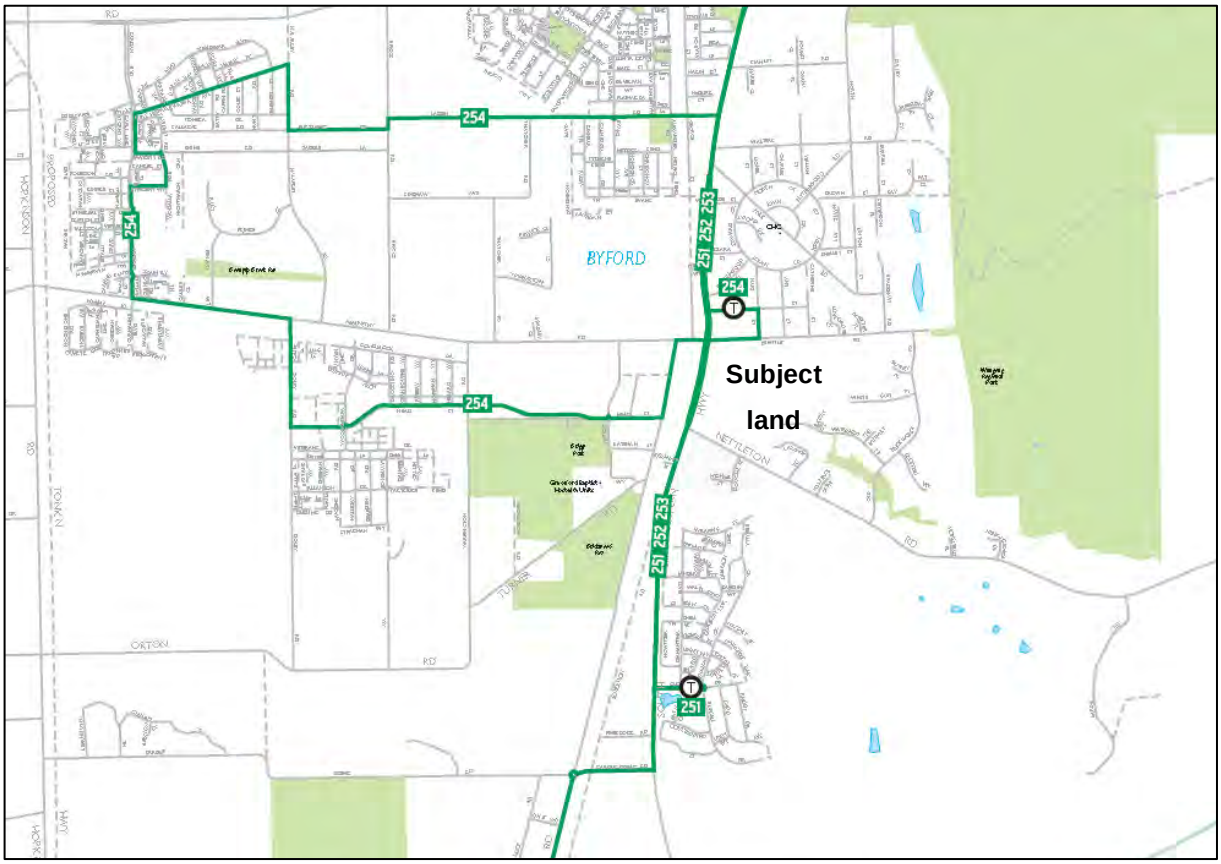
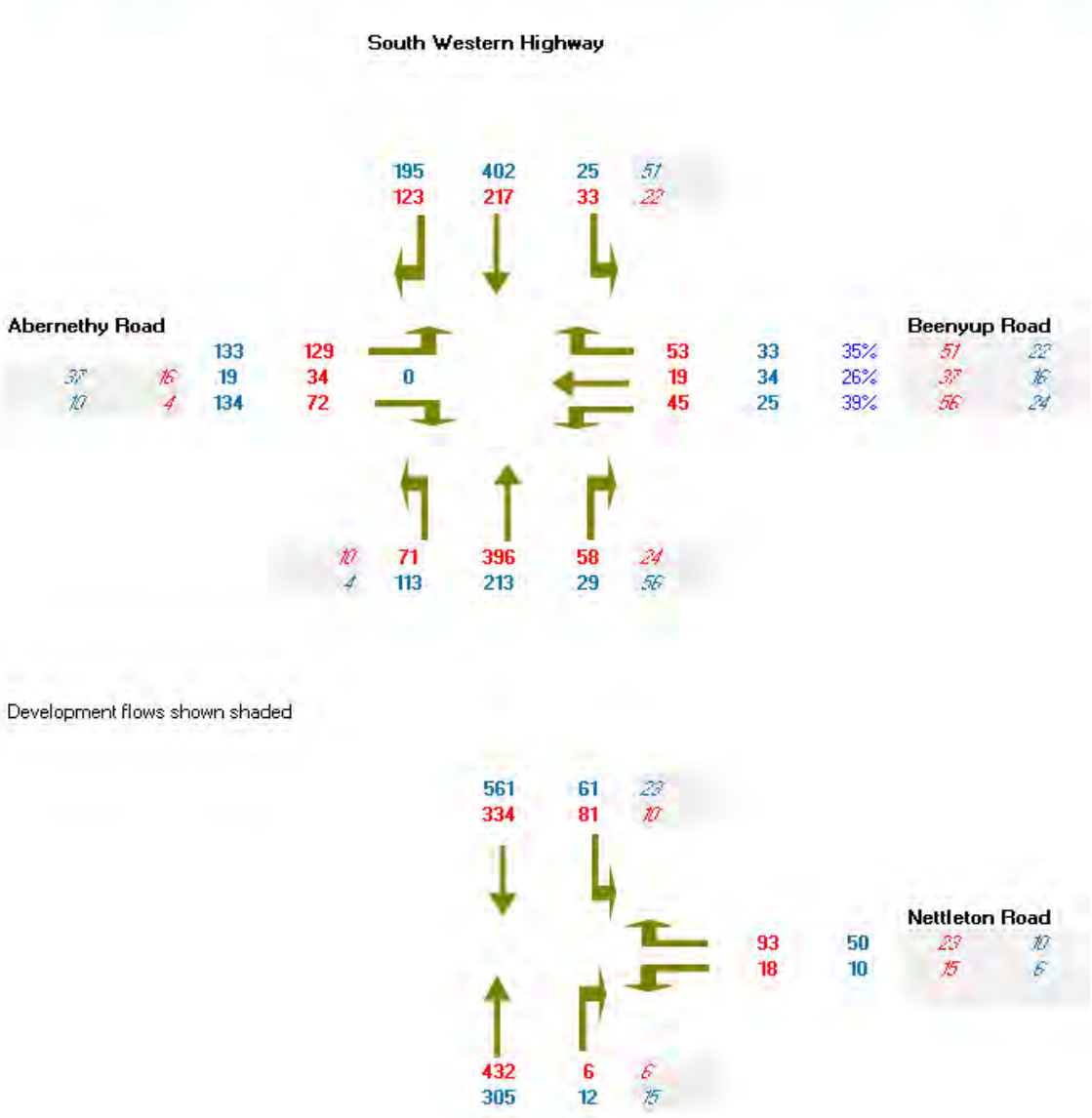


Figure 5 Local Bus Routes

APPENDIX A

SOUTH WESTERN HIGHWAY PEAK HOUR TURNING DATA AND FORECAST DEVELOPMENT FLOWS



Based on Scats data April 2013

APPENDIX B

Levels of Service by Daily Volume

LOS	Single Carriageway[1]	2 Lane Boulevard[2]	Dual Carriageway (4 Lanes)[3]	Dual Carriageway (4 lane Clearway)[3]
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 C

MOVEMENT SUMMARY

Site: SWH - Abernethy AM ex-isitng

South Western Highway / Abernethy Road
Exisitng AM peak hour
Signals - Fixed Time Cycle Time = 60 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: South Western Highway South											
1	L	75	3.0	0.294	19.6	LOS B	6.1	45.5	0.67	0.86	40.4
2	T	417	9.0	0.294	11.4	LOS A	6.1	46.4	0.67	0.57	43.2
3	R	61	3.0	0.119	19.9	LOS B	1.7	12.3	0.64	0.74	38.8
Approach		553	7.5	0.294	13.4	LOS A	6.1	46.4	0.67	0.62	42.3
East: Beenyup Road											
4	L	47	3.0	0.103	22.6	LOS B	2.0	14.5	0.71	0.77	37.6
5	T	20	3.0	0.103	14.3	LOS A	2.0	14.5	0.71	0.55	39.4
6	R	56	3.0	0.137	25.0	LOS B	1.9	13.4	0.76	0.74	35.6
Approach		123	3.0	0.137	22.3	LOS B	2.0	14.5	0.73	0.72	36.9
North: South Western Highway North											
7	L	35	3.0	0.157	18.8	LOS B	3.3	24.7	0.62	0.85	41.0
8	T	228	9.0	0.157	10.6	LOS A	3.3	25.1	0.62	0.50	44.1
9	R	129	3.0	0.329	23.5	LOS B	4.0	29.1	0.76	0.78	36.5
Approach		393	6.5	0.329	15.6	LOS B	4.0	29.1	0.67	0.63	41.0
West: Abernethy Road											
10	L	136	3.0	0.301	23.6	LOS B	5.0	36.2	0.76	0.79	36.8
11	T	36	3.0	0.302	15.3	LOS B	5.0	36.2	0.76	0.62	38.2
12	R	76	3.0	0.154	23.6	LOS B	2.4	17.1	0.74	0.75	36.5
Approach		247	3.0	0.301	22.4	LOS B	5.0	36.2	0.75	0.75	36.9
All Vehicles		1316	5.9	0.329	16.6	LOS B	6.1	46.4	0.69	0.66	40.3

MOVEMENT SUMMARY

Site: SWH - Abernethy PM ex-isitng

South Western Highway / Abernethy Road
Exisitng PM peak hour
Signals - Fixed Time Cycle Time = 60 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: South Western Highway South											
1	L	119	3.0	0.206	19.1	LOS B	4.3	31.3	0.64	0.80	39.9
2	T	224	9.0	0.206	10.8	LOS A	4.3	32.6	0.64	0.53	43.7
3	R	31	3.0	0.074	21.1	LOS B	0.9	6.5	0.66	0.72	38.0
Approach		374	6.6	0.206	14.3	LOS A	4.3	32.6	0.64	0.63	41.9
East: Beenyup Road											
4	L	26	3.0	0.094	22.5	LOS B	1.9	13.4	0.70	0.79	38.2
5	T	36	3.0	0.094	14.2	LOS A	1.9	13.4	0.70	0.54	40.0
6	R	35	3.0	0.084	24.7	LOS B	1.2	8.3	0.75	0.72	35.9
Approach		97	3.0	0.094	20.2	LOS B	1.9	13.4	0.72	0.67	37.9
North: South Western Highway North											
7	L	26	3.0	0.268	19.5	LOS B	5.6	42.1	0.66	0.90	41.0
8	T	423	9.0	0.269	11.2	LOS A	5.6	42.4	0.66	0.55	43.5
9	R	205	3.0	0.436	22.7	LOS B	6.1	43.6	0.77	0.80	37.0
Approach		655	6.9	0.436	15.2	LOS B	6.1	43.6	0.70	0.64	41.2
West: Abernethy Road											
10	L	140	3.0	0.281	23.5	LOS B	4.7	33.8	0.75	0.78	36.7
11	T	20	3.0	0.281	15.2	LOS B	4.7	33.8	0.75	0.61	38.2
12	R	141	3.0	0.285	24.4	LOS B	4.4	31.6	0.78	0.78	36.0
Approach		301	3.0	0.285	23.3	LOS B	4.7	33.8	0.76	0.77	36.5
All Vehicles		1426	5.7	0.436	17.0	LOS B	6.1	43.6	0.70	0.67	40.0

MOVEMENT SUMMARY

Site: SWH - Abernethy AM +Lot 2

South Western Highway / Abernethy Road
2013 AM peak hour with development
Signals - Fixed Time Cycle Time = 60 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: South Western Highway South											
1	L	75	3.0	0.294	19.6	LOS B	6.1	45.5	0.67	0.86	40.4
2	T	417	9.0	0.294	11.4	LOS A	6.1	46.4	0.67	0.57	43.2
3	R	86	3.0	0.172	20.3	LOS B	2.4	17.5	0.66	0.75	38.6
Approach		578	7.3	0.294	13.8	LOS A	6.1	46.4	0.67	0.63	42.1
East: Beenyup Road											
4	L	113	3.0	0.262	23.6	LOS B	5.0	36.1	0.76	0.81	37.1
5	T	59	3.0	0.262	15.3	LOS B	5.0	36.1	0.76	0.62	38.5
6	R	116	3.0	0.294	26.8	LOS B	3.9	28.2	0.82	0.78	34.6
Approach		287	3.0	0.294	23.2	LOS B	5.0	36.1	0.78	0.75	36.3
North: South Western Highway North											
7	L	58	3.0	0.171	18.9	LOS B	3.6	26.6	0.63	0.83	40.6
8	T	228	9.0	0.171	10.6	LOS A	3.6	27.3	0.63	0.51	43.9
9	R	129	3.0	0.329	23.5	LOS B	4.0	29.1	0.76	0.78	36.5
Approach		416	6.3	0.329	15.8	LOS B	4.0	29.1	0.67	0.64	40.9
West: Abernethy Road											
10	L	136	3.0	0.331	23.7	LOS B	5.5	39.6	0.76	0.80	36.8
11	T	53	3.0	0.330	15.5	LOS B	5.5	39.6	0.76	0.63	38.3
12	R	76	3.0	0.186	25.4	LOS B	2.5	18.2	0.78	0.75	35.4
Approach		264	3.0	0.331	22.6	LOS B	5.5	39.6	0.77	0.75	36.7
All Vehicles		1545	5.5	0.331	17.6	LOS B	6.1	46.4	0.71	0.68	39.6

MOVEMENT SUMMARY

Site: SWH - Abernethy PM + Lot 2

South Western Highway / Abernethy Road
2013 PM peak hour with Lot 2

Signals - Fixed Time Cycle Time = 60 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: South Western Highway South											
1	L	119	3.0	0.206	19.1	LOS B	4.3	31.3	0.64	0.80	39.9
2	T	224	9.0	0.206	10.8	LOS A	4.3	32.6	0.64	0.53	43.7
3	R	89	3.0	0.231	22.9	LOS B	2.8	20.0	0.73	0.76	36.9
Approach		433	6.1	0.231	15.6	LOS B	4.3	32.6	0.66	0.65	41.1
East: Beenyup Road											
4	L	52	3.0	0.158	22.9	LOS B	3.1	22.3	0.72	0.80	37.8
5	T	53	3.0	0.158	14.6	LOS B	3.1	22.3	0.72	0.57	39.5
6	R	63	3.0	0.164	26.0	LOS B	2.2	15.5	0.79	0.75	35.1
Approach		167	3.0	0.164	21.5	LOS B	3.1	22.3	0.75	0.71	37.2
North: South Western Highway North											
7	L	80	3.0	0.301	19.7	LOS B	6.3	46.6	0.68	0.86	40.3
8	T	423	9.0	0.301	11.4	LOS A	6.3	47.4	0.68	0.57	43.1
9	R	205	3.0	0.436	22.7	LOS B	6.1	43.6	0.77	0.80	37.0
Approach		708	6.6	0.436	15.6	LOS B	6.3	47.4	0.70	0.67	40.8
West: Abernethy Road											
10	L	140	3.0	0.349	23.8	LOS B	5.8	41.7	0.77	0.81	36.8
11	T	59	3.0	0.349	15.6	LOS B	5.8	41.7	0.77	0.63	38.2
12	R	141	3.0	0.306	25.3	LOS B	4.5	32.4	0.80	0.78	35.5
Approach		340	3.0	0.349	23.0	LOS B	5.8	41.7	0.78	0.77	36.5
All Vehicles		1648	5.4	0.436	17.7	LOS B	6.3	47.4	0.71	0.69	39.5

Note the signal cycle times are selected by SIDRA and are used for comparison purposes only. MRWA may operate the traffic signals with different cycle time to reflect road network policy.

APPENDIX D

South Western Highway / Nettleton Road Analysis

South Western Highway / Nettleton Road AM Peak hour
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
South: South Western Highway south											
2	T	455	3.0	0.238	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
3	R	6	0.0	0.008	10.2	LOS A	0.0	0.2	0.44	0.65	46.8
Approach		461	3.0	0.238	0.1	LOS A	0.0	0.2	0.01	0.01	59.8
East: Nettleton Road											
4	L	19	0.0	0.474	28.3	LOS B	2.7	19.1	0.81	1.04	33.7
6	R	98	0.0	0.473	28.3	LOS B	2.7	19.1	0.81	1.04	33.7
Approach		117	0.0	0.474	28.3	LOS B	2.7	19.1	0.81	1.04	33.7
North: South Western Highway north											
7	L	85	0.0	0.046	8.2	LOS A	0.0	0.0	0.00	0.67	49.0
8	T	352	3.0	0.184	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		437	2.4	0.184	1.6	LOS A	0.0	0.0	0.00	0.13	57.5
All Vehicles		1015	2.4	0.474	4.0	NA	2.7	19.1	0.10	0.18	54.0

South Western Highway / Nettleton Road PM Peak hour
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
South: South Western Highway south											
2	T	321	3.0	0.168	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
3	R	13	0.0	0.018	11.7	LOS A	0.1	0.6	0.54	0.74	45.4
Approach		334	2.9	0.168	0.4	LOS A	0.1	0.6	0.02	0.03	59.3
East: Nettleton Road											
4	L	11	0.0	0.310	28.8	LOS C	1.5	10.4	0.83	1.00	33.4
6	R	53	0.0	0.313	28.9	LOS C	1.5	10.4	0.83	0.99	33.4
Approach		63	0.0	0.313	28.9	LOS C	1.5	10.4	0.83	0.99	33.4
North: South Western Highway north											
7	L	64	0.0	0.035	8.2	LOS A	0.0	0.0	0.00	0.67	49.0
8	T	591	3.0	0.309	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		655	2.7	0.309	0.8	LOS A	0.0	0.0	0.00	0.07	58.7
All Vehicles		1052	2.6	0.313	2.4	NA	1.5	10.4	0.06	0.11	56.3

South Western Highway / Nettleton Road 2013 AM Peak hour with Lot 2
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue		Prop. Queued	Effective Stop Rate	Average Speed
							Vehicles	Distance			
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: South Western Highway south											
2	T	455	3.0	0.238	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
3	R	13	0.0	0.016	10.3	LOS A	0.1	0.5	0.45	0.68	46.7
Approach		467	2.9	0.238	0.3	LOS A	0.1	0.5	0.01	0.02	59.5
East: Nettleton Road											
4	L	35	0.0	0.620	32.4	LOS C	4.2	29.6	0.84	1.18	31.7
6	R	122	0.0	0.620	32.4	LOS C	4.2	29.6	0.84	1.12	31.7
Approach		157	0.0	0.618	32.4	LOS C	4.2	29.6	0.84	1.14	31.7
North: South Western Highway north											
7	L	96	0.0	0.052	8.2	LOS A	0.0	0.0	0.00	0.67	49.0
8	T	352	3.0	0.184	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		447	2.4	0.184	1.8	LOS A	0.0	0.0	0.00	0.14	57.2
All Vehicles		1072	2.3	0.618	5.6	NA	4.2	29.6	0.13	0.23	52.0

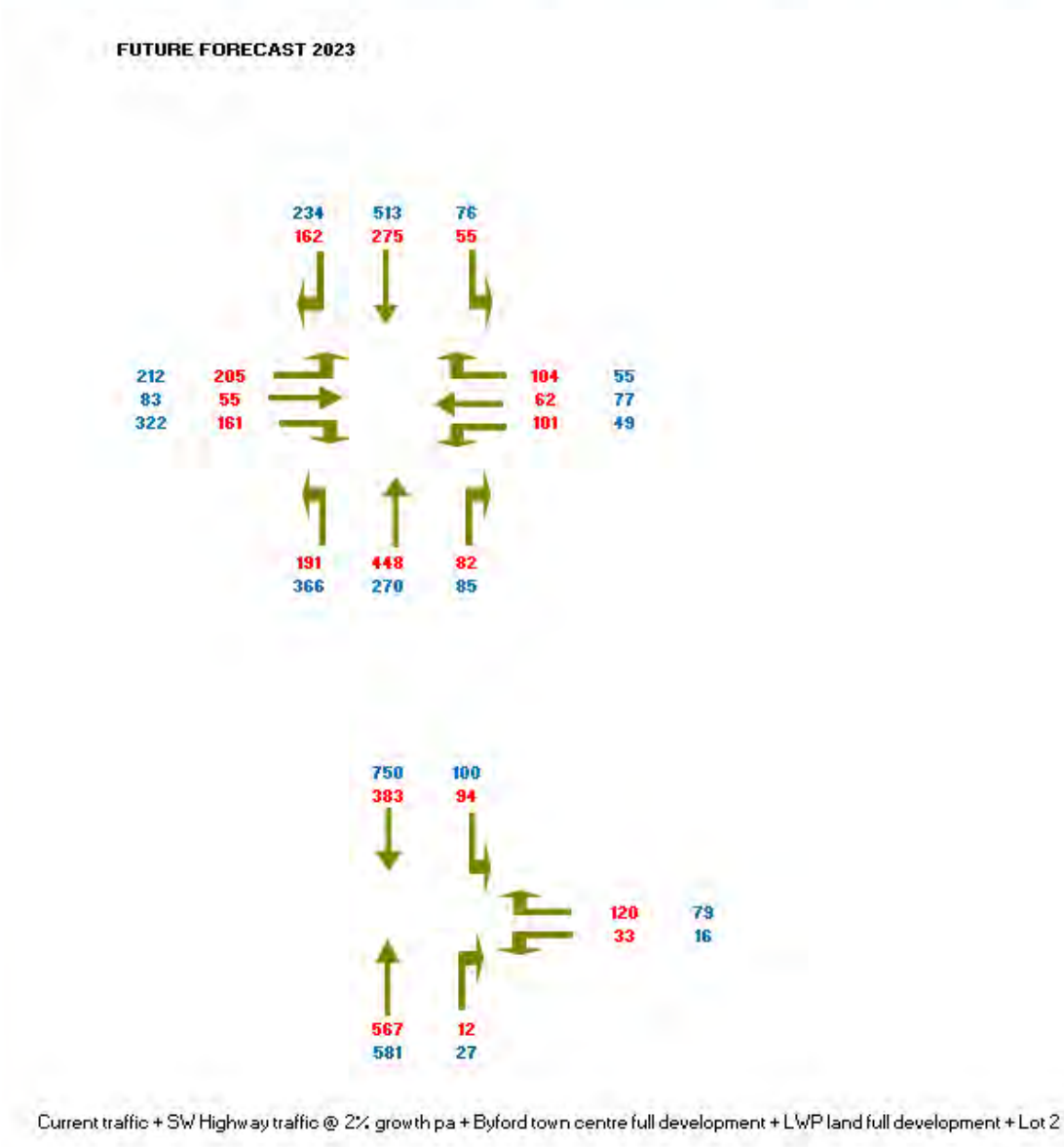
South Western Highway / Nettleton Road PM Peak hour with Lot 2
Giveway / Yield (Two-Way)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue		Prop. Queued	Effective Stop Rate	Average Speed
							Vehicles	Distance			
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: South Western Highway south											
2	T	321	3.0	0.168	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
3	R	28	0.0	0.041	11.9	LOS A	0.2	1.3	0.55	0.78	45.1
Approach		349	2.8	0.168	1.0	LOS A	0.2	1.3	0.05	0.06	58.4
East: Nettleton Road											
4	L	17	0.0	0.401	31.5	LOS C	2.0	14.2	0.85	1.04	32.1
6	R	63	0.0	0.405	31.6	LOS C	2.0	14.2	0.85	1.02	32.1
Approach		80	0.0	0.404	31.6	LOS C	2.0	14.2	0.85	1.02	32.1
North: South Western Highway north											
7	L	88	0.0	0.048	8.2	LOS A	0.0	0.0	0.00	0.67	49.0
8	T	591	3.0	0.309	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		679	2.6	0.309	1.1	LOS A	0.0	0.0	0.00	0.09	58.3
All Vehicles		1108	2.5	0.404	3.2	NA	2.0	14.2	0.08	0.15	55.1

APPENDIX E

2023 Peak Period Traffic Forecasts



Current traffic + SW Highway traffic @ 2% growth pa + Byford town centre full development + LWP land full development + Lot 2

APPENDIX F

Sidra Analysis 2023

South Western Highway / Abernethy Road AM peak hour
2023 Full Development Signals - Fixed Time Cycle Time = 60 seconds (Practical Cycle Time)

MOVEMENT SUMMARY Site: SWH - Abernethy AM 2023

South Western Highway / Abernethy Road
AM peak hour
2023 Full Development
Signals - Fixed Time Cycle Time = 60 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: South Western Highway South											
1	L	201	3.0	0.403	20.4	LOS B	8.4	61.3	0.72	0.84	39.3
2	T	472	9.0	0.403	12.1	LOS A	8.4	63.5	0.72	0.61	42.3
3	R	86	3.0	0.185	21.1	LOS B	2.5	18.0	0.68	0.75	38.1
Approach		759	6.7	0.403	15.3	LOS B	8.4	63.5	0.71	0.69	41.0
East: Beenyup Road											
4	L	106	3.0	0.262	23.6	LOS B	5.0	36.1	0.76	0.81	37.2
5	T	65	3.0	0.262	15.3	LOS B	5.0	36.1	0.76	0.62	38.6
6	R	109	3.0	0.332	28.8	LOS C	3.9	28.2	0.86	0.78	33.6
Approach		281	3.0	0.332	23.7	LOS B	5.0	36.1	0.80	0.75	36.0
North: South Western Highway North											
7	L	58	3.0	0.208	19.1	LOS B	4.4	32.3	0.64	0.85	40.7
8	T	289	9.0	0.208	10.9	LOS A	4.4	33.0	0.64	0.53	43.7
9	R	171	3.0	0.539	26.7	LOS B	5.8	41.7	0.86	0.81	34.7
Approach		518	6.4	0.538	17.0	LOS B	5.8	41.7	0.71	0.66	39.9
West: Abernethy Road											
10	L	216	3.0	0.482	24.6	LOS B	7.9	56.9	0.81	0.82	36.2
11	T	58	3.0	0.482	16.4	LOS B	7.9	56.9	0.81	0.68	37.3
12	R	169	3.0	0.416	26.9	LOS B	5.6	40.3	0.84	0.80	34.6
Approach		443	3.0	0.482	24.4	LOS B	7.9	56.9	0.82	0.79	35.7
All Vehicles		2001	5.3	0.538	18.9	LOS B	8.4	63.5	0.75	0.71	38.7

South Western Highway / Abernethy Road PM peak hour
2023 Full Development Signals - Fixed Time Cycle Time = 60 seconds (Practical Cycle Time)

MOVEMENT SUMMARY Site: SWH - Abernethy PM 2023

South Western Highway / Abernethy Road
PM peak hour
2023 Full Development
Signals - Fixed Time Cycle Time = 60 seconds (Practical Cycle Time)

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: South Western Highway South											
1	L	385	3.0	0.466	20.8	LOS B	9.7	69.4	0.74	0.81	38.2
2	T	284	9.0	0.339	11.7	LOS A	7.1	53.4	0.69	0.58	43.2
3	R	89	3.0	0.266	24.0	LOS B	2.9	20.8	0.75	0.77	36.2
Approach		759	5.2	0.466	17.8	LOS B	9.7	69.4	0.72	0.72	39.7
East: Beenyup Road											
4	L	52	3.0	0.200	23.2	LOS B	3.9	28.1	0.74	0.82	37.9
5	T	81	3.0	0.200	14.9	LOS B	3.9	28.1	0.74	0.59	39.5
6	R	58	3.0	0.191	28.9	LOS C	2.1	15.4	0.84	0.75	33.6
Approach		191	3.0	0.200	21.4	LOS B	3.9	28.1	0.77	0.70	37.1
North: South Western Highway North											
7	L	80	3.0	0.371	20.1	LOS B	7.7	57.5	0.70	0.88	40.2
8	T	540	9.0	0.371	11.9	LOS A	7.7	58.4	0.70	0.60	42.7
9	R	246	3.0	0.811	37.2	LOS C	10.1	72.5	0.98	1.01	29.7
Approach		866	6.7	0.811	19.8	LOS B	10.1	72.5	0.78	0.74	37.8
West: Abernethy Road											
10	L	223	3.0	0.547	25.0	LOS B	9.0	64.3	0.83	0.83	36.1
11	T	87	3.0	0.546	16.8	LOS B	9.0	64.3	0.83	0.70	37.1
12	R	339	3.0	0.772	32.7	LOS C	12.0	86.4	0.96	0.94	31.7
Approach		649	3.0	0.772	27.9	LOS B	12.0	86.4	0.90	0.87	33.8
All Vehicles		2465	5.0	0.811	21.4	LOS B	12.0	86.4	0.79	0.77	37.1

APPENDIX G

Sidra Analysis 2023

South Western Highway / Nettleton Road AM Peak hour 2023
Full Development Scenario 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
South: South Western Highway south											
2	T	597	3.0	0.312	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
3	R	13	0.0	0.016	10.6	LOS A	0.1	0.5	0.48	0.69	46.4
Approach		609	2.9	0.312	0.2	LOS A	0.1	0.5	0.01	0.01	59.6
East: Nettleton Road											
4	L	35	0.0	0.939	87.3	LOS F	10.1	70.5	0.95	1.84	17.6
6	R	126	0.0	0.929	87.3	LOS F	10.1	70.5	0.95	1.58	17.6
Approach		161	0.0	0.928	87.3	LOS F	10.1	70.5	0.95	1.63	17.6
North: South Western Highway north											
7	L	99	0.0	0.053	8.2	LOS A	0.0	0.0	0.00	0.67	49.0
8	T	403	3.0	0.211	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		502	2.4	0.211	1.6	LOS A	0.0	0.0	0.00	0.13	57.5
All Vehicles		1273	2.4	0.928	11.8	NA	10.1	70.5	0.13	0.27	45.3

South Western Highway / Nettleton Road PM Peak hour with Lot 2 2023
Full Development Scenario 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
South: South Western Highway south											
2	T	612	3.0	0.320	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
3	R	28	0.0	0.055	14.1	LOS A	0.2	1.7	0.65	0.87	43.2
Approach		640	2.9	0.320	0.6	LOS A	0.2	1.7	0.03	0.04	59.0
East: Nettleton Road											
4	L	17	0.0	1.404	511.4	LOS F	26.3	184.2	1.00	2.65	4.0
6	R	83	0.0	1.434	511.4	LOS F	26.3	184.2	1.00	2.31	4.0
Approach		100	0.0	1.426	511.4	LOS F	26.3	184.2	1.00	2.37	4.0
North: South Western Highway north											
7	L	105	0.0	0.057	8.2	LOS A	0.0	0.0	0.00	0.67	49.0
8	T	789	3.0	0.413	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		895	2.6	0.413	1.0	LOS A	0.0	0.0	0.00	0.08	58.5
All Vehicles		1635	2.6	1.426	32.1	NA	26.3	184.2	0.07	0.20	31.9

South Western Highway / Nettleton Road PM Peak hour with Lot 2 2023
Full Development Scenario Giveway / Yield (Two-Way) MRWA Layout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue		Prop. Queued	Effective Stop Rate	Average Speed
							Vehicles	Distance			
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: South Western Highway south											
2	T	612	3.0	0.320	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
3	R	28	0.0	0.055	13.8	LOS A	0.2	1.7	0.65	0.86	43.5
Approach		640	2.9	0.320	0.6	LOS A	0.2	1.7	0.03	0.04	59.0
East: Nettleton Road											
4	L	17	0.0	0.040	14.8	LOS B	0.2	1.1	0.66	0.87	42.6
6	R	83	0.0	1.386	491.4	LOS F	21.8	152.7	1.00	2.09	4.1
Approach		100	0.0	1.386	411.2	LOS F	21.8	152.7	0.94	1.88	4.9
North: South Western Highway north											
7	L	105	0.0	0.057	8.2	LOS A	0.0	0.0	0.00	0.67	49.0
8	T	789	3.0	0.413	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		895	2.6	0.413	1.0	LOS A	0.0	0.0	0.00	0.08	58.5
All Vehicles		1635	2.6	1.386	25.9	NA	21.8	152.7	0.07	0.17	35.0

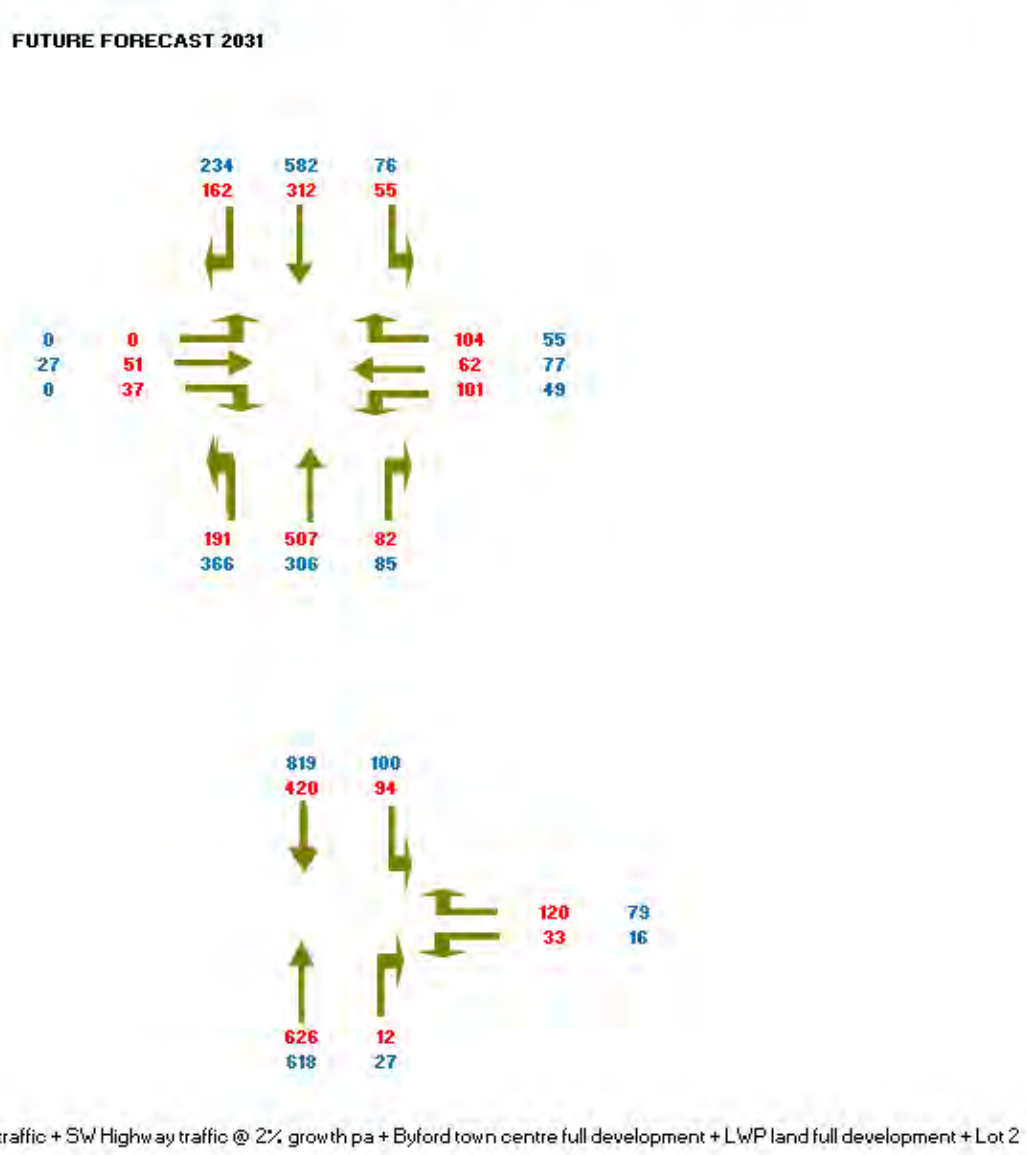
South Western Highway / Nettleton Road Saturn Analysis

```
    NODE      5 (PRIORITY)    - ORIGINAL INPUT DELAYS AND FLOWS PER TURN/LINK:
 FROM     TO  AVERAGE   FIXED DEMAND  QUED ARRIVE QUED ACTUAL  CAPAC   V/C
              DELAY     FLOW   FLOW    UP   FLOW  HERE  FLOW    -ITY    %  TPM
   NODES      SECONDS   (      ALL       IN       PCUS / HOUR       )

    2      7    3.6            27.0  0.00   27.0  0.00   27.0 1108.8   2.4    G

    4      7    0.0           120.0  0.00  120.0  0.00  120.0 1350.0   8.9
    4      6    0.0            16.0  0.00   16.0  0.00   16.0 2675.6   0.6
  TOTALS
 FROM      4    0.0           136.0   0.0  136.0   0.0  136.0 2750.0   4.9

    7      6    3.1           750.0  0.00  750.0  0.00  750.0 1320.2  56.8    G
    7      2    3.1           100.0  0.00  100.0  0.00  100.0 1418.0   7.1    G
  TOTALS
 FROM      7    3.1           850.0   0.0  850.0   0.0  850.0 2738.3  31.0

  OVERALL       2.7          1013.0   0.0 1013.0   0.0 1013.0 6597.1  15.4

    NODE      2 (PRIORITY)    - ORIGINAL INPUT DELAYS AND FLOWS PER TURN/LINK:
 FROM     TO  AVERAGE   FIXED DEMAND  QUED ARRIVE QUED ACTUAL  CAPAC   V/C
              DELAY     FLOW   FLOW    UP   FLOW  HERE  FLOW    -ITY    %  TPM
   NODES      SECONDS   (      ALL       IN       PCUS / HOUR       )

    1      3    0.0           581.0  0.00  581.0  0.00  581.0 2800.0  20.8
    1      5    0.0            27.0  0.00   27.0  0.00   27.0 1350.0   2.0
  TOTALS
 FROM      1    0.0           608.0   0.0  608.0   0.0  608.0 4150.0  14.7

    5      3   10.0           100.0  0.00  100.0  0.00  100.0  435.8  22.9    G

  OVERALL       1.4           708.0   0.0  708.0   0.0  708.0 4585.8  15.4
```

	AM Peak			PM Peak		
Road	Sat	Delay	LoS	Sat	Delay	LoS
Nettleton Road left				0.071	3.1s	
Right				0.568	3.1s	
Right from Median				0.229	22.9s	
SW Highway Right				0.024	3.6s	

APPENDIX H

2031 Peak Period Traffic Forecasts



Current traffic + SW Highway traffic @ 2% growth pa + Byford town centre full development + LWP land full development + Lot 2

APPENDIX I

South Western Highway / Abernethy Road AM peak hour
2031 Full Development Signals - Fixed Time Cycle Time = 60 seconds (Practical Cycle Time)

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
South: South Western Highway South											
1	L	201	0.0	0.426	20.4	LOS B	9.1	64.1	0.73	0.84	39.3
2	T	534	3.0	0.426	12.2	LOS A	9.2	65.9	0.73	0.62	42.2
3	R	86	0.0	0.191	21.0	LOS B	2.5	17.6	0.68	0.75	38.0
Approach		821	2.0	0.426	15.2	LOS B	9.2	65.9	0.72	0.69	41.0
East: Beenyup Road											
4	L	106	0.0	0.257	23.4	LOS B	5.0	35.1	0.75	0.81	37.2
5	T	65	0.0	0.256	15.2	LOS B	5.0	35.1	0.75	0.62	38.7
6	R	109	0.0	0.329	28.7	LOS C	3.9	27.4	0.86	0.78	33.6
Approach		281	0.0	0.329	23.6	LOS B	5.0	35.1	0.79	0.75	36.0
North: South Western Highway North											
7	L	58	0.0	0.223	19.1	LOS B	4.8	34.2	0.65	0.86	40.7
8	T	328	3.0	0.223	10.9	LOS A	4.8	34.7	0.65	0.53	43.7
9	R	171	0.0	0.567	27.1	LOS B	5.9	41.4	0.87	0.82	34.4
Approach		557	1.8	0.567	16.7	LOS B	5.9	41.4	0.72	0.66	40.1
West: Abernethy Road											
10	L	216	0.0	0.470	24.5	LOS B	7.9	55.2	0.81	0.82	36.2
11	T	58	0.0	0.470	16.3	LOS B	7.9	55.2	0.81	0.68	37.4
12	R	169	0.0	0.414	26.8	LOS B	5.6	39.2	0.84	0.80	34.6
Approach		443	0.0	0.470	24.3	LOS B	7.9	55.2	0.82	0.79	35.7
All Vehicles		2102	1.2	0.567	18.6	LOS B	9.2	65.9	0.75	0.71	38.8

South Western Highway / Abernethy Road PM peak hour
2031 Full Development Signals - Fixed Time Cycle Time = 60 seconds (Practical Cycle Time)

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
South: South Western Highway South											
1	L	354	0.0	0.419	20.4	LOS B	8.8	61.7	0.72	0.81	38.4
2	T	322	3.0	0.370	11.8	LOS A	8.0	57.2	0.70	0.60	43.0
3	R	89	0.0	0.283	24.8	LOS B	3.0	20.9	0.77	0.77	35.7
Approach		765	1.3	0.419	17.3	LOS B	8.8	61.7	0.72	0.71	39.9
East: Beenyup Road											
4	L	52	0.0	0.196	23.0	LOS B	3.9	27.4	0.73	0.82	37.9
5	T	81	0.0	0.196	14.8	LOS B	3.9	27.4	0.73	0.59	39.5
6	R	58	0.0	0.189	28.8	LOS C	2.1	15.0	0.84	0.75	33.6
Approach		191	0.0	0.196	21.3	LOS B	3.9	27.4	0.77	0.70	37.1
North: South Western Highway North											
7	L	80	0.0	0.400	20.2	LOS B	8.6	61.0	0.71	0.88	40.2
8	T	613	3.0	0.400	12.0	LOS A	8.6	61.7	0.71	0.61	42.5
9	R	246	0.0	0.779	34.3	LOS C	9.7	67.7	0.96	0.97	30.9
Approach		939	2.0	0.780	18.6	LOS B	9.7	67.7	0.78	0.73	38.5
West: Abernethy Road											
10	L	223	0.0	0.534	24.9	LOS B	8.9	62.5	0.82	0.83	36.2
11	T	87	0.0	0.533	16.7	LOS B	8.9	62.5	0.82	0.70	37.2
12	R	339	0.0	0.770	32.5	LOS C	12.0	84.0	0.96	0.94	31.7
Approach		649	0.0	0.770	27.7	LOS B	12.0	84.0	0.90	0.87	33.8
All Vehicles		2544	1.1	0.780	20.7	LOS B	12.0	84.0	0.79	0.76	37.5

POS STAGE 1
CENTRAL PUBLIC OPEN SPACE PROVIDING SEATING AND bbq NODE, OPEN TURF KICK-A-BOUT SPACE AND PLAY/EXERCISE ELEMENTS FOR ALL AGES.
REFER TO DETAILED PLAN 13031-02 C1-101

POS
LARGE ADVENTURE POS. FORMALISED SEATING NODES AND SHADED TURF SPACES TO SURROUND CENTRAL PLAY AREA.
REFER TO DETAILED PLAN 13031-0 C1-101

ENTRY ROAD 2
VEGETATED MEDIAN AND VERGES TO WIDENED PAVED ROAD. FEATURE ART-WORK MARKERS TO MARK ENTRANCES TO THE SITE.

ENTRY ROAD 1
VEGETATED MEDIAN AND VERGES TO WIDENED PAVED ROAD. FEATURE ART-WORK MARKERS TO MARK ENTRANCES TO THE SITE.

VEGETATED BUFFER
BUFFER TO BE DENSELY PLANTED WITH NATIVE TREES AND SHRUBS TO PROVIDE BUFFER BETWEEN THE ESTATE AND SOUTH WESTERN HIGHWAY.

DRAINAGE BASINS
BASINS TO BE PLANTED OUT WITH NATIVE SPECIES SUITABLE FOR INUNDATION. STANDS OF NATIVE TREES TO BE INSTALLED DIN DRAINAGE BASINS.

MULTIPLE USE CORRIDOR
STREAM TO BE REHABILITATED AS PER MANAGEMENT PLAN. AREAS OUTSIDE THE REHABILITATION ZONE WILL BE PLANTED WITH NATIVE SPECIES OR LEFT AS EDGED PASTORAL GRASSES. THESE AREAS WILL PROVIDE NATURAL PASSIVE RECREATIONAL FACILITIES SUCH AS WALKING PATHS AND PICNIC NODES.

CONSERVATION
REHABILITATION AREA. ALL EXISTING TREES AND NATIVE UNDERGROWTH TO BE RETAINED. AREAS THAT HAVE BEEN DEGRADED ARE TO HAVE SOIL PREPARATION AND RE-PLANTING WORKS UNDERTAKEN TO ACHIEVE NOMINATED COMPLETION CRITERIA. WEED CONTROL TO TAKE PLACE ACROSS WHOLE SITE. PATHWAYS TO BE INSTALLED IN AREAS THAT WONT REQUIRE CLEARING TO ALLOW MAINTENANCE VEHICLE ACCESS AND FIRE BREAKS.

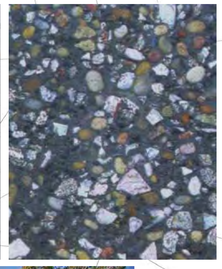
DRAINAGE BASINS
BASINS TO BE PLANTED OUT WITH NATIVE SPECIES SUITABLE FOR INUNDATION. STANDS OF NATIVE TREES TO BE INSTALLED DIN DRAINAGE BASINS.

EXISTING TREES
ALL EXISTING TREES ON SITE TO BE RETAINED IN PUBLIC OPEN SPACES AND CONSERVATION SITES WHEN POSSIBLE.

STREET TREES
POST CONSTRUCTION OF EACH LOT HOUSES WILL HAVE A STREET TREE INSTALLED AS PER AN APPROVED STREET TREE MASTERPLAN.








NETTLETON ROAD - BYFORD

PREPARED FOR CEDAR WOODS PTY LTD

LANDSCAPE MASTERPLAN

JOB NO. 13031-01
1:1500 @ A1

M1.104 REV A OCT 2013

0 5 10 20 30 50m

SJS TRIM - IN15/13980

LANDSCAPE ARCHITECTS
414 ROKEBY RD SUBIACO WA 6008
T: (08) 9388 9566 E: mail@plane.com.au
LANDSCAPE PTY LTD ACN 056 538 679

PLAN E

SECTION 1
1:500

SEATING/PICNIC NODES

POTENTIAL FOR SCULPTURAL ELEMENTS TO BE PLACED IN BUSHLAND, CREATING SCULPTURE WALK.

SECTION 2
1:500

NOTES:

- TREES SHOWN IN DRAWING FOR ARE FOR ILLUSTRATION PURPOSES ONLY AND DO NOT REFLECT ACTUAL PROPOSED TREE SPECIES.
- FIRE MANAGEMENT WILL BE AS PER THE FIRE MANAGEMENT PLAN, WHICH IS YET TO BE FINALISED. THIS WILL INCLUDE ACCESS TRACKS AND SPECIES WITH A LOW FIRE RATING IN SOME AREAS.
- LEVELS WILL BE AS PER CIVIL DESIGNS. LEVELS SHOWN HERE ARE BASED ON CURRENT DESIGNS AND MAY BE ADJUSTED TO REFLECT SITE REQUIREMENTS.
- REHABILITATION WORKS TO BE AS PER REVEGETATION AND WEED MANAGEMENT PLAN.

'THE BROOK' NETTLETON ROAD - BYFORD
PREPARED FOR CEDAR WOODS PTY LTD.

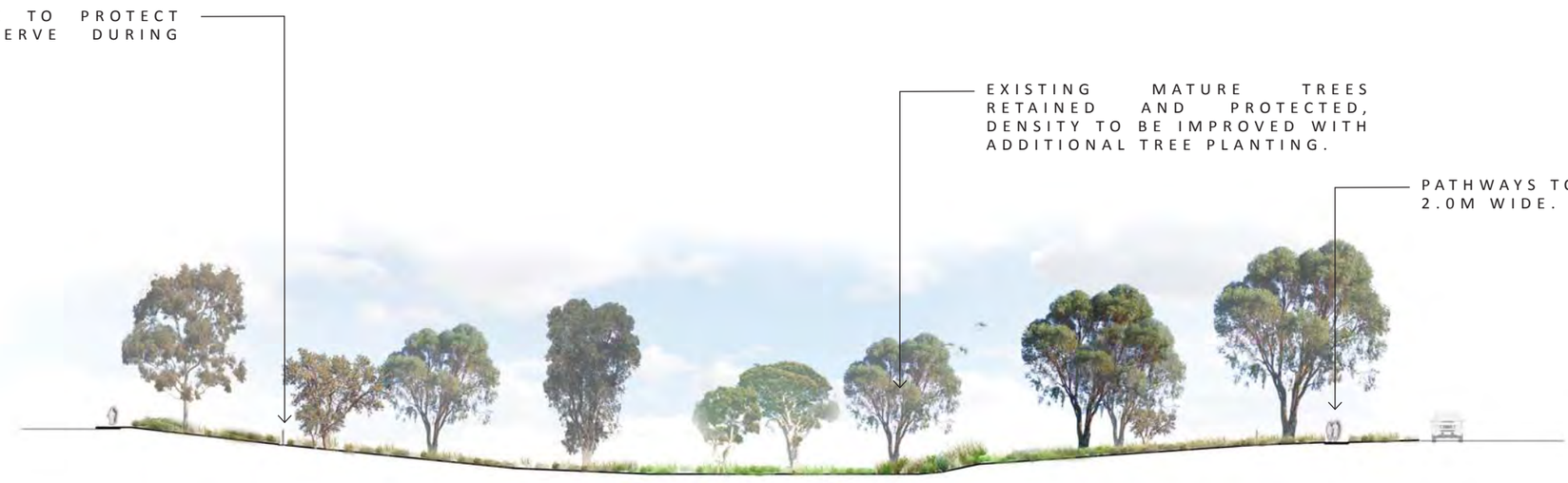
MULTIPLE USE CORRIDOR - SECTIONS 1 & 2

JOB NO. 13031-01 M2.101 REV A JAN 2014
1:500 @ A3
2.5 5 10 15 20

SJS TRIM - IN15/13980

LANDSCAPE ARCHITECTS
414 ROKEBY RD SUBIACO WA 6008
T: (08) 9388 9566 E: mail@plane.com.au
LANDSCAPE PTY LTD ACN 056 538 679

PLAN E



MEANDERING FOOTPATH THROUGH BUSHLAND.

NOTES:

- TREES SHOWN IN DRAWING FOR ARE FOR ILLUSTRATION PURPOSES ONLY AND DO NOT REFLECT ACTUAL PROPOSED TREE SPECIES.
- FIRE MANAGEMENT WILL BE AS PER THE FIRE MANAGEMENT PLAN, WHICH IS YET TO BE FINALISED. THIS WILL INCLUDE ACCESS TRACKS AND SPECIES WITH A LOW FIRE RATING IN SOME AREAS.
- LEVELS WILL BE AS PER CIVIL DESIGNS. LEVELS SHOWN HERE ARE BASED ON CURRENT DESIGNS AND MAY BE ADJUSTED TO REFLECT SITE REQUIREMENTS.
- REHABILITATION WORKS TO BE AS PER REVEGETATION AND WEED MANAGEMENT PLAN.

'THE BROOK' NETTLETON ROAD - BYFORD
PREPARED FOR CEDAR WOODS PTY LTD.

MULTIPLE USE CORRIDOR - SECTIONS 3 & 4

JOB NO. 13031-01 M2.102 REV A JAN 2014

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PLAN E

byford

lot two nettleton road BYFORD

01.06.2008

landscape management plan

prepared by **mnla** for **ASPEN GROUP** in consultation with: env+design inc+jda+Charles Aldous-Ball+wood & grieve+coffey

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2. visual impact assessment elevations

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4. existing landform analysis sections

appendices

1. Flora and Vegetation of Lot 2 South West Highway.
(ENV, 2008)

2. Aboricultural assessment with tree management recommendations
(Aldous- Ball, 2008)

3. Report on Geotechnical Investigation.
Lot 2 South Western Highway, Byford.
(Coffey Geotechnics 2008).

The Landscape Management Plan has been produced by **mnla** at the request of Aspen Group as part of the Local Structure Plan submission for Lot 2 Nettleton Road, Byford.

The development area is approximately 32 hectares and is located on existing intensive pasture at the foot of the Darling Scarp, approximately 38 km's south east of Perth. The area is bordered by South West Highway to the west, Beenyup Road to the north, Nettleton Road to the south and private property to the east.

The existing Beenyup Brook flows through the property in an east-west direction.

The Landscape Management Plan aims to provide further assessment and information relating to a number of key aspects of the development and the immediate surrounding area including visual impact, landscape values, site charecteristics, drainage and erosion potential and specific planning guidelines.

With the development area being located at the foot of the Darling Scarp the need to fully utilise the surrounding views and minimise the development's impact upon these is paramount. Currently the Darling Scarp provides a dramatic backdrop to the site and will be strongly considered in the design and siting of the subdivision. A number of other key visual factors including the interface between major roads and the site, and adjacent residential and commercial land and the site has also been considered.

The attached analysis has highlighted the predominant visual corridors and visual interfaces which will be strongly considered in the development of Lot 2 Nettleton Road, Byford. These highlighted areas have been detailed below:

1. Visual Interface between South West Highway and the Development Area

South West Highway is the major tourist route through the Byford region and also acts as a vital road distributor to local residents. At this stage, views across the site to the Darling Scarp are open and provide a strong backdrop to the site. Impacts upon these views should be minimised where possible and any buildings and fences screened by native planting.

The use of native planting and appropriate selection of building and fencing materials will assist in minimising the impact of the development upon the Darling Scarp vista.

It should also be noted that the proposed work to the interface will ensure views from the development to the west will be enhanced by the reduction of the visual impact the South West Highway has on Lot 2 Nettleton Road, Byford.

2. Visual Interface between Nettleton Road and the Development Area

Nettleton Road is a key local distributor road and is bordered by the site to the north and commercial use area to the south. The road verge is currently heavily planted with native trees providing a natural screen to the development site.

All trees in adequate condition should be retained and enhanced by the installation of additional planting. This will assist in reducing the impact of the proposed development upon the surrounding area and in particular Nettleton Road.

3. Visual Interface between Private Property and the Development Area

The proposed development borders a number of private properties in particular to the east and north.

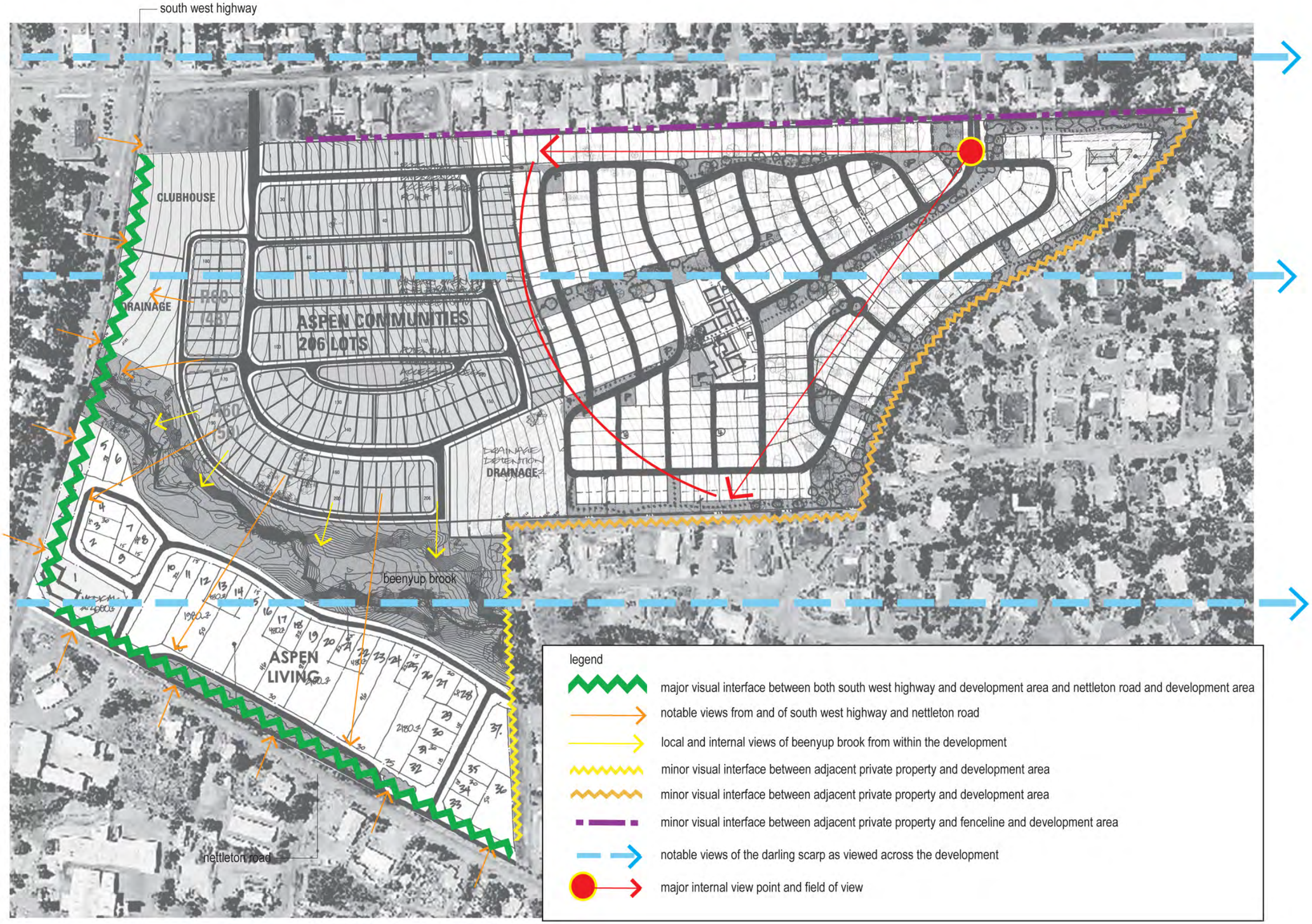
The interface to the east will be softened by the retention of significant existing trees contained within a 10-15m wide buffer strip. This will ensure the impact of the proposed development will be minimised, local security will be enhanced and a valuable amenity will be provided to the adjacent residents.

The interface to the north differs somewhat in that the boundary of the existing properties are currently delineated by a mixture of fence types providing an undesirable visual appearance. It is likely that these fences will be screened by the implementation of private lot landscaping to Aspen Communities' Lots which will be undertaken by the developer.

4. Internal Views

The site slopes from east to west and provides the opportunity to utilise the views looking west from the development over the nearby Byford region. The orientation of local roads and public open space will assist in maintaining this vista.

Views from the Aspen Communities and Aspen Villages stages over the existing Beenyup Brook will also be utilised and enhanced by the likely construction levels of the properties. This will provide a strong visual corridor of and over the Brook to the local Byford region.



1. south west highway looking east (existing)

2. south west highway looking east (including proposed built form)

3. south west highway looking east (including proposed built form and landscape)

4. nettleton road looking north (existing)

A detailed visual survey of the area immediately surrounding the proposed development was undertaken and identified a number of key characteristics which were prominent in the area.

In assessing the landscape values of the area particular importance was placed on the existing treatment of Streetscapes, Passive and Active Public Open Space, Bush and Conservation areas and Private Front Yards.

The dominant characteristics of the area have been identified below:

1. Retention of Existing Vegetation

It is evident that the retention of significant native tree species including *Corymbia calophylla* and *Eucalyptus marginate* in particular, is of importance to the local community. This is noted throughout surrounding streetscapes, major road verges (E.g. Southwest Highway, Nettleton Road), existing public open space and conservation areas.

The retention of tree and plant species is also evident within the Briggs Park Conservation area.

The retention of these trees has added considerable value to the above mentioned areas and provides a strong sense of place.

2. Use of Endemic and Native Plant Species

It is noted that throughout the area native and endemic plant species were predominantly used in manicured planting beds and areas of revegetation and conservation.

By carefully selecting plant species endemic to a region a number of environmental benefits are likely to result including a reduction in the usage of water for reticulation, reductions in nutrient supplements and an increase in fauna habitat.

The use of native and endemic plant species has also ensured a strong linkage and continuity between developed precincts and the existing vegetation evident within conservation areas and the Darling Scarp.

3. Use of Laterite Gravel and Rock Work

The distinctive use of laterite gravel and rock work is noted within the area. Laterite gravel has been used regularly as an alternative paving material, dryscape fill to road verges and driveways.

Laterite rock work has been used in the stabilisation of creek banks, as edging to water bodies and planting beds, and as a feature within garden beds.

When used appropriately, the use of these materials can be a sensible, locally sourced and viable alternative to other landscape materials including concrete, unit paving and limestone and assists in the enhancement of Byford's sense of place.



4. Use of Recycled Elements and Earth Coloured Materials

Recycled materials including logs, timber sleepers and steel members were utilised strongly within the study area. These materials were used as seating, fencing and features within distinctive planting beds or as a border between varying landscape zones.

It was also noted that the use of earth coloured materials including coloured concrete footpaths and rammed earth retaining walls were favoured for use where applicable within the local area.

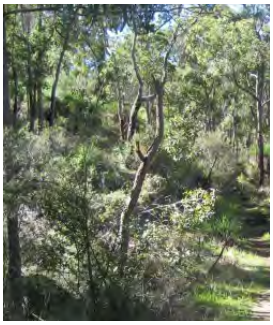
The use of recycled materials and earth coloured materials has complimented the existing environment. Recycled materials have also been used in combination with laterite rock and gravel and native plant species to good effect.



5. The Darling Scarp

The Darling Scarp provides a strong backdrop and a valued amenity to local residents. The area holds a strong conservation and environmental value and has remained untouched in some areas. These areas have provided valuable opportunities to local residents and tourists to experience the natural environment whilst following a series of meandering walkways.

It is evident that a number of connections have been made to the Scarp and efforts should be considered to enhance these in the future.



Summary

Through a detailed visual survey of the area immediately surrounding the proposed development site a number of key landscape values became apparent.

It would appear that the local community has placed a strong emphasis and value upon the creation of a naturalistic setting that strongly utilises elements of the local area. The retention of existing vegetation and environment where possible has been enhanced through the supplemental planting of predominantly native and endemic plant species and the use of locally sourced natural and recycled materials that have combined to create a strong sense of place. Where natural materials were unable to be used efforts have been made to use materials of a natural earthy appearance.

The proposed development will strongly consider the retention of all existing native vegetation where possible and the use of materials consistent with the surrounding local area dependant upon specific site requirements.

An extensive survey of the existing flora contained within Lot 2 Nettleton Road, Byford was undertaken by ENV Environmental Consultants. This report has been attached as Appendix 1.

A more detailed survey of existing trees being undertaken by Charles Aldous-Ball (M. Arb. R.F.S. "F. Arbor A"). This survey and report has been attached as Appendix 2.

As a result of extensive clearing for agricultural and grazing purposes few areas of remnant vegetation remain. These areas have been rated according to their condition with the various areas ranging from a rating of Good to a rating of Degraded condition. Open woodland with a high weed component to the understorey is consistent throughout the site. The 2 predominant vegetation types noted within the area are:

1. Woodland of *Corymbia calophylla* and *Eucalyptus marginata* over *Hibbertia hypericoides*, *Mesomelaena tetragona* and *Desmocladus flexuosus*.

2. Open Woodland of *Eucalyptus rudis* over *Taxandria linearifolius*, *Watsonia mariana var. bulbillifera* and *Oxalis pes-caprae* with occasional strands of *Eucalyptus wandoo* and *Corymbia calophylla*.

Despite the overall condition of the above floristic types it should be noted that a large of number of existing trees are in adequate condition for retention. Should these trees be considered for retention it is likely that opportunities for the local bird life to continue to

A full Geotechnical Investigation and Report was undertaken by Coffey Geotechnics Pty Ltd for Wood and Grieve Engineers on 29 April 2008.

A summary of the soil and surface conditions is provided below:

The surface geology of the site consists of gravelly sandy clay of colluvial origin to the west of the site and gravelly clayey sand of collivial origin to the east of the site.

A generalised subsurface profile produced from a series of test pits by Coffey Geotechnics Pty Ltd is shown below:

Unit	Typical Depth to Top of Layer (m)	Typical Layer Thickness (m)	Description/Remarks
1	0m	0-0.1m	SAND(Topsoil), loose sandy, fine to medium grained, grey to dark grey, traces of fines and root fibres.
2	0.1m	0-0.5m	SAND (SP/SM), fine to medium grained, off white, with some gravel, traces of fines and tree roots.
3	0.3-0.5m	0-0.7m	Clayey Gravel/Clayey Sand (GP/GC), fine to medium grained, off white, low plasticity, trace of tree roots.
4	0.2-1.0m	>1.2m	Clayey Gravel (GC), fine to medium grained, brown mottled grey, low plasticity.

The full Report on Geotechnical Investigation for Lot 2 South Western Highway, Byford has been attached as Appendix 3.

The development area is located at the foot of the Darling Scarp and as such slopes gently and consistently from the eastern boundary to South West Highway on the western boundary. This is depicted in figures 3 and 4.

In general the site is characterised by its gently sloping terrain (between 2 and 4 degrees), however, noticeable differences in level are noted within the existing creek line and its immediate foreshore surrounds (slopes of up to 60 degrees in specific locations).

Development area looking south west (panorama)

Development area looking north east (panorama)

Development area looking east (panorama)

The associated effects of erosion and sediment disposition have formed a creek with shallow yet steep banks in some locations. Some steep banks are also noted within the foreshore reserve adjacent to the existing creek line.

Beenyup Brook Banks

It is anticipated that some earthworks will be required to reduce the grade in some sections of Beenyup Brook to enable revegetation, minimise further erosion and alleviate any possible safety risks to residents. Further remedial action including revegetation, installation of rock riffles and geotextile bank stabilisation may also be considered to minimise the effects created by significant winter flow.

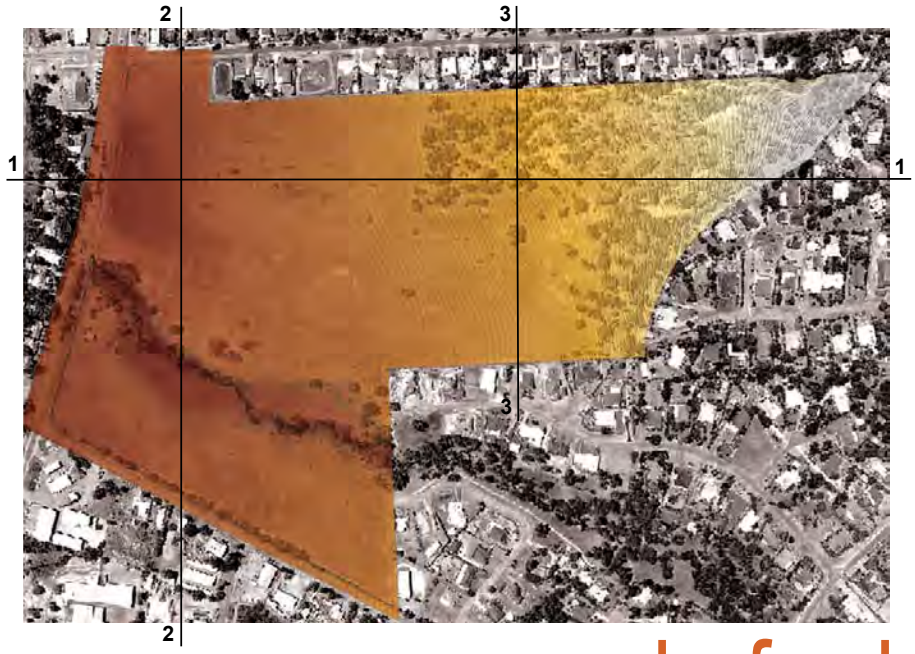
It is also anticipated that civil earthworks will be required in the provision of suitable housing lots, roads and drainage.

mnla scale 1:2000 @ A3

1. existing landform section (west-east)

2. existing landform section (south-north)

3 existing landform section (south-north)



Erosion and Sediment Control Plan

The following detailed erosion and sediment control plan relative to all civil construction works has been prepared by Wood and Grieve Engineers. In addition, details relevant to the landscape design and implementation of this have been provided.

EROSION CONTROL REPORT

The following details information on erosion control for the proposed Superlot subdivision of Lot 2 Nettleton Road Byford.
Prevention of soil movement and erosion will be incorporated into the development in accordance with guidelines in the Erosion and Sediment Control Manual for the Darling Range, Perth Western Australia. Control measures will be considered at the design stage to minimise soil movement during construction and post construction stabilisation and include appropriate construction methods and built form outcomes into the construction contract.

1. Existing Soil and Terrain Conditions

Geotechnical testing has been carried out over the site by Coffey Geotechnics as detailed in their report dated 29 April 2008. The site is predominantly covered with grasses and large trees with denser vegetation occurring in the north east of the site and along the creek line.
The geotechnical report notes that the surface of the site is generally covered with a sandy topsoil layer about 100mm thick over sandy, gravely sand and clayey sand layers.
The natural surface profile is generally gently sloping at the western side at about 3 percent grade and steeper in the eastern side and around the creek line.

2. Proposed Earthworks and Drainage Design

The site will be initially subdivided into 3 large parcels of land, two on the northern side of the creek and one to the south.
The north eastern lot is proposed to be a residential village style development where minimal earthworks is proposed and road pavements are cut in to suit the natural surface. This will allow selected existing trees and some vegetation to be kept helping to stabilise the soil and prevent erosion.
Stormwater will be controlled by using a pipe and pit system to collect the 1 in 5 year flow, including subsoil pipes along all roads and providing a connection for roof runoff as well. Larger storms will flow along the road pavements and several drainage flow paths (landscaped swales). Disposal will be via controlled outlets into a drainage basin with a piped overflow to the creek.
A cut off bund and swale is also proposed to control stormwater runoff from the uphill southern and eastern catchment area and prevent water runoff crossing over this lot. Installation of rock spalls and landscaping will be used to minimise sediment movement in swales.
The proposed north western lot is to be an independent living retirement village and this gently sloping site will be covered with just over a metre of sand to elevate the structures and pavements above the ground water level. Retaining walls will be constructed to provide level building lots and help prevent sand movement over and off the site.
A pipe and pit stormwater drainage system is also proposed for this lot which will discharge into a landscaped drainage basin with a controlled overflow pipe outlet to the creek.
The proposed southern lot is expected to have some fill and retaining walls to enable the lots and roads to be constructed to a reasonable level and grade.
Stormwater drainage control will also be via pipe and pit network to a drainage basin.
For all lots, all road and carpark pavements will be sealed and kerbed to control stormwater flow.
Also stormwater runoff from rooves will be directed into the drainage system as required, which will reduce erosion and sediment movement.
Drainage outlets will be stabilised with rock pitching.

3. Construction Erosion Control

The following items will be implemented to help control erosion during construction.

- There will be controlled and stabilised access points to each lot to minimise soil transport onto existing roads.
- Strips of existing vegetation to be kept will be marked out on site to make it clear for the contractor to protect this.
- Construction will be timed to avoid the wettest part of the year when soil movement is very hard to control.
- Drainage detention basins will be constructed early in the contract to provide emergency sediment control if required.
- Wind break fencing will be used to help prevent dust and erosion and sediment trap fencing may be used where required, particularly down hill of topsoil stockpiles.
- During construction prior to stabilisation a water cart will be used to minimise dust and wind erosion.
- Sand fill on site will be stabilised progressively by hydromulch or similar to help prevent wind erosion.
- Contractor to control storage of materials and removal of rubbish to ensure a clean site.
- Ensure contractor provides adequate supervision and implements an environmental management plan.
- Ensure contractor maintains fencing in good order and other control measures are working.
- Contractor to repair any erosion promptly and add measures to help prevent further erosion.

4. Post Construction Stabilisation

The following items will be implemented to help control erosion after construction is completed or at the end of the construction period.

- Topsoil will be replaced on batters and open space areas.
- Vegetation stripped and mulched will be reused to stabilise batters.
- Thorough clean up of the site will occur.
- Areas outside imminent building envelopes to be stabilised with hydromulch or similar product.
- Revegetation and landscaping to be completed.

Erosion control measures such as stabilisation, revegetation, landscaping and drainage structures will be monitored after construction to ensure they adequately control erosion. Any modifications or repairs will be carried out as required to ensure soil movement is stabilised.

BEENYUP BROOK

The Beenyup Brook is a seasonal drainage line that is currently eroded in specific sections. With a likely increase in water volume and water flow as a result of increased development it is essential that measures are undertaken to minimise the affects of previously eroded banks and to reduce the possibility of erosion into the future.

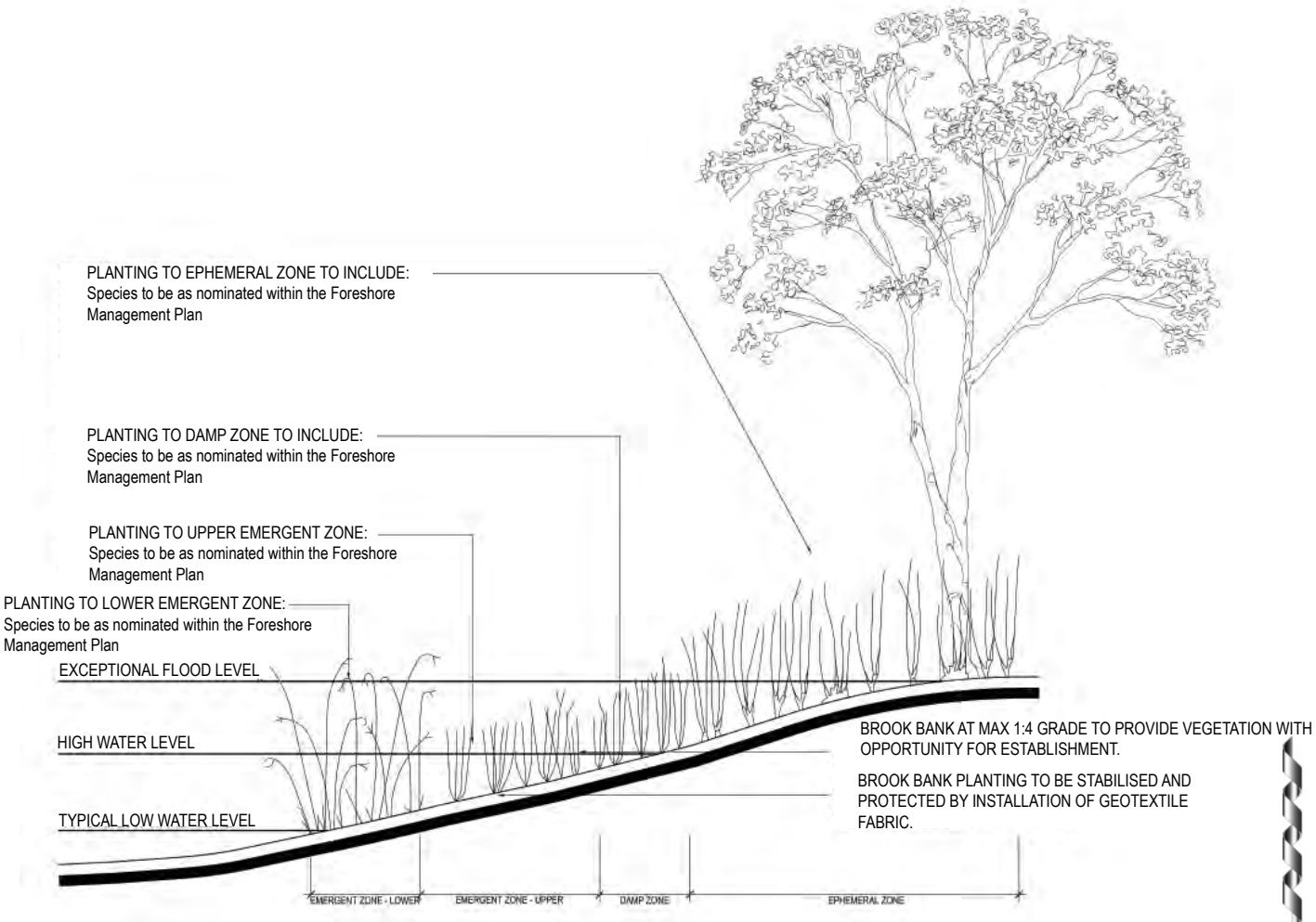
By actively reducing the affects of erosion within the Brook, the affects of sediment disposition will also be reduced.

To ensure erosion is minimised a number of key measures will be undertaken:

1. Revegetation

All creek banks will be planted with a suitable variety of reed, sedge and tree species that provide a fast growing and wide spread root system crucial in stabilising the Beenyup Brook banks. Plant species will be native and selected with hydrological and geotechnical requirements in mind.

To assist in the establishment of the plant species and to reduce the likelihood of erosion during this phase it is recommended that the use of suitable geotextile fabric be considered to steeper bank sections.



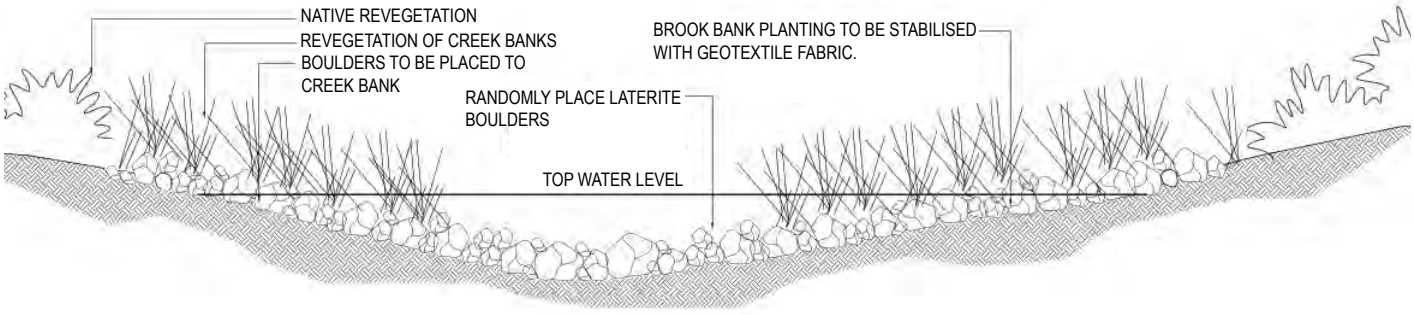
Typical Creek Revegetation Works

2. Rock and Log Riffles

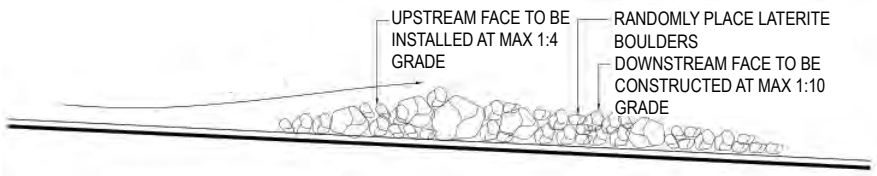
The reduction of water velocity within the Beenyup Brook will also assist in minimising erosion. This can be achieved through the use of strategically located rock and log riffles.

It is anticipated that laterite rock and locally sourced logs from removed trees would be used in the construction of the riffles.

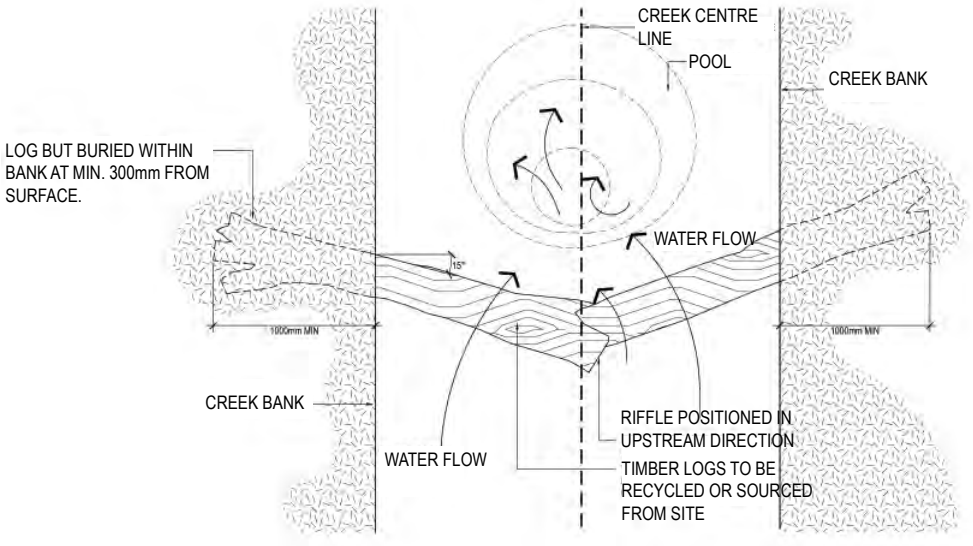
Riffles should be located at the entry and exit to river bends and at points where water velocity is likely to increase and therefore prone to cause erosion to the brook banks.



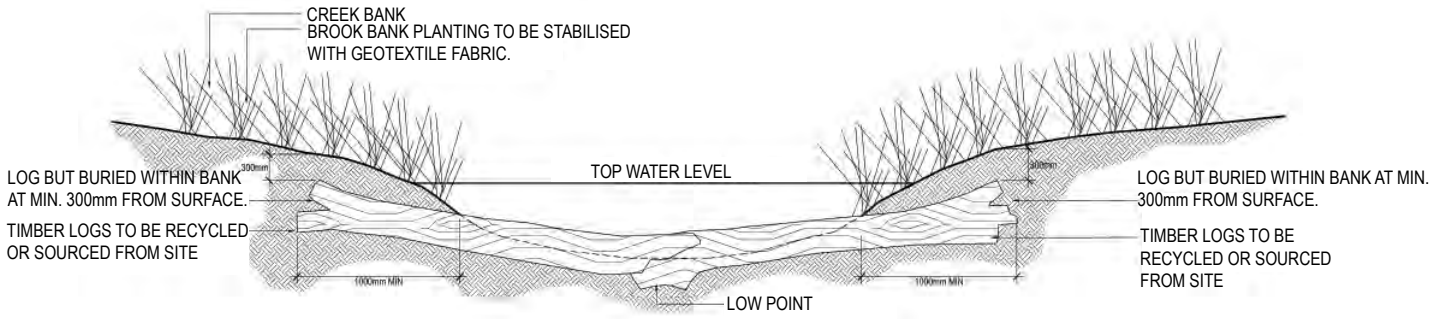
Rock Riffle Section



Rock Riffle Section



Log Riffle Section



Log Riffle Section

3. Rock and Log Bank Stabilisation

In areas where creek banks are particularly steep and exceed a grade of 1:3 the use of rock work and logs should be considered to assist in stabilising the bank structure.

It is anticipated that laterite rock and locally sourced logs from removed trees would be used in the construction of any creek bank stabilisation. In addition to this, geotextile fabric may be used as a temporary method whilst plant roots spread and stabilise.

4. Earthworks

The use of earthworks to Beenyup Brook will also be investigated. By reducing the grade of the Brook banks to a 1:4 max grade the effects of erosion will be minimised and the prospect of plant establishment enhanced.

The creation of a series of pools that allow small detention capacity and therefore enable at source infiltration and reduce water velocity of flow will also be considered.

POS AREAS

1. General

All private and public open space within the development area will be treated through the use of both soft and hard landscape materials and will be designed to minimise steep gradients i.e. paths to follow contours.

The installation of specifically selected trees, plants and turf species will ensure an adequate ground cover and root mat is provided that will considerably diminish the likelihood of erosion.

All planting will be undertaken with either organic or rock aggregate mulch which will assist in reducing the affects of both erosion and sedimentation.

2. Drainage Basin Areas – Linear (Landscaped Development Buffer Strip)

Linear drainage basins located within the landscaped buffer areas will form part of the full integrated drainage network. A combination of carefully selected tree, reed and sedge species and laterite rock and gravel will be utilised to ensure the surrounding and underlying soils are not removed by water flow and wind and do not contribute to sediment disposition.

3. Drainage Basin Areas – Main

Large drainage basins will also form an integral component of the overall drainage strategy. As such their design will be undertaken to minimise erosion and sedimentation of the site and its surrounds.

The use of rock spalling will be required to all drainage out flow points where water flow rates are at their highest to minimise erosion. Vegetation and rock work will also be installed to assist in reducing water velocity and to stabilise the subgrade.

Sediment from the surrounding development area will be deposited within the drainage basin to ensure this does not flow directly into the adjacent Beenyup Brook and downstream water bodies.

Drainage basins will also filter nutrients and pollutants from stormwater flows prior to releasing clean water into the groundwater flow.

Planning Controls

A series of planning controls over key aspects of the development have been considered and are detailed below.

The planning controls will assist in determining the design and siting of the subdivision and housing development with an emphasis upon minimising the impact to landscape values. This includes reference to building materials/colour, road layout and siting of buildings.

Building Materials/Colours

1. Materials and colours of the dwellings will be as per a pre determined palette which will be submitted and approved as part of the formal Development Application.

2. Building materials including masonry (rendered or unrendered), weatherboard and fibro-cement weatherboard will be considered.

3. All colours utilised within the development are to be of an earthy tone or similar that take inspiration from the local soils and vegetation.

Development Siting

1. The development siting and building type will allow for the retention of the majority of significant existing trees. The majority of existing trees are situated within the Aspen Park Homes precinct, an area where little or no earthworks will be conducted to residential lots.

2. In addition to this, trees will also be protected within a 15m landscape buffer area located to the eastern boundary of the development and within arbor ways and an internal park network.

3. The Beenyup Brook is a central focal point of the development and as such will be highlighted and rehabilitated.

Built Form (General)

1. Aspen Group will manage and develop the built form as a single land owner. As such, this will enhance the ease of any dealings between the Shire of Serpentine Jarrahdale and Aspen Group and ensure a level of consistency across the site.

2. With the possible exception of the local community centre and possible apartment development, all buildings are to be restricted to one storey.

Built Form (Aspen Communities)

1. Within the Aspen Communities site residents will be provided with fully independent accommodation that comprises a mix of single storey villas and possibly multi storey apartments. All houses will be set in the secure housing environment.

2. All Villas and Apartments will be designed around the concept of adaptable housing with all homes including features that can be altered to the individual needs of the resident.

3. All materials and aesthetic values will be detailed as part of the formal Development Application and will be consistent with the Shire of Serpentine Jarrahdale's standards for the Byford region.

Built Form (Aspen Villages)

1. Within the Aspen Villages site residents will be provided with single storey villas that are responsive to the surrounding environment and consider the concept of water sensitive urban design.

2. All materials and aesthetic values will be detailed as part of the formal Development Application and will be consistent with the Shire of Serpentine Jarrahdale's standards for the Byford region.

Road Layout

1. The road layout respects the topography of the existing land surface and drainage patterns. The layout is logical and permeable but retains an organic, rural feel with notable meanders and curvature. This will also assist in the restriction of local speeds throughout the development.

Potential Uses within the Rezoning for Subdivision

The potential uses within the rezoning of the development area have been considered despite the fact that this development is not considered to be situated on the Darling Scarp.

These uses have been considered to ensure that degradation of the land does not occur.

As has previously been noted the development area is currently on former intensive farmland with the previously degraded Beenyup Brook flowing through the site from east to west. There is no significant vegetation within the site that demands retention however some trees are in adequate condition for retention. The land is predominantly covered by weed species and pasture grasses with some notable trees and will not be adversely affected by the development process.

To ensure degradation of the site is minimised as a result of an increase in residential dwellings and overall hardstand, the following items will be undertaken:

1. The Beenyup Brook and surrounding foreshore will be rehabilitated and revegetated.

2. Existing trees throughout the site considered adequate for retention will be retained as far as practicable. This will include trees with growth potential to ensure a replenishing of the landscape stock.

3. Pre/post water quality will be maintained and enhanced.

4. The road layout respects the lay of the land and natural drainage flows.

5. A recycling program, waterwise landscaping program, rain water tanks and innovative structural design will all assist in avoiding and managing degradation of the site.

The above measures to be undertaken by the developer will not only ensure that the developed land is not further degraded but will also enhance the site and its surrounding environment.

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LOT 2 NETTLETON ROAD, BYFORD

FAUNA MANAGEMENT PLAN

Prepared for: Cedar Woods

Report Date: 22 August 2013

Version: 2

Report No. 2013-102

Serpentine Jarrahdale Shire
ACCEPTED
subject to approval ~~letter~~ email Attached
Charles C. Portlock 23/9/2013
Authorised Officer Date

pgv ENVIRONMENTAL

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1 INTRODUCTION

1.1 Background

Lot 2 Nettleton Road, Byford (the site) is located approximately 36km from the Perth Central Business District (Figure 1). The lot is approximately 32ha and is zoned for urban development. The site is bounded by the South West Highway to the west and existing developed areas to the north, south and east (Figure 2).

Subdivision approval has been granted for the western part of the lot (WAPC 146045) which will be Stage One of the development (Figure 3). Condition 22 of the subdivision approval refers to a Fauna Management Plan particularly for the kangaroos that are present on the site (Appendix 1). Condition 22 of the subdivision approval states:

> *Prior to the commencement of on-site subdivision works a fauna management plan to address the presence of kangaroos on the site and plans to ensure they are managed/relocated in a suitable manner is to be prepared to the satisfaction of the Western Australian Planning Commission on the advice of the Shire of Serpentine Jarrahdale and the Department of Environment and Conservation (Local Government).*

This management plan has been prepared in consultation with the Shire of Serpentine-Jarrahdale and the Department of Parks and Wildlife (DPaW – formerly the Department of Environment and Conservation) to satisfy Condition 22.

1.2 Objective

The aim of the Fauna Management Plan is to manage the relocation of Western Grey Kangaroos from the site to the nearby bushland on the Darling Scarp and provide short-term and long-term strategies to control the Kangaroo population within the development area in order to reduce the impact on remnant vegetation and minimise the potential health and safety risks for both the public and the long-term Kangaroo population.

To ensure that the objectives of the management actions are achieved, a number of management measures are addressed in the management plan. These measures include:

- Control of current and future Kangaroo population density;
- Consideration of future Kangaroo movement through the site; and
- Review of the Management Plan.

2 SITE DESCRIPTION

2.1 Historical Land Use

The site historically has been part of a rural agricultural property. The majority of Lot 2 Nettleton Road was cleared prior to 1953 as shown in historical aerial photography (Plate 1).

Plate 1: Historical Aerial Photography from 1953 (Landgate, 2013)

2.2 Vegetation

The vegetation on the site has been extensively grazed as the area has been farmed from prior to 1953 to the present. The majority of the site is cleared pasture containing exotic weed species. A small bushland area in the north-east corner appears to be retained since 1953. This vegetation was mapped as a Woodland or specifically a "Woodland of *Corymbia calophylla* and *Eucalyptus marginata* over *Hibbertia hypericoides*, *Mesomelaena tetragona* and *Desmocladus flexuosus*" and an "Open Woodland of *Eucalyptus rudis* over *Taxandria linearifolia*, **Watsonia mariana* var. *bulbillifera* and **Oxalis pes-caprae* with occasional strands of *Eucalyptus wandoo* and *Corymbia calophylla*" (ENV, 2007).

The condition of the vegetation was assessed according to the system devised by Keighery and described in Bush Forever (Government of Western Australia, 2000). The bushland area was rated as Very Good and Good. The pasture areas are considered to be Completely Degraded.

2.3 Fauna

A fauna survey was undertaken by ENV in December 2007 (ENV, 2008). The survey concluded that the site had limited connectivity with surrounding bushland and was mostly used by avifauna. The high predator levels from domestic and feral animals would limit the number of native fauna on the site. Kangaroos are the predominant species present on the site. These kangaroos are present in very large numbers, up to 80 individuals, grazing within the completely degraded pasture area (Plate 2) and resting within the remnant woodland in the north-east corner. The understorey of the north-east woodland shows signs of overgrazing by kangaroos.

Plate 2: Large numbers of Kangaroos on the site

2.4 Human Use

The site is adjacent to developed lots on the north, south and eastern boundaries. A large proportion of the properties in the north-east corner of the site have gates in their back fences that lead into a bushland area. There are anecdotal reports that the surrounding residents feed the kangaroos and consider them to be 'part of the community'. The kangaroos are accordingly a lot tamer than wild kangaroos.

3 THE WESTERN GREY KANGAROO

3.1 General Biology and Ecology

The Western Grey Kangaroo (*Macropus fuliginosus*) is a grazing animal feeding on grass, young shoots and leaves of plants. Their pelage is variable in colour, ranging anywhere from greyish-brown to chocolate brown. The western group is slender and greyish-brown in colour and the southern group is stockier and brown in colour with bluish-grey underparts.

Western Grey Kangaroos range in height from 0.9m to 2.1m and in weight from 28kg to 54kg. Females are smaller than males and typically weigh 27kg when adult, live for greater than 20 years and become sexually mature at 18-20 months. Unlike the other macropods the Western Grey Kangaroo does not exhibit embryonic diapause.

The Western Grey Kangaroo is gregarious, forming groups of at least two to three individuals up to 100 individuals that are usually unstable in composition. Forage availability seems to play a bigger role than sociality in the distribution of females, while males have home ranges which are usually larger than and overlap those of females.

3.2 Distribution and Habitat

The distribution of the Western Grey Kangaroo corresponds to areas of seasonal or winter rainfall (Caughley *et al.*, 1987). It occurs in the forest scrub of Western Australia, southern South Australia, western New South Wales, southern Queensland and western Victoria. The Western Grey Kangaroo prefers dense cover to open grassland.

3.3 Conservation Status

The Western Grey Kangaroo is one of 50 species of macropod found in Australia, 23 of which were present in Western Australia at the time of European settlement. Subsequent changes to the natural landscape, such as agricultural, pastoral and urban development, have markedly changed the abundance and distribution of some macropod species. In 2002, only 19 macropod species in Western Australia remain extant, and two of those are now restricted to offshore islands (CALM, 2002). Six species of macropod are currently considered 'rare or likely to become extinct' under the Western Australian Wildlife Conservation Act 1950, and a further four species are listed as 'presumed extinct'.

The Western Grey Kangaroo is considered common and abundant in Western Australia and is not listed as threatened under either State or Commonwealth legislation.

3.4 Population Trends

European settlement has had a greater negative impact on the smaller macropods, namely the smaller wallabies, hare-wallabies and bettongs, than the larger kangaroo species. The larger-bodied kangaroo species have generally been advantaged by European settlement and these species are secure and widespread across Western Australia. In Western Australia, kangaroo populations

recovered from a drought in the late 1970s, increasing to a peak around 1990 following above average rainfall. Populations then declined with years of both good and poor rainfall. Table 1 below shows a marked increase in the Western Grey Kangaroo population reported in 2004 and 2007. A reduction in predation following the establishment of dingo baiting programs throughout the sheep rangelands, the construction of dingo-proof fences and the provision of additional water sources and pasture are the most likely reasons for population increases (Pople and Grigg, 1999). The Western Grey Kangaroo has been advantaged by pastoralism but it has been disadvantaged by intensive agriculture (Short and Grigg, 1982). It has been noted, however, that kangaroos are naturally prolific breeders, capable of increasing their population fourfold in five years under conditions of plentiful food and available habitat (ADFAT, 2013).

Table 1: Population Estimates of Western Grey Kangaroos in Western Australia (2001-20011)

Year	Population Estimate
2001	642,380
2002	566,700
2003	666,900
2004	1,433,900
2005	1,473,500
2006	1,412,700
2007	1,893,295
2008	1,264,929
2009	1,653,464
2010	1,407,376
2011	1,177,534

Population estimates from SEWPaC, 2013.

Some kangaroo species have also recorded increases to their distribution range. The Western Grey Kangaroo is confined to the southerly parts of Western Australia and has not extended its range since European settlement (Caughley *et al.,* 1984).

3.5 Current Management of Western Grey Kangaroos in Western Australia

Western Grey Kangaroos and native fauna are protected under the *Wildlife Conservation Act 1950.* The *Western Grey Kangaroo Management Plan for Western Australia 2003-2007* was developed by the Department of Parks and Wildlife (DPaW), formerly the Department of Conservation and Land Management (CALM, 2002) to satisfy the requirements of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Considered in the DPaW management plan is the commercial utilisation of the Western Grey Kangaroo. The aims of the management plan are to:

- Maintain populations of Kangaroos over their natural range in Western Australia in an ecologically sustainable manner;
- Contain the deleterious effects of Western Grey Kangaroos on other land management values; and
- Manage, where possible, kangaroo species as a renewable natural resource providing the conservation of the species is not compromised.

4 MANAGEMENT ACTIONS

4.1 Management of Kangaroo Population

Retention of kangaroos on most of the site in the long term is not possible due to its development for residential purposes. It is considered that the maintenance of kangaroo populations within the proposed 3ha retained remnant bushland area of the site will be unsustainable due to the large numbers of kangaroos and associated impacts of grazing upon the vegetation, and a greater potential for kangaroo and human conflicts. The site is also surrounded by an increasingly urbanised area that is unsuitable for Kangaroos, particularly as a diurnal refuge.

As a result of the encroaching urbanisation and small area of remnant vegetation that are being retained on site removal of the existing population is likely to provide the only effective management measure.

Two possible management measures to control Kangaroos numbers were considered:

- Relocation of kangaroos; and
- Commercial harvesting.

Commercial harvesting is not considered viable in this case given the strong emotional connection of the local residents with the kangaroos. Therefore the relocation of the kangaroos is considered to be the better option. This management plan outlines the methodology by which the kangaroos will be encouraged to relocate into the nearby bushland in the Darling Range Regional Park.

4.2 Relocation

4.2.1 Current Kangaroo Movements

There is evidence that the kangaroos utilise two main points from the site to move to the nearby bushland. These are located in the north-east corner of the site between existing houses and in the central eastern area along the creekline (Figure 3). These offsite access points will be maintained to provide points at which the kangaroos are familiar with to leave the site.

4.2.2 Stage 1 Exclusion Fencing

A fence will be constructed around stage one prior to vehicles being moved on site to exclude kangaroos from the construction area. This will be constructed starting from the south-west corner of the site and moving to the north. The fence will be completed along the South West Highway first to discourage kangaroo movement to the main road. The fence will then be constructed along the northern boundary of the site to discourage kangaroos from exiting the site to Beenyup Road.

Openings at least 25m wide will be left on the south-eastern corner and eastern boundaries. These will align with the off-site access points as shown in Figure 3.

Over a period of five days the openings will be closed by adding panels every second day. The additional panels will be erected during the day when the kangaroos are not active. After the fifth day if any kangaroos remain in the development area they will be herded out of the fenced area under the supervision of a zoologist.

4.2.3 Proposed Fencing

The temporary fencing will be at least 2m high and each panel secured in two places as shown in Plate 3.

Plate 3: Proposed Fencing Material

4.2.4 Fencing Relocation

At the completion of Stage 1 site works the fence will be relocated and extended to include Stage 2. Kangaroo Management for future stages will follow the same procedure as for Stage 1.

4.3 Tranquilising and Relocation

In the event that individual kangaroos remain on the area to be developed or keep returning, relocation of kangaroos through darting and removal to an area approved by DPaW may need to be considered. This would be considered as a last resort and will be undertaken in accordance with DPaW requirements.

4.4 Communication

4.4.1 Signage

To ensure existing owners are informed and understand the need for the relocation signage located on the corner of the development near the South West Highway and Beenyup Road outlining the need for the kangaroos to be moved as the development progresses.

4.4.2 Complaints Management

Complaints received by the developer, if any, regarding the treatment of kangaroos will be forwarded to the Development Manager. The complainant will be contacted to discuss concerns. Outcomes will be communicated to the Shire of Serpentine-Jarrahdale to determine if the management plan requires review.

4.5 Monitoring

Monitoring will be undertaken to determine the effectiveness of the management plan. It is envisaged that over time, as each stage is developed, the number of kangaroos in the undeveloped portion of the site should reduce.

Kangaroo numbers will be counted by one person traversing the lot at dusk to count the number of individuals present on a weekly basis from the start of the installation of the fence until earthworks commence.

Once the fence is installed the number of kangaroos on the remainder of the lot will be counted every two months until the completion of construction.

4.6 Reporting

The number of kangaroos recorded on the site will be reported annually to DPaW and the Shire of Serpentine-Jarrahdale.

5 SUMMARY OF MANAGEMENT ACTIONS, TIMING AND RESPONSIBILITIES

Table 2 outlines the Management Strategies and timeframes for this management plan. All Management Actions will initially be the responsibility Cedar Woods. Works will be undertaken by specialist contractors.

Table 2: Management Action and Timeframes

Factor	Management Action	Timeframe	Responsibility
Egress	Two main egress points will be maintained during construction to allow the movement of kangaroos from the site	During Construction	Cedar Woods
Fencing	Fencing to be installed prior to construction in an anticlockwise direction from the south-west corner of the construction area.	Prior to construction	Cedar Woods
	Openings at least 25m wide aligning with egress points will be left	During fencing	Cedar Woods
	Opening to be closed over five days	Five days after the completion of the fence	Cedar Woods
	Temporary fencing to be used		Cedar Woods
Tranquilising and Relocation	To be undertaken as a last resort in consultation with DPaW	If required	Cedar Woods
Communication	Signage to be installed at the development.	Prior to installing the fence	Cedar Woods
	Complaints management to be undertaken by the developer in consultation with the Shire of Serpentine Jarrahdale	Ongoing	Cedar Woods
Monitoring	Weekly monitoring of kangaroo numbers on the site	During earthworks for Stage 1	Cedar Woods
	Every two months, monitoring of numbers on the site for the duration of the development	Ongoing	Cedar Woods
Reporting	Annual reports of kangaroo numbers to be forwarded to DPaW and the Shire of Serpentine-Jarrahdale	Ongoing	Cedar Woods

6 REVIEW OF THE MANAGEMENT PLAN

The management strategies prescribed in this management plan are intended to be dynamic and flexible to allow them to respond to changes in the habitat environment and community values and behaviour.

If monitoring shows evidence that the number of kangaroos on the site does not decrease with the installation of the exclusion area this management plan will be reviewed in consultation with the Department of Parks and Wildlife and the Shire of Serpentine Jarrahdale to determine alternate methods of management.

A reporting programme co-ordinated by the proponent will track the implementation of management strategies to facilitate:

- Revision of management actions as needed;
- Identification of management issues and trends; and
- Review and update of the management plan if necessary.

This review strategy will ensure that the objectives of the management plan will be achieved through an adaptive process that allows for the consideration of circumstantial change and new management techniques and strategies.

The duration of this management plan will be five years and the management plan will be reviewed in August 2018.

7 REFERENCES

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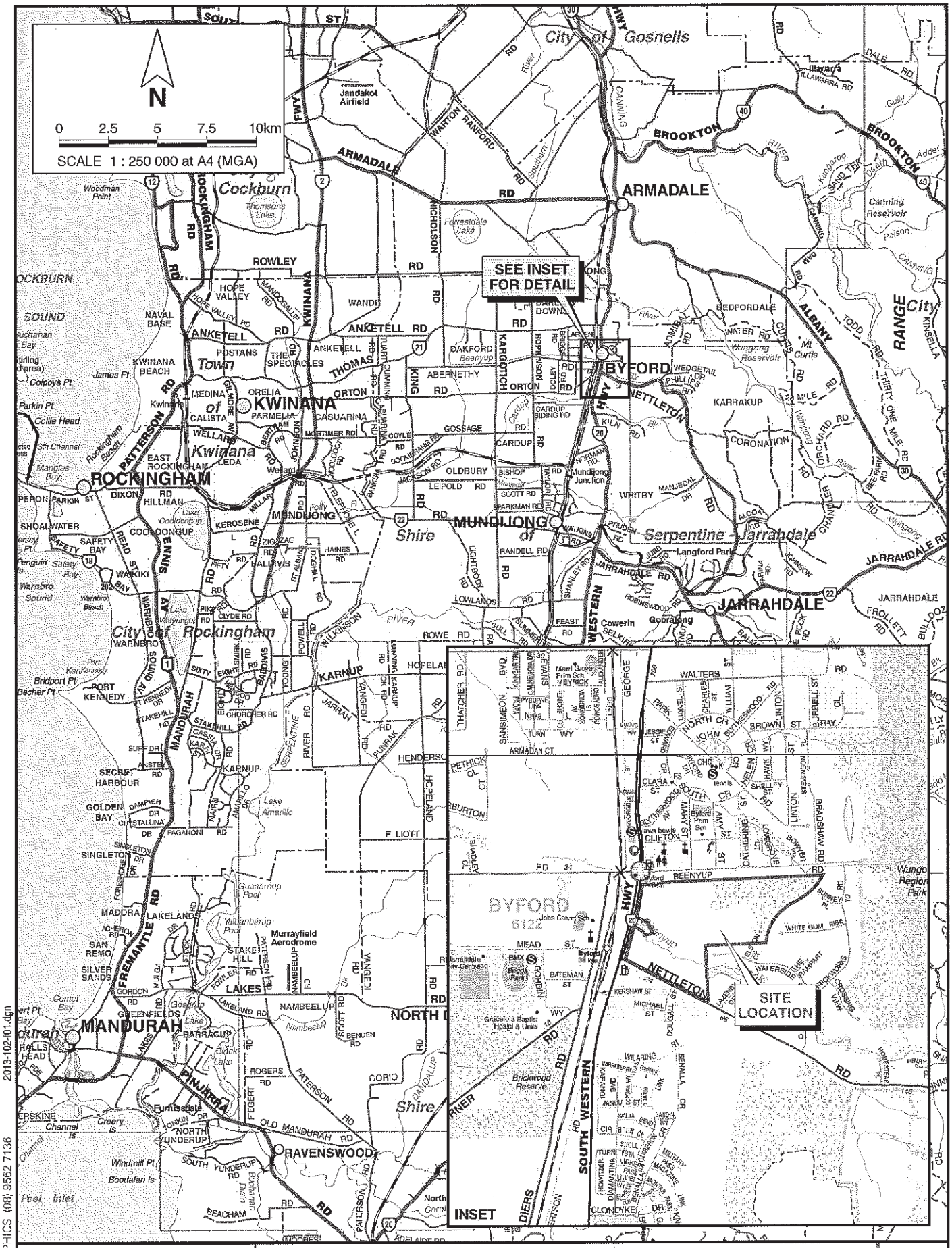
FIGURES



PINPOINT CARTOGRAPHICS (08) 9562 7136 2013-102-101.dgn

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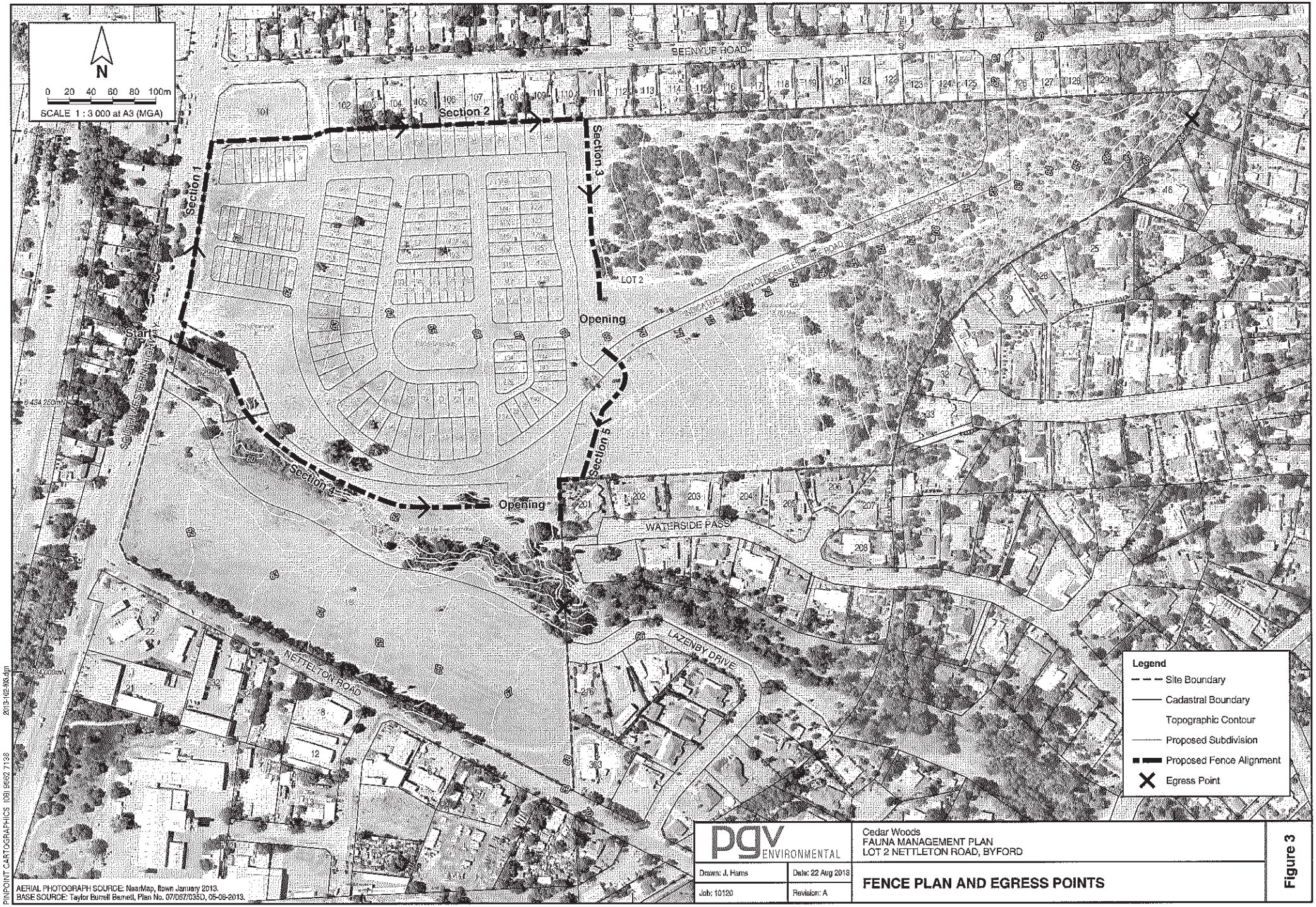
Cedar Woods
FAUNA MANAGEMENT PLAN
LOT 2 NETTLETON ROAD, BYFORD

Drawn: J. Hams	Date: 21 Aug 2013
Job: 10120	Revision: A

SITE LOCATION

Figure 1



APPENDIX 1

Subdivision Approval

Western Australian Planning Commission

Your Ref :
Enquiries : Lisa Powell (Ph 6551 9487)

Taylor Burrell Barnett
P O Box 8186
SUBIACO EAST WA 6008

Approval Subject To Condition(s)
Freehold (Green Title) Subdivision
(Amended Plan)

Application No : 146045

Planning and Development Act 2005

Applicant	:	Taylor Burrell Barnett P O Box 8186 SUBIACO EAST WA 6008
Owner	:	Aspen Communities Limited Level 8, Adelaide Terrace PERTH WA 6000
Application Receipt	:	8 May 2012

Lot Number	:	2
Diagram / Plan	:	Diagram 35560
Location	:	-
C/T Volume/Folio	:	2007/85
Street Address	:	South Western Highway, Byford
Local Government	:	Shire of Serpentine-Jarrahdale

The Western Australian Planning Commission has considered the application referred to and is prepared to endorse a deposited plan in accordance with the amended plan date-stamped 11 September 2012 once the condition(s) set out have been fulfilled.

This decision is valid for four years from the date of this advice, which includes the lodgement of the deposited plan within this period.

The deposited plan for this approval and all required written advice confirming that the requirement(s) outlined in the condition(s) have been fulfilled must be submitted by 07 November 2016 or this approval no longer will remain valid.

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Western Australian Planning Commission

Reconsideration - 28 days

Under section 151(1) of the *Planning and Development Act 2005*, the applicant/owner may, within 28 days from the date of this decision, make a written request to the WAPC to reconsider any condition(s) imposed in its decision. One of the matters to which the WAPC will have regard in reconsideration of its decision is whether there is compelling evidence by way of additional information or justification from the applicant/owner to warrant a reconsideration of the decision. A request for reconsideration is to be submitted to the WAPC on a Form 3A with appropriate fees. An application for reconsideration may be submitted to the WAPC prior to submission of an application for review. Form 3A and a schedule of fees are available on the WAPC website: http://www.planning.wa.gov.au

Right to apply for a review - 28 days

Should the applicant/owner be aggrieved by this decision, there is a right to apply for a review under Part 14 of the *Planning and Development Act 2005*. The application for review must be submitted in accordance with part 2 of the *State Administrative Tribunal Rules 2004* and should be lodged within 28 days of the date of this decision to: the State Administrative Tribunal, 12 St Georges Terrace, Perth, WA 6000. It is recommended that you contact the tribunal for further details: telephone 9219 3111 or go to its website: http://www.sat.justice.wa.gov.au

Deposited plan

The deposited plan is to be submitted to the Western Australian Land Information Authority (Landgate) for certification. Once certified, Landgate will forward it to the WAPC. In addition, the applicant/owner is responsible for submission of a Form 1C with appropriate fees to the WAPC requesting endorsement of the deposited plan. A copy of the deposited plan with confirmation of submission to Landgate is to be submitted with all required written advice confirming compliance with any condition(s) from the nominated agency/authority or local government. Form 1C and a schedule of fees are available on the WAPC website: http://www.planning.wa.gov.au

Condition(s)

The WAPC is prepared to endorse a deposited plan in accordance with the plan submitted once the condition(s) set out have been fulfilled.

The condition(s) of this approval are to be fulfilled to the satisfaction of the WAPC.

The condition(s) must be fulfilled before submission of a copy of the deposited plan for endorsement.

The agency/authority or local government noted in brackets at the end of the condition(s) identify the body responsible for providing written advice confirming that the WAPC's requirement(s) outlined in the condition(s) have been fulfilled. The written advice of the agency/authority or local government is to be obtained by the applicant/owner. When the written advice of each identified agency/authority or local government has been obtained, it should be submitted to the WAPC with a Form 1C and appropriate fees and a copy of the deposited plan.

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If there is no agency/authority or local government noted in brackets at the end of the condition(s), a written request for confirmation that the requirement(s) outlined in the condition(s) have been fulfilled should be submitted to the WAPC, prior to lodgement of the deposited plan for endorsement.

Prior to the commencement of any subdivision works or the implementation of any condition(s) in any other way, the applicant/owner is to liaise with the nominated agency/authority or local government on the requirement(s) it considers necessary to fulfil the condition(s).

The applicant/owner is to make reasonable enquiry to the nominated agency/authority or local government to obtain confirmation that the requirement(s) of the condition(s) have been fulfilled. This may include the provision of supplementary information. In the event that the nominated agency/authority or local government will not provide its written confirmation following reasonable enquiry, the applicant/owner then may approach the WAPC for confirmation that the condition(s) have been fulfilled.

In approaching the WAPC, the applicant/owner is to provide all necessary information, including proof of reasonable enquiry to the nominated agency/authority or local government.

The condition(s) of this approval, with accompanying advice, are:

CONDITION(S):

Contributions

1. The applicant/owner entering into a legally binding agreement with the Shire of Serpentine Jarrahdale to contribute toward the cost of providing the common infrastructure costs of the Byford Structure Plan as established through an amendment to the Shire of Serpentine Jarrahdale Town Planning Scheme No. 2 (when gazetted). (Local Government)

Road and Movement Network

2. Engineering drawings and specifications are to be submitted, approved, and subdivisional works undertaken in accordance with the approved plan of subdivision, engineering drawings and specifications, to ensure that those lots not fronting an existing road are provided with frontage to a constructed road(s) connected by a constructed road(s) to the local road system and such road(s) are constructed and drained at the landowner/applicant's cost.

   As an alternative, and subject to the agreement of the Local Government the Western Australian Planning Commission (WAPC) is prepared to accept the landowner/applicant paying to the local government the cost of such road works as estimated by the local government and the local government providing formal assurance to the WAPC confirming that the works will be completed within a reasonable period as agreed by the WAPC.

   (Local Government)

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Western Australian Planning Commission

3. Engineering drawings and specifications are to be submitted and approved, and subdivisional works undertaken in accordance with the approved plan of subdivision, engineering drawings and specifications to ensure that:

   a) street lighting is installed on all new subdivisional roads to the standards of the relevant licensed service provider; and/or

   b) roads that have been designed to connect with existing or proposed roads abutting the subject land are coordinated so the road reserve location and width connect seamlessly; and/or

   c) temporary turning areas are provided to those subdivisional roads that are subject to future extension; and

   d) embayment parking is provided within the road reserves and abutting the proposed Public Open Space 3 as depicted on the approved plan

   to the satisfaction of the Western Australian Planning Commission.

   (Local Government)

4. Engineering drawings and specifications are to be submitted, approved, and subdivisional works undertaken in accordance with the approved plan of subdivision, engineering drawings and specifications, for the provision of shared paths and footpaths through and connecting to the application area to the satisfaction of the Western Australian Planning Commission.

   The approved shared paths are to be constructed by the landowner/applicant. (Local Government)

5. Satisfactory arrangements being made with the local government for the cost of upgrading and/or construction of the access road from Beenyup Road. (Local Government)

6. All local streets within the subdivision being truncated in accordance with the Western Australian Planning Commission's *Liveable Neighbourhoods* policy. (Local Government)

7. A Transport Noise Assessment being prepared and approved to the satisfaction of the Western Australian Planning Commission. (Main Roads Western Australia)

8. Subject to the findings of the Transport Noise Assessment required under Condition 7, appropriate treatments are to be undertaken to the specification of the Shire of Serpentine Jarrahdale on the advice of Main Roads Western Australia, to the satisfaction of the Western Australian Planning Commission. (Local Government)

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Drainage & Subdivision Works

9. Prior to the commencement of subdivisional works, an Urban Water Management Plan is to be prepared and approved, in consultation with the Department of Water, consistent with the approved Local Water Management Strategy. (Local Government)

10. Engineering drawings and specifications are to be submitted and approved, and works undertaken in accordance with the approved engineering drawings and specifications and approved plan of subdivision, for the filling and/or draining of the land, including ensuring that stormwater is contained on-site, or appropriately treated and connected to the local drainage system. Engineering drawings and specifications are to be in accordance with an approved Urban Water Management Plan (UWMP) for the site, or where no UWMP exists, to the satisfaction of the Western Australian Planning Commission. (Local Government)

11. Engineering drawings and specifications are to be submitted, approved, and works undertaken in accordance with the approved engineering drawings, specifications and approved plan of subdivision, for grading and/or stabilisation of the site to ensure that:

    a) lots can accommodate their intended use; and

    b) finished ground levels at the boundaries of the lot(s) the subject of this approval are to appropriately interface with the land abutting to the satisfaction of the Shire of Serpentine Jarrahdale.

    (Local Government)

12. Drainage easements and reserves as may be required by the local government for drainage infrastructure being shown on the diagram or plan of survey (deposited plan) as such, granted free of cost, and vested in that local government under Sections 152 and 167 of the *Planning and Development Act 2005.* (Local Government)

13. Prior to the commencement of subdivisional works, the landowner/applicant is to provide a pre-works geotechnical report certifying that the land is physically capable of development or advising how the land is to be remediated and compacted to ensure it is capable of development; and

    In the event that remediation works are required, the landowner/applicant is to provide a post geotechnical report certifying that all subdivisional works have been carried out in accordance with the pre-works geotechnical report.

    (Local Government).

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Servicing

14. Arrangements being made with the Water Corporation so that provision of a suitable water supply service will be available to the lots shown on the approved plan of subdivision. (Water Corporation)

15. Arrangements being made with the Water Corporation that provision of a sewerage service will be available to the lots shown on the approved plan of subdivision. (Water Corporation)

16. Arrangements being made to the satisfaction of the Western Australian Planning Commission and to the specification of Western Power for the provision of an underground electricity supply to the lot(s) shown on the approved plan of subdivision. (Western Power)

17. The transfer of land for the purpose of electricity supply infrastructure to be shown on the diagram or plan of survey (deposited plan) as a reserve and vested in the Crown under Section 152 of the *Planning and Development Act 2005*, such land to be ceded free of cost and without payment of compensation. (Western Power)

Public Open Space

18. The proposed reserve(s) shown on the approved plan of subdivision being shown on the diagram or plan of survey (deposited plan) as reserve(s) for Public Open Space and vested in the Crown under Section 152 of the *Planning and Development Act 2005*, such land to be ceded free of cost and without any payment of compensation by the Crown. (Local Government)

Miscellaneous

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

20. Prior to the commencement of subdivision works a Bushland Management Plan for the existing bushland in the north-east portion of Lot 2 is to be prepared and approved to ensure the protection and management of the sites environmental assets with satisfactory arrangements being made for the implementation of the approved plan. (Local Government)

21. A revegetation plan being prepared, approved and implemented for the revegetation of road reserves and public open space with appropriate native species to the specifications of the Department of Environment and Conservation. (Local Government)

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Western Australian Planning Commission

22. Prior to the commencement of on-site subdivision works a fauna management plan to address the presence of kangaroos on the site and plans to ensure they are managed/relocated in a suitable manner is to be prepared to the satisfaction of the Western Australian Planning Commission on the advice of the Shire of Serpentine Jarrahdale and the Department of Environment and Conservation. (Local Government)

23. A Fire Management Plan being prepared, approved and relevant provisions implemented during subdivisional works, in accordance with the WAPC's *Guideline Planning for Bushfire Protection Edition 2, May 2010 (in particular Appendix 3)* to the specifications of the local government. (Local Government)

24. Detailed Area Plan(s) being prepared and approved for lots:

- Adjacent to public open space,

- With laneway access,

- Lots with dual frontage (including laneways), and

- Less than 350m^2 in area,

to the satisfaction of the Western Australian Planning Commission.

(Local Government)

25. The landowner/applicant shall make arrangements to ensure that prospective purchasers of lots subject of a Detailed Area Plan are advised in writing that Detailed Area Plan provisions apply. (Local Government).

26. Uniform fencing being constructed along the boundaries of all of the proposed lots abutting public open space and Lots 28 to 43. (Local Government)

ADVICE:

1. The Shire of Serpentine Jarrahdale advises of the following:

   a) The landowner/applicant and the local government are advised to refer to the Institute of Public Works Engineering Australia Local Government Guidelines for Subdivisional Development (current edition). The guidelines set out the minimum best practice requirements recommended for subdivision construction and granting clearance of engineering conditions imposed.

   b) Conditions 9 and 10 have been imposed in accordance with *Better Urban Water Management Guidelines (WAPC 2008).* Further guidance on the contents of urban water management plans is provided in *'Urban Water Management Plans: Guidelines for preparing and complying with subdivision conditions' (Department of Water 2008).*

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c) The landowner/applicant is advised that the Department of Environment and Conservation has prepared dust control guidelines for development sites, which, outline the procedures for the preparation of dust management plans. The dust management plans are generally approved, and their implementation overseen, by Local Government. Further information on the guidelines can be obtained from the Department of Environment and Conservation's website www.dec.wa.gov.au under air quality publications.

d) In relation to Condition 21, the plan shall incorporate or address the needs of:

a) the Noise Management Plan;

b) any proposed fencing or treatments to South Western Highway; and

c) the Fire Management Plan.

2. Main Roads Western Australia advises the landowner/application with regard to the South Western Highway road reserve:

a) no earthworks are to encroach onto the road reserve;

b) no stormwater drainage is to be discharged onto the road reserve; and

c) the landowner/applicant shall make good any damage to the existing verge vegetation within the road reserve.

3. Water Corporation advises the following:

a) In regard to Conditions 14 and 15, the landowner/applicant shall make arrangements with the Water Corporation for the provision of the necessary services. On receipt of a request from the landowner/applicant, a Land Development Agreement under Section 67 of the *Water Agencies (Powers) Act 1984* will be prepared by the Water Corporation to document the specific requirements for the proposed subdivision.

b) The proposed subdivision is located within the Mundijong Rural Drainage District. All stormwater drainage outlet flows into the Corporation's rural drains should be limited to pre-development levels. It is the responsibility of the Department of Water to ensure that the drainage scheme for this development meets these requirements.

4. The Department of Water advises that the subject area is located within the Serpentine Groundwater Area as proclaimed under the *Rights in Water and Irrigation Act 1914*. For information regarding Groundwater Licensing requirements in this area, please contact the Department of Water.

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Western Australian Planning Commission

5. With regard to Condition 16, Western Power provides only one underground point of electricity supply per freehold lot.

Neil Thomson
Secretary
Western Australian Planning Commission
7 November 2012

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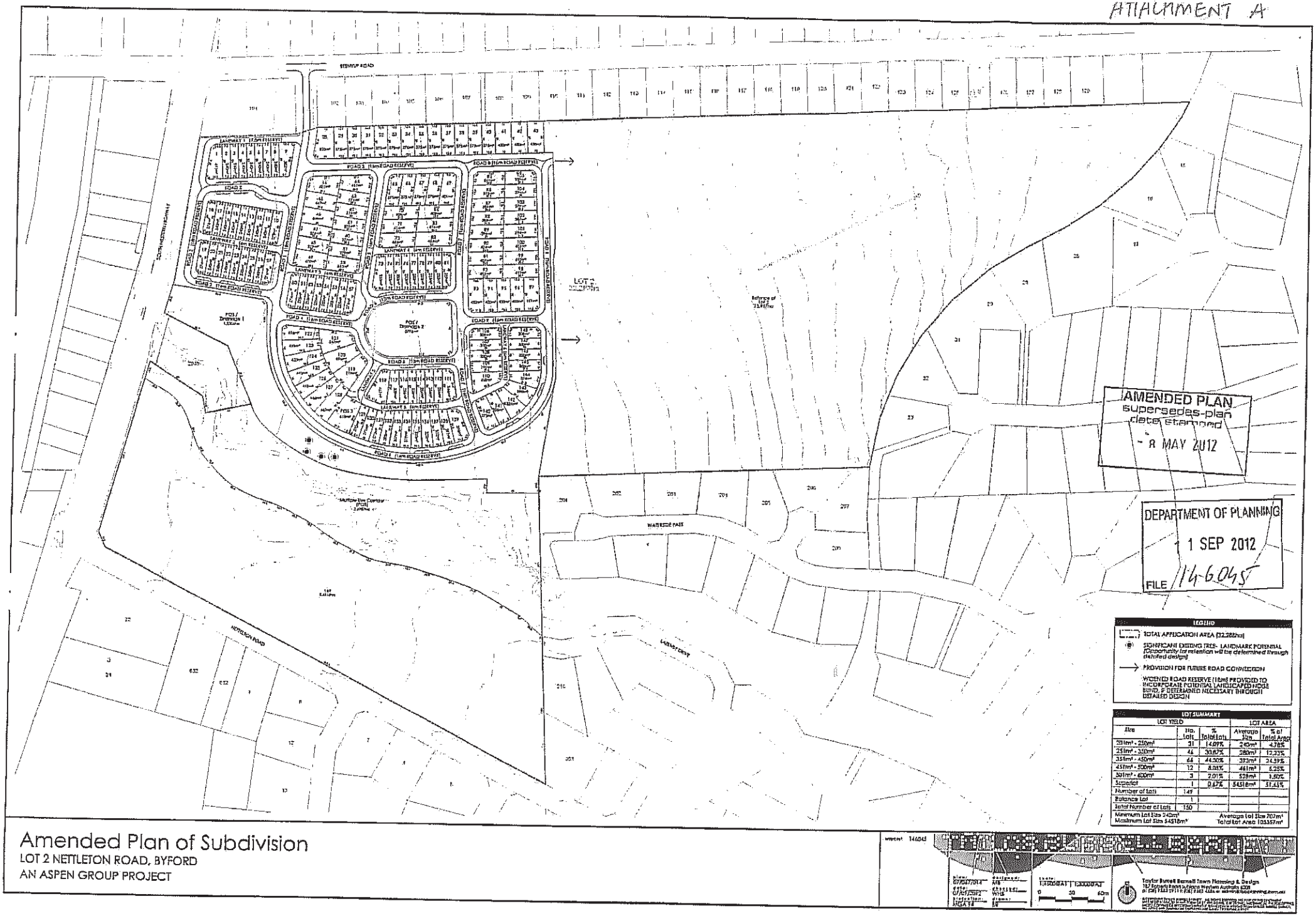
ATTACHMENT A



Amended Plan of Subdivision

LOT 2 NETTLETON ROAD, BYFORD

AN ASPEN GROUP PROJECT

Taylor Burrell Barnett Town Planning & Design

SJS TRIM - IN15/13980

FORESHORE MANAGEMENT PLAN FOR BEENYUP BROOK AT LOT 2, NETTLETON ROAD, BYFORD

Prepared for:

Aspen Group

Job No: 08.086

Report No: RP001

Australia

SJS TRIM - IN15/13980

FORESHORE MANAGEMENT PLAN FOR BEENYUP BROOK AT LOT 2 NETTLETON ROAD

Prepared for:

ASPEN GROUP

Prepared by:

ENV Australia Pty Ltd
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Prepared by:	*Sian Edwards*
Status:	*Final*
QA Review:	*Teresa Ge[[*
Technical Review:	*Dale Newsome*
Content Review:	*Teresa Gepp*
Date:	*25/06/08*

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STATEMENT OF LIMITATIONS

Scope of Services

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

Reliance on Data

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

Environmental Conclusions

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

On all sites, varying degrees of non-uniformity of the vertical and horizontal soil or groundwater conditions are encountered. Hence no monitoring, common testing or sampling technique can eliminate the possibility that monitoring or testing results/samples are not totally representative of soil and/or groundwater conditions encountered. The conclusions are based upon the data and the environmental field monitoring and/or testing and are therefore merely indicative of the environmental condition of the site at the time of preparing the report, including the presence or otherwise of contaminants or emissions. Also it should be recognised that site conditions, including the extent and concentration of contaminants, can change with time.

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

Report for Benefit of Client

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

Other Limitations

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

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

1 INTRODUCTION

ENV Australia Pty (ENV) was commissioned by the Aspen Group to prepare a Foreshore Management Plan (FMP) for a section of Beenyup Brook at Lot 2 Nettleton Road, Byford.

The objective of an FMP is to determine the foreshore reserve, devise an appropriate weed management and revegetation plan, provide areas of public access and recreation, ensure that stormwater retention capabilities are adequate and provide prescriptive management and monitoring responsibilities. Fire management and emergency access requirements are also examined as part of this plan.

1.1 LOCATION

The subject site is located at Lot 2 Nettleton Road, Byford within the Serpentine-Jarrahdale Shire (Figure 1). This is situated approximately 38km south east of Perth on the north east side of the intersection of Nettleton Road and South Western Highway. The property has an area of approximately 33.32ha and has been predominately cleared for rural use.

The primary area of focus for this management plan is Beenyup Brook and the 'foreshore' area, which has an area of approximately 5ha. The Brook runs from east to west through the southern portion of Lot 2. This is a natural drainage line that will be preserved within the proposed development.

1.2 TOPOGRAPHY

The Lot 2 Nettleton Road site lies nearly at the base of the Darling Scarp and slopes from 88m in the north east corner to 61m on the eastern boundary. There is little change in the channel's elevation from the eastern edge to the western boundary of Lot 2. There is however, a marked difference in the topography between the northern and southern banks of Beenyup Brook, with the northern bank being 3m higher than the southern bank at one point. The banks of Beenyup Brook are very steep in places, particularly sections of the northern bank.

The creekline channel averages approximately 2m wide but extends to a width of 5m at its widest point. The portion of Beenyup Brook at Lot 2 has a total length of approximately 500m, including meanders.

1.3 FLORA

The site is located in the Southwest province of the Darling Botanical District. This district typically consists of forest country with related woodlands, in the

southwest part of the province. It is divided into four subregions or botanical subdistricts. Of these, the site is located within the Swan Coastal Plain Subregion and the Drummond Botanical Subdistrict, which consists mainly of the following vegetation communities:

- *Banksia* low woodlands;
- *Melaleuca*;
- Tuart (*Eucalyptus gomphocephala)*; and
- Jarrah (*Eucalyptus marginata)* (Beard, 1990).

ENV reported on the flora of Lot 2 Nettleton Road within the Flora and Vegetation Report (ENV, 2007a), which involved a spring survey, reporting on the condition of the vegetation and identifying any significant species within the subject area. The assessment surveyed and mapped the condition of vegetation within and surrounding Beenyup Brook.

Within the ENV report, the Brook vegetation was described as community type 'ErTlJp', a description assigned by ENV. This is defined as 'Open woodland of *Eucalyptus rudis* over *Taxandria linearifolius*, **Watsonia mariana* var. *bulbillifera* and **Oxalis pes-caprae* with occasional stands of *Eucalyptus wandoo* and *Corymbia calophylla*'.

ENV vegetation community type ErTlJp was inferred as being equivalent to Floristic Community Type SCP6 'Weed dominated wetlands on heavy soils woodlands'. This Floristic Community Type is not listed under the Department of Environment and Conservation's (DEC) or the Department of Environment, Water, Heritage and the Arts' (DEWHA) Threatened Ecological Communities databases.

The vegetation surrounding Beenyup Brook, which runs east to west through the southern portion of the site, is considered to be in 'Degraded' condition (ENV, 2007a). This is based on the predominantly denuded nature of Beenyup Brook, as a result of livestock grazing. Bank erosion and weed invasion are also evident. The vegetation condition map for the whole of Lot 2 can be found in Figure 2.

As part of the foreshore management plan work, an additional vegetation survey was undertaken in March 2008 to give an idea as to the species present within Beenyup Brook and the surrounding area. This included both native vegetation and weeds.

A number of established native tree, shrub and sedge species occur along most of the creekline, but do not occur far from the water's edge. Some sections are quite dense, and there are some short sections that are devoid of vegetation.

Table 1: Native Species at Beenyup Brook

Species	Common Name	Growth Form
Acacia pulchella	Prickly Moses	Shrub
Baeckea camphorosmae	Camphor Myrtle	Shrub
Corymbia calophylla	Marri, Red Gum	Tree
Eucalyptus rudis	WA Flooded Gum	Tree
Hakea lissocarpha	Homey Bush	Shrub
Hibbertia hypericoides	Yellow Buttercup	Shrub
Hypocalymma angustifolium	White Myrtle	Shrub
Juncus pallidus	Pale Rush	Sedge
Melaleuca lateritia	Robin Redbreast	Shrub
Melaleuca rhaphiophylla	Freshwater Paperbark	Tree
Mesomolaena tetragona	Semaphore Sedge	Sedge
Taxandria linearifolia		Shrub

Several introduced species were found to be present at Beenyup Brook. The table below shows the most problematic weed species observed, of which one, *Gomphocarpus fruiticosus*, is declared pursuant to Section 37 of the *Agriculture and Related Resources Protection Act, 1976*. The locations of weeds are provided within Figure 3.

Table 2: Introduced Species at Beenyup Brook

Species	Common Name	Growth Form
**Dittrichia graveolens*	Stinkwort	Annual herb
**Ficus sp.*	Fig	Tree
**Gomphocarpus fruiticosus*	Narrow Leaf Cotton Bush	Shrub
**Nerium oleander*	Oleander	Shrub
**Pennisetum clandestinum*	Kikuyu Grass	Grass
**Rubus sp.*	Blackberry	Shrub
**Rumex sp.*	Dock	Perennial herb
**Schinus terebinthifolius*	Japanese Pepper	Tree
**Solanum nigrum*	Black Nightshade	Annual herb
**Typha orientalis*	Typha	Rush
**Watsonia meriana var bulbillifera*	Bulbil Watsonia	Corm (annual)

1.3.1 Tree Condition

An arboricultural assessment was undertaken over the whole of Lot 2 Nettleton Road (Aldous-Ball, 2007). This was to identify structurally sound trees worthy of retention. The condition of the trees situated within the foreshore area were

categorised as 'Fair to Sound' and it was advised that 'the vegetation….was found to be relatively high in habitat value. However, some selective thinning would be advisable' (Aldous-Ball, 2007).

Trees that are identified as being worthy of retention are shown on Figure 4. The foreshore reserve includes the trees to be retained. Management and protection recommendations, which are stipulated within the management section of the arboricultural report, will be followed (Appendix A).

1.4 FAUNA

A fauna survey was undertaken by ENV in December 2007 for the whole of Lot 2 Nettleton Road (ENV 2007b). This section outlines the results of this fauna survey, specific to the Brook and immediate surrounding area.

The site is situated within 1km of a major expanse of native vegetation to the east. The site and habitats present are surrounded by urbanisation in the form of housing and roads and therefore this site is isolated from the expanse of native bushland. Beenyup Brook, which traverses the site in a south-easterly direction, culminates at a road interface and is considered too degraded to allow fauna movement. As a result, habitats that are present on site are not considered to be a part of an ecological linkage. Fauna movement to and from the site can be expected to be limited to highly mobile species such as birds and bats.

The Beenyup Brook drainage line habitat is of low fauna value owing to its degraded state and lack of ecological connectivity. Microhabitats for fauna to utilise are lacking within this habitat. The Eucalypts present may provide nesting or feeding habitat for birds. The actual drainage line is likely to support amphibian species and to a limited extent, ground-dwelling reptiles. No ground-dwelling mammals are expected to utilise this habitat owing to the lack of ground cover and shrubbery, and therefore, refuge from predators. As with the alluvial habitat, arboreal mammals are not expected to utilise this habitat owing to the lack of refuge from predators.

The drainage line habitat is degraded in condition and lacks microhabitats for fauna to exploit, and as a result is considered to be of low habitat value.

The fauna survey did not find any evidence of habitat likely to support significant or 'Priority' species. It was stated that, although the Quenda is likely to occur in the Byford area, it is unlikely to utilise the habitats within the site due to the high disturbance level of Beenyup Brook. Therefore, no specific management is recommended for particular species within this FMP.

1.5 HERITAGE

An archaeological survey was undertaken by Tempus Archaeology to conduct a Phase 1 archaeological site identification survey and provide a report in accordance with the *Aboriginal Heritage Act 1972* and the Department of Indigenous Affairs requirements.

Ethnosciences was commissioned by the Aspen Group to undertake an ethnographic survey of Lot 2 Nettleton Road in 2007. This involved consultation with representatives of four key Aboriginal groups who have associations with and knowledge of the Aboriginal heritage values of the survey area: the Bibbulmun Tribal Group, the Ballaruk Aboriginal Corporation, the Independent Aboriginal Environmental Group (IAEG) and the Bilya Noongar Organisation. As part of this consultation, Beenyup Brook was identified as being an ethnographic site, being of spiritual significance. It was not, however, deemed to be an 'Aboriginal Site' under the Aboriginal Heritage Act, 1972 (Ethnosciences 2007).

All groups consulted were primarily concerned with the need to protect the brook and its associated flora and fauna. The groups were satisfied that the buffer shown on the preliminary concept plan would help to ensure that there would be no direct impact to the brook as a result of the proposed development. This buffer has not decreased in width and has in fact increased in areas (See Section 3).

The groups were concerned about drainage and water run-off from the proposed development into the Brook. The development plan includes areas for stormwater retention and therefore there will not be direct run-off from stormwater drains into the Brook. The drainage through the whole site has been designed so that run-off enters the stormwater drains or the retention areas. The increase in flow that will be received via the detention basins during stormwater events has been modelled. It has been found that the additional volume is considerably less than the present flows through Beenyup Brook (Sasha Martens, JDA *pers. comm.* 2008).

The IAEG also requested the following:

- 'That introduced weeds along the brook be cleared to ensure unobstructed water flow;
- That only local sand be used for any required fill (to prevent fungus etc being imported from elsewhere);
- That no sprays be used to control weeds; and

- That an environmental centre and/or education material and talks be provided to raise awareness in the community about the importance of protecting the brook and other aspects of the local environment and ecosystem'.

The IAEG requested that they be consulted following any changes to the proposed development plan, particularly regarding the final buffer zone along the brook. This will be undertaken as part of the planning process if any reduction in the foreshore buffer is proposed.

The report recommended, with regard to Beenyup Brook and the foreshore management plan, that:

- All impacts to Beenyup Brook be avoided where possible through the provision of a buffer zone extending to 30m on either side of the brook.

It is believed that this FMP addresses the concerns raised by the IAEG and is discussed further in Section 3.

2 POLICY

2.1 POLICY AND FORESHORE ASSESSMENT CRITERIA

A foreshore is the land that adjoins or directly influences a waterway; it is the transition between the edge of the waterway and the furthest extent of riparian vegetation, flood prone land, and riverine landform or the adjacent upland. In practice, where human activities have affected creek, river and estuary foreshores, the foreshore area may be the land between the waterway and that being actively used by humans (Water and Rivers Commission 1999). A foreshore may also be considered part of a waterway protection precinct.

Historically in Western Australia, foreshore protection and management policies have relied on a standard pre-determined figure for establishing a foreshore reserve, such as 30 meters for rivers (Western Australian Planning Committee Development Control 2.3) and 50m for estuaries (Western Australian Planning Committee Development Control 6.1).

Two guiding policies describe the process for determining foreshore reserves in Western Australia; River Restoration Series No. RR16 *'Determining Foreshore Reserves'* (Water and Rivers Commission, 2001) and *Foreshore Policy 1 – Identifying the Foreshore Area* (Water and Rivers Commission 2002). These policies are complimentary in that they present the same methodology for foreshore reserve determination, a biophysical assessment which is described below. The principle point of difference is that Foreshore Policy 1 reintroduces the principle of a default reserve or buffer distance for waterways and estuaries. For waterways the reserve default is set at 30m "in the event that the assessment for biophysical criteria determines a buffer of less than 30m". The final negotiated foreshore alignment, however, represents an agreed position between all parties, allowing for the future management of the foreshore reserve (Water and Rivers Commission, 2001).

RR16 *'Determining Foreshore Reserves'* details the biophysical criteria that are to be used to determine the required width. This criteria includes:

- Vegetation or the extent of riparian vegetation, including identifying soil types that typically support riparian vegetation;
- Hydrology and the extent of the floodway and floodplain;
- Soil types that are prone to erosion;
- Landforms important to watercourse function such as drainage lines, steep slopes, ridges, low-lying or seasonally inundated lands;

- Valuable habitat areas such as pools, riffles, marshes and terrestrial habitats such as mudflats, trees, fallen logs and vegetated corridors;
- Adjacent land use pressures that may affect the foreshore area. The location of housing, services, public access and recreation nodes should all be identified; and
- Archaeological and ethnographic sites adjacent to the waterway. These sites should be included in the foreshore reserve where possible.

2.2 SHIRE POLICY

The Shire recently published a Discussion Paper on the Serpentine Jarrahdale Shire Local Biodiversity Strategy (Del Marco and Penna 2007). Section 8.1 of this Discussion Paper is titled 'Landscaping and revegetation in Multiple-Use Corridors (MUC's). A Multiple-Use Corridor is defined as 'land surrounding waterways in the Shire which are to be developed and used for stormwater management, recreation and wildlife habitat' (Del Marco and Penna 2007).

The Strategy states that guidelines are 'being put in place for the revegetation of MUC's to ensure that the areas of revegetation will be able to resist weed invasion, assist in nutrient management and provide habitat for the more hardy or mobile aquatic and aerial fauna'. It is believed that this foreshore management plan would satisfy any guidelines outlined by the Shire and the revegetation program has considered the planting density standards and revegetation policy currently stipulated by the Shire.

A number of MUC's in Byford and Mundijong have been identified as regional ecological linkages; Beenyup Brook is not shown as being part of an important linkage, however, the treatment applied to Beenyup Brook through this management plan will enhance the area as an ecological linkage habitat, as well as it functioning as an MUC.

3 FORESHORE RESERVE

3.1 FORESHORE RESERVE DETERMINATION

A foreshore assessment in accordance with the policies described in Section 2.1 was undertaken for Beenyup Brook on the Lot 2 Nettleton Road property. Where the biophysical criteria led to a foreshore reserve of less than 30m, the default of 30m on either side, as specified within Foreshore Policy 1 (Water and Rivers Commission 2002), was applied to define the minimum foreshore reserve and to comply with local indigenous representative's desires. The foreshore reserve is represented on an aerial, together with the 30m foreshore reserve default boundary, on Figure 4.

3.1.1 Vegetation and Extent of Riparian Vegetation

The foreshore area of Beenyup Brook is predominately cleared for grazing, with the channel vegetation classed as 'degraded'. Riverine and wetland vegetation was predominately confined to the channel width and at most, within 15m of the central creekline.

3.1.2 Hydrology and Extent of Floodway and Floodplain

Information within the Byford Drainage and Water Management Plan – Byford Townsite Briefing Paper (GHD 2007) stipulated that the floodway width at Beenyup Brook by South Western Highway must be at least 50m. The foreshore reserve is greater than 50m in total width throughout the Brook within Lot 2, Nettleton Road (Figure 4).

The Department of Water supplied information relating to the 100 year Average Recurrence Interval (ARI) flood levels. These levels were modelled by JDA. The proposed foreshore reserve has been provided to JDA, who have confirmed that the proposed foreshore reserve and its alignment is sufficient to contain the 1 in 100 year flood level (Sasha Martens, JDA, *pers. comm.* 2008).

A Local Water Management Strategy, dealing with stormwater retention and drainage, has been developed for the proposed development over the whole of Lot 2 Nettleton Road. This has modelled to calculated run off to Beenyup Brook. It was found that the portion of additional water volume was very small in comparison to the volumes already carried by the Brook. There will not be a significant difference in the hydrological regime and therefore the channel morphology will not significantly change, thus additional width for increased run off is not required (Sasha Martens, JDA *pers. comm.* 2008).

3.1.3 Soil Types

The soil underlying Beenyup Brook and the immediate surrounding area is classified as Pinjarra P1a Phase. This is categorised as 'flat to very gently undulating plain with deep acidic mottled yellow duplex (or 'effective duplex'); Shallow pale sand to sandy loam over clay; imperfect to poorly drained and generally not susceptible to salinity' (Department of Agriculture, 2003).

This soil is prone to erosion, as the undercut and heavily eroded sections of the banks show. It is however, believed that a large portion of Lot 2 has these soils, due to the site being very wet, which is reflected in its mapping as a multiple use wetland. Therefore, it is believed that the soil type is not a differentiating factor in determining the foreshore reserve.

3.1.4 Landforms

The landform is the predominant feature in ascertaining the foreshore reserve. The channel is deeply incised in places resulting in very steep banks, especially on the western portion of the northern bank side and the eastern half of the southern side. The channel width and immediate foreshore area is therefore narrow in this section due to the steep topography.

The eastern half of the northern section has two bank landforms, with a gentle bank type slope located approximately 40m from the central creekline and a steep bank slope adjacent to the immediate channel width. The widest extent of the landform associated with the Brook was taken as the foreshore boundary and therefore, at this point, the foreshore reserves spans 85m.

There is a section on the south western side where the topography is fairly low lying and is believed to be seasonally inundated. Consequently, this has been included within the foreshore reserve.

There are two areas where the foreshore reserve is less than the 30m default buffer. On the northern section, this corresponds to the very steep banks in the northern side. A greater foreshore area is provided on the corresponding southern section, to give a total width of 55m. On the steep southern side, the foreshore reserve is slightly less than 30m; however the boundary of the reserve has been extended on the northern side to incorporate the topographical features, thus giving a foreshore reserve of 85m.

3.1.5 Adjacent Land Uses

The land at present is cleared and has a vegetation condition of 'completely degraded' (ENV 2007a). It is proposed that Lot 2 Nettleton Road will be developed into residential housing, although there will be landscaping incorporated into the development plan. There will be public access and

recreation areas as part of the management plan and therefore these will be suitably located and controlled in terms of safety and potential environmental damage.

3.1.6 Archaeology and Ethnographic Sites

The archaeological survey identified a number of significant artefacts within Lot 2 Nettleton Road (Tempus 2007). Of these finds, one significant location was highlighted adjacent to Beenyup Brook. This is included within the foreshore reserve and will therefore be protected from development.

3.2 ASSUMPTIONS

In keeping with the principles described in Foreshore Policy 1, the biophysical criteria have been considered. This was discussed with the Department of Water (James Macintosh, *pers. comm.* 2008) and it was stipulated that the foreshore reserve should be at least the minimum floodway width (50m), as stated within the Byford Drainage and Water Management Plan – Byford Townsite Briefing Paper (GHD 2007).

The assumptions on which the foreshore reserve has been determined include:

- As most of Beenyup Brook at the time of survey was not carrying water, the 30m default buffer was taken from the centre of the creekline as a guide to the reserve where no clear biophysical characteristics were available, or where the biophysical criteria assessment would result in a narrow foreshore reserve; and

- The topographic contours were the main biophysical criteria used to ascertain the foreshore reserve.

4 PUBLIC ACCESS AND RECREATION

4.1 OBJECTIVE

The objective of designing public access to Beenyup Brook is to provide safe, multiple use paths that provide access to a number of different users whilst preventing undue environmental damage. The path location route is to be useful for the community, giving accessibility and linkage to both sides of the Brook and into the development or Nettleton Road.

The objective for recreation within the Beenyup Brook foreshore is to provide low key, passive recreation opportunities with an educational aspect.

4.2 LOCATION

The multiple use path location is shown on Figure 5. This provides access and recreation opportunities on the gentler slopes of Beenyup Brook and steers away from the potentially dangerous steeper banks. This also gives an opportunity to have good revegetation outcomes within the areas that will not be accessible from the path.

The path along the northern bank connects with the development path at the eastern entry point. The path then travels down into the wide foreshore section to allow recreation opportunities. Figure 6 shows the locations of cross sections through Beenyup Brook and cross section 4 in Figure 8 shows the proposed layout of this section.

The path then crosses Beenyup Brook via a crossing point where the topography is relatively flat (Figure 4). This provides a connection between the north and south side of the Brook.

The crossing connects to the southern bank path, which is shown on cross section 1 and cross section 2 of Figure 7. As there is very steep topography on the western half of the northern bank, public access is confined to alongside the road reserve.

The southern path does not connect to the South Western Highway, as there is to be no direct access due to safety reasons. The path will connect to roads and pavements that access through potential commercial/medical facilities and residential development before emerging out onto Nettleton Road.

In the lower lying section on the southern side, the path is located on the margin of the foreshore reserve in order to elevate the path above the 100 year ARI flood level.

4.3 PATH SPECIFICATIONS

The multiple use path will be 2.5m wide and constructed with coloured concrete in an earthy tone to provide a trafficable surface for wheelchairs, people using mobility aids and prams, as well as walkers. The path will traverse over the channel via a crossing to provide linkage to both sides of the Brook.

There is an existing timber bridge located on the western section of the Brook, which was historically used by the residents of Lot 2. This is not wide enough for a multiple use path, nor is it structurally sound and will be removed for safety reasons.

4.4 RECREATION

The northern shore recreation section (Figure 7) will be landscaped with native, dryland species. There will be seating provided along the path and two interpretive signs, one regarding the ecology of the Brook and surrounding land, the other giving an insight into the heritage of the area. There will also be a picnic area and a shelter within this recreation area.

The southern side and northern side will provide a viewing platform with seating to allow the public a wide vista over the Brook and foreshore. This can be seen in cross section 3 (Figure 8).

The northern and southern areas will offer seating and picnic areas, with the larger northern shore foreshore area offering a feature shelter and picnic area. This can be seen in cross section 4 (Figure 8). Bins will be provided on the road reserves on the foreshore reserve boundary. Bins will not be provided within the foreshore reserve and signs will be erected next to picnic areas encouraging people to take their litter to the bins at the foreshore reserve boundary.

5 REVEGETATION AND WEED MANAGEMENT

5.1 OBJECTIVE

The objective of the revegetation and weed management works is to provide appropriate planting for the foreshore reserve, in accordance with the 'Draft Environmental Policy' (Serpentine Jarrahdale Shire, 2005). Weed removal and continuing weed management is a critical element for the preparation and ongoing success of the revegetation work.

5.2 REVEGETATION AREA

Beenyup Brook has four distinct revegetation zones, namely the creekline, the embankments, the open flats and the landscape areas. The topography and different drainage regimes within areas of Beenyup Brook have led to the development of different revegetation treatments. This is demonstrated within the Foreshore Revegetation and Weed Management Plan (Tranen, 2008), which is located in Appendix B. The different revegetation zones are shown within Figure 5. Cross sections are provided to give an aesthetic impression as to how the foreshore reserve will appear at different vantage points. The cross section locations are shown in Figure 6, while the cross sections are shown in Figure 7 and Figure 8.

Native vegetation will be retained wherever practicable. Specific trees to be retained are shown in Figure 5.

Weed management and any required earthworks will be undertaken prior to planting.

5.2.1 Creekline

The creekline vegetation area (Figure 5) is relatively small due to the channel of Beenyup Brook being narrow and incised. The creekline length is approximately 500m, with an average of 2m wide. Therefore, it has been calculated that the total area to be revegetated for the creekline zone is approximately 1,000m^2.

The Serpentine Jarrahdale Shire planting guidelines require water bodies to be planted at a density of 6 plants/m^2. A total of 6,000 plants will therefore be required. Only sedges have been selected for this revegetation. Further information on species and quantities can be found within Appendix 4 of the revegetation report (Appendix B).

In areas that are already vegetated with native species or where high velocity flows are apparent, the seedlings planned for these areas will be located in the most sparely vegetated sections or to the immediate edges of the creekline.

Planting within the creekline will take place later in the spring season following development of adjoining land, once water levels have peaked and began to recede. This is to ensure that the seedlings are given optimum conditions for growth and survival.

5.2.2 Embankments

The embankment areas are defined as those that have the steeper topography and are situated out of the creekline (Figure 5). Banks that are particularly steep will be modified where practicable (see Section 6).

The embankment areas will be revegetated with tree and shrub species to increase the vegetation density at ground and canopy levels. Species allocated to the embankment will be more dryland species, as soil moisture levels are expected to be less than in the open flats.

Planting will be at a density of 2 plants/m^2 in the embankment zone. Species representation will be 30% trees, with 70% shrubs and ground covering species. Quantities and species selected are detailed within Appendix 3 of the revegetation plan (Appendix B).

5.2.3 Open Flats

The open flat areas are situated close to the creekline area (generally within 15m of the central creekline), on flat land out of the creek channel. The location of this zone is shown on Figure 5 and the total area of the open flat zone is estimated to be 8,300m^2. The species used within this zone will therefore be more adapted to wet situations.

The open flat area will be revegetated with tree and shrub species to increase the vegetation density at ground and canopy levels.

According to the Serpentine Jarrahdale Shire planting guidelines, these works fall into a biodiversity purpose and therefore, planting at a density of 2 plants/m^2 is required. Species representation will be 30% trees, 60% shrubs and ground covering plants and 10% sedges. Species are detailed within Appendix 3 of the revegetation management plan (Appendix B).

Planting will be conducted around the existing vegetation. Rushes and sedges will be planted in clusters, to mirror the natural form. Where practicable, flat areas will be ripped to a depth of 500mm to reduce surface compaction prior to planting. This will facilitate better root growth and plant development.

5.2.4 Landscape Areas

The planting of the wider foreshore area will mirror the landscape treatment of the wider development area. This will be slightly more formal than the other vegetation zones and will complement the public access and recreation features that will also be part of this vegetation zone (Figure 5).

Bore water for irrigation is unlikely to be available for this development. Therefore, the landscape area will be revegetated with dryland species. These species and quantities are detailed within Appendix C. In the unlikely event that bore water does become available for irrigation, turf parkland areas and ornamental plant areas may be introduced to a few areas within the reserve to encourage and direct areas of human interaction.

All native vegetation will be retained wherever possible. Some trees may be removed or lopped for fire or safety reasons.

5.3 WEED MANAGEMENT PLAN

The control of weeds is a major issue in all revegetation works as weeds will compete against seedlings for light, nutrients and space (Tranen, 2008). The location of weeds at Beenyup Brook is shown on Figure 3.

Weed management will take place through the whole of the foreshore reserve and is fully detailed within Section 3 of the Revegetation and Weed Management Plan (Tranen, 2008) in Appendix B.

The initial management will treat weeds that are already present, but the weed control program will need to continue for several years before weed stored in the soil is exhausted.

The various species of weed that have been identified to date each fall into one of four different categories of growth form, each with a specific management strategy:

- Woody weeds (trees and shrubs);
- Grasses;
- Annual/perennial broadleaf herbs and sedges; and
- Corms, bulbs and tubers.

As the growth and reproduction mechanisms differ, as to their responses to various treatment options. Each species may have a specific or best control method that will be applied as per Bushland Weeds: A Practical Guide to their Management (Tranen, 2008).

Herbicide application will be the main control method due to the size of infestations. It will not be viable to hand pull all the weeds. The Independent Aboriginal Environmental Group suggested that herbicide use should not be permitted around the Brook (Section 1.5). However, selective herbicide will be used as much as possible, especially in areas where existing native vegetation may be susceptible to the application of glyphosate (broad spectrum herbicide). The appropriate type of herbicide (e.g. grass specific) will be selected according to the area to be treated. Glyphosate is also not appropriate for use around exposed water bodies, and therefore, Roundup Biactive® (or similar) will be used. This is specially formulated for use in aquatic situations and is widely used in Western Australia for killing riparian or aquatic weeds.

Spot spraying methods must be implemented to protect the native vegetation present along the Brook. An experienced operator with a good knowledge of native and weed species, who is also trained and licensed in the use of herbicide, will be contracted to undertake the work.

Manual control or hand removal will be carried out where low numbers exist too close to a plant, but being careful to minimise soil disturbance.

Section 3 of the Foreshore Revegetation and Weed Management Plan (Tranen, 2008) in Appendix B details the specific treatment for each different weed growth form.

The comprehensive weed management schedule details all the required activities and timing for the different treatments according to the species. This is located within Appendix 5 of the Foreshore Revegetation and Weed Management Plan (Tranen, 2008) in Appendix B.

5.4 REVEGETATION PROGRAM

Seed collection was undertaken at the site during autumn 2008. The full revegetation program is detailed within the Foreshore Revegetation and Weed Management Plan' (Tranen, 2008), which is located in Appendix B.

5.4.1 Installation Methodology

The Foreshore Revegetation and Weed Management Plan commenced in autumn 2008. Planting will take place in winter/spring 2009 or the winter/spring following development on Lot 2, Nettleton Road. The seedlings and materials will be ordered once this plan is approved.

Planting of seedlings will commence after the first rains have made the soils sufficiently wet to plant (expected to be around May/June). It is intended that all installation works be completed by August of the year of installation.

5.4.2 Ripping

Ripping breaks the surface compaction and increases root and plant growth. Only the flat areas classified as 'Open Flats' will be ripped, along with the 'Landscape Areas' where required. It will be unsafe and impractical to rip on the embankments or within the creekline.

Rip lines at a minimum depth of up to 500mm should be spaced at intervals of 1m for the entire length of the areas to be revegetated. As the ground may be very compacted in places, or due to the presence of rocks within the soil, it may not be possible to rip all areas.

5.4.3 Seedling Supply

The seedling species is detailed within Appendix 4, located in the Foreshore Revegetation and Weed Management Plan (Tranen, 2008) in Appendix B. If the nurseries are unable to supply the species stipulated, recommended substitutions will be presented to the Serpentine Jarrahdale Shire for approval.

Seedlings will be supplied in tubestock sizes, to industry standards:

- Soil in containers at the time of delivery will be free of weeds, insects and disease (e.g. dieback);
- All plants will be true to the species name, well formed and hardened off nursery stock;
- The root system will be fibrous, of a whitish colour and not browned off, firmly established but not root bound and with no large roots protruding from the container; and
- Leaves will be of normal size, colour and texture for that specified species.

5.4.4 Seedling Planting

Trees will be planted first to ensure an even distribution within the barer areas of the reserve. Other plants will then be infill planted to fill the remainder of the space. Rushes and sedges will be planted in all the wet depressions of the creek bed, except in areas of high water velocity.

Fertiliser will not be used for the creekline as it would add to the already high nutrient loads. In the other areas, one 10g slow release fertiliser tablet, appropriate for use with native species, will be buried adjacent to each plant. The tablets will be placed 100mm - 200mm from each seedling to promote healthy root development. The nutrients contained within the tablets will be less mobile as they buried underground. This method is therefore considered appropriate for use.

5.5 ACCESS MANAGEMENT

Conservation fencing approximately 1.2m high will be installed around the Beenyup Brook foreshore reserve to exclude stock, pedestrians and kangaroos from accessing and damaging plants. These may be removed by the Shire after a minimum of three years protection of the revegetation in progress.

6 BANK STABILISATION

The revegetation work will stabilise existing vulnerable banks and 'fill in' areas exposed from the weed management work.

6.1 OBJECTIVE

It is an objective of the bank stabilisation work that the Brook is modified as little as possible. Beenyup Brook is naturally incised in places and therefore, where the erosion is not severe or does not pose a safety risk, the banks will be unaltered and stabilised by the revegetation work.

6.2 METHODS

There are a few locations where the banks are severely eroded or undercut (Plate 1).

Plate 1: Heavily eroded bank on northern side of Beenyup Brook

In areas where there will be easy public access, or where there is severe erosion that will limit revegetation success, banks will be slightly modified to a suitable batter. This will be done during the earthworks stage of the development. The physical bank stabilisation works is subject to approval of the lodged Section 18 Notice under the *Aboriginal Heritage Act 1972*.

Where there are trees to be retained, the bank will be stabilised around the tree as much as possible, using methods recommended within the arboricultural assessment (Appendix A).

Following any regrading, revegetation will take place to stabilise the slope and prevent further erosion.

In areas that are heavily shaded or where there is limited revegetation success during the first year (which will be highlighted during the revegetation monitoring

works), the banks may need to be stabilised with geotextile fabric. If water velocity is such that banks continue to be eroded, further channel modification, such as rock riffles, will be investigated.

7 FIRE MANAGEMENT

Fire Management has been considered for Beenyup Brook and for the wider development.

The fire/maintenance vehicle access track is shown within Figure 5. This will consist of a road base material located just inside the foreshore boundary on the northern edge. The track will be approximately 4m wide and join the crossing point over Beenyup Brook.

Fire breaks have been indicatively shown to the boundary of the multiple use corridor within cross section 1-4 in Figure 7 and 8.

The fire and emergency access for the whole development is detailed within the 'Emergency Risk Management Plans'. This has been undertaken separately from this Foreshore Management Plan by Fireplan Pty Ltd and is lodged concurrent with this report.

8 MONITORING AND MAINTENANCE

8.1 PUBLIC ACCESS

The multiple use paths that will run within the foreshore will be inspected for stability and any defects at the same time as weed management and revegetation works are undertaken. If it is found that the path is failing before handover, works will be undertaken to rectify or relocate the path.

8.2 REVEGETATION AND WEED MANAGEMENT MONITORING

The 'Revegetation and Weed Management Plan' details the suggested monitoring and maintenance for the foreshore reserve. This will be incorporated within the ongoing monitoring and maintenance plan for the wider landscaping work. The immediate foreshore revegetation will be maintained for 2 years after planting, after which time, the responsibility will transfer to the Shire.

In summary, it is suggested the following monitoring and maintenance take place:

8.2.1 Revegetation Performance Criteria

The Serpentine-Jarrahdale Shire have set performance criteria at a minimum of 80% of required stems being present two years after planting (Serpentine Jarrahdale Shire, 2005).

Therefore, the final creekline density needs to be an average of 4.8 plants/m^2, and 1.6/m^2 in the embankment, open flat and landscape areas.

8.2.2 Revegetation and Weed Monitoring Program

The monitoring program will be undertaken as follows.

Table 3: Revegetation and Weed Monitoring Schedule

Visit	Assessment	Action
1st spring – October	Short term survival of seedlings Emergence of summer weeds	Remedial action in the case of any early failure. The weed management regime to be altered if unsuccessful.
1st autumn – April	Survival rates of seedlings over summer Annual weed encroachment	Infill planting following winter if below 80% survival. Watering an option if there is an exceptionally dry summer Weed management program altered if required

Visit	Assessment	Action
2nd spring – October	Ongoing success and weed levels	Infill or altered management if required. Weed control if required.
2nd autumn – April	Ongoing success and weed levels. Long term monitoring and maintenance requirements.	As above – long term requirements and maintenance programme to be developed if required.

8.3 BANK STABILISATION MONITORING

The bank stabilisation works will be monitored throughout the two year period, during the same inspection times as for the revegetation schedule.

The objective of the bank stabilisation works is to modify the bank as little as possible and therefore bank regrade will only occur in areas already severely eroded or undercut.

As the hydrological regime will change slightly, the Brook will be inspected during all site works, such as during weed management or during the revegetation monitoring works. The stabilisation inspection will ascertain if any new areas of erosion require treatment and also to assess the success of the bank modification. This will be measured by surveying the bank sides for any new areas of erosion, any failing revegetation areas or any 'slipping' of bank material. Any new areas of high velocity water will start to undercut banks and therefore any areas of new undercutting will also be mapped.

If areas of revegetation are failing, the cause of this failure will be investigated. The results of this assessment may lead to a bank modification if the banks are too steep, or replacing the initial revegetation area with geotextile fabric to ensure that the banks are protected until vegetation is established.

If it is found that water velocity is too high and is eroding or undercutting the banks, other measures to break the flow, such as rock riffles, will be put in place. This will slow the water and prevent the high energy erosion.

The ongoing monitoring and maintenance during the first 2 years will lead to an understanding of how the Brook will adapt to the new regime and also how the bank modification and revegetation program will perform. The details of the bank stabilisation works and any required ongoing management and inspection schedule will be included within this Foreshore Management Plan at the time of handover to the Shire.

8.4 ONGOING MANAGEMENT

All monitoring and management will be detailed within the management plan. Work undertaken and any amended regimes will also be documented. The management plan will then be lodged with Council at the handover stage to enable ongoing, appropriate management of the reserve.

9 REFERENCES

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FIGURES

PRINTED: Wed 28 May 08

BEENYUP ROAD

SOUTH WESTERN HIGHWAY

Brickworks Road

LOT 2

Beenyup Brook

Waterside Pass

NETTLETON ROAD

N

metres

0 30 60 90 120 150

SCALE 1 : 3 000 @ A3

LEGEND

Subject Land Boundary

08-086-1F1.dgn
DATUM: MGA50
DRAWN: TE 27-05-08
AUTHOR: SE 27-.5-08
Aerial Photograph supplied by: Landgate, Dec 2006

Aspen
LOT 2 NETTLETON ROAD
FORESHORE MANAGEMENT PLAN
LOCATION
FIGURE 1

env Australia

SJS TRIM - IN15/13980

PRINTED: Tue 27 May 08

BEENYUP ROAD

SOUTH WESTERN HIGHWAY

NETTLETON ROAD

Brickworks Road

White Gum Rise

Waterside Pass

Beenyup Brook

LOT 2

CD

D

G

N

metres

0 30 60 90 120 150

SCALE 1 : 3 000 @ A3

LEGEND

Subject Land

VEGETATION CONDITION

(Legend Source: BUSH FOREVER Govt. of W.A.)

P	Pristine. (Not Applicable)
Ex	Excellent. (NA)
VG	Very Good. (NA)
G	Good.
D	Degraded.
CD	Completely Degraded.

08-086-1F2.dgn
DATUM: MGA50
DRAWN: TE 27-05-08
AUTHOR: SE 27-05-08

Aspen
LOT 2 NETTLETON ROAD
FORESHORE MANAGEMENT PLAN
VEGETATION CONDITION
FIGURE 2

env Australia

SJS TRIM - IN15/13980

FIGURE 3: Location of Weeds	**Job No: 08.086**
	Drawn By: SE
Client: Aspen Group	Checked By:
Project: Lot 2 Nettleton Road – Foreshore Management Plan	Scale: NTS Date: 23/05/08

PRINTED: Tue 27 May 08

LEGEND

- Topographic Contours
- Foreshore Reserve
- Creekline
- 30m Default Foreshore Reserve

64m
55m
85m
SOUTH WESTERN HIGHWAY
NETTLETON ROAD
62
63
64
65
66
67

N

metres

0 10 20 30 40 50

SCALE 1 : 1 500 @ A3
DATUM: MGA 50

08-086-1F3.dgn
DRAWN: TE 27-05-08
AUTHOR: SE 27-05-08

Aerial Photography supplied by: Landgate, Dec 2006

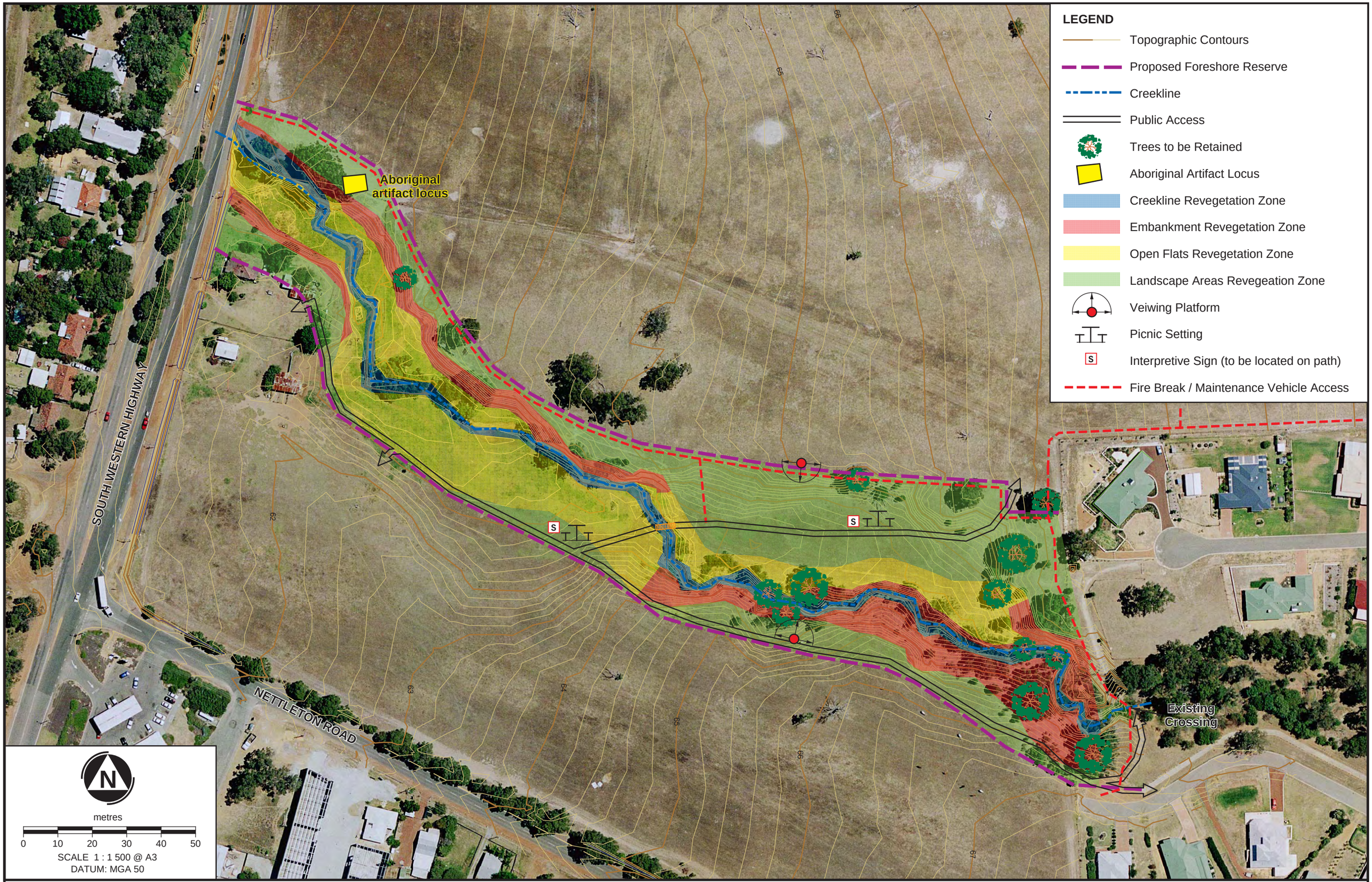
Aspen
LOT 2 NETTLETON ROAD
FORESHORE MANAGEMENT PLAN

PROPOSED FORESHORE RESERVE

FIGURE 4

env Australia

PRINTED: Tue 24 Jun 08



LEGEND

- Topographic Contours
- Proposed Foreshore Reserve
- Creekline
- Public Access
- Trees to be Retained
- Aboriginal Artifact Locus
- Creekline Revegetation Zone
- Embankment Revegetation Zone
- Open Flats Revegetation Zone
- Landscape Areas Revegeation Zone
- Veiwing Platform
- Picnic Setting
- S — Interpretive Sign (to be located on path)
- Fire Break / Maintenance Vehicle Access

N

metres

0 10 20 30 40 50

SCALE 1 : 1 500 @ A3

DATUM: MGA 50

08-086-1F4.dgn

DRAWN: TE 23-06-08

AUTHOR: SE 23-06-08

Aerial Photography supplied by: Landgate, Dec 2006

Aspen

LOT 2 NETTLETON ROAD

FORESHORE MANAGEMENT PLAN

FORESHORE MANAGEMENT PLAN

FIGURE 5

env Australia

PRINTED: Tue 27 May 08

metres
0 10 20 30 40 50
SCALE 1 : 1 500 @ A3
DATUM: MGA 50

08-086-1F4.dgn
DRAWN: TE 27-05-08
AUTHOR: SE 27-05-08

Aerial Photography supplied by: Landgate, Dec 2006

Aspen
LOT 2 NETTLETON ROAD
FORESHORE MANAGEMENT PLAN
CROSS SECTION LOCATIONS
FIGURE 6

env Australia

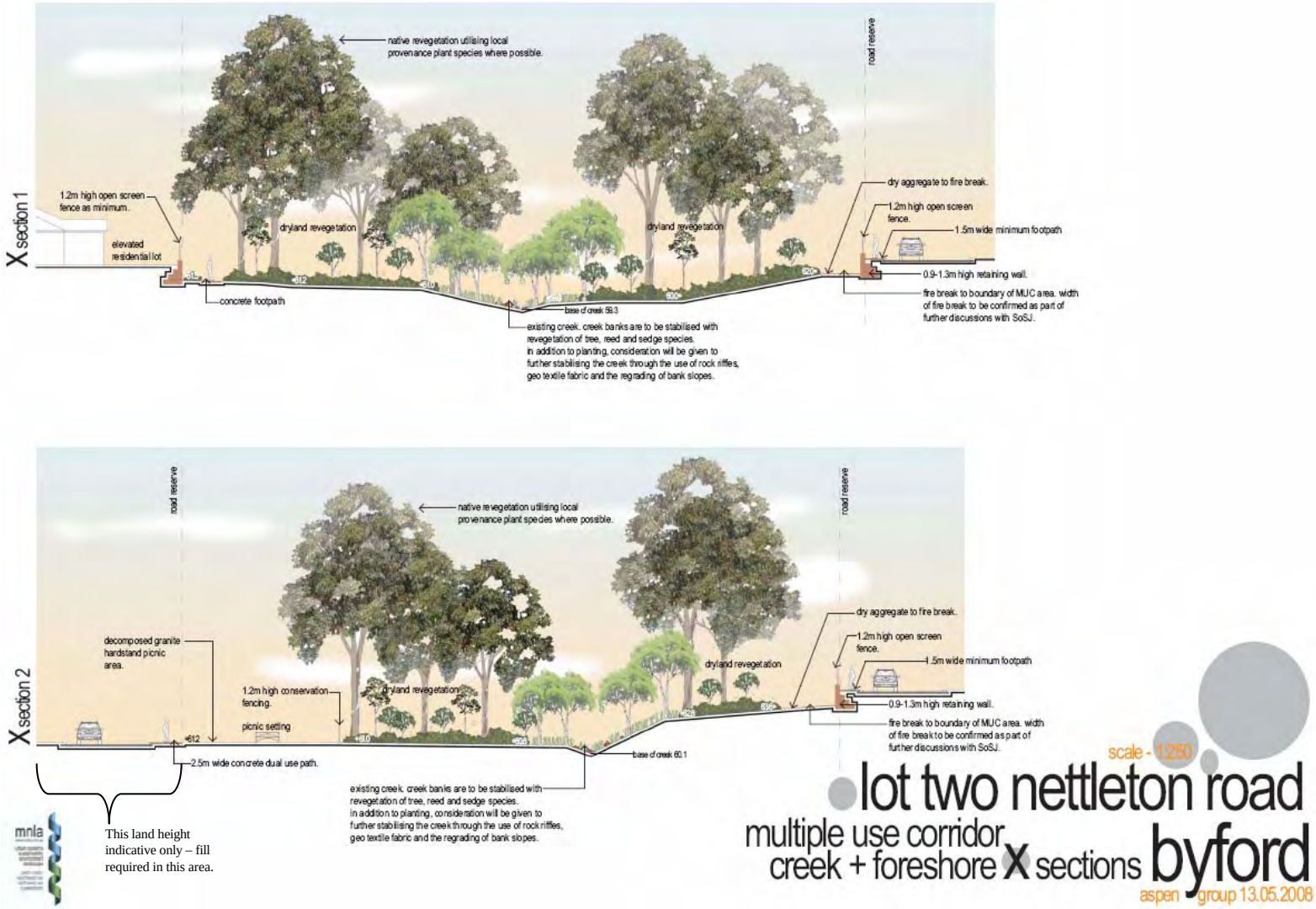


FIGURE 7: Cross sections 1-2	**Job No: 06.086**	
	Drawn By: MNLA	
Client: Aspen Group	Checked By: SE	
Project: Lot 2 Nettleton Road	Scale: NTS Date: 20/05/08	

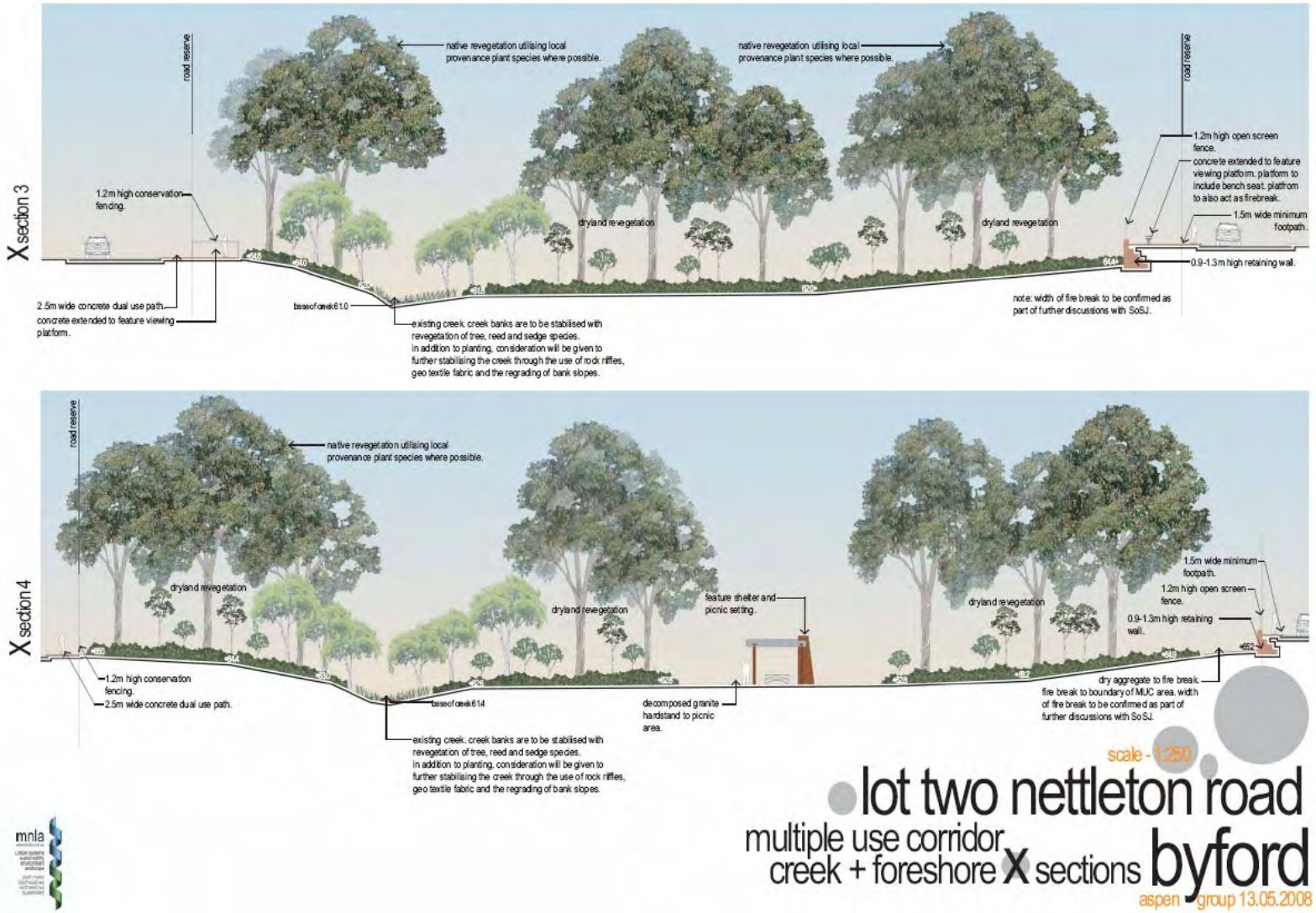


FIGURE 8: Cross sections 3-4	**Job No: 06.086**	
	Drawn By: MNLA	
Client: Aspen Group	Checked By: SE	
Project: Lot 2 Nettleton Road	Scale: NTS Date: 20/05/08	

APPENDIX A
ABORICULTURAL ASSESSMENT

TABLE OF CONTENTS

1. BRIEF:

Aspen Group has commissioned this consultant to inspect and submit a report in the respect of trees within the proposed development of Lot 2 Nettleton Road, Byford.

The objective of the arboricultural assessment was to undertake an inspection and carry out an examination of each tree or group of trees within the delineated area as supplied by Whelans Surveyors, to establish the trees mechanical structure, health, safe useful life expectancy, and any future management requirements.

The inspection consisted of several parts.

- Examination, observation and documenting the health and the condition of the tree.

- To investigate the possible or probable cause of each abnormality, and to document the immediate and future consequences for the tree.

- Document any remedial action that is required to perpetuate the future retention of the tree.

- Provide an estimate on the safe useful life expectancy of the tree.

2. FORM AND APPROACH:

The only safe way to identify a specimen in a collection is to give it a number, so that the position of the tree within the collection is clearly understood. Each tree or group of trees inspected has been tagged by Whelans Surveyors, upon which a numerical character was stamped so that the position of the tree relative to the plan could be clearly identified upon the site, with the appropriate numerical character assigned to the tree documented upon the survey sheet.

Botanical Information:

Botanical names are listed detailing the generic name followed by the specific epithet. The variety is named where applicable.

Condition:

Each tree surveyed was examined in detail to ascertain its overall condition.

The assessed tree was then placed into three categories:

- *Sound:* The tree was found to be in a structurally sound and healthy condition with no evidence of mechanical defects, fungal or insect pathogens.

- *Fair:* The tree was displaying a few minor defects but not at a stage to become detrimental to the mechanical structure or to the health of the tree.

- *Poor:* The tree was found to have major defects or of poor development as to substantial reduce the safe useful life expectancy of the tree.

Safe Useful Life Expectancy (SULE):

The criteria used to calculate the remaining safe useful life expectancy of the tree is based on numerous factors.

The key information required for long term planning is how long each tree can be expected to remain on site with an acceptable degree of safety.

Assessment for each tree is based on the potential of the species in the locality, and the final assessment made gives particular consideration to the following:

- Obvious past influences.

- Health and Vitality – present a future potential for the species on the site.

- Estimated age in relation to the expected life expectancy for the species.

- Structural defects, which may influence the potential life expectancy of the tree or represent a risk factor to the proposed development.

On the basis of the above guidance notes, each tree was allocated an expected safe useful life expectancy from 1-50 years.

Trees that appear to be retainable with an acceptable level of risk for more than 30-50 years.

- Structurally sound trees located in positions that can accommodate future growth.

Trees that appear to be retainable with an acceptable level of risk for 20-30 years.

- Trees that may only have between 20-30 years remaining life span.
- Trees that may live for more than 20-30 years but would be removed during the course of management for safety and nuisance reasons.
- Damaged or defective trees that can be made suitable for retention in the medium term by remedial work.

Trees that appear to be retainable with an acceptable level of risk for 10-20 years.

- Trees that may only have10-20 years remaining life span.
- Trees that may live for more than 10-20 years but would be removed during the course of management for safety or nuisance reasons.
- Defective trees that require substantial remedial work to make safe and are only suitable for retention in the short-term.

Trees with a high level of risk that would need removing within the next 1-10 years.

- Dead trees.
- Dying or suppressed and declining trees through disease.
- Dangerous trees through instability.
- Dangerous trees through structural defects including cavities, decay wounds or poor form.
- Damaged trees, which are considered unsafe to retain.

Development Proposals:

The future management, maintenance and condition of the trees have a considerable bearing on their location, with safety to property and persons the main priority. Therefore any proposed development including the construction of roadways, footpaths and buildings within the target zone of any proposed retained tree has to be taken into consideration, including the effect that the proposed development may have upon the future health and the mechanical structure of the tree and therefore the level of risk that the tree may represent in the future to property and to persons.

Remedial Works:

On completion of the assessment of each tree, any remedial works required to render the tree safe or to sustain the future health of the tree was documented.

3. SITE ANALYSIS:

The site in question is located at the junction of Nettleton Road and the South Western Highway, and consists of predominantly arable land, which is dissected to the south by a creek, which meanders in an easterly / westerly direction and is lined by native vegetation. The open grassland area was relatively sparse in vegetation with isolated trees providing previous shade and shelter to animal stock. Dense bushland was evident to the eastern and northern section of the site, which contained a high forest of native remnant vegetation. The high forest was found to have an uneven age class with good regeneration growth evident, and consist of a mixture of Corymbia calophylla (Marri) and Eucalyptus marginata (Jarrah), with sporadic specimens of Nuytsia floribunda (Western Australian Christmas Tree).

It was evident that throughout the site a number of trees have declined and died, particularly the Eucalyptus marginata surrounding the native bushland and in the open grassland area, with such symptoms indicative of infestation by the soil pathogen Phytophyhora cinnamomi (Dieback).

A number of trees within the open grassland area have also become windblown, with the recent failure of a few trees that were tagged. It was evident that their upturned root plates were relatively poor in overall size and lateral spread.

4. TREE SURVEY DETAILS:

Tree No	Species	Condition	Sule	Comments / Recommendations
G1	Corymbia calophylla (Marri)	Fair-Sound	25-50	This row of trees, which run parallel to Nettleton Road were found to be predominantly in a structurally sound condition, which provide significant aesthetic and screening value to the site.
837	Corymbia calophylla (Marri)	Sound	40	Worthy of retention
838	Corymbia calophylla (Marri)	Sound	40	Worthy of retention.
839	Corymbia calophylla (Marri)	Sound	40	Worthy of retention.
840	Corymbia calophylla (Marri)	Sound	40	Worthy of retention.
836	Corymbia calophylla (Marri)	Poor	10	Poor form and in decline, not worthy of retention.
832	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy, worthy of retention.
833	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy, worthy of retention.
834	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy, worthy of retention.
835	Corymbia calophylla	Sound	40	Structurally sound and healthy,

	(Marri)			worthy of retention.
846	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy, worthy of retention.
843	Corymbia calophylla (Marri)	Poor	15	Poor form and in decline, not worthy of retention.
841	Corymbia calophylla (Marri)	Poor	15	Poor form and in decline, not worthy of retention.
844	Eucalyptus rudis (Flooded Gum)	Fair	30	Canopy in decline, requires the removal of deadwood.
850	Eucalyptus rudis (Flooded Gum)	Fair	30	Canopy in decline, requires the removal of deadwood.
826	Eucalyptus rudis (Flooded Gum)	Fair	40	Structurally sound, worthy of future retention.
825	Corymbia calophylla (Marri)	Poor	5	Uprooted, not worthy of future retention
G2	Brachychiton populneus (Kurrajong), Eucalyptus botryoides (Southern Mahogany) & Eucalyptus rudis (Flooded Gum).	Fair-Sound	20-50	These specimens were located surrounding the drainage sump to the north of the existing dwelling. The Eucalyptus rudis consist of regeneration growth and therefore were insignificant in age class, and although the Eucalyptus botryoides was found to be a significant specimen, it is a species that has a high propensity to shed limbs and therefore if retained its limbs should not extend within the target zone of roadways or dwellings.
824	Ceratonia siliqua (Carob)	Sound	50	Structurally sound and healthy, worthy of future retention.
823	2 Eucalyptus wandoo (Wandoo)	Poor	20	Not worthy of retention, in severe decline with termite infestation evident.
807	Eucalyptus wandoo (Wandoo)	Fair	30	If retained will require all dead limbs reduced back to source.
806	Eucalyptus wandoo (Wandoo)	Poor	15	A young specimen, poor in form and in decline, not worthy of retention.
805	Eucalyptus wandoo (Wandoo)	Poor	15	Poor in form and in decline, not worthy of retention.
804	Eucalyptus wandoo (Wandoo)	Fair	30	If retained will require all dead limbs reduced back to source.
803	Eucalyptus wandoo (Wandoo)	Poor	10	Poor in form and in decline, not worthy of retention.
802	Eucalyptus wandoo (Wandoo)	Poor	10	Poor in form and in decline, due to termite infestation, not worthy of retention.
801	Eucalyptus wandoo (Wandoo)	Poor	10	Poor in form and in decline, not worthy of retention.
800	Eucalyptus wandoo (Wandoo)	Poor	10	In severe decline, not worthy of future retention.
808	Eucalyptus wandoo (Wandoo)	Poor	10	Poor in form and in decline, due to termite infestation, not worthy of

				retention.
809	Eucalyptus wandoo (Wandoo)	Poor	10	Poor in form and in decline, due to termite infestation, not worthy of retention.
810	Eucalyptus wandoo (Wandoo)	Poor	5	80% dead, not worthy of future retention.
811	Eucalyptus wandoo (Wandoo)	Poor	10	In severe decline, not worthy of future retention.
195	Eucalyptus wandoo (Wandoo)	Fair	30	If retained will require all dead limbs reduced back to source.
200	Eucalyptus wandoo (Wandoo)	Poor	10	Has a large basal cavity, which has reduced the localized structural strength of the tree, therefore is not worthy of future retention.
198	Corymbia calophylla (Marri)	Sound	50	Significant specimen, worthy of future retention.
173	Corymbia calophylla (Marri)	Sound	50	Significant specimen, worthy of future retention.
817	Corymbia calophylla (Marri)	Sound	50	Semi-mature, not significant due to age class.
818	Corymbia calophylla (Marri)	Sound	50	Semi-mature, not significant due to age class.
819	Corymbia calophylla (Marri)	Sound	50	Semi-mature, not significant due to age class.
820	Corymbia calophylla (Marri)	Sound	50	Semi-mature, not significant due to age class.
821	Corymbia calophylla (Marri)	Sound	50	Semi-mature, not significant due to age class.
822	Corymbia calophylla (Marri)	Sound	50	Semi-mature, not significant due to age class.
812	Corymbia calophylla (Marri)	Sound	50	Semi-mature, not significant due to age class.
813	Corymbia calophylla (Marri)	Sound	50	Semi-mature, not significant due to age class.
814	Corymbia calophylla (Marri)	Fair	50	Semi-mature, not significant due to age class.
815	Eucalyptus wandoo (Wandoo)	Fair	30	If retained will require the major central dead stem reduced back to source.
184	Eucalyptus marginata (Jarrah)	Sound	50	Worthy of retention.
194	Eucalyptus marginata (Jarrah)	Poor	10	In severe decline, not worthy of future retention.
117	Eucalyptus marginata (Jarrah)	Sound	50	Worthy of retention.
540	Eucalyptus marginata (Jarrah)	Sound	50	Significant specimen, worthy of future retention.
568	Nuytsia floribunda (Western Australian Christmas Tree)	Sound	50	Worthy of retention.
31	Eucalyptus marginata (Jarrah)	Sound	50	Worthy of retention.
51	Corymbia calophylla	Sound	40	Structurally sound and healthy,

	(Marri)			worthy of retention if feasible.
1	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy, worthy of retention if feasible.
596	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy, worthy of retention if feasible.
188	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy, worthy of retention if feasible.
126	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy, worthy of retention if feasible.
125	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy, worthy of retention if feasible.
128	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy, worthy of retention if feasible.
164	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy, worthy of retention if feasible.
599	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy, worthy of retention if feasible.
837	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy, worthy of retention if feasible.
828	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy, worthy of retention if feasible.
612	Eucalyptus marginata (Jarrah)	Sound	50	Structurally sound and healthy, worthy of retention if feasible.
116	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy worthy of retention if feasible.
816	Melaleuca rhaphiophylla (Swamp Paperbark)	Fair	30	Some sporadic decline, but can be retained if required.
801	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy, worthy of retention if feasible.
824	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy, worthy of retention if feasible.
810	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy, worthy of retention if feasible.
825	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy, worthy of retention if feasible.
124	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy, worthy of retention if feasible.
189	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy, worthy of retention if feasible.
165	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy, worthy of retention if feasible.
105	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy, worthy of retention if feasible.
132	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy, worthy of retention if feasible.
155	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy, worthy of retention if feasible.
822	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy, worthy of retention if feasible.
808	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy, worthy of retention if feasible.
157	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy, worthy of retention if feasible.
607	Corymbia calophylla	Sound	40	Structurally sound and healthy,

	(Marri)			worthy of retention if feasible.
161	Eucalyptus marginata (Jarrah)	Poor	20	Poor and in decline, not worthy of retention.
568	Nuytsia floribunda (Western Australian Christmas Tree)	Sound	50	Worthy of retention.
509	Nuytsia floribunda (Western Australian Christmas Tree)	Sound	50	Worthy of retention.
48	Nuytsia floribunda (Western Australian Christmas Tree)	Sound	50	Worthy of retention.
40	Nuytsia floribunda (Western Australian Christmas Tree)	Poor	10	In severe decline, not worthy of retention.
115	Nuytsia floribunda (Western Australian Christmas Tree)	Sound	50	Worthy of retention.
895	Nuytsia floribunda (Western Australian Christmas Tree)	Sound	50	Worthy of retention.
805	Nuytsia floribunda (Western Australian Christmas Tree)	Sound	50	Worthy of retention.
113	Nuytsia floribunda (Western Australian Christmas Tree)	Sound	50	Worthy of retention.
156	Corymbia calophylla (Marri)	Sound	50	Semi-mature, not significant due to age class.
144	Corymbia calophylla (Marri)	Sound	50	Semi-mature, not significant due to age class.
145	Corymbia calophylla (Marri)	Sound	50	Semi-mature, not significant due to age class.
111	Corymbia calophylla (Marri)	Sound	50	Semi-mature, not significant due to age class.
104	Corymbia calophylla (Marri)	Sound	50	Semi-mature, not significant due to age class.
143	Corymbia calophylla (Marri)	Sound	50	Semi-mature, not significant due to age class.
108	Corymbia calophylla (Marri)	Sound	50	Semi-mature, not significant due to age class.
146	Corymbia calophylla (Marri)	Sound	50	Semi-mature, not significant due to age class.
110	Corymbia calophylla (Marri)	Sound	50	Semi-mature, not significant due to age class.
142	Corymbia calophylla (Marri)	Sound	50	Semi-mature, not significant due to age class.
166	Corymbia calophylla (Marri)	Sound	50	Semi-mature, not significant due to age class.
830	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy, worthy of retention if feasible.
833	Corymbia calophylla (Marri)	Sound	40	Structurally sound and healthy, worthy of retention if feasible.
847	Eucalyptus rudis (Flooded	Fair	30	Canopy in decline due to

	Gum)			infestation by Psyllids. If retained will require the removal of the dead material
197	Eucalyptus marginata (Jarrah)	Poor	10	In severe decline, not worthy of future retention.
172	Eucalyptus marginata (Jarrah)	Sound	50	Worthy of retention
154	Eucalyptus marginata (Jarrah)	Fair	30	If retained will require the removal of the dead material
174	Eucalyptus marginata (Jarrah)	Poor	10	In severe decline, not worthy of future retention.
175	Eucalyptus marginata (Jarrah)	Poor	15	In severe decline, not worthy of future retention.
610	Eucalyptus marginata (Jarrah)	Poor	15	Mechanically weak lower compression fork, not worthy of retention.
153	Eucalyptus marginata (Jarrah)	Poor	15	Mechanically weak lower compression fork fractured, not worthy of retention.
150	Nuytsia floribunda (Western Australian Christmas Tree)	Sound	50	Worthy of retention.
159	Eucalyptus marginata (Jarrah)	Fair	30	Canopy displaying some decline, but not at a stage to represent a risk factor.
109	Eucalyptus marginata (Jarrah)	Fair	30	Canopy displaying some decline, but not at a stage to represent a risk factor.
565	Eucalyptus marginata (Jarrah)	Poor	5	In severe decline, not worthy of future retention.
181	Nuytsia floribunda (Western Australian Christmas Tree)	Poor	5	In severe decline, not worthy of future retention.
508	Corymbia calophylla (Marri)	Poor	5	In severe decline, not worthy of future retention.
506	Corymbia calophylla (Marri)	Fair	30	Canopy displaying some decline, but not at a stage to represent a risk factor.
504	Corymbia calophylla (Marri)	Sound	50	Structurally sound and healthy, worthy of retention if feasible.
502	Corymbia calophylla (Marri)	Sound	50	Structurally sound and healthy, worthy of retention if feasible.
501	Corymbia calophylla (Marri)	Fair	30	Canopy displaying some decline, but not at a stage to represent a risk factor.
478	Corymbia calophylla (Marri)	Poor	15	Leans significantly out of vertical rendering future failure from its root plate imminent.
503	Corymbia calophylla (Marri)	Sound	50	Structurally sound and healthy, worthy of retention if feasible.
507	Eucalyptus marginata (Jarrah)	Poor	15	In decline, not worthy of future retention.
524	Eucalyptus marginata (Jarrah)	Poor	-	Recently failed from its root plate.

519	Eucalyptus marginata (Jarrah)	Poor	15	In decline, not worthy of future retention.
572	Eucalyptus marginata (Jarrah)	Sound	50	Worthy of retention
562	Eucalyptus marginata (Jarrah)	Poor	15	In decline, not worthy of future retention.
564	Eucalyptus marginata (Jarrah)	Sound	50	Multi-stemmed specimen, worthy of retention
122	Corymbia calophylla (Marri)	Sound	50	Structurally sound and healthy, worthy of retention.
167	Eucalyptus marginata (Jarrah)	Sound	50	Worthy of retention
112	Eucalyptus marginata (Jarrah)	Sound	50	Worthy of retention
119	Eucalyptus marginata (Jarrah)	Sound	50	Worthy of retention
169	Eucalyptus marginata (Jarrah)	Sound	50	Worthy of retention
103	Eucalyptus marginata (Jarrah)	Sound	50	Worthy of retention
168	Eucalyptus marginata (Jarrah)	Sound	50	Worthy of retention
4	Corymbia calophylla (Marri)	Sound	50	Semi-mature, not significant due to age class.
2 to 29	Corymbia calophylla (Marri)	Fair to Sound	30-50	Provide good screening, but can be selectively thinned by removing the weak specimens if required.
30 to 34, 35 to 39	Corymbia calophylla (Marri)	Fair to Sound	30-50	Structurally sound, but poor in form, due to light suppression.
80 to 100, 119, 135, 137, 138, 139, 140, 148, 151, 167 to 171, 178 to 180, 182, 183, 185, 186, 187, &196	Mixed Corymbia calophylla (Marri) & Eucalyptus marginata (Jarrah)	Fair to Sound	30-50	Structurally sound, but poor in form, due to light suppression.
41, 42, 43, 44, 45, 46, 47 49, 50, 52 to 59	Corymbia calophylla (Marri)	Fair	30-50	Structurally sound, but poor in form, due to light suppression.
60 to 65, 69 to 78	Corymbia calophylla (Marri)	Sound	50	Structurally sound, but poor in form, due to light suppression.
300 to 333	Mixed Corymbia calophylla (Marri) & Eucalyptus marginata (Jarrah)	Fair	30-50	Provide good screening, but can be selectively thinned if required.
334 to 421	Mixed Corymbia calophylla (Marri) & Eucalyptus marginata	Fair	30-50	Provide good screening, but can be selectively thinned if required.

	(Jarrah)			
437, 438, 441 to 477, 479 to 500	Mixed Corymbia calophylla (Marri) & Eucalyptus marginata (Jarrah)	Fair	30-50	Structurally sound, but poor in form, due to light suppression.
101, 102, 106, 107, 109, 120, 123 & 127	Corymbia calophylla (Marri)	Fair	50	Structurally sound, but poor in form, due to light suppression.
160 & 163	Corymbia calophylla (Marri)	Fair	50	Structurally sound, but poor in form, due to light suppression.
510 to 518, 520 to 523, 530 to 539, 541, 542, 543, 544, 545, 546, 547, 548, 549 & 550	Corymbia calophylla (Marri) & Eucalyptus marginata (Jarrah)	Fair	50	Structurally sound, but poor in form, due to light suppression.
560, 561, 563, 565, 566 to 567	Corymbia calophylla (Marri)	Fair	50	Structurally sound, but poor in form, due to light suppression.
569 to 571, 575, 574, 581 & 582	Corymbia calophylla (Marri)	Fair	50	Structurally sound, but poor in form, due to light suppression.
573 to 579	Corymbia calophylla (Marri)	Fair	50	Structurally sound, but poor in form, due to light suppression.
583 to 593	Mixed Corymbia calophylla (Marri) & Eucalyptus marginata (Jarrah)	Fair	30-50	Structurally sound, but poor in form, due to light suppression.
598 & 600	Corymbia calophylla (Marri)	Fair	50	Structurally sound, but poor in form, due to light suppression.
606	Corymbia calophylla (Marri)	Fair	50	Structurally sound, but poor in form, due to light suppression.
613 to 615	Corymbia calophylla (Marri)	Fair	50	Structurally sound, but poor in form, due to light suppression.
Area parallel to the creek.	Mixture of Melaleuca rhaphiophylla (Swamp Paperbark), Eucalyptus rudis (Flooded Gum) & Corymbia calophylla.	Fair to Sound	25-50	The vegetation that runs parallel to the creek was found to be relatively high it habitat value. However, some selective thinning would be advisable.
Area surrounding the existing house	Ulmus parvifolia (Chinese Elm), Citherxylem spinosum (Fiddlewood), Melia azaderach (White Cedar).	Sound	20-40	Structurally sound, but not significant.

5. CONCLUSIONS:

This consultant's inspection of the trees within the site known as Lot 2 Nettleton Road revealed that although the site contained a number of significant trees, particularly the Corymbia calophylla and Nuytsia floribunda, which are well worthy of future retention, sporadic trees within and surrounding the bushland area, particularly the Eucalyptus marginata, were found to be in progressive decline, and although such symptoms are indicative of infestation by the soil pathogen Phytophthora, it may be advisable to implement hygiene precautions for vehicles during any clearing of the site within the areas of decline to reduce the spread of the disease.

It was evident that sporadic trees in the open grassland area have previously and recently become uprooted, and therefore taking into consideration the lack of lateral root spread that some of the uprooted trees displayed, care should be taken when selecting trees for retention within the proposed development that they were not previously protected from extreme weather conditions by the surrounding trees.

As previously confirmed the site contained a number of significant specimens of Nuytsia floribunda, which are well worthy of preserving in their own right. However, extreme care should be taken when selecting which trees are to be retained within the development as they are semi-parasitic and depend partly on the roots of other plants for their nourishment, particularly grasses.

This consultant confirms that it was evident that a few specimens require the implementation of remedial tree surgery works, in respect to the removal of major sections of deadwood, and although the recommended remedial tree surgery operations are not categorised as urgent, it would be advisable to implement the works following clearing operations.

However, although trees identified for retention were found to be predominantly in a structurally sound condition, their future healthy retention is dependent upon the proximity of any future proposed roadways, underground services and buildings.

To prevent future detrimental damage to the proposed retained trees this consultant recommends that it would be advisable to construct suitable protection, where feasible around their canopy spread to alleviate root, trunk and canopy damage and to prevent the storage of building materials or heavy machinery within the root plate zone of the tree.

6: TREE MANAGEMENT PRIOR, DURING AND UPON COMPLETION OF DEVELOPMENT WORKS.

To reduce the effects that a building development can have upon the health of retained trees, suitable forms of protection are required together with the steps necessary to limit deterioration of those species left standing on the site.

This consultant confirms that there is clear evidence that mature trees are more sensitive to development pressure than young and semi-mature specimens, where the younger trees are able to compensate and adapt to new ground conditions by producing new roots. However, although younger

trees can exhibit a remarkable tolerance to the adverse effects of building operations and site alterations, this is conditional upon the location and extent of works carried out within the root zone of the tree and therefore the extent of primary root removal.

As with predominantly most trees they store vast amounts of carbohydrate in their root system, subsequently when major roots are severed the tree is unable to replenish its depleted energy levels, which gradually results in the decline of the canopy and often the death of the tree with such symptoms often not evident until some years later.

Therefore there must be clear recommendations to alleviate detrimental tree damage from the commencement through to the completion of the development, with the recommendations enforced and clearly understood by all contractor staff.

Prior to Site Clearance Works

* All trees identified for retention shall be clearly marked and an exclusion zone erected using suitable protection preferable around the drip-line of the tree or group of trees with conspicuous signage identifying that the fenced off area is a tree protection zone.

* The exclusion zone shall be maintained throughout the period of construction and should not be breached.

* Any remedial works, which requires the removal of lower limbs to facilitate access by large machinery or to alleviate the level of risk to the contract staff shall be carried out by a competent arborist to the relevant Australian Standards.

* If trees are growing close together any felling and root removal shall be done with care to avoid damage to the retained trees.

Tree Management During Site Clearance and Construction Works.

* All heavy machinery shall keep outside the tree protection zone, with any roots damaged or torn with a diameter of 50mm or more cleanly severed to initiate occlusion.

* No building materials are to be stored or disposed off within the tree protection zone, with provisions implemented so that building chemicals do not come into contact with the root rhizosphere or the roots themselves.

* Any excavations to be carried out within close proximity to the tree protection zone or within the zone to install services are to be carried out under the strict supervision of an arboriculturist so that root damage is kept to a minimum.

* Where the extent of construction works have resulted in a nominated tree becoming structurally unstable or within a location to render the tree a high level of risk to property and persons, the contractor shall inform the works supervisor for further instructions.

* Excavated soil shall not be stored or built up around or within the protection zone of the tree

* Any damage to a retained tree during the preliminary stages of site clearance or during the construction works shall be reported immediately to the site supervisor with remedial works carried out by a qualified arborist to the relevant Australian Standard.

* The laying of surface material (Paving or Asphalt Paths & Roadways) within the root plate spread of the tree shall take into consideration the cultural requirements of the tree, particularly in relation to moisture and oxygen levels, with the retention of a suitable open surface area.

* Any compaction with the root plate zone of the protected tree to lay paving shall be carried out using a plate compactor only.

Completion of Development Works.

* The retained trees shall be inspected by a qualified arboriculturist on completion of the development to ascertain their health, structure and any remedial works, which may be required to improve the health and future safe useful life expectancy of the tree.

* It would be advisable that a periodical inspection of the trees on an annual basis is implemented to monitor any decline of the canopy, with remedial works implemented if required to improve overall foliage biomass.

* All remedial works recommended on completion of the development shall be carried out by a competent arborist to the relevant Australian Standards.

Charles Aldous-Ball M. Arb. R.F.S. “F. Arbor A”.

APPENDIX B

FORESHORE REVEGETATION AND WEED MANAGEMENT PLAN

Lot 2 Nettleton Road, Byford

Foreshore Revegetation and Weed Management Plan

March 2008

P270-01-Rev0

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1 INTRODUCTION

In March 2008, ENV Australia commissioned Tranen Revegetation Systems to prepare a Revegetation and Weed Management Plan for part of Lot 2, Nettleton Road, Byford. This plan will be incorporated into the Foreshore Management Plan required for the site to satisfy the conditions of subdivision approval.

This Plan incorporates four main components:

- Layout concept;
- Weed management plan;
- Revegetation program, including weed management strategy and details of the revegetation, including species to be used, density and distribution of planting; and
- Post-installation management.

Two site inspections were conducted by Tranen Revegetation Systems in March 2008 to assess existing native vegetation, weed infestation, topography, and soil condition.

1.1 Location and Site Description

Lot 2 is located on the north east side of the intersection of Nettleton Rd and South Western Highway in Byford. The site is located at the foothills of the Darling Scarp. The primary area of focus for this management plan is Beenyup Brook, which runs east west through Lot 2 (see Appendix 1). This is a locally significant natural drainage line that requires preservation.

Soil is Pinjarra Phase, which is categorised as “flat to very gently undulating plain with deep acidic mottled yellow duplex (or ‘effective duplex’) soils. Shallow pale sand to sandy loam over clay; imperfect to poorly drained and generally not susceptible to salinity”. (Department of Agriculture, 2003).

There is little change in the elevation of the creekline from east to west, however there is some undulation in the surrounding terrain on both the north and south of the brook. The creekline footprint at its widest point is 5 m across, but averages approximately 2 m. From end to end the creekline spans 420 m but including meanders has a total length of around 500 m.

1.2 Existing Vegetation

Due to the timing of the Tranen assessment, many of the annual species expect to occur locally were not observed, as the inspection was conducted during the inactive period for these species. However, the decaying remains of some annual species were observed, as were several perennial weed species.

ENV Australia carried out a spring flora assessment in September 2007, as part of previous work on the site. This report is located in Appendix B of the Foreshore Management Plan.

1.2.1 Native Vegetation

A number of established native tree, shrub, and sedge species occur along most of the creekline, but do not occur far from the waters edge (see Table 1 and aerial photo in Appendix 1). Some sections are quite dense, and there are some short sections that are devoid of vegetation. The surrounds of the area where previously cleared for farming.

Table 1 Native Species Observed

Species	Common Name	Growth Form
Acacia pulchella	Prickly Moses	Shrub
Baeckea camphorosmae	Camphor Myrtle	Shrub
Corymbia calophylla	Marri, Red Gum	Tree
Eucalyptus rudis	WA Flooded Gum	Tree
Hakea lissocarpha	Honey Bush	Shrub
Hibbertia hypericoides	Yellow Buttercup	Shrub
Hypocalymma angustifolium	White Myrtle	Shrub
Juncus pallidus	Pale Rush	Sedge
Melaleuca lateritia	Robin Red Breast	Shrub
Melaleuca rhaphiophylla	Freshwater Paperbark	Tree
Mesomolaena tetragona	Semaphore Sedge	Sedge
Taxandria linearifolia		Shrub

1.2.2 Introduced Species

Several introduced species were also recorded. Appendix 4 shows the distribution across the site. Table 2 lists the most problematic weed species observed, of which one, *Gomphocarpus fruiticosus,* is declared pursuant to Section 37 of the *Agriculture and Related Resources Protection Act, 1976*.

Table 2 Key Introduced Species Observed

Species	Common Name	Growth Form
**Dittrichia graveolens*	Stinkwort	Annual herb
**Ficus sp.*	Fig	Tree
**Gomphocarpus fruiticosus*	Narrow Leaf Cotton Bush	Shrub
**Nerium oleander*	Oleander	Shrub
**Pennisetum clandestinum*	Kikuyu Grass	Grass
**Rubus sp.*	Blackberry	Shrub
**Rumex sp.*	Dock	Perennial herb
**Schinus terebinthifolius*	Japanese Pepper	Tree
**Solanum nigrum*	Black Nightshade	Annual herb
**Typha orientalis*	Typha	Rush
**Watsonia meriana var bulbillifera*	Bulbil Watsonia	Corm (annual)

1.3 Fauna

Fauna has not been specifically surveyed, but the presence of kangaroos (droppings) has been noted. Large numbers of bull ants and large nests were observed during the initial site inspections.

2 LAYOUT CONCEPT

A 30 m wide reserve, is to be set aside as public open space, to include revegetation and recreation opportunities. The reserve will be aligned to take into account topographic features, taking advantage of flatter areas closer to the water line (instead of at the top of the embankments). Lower lying areas will be treated differently to embankments, using species more adapted to the moister situations.

The area will be split into three management zones (as illustrated in Figure 1 below):

1. Creekline
2. Flat areas
3. Embankments

Figure 1 Typical Management Zone Cross Section

Appendix 2 shows the extent of the foreshore reserve, and the three management zones. The area is 420 m long, and 30 m wide, giving a total revegetation area of 12,600 m^2. Weed management will be the same for each zone, depending on whether each of the key species are present.

Appendix 3 contains the details of the species and quantities allocated to each area. The species chosen occur within the reserve or neighbouring areas and are indigenous to the local area. The species selected are based on a combination of the following:

- Existing vegetation of and around the site (and existing soil conditions);
- Vegetation found at Cardup Brook (Bush Forever Site No 271, Dec 2000).

2.1 Creekline

As the creekline is 500 m long (following all meanders), and an average of 2 m wide, the total area covered is 1,000 m^2. The majority of the native species found within the creekline are sedges, as the trees and shrubs are generally found along the edges, rather than within the creek line (due to water flow).

Shire of Serpentine Jarrahdale planting guidelines require water bodies to be planted at a density of 6 plants / m^2. Therefore a total of 6,000 plants will be required. Only sedges have been selected for this area, and the quantities can be found in Appendix 4.

It may not be appropriate to plant some parts of the channel, such as those that are that are already densely vegetated, or where high velocity flows are concentrated. The seedlings allowed for these sections will be reallocated to the most sparsely vegetated areas, where they will have a greater impact, and to the immediate edges of the creekline.

Planting within the creekline will take place later in the season (spring) once water levels have peaked and begin to recede, to ensure that seedlings are not washed away or drowned during high velocity flows.

2.2 Open Flats

The approximate total area considered open flats is 8,300 m^2 and the locations are shown on the drawing in Appendix 2.

The open flat areas will be revegetated with tree and shrub species to increase the vegetation density at ground and canopy levels. As the open flats will be close to the creekline elevation and water level, species more adapted to wet situations will be planted in these regions.

According to the Shire of Serpentine Jarrahdale planting guidelines, these works fall into a biodiversity purpose, and therefore planting at a density of 2 plants / m^2 is required. A total of 8,300 plants are therefore required. Species representation will be 30% trees, 60% shrubs and groundcovers, and 10% sedges, with allocations shown in Appendix 3.

Planting will be conducted around the existing vegetation. Rushes and sedges will be planted in clusters, as is how they occur naturally. Where possible, flat areas will be ripped to 500 mm, which will facilitate better root growth and plant development.

2.3 Embankments

Appendix 2 shows the areas delineated as embankment, which covers a total area of 3,300 m^2.

The embankment areas will be revegetated with tree and shrub species to increase the vegetation density at ground and canopy levels. Species allocated to the embankment will be more dryland species, as soil moisture levels are expected to be less than in the open flats.

Planting will also be at a density of 2 plants / m^2 in these zones. Species representation will be 30% trees, and 70% shrubs and groundcovers. Quantities of each species selected are detailed in Appendix 3.

3 WEED MANAGEMENT PLAN

Weed control is a major issue in all revegetation works as weeds will compete against seedlings for light, nutrients, and space. Initial management will treat weeds that are already present, but the weed control program will need to continue for several years before weed seed stored in the soil is exhausted.

The various species of weed identified to date each fall into one of four different categories of growth form, each with its own management strategy:

- Woody weeds (trees and shrubs);
- Grasses;
- Annual / perennial broadleaf herbs and sedges; and
- Corms, bulbs, and tubers.

As the growth and reproduction mechanisms differ, as do their responses to various treatment options. Each species may have a specific or best control method that will be applied as per Bushland Weeds: A Practical Guide to their Management (Brown et al, 2002). Appendix 5 summarises the control methods and gives a provisional works schedule.

Herbicide application will be the main control method due to the size of infestations. Due to the presence of existing remnant native vegetation within the reserve, spot spraying methods must be implemented by a specialised operator with good knowledge of both native and weed species, trained and licensed in the use of herbicide chemicals in public open space, in accordance with the manufacturers' recommendations.

Selective herbicides will also be used as much as possible, especially in areas where existing native vegetation may be susceptible to the application of glyphosate (broad spectrum herbicide). The appropriate type of herbicide (e.g. grass specific) will be selected at the time. Glyphosate is also not appropriate for use around exposed water bodies, and therefore the more water friendly Roundup Biactive ® (or similar) should be used.

Manual control (hand removal) may also be carried out where low numbers exist too close to a plant, but being careful to minimise soil disturbance.

3.1 Woody Weeds

The weed species within this category are Fig, Cotton Bush, Oleander, Blackberry, and Japanese Pepper. The Fig, Oleander, and Japanese Pepper are of reasonable sizes and will be treated by the cut and paint method. This involves cutting the base of the trunk to remove the plant, and then immediately painting the freshly exposed stump with herbicide (glyphosate or triclopyr).

Trees are best controlled in the warmer spring months when the plants are most active. Cut plants will be removed from site. Care must be taken when handling Oleander as the sap is poisonous and can affect the eyes.

Cotton Bush will be spot sprayed first, and once killed will then be slashed. Seed heads should be removed immediately to prevent further seed set and spread. Smaller plants that can be hand pulled should be removed at the same time, so that no more spraying is required than necessary. The best time for chemical Cotton Bush control is spring, as this is when the plant is most active.

The Blackberry is confined to a small cluster in the east of the brook. Due to its size the entire thicket can be reached by herbicide spray, and will be sprayed with glyphosate. Once the spraying has had a visible effect, the dying plants will be slashed to ground level to make new shoots / seed germinants more easily visible, and more easily targeted during follow up applications.

3.2 Grasses

The main grass species observed is Kikuyu, and is the dominant weed species in the western end of the foreshore reserve. Other dried annual grasses were observed in some sections, but were decomposed and did not have enough material to allow positive identification. The treatment for Kikuyu and the annual grasses should be the same.

Due to the size of infestation and location, Kikuyu and annual grasses will be controlled by herbicide application. All will respond to glyphosate application, however specific herbicides (such as Fusilade®) are available that will target grass species only. It is recommended that specific herbicides be used around native species, as this removes the potential for off target damage.

Kikuyu is active in the warmer months (spring to autumn) and control is best undertaken during this period.

3.3 Broadleaf Herbs and Sedges

Four significant broadleaf herb and sedge species were observed: Stinkwort, Dock, Black Nightshade, and Typha. Stinkwort and Black Nightshade are annual species, and the Typha and most Dock species are perennial species.

Annual species go through one life cycle each year and reproduce through the production of large quantities of seed. The best method of control populations of these species is spot spraying before the plants have a chance to flower and set seed. Stinkwort is a summer active species that generally flowers between January and April, and should generally be targeted during this time. Black Nightshade flowers year round and should be sprayed at every opportunity.

Annual species generally require disturbance to proliferate. Disturbance generally means less competition and more light. By reducing the amount of light by introduction of native canopy for shade, weed levels and seed production can be reduced. This is especially true of Black Nightshade.

Perennial species require a slightly different approach as they are longer lived and don't always set seed each year. Dock species generally flower in winter / spring, and are best controlled by spot spraying with glyphosate in early bud stage. Typha has several control techniques, but given the site conditions some may not be applicable (usually grows in permanent water bodies). The method of control will be spraying with glyphosate, and the best time is the period between male flowers opening, and six weeks after female flower emergence (flowering normally October to December). This will be followed several weeks later with slashing once the herbicide has been absorbed into the plant and it begins to die. The slashing will make any new growth immediately evident, which will allow for easier and more direct follow up herbicide application.

3.4 Corms, Bulbs, and Tubers

Corms, bulbs and tubers are all underground storage organs found on plants referred to as geophytes. These provide mechanisms for coping for fire, drought, and low nutrient soils, and as such require different management strategies to other species. One cormous species occurs on site (Watsonia), and it is the most dominant species along the eastern half of the brook.

Watsonia is summer dormant, and sends up its first shoots in autumn with the first rains. Timing is very important when spraying cormous plants for them to be effectively killed, as they generally produce new daughter corms each year. Treated too early, the surface parts of the plant may be killed off but not the corm, and treated too late the parent may be killed but not the daughter. Watsonia should be spot sprayed with glyphosate just on flowering (which signals corm exhaustion). Flowering is typically September to December each year.

4 REVEGETATION PROGRAM

All remnant native vegetation will be retained, and revegetation of the remainder of the reserve will be by seedling planting. This will ensure that the desired landscape is achieved in both the short and long term.

4.1 Installation Methodology

Implementation of the Revegetation and Weed Management Plan will commence with weed control in autumn 2008. Planting will take place in winter / spring 2009, and all preliminary activities (i.e. seedlings and materials ordering) will be undertaken once the plan has been approved.

Planting of seedlings will commence in 2009 after the first rains have made the soil sufficiently wet to plant (expected to be around May/June). All works should be completed by August 2009.

4.2 Ripping

Ripping breaks the surface compaction and increases root and plant growth. Only the flat areas classified as Open Flats will be ripped as it will be unsafe / impractical to rip on the embankments or within the creekline.

Rip lines at a minimum depth of up to 500 mm should be spaced at intervals of 1 m for the entire length of the open flat areas. Due to very compacted ground, and the presence of rocks within the soil, it may not be possible to rip all areas.

4.3 Seedling Supply

Appendix 4 contains details of the seedling species. Forward orders will be placed in 2008 ready for planting in 2009. However, seedling quantities and species representation are subject to availability from nurseries at time of supply. Should any species be unavailable, recommended substitutions will be presented to the Shire of Serpentine-Jarrahdale for approval prior to supply and planting.

Seedlings will be supplied in tubestock sizes, to industry standards:

- Soil in containers at the time of delivery will be free of weeds, insects and disease (e.g. dieback);
- All plants will be true to species name, well formed and hardened off nursery stock;
- The root system will be fibrous, of a whitish colour and not browned off, and firmly established but not root bound, and with no large roots growing out of the container; and
- Leaves will be of normal size, colour and texture for the specified species.

4.4 Seedling Planting

Trees will be planted first, to ensure an even distribution within the barer areas of the reserve. Other plants will then be infill planted to fill the remainder of the space.

Rushes and sedges will be planted in all the wet depressions of the creek bed, except areas of high water velocity.

Fertiliser will not be used for the creekline as it would add to already high nutrient loads. In the embankment and open flat areas one 10 g slow release fertiliser tablet appropriate for use with native species will be buried adjacent to each plant. The tablets will be placed 100 to 200 mm from each seedling to promote healthy root development. The nutrients contained within the tablets will be less mobile being buried underground, and therefore are considered appropriate for use.

4.5 Protection

Fencing will be installed around the Beenyup Brook reserve to exclude stock, pedestrians, and kangaroos from accessing and damaging plants. These will be removed by the Shire to allow public access after a minimum of three years protection of the revegetation in progress.

5 POST-INSTALLATION MANAGEMENT

5.1 Performance Criteria

The Shire of Serpentine Jarrahdale have set performance criteria at a minimum of 80% of required stems being present two years after planting (Shire of Serpentine Jarrahdale, 2005). The site will be maintained for the two year period, after which time the ownership will revert to the Shire.

Therefore the final creekline density needs to be an average of 4.8 plants / m^2, and 1.6 plants / m^2 in the open flat and embankment areas.

5.2 Monitoring Program

Rehabilitation progress will be continually monitored. Four visits over the two year maintenance period will be sufficient to monitor progress:

- First spring (October 2009);
- First autumn (April 2010);
- Second spring (October 2010); and
- Second autumn (April 2011).

The timing of the assessments may be adjusted to suit the weather conditions at the time.

The first assessment will look at the short term survival of seedlings. Any problems will be identified early, so that remedial action can be carried out if required. Emergence of summer weeds will also be assessed.

The second assessment will determine if there are any losses over the dry summer period, and consequently the survival rates. Species diversity, stem density, and growth rates will be assessed. The first summer is the expected period of greatest mortality, as the seedlings are in their most vulnerable state. Annual weed encroachment will also be monitored to determine if control is required. The results of each monitoring assessment will be compared to determine growth and mortality rates, and provide a quantitative measure of progress.

After the third and fourth assessments the long term health and success of the revegetation operation will be indicated. Predicted weed impacts, and future monitoring and maintenance requirements will be better known at this point.

Weed levels will at each assessment be generally monitored in terms of species, area covered and the severity of the infestation. Areas will be classed as requiring control, monitoring, or no action depending on the species and area affected.

5.3 Site Maintenance

Maintenance activities:

- Ongoing weed management;
- Infill planting to achieve required plant numbers;
- Fence repair and removal; and
- Seedling watering if required.

Weeds will certainly continue to have an impact on the revegetation due to the species present (some species have long soil seed life), and the previous usage of the land. Whether maintenance weed control (summer weeds and winter weeds) is required or not will be determined through the monitoring.

Infill planting will occur when plant numbers drop below the minimum 80% survival rate. If survival rates are identified as below target, infill planting will not take place until the following winter. Autumn assessments are the most critical in terms of infill planting, as plants that have survived through the summer are highly likely to survive in the longer term.

Adverse weather conditions (such as droughts and storms) and unauthorized access to revegetated areas may lead to loss of vegetation in some sections of the site, which is outside of normal control but nevertheless has been allowed for within the performance criteria.

Watering over dry periods should not be necessary under normal conditions due to the tolerance of the selected species. The exception may be the first year when plant roots have not developed sufficiently and watering may be considered on an as needed basis.

6 REFERENCES

Brown, K., and Brooks, K. Bushland Weeds, A Practical Guide to Their Management. Environmental Weeds Action Network. 2002.

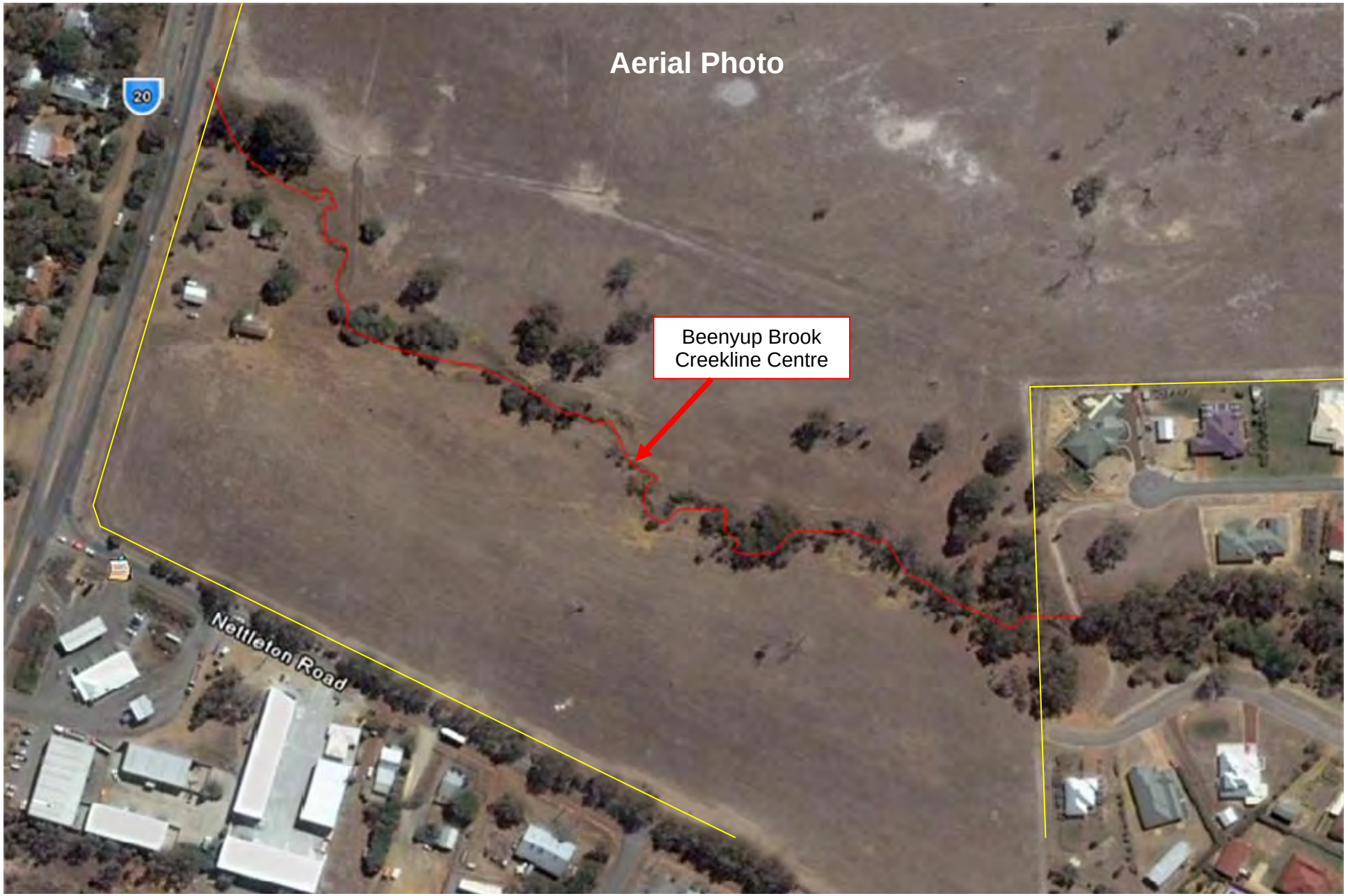
Department of Agriculture, 2003. AgMaps Land Profiler CD-ROM. 2003.

Department of Agriculture and Food, 2008. Declared Plants. http://agspsrv95.agric.wa.gov.au/dps/version02/01_plantsearch.asp

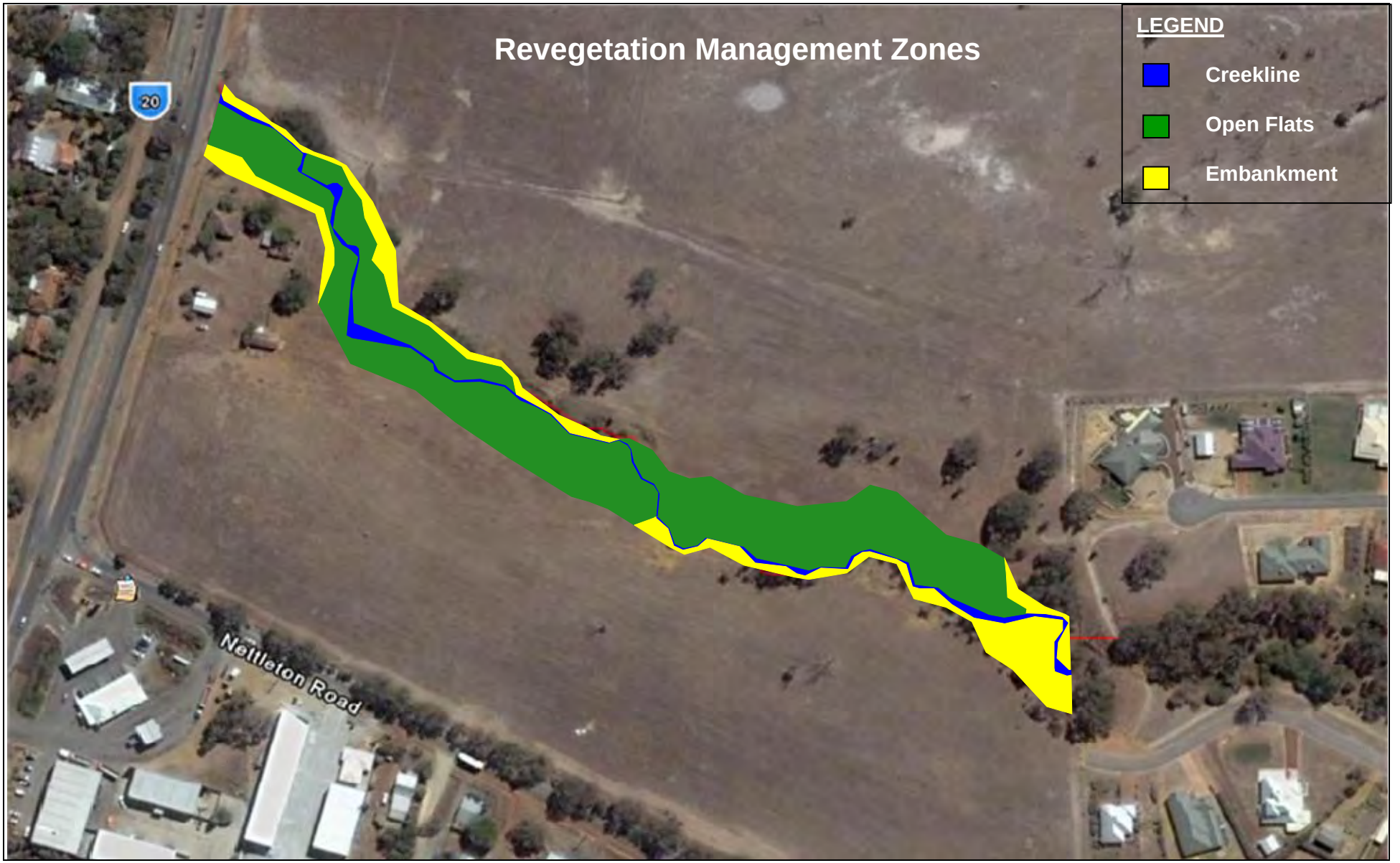
Shire of Serpentine Jarrahdale, 2005. Shire of Serpentine Jarrahdale, Draft Environmental Policy, Revegetation. December 2005.

Appendix 1 Site Location and Aerial Photo

Client:	Job No:
Project: Lot 2 Nettleton Road	Drawn By: SE
FIGURE 1: Site Location	Checked By:
	Scale: NTS


Aerial Photo
20
Beenyup Brook
Creekline Centre
Nelleton Road

Appendix 2 Revegetation Zones


Revegetation Management Zones
LEGEND
Creekline
Open Flats
Embankment
20
Nellieton Road

Appendix 3 Seedling Allocations

tranen
revegetation systems

Lot 2 Nettleton Rd
Seedlings

Species	Growth Form	Creekline	Open Flats	Embankment	Total
Trees					
Casuarina obesa	Tree		500		500
Corymbia calophylla	Tree		500	400	900
Eucalyptus marginata	Tree			200	200
Eucalyptus rudis	Tree		500	390	890
Melaleuca preissiana	Tree		490		490
Melaleuca rhaphiophylla	Tree		500		500
Total		**0**	**2,490**	**990**	**3,480**
Required		**0**	**2,490**	**990**	
Shrubs and Groundcovers					
Acacia pulchella	Shrub		400	400	**800**
Astartea scoparia	Shrub		400		**400**
Baeckea camphorosmae	Shrub		500	400	**900**
Banksia dallanneyi (formerly Dryandra lindelyana)	Groundcover		100		**100**
Daviesia decurrens	Shrub		300	200	**500**
Hakea lissocarpha	Shrub		400	400	**800**
Hibbertia hypericoides	Shrub		100	110	**210**
Hypocalymma angustifolium	Shrub		400	400	**800**
Kennedia prostrata	Groundcover		380	400	**780**
Kunzea glabrescens	Shrub		300		**300**
Melaleuca lateritia	Shrub		400		**400**
Pericalymma ellipticum	Shrub		400		**400**
Taxandria linearifolia	Shrub		500		**500**
Viminaria juncea	Shrub		400		**400**
Total		**0**	**4,980**	**2,310**	**7,290**
Required		**0**	**4,980**	**2,310**	
Sedges					
Juncus kraussii	Sedge	1,000	200		1,200
Juncus pallidus	Sedge	4,000	400		4,400
Meeboldina cana	Sedge	1,000	230		1,230
Total		**6,000**	**830**	**0**	**6,830**
Required		**6,000**	**830**	**0**	**6,830**
Overall Total		**6,000**	**8,300**	**3,300**	**17,600**
Overall Required		**6,000**	**8,300**	**3,300**	**17,600**

Appendix 4 Weed Distribution March 2008

SJS TRIM - IN15/13980

Appendix 5 Weed Management Schedule

tranen revegetation systems

Lot 2 Nettleton Rd
Weed Management Schedule

Species	Common Name	Control Method	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
**Dittrichia graveolens*	Stinkwort	Spray glyphosate before flowering												
**Ficus sp.*	Fig	Cut and paint												
**Gomphocarpus fruiticosus*	Narrow Leaf Cotton Bush	Spray glyphosate, remove seed heads, slash												
**Nerium oleander*	Oleander	Cut and paint												
**Pennisetum clandestinum*	Kikuyu Grass	Spray Fusilade												
**Rubus sp.*	Blackberry	Spray glyphosate, slash												
**Rumex sp.*	Dock	Spray glyphosate early bud stage												
**Schinus terebinthifolius*	Japanese Pepper	Cut and paint												
**Solanum nigrum*	Black Nightshade	Spray glyphosate												
**Typha orientalis*	Typha	Spray glyphosate, slash												
**Watsonia meriana var bulbillifera*	Bulbil Watsonia	Spray glyphosate at flowering												

- Spray glyphosate
- Spray fusilade
- Slash
- Cut and paint
- Manual removal

APPENDIX C
LANDSCAPE SPECIES LIST

LOT 2 NETTLETON RD, BYFORD - PLANT SPECIES LIST

Botanic Name	Common Name	No.	Pot Size	Size at 6mths	Size at Year 1	Size at year 2	Size at Year 3	Size at Year 5
ZONE 1a: DRYLAND VEGETATION (2 PLANTS/SQ M) **Total Area:** **Total Plants:**								
TOTAL COVERAGE				10.00%	40.00%	85.00%	100.00%	100.00%
TREES								
Allocasuarina fraseriana	Sheoak	2%	tube stock	0.5m	0.75m	2.0m	3.5m	10.0m
Corymbia calophylla	Marri	100No.	5 litre	1.05m	1.5m	3.0m	4.5m	12.0m
Corymbia calophylla	Marri	1%	tube stock	0.7m	1.0m	2.5m	4.0m	12.0m
Eucalyptus marginata	Jarrah	100No.	5 litre	1.05m	1.5m	3.0m	4.5m	12.0m
Eucalyptus marginata	Jarrah	1%	tube stock	0.7m	1.0m	2.5m	3.5m	12.0m
Eucalyptus rudis	Flooded Gum	10No.	5 litre	1.05m	1.5m	3.0m	4.0m	8.0m
Eucalyptus wandoo	Wandoo	1%	tube stock	0.7m	1.0m	2.5m	3.25m	8.0m
Nuytsia floribunda	Christmas Tree	1%	tube stock	0.7m	1.0m	2.5m	3.0m	6.0m
SHRUBS and HERBS								
Acacia divergens		4%	tube stock	0.15m	0.2m	0.5m	0.8m	1.5m
Acacia pulchella	Prickly Moses	6%	tube stock	0.2m	0.3m	0.7m	1.2m	2.0m
Acacia saligna	Orange Wattle	3%	tube stock	0.3m	0.4m	1.4m	2.5m	4.0m
Allocasuarina humilis	Dwarf Sheoak	7%	tube stock	0.1m	0.15m	0.5m	0.8m	1.2m
Anigozanthos manglesii	Mangles Kangaroo Paw	10%	tube stock	0.2m	0.35m	0.7m	0.8m	1.0m
Conostylis aculeata	Prickly Conostylis	5%	tube stock	.07m	0.1m	0.2m	0.25m	0.3m
Dampiera linearis	Common Dampiera	5%	tube stock	0.15m	0.15m	0.2m	0.25m	0.4m
Dianella revoluta	Dianella	7%	tube stock	0.15m	0.2m	0.5m	0.35m	0.5m
Dryandra nivea	Honeypot Dryandra	4%	tube stock	0.15m	0.15m	0.5m	0.5m	1.0m
Grevillea pilulifera	Woolly Flowered Grevillea	4%	tube stock	.07m	0.1m	0.25m	0.4m	0.75m
Hakea ceratophylla	Norned Leaf Hakea	2%	tube stock	0.15m	0.2m	0.5m	0.9m	1.5m
Hakea lissocarpha	Honey Bush	2%	tube stock	0.15m	0.15m	0.5m	0.6m	1.0m
Hakea prostrata	Harsh Hakea	2%	tube stock	0.15m	0.25m	0.7m	1.2m	2.0m
Hakea stenocarpa	Narrow Fruited Hakea	1%	tube stock	.07m	0.1m	0.25m	0.4m	0.7m
Hakea trifurcata	Two Leaf Hakea	3%	tube stock	0.15m	0.25m	0.7m	1.2m	2.0m
Hypocalymma angustifolium	White Myrtle	4%	tube stock	0.15m	0.2m	0.5m	0.8m	1.5m
Hypocalymma robustum	Swan River Myrtle	3%	tube stock	.07m	0.1m	0.35m	0.5m	0.8m
Kunzea micrantha		2%	tube stock	0.15m	0.2m	0.45m	0.65m	1.2m
Melaleuca laterifolia	Gorada	2%	tube stock	0.35m	0.5m	2.0m	3.0m	5.0m
Patersonia occidentalis	Purple Flag	7%	tube stock	0.15m	0.25m	0.7m	0.5m	1.0m
GROUNDCOVERS								
Eremophila glabra	Tar Bush	3%	tube stock	0.15m	0.25m	0.7m	1.0m	2.0m
Grevillea crithmifolia		3%	tube stock	0.1m	0.15m	0.5m	0.7m	1.4m
Grevillea obtusifolia 'Gin Gin Gem'	Gin Gin Gem	5%	tube stock	0.1m	0.15m	0.4m	0.5m	1.0m
ZONE 1b: DRYLAND VEGETATION (2 PLANTS/SQ M) **Total Area:** **Total Plants:**								
TOTAL COVERAGE				15.00%	50.00%	90.00%	100.00%	100.00%
Corymbia calophylla	Marri	20No.	5 litre	1.05m	1.5m	3.0m	4.5m	12.0m
Eucalyptus marginata	Jarrah	15No.	5 litre	1.05m	1.5m	3.0m	4.5m	12.0m
Plant species as above. Plants to be planted at higher density than within Zone 1a.								

Ethnosciences

ABN 47 065 099 228

Aboriginal Heritage

Draft Report of an Ethnographic Aboriginal Heritage Survey of Lot 2 Nettleton Road, Byford, Western Australia

Prepared for Aspen Group

By Edward McDonald PhD and Bryn Coldrick M.A.

October 2007

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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.

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Summary & Recommendations

Ethnosciences was commissioned by Aspen Group to undertake an ethnographic survey of Lot 2 Nettleton Road, Byford, Western Australia. Aspen proposes to subdivide and develop the land for residential purposes.

Previously, in July 2007, Ethnosciences carried out a desktop assessment and preliminary ethnographic consultation in relation to Lot 2 as part of a due diligence assessment prior to Aspen purchasing the land (McDonald 2007). The search of the Register of Aboriginal Sites using the AHIS confirmed that no sites have been listed on Lot 2. The Register search indicates that 36 places are recorded in the wider search area with 19 archaeological locales having been registered at Byford by the Scarp to the south following archaeological investigations there. There are two ethnographic sites listed in the wider area, both mythological sites associated with watercourses: Site IDs 3512 Wungong Brook and 16108 Cardup Brook. However, the latter (Cardup Brook) has been assessed as 'not a site' within the meaning of Section 5 of the AHA.

Ethnosciences had also previously carried out an archaeological reconnaissance of Lot 2 in November 2006 for another client and this resulted in the identification of three artefact scatters (NR#1-06 – NR#3-06) and one isolated artefact (NRIOS#1-06) on the land.

A more detailed archaeological survey was undertaken by Tempus Archaeology in September 2007. This survey relocated the three previously recorded archaeological sites along with an additional sixteen flaked stone artefacts, eleven of which were provisionally grouped into three new archaeological loci (Nettleton 19-09-07/001 to 003) with the balance classified as isolated finds (Edwards 2007).

The ethnographic survey involved representatives of four key Aboriginal groups who have associations with and knowledge of the Aboriginal heritage values of the survey area: the Bibbulmun Tribal Group, the Ballaruk Aboriginal Corporation, the

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Independent Aboriginal Environmental Group (IAEG) and the Bilya Noongar Organisation. As predicted in the desktop study, one ethnographic site, Beenyup Brook, was reported during the survey. No other ethnographic sites were reported on the property.

The Bibbulmun Tribal Group reported Beenyup Brook as being of spiritual significance to Aboriginal people but was not aware of any specific mythological narratives associated with the brook. It is the opinion of the authors that in the absence of specific cultural information, it is difficult to regard the brook as an 'Aboriginal site' under the Act as there is insufficient supporting information to meet any of the definitions of Section 5. However, this assessment is not intended to downplay the brook's obvious importance to the Aboriginal consultants.

All groups consulted were primarily concerned with the need to protect the brook and its associated flora and fauna. The groups were satisfied that the buffer shown on the preliminary concept plan would help to ensure that there would be no direct impact to the brook as a result of the proposed development. The Independent Aboriginal Environmental Group made reference to the need to construct a bridge over the brook in the future, though they expressed no major concerns about this. They were, however, concerned about indirect impacts on the brook as a result of drainage and water run-off. The groups were also concerned about the native flora and fauna on the property and were particularly interested in the fate of the kangaroos and bandicoots. It was requested that these animals be safely relocated prior to development.

The results of the archaeological reconnaissance and the more recent archaeological survey were also discussed with the groups with the use of photographic material and mapping. The Aboriginal consultants were satisfied with the archaeological report's recommendations (Edwards 2007) that these sites be avoided where possible through inclusion in POS and that Section 18 approval be obtained prior to any

impact as a result of the development. All groups requested monitoring of ground preparation works (i.e. vegetation clearance and topsoil stripping) which is consistent with the archaeological recommendations (Edwards 2007).

Recommendations

Based on the outcomes of the ethnographic survey results, the following recommendations are made:

1. That the subdivision and development of Lot 2 Nettleton Road be allowed to proceed;
2. That Aspen Group apply for Ministerial consent to use the land under Section 18 of the *Aboriginal Heritage Act 1972* making reference to the identified archaeological and ethnographic heritage values of the property;
3. That all impacts to Beenyup Brook be avoided where possible through the provision of a buffer zone extending to 30m on either side of the brook and that a Drainage and Nutrient Management Plan be prepared to ensure the brook's long-term protection;
4. That the recommendations made in the archaeological report (Edwards 2007) be followed, in particular that the proponent engage a suitably qualified archaeologist and Aboriginal community representatives to undertake a strategic watching brief of topsoil stripping activities; and
5. That an Aboriginal Heritage Management Plan (AHMP) be prepared to ensure the long-term protection of any Aboriginal heritage sites that are to be preserved within the development.

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Introduction

Ethnosciences was commissioned by Aspen Group to undertake an ethnographic Aboriginal heritage survey of Lot 2 Nettleton Road, Byford, Western Australia. Aspen proposes to subdivide and develop the land for residential purposes.

The subject land is located approximately 30km south of the Perth CBD and is bounded on the west by South Western Highway, on the north by Beenyup Road and on the south by Nettleton Road. The eastern boundary is in part formed by the ends of the present urban development which includes Bunney Place, White Gum Rise and Waterside Pass (Figure 1).

Lot 2 is largely cleared and the paddocks have been used for grazing horses etc although the northeastern corner of the property contains remnant Jarrah woodland. Beenyup Brook runs east–west through the southern third of the property and there is a narrow belt of remnant riparian vegetation along its banks. The property is currently vacant.

In July 2007, Ethnosciences carried out a desktop assessment and preliminary ethnographic consultation in relation to Lot 2 as part of a due diligence assessment prior to Aspen purchasing the land (McDonald 2007). Ethnosciences had also previously carried out an archaeological reconnaissance of Lot 2 in November 2006 for another client and this resulted in the identification of three artefact scatters (NR#1-06 – NR#3-06) and one isolated artefact (NRIOS#1-06).

A more detailed archaeological survey was undertaken in September 2007 by Tempus Archaeology and the results of this survey are reported under a separate cover (Edwards 2007). The survey relocated the three previously recorded archaeological sites (NR#1-06 – NR#3-06) and isolated find NR ISO#1-06. An additional sixteen flaked stone artefacts were also found, eleven of which were provisionally grouped into three new archaeological loci (Nettleton 19-09-07/001 to

003) with the balance classified as isolated finds (Edwards 2007:1; **Error! Reference source not found.**).

The archaeological report contains a number of recommendations, most notably that the proponent seek appropriate consent from the Minister of Indigenous Affairs in accordance with Section 18 of the *Aboriginal Heritage Act 1972* prior to undertaking any activity that may result in a breach of the Act under Section 17. It was recommended that the archaeological material be retained wherever possible (e.g. through design or the sensitive allocation of public open space) and that further evaluation of the archaeological sites be undertaken. Where preservation *in situ* is not possible, it was recommended the proponent undertake consultation with relevant Aboriginal community representatives to determine management regime(s) should this be deemed appropriate. It was also recommended that the proponent engage a suitably qualified archaeologist and Aboriginal community representatives to undertake a watching brief of topsoil stripping activities within the survey area (Edwards 2007:2).

This report presents the results of the ethnographic survey which involved representatives of four key Aboriginal groups who have associations with and knowledge of the Aboriginal heritage values of the survey area: the Bibbulmun Tribal Group, the Ballaruk Aboriginal Corporation, the Independent Aboriginal Environmental Group and the Bilya Noongar Organisation. The purpose of the survey was to identify any previously unreported ethnographic sites and to seek the views of the Aboriginal community with regards to the archaeological findings outlined above and the proposed development in general.

Figure 1: Map showing the location of Lot 2 Nettleton Road, Byford

Figure 2: Location of archaeological material identified on Lot 2 in November 2006 and September 2007 (Source: Tempus Archaeology 2007)

Plate 1: Lot 2 Nettleton Rd, Byford: view northeast from South Western Highway towards Darling Scarp (note dense ground cover) (Source: Coldrick October 2007)

Plate 2: View of Beenyup Brook from South Western Highway showing resident herd of kangaroos (Source: Coldrick October 2007)

Plate 3: View eastwards across Lot 2 Nettleton Rd towards remnant woodland and Darling Scarp (Source: Coldrick October 2007)

Ethnographic Survey Methods

The ethnographic survey was undertaken in accordance with the Department of Indigenous Affairs' (DIA's) *Draft Guidelines for Aboriginal Heritage Assessment in Western Australia* (2002). The objectives of the ethnographic survey were to:

- Identify any known or potential Aboriginal heritage issues that may affect the proposed development;
- Undertake research and/or consultation that may be necessary to meet the requirements of the *Aboriginal Heritage Act 1972*;
- Locate/record Aboriginal sites and any other Aboriginal heritage issues; and
- Make recommendations regarding the management of any sites identified including any further research and/or consultation that may be required during or after the works component of the project.

The ethnographic survey employed a 'site identification' methodology which the DIA guidelines describes as follows:

> *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* (DIA 2002:17).

The ethnographic survey was conducted in the following stages:

- Desktop research and preliminary consultation with the Bilya Noongar Organisation (July 2007);
- Interviews and site inspections with Aboriginal consultants from the Bibbulmun Tribal Group, the Ballaruk Aboriginal Corporation and the Independent Aboriginal Environmental Group (October 2007); and
- Report preparation.

The original desktop study undertaken by McDonald in November 2006 included an examination of the Register of Aboriginal Sites using the online Aboriginal Heritage Inquiry System (AHIS) maintained by DIA, as well as a number of relevant site files. A range of pertinent published and unpublished archaeological and ethnographic

material relating to the Aboriginal heritage values of the study area and its environs was also reviewed, including a number of Aboriginal heritage assessment reports. The desktop survey was updated by McDonald in July 2007 and by Coldrick in October 2007 with re-examinations of the Register of Aboriginal Sites using the AHIS.

As mentioned above, the original (2006) study also included an archaeological reconnaissance in order to assess the potential for archaeological material to be located on the land (McDonald 2006a). This reconnaissance did not involve a systematic study of the area. Rather, areas of high surface visibility and archaeological potential (e.g. sand exposures and tracks) were targeted. The efficacy of the archaeological reconnaissance was limited by the dense ground cover on the property and resulting limited surface visibility which in places was a little as 5%, especially in the grazing paddocks (see Plates 1 & 2). Despite these limitations, a range of archaeological material was identified on the property. A more detailed archaeological survey was subsequently carried out by Tempus Archaeology in September 2007 and the results of this survey are presented separately (Edwards 2007). The survey findings were discussed with the Aboriginal groups during the ethnographic consultation.

The four Nyungar groups involved in the ethnographic survey (Bilya Noongar Organisation, Bibbulmun Tribal Group, the Ballaruk Aboriginal Corporation and the Independent Aboriginal Environmental Group) comprise Aboriginal consultants who have associations with and knowledge of the Aboriginal heritage values of the Byford area. Senior members of the families comprising these group have been consulted about the heritage values of the Byford area and its environs in the past (see, for example, Blockley, Greenfeld, Edwards, McDonald and Murphy 1996; Prince, Hovingh, Lewington and Lamond 1996; Hovingh and Locke 1997; Burke, Hovingh, Gardoz, Edwards, Murphy and Collard 1998; Edwards and McDonald 1999; and McDonald 2006a and 2006b).

The ethnographic consultation was conducted in two stages. The Bilya Noongar Organisation was consulted by Edward McDonald and Bryn Coldrick on July 19, 2007 and the remaining groups were consulted by Bryn Coldrick on October 8 & 9, 2007 (see Table 1 for a full list of people involved). The consultation took the form of on-site meetings with each group and inspections of the proposed development area (PDA) from key vantage points along Nettleton Road, Lazenby Drive and Beenyup Drive.

Name	Aboriginal Group	Date
Clarry Walley	Bilya Noongar Organisation	July 19, 2007
Harry Nannup	Bilya Noongar Organisation	July 19, 2007
Elder Abraham	Bilya Noongar Organisation	July 19, 2007
Ivan Lyndon	Bilya Noongar Organisation	July 19, 2007
Ken Colbung	Bibbulmun Tribal Group	October 8, 2007
Essandra Colbung	Bibbulmun Tribal Group	October 8, 2007
Phil Prosser	Bibbulmun Tribal Group	October 8, 2007
Melanie King	Bibbulmun Tribal Group	October 8, 2007
Corrie Bodney	Ballaruk Aboriginal Corporation	October 9, 2007
Violet Mippy	Ballaruk Aboriginal Corporation	October 9, 2007
Violet Bodney	Ballaruk Aboriginal Corporation	October 9, 2007
Tanya Bodney	Ballaruk Aboriginal Corporation	October 9, 2007
Patrick Hume	Independent Aboriginal Environmental Group	October 9, 2007
Rebecca Hume	Independent Aboriginal Environmental Group	October 9, 2007
Gladys Yarran	Independent Aboriginal Environmental Group	October 9, 2007
Jocelyn Indich	Independent Aboriginal Environmental Group	October 9, 2007

Table 1:Aboriginal People and Groups Consulted in Relation to Lot 2 Nettleton Road

Results of the Ethnographic Survey

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), located to the south of the survey area was the territory of the *Pindjarup*.

Bates (1985), on the other hand, uses the term *Bibbulmun* to refer to people who would today refer to themselves as *Nyungar*. 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) wrote that the Aboriginal people of the Perth/Swan River area were known as the *Yabbaru Bibbulmun* [northern Bibbulmun] or *Illa Kuri Wongi*.[1] She reported that the people of the Murray district referred to themselves as the *Kuri Wongi* and gave the Serpentine River as the boundary between the Swan and Murray River people (Bates 1985:53). This roughly corresponds to the boundary noted by Tindale (1974; see also Australia S.W. Sheet – Tribal Boundaries Map).

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[1] 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.

Recently, Keen (1997:261) has 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 the '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.[2]

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 further imposed European concepts in describing both territorial affiliations and Aboriginal 'leaders'. Various 'territories' have been described in which these social units were principally located and moved.

According to Lyon (1833, cited in Green 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 and Tilbrook 1990 discuss some of these differences). Armstrong (1836, cited in Hallam and 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 about 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

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[2] 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 and Christensen n.d.).

description is that of a system of overlapping sets of ritual and social connections with land usage rights based on both patri- and matri-filiation. Individuals, families and bands moved between areas, generating a fluid local population in both size and composition.

The ethnohistorical evidence shows that rivers, creeks and wetlands in the Perth 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 the 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; McDonald and Cooper 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 these original Aboriginal pads. For example, Popham (1980:17) notes that Albany Highway follows a route surveyed by Hillman in 1836 that "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."

Aboriginal Heritage

The ravages wrought by the European colonisation on Nyungar society did not destroy Nyungar social bonds or identity completely and 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 (i.e. colonisation) in the early chapters and then rarely, if ever, mention Aboriginal people again. For example, McDonald and Cooper's (1988) *The Gosnells Story* does not have an indexed listing for 'Aborigine' after Chapter 3 (pp. 36–46) which deals with the period 1833 to 1865. The other local histories fair little better.

Rather than disappearing, Aboriginal people continued to play a part, albeit a marginal one, 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 in the South West, Aboriginal people, 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 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, 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 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 in a number of locations near Armadale in the 1930s and 1940s. Camps were located, for instance, in Forrestdale, Cardup and Bedfordale.

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). Aboriginal history is also reflected in the continuing use of Nyungar place names in the region, albeit in often modified forms (Coy 1984 discusses some of the Nyungar places names and their significance in the Serpentine area). Further research is required to detail Aboriginal habitation in the Serpentine area from the commencement of colonisation to the 1970s.

The adversity faced by Nyungars strengthened a sense of common identity and social bonds and new links with the country have been forged based on biographical and historical associations. Over the past three decades, there has been a growing movement to reconstruct Nyungar culture which 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.

Archival Search Results

Sites within the Study Area

The original search of the Register of Aboriginal Sites using the AHIS (November 2006) did not identify any listed archaeological or ethnographic sites within Lot 2 Nettleton Road, Byford. The updated searches (July and October 2007) produced the same results, confirming that no sites have been listed on the land in the interim.

Sites outside the Study Area

It is recognised that the Register search results may be a reflection of factors such as the lack of specifically focused heritage research rather than the absence of sites *per se*. In order to test this proposition, a Register search was undertaken of a wider area in the general vicinity of the Byford area. The coordinates of this search are shown in Table 2 below.

Easting	Northing
403112	6432276
408524	6436322
MGA Zone 50	

Table 2: Coordinates of wider Register Search using the AHIS

The Register search indicates that 36 places are recorded in the wider search area (Figure 3; Table 3). Eleven of these places (Site IDs 21305, Byford Isolated Finds; 23914, Byford Archaeological Survey 001; 23915, Byford Archaeological Survey 002; 23916, Byford Archaeological Survey 003; 23918, Byford Archaeological Survey 005; 23920, Bas/iso - 001; 23921, Bas/iso - 002; 23922, Bas/iso - 003; 23923, Bas/iso - 004; 23924, Bas/iso - 005; 23925 Bas/iso – 006), despite containing artefactual material and, in the case of Site ID 23914 Byford Archaeological Survey 001, artefacts and a scarred tree, have been assessed by the Aboriginal Cultural Material Committee (ACMC) as not being a "site" within the meaning of Section 5 of the *Aboriginal*

Heritage Act 1972 (AHA) with the relevant information archived in 'Stored Data'.[3] Site ID 23917, Byford Archaeological Survey 004 is on the Permanent Register while Site ID 23919, Byford Archaeological Survey 006 remains on the Interim Register.

There are two ethnographic sites listed in the wider area, both reported to be mythological sites associated with watercourses: Site IDs 3512 Wungong Brook and 16108 Cardup Brook. However, the latter (Cardup Brook) has been assessed as not a site within the meaning of Section 5 of the AHA (see below for further discussion).

The balance of sites in the wider area (n=23) are archaeological sites, that is, artefact scatters. Of these, 19 are located in the Byford by the Scarp subdivision to the south of Lot 2 (Prince, Hovingh, Lewington and Lamond 1996) and two of these archaeological locales are to be preserved in POS. As a condition of the consent to use the land obtained by the proponents at Byford by the Scarp under Section 18 of the AHA, additional archaeological recording was required at certain locales. This work took place in June 1998 in conjunction with further consultation with the local Aboriginal community (Burke, Hovingh, Gardoz, Edwards, Murphy and Collard 1998) and led to the discovery of one additional locale for which S18 consent to use the land was subsequently granted.

In the vicinity of the Tonkin Highway alignment is Site ID 396 South-East Corridor 07/Cardup Siding, and Site ID 3310 Cardup is reportedly located approximately 50m from the north bank of Cardup Brook. In a recent survey of the proposed LWP Byford Project area, Tempus Archaeology (2006) reported that Site ID 3310 could not be relocated on the ground and that it might have been destroyed.

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[3] Places deemed by the ACMC not to fulfil any of the criteria under Section 5 of the Act are entered in the Stored Data index. This is also the case for those places which the ACMC finds do not have any Aboriginal association. Stored or Archived Data is retained so that these places either need not be referred to the ACMC for assessment if they are reported again later, or can be re-assessed if further information is submitted at a later date.
@ http://www.dia.wa.gov.au/heritage/standardsweb/glossary.aspx#Interim

Aboriginal Heritage

Tempus Archaeology's 2006 survey of the proposed LWP Byford Project area identified five new open artefact clusters (now listed as Site ID's 23914 Byford Archaeological Survey 001; 23915 Byford Archaeological Survey 002; 23916 Byford Archaeological Survey 003; 23917 Byford Archaeological Survey 004; and 23918 Byford Archaeological Survey 005) and six isolated stone artefacts (now listed as Site 23920, Bas/iso - 001; 23921, Bas/iso - 002; 23922, Bas/iso - 003; 23923, Bas/iso - 004; 23924, Bas/iso - 005; 23925, Bas/iso – 006) within the LWP Byford project area (Tempus Archaeology 2006).

Apart from BAS-005, which is located in the Byford by the Glades precinct, all of the artefact scatters were located within the Byford by the Brook precinct on the south side of the brook. With the exception of a couple of sites (e.g. Site ID 396 and Site ID 16096), these were quartz-rich open artefact scatters, relatively small in extent, located within disturbance exposures or other areas of high ground surface visibility associated with exposures of sandy sediment.

Site ID 396, on the other hand, is quite extensive and contains several hundred artefacts of a wider range of materials including chert, silcrete, greenstone, granite and glass. Site ID 16096 contains approximately 130 artefacts of a similar range of material. According to Tempus Archaeology (2006), a number of the newly recorded sites (i.e. Site ID 396, BAS-001, BAS-003, BAS-004 and BAS-005) have the potential to be associated with near- and sub-surface cultural material. However, as indicated above, the ACMC has determined that a number of these places, though containing archaeological material, are not sites within the meaning of the Act.

Figure 3: Map showing the location of Registered Aboriginal Sites in the vicinity of the study area (Source: AHIS)

Site ID	Site Name	Site Type	Register Listing	Access	Spatial Reliability
396	South-East Corridor 07 /Cardup Siding	Artefacts / Scatter	Permanent	Open	Reliable
3310	Cardup	Artefacts / Scatter	Interim	Open	Unreliable
3512	Wungong Brook	Mythological	Interim	Closed	N/A
16089	Byford 01	Artefacts / Scatter	Permanent	Open	Unreliable
16090	Byford 02	Artefacts / Scatter	Permanent	Open	Unreliable
16091	Byford 03	Artefacts / Scatter	Permanent	Open	Unreliable
16092	Byford 04	Artefacts / Scatter	Permanent	Open	Unreliable
16093	Byford 05	Artefacts / Scatter	Permanent	Open	Unreliable
16094	Byford 06	Artefacts / Scatter	Permanent	Open	Unreliable
16095	Byford 07	Artefacts / Scatter	Permanent	Open	Unreliable
16096	Byford 08	Artefacts / Scatter	Permanent	Open	Unreliable
16097	Byford 09	Artefacts / Scatter	Permanent	Open	Unreliable
16098	Byford 10	Artefacts / Scatter	Permanent	Open	Unreliable
16099	Byford 11	Artefacts / Scatter	Permanent	Open	Unreliable
16100	Byford 12	Artefacts / Scatter	Permanent	Open	Unreliable
16101	Byford 13	Artefacts / Scatter	Permanent	Open	Unreliable
16102	Byford 14	Artefacts / Scatter	Permanent	Open	Unreliable
16103	Byford 15	Artefacts / Scatter	Permanent	Open	Unreliable

Site ID	Site Name	Site Type	Register Listing	Access	Spatial Reliability
16104	Byford 16	Artefacts / Scatter	Permanent	Open	Unreliable
16105	Byford 17	Artefacts / Scatter	Permanent	Open	Unreliable
16106	Byford 18	Artefacts / Scatter	Permanent	Open	Unreliable
16107	Byford 19	Artefacts / Scatter	Permanent	Open	Unreliable
16108	Cardup Brook	Mythological	Interim	Open	Unreliable
21305	Byford Village Isolated Finds	Artefacts / Scatter	Stored Data	Open	Unreliable
23914	Byford Archaeological Survey 01	Modified Tree Artefacts / Scatter	Stored Data	Open	Reliable
23915	Byford Archaeological Survey 002	Artefacts / Scatter	Stored Data	Open	Reliable
23916	Byford Archaeological Survey 003	Artefacts / Scatter	Stored Data	Open	Reliable
23917	Byford Archaeological Survey 004	Artefacts / Scatter	Permanent	Open	Reliable
23918	Byford Archaeological Survey 005	Artefacts / Scatter	Stored Data	Open	Reliable
23919	Byford Archaeological Survey 005	Artefacts / Scatter	Interim	Open	Reliable
23920	Bas/iso - 001	Artefacts / Scatter	Stored Data	Open	Reliable
23921	Bas/iso - 002	Artefacts / Scatter	Stored Data	Open	Reliable
23922	Bas/iso - 003	Artefacts / Scatter	Stored Data	Open	Reliable
23923	Bas/iso - 004	Artefacts / Scatter	Stored Data	Open	Reliable
23924	Bas/iso - 005	Artefacts / Scatter	Stored Data	Open	Reliable
23925	Bas/iso - 006	Artefacts / Scatter	Stored Data	Open	Reliable

Table 3: Aboriginal sites listed in the wider Register search area

The desktop survey concluded that there was a potential for both ethnographic and archaeological sites to be discovered within the Nettleton Road survey area. It was pointed out that Nyungars might report that Beenyup Brook is associated with the Waugal and is therefore of significance, in the same way that Wungong Brook [River] (Site ID 3512) and Cardup Brook (Site ID 16108) have been reported. However, it was also pointed out that the reported association would probably be of a generalised nature and lack the detailed mythological narrative that the ACMC typically requires in its deliberations in relation to the status of a place in terms of the provisions of Section 5 of the AHA.

Ethnographic Survey Outcomes

As predicted in the desktop study (July 2007), one ethnographic site, Beenyup Brook, was reported during the survey of Lot 2 Nettleton Road. No other ethnographic sites were reported on the property.

All groups consulted were primarily concerned with the brook's protection and the senior members of the Bibbulmun Tribal Group specifically requested that it be placed on the Register of Aboriginal Sites. One member of this group explained that because water is "the means of all survival and spirituality" it follows that any waterway, river or tributary is "a site" in their view. However, the group was not aware of any specific mythological narratives associated with the brook and suggested that Dr McDonald may have more information. It was explained to the group that in the absence of specific cultural information, the ACMC would be unlikely to assess the brook as a site under the AHA (see the 'Discussion of the Ethnographic Survey Results' below for further discussion).

The Independent Aboriginal Environmental Group (IAEG) reflected the views of the Bibbulmun Tribal Group by using the analogy of blood flowing through a person's veins to describe the importance of protecting water flow in the brook. As with a blood clot, obstructions to water flow could have adverse consequences for

dependent wildlife and, they believe, people. This group referred to the presence of a large herd of kangaroos along the brook as "living proof that life is here" and emphasised the importance that the brook be allowed to "live and flow".

Members of the Bibbulmun Tribal Group were concerned that the brook should be protected as a "live corridor" or "release" for fauna such as birds and kangaroos, and they felt that the buffer shown on the preliminary concept plan was adequate in this respect (see Figure 4). They also requested that as many of the large trees as possible be protected within the development, particularly along the brook, and pointed out that the sap or gum of the Marri tree was a source of medicine for Aboriginal people and that the trees continue to provide food for birds.

The concern for the retention of the large trees along the brook was also expressed by the Ballaruk Aboriginal Corporation and the IAEG. The groups were also interested in the fate of the kangaroos and bandicoots on the property and the Bibbulmun Tribal Group requested that these animals be safely relocated prior to development.[4]

Although all groups were satisfied that the buffer zone indicated on the preliminary concept plan was adequate to ensure there would be no direct impact on Beenyup Brook as a result of the proposed residential development, the IAEG made reference to the need to construct a bridge over the brook in the future, though they expressed no major concerns about this. They were, however, concerned about indirect impacts on the brook as a result of drainage and water run-off.[5] This group also requested the following:

- that introduced weeds along the brook be cleared to ensure unobstructed water flow;

[4] It is understood that a relocation plan for the kangaroos is being prepared by the Department of the Environment and Conservation in conjunction with the developers and the local authority.

[5] It is understood that a Drainage and Nutrient Management Plan will be prepared to address these issues.

- that only local sand be used for any required fill (to prevent fungus etc being imported from elsewhere);
- that no sprays be used to control weeds; and
- that an environmental centre and/or education material and talks be provided to raise awareness in the community about the importance of protecting the brook and other aspects of the local environment and ecosystem.

The IAEG requested that they be consulted following any changes to the proposed development plan, particularly regarding the final buffer zone along the brook.

Figure 4: Preliminary Concept Plan for Lot 2 Nettleton Road showing buffer zone along Beenyup Brook (Source: Aspen Group)

Consultation Regarding the Archaeological Findings

As mentioned above, the original archaeological reconnaissance of Lot 2 in November 2006 resulted in the identification of three artefact scatters (NR#1-06 – NR#3-06) and one isolated artefact (NRIOS#1-06). A more detailed archaeological survey undertaken in September 2007 identified an additional sixteen flaked stone artefacts, eleven of which were provisionally grouped into three loci (Nettleton 19-09-07/001 to 003) with the balance classified as isolated finds (Edwards 2007:1; Figure 2). The identified archaeological sites and isolated finds are considered to be of low significance in scientific terms though it was recognised that the input of Aboriginal people would be required during the ethnographic survey before any statements of significance could be formulated (Edwards 2007:1).

During the ethnographic consultation, the results of the archaeological reconnaissance and the more recent archaeological survey were reported to the groups with the use of photographic material and mapping. It was explained that the archaeological material was found in sandy exposures and that all six sites were minor artefact scatters containing no more than four artefacts each and that they were attributed low scientific significance by the archaeologist (Edwards 2007:47). It was also pointed out that surface visibility across the survey area was poor due to the thick vegetation and that the potential remained for additional material to remain as-yet unidentified.

The consultants representing the Bilya Noongar Organisation (who were consulted prior to the more detailed archaeological survey) were satisfied with the summary of the archaeological reconnaissance and with the recommendation for additional archaeological work. They commented that the area would have been a good camping place in the past because of Beenyup Brook and other creeks in the Byford area, the proximity to the hills and access to resources, and they were (correctly) of the view that further archaeological material would be discovered on Lot 2. They

also recommended that archaeological monitoring be undertaken when earthworks for the proposed subdivision commence.

The views of the Bilya Noongar Organisation were echoed by the three groups consulted in October 2007 after the archaeological survey had been completed. The groups were satisfied with the archaeological findings and recommendations and expressed no major concerns in relation to these. All groups requested monitoring of site preparation works by Aboriginal consultants. This request is consistent with the archaeological report's recommendation for "a watching brief of topsoil stripping activities" involving Aboriginal community representatives (Edwards 2007:50).

Plate 4: Edward McDonald (left) consults Bilya Noongar Organisation representatives Harry Nannup, Elder Abraham, Ivan Lyndon and Clarry Walley (with hat) about the heritage values of Lot 2, Nettleton Road (Source: Coldrick, July 2007)

Plate 5: Members of the Bibbulmun Tribal Group at Lot 2 Nettleton Road: (from left) Melanie King, Essandra Colbung, Ken Colbung and Phil Prosser (Source: Coldrick, October 2007)

Plate 6: The Independent Aboriginal Environmental Group inspects Beenyup Brook: (from left) Jocelyn Indich, Rebecca Hume, Patrick Hume and Gladys Yarran (Source: Coldrick, October 2007)

Discussion of the Ethnographic Survey Results

It was predicted during the desktop survey (McDonald 2007) that Beenyup Brook could be attributed mythological significance by the Nyungar community in the same way as Wungong Brook (Site ID 3512) and Cardup Brook (Site ID 16108) have been previously. This was confirmed during the ethnographic survey when the Bibbulmun Tribal Group reported Beenyup Brook as an ethnographic site of spiritual significance to Aboriginal people. However, the group was not aware of any specific mythological narratives associated with the brook.

The views articulated by the Bibbulmun Tribal Group in relation to the spiritual significance of water during this survey are consistent with those expressed during previous Aboriginal heritage surveys. For example, during a recent ethnographic survey of a proposed mineral sands mine near Capel, a senior member of this group described the spiritual aspects of water as "part of the soul and being of Aboriginal culture" and when asked to elaborate on the spiritual significance of water to Nyungars he went on to state that the Waugal (Rainbow Serpent) created the waterways and that "without the water, there wouldn't be any Aboriginal spiritual life" (McDonald & Coldrick 2007:6).

This view is also consistent with the findings of a recent major study into Aboriginal cultural values associated with groundwater on the Gnangara Mound, an aquifer which covers the northern metropolitan area (McDonald, Coldrick & Villiers 2005). The Gnangara Mound study found (as have others before it) that Nyungars base much of their culture, identity and spirituality on their close association with groundwater and that the increasing deterioration of groundwater resources in the metropolitan area has cultural as well as environmental implications. Access to healthy freshwater resources has been central to survival across the continent ever since humans first settled in Australia and it has been argued that Aboriginal people are now so closely connected with groundwater in all its forms that the long-term

health of their culture depends on its maintenance (McDonald, Coldrick & Villiers 2005:1).

During the ethnographic survey of Lot 2 Nettleton Road, the Bibbulmun Tribal Group specifically requested that Beenyup Brook be placed on the Register of Aboriginal Sites. However, it will be the role of the Aboriginal Cultural Material Committee (ACMC) with the support of the Department of Indigenous Affairs to determine whether Beenyup Brook is an "Aboriginal site" under the meaning of Section 5 of the *Aboriginal Heritage Act 1972* and such an assessment is only likely to be made in the context of a Section 18 application to use the land.

In order to be considered an "Aboriginal site" under the Act, Beenyup Brook would have to satisfy one of the site definitions as described under Section 5. The most likely subsections of relevance here are Section 5(b) and, to a lesser extent, Section 5(c).

Section 5(b) of the AHA refers to "any sacred, ritual or ceremonial site which is of importance and special significance to persons of Aboriginal descent" while Section 5(c) relates to "any place which, in the opinion of the Committee, is or was associated with the Aboriginal people and which is of historical, anthropological, archaeological or ethnographical interest and should be preserved because of its importance and significance to the cultural heritage of the State". However, it is uncertain whether the brook could be considered an "Aboriginal site" under these definitions in the absence of any specifically contexted mythological information which the ACMC has in recent times been seeking when making its determinations regarding such sites.

In their description of the spiritual importance of Beenyup Brook, the Aboriginal consultants were expressing what has come to be termed "generalised significance". In this context, the specific expression of ancestral action and relationships that would help support a successful assessment under the Act is replaced by a generalised sentiment and an attribution of significance to entire waterscapes rather

than specific places within waterscapes (see McDonald, Coldrick and Christensen 2006 for a more detailed discussion of this issue).

In making their assessment as to whether or not the brook constitutes a site under Section 5 or if it is an expression of 'generalised significance', the ACMC will examine the available information including the views expressed by the Aboriginal community as described in this report. Previous determinations in respect of watercourses in the area have led to certain watercourses being assessed as a "site" and placed on the Permanent Register (e.g. Wungong Brook to the north of Lot 2) while others have been assessed as "not a site" and placed in the "Stored Data" archive (e.g. Cardup Brook to the south of Lot 2). It is worth considering these watercourses and the contrasting determinations in more detail.

Wungong Brook (Site ID 3512) forms part of the Southern River system which was reported by O'Connor and Quartermaine in 1987. O'Connor and Quartermaine reported that Aboriginal people from Armadale believed that this river system was formed by the creative actions of the Waugal which still inhabits it and thus guarantees the flow of water (O'Connor and Quartermaine 1987:2.1). This account is consistent with the accounts of early recorders such as Daisy Bates who reported that the Waugal made all the "big rivers of the Southwest" and "wherever it travelled it made a river" (Bates 1985:221). However, Bates (1985:221) also noted that those "**places where it camped in these travels were always scared**" (emphasis added). Bates points to the specific and contexted rather than a general significance.

However, the presence of the Waugal in all watercourses (major and minor) seems to be open to interpretation. O'Connor and Quartermaine (1987) seemed to argue that the existence of a/the Waugal in a waterway results in the entire river system being imbued with significance. It follows from this line of reasoning that the mythic significance of one waterway is transferred to another if the former is a tributary of the latter. However, later research conducted by Murphy, Machin and McDonald (1990) found that the entire Southern River was not necessarily considered to be a

site and, interestingly, Wungong Brook is not referred to in O'Connor, Quartermaine and Bodney's 1989 report on the Aboriginal significance of wetlands and rivers between Perth and Bunbury (O'Connor, Quartermaine and Bodney 1989).

In contrast, despite its reported significance to Aboriginal people, Cardup Brook (DIA Site ID 16108) which flows through Aspen's Byford by the Scarp development to the south of Lot 2, is now not regarded as an Aboriginal site as defined by Section 5 of the AHA. This may be due to a lack of specific cultural information relating to the brook and should not be taken as an indication that the watercourse has no cultural significance for Aboriginal people (McDonald & Coldrick 2007b:20).

The Gnangara Mound study found that many Nyungars believe that the life force of the Waugal is present in all forms of *flowing* water and Aboriginal people consistently request that water flow and associated ecological values (e.g. important natural habitats) be protected from development (McDonald, Coldrick & Villiers 2005:2).

This concern for maintenance of water flow and vitality was explicitly expressed by both the Bibbulmun Tribal Group and the Independent Aboriginal Environmental Group during the ethnographic survey of Lot 2 and, in the case of the former, this concern was framed in spiritual terms. Whether this is sufficient to satisfy Section 5(b) of the AHA remains a decision for the ACMC. It is the opinion of the authors that in the absence of specific cultural information, it is difficult to regard the brook as an 'Aboriginal site' under the Act as there is insufficient supporting information to meet any of the definitions of Section 5. However, this assessment is not intended to downplay the brook's obvious importance to the Aboriginal consultants.

Conclusions and Recommendations

The search of the Register of Aboriginal Sites (updated in October 2007) did not reveal any previously recorded ethnographic or archaeological sites within the Lot 2 Nettleton Road survey area. A review of additional documentary sources also did not bring to light any known Aboriginal heritage values on the property.

Prior to the ethnographic survey, it was considered likely that Beenyup Brook would be attributed mythological significance by the Nyungar community. This hypothesis was confirmed when the Bibbulmun Tribal Group requested that Beenyup Brook be registered as a site with the Department of Indigenous Affairs due to its spiritual significance. However, the group was not aware of any specific mythological narratives associated with the brook. No other ethnographic sites were reported on the property.

All groups consulted were primarily concerned with the need to protect the brook and its associated flora and fauna. The groups were satisfied that the buffer shown on the preliminary concept plan would help to ensure that there would be no direct impact to the brook as a result of the proposed development. The Independent Aboriginal Environmental Group made reference to the need to construct a bridge over the brook in the future, though they expressed no major concerns about this. They were, however, concerned about indirect impacts on the brook as a result of drainage and water run-off.

The results of the archaeological investigations were also discussed with the groups. It was explained that six minor artefact scatters and a number of isolated finds had been located in sandy exposures throughout the property and that they were attributed low scientific significance by the archaeologist. It was also pointed out that surface visibility across the survey area was poor due to the thick vegetation and that the potential remained for additional material to remain as-yet unidentified.

The Aboriginal consultants were satisfied with the archaeological report's recommendations that these sites be avoided where possible through inclusion in POS and that Section 18 approval be obtained prior to any impact as a result of the development. All groups requested monitoring of ground preparation works (i.e. vegetation clearance and topsoil stripping) which is consistent with the archaeological report's recommendations (Edwards 2007).

Because Aboriginal sites have been identified on the property, the proponent will be required to seek Ministerial consent to use the land for residential development under Section 18 of the *Aboriginal Heritage Act 1972*. In considering the application, the ACMC may determine that all or none of the known and presently unknown 'sites' on the Nettleton Road property are sites within the meaning of the AHA, or if they are sites, assess them as having a low level of significance under Section 39(2) of the AHA.

The ACMC, in advising the Minister in respect of Section 18 applications, is typically interested in a balance between the preservation, protection and commemoration of heritage values on the one hand, and recommending consent to use the land on the other. The committee is also interested in seeing developers endeavouring to avoid disturbance to sites through planning and community consultation. For further discussion of the Section 18 process, see the appendix.

Recommendations

Based on the outcomes of the ethnographic survey results, the following recommendations are made:

1. That the subdivision and development of Lot 2 Nettleton Road be allowed to proceed;
2. That Aspen Group apply for Ministerial consent to use the land under Section 18 of the *Aboriginal Heritage Act 1972* making reference to the identified archaeological and ethnographic heritage values of the property;

3. That all impacts to Beenyup Brook be avoided where possible through the provision of a buffer zone extending to 30m on either side of the brook and that a Drainage and Nutrient Management Plan be prepared to ensure the brook's long-term protection;
4. That the recommendations made in the archaeological report (Edwards 2007) be followed, in particular that the proponent engage a suitably qualified archaeologist and Aboriginal community representatives to undertake a strategic watching brief of topsoil stripping activities; and
5. That an Aboriginal Heritage Management Plan (AHMP) be prepared to ensure the long-term protection of any Aboriginal heritage sites that are to be preserved within the development.

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Appendix: The Aboriginal Heritage Act 1972

Section 18 of the *Aboriginal Heritage Act 1972* (AHA) provides a mechanism for a landowner or lessee to obtain permission to use the land on which an Aboriginal site is located, as outlined below.

> *Consent to certain uses*
>
> *1) For the purposes of this section, the expression "the owner of any land" includes a lessee from the Crown, and the holder of any mining tenement or mining privilege, or of any right or privilege under the Petroleum Act 1967 , in relation to the land.*
>
> *(1a) A person is also included as an owner of land for the purposes of this section if —*
>
> *(a) the person —*
>
> *(i) is the holder of rights conferred under section 34 of the Dampier to Bunbury Pipeline Act 1997 in respect of the land or is the holder's nominee approved under section 34(3) of that Act; or*
>
> *(ii) has authority under section 7 of the Petroleum Pipelines Act 1969 to enter upon the land;*
>
> *or*
>
> *(b) the person is the holder of a distribution licence under Part 2A of the Energy Coordination Act 1994 as a result of which the person has rights or powers in respect of the land.*
>
> *(2) Where the owner of any land gives to the Committee notice in writing that he requires to use the land for a purpose which, unless the Minister gives his consent under this section, would be likely to result in a breach of section 17 in respect of any Aboriginal site that might be on the land, the Committee shall, as soon as it is reasonably able, form an opinion as to whether there is any Aboriginal site on the land, evaluate the importance and significance of any such site, and submit the notice to the Minister together with its recommendation in writing as to whether or not the Minister should consent to the use of the land for that purpose, and, where applicable, the extent to which and the conditions upon which his consent should be given.*
>
> *(3) Where the Committee submits a notice to the Minister under subsection (2) he shall consider its recommendation and having regard to the general interest of the community shall either —*

(a) consent to the use of the land the subject of the notice, or a specified part of the land, for the purpose required, subject to such conditions, if any, as he may specify; or

(b) wholly decline to consent to the use of the land the subject of the notice for the purpose required,

and shall forthwith inform the owner in writing of his decision.

(4) Where the owner of any land has given to the Committee notice pursuant to subsection (2) and the Committee has not submitted it with its recommendation to the Minister in accordance with that subsection the Minister may require the Committee to do so within a specified time, or may require the Committee to take such other action as the Minister considers necessary in order to expedite the matter, and the Committee shall comply with any such requirement.

(5) Where the owner of any land is aggrieved by a decision of the Minister made under subsection (3) he may, within the time and in the manner prescribed by rules of court, appeal from the decision of the Minister to the Supreme Court which may hear and determine the appeal.

(6) In determining an appeal under subsection (5) the Judge hearing the appeal may confirm or vary the decision of the Minister against which the appeal is made or quash the decision and substitute his own decision which shall have effect as if it were the decision of the Minister, and may make such order as to the costs of the appeal as he sees fit.

(7) Where the owner of any land gives notice to the Committee under subsection (2), the Committee may, if it is satisfied that it is practicable to do so, direct the removal of any object to which this Act applies from the land to a place of safe custody.

(8) Where consent has been given under this section to a person to use any land for a particular purpose nothing done by or on behalf of that person pursuant to, and in accordance with any conditions attached to, the consent constitutes an offence against this Act.

The Committee comprises, among others, an anthropologist and archaeologist and Indigenous Affairs Departmental and Crown Law representatives along with Aboriginal community representatives. In practice, the Committee's work involves consideration of such applications to disturb land on which Aboriginal sites are known to be located, either by development (governed by Section 18 of the Act) or scientific investigation (governed by Section 16 of the Act).

The Committee is required first to determine whether a place referred to in any such application is indeed an Aboriginal site (under Section 5 of the Act), then assess the relative significance of the place if it is considered to be within the ambit of the Act. The legislation is silent, however, on precisely how this significance should be attributed, although a series of guidelines are offered (Section 39[2] and [3]), giving primacy to sites of 'mythological', 'ceremonial and ritual significance'. Dependent upon the degree to which the ACMC believes a site to be of importance, any application can be recommended for consent (i.e. permission is given for disturbance), consent with conditions or refusal.

The listing of conditions on an approval usually mirrors recommendations made by heritage consultants and/or Aboriginal people. Conditions typically listed include further archaeological recording, archaeological monitoring of ground disturbance, the recognition of Aboriginal heritage values through the use of information displays, naming of streets and public open space etc, and/or further consultation.

Any decision made by the Committee is presented to the Minister for Indigenous Affairs in the form of a recommendation and he/she makes the final decision on any matter. Ministerial decisions in general reflect the recommendations of the ACMC except in exceptional circumstances. If aggrieved by Ministerial decisions, a proponent has the right of appeal. Similarly, members of the Aboriginal community have the right to make a common law appeal through the court system.

As a consequence of the Act's drafting, it is only possible for landowners to apply for permission to use land under Section 18 of the Act. However, those who are actually the registered proprietors do not necessarily undertake development. Consequently, there are mechanisms for a limited power of attorney to be provided by landowners to proponents to enable them to act as agents for the purposes of the *Aboriginal Heritage Act* (*1972 as amended*). The "authority to act as an agent" pro-forma, which is the only instrument acceptable to the ACMC, specifically limits the scope of the

agency to the operation of the Act. As a result, landowners are not in danger of assigning any broader rights or responsibilities to proponents.

All Section 18 notices must include a description of the subject land, Aboriginal sites for which permission is sought and a detail of the land use/activities which are likely to disturb the identified sites. Any permission subsequently granted is phrased in similarly specific terms, especially the land use envisaged. Thus, a proponent can only obtain consent to use the land for the purposes they request. Should either the purpose or proponent change, then the permission obtained effectively lapses, as does any agency associated with earlier applications. Thus the landowner's proprietary rights are ensured additional protection.

Because consent given under the Act does not run with the land but with the applicant and is specific to the land use/purpose stated in the application, the agent could/should be a person or body corporate that will either control or have a long-term involvement in the development. Under normal circumstances, Section 18 consent functions as though it was granted in perpetuity. However, there have been cases where a radical change in land use from that outlined in a Section 18 submission has resulted in a need to reapply for Ministerial consent (e.g. residential subdivision to industrial use). In addition, consent is not technically given to disturb or destroy an Aboriginal site. As a consequence, once the Committee defines a place as a site, its legal status is not actually altered by the Ministerial consent to use the land. It is important, therefore, that any application is framed as widely a possible (e.g. residential subdivision, commercial and retail and related infrastructure – services, roads and so on) to ensure that it operates under the widest possible parameters.

In the absence of specific conditions, the Section 18 consent allows a proponent to proceed without further reference to the Act. However, there may be circumstances where further action is necessary. For example, new archaeological material may be discovered, the presence of which could not be determined by standard survey

techniques (such as a subsurface deposit or an Aboriginal burial which would require further attention). However, reports are usually prepared with these contingencies in mind. In others words, a development area is assessed not only on the actual research findings, but also on its potential with regards to burials and subsurface deposits and appropriate recommendations are presented.

Prior to the Committee reviewing an application and supporting documentation, a Departmental officer assesses both and prepares briefing notes. If problems are encountered, they routinely contact the proponent and/or the heritage consultants and seek clarification. The key point with regard to an application for Ministerial consent under Section 18 of the Act is that hundreds of such applications are handled annually and without major problems by the Department of Indigenous Affairs and the Aboriginal Cultural Material Committee.

Bushfire Safety
CONSULTING

Fire Management Plan

Local Structure Plan

Lot 2 Nettleton Road
Byford

Serpentine Jarrahdale Shire
October 18, 2012

Fire Management Plan
Lot 2 Nettleton Road
Byford
Serpentine Jarrahdale Shire

Front Cover Photo: Aerial photograph of development site (source: nearmap.com)

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Table of Contents

Executive Summary

This Fire Management Plan (FMP) has been prepared following the assessment of Lot 2 Nettleton Road, Byford in the Serpentine Jarrahdale Shire.

The development site has been assessed for vegetation class and bushfire hazard rating levels. It has been determined that all proposed buildings will fall within the acceptable level of risk. Existing extreme bushfire hazard will be managed to Hazard Separation Zone (HSZ) standards on the site. Areas of Public Open Space (POS) will be revegetated to comply with the definition of "low threat" vegetation as defined under the Australian Standard AS3959-2009 Construction of buildings in bushfire prone areas.

Most dwellings will be sited greater than 100m from classified vegetation and will not require additional bushfire construction standards. The predicted maximum Bushfire Attack Level (BAL) BAL-12.5 is achieved for the exposed dwellings. All dwellings adjacent to areas of POS within the development will have a 20m minimum Building Protection Zone (BPZ).

This Plan includes a table on page 26 showing responses to the Performance Criteria outlined in the Planning for Bushfire Protection Guidelines - Edition 2 (WAPC et al. 2010).

Access and egress from the development will adequately service residents and emergency service vehicles. Water is adequate for residential needs and for a water supply during fire emergencies by the provision of fire hydrants on public roads.

Both the Serpentine Jarrahdale Shire and Fire and Emergency Services Authority of Western Australia (FESA) have a public education program to raise the community's awareness to its responsibilities regarding preparing homes from a bushfire attack and what to do if an event happens.

If there is a bushfire within or near the site, implementing this Fire Management Plan will reduce the threat to residents and firefighters.

1. Introduction

The site subject to this FMP is Lot 2 Nettleton Road, Byford in the Serpentine Jarrahdale Shire. The FMP has been produced as part of the Local Structure Plan (LSP) submission for the site. The site is 32.288 ha and is located approximately 38 kms south east of Perth. The site is bordered by Nettleton Road to the south, The South Western Highway to the west, Beenyup Road to the north and residential properties to the east (Appendix A).

The site is dissected by Beenyup Brook which is a seasonal drainage line that runs east west through the site. When complete, the site will accommodate over 350 residential lots and seven Public Open Space (POS) areas as outlined in Appendix B. Remnant woodland vegetation will be retained in the conservation area located in the north east corner of the site.

The site is currently zoned “Urban Development” under the Metropolitan Regional Scheme.

As part of the Local Structure Plan submission, this FMP has been produced to assess bushfire hazard and provide mitigation strategies to ensure the development is consistent with current guidelines.

The FMP provides responses to the performance criteria that fulfil the intent of the bushfire hazard management issues outlined in the Planning for Bushfire Protection Guidelines - Edition 2 (WAPC et al. 2010).

Community bushfire safety is a shared responsibility between governments, fire agencies, communities and individuals. The planning and building controls outlined in this Plan, if fully implement, will mitigate the risk to people and property; however, it will not remove the risk. How people interpret the risk, prepare and maintain the property and buildings and what decisions and actions they take (i.e. evacuate early or stay and defend or other) greatly influence the outcome of a bushfire.

1.1 The Proposal

The LSP will guide future development of the site. In order to guide this process a preliminary subdivision concept has been developed (Appendix B).

The proposal includes two residential areas separated by the multiple use corridor along the Beenyup Brook. Over 350 residential lots and seven POS areas are proposed.

1.2 Objectives

The purpose of this FMP is to address bushfire management issues within the proposed development. If there is a bushfire within or near the site, implementing the FMP will reduce the threat to residents and firefighters.

Achievable and measurable goals of this Plan include ensuring:

- The development is located in an area where the bushfire hazard does not present an unreasonable level of risk to life and property
- Vehicular access to the development is safe, if there is a bushfire occurring
- Water is available to the development so that life and property can be defended from bushfire
- The development is sited to minimise the effects of a bushfire, and
- The development design will minimise the effects of a bushfire.

This document sets out the roles and responsibilities of the developer, residents and the Serpentine Jarrahdale Shire. It is important that the measures and procedures outlined in this FMP are reviewed as necessary.

This FMP includes:

- A description of the site, the surrounding area, fire climate and bushfire history
- A summary of research into the related effects of a bushfire
- A bushfire hazard assessment
- Addressing vehicular access
- Siting buildings to include building protection and hazard separation zones
- Water supply, and
- Maps and plans of fire reduction measures.

2. Statutory and Policy Framework

Relevant key legislation, policy and guidelines include the following:

2.1 Bush Fires Act

The Act sets out provision to diminish the dangers resulting from bushfires, prevent, control and extinguish bushfires and for other purposes. The Act addresses various matters including prohibited burning times, enabling Local Government to require land owners/occupiers to plough or clear firebreaks, to control and extinguish bushfires and establish and maintain Bush Fire Brigades.

2.2 State Planning Policy No. 3.4 Natural Hazards and Disasters

The objectives of this Policy are to:

- Include planning for natural disasters as a fundamental element when preparing all statutory and non-statutory planning documents, specifically town planning schemes and amendments, and local planning strategies, and
- Use these planning instruments to minimise the adverse effects of natural disasters on communities, the economy and the environment.

The Policy determines those areas that are most vulnerable to bushfire and where development is appropriate and not appropriate. The provisions and requirements contained in Planning for Bush Fire Protection Guidelines - Edition 2 (WAPC et al. 2010) were used in this determination.

2.3 Planning for Bush Fire Protection Guidelines (2010)

These Guidelines were prepared by FESA, the Western Australian Planning Commission (WAPC) and the Department of Planning. The document is the foundation for fire risk management planning on private land in Western Australia.

The document addresses important fire risk management and planning issues and sets out performance criteria and acceptable solutions to minimise the risk of bushfires in new subdivisions and developments. It addresses management issues including the location, design and siting of the development, vehicular access and water.

3. Bushfire Impacts

Reliable records began in 1900 and since then there have been 729 civilian fatalities from bushfires in Australia, of those 21 (or 3 per cent of the national total) have occurred in Western Australia. Bushfires have killed more people in Australia than any other natural disaster.

3.1 Building Survival

Buildings survive bushfires due to a number of factors; some relate to the way a bushfire behaves at a site, others relate to the design and construction materials in the building and siting of surrounding elements. Infrastructure, utilities and human behaviour are also factors. Leonard (2009) identified the following factors:

- Terrain (slope)
- Vegetation - overall fuel load, steady state litter load, bark fuels, etc.
- Weather (temperature, relative humidity and wind speed)
- Distance of building from unmanaged vegetation
- Individual elements surrounding the building that are either a shield or an additional fuel source
- Proximity to surrounding infrastructure
- Building design and maintenance
- Human behaviour - ability to be present and capacity to fight the fire
- Access to the building and how that influences human behaviour
- Water supply for active and/or passive defence, and
- Power supply.

It is likely that buildings are lost because of their vulnerability to the mechanisms of bushfire attack. Buildings constructed to Australian Standard (AS 3959) are more likely to survive a bushfire compared to buildings with no construction standards; however, building survival is not guaranteed.

3.2 Human Fatalities

The final report from the Victorian Bushfires Royal Commission (VBRC) into the Black Saturday bushfires handed down on 31 July 2010 is the most comprehensive evidence ever assembled about the circumstances surrounding fatalities in an Australian bushfire.

Where people died on Black Saturday contrasts strikingly with studies from previous bushfire fatalities (VBRC 2010). Historically about 32 per cent of people have died in late evacuations (Risk Frontiers et al. 2008); however, on Black Saturday the majority of people (113 out of 173) died inside or close to structures. In a "Black Saturday" type of bushfire, safety can only be assured if people leave early, well before any fire arrives. When the Fire Danger rating is "Catastrophic" most buildings cannot be defended.

Most people die in bushfires from being exposed to radiant heat. Protection is provided by wearing long sleeved natural fibre clothing, having solid barriers and maintaining a long distance between people and the fire (i.e. source of radiant heat).

Bushfires also generate enormous amounts of smoke and wind, and when these factors are combined with the fire, they can cause many trees to come down.
If people do not evacuate early before a fire impacts, road conditions become extremely hazardous. Many fatalities have occurred during late evacuation or fleeing.

4. Description of the Area

Byford is a suburb located 38 kilometers south east of Perth, it was originally founded as the townsite of Beenup in 1906. Recently Byford has seen a rise in the number of residents due to a number of residential estates being developed.

In 2006, the total population of the Shire was estimated at 13,393. It is expected to increase significantly by almost 12,700 people to 26,054 by 2016, at an average annual growth rate of 6.88%. This is based on an increase of more than 4,200 households during the period, with the average number of persons per household remaining relatively stable at about 2.95 (http://www.sjshire.wa.gov.au/about-sj/).

The subject land is bounded by residential development to the north and east and Light industrial to the south. The South Western Highway borders the western perimeter.

4.1 Description of the Subject Land

The site covers 32.288 ha, and is dissected east west by the seasonal Beenyup Brook. The development site will accommodate over 350 residential lots.

This FMP focuses on the subject land and immediate surrounding area (Appendix B).

In summary this land is:

- Undeveloped and generally vegetated in grassland and weeds with remnant woodland in the north east corner and in Beenyup Brook; and
- Gently sloping, downhill from the east to the west in the range of 1-2 degrees.

4.2 Fire Climate

The behaviour of bushfires is significantly affected by weather conditions and they burn more aggressively when high temperatures combine with low humidity and strong winds.

In Perth and surrounding areas, the fire risk is greatest from summer through autumn, when the moisture content in vegetation is low. Summer and autumn days with high temperatures, low humidity and strong winds are particularly conducive to the spread of fire. This threat is enhanced if thunderstorms develop accompanied by lightning and little or no rain.

Research indicates that virtually all house losses occur during severe, extreme or catastrophic conditions (i.e when the Fire Danger Index is over 50) (Blanchi et al. 2010).

The Bureau of Meteorology website (www.bom.gov.au/weather/wa/sevwx/perth/bushfires.shtml) states that extreme fire weather conditions in the Perth region typically occur with strong easterlies or north easterly winds associated with a strong high to the south of the state and a trough offshore. Easterly winds represent about 60 per cent of extreme fire weather days (events) compared to less than 5 per cent associated with southerly winds. About 15 per cent of Perth events occurred in a westerly flow following the passage of a trough.

Very dangerous fire weather conditions often follow a sequence of hot days and easterly winds that culminate when the trough deepens near the coast and moves

inland. Winds can change from easterly to northerly and then to westerly during this sequence of climatic events.

Katabatic winds are common at Byford on summer mornings. These are winds that blow downhill from the Darling Scarp west towards the coast. They can be strong and blow from midnight well into the next morning.

Data from the Bureau of Meteorology weather station at Gosnells (11 km north of the study site) indicate the area experiences warm dry summers and cool wet winters (Figure 1), and is classified as a Mediterranean climate. Mean maximum temperatures vary from 32 degrees Celsius in February to 19 degrees Celsius in July.

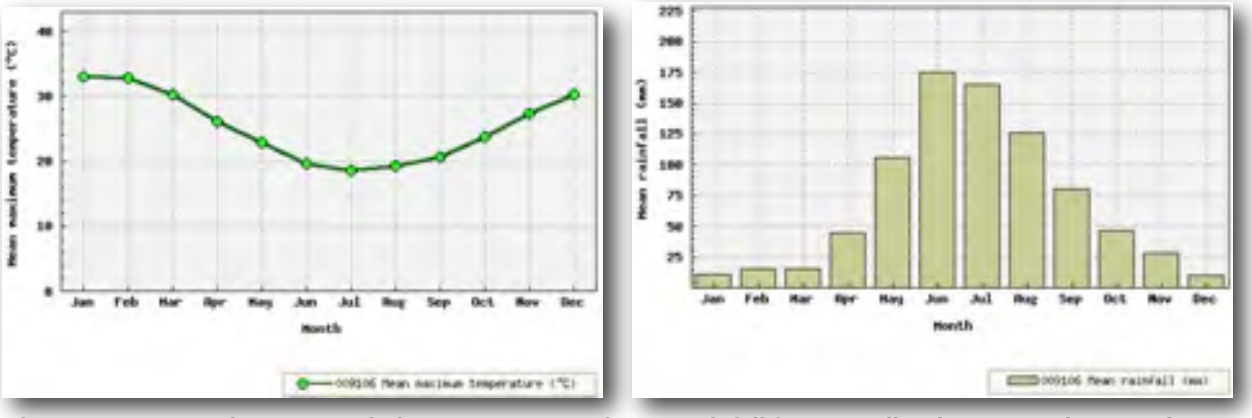

Figure 1: Mean maximum recorded temperatures and mean rainfall for Gosnells City Meteorology Station between 1993 and 2010

The site is 22 kms from the coast and is significantly influenced by land and sea breezes. These are created by the daily heating and cooling of the land surface next to the ocean. The sea breeze occurs when the air over the land heats up and becomes more buoyant and rises, denser moist air over the ocean then flows inland. Sea breezes can strengthen prevailing wind, reduce it or even reverse it, depending on the strength and direction of the two airstreams (Cheney and Sullivan 2008).

Data from the Bureau of Meteorology Meteorology Station at Gosnells indicate that the predominant winds in the summer months at 3 pm near the study site are westerlies, south-westerlies and southerlies (Figure 2). In terms of wind strength, direction and frequency, these wind directions occur 60 - 70% of the time. Winds from the east and south east occur 10-20% of the time.

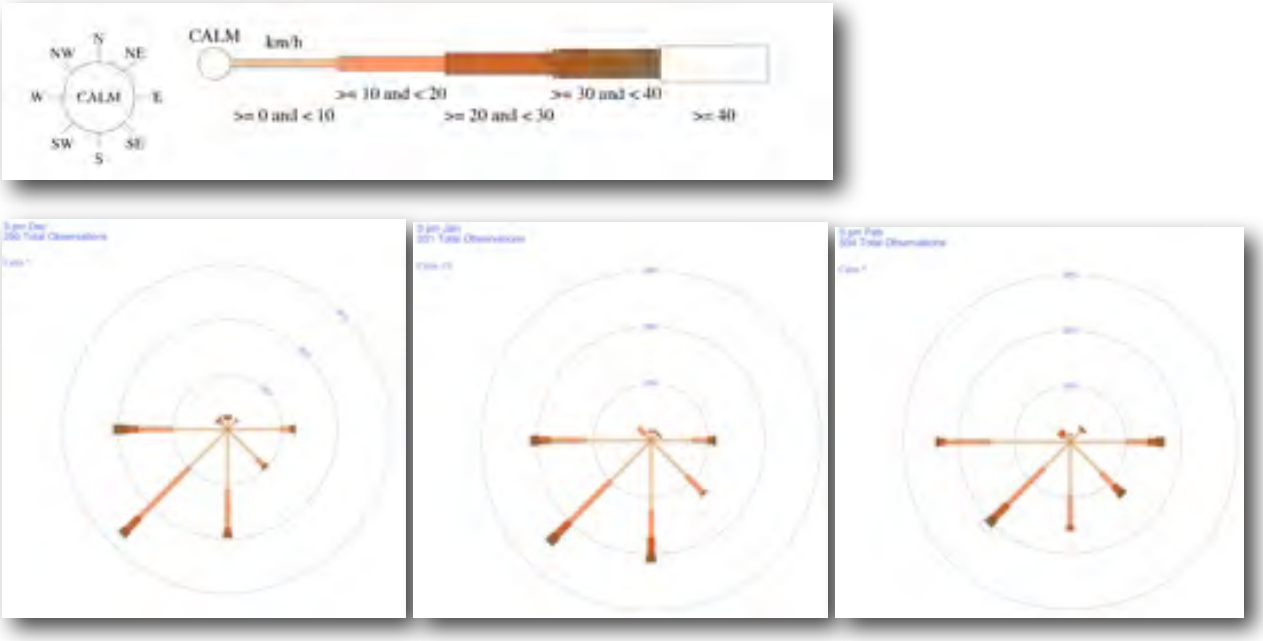

Figure 2: Rose of wind direction and wind speed in km/hr for December, January and February between 1983 and 2010 at the Gosnells Bureau of Meteorology Station

Interpreting Figure 2 - Wind speed Vs Direction Plot

Wind roses summarise the occurrence of winds at a location, showing their strength, direction and frequency. The percentage of calm conditions is represented by the size of the centre circle - the bigger the circle, the higher is the frequency of calm conditions. Each branch of the rose represents wind coming from that direction, with north to the top of the diagram. Eight directions are used. The branches are divided into segments of different thickness and colour, which represent wind speed ranges in that direction. Speed ranges of 10 km/hr are used. The length of each segment within a branch is proportional to the frequency of winds blowing within corresponding range of speeds from that direction (BOM 2010).

4.3 Bushfire Fuels

The study site is vegetated predominantly in grass fuels and weed fuels. The Beenyup Brook drainage line is heavily weed infested under an open woodland canopy. Remnant woodland is concentrated in the north east corner of the site. The condition varies from degraded (where fuel structure layers are missing) to good (where shrub fuel layers are intact).

Bushfire fuels will be significantly reduced on the site when development infrastructure, building envelopes and landscaped areas are established and managed.

4.4 Assets

When the site is fully developed it will contain over 350 residential lots. Most will be located greater than 100 m from classified vegetation. Dwellings located within 100 m of residual bushfire hazard and classified vegetation will be most at risk of bushfire attack such as radiant heat, flames and embers.

4.5 Access

The subdivision will be serviced by many loop and perimeter roads. Overall there will be four access points to surrounding public roads. Beenyup Brook dissects the development into two distinct areas.

4.6 Water Supply

Reticulated water is provided to the entire development. Fire hydrants will be sited at maximum 200 m intervals throughout the estate.

4.7 Bushfire History

A recent study has concluded that bushfires may have been in the Australian Landscape for 50 million years longer than previously thought. The adaption of eucalypts that allows them to recover from bushfires has been traced back more than 60 million years (Crisp et al. 2011), indicating fire has been in the Australian landscape since that time.

Like many other Eucalypt ecosystems, Jarrah and Marri Forests have had a long association with fire and the arrival of Aboriginal people led to the dramatic changes in fire regimes and patterns in the landscape. Abbott (2003) proposes that in forested areas of south-west Western Australia, Aboriginal people lit fires, principally in summer, which could be large and burn up to hundreds of hectares at 3–5 year intervals, although this would have varied depending on the vegetation and climate.

Jarrah and Marri forests which dominate the nearby Darling Range Regional Park and Bungendore Park have had a long association with fire and are believed to have been frequently burnt by the Aborigines prior to European settlement. There is research data from the colour banding on Xanthorrhoea spp. stems (Ward et al. 2001) and E. marginata stem fire scars (Burrows et al. 1995) that suggests frequent burning (ie. at 3 to 5 year intervals) characterised the fire regime prior to European settlement in

Jarrah (E. marginata) forests of southwestern Australia. Where populations of Aborigines were relatively large, such as in coastal areas of south-western Australia, the collective evidence suggests that burning was conducted at near maximal frequencies in some parts of the landscape (Hassell and Dodson 2003). Consequently, due to limited fuel accumulation periods, many of the fires lit by the Aborigines would have been of low to moderate intensity and relatively small in extent (Burrows et al. 1995, Abbott 2003). A fine-scale mosaic comprising a complex of burn histories, from recently burnt to even long unburnt, was the likely result of this fire regime (Bowman 2003).

In 1994 a large bushfire burn't 85% of nearby Bungendore Park and there have been smaller bushfires in 2003, 2004, 2006 and 2007. Forests and woodlands surrounded by urban areas are also particularly susceptible to frequent bushfires due to the high risk of arson and great potential for accidental ignitions (Walker 1981, Burrows and Abbott 2003).

5. Bushfire Hazard Assessment

Assessing bushfire hazards at a strategic level takes into account the predominant class of vegetation on the site and surrounding area for a minimum of 100 m. The vegetation class map for the site and surrounding area for a minimum of 100 m is shown in Appendix C. Fuel layers in a typical forest environment can be broken down into five obvious segments (Figure 3). These defined fuel layers are used in the following descriptions regarding vegetation types, fuel structure and bushfire hazard levels.

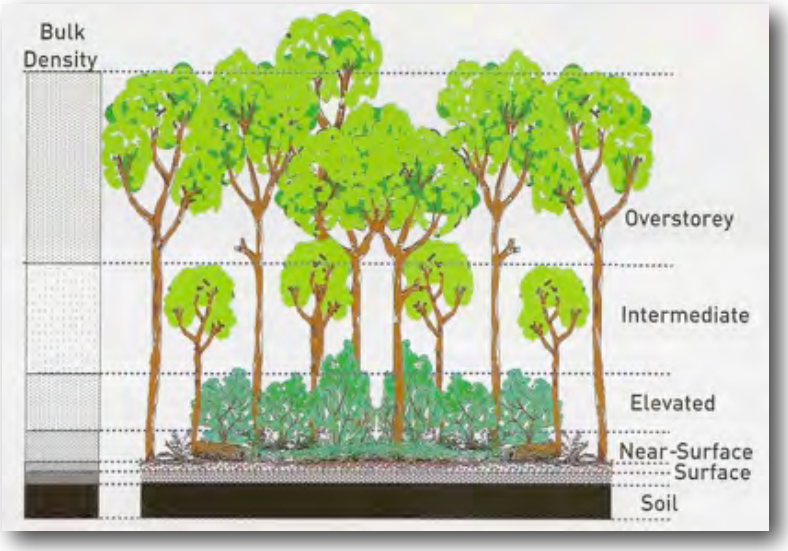

Figure 3 : The five obvious fuel layers in a forest environment that could be associated with fire behaviour (Gould et al. 2007)

5.1 Vegetation Type and Class

The site assessment undertaken for this study identified three distinct vegetation classes (and one revegetation area) as identified and mapped in Appendix C. The site is 60 per cent covered in a pasture grasses and weeds which form a near surface fuel layer 0 - 1 m in height. The grass fuels over the most of the site are usually less than 200 mm high (Figure 4) , however in the south west corner a weed infestation has created fuels up to 1 m in height (Figure 5).

Woodland vegetation is concentrated in the north east corner of the site and in a strip of vegetation in the drainage line (Beenyup Brook). A flora and vegetation survey undertaken by ENV. Australia Pty Ltd in 2007 identified 2 distinct woodland vegetation types. Occupying 8.9ha in the north east portion of the site, the woodland consists predominantly of Marri (*Corymbia callophylla*) and some Jarrah (*Eucalyptus marginata*) over an open shrub elevated layer and near surface grass/weeds. The woodland fuel structure is degraded where the elevated fuel layer is missing (Figure 6). In the far north east corner, an open shrubland layer is present and occupies the elevated fuel component up to a height of 0.7 m (Figure 7). The vegetation condition is rated as degraded or good depending on how intact the understorey vegetation is (ENV. Australia 2007).

The woodland in the riparian zone of Beenyup Brook is infested with weeds in near surface and elevated layer including Watsonia sp. and Arum Lily's (Figure 8). It is all rated as degraded condition (ENV. Australia 2007). A strip of open forest vegetation is located west of the South Western Highway between the highway and railway line. Canopy height is 12-15m and there is a significant elevated scrub fuel layer (Figure 9).

A revegetation area has been planted with Eucalyptus species adjacent to the South Western Highway, in its current condition is classified as grassland (Figure 10).

Figures 4 and 5: Low grassy weed fuel layer (left) and an infestation of weeds creating an elevated shrublike fuel layer (right)

Figures 6 and 7: Degraded Marri / Jarrah woodland with grass near surface fuels and without an elevated fuel layer (left) and a more intact fuel structure under the woodland with a native open shrubland layer (right)

Figures 8 and 9: Degraded woodland vegetation in Beenyup Brook (left) the strip of open forest vegetation with elevated scrub fuels and grass/weed near surface fuels layer located west of the South Western Highway (right)

Figures 10: Area under revegetation adjacent to the South Western Highway

5.2 Slope

The site slopes gently (i.e. in the range 1-2 degrees) from the east downslope to the west. Some short steep slopes exist into the Beenyup Brook drainage line with maximum changes in elevation only in the range of 2-3 metres. Contour lines with intervals of 1 m can be seen in the overall concept design (Appendix B).

5.3 The Bushfire Hazard Assessment Level - Pre development

The vegetation class map (Appendix C) outlines the dominant vegetation types on the study site and surrounding area for a minimum of 100 m. Descriptions of the vegetation class structure and dominant species are outlined in section 5.1 Vegetation Type and Class. The bushfire hazard assessment levels were determined using Appendix 1 of the Planning for Bushfire Protection Guidelines - Edition 2 (WAPC et al. 2010).

The study site has a bushfire hazard rating of moderate and extreme due to the extent of unmanaged grass and weed fuels and woodland vegetation. Low bushfire hazard occurs in many surrounding areas areas due to residential properties and road infrastructure.

The bushfire hazard rating map for the site and surrounding area as it currently exists is shown in Appendix D.

5.4 The Bushfire Hazard Assessment Level - Post development

As the site is developed with roads, infrastructure, dwellings and landscaped parks and gardens, native and unmanaged vegetation will be removed and managed within the site. This will result in a reduction in the quantity of bushfire hazard on the site.

Long-term hazard will remain in the conservation area in the north east corner and in adjoining land in the Beenyup Brook to the east and south west of South Western Highway. Long bushfire runs are possible from the corridors of vegetation from the south of the site, west of the South Western Highway and possibly within the Beenyup Brook corridor to the east. A bushfire in the conservation area is unable to run a great distance and generate increased intensity before impacting on the development due to it being quite a small area and isolated from other bushfire hazards.

The remnant woodland in the Conservation Area is proposed to be fuel managed to HSZ standards. The bushfire hazard rating map for the site and surrounding area after the site is fully developed is shown in Appendix E.

6. Fire Mitigation Strategies

This report adopts an acceptable solution and performance-based system of control for each bushfire hazard management issue. It is consistent with Appendix 2 of the Planning for Bushfire Protection Guidelines - Edition 2 (WAPC et al. 2010). The management issues are:

- Location of the development
- Vehicular Access
- Water
- Siting of the development, and
- Design of the development.

Acceptable solutions are provided for four out of the five management issues and each illustrates one example of satisfactorily meeting the corresponding performance criteria. A performance-based approach is provided for one management issue.

6.1 Element: Location of the Development

Intent

To ensure that development/intensification of land use is located in areas where bush fire hazard does not present an unreasonable level of risk to life and property.

Acceptable Solution

Bushfire hazard levels are rated as moderate and extreme on the development site due to vegetation being either unmanaged grasslands or weeds and woodland. Low bushfire hazard occurs surrounding the site in residential and light industrial areas.

The predicted maximum Bushfire Attack Level (BAL) is BAL-12.5 and this will only occur where dwellings are sited within 100 m of classified vegetation.

A HSZ reduces fire intensity on dwellings due to the management of fuel loads. The developer will establish low fuel litter levels by fuel reduction burning the remnant woodland prior to the development commencing in consultation with the Serpentine Jarrahdale Shire and local Bush Fire Brigades. Construction standards will be increased to align with the appropriate BAL to mitigate predicted impacts from the classified vegetation external to the site.

Significant landscaping and revegetation is to occur on this site in road reserves and areas of POS. This plan outlines minimum standards to ensure unnecessary fuels loads and hazards are not created which would increase bushfire risk levels to peoples lives and property.

The site will be provided with an adequate water supply and access to fight fires and all exposed dwellings should be constructed to AS 3959 standards.

6.2 Element: Vehicular Access

Intent

To ensure vehicular access serving a subdivision development is safe if a bushfire occurs.

Background

The development site is located adjacent to a residential area to the east and north, a light industrial area to the south and residential and retail development to the west. The site is situated within a network of surrounding public roads in a low bushfire hazard environment.

The road network with the site is outlined in Appendix F.

This proposal complies with the performance criteria by applying the following acceptable solutions:

Acceptable Solution A2.1: Two Access Routes

There are two public road access routes onto Beenyup Road north of the site and two access roads linking into Nettleton Road. All lots within the subdivision have direct public road frontage and the internal design includes many loop roads. This subdivision design complies with the requirements for two access routes.

Acceptable Solution A2.2: Public Roads

All public roads within the development must comply with the following standards:

- Minimum trafficable surface: 6 m
- Horizontal clearance: 6 m
- Vertical clearance: 4 m
- Maximum grades: 1 in 8
- Maximum grades over 50 m: 1 in 5
- Maximum average grade: 1 in 7
- Minimum weight capacity: 15 tonnes
- Maximum crossfall: 1 in 33
- Minimum inner radius of curves: 12 m

Acceptable Solution A2.3: Cul-de-sacs (including dead end roads)

One short (45 m long) dead end road is proposed. Where it intersects with the public road a fire appliance can turn around safely. One 75 m cul-de-sac is also proposed which will have a compliant turn-around installed. The following standards apply:

- Maximum length: 200 m, but can be extended to 600 m if less than eight lots are serviced and if alternative emergency access is provided
- Minimum trafficable surface: 6 m
- Horizontal clearance: 6 m
- Maximum grades: 1 in 8
- Maximum grades over 50 m: 1 in 5
- Maximum average grade: 1 in 7
- Minimum weight capacity: 15 tonnes
- Maximum crossfall: 1 in 33
- Minimum inside radius of curves: 12 m
- Turn around area requirements: (see Appendix F)

Acceptable Solutions A2.8 : Gates

Gates are required at each end of the two proposed trafficable firebreaks. The gates must meet the following requirements:

- Minimum width : 3.6 metres
- Design and Construction : to be approved by the Serpentine Jarrahdale Shire
- May be locked, but only with a common key that is available to local fire service personnel

Acceptable Solutions A2.9 : Firebreak Widths

A trafficable firebreak currently exists exists on the east boundary of the woodland area. It requires minimal works to comply with the Serpentine Jarrahdale Shire Fire Break Notice and Fuel Hazard Reduction Notice. This firebreak requires upgrading and maintenance to comply as a trafficable firebreak. A trafficable surface and gate needs to be installed at both ends of the firebreak to link into the public road and the emergency access easement.

A new trafficable firebreak is to be installed on the east side of POS / Drainage 6 and is to link the public road with the emergency access easement that connects with Waterside Pass.

All vehicular access details are outlined in Appendix F. Firebreaks must be designed, constructed and maintained to Serpentine Jarrahdale Shire standards which includes :

- Three metres width and located as close as possible to the lot boundary
- to have a clear vertical access over them; and
- No new tree is to be planted within 6 metres of the centre of the firebreak.

6.3 Element: Water

Intent

To ensure water is available to the development to enable life and property to be defended from bushfire.

Acceptable Solution

The development is provided with a reticulated water supply, together with fire hydrants, that meet the specifications of the Water Corporation and FESA.

Residential dwellings (Class 1a) require fire hydrants to be sited within (or every) 200 m in land zoned residential.

Fire services require ready access to an adequate water supply during fire emergencies.

6.4 Element: Siting of the Development

Intent

To ensure the siting of the development minimises the level of bushfire impact.

Acceptable Solution: Building Protection Zone (BPZ)

One of the most important fire protection measures influencing the safety of people and property is to create a BPZ around buildings. The building protection zone is a low fuel area immediately surrounding a building. Non-flammable features such as driveways, roads, road reserves, footpaths, lawn or landscaped gardens (including deciduous trees) can form parts of a BPZ.

World first research into land management and house loss during the Black Saturday Victorian bushfires concluded that the action of private landholders, who managed fuel loads close to their houses, was the single most important factor to determine house survival when compared with other land management practices, such as broad scale fuel reduction burning remote from residential areas (Gibbons et al. 2012).

Creating a BPZ will ensure vegetation and fuels, within close-proximity to dwellings, are managed to reduce predicted radiant heat flux levels and improve the survival of buildings.

Managing vegetation in the BPZ has two main purposes:

- To reduce direct flame contact and radiant heat from igniting the building during the passage of a fire front, and
- To reduce ember attack and provide a safer space for people to defend (if required) before, during and after a fire front.

A permanent BPZ will be established between dwellings and vegetation in areas of POS. This zone will include perimeter road reserves and in some areas a strip of vegetation in the POS adjacent to the road reserve. The BPZ is outlined in Appendices G, H and I.

External to the site, the South Western Highway will provide a setback of 45 m between open forest vegetation and proposed dwellings located in the south west corner of the development. The four lane highway provides a permanent BPZ in this context.

The BPZ must be established and maintained to the following standards:

- Width: 20 m minimum from the walls of all dwellings as outlined in Appendices G, H and I
- Fuel load: reduced to and maintained at 2 tonnes per hectare
- All tree crowns are a minimum of 10 m apart
- All trees to have lower branches pruned to a height of 2 m
- All tall shrubs or trees are not to be located within 2 m of a building (including windows)
- No tree crowns or foliage is to be within 2 m of any building, this includes existing trees and shrubs and new plantings
- All fences and sheds are constructed with non-combustible materials (i.e. colorbond, brick or limestone)
- All shrubs to contain no dead material within the plant
- No tall shrubs are to be in clumps within 3 m of the building
- No trees are to contain dead material in the crown or on the bole.

By achieving these standards, it will be possible to construct dwellings to a compliant standard (i.e. BAL-29 or less) under the Australian Standard (AS 3959-2009) Construction of buildings in bushfire-prone areas.

Acceptable Solution: Hazard Separation Zone (HSZ)

A Hazard Separation Zone (HSZ) is an additional fuel managed zone to create further separation between buildings and bushfire hazard. It can extend out to 100 m from buildings. In this development proposal, the HSZ will occupy the entire Woodland conservation area in the north east corner of the site (Appendix I). The HSZ will meet the following standards :

- Dimensions: as outlined in Appendix I.
- Location: within the boundary of the Conservation Area
- Fuel load: maintained at between 5 and 8 tonnes per hectare
- Tree crowns: minimum of 10 metres apart
- Trees have no dead material within the plant's crown or on the bole

This will be achieved by the developer arranging a fuel reduction burn by the local brigade to establish low fuel litter levels. This fuel reduction burning regime will then require on-going management and a burning rotation of between 8 - 10 years depending on fuel accumulation rates. This management practice will offer benefits to existing residences outside of the development which immediately adjoin the woodland area and will lower all surrounding residents predicted radiant heat and ember attack exposure.

Trees in the woodland area do not strictly have 10 m separation between between canopies as some trees occur in clumps or groupings. In the context of the isolated site and relatively small size, this is not considered as crucial as managed low fuel litter levels will in most cases reduce the ability of a canopy fire to take hold. In many areas of the woodland, canopy foliage is separated by gaps greater than 20 m.

6.4.1 Landscaping and Revegetating POS Areas to "Low Threat" standards

Landscaping and revegetation can both assist in the survival of a dwelling and be a determining measure in its destruction. Areas of POS to be landscaped and revegetated provide an opportunity to create a low bushfire threat environment. This is an objective in the POS areas and provides obvious benefits to all surrounding residents and fire fighters. "Low Threat" vegetation is defined under the Australian Standard (AS3959-2009 - Construction of buildings in bushfire-prone areas) is one or a combination of any of the following:

- Vegetation of any type that is more than 100 m from the site
- Single areas of vegetation less than 1 ha in area and now within 100m of other areas of vegetation being classified
- Multiple areas of vegetation less than 0.25 ha in area and not within 20 m of the site, or each other; and
- Strips of vegetation less than 20 m in width (measured perpendicular to the elevation exposed to the strip of vegetation) regardless of length and not within 20 m of the site or each other, or other areas of vegetation being classified.

Landscaping can protect buildings by forming a barrier or deflector for wind borne debris and radiant heat. It can also bring the fire directly to the building so a degree of care needs to be exercised when selecting and locating plants and landscaping.

All plants will burn under the right conditions and plants do not achieve a "fire resistance level" to meet the Building Code of Australia (BCA). The FESA document titled "Plant Guide within the Building Protection Zone" provides a useful list of species and spacing requirements to achieve compliance with vegetation within a

building protection zone in the Swan Coastal Plain. It can be downloaded at http://www.fesa.wa.gov.au/safetyinformation/fire/bushfire/BushfireProtectionPlanningPublications/FESA%20Plant%20Guide-BP%20Zone-Final-w.pdf. It will provide guidance for appropriate revegetation of POS areas.

Work from Ramsay and Rudolf (2003) has identified 14 major plant attributes that assist people to determine suitable plant species for gardens surrounding buildings (i.e. in the building protection zone). This is a useful reference book for residents to plan their garden design and select suitable plant species.

This fuel management and revegetation strategy (i.e designed to "low threat" standards) in areas of POS will significantly reduce the number of exposed dwellings in the development. Classified vegetation external to the site is limited to two distinct areas including the corridor of vegetation in Beenyup Brook east of the site and the open forest area west of the South Western Highway.

Concerning these areas of predicted bushfire attack, it will be possible to construct buildings to an appropriate standard (i.e. BAL-12.5) under the Australian Standard (AS 3959-2009) Construction of buildings in bushfire-prone areas.

The following Bushfire Attack Level (BAL) assessment demonstrates that proposed dwellings are exposed to acceptable levels of risk.

6.4.2 Building Siting and Predicted Bushfire Attack Levels

The following Bushfire Attack Level (BAL) assessment demonstrates that the fuel management surrounding dwellings achieves acceptable levels of risk.

The AS 3959-2009 has six categories of BAL, namely BAL-LOW, BAL-12.5, BAL-19, BAL-29, BAL-40 and BAL-FZ. These categories are based on heat flux exposure thresholds.

The method for determining the BAL involves a site assessment of vegetation and local topography. The assumed Fire Danger Index (FDI) for Western Australia is 80. The BAL identifies the appropriate construction standard that applies as a minimum standard in Construction of buildings in bushfire-prone areas (AS 3959-2009).

Methodology and Assumptions

The following BAL examples were determined using the methodology in Appendix A of AS 3959-2009. This methodology is also outlined in the Planning for Bush Fire Protection Guidelines. Example BAL assessments were undertaken in two

representative locations adjacent to bushfire hazard (Appendices J & K). The results of these assessments are shown in Table 1.

The criteria to determine the BAL is outlined as follows:

Designated FDI : 80
Flame Temperature : 1090
Slope : Downslope 2-3 degrees (See Table 1)
Vegetation Class : Woodland and Open Forest
Setback distances : 45 m and 77 m (See Table 1)

Appendix	Number of Lots impacted	Setback Distance (m)	Classified Vegetation	Effective Slope (degrees)	BAL Rating
J	9	45	Open Forest	Downslope 2	BAL-12.5
K	3	77	Woodland	Downslope 3	BAL-12.5

Table 1: Bushfire Attack Level (BAL) Assessment for six example dwellings (See Appendix J & K for site details)

A dwelling with 45 m setback and adjacent to open forest vegetation with an effective downslope of 2 degrees results in a BAL-12.5 rating. A dwelling with 77 m setback from woodland with an effective slope of downslope 3 degrees also results in a BAL-12.5 rating (Table 1).

Nine lots are predicted to be impacted with a BAL-12.5 rating in the south west corner of the site. Three lots are predicted to be impacted with a BAL-12.5 rating in the south east corner of the site.

A Bushfire Attack Level of BAL-12.5 means the risk is considered to be low. The construction elements are expected to be exposed to a radiant heat flux not greater than 12.5kW/m^2.

There is a risk of ember attack and burning debris ignited by wind borne embers and a likelihood of exposure to radiant heat (Standards Australia 2009). The recommended construction sections are 3 and 5 in AS 3959-2009.

This example assessment demonstrates that all proposed buildings will fall within the acceptable level of risk (i.e. BAL-29 and lower) and will have construction standards increased to meet AS 3959 requirements. All identified lots require a BAL assessment at building licence application stage to confirm exposure and construction standard.

6.5 Design of the Development

Performance Criteria

The design of the development is appropriate to the level of bushfire hazard that applies to the site.

Acceptable Solution

All on site development is to comply with the performance criteria or acceptable solutions 1-4 in “Planning for Bushfire Protection” Guidelines. The buildings are to comply with AS 3959-2009 Construction of buildings in bushfire-prone areas and the Serpentine Jarrahdale Shire has the responsibility to ensure dwellings meet this standard.

The predicted highest BAL level for any dwelling is BAL-12.5 which will be mitigated by compliance with the Australian Standard AS3959.

6.6 Public Education and Community Awareness

Community bushfire safety is a shared responsibility between individuals, the community, government and fire agencies. FESA has an extensive Community Bushfire Education Program including a range of publications, a website and Bushfire Ready Groups. The 30 page booklet Prepare, Act, Survive provides excellent advice on preparing for and surviving the bushfire season. Other downloadable brochures include ‘Fire Danger Ratings and what they mean for you’ and ‘Bushfire Warnings and what you should do’.

The Serpentine Jarrahdale Shire, their website and local bushfire brigades provide bushfire safety advise to residents. The website provides extension information and links to other sites related to Fire Danger Ratings and the FESA website. Research into the devastating bushfires on the Eyre Peninsula in South Australia confirmed residents were much more likely to make good decisions if they were current or past members of the local bushfire brigade. Invaluable experience can be gained by being a member of the local bushfire brigade. Professional consultants also offer bushfire safety advise and relevant services to residents.

6.7 Community Fire Refuges and Fire Safer Areas

There are no designated Community Fire Refuges in the Serpentine Jarrahdale Shire. However, at the time of an emergency, the relevant authorities can select an evacuation centre and FESA, the City and Police will provide this information to residents.

A predetermined centre cannot be nominated because there are no purpose built structures (such as bunkers) designed to withstand the impacts of a bushfire. This means the location of an evacuation centre is not determined until the position of the fire and the characteristics of a specific event are considered by authorities. There would be nothing more dangerous than sending residents to a centre which is in the direct path of a fire.

The safest place to be during a bushfire is away from it. Where to go is an important element when people are relocating during a time of emergency (NSW Rural Fire Service 2004). The preferred option for residents is to designate a destination that is not in a bushfire-prone area and will be safe to travel to before a bushfire attack.

Those who find themselves threatened by a bushfire need options (VBRC 2009). This may be because their plan to leave is no longer possible because they cannot reach a place away from the fire front, or their plan to defend their property fails. Residents may also be caught away from their home when a bushfire threatens.

The concept of a “Neighbourhood Safer Place” and Neighbourhood Safer Precincts” has arisen from recommendations by the Victorian Bushfire Royal Commission into the Black Saturday bushfires.

There are many areas within the Serpentine Jarrahdale Shire that are not bushfire-prone, but they have not been declared. Obviously a non-bushfire-prone area can provide a safe location for people during a bushfire, but there is no official criteria in Western Australia to determine these areas. As there is no specific criteria to guide this process, FESA’s general advice is for residents, when their household bushfire survival plans have failed, is to go to a safer place such as a local open space or building where people may go to seek shelter from a bushfire (FESA 2010).

7. Conclusion

This Plan provides acceptable solutions and responses to the performance criteria that fulfil the intent of the bushfire hazard management issues outlined in Planning for Bushfire Protection Guidelines - Edition 2 (WAPC et al. 2010). However, community bushfire safety is a shared responsibility between governments, fire agencies, communities and individuals.

The planning and building controls outlined in this Plan will reduce the risk of bushfire to people and property, it will not remove all risk. How people interpret the risk, prepare and maintain their properties and buildings and what decisions and actions they take (i.e. evacuate early or stay and defend or other) greatly influence their personal safety. Residents need to be self reliant, and not expect warnings or assistance from emergency services.

7.1 Compliance Checklist for Performance Criteria and Acceptable Solutions

Element	Question	Answer
1: Location	Does the proposal comply with the performance criteria by applying acceptable solution A1.1?	Yes
2: Vehicular access	Does the proposal comply with the performance criteria by applying acceptable solution A2.1?	Yes

Element	Question	Answer
2: Vehicular access	Does the proposal comply with the performance criteria by applying acceptable solution A2.2?	Yes
	Does the proposal comply with the performance criteria by applying acceptable solution A2.3?	Yes
	Does the proposal comply with the performance criteria by applying acceptable solution A2.4?	N/A
	Does the proposal comply with the performance criteria by applying acceptable solution A2.5?	N/A
	Does the proposal comply with the performance criteria by applying acceptable solution A2.6?	Yes
	Does the proposal comply with the performance criteria by applying acceptable solution A2.7?	N/A
	Does the proposal comply with the performance criteria by applying acceptable solution A2.8?	Yes
	Does the proposal comply with the performance criteria by applying acceptable solution A2.9?	Yes
	Does the proposal comply with the performance criteria by applying acceptable solution A2.10?	N/A
3: Water	Does the proposal comply with the performance criteria by applying acceptable solution A3.1?	Yes
	Does the proposal comply with the performance criteria by applying acceptable solution A3.2?	N/A
	Does the proposal comply with the performance criteria by applying acceptable solution A3.3?	N/A

Element	Question	Answer
4: Siting of the Development	Does the proposal comply with the performance criteria by applying acceptable solution A4.1?	Yes - Construction standards are increased to align with site bushfire attack level.
	Does the proposal comply with the performance criteria by applying acceptable solution A4.2?	Yes
	Does the proposal comply with the performance criteria by applying acceptable solution A4.3?	Yes
	Does the proposal comply with the performance criteria by applying acceptable solution A4.4?	No - However the proposal does satisfactorily comply with performance criterion P4 because building construction standards are to be increased to comply with AS 3959-2009 to offset the fact vegetation external to the site cannot accommodate a HSZ. Construction standards will achieve a maximum of BAL-12.5.
	Does the proposal comply with the performance criteria by applying acceptable solution A4.5?	N/A - Shielding not applicable.
5: Design of the Development	Does the proposal comply with the performance criteria by applying acceptable solution A5.1?	No - However the proposal does comply with the performance criterion P5 because building construction standards will be increased to comply with AS 3959-2009 to offset the requirement for a complete 80 m HSZ. BAL-29 is not exceeded.
	Does the proposal comply with the performance criteria by applying acceptable solution A5.2?	Yes - The proposal complies as the development will meet the performance criteria because of compliance with AS 3959 and BAL-29 is not exceeded.

8. Implementing the Fire Management Plan

8.1 Developer's Responsibilities

To maintain a reduced level of risk from bushfire, the developer's responsibilities are to:

- Install all public roads, firebreaks and gates to standards outlined in Element 6.2 Vehicular Access
- Establish and Maintain Building Protection, Hazard Separation Zones and "Low Threat" by revegetating areas of POS according to standards outlined in Section 6.4
- Fuel reduce burn the area of Woodland designated a Conservation Area (POS / Drainage 7) to establish HSZ standards
- Installation of reticulated water supply (including hydrants) to be provided to the satisfaction of the Water Corporation, the Fire and Emergency Services Authority and the Serpentine Jarrahdale Shire.
- All purchasers/new property owners are to be advised of the location of any hydrant that is positioned on their Lot or verge and the requirement for the hydrant to remain unobstructed at all times;
- Developer is to notify any landscaping contractor's, under direction of the developer, of relevant hydrant locations and the requirement to ensure the hydrant is not obstructed, covered over or damaged;
- Lodge a Section 70A Notification on each Certificate of Title exposed to AS 3959 construction standards, proposed by this subdivision. The notification shall alert purchasers and successors in title, to these exposed lots, of the responsibilities of the Fire Management Plan and bush fire building construction requirements
- Comply with the Serpentine Jarrahdale Shire Firebreak Notice and Fuel Hazard Reduction Notice as published, on all vacant land, and
- Supply a copy of this Fire Management Plan and The Homeowners Bush Fire Survival Manual, Prepare, Act, Survive (or similar suitable documentation) to each lot owner subject to AS 3959 construction standards.

8.2 Property Owners' Responsibilities

The owners/occupiers of the site, as created by this proposal, are to maintain a reduced level of risk from bushfire, and will be responsible for undertaking, complying and implementing measures to protect their own assets (and people under their care) from the threat and risk of bushfire. The owners' will be responsible for:

- Complying with the Serpentine Jarrahdale Shire's annual Firebreak Notice and Fuel Hazard Reduction Notice
- Maintain the property in good order to minimize potential bushfire fuels to mitigate the risk of fire on the property;
- Ensuring that vacant lots comply with the Serpentine Jarrahdale Shire Firebreak Notice and Fuel Hazard Reduction Notice Ensuring construction of dwellings complies with AS 3959, and
- As part of the building license application, the property owner of lots identified in this plan shall have the proposed dwelling re-assessed for Bushfire Attack Level (at the time of construction) with results to be submitted as part of the building licence application.

8.3 Serpentine Jarrahdale Shire Responsibilities

The responsibility for compliance with the law rests with individual property owners and occupiers and the following conditions are not intended to unnecessarily transfer some of the responsibilities to the Serpentine Jarrahdale Shire.

The Serpentine Jarrahdale Shire shall be responsible for:

- Providing fire prevention and preparedness advice to landowners upon request
- Maintain HSZ fuel litter levels in the Conservation Area (POS 7)
- Monitoring bush fuel loads in all areas of public open space, road reserve sites and liaising with relevant stakeholders to maintain fuel loads at safe levels
- Maintaining public roads and firebreaks on POS to appropriate standards and ensuring compliance with the Serpentine Jarrahdale Shire's Firebreak Notice and Fuel Hazard Reduction Notice
- Ensuring dwellings are constructed to AS 3959 where applicable, and
- Endorsing a section 70A notification on each title affected by this Fire Management Plan.

9. References

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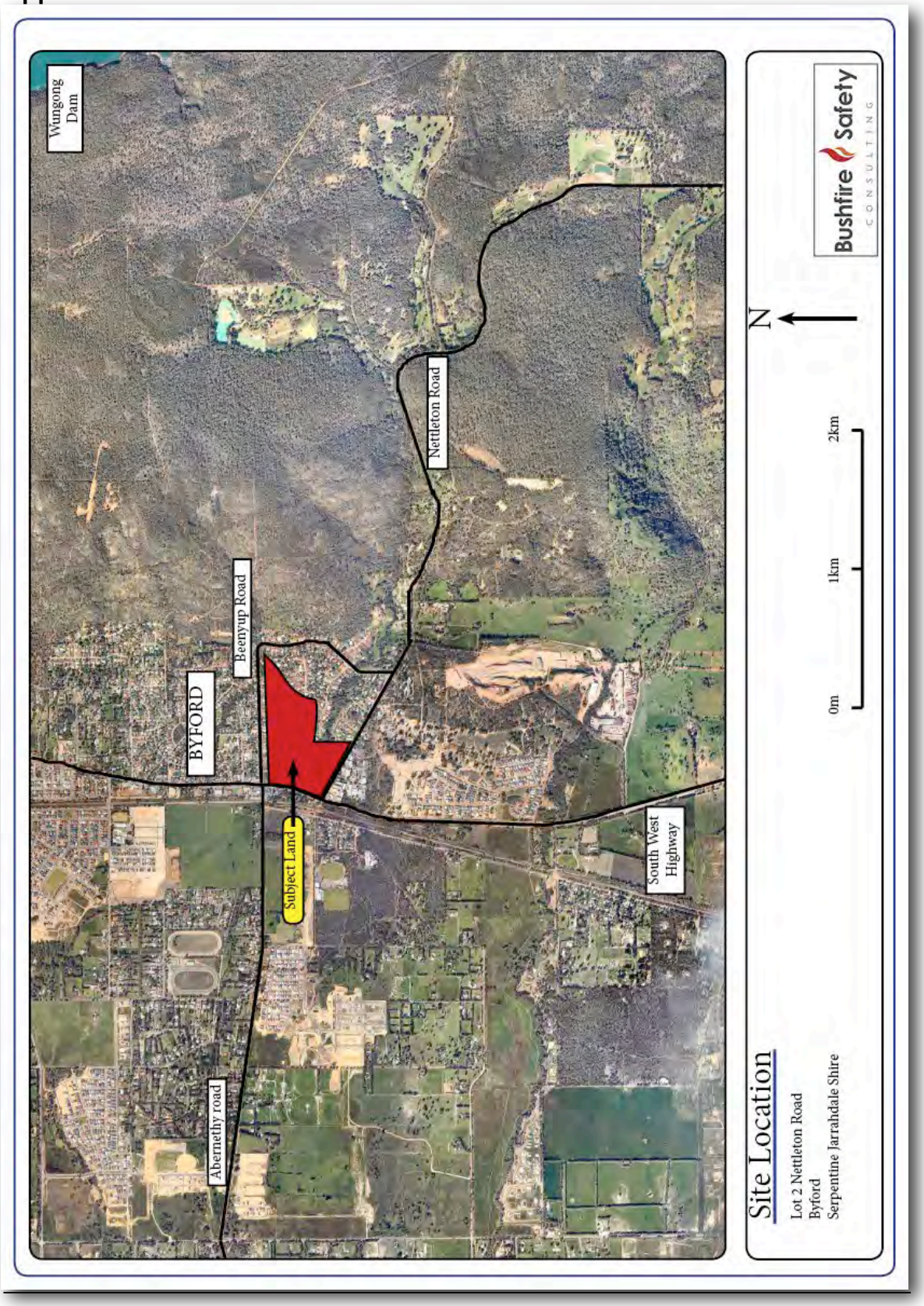
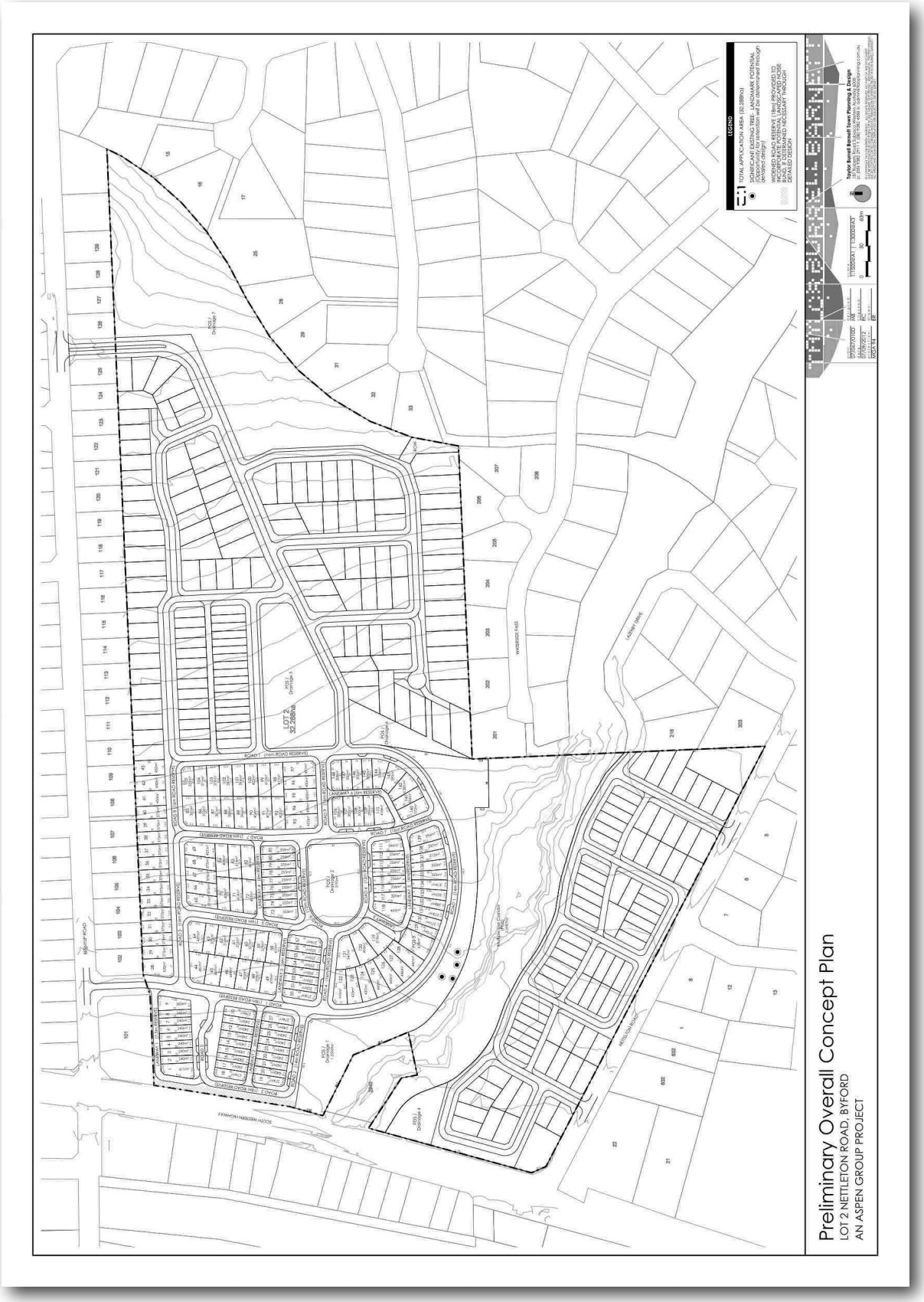
10. Appendices

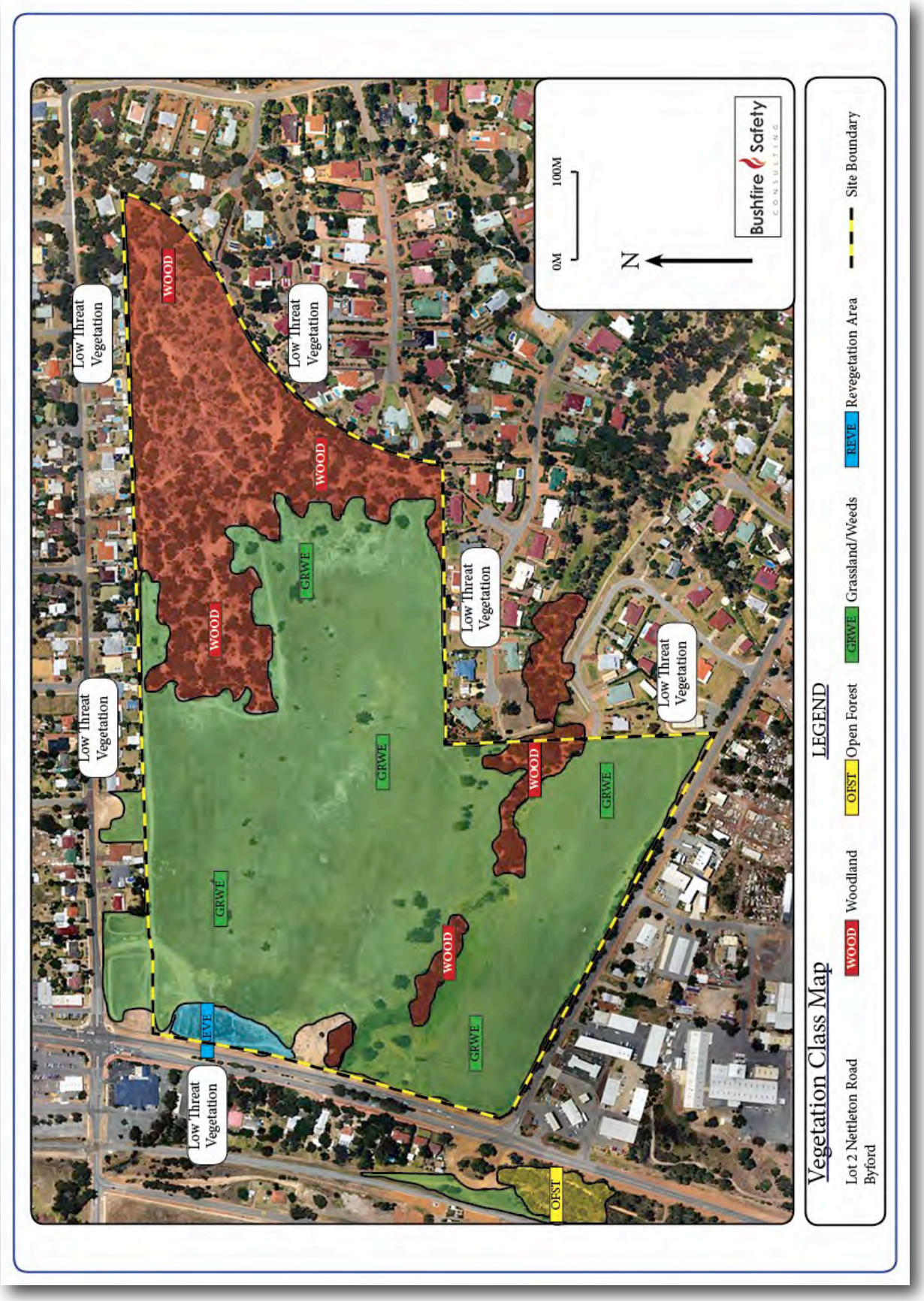
Appendix A: Site Location



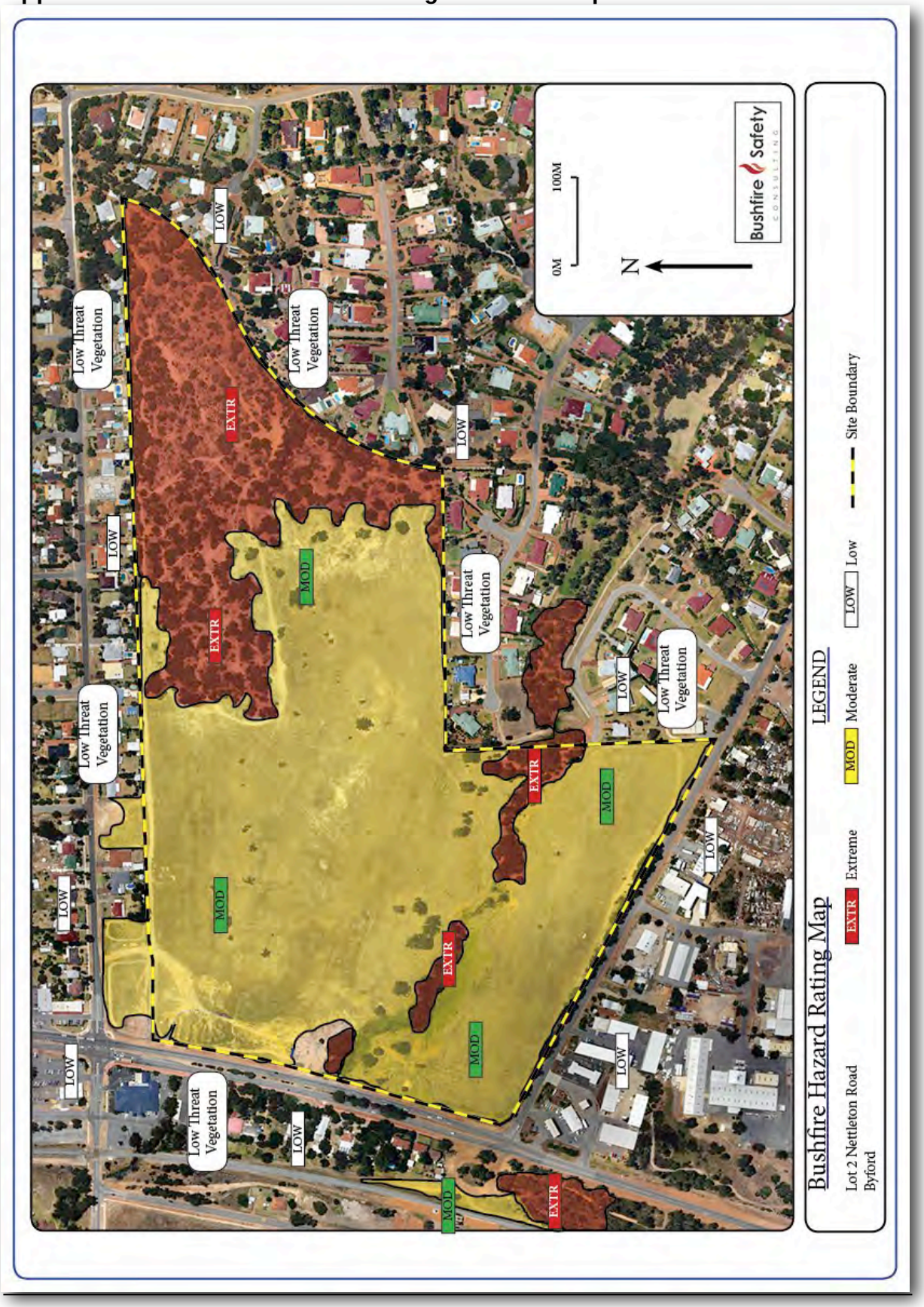
Appendix B: Preliminary Overall Concept Plan



Appendix C: Vegetation Class Map

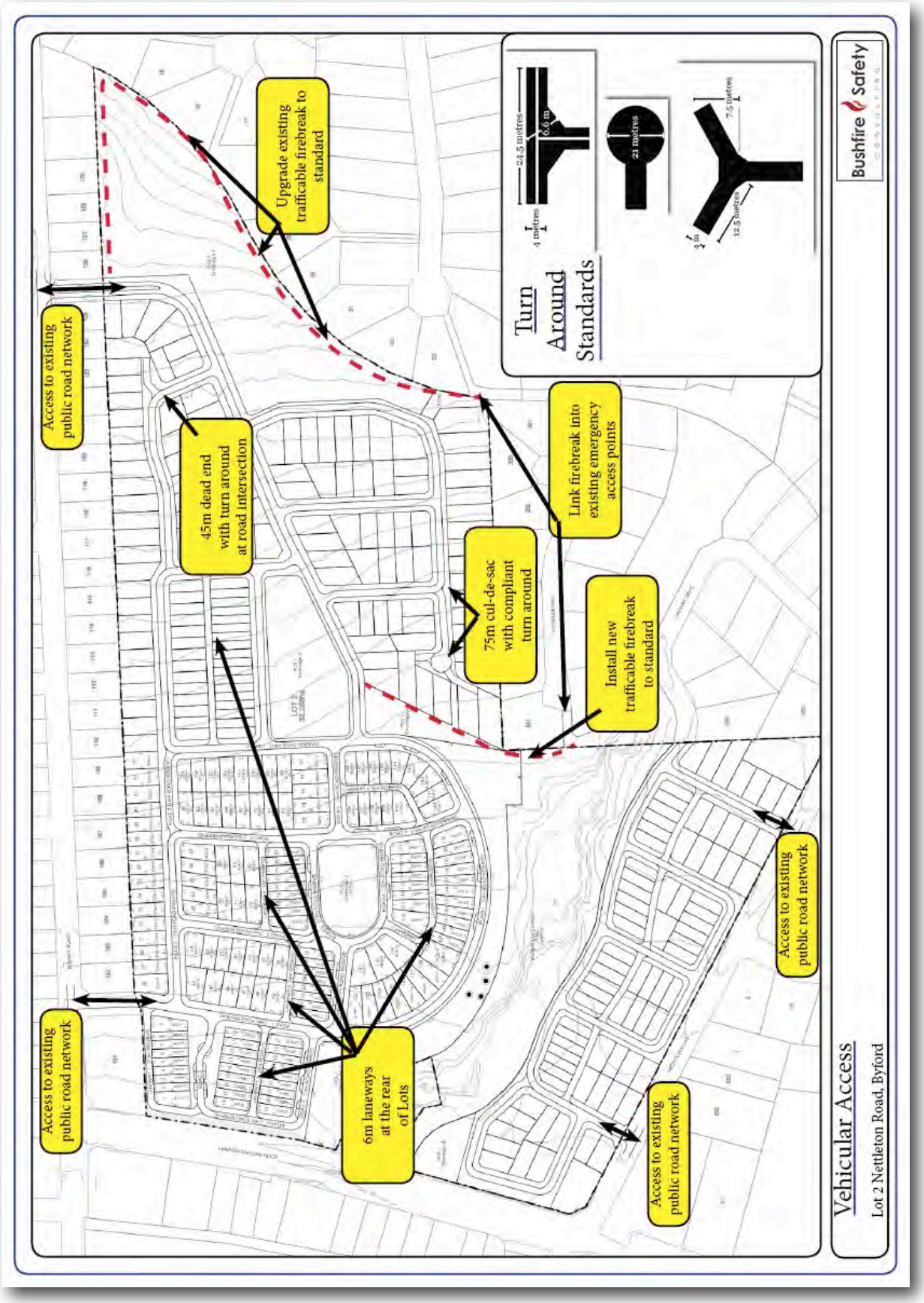


Appendix D: Bushfire Hazard Rating - Pre development

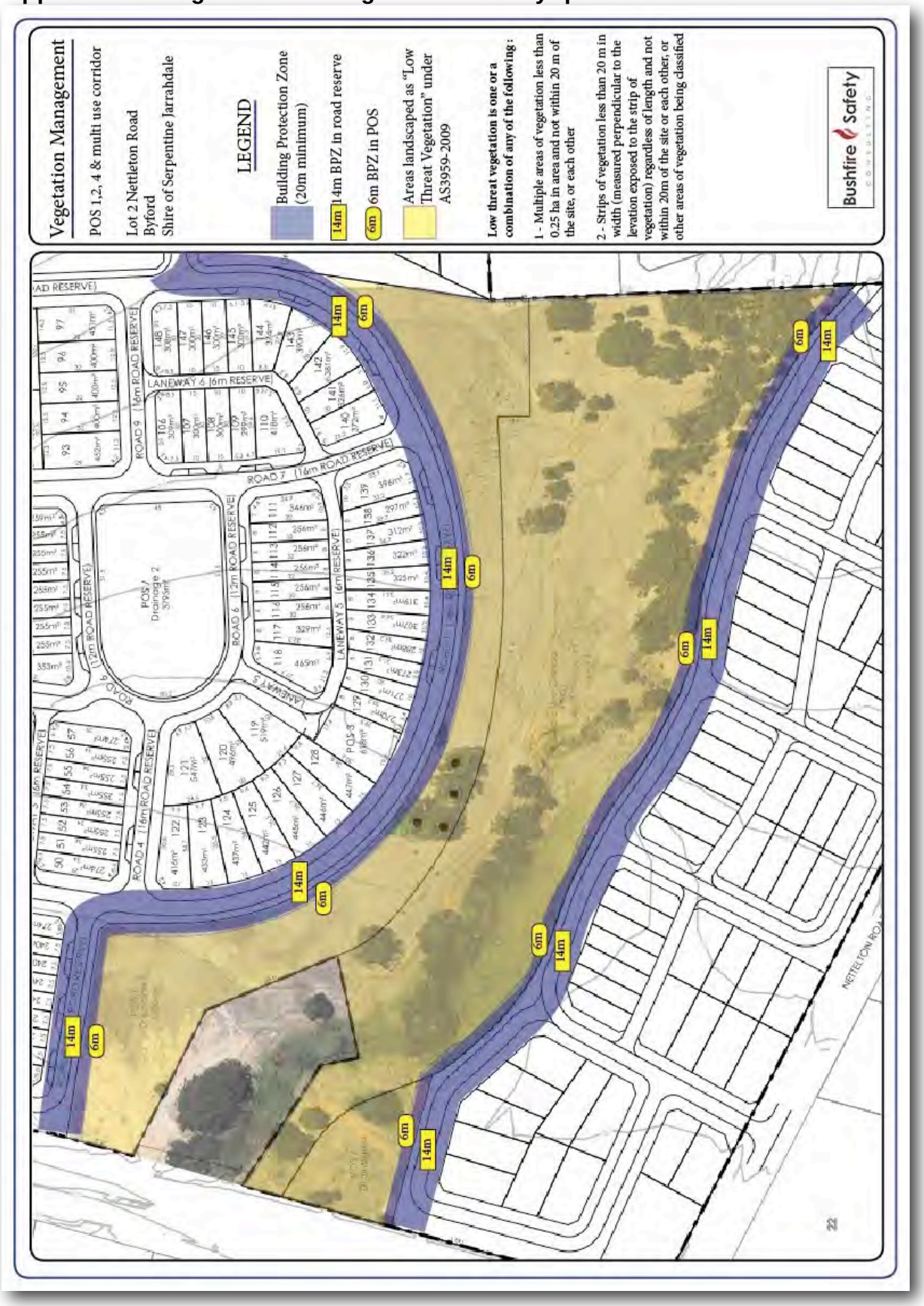


Appendix E: Bushfire Hazard Rating - Post development

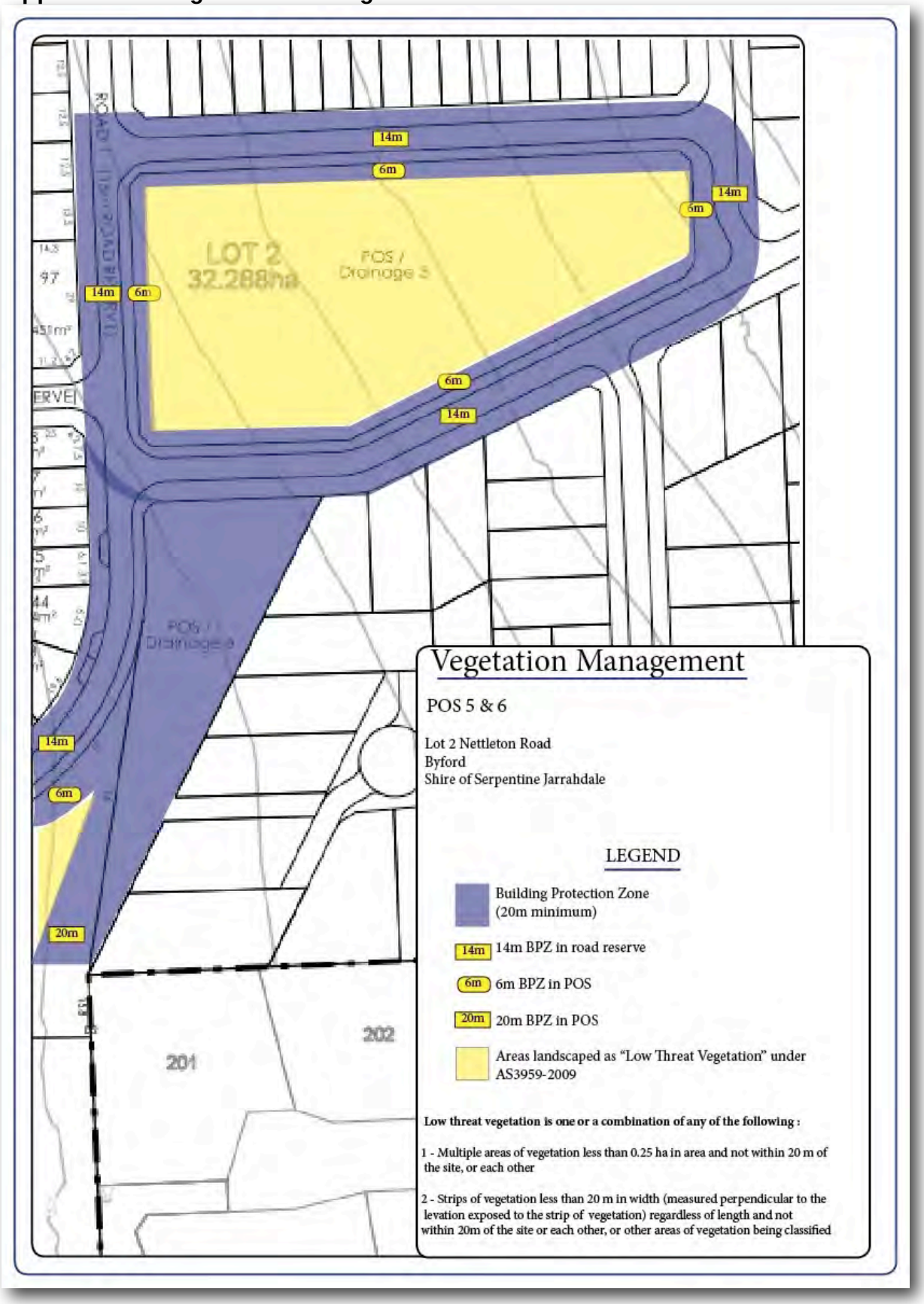
Appendix F: Vehicular Access



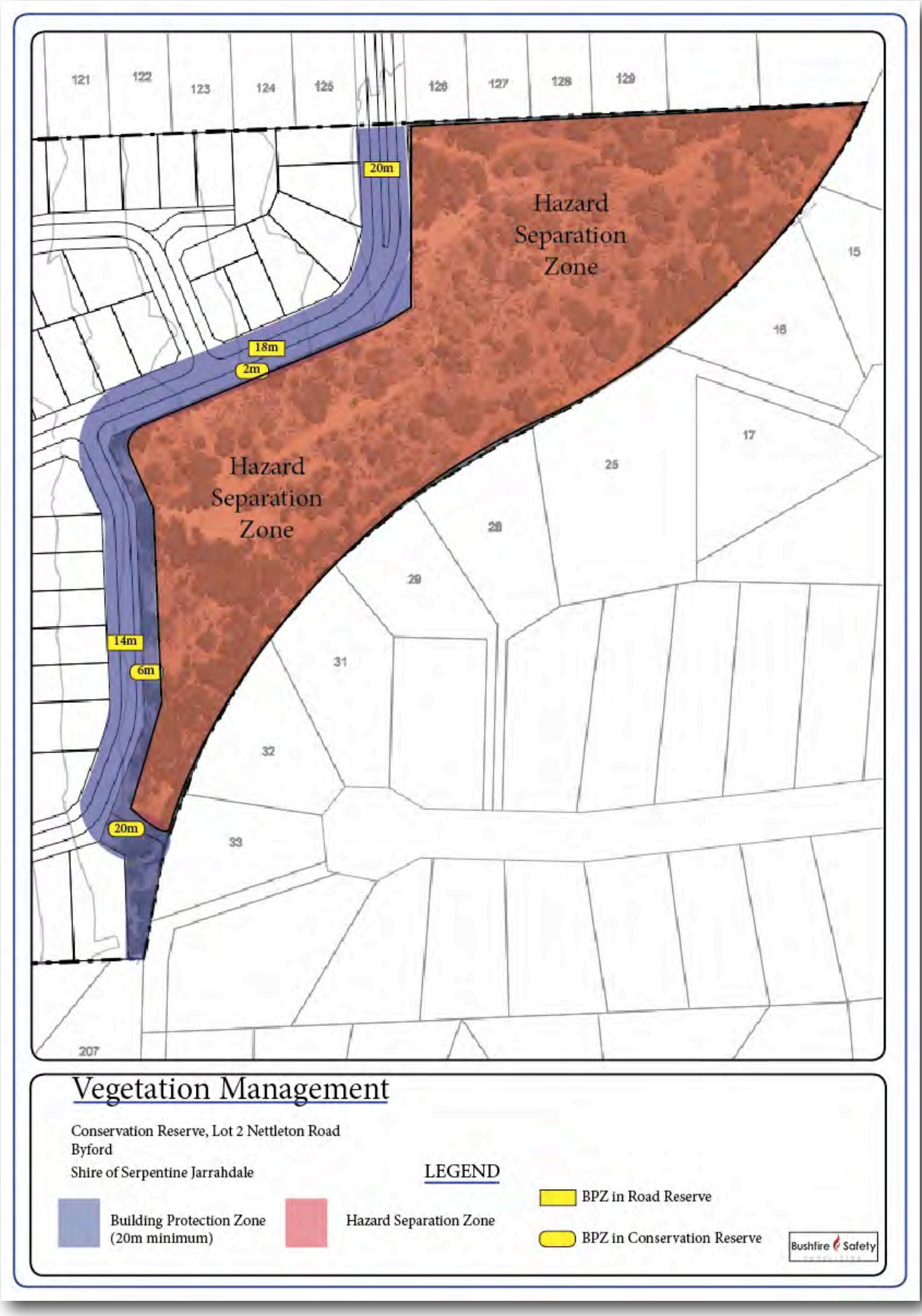
Appendix G: Vegetation Management - Beenyup Brook



Appendix H: Vegetation Management - POS 5 & 6

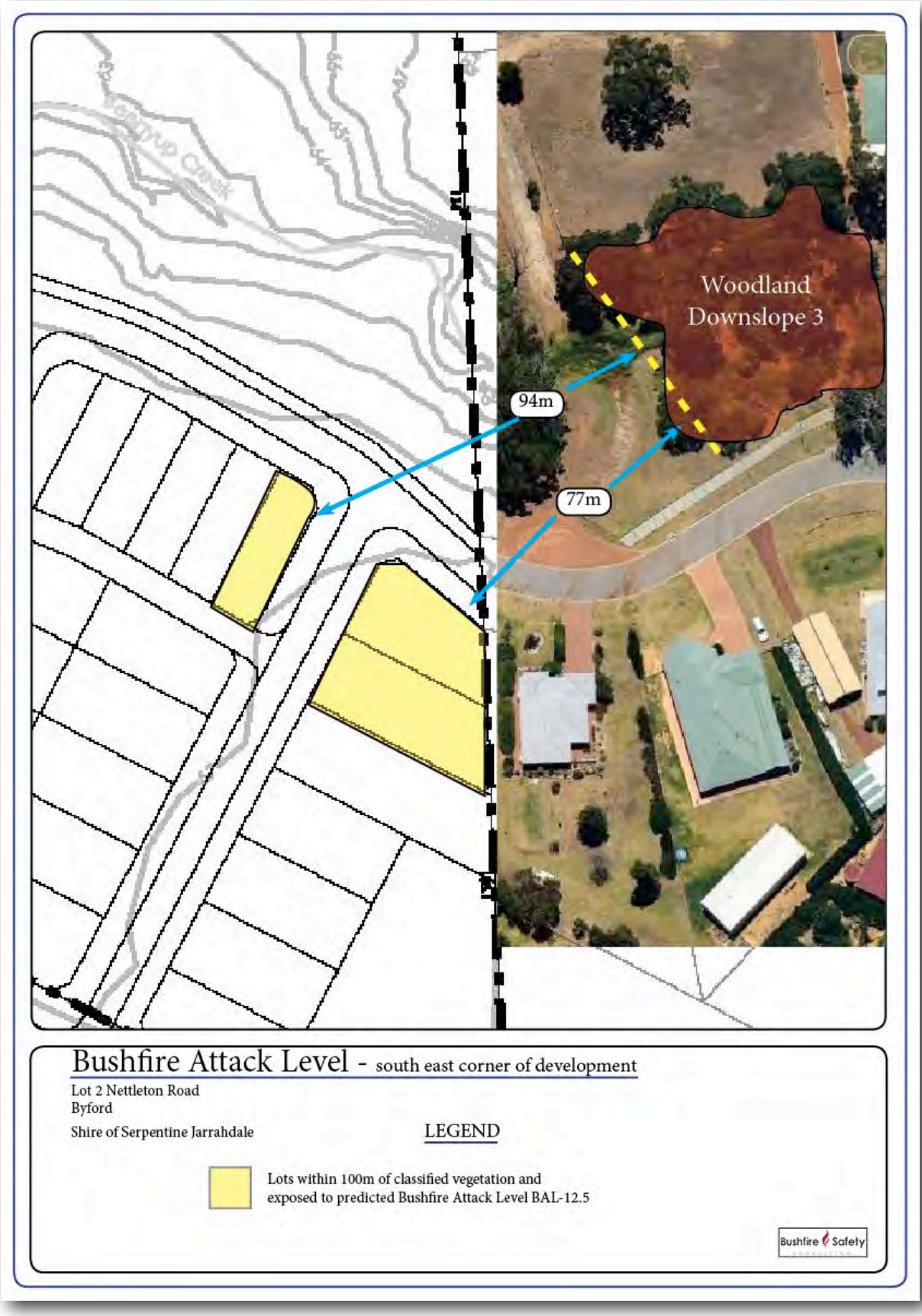


Appendix I: Vegetation Management - Conservation Area



Appendix J: BPZ and Example BAL Assessment - SW Corner

Appendix K: BPZ and Example BAL Assessment - SE Corner



coffey geotechnics
SPECIALISTS MANAGING THE EARTH

REPORT ON GEOTECHNICAL INVESTIGATION

LOT 2 SOUTH WESTERN HIGHWAY, BYFORD
Wood & Grieve Engineers

GEOTHERD08278AC- AB
29 April 2008

Coffey Geotechnics Pty Ltd ABN 93 056 929 483
24 Hasler Road Herdsman WA 6017 Australia

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

29 April 2008

Wood & Grieve Engineers
Level 3 Hyatt Centre
3 Plain Street
EAST PERTH WA 6004

Attention: Mark Sobey

RE: LOT 2 SOUTH WESTERN HIGHWAY, BYFORD SUBDIVISION AND VILLAGE DEVELOPMENT

REPORT ON GEOTECHNICAL INVESTIGATION

This letter presents our report on a geotechnical investigation carried out at the above site.

If you have any questions related to the report or we can be of further assistance, please do not hesitate to contact the undersigned.

For and on behalf of Coffey Geotechnics Pty Ltd

HAMISH NELSON

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1 INTRODUCTION

This report describes geotechnical studies carried out by Coffey Geotechnics Pty Ltd (Coffey) for Wood & Grieve Engineers on the proposed project located to the east of South Western highway, between Beenyup Road and Nettleton Road, Byford.

This work was commissioned by Mr Graeme Morris of Aspen Group on 13 February 2008 (Ref. "GEOTHERD08278AC-P-AA dated 31 January 2008").

This report is prepared and is to be read subject to the terms and conditions contained in our proposal dated **31 January 2008**. Our advice is based on the information stated and on the assumptions expressed herein. Should that information or the assumptions be incorrect then Coffey Geotechnics Pty Ltd shall accept no liability in respect of the advice whether under law of contract, tort or otherwise.

2 PROPOSED DEVELOPMENT

You have indicated that the development proposed for the site comprises construction of a residential village inclusive of up to 585 lots (final lot yield subject to engineering advice) of varying sizes, from 220m^2 to 300m^2 and surrounding features, including pavements and public open space.

3 OBJECTIVES

The objectives of the geotechnical investigation were to assess the following:

- Soil, rock and groundwater conditions within the significant foundation support zone and at the number of investigation stations specified;
- Site classification in accordance with AS2870-1996 and requirements to improve the classification;
- Earthworks recommendations, including compaction method, type and extent of testing, expected shrinkage and bulking factors, plasticity, sub-surface settlement during compaction of fill and future settlement etc. Working with in situ materials and imported material as appropriate;
- Suitability of excavated material for fill (including recommendations for crushing, screening & blending), working with in situ materials and imported material as appropriate;
- Recommended trench compaction methodologies and requirements;
- Comments on proposed construction works during winter and additional requirements for such;
- Dewatering requirements for earthworks and trenching;
- Pavement design recommendations, including requirements for subsoil drainage and specific design pavement profile:
    - Comment on suitability of the minimum standard pavement profile (generally based on Shire of Serpentine Jarrahdale requirements – 40 years design life) as detailed below and any recommended changes:

  - Subgrade compacted to 95% MMDD to a minimum standard depth of 150mm below the subgrade surface. Subbase of a 150mm layer of limestone rubble material compacted to 95% MMDD. Basecourse of a 100mm layer of propriety produced crushed rock base compacted to 98% MMDD. Primerseal. 25mm Asphalt (AC10) with tack coat.

- Soil permeability criteria, potential for stormwater disposal by soakage (soakwells and drainage basins);
- Subsoil drainage requirements to protect pavements and structures;
- Earth pressure coefficients for granular backfill to earth retaining structures such as headwalls;
- Site suitability and requirements for building mixed use type development (noting building pad requirements) and recommendations for disposal of roof stormwater.

Coffey understand the principal has separately engaged Environmental and Hydrological consultants to provide advice in their respective fields.

4 INFORMATION SUPPLIED BY OTHERS

You have provided us with the following information:

- A copy of the Taylor Burrell Barnett Preliminary Concept Plan – Option 2
- A copy of the feature survey of the site
- A site plan showing the location of aboriginal archaeological sites.
- A survey drawing showing estimated AAMGL.

5 FIELD AND LABORATORY WORK

5.1 General

Fieldwork was carried out on the 21 and 22 February 2008 in the full time presence of personnel from Coffey. Test locations were measured by DGPS to an accuracy of ±0.1m. Due to wide fluctuations in the elevation readings from the DGPS, the elevations were estimated from the supplied topographic plan.

Engineering logs of test pits, together with explanation sheets defining the terms and symbols used, are presented in Appendix A.

Water level readings were recorded where possible in the test pits, and are shown on the test pit logs. It must be noted that fluctuations in the level of the groundwater may occur due to variations in rainfall, temperature, and other factors.

Access at the site was available through a gateway along the site boundary off Nettleton Road.

Weather conditions at the time of fieldwork were fine and dry, and trafficability of the site was good for both the tracked machinery and 4WD.

Approximate test pit locations are shown in Figure 1.

5.2 Test Pitting

A total of 35 test pits were excavated by backhoe to depths varying from 1.9m to 2.4m below the existing ground surface at the approximate locations shown on Figure 1.

Disturbed samples were taken from 9 locations of representative soil types for laboratory examination and testing.

The records of the test pit logs showing the description of the major strata intersected, the depths at which the samples were taken and the results of these tests together with Explanation Sheets defining the terms used are presented in Appendix B.

6 DESCRIPTION OF LABORATORY TESTING

Laboratory testing was carried out in accordance with the general requirements of the latest edition of AS 1289.

The testing was carried out by a Coffey's NATA registered soils laboratory.

The extent of testing carried out to provide the geotechnical parameters required for this study are presented in Table 1.

Table 1 - Extent of Laboratory Testing

Type of Test	Number
Particle size distribution	9
Atterberg limits	9
Moisture content	9

Test results for the above mentioned tests are attached in Appendix B.

7 SITE CONDITIONS

7.1 Surface Conditions

The site occupies an area of 19 ha and is situated in gently undulating topography with slopes generally of less than 10 degrees; some of the shallow drainage channels had slopes of more than 60 degrees, but these were limited to a depth of less than about 2.0m. Most of the site is sparsely vegetated with grasses and some large trees, with some denser regions of vegetation occurring on the north east of the site and along the banks of the creek that runs through the southern end of the site.

Existing site development consists of:

- Several old farming sheds and structures located on the western side of the site.
- A network of sand/gravel roads running in generally a north-south east-west grid.

- Dilapidated fence lines running in generally a north-south east-west grid.
- Aboriginal archaeological sites sparsely located over the site.

Access to the site is by was by a gate off Nettleton Road and trafficability at the time of fieldwork was good under prevailing weather conditions which were dry and hot with some low winds.

7.2 Subsurface Conditions

The 1:50,000 Environmental Geology Armadale Sheet indicates that the surface geology of the site consists of gravelly sandy clay of colluvial origin to the west of the site and gravelly clayey sand of collivial origin to the east of the site.

Based on the test pit logs the site has a generalised subsurface profile presented in Table 2.

Table 2 - Subsurface Profile

Unit	Typical Depth to Top of Layer (m)	Typical Layer Thickness (m)	Description/Remarks
1	0m	0 - 0.1m	SAND (Topsoil), loose sandy, fine to medium grained, grey to dark grey, trace of fines and root fibres.
2	0.1 m	0 – 0.5m	SAND (SP/SM), fine to medium grained, off white, with some gravel, trace of fines and tree roots
3	0.3 – 0.5m	0 – 0.7m	Clayey Gravel/Clayey Sand (GP/GC), fine to medium grained, off white, low plasticity, trace of tree roots.
4	0.2 – 1.0m	>1.2m	Clayey Gravel (GC), fine to medium grained, brown mottled grey, low plasticity

It should be noted that although the lab testing indicated predominantly granular material, the strength of the Clayey Sand/Clayey Gravel has been described as a cohesive material as Coffey's field staff feel these terms better describe the in-situ characteristics of the material.

7.3 Groundwater Levels

Groundwater levels measured during the course of the investigation are presented in Table 3.

Table 3 - Groundwater Elevations

Testpit No.	Depth to Groundwater (m)	Approx. Surface Level (m AHD)	Approx. Level of Groundwater (m AHD)
TP14	1.8	60.6	58.8
TP22	2.2	66.4	64.2
TP24	2.2	67.6	65.4

Groundwater was encountered below the level of AAMGL on the provided hydrology map (Attached Figure 3). This is due to the fieldwork being completed at the end of the summer months, when the groundwater table is near its lowest.

It should be noted that groundwater levels are subject to variation due to the influence of rainfall, temperature, local drainage and the seasons. There is potential for development of perched groundwater tables following periods of rainfall.

The Perth Groundwater Atlas, published by the Water & Rivers Commission of Western Australia, does not cover this area.

Client supplied data (Attached Figure 3), showing estimated AAMGL shows that for a large portion of the site, in particular the north western area of the site, the AAMGL is at natural ground surface or close to natural ground surface. This has the potential to cause significant problems if adequate subsoil drainage throughout the site is not provided.

8 RECOMMENDATIONS

8.1 General

It should be noted that the ground encountered by the testpits represent the ground conditions at the location where the tests have been undertaken and as such are an extremely small proportion of the site to be developed. Accordingly, variations to the ground conditions are likely and allowance should be made for variability in the design and construction budgets.

Whilst, to the best of our knowledge, the information contained in this report is accurate at the date of issue, ground conditions including groundwater levels can change in a limited time or due to seasonal fluctuations. For example fill could be added to a site or surface materials removed from a site that will change the thickness of surface materials and depth to the underlying materials. The potential for change in ground conditions should be recognised particularly if this report is used after a protracted delay.

It is also recommended that any plans and/or specifications prepared which relate to the content of this report or amendments to original plans and specifications be reviewed by Coffey to verify that the intent of the recommendations contained in this report are properly reflected in the design.

8.2 Site Classification

Australian Standard AS2870-1996 provides a system of site classification for residential slabs and footing design as follows:

Table 4 - General Definition of Site Classes

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites with only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes
H	Highly reactive clay site, which can experience high ground movement from moisture changes
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes
A to P	Filled sites
P	Sites which include: Soft soils, such as soft clays or silts or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise

An in-situ classification of M is judged to be appropriate for the site based on the procedure by Kay (1990). The site could be upgraded to Class S by placement of controlled sand fill over the clay so that the total in-situ and imported granular material thickness is 1.0m. The imported sand used should contain not more than 5% passing a 0.075mm sieve. To assist in assessing the volume of sand fill required to upgrade the site to a Class S the depth of in-situ sand overlying the clay that can be considered as part of the 1.0m of controlled fill is shown on Figure 2.

In test pit 13 the linear shrinkage was noted to be abnormally high, whilst the liquid limit and plastic limit were within the standard range. Coffey have therefore excluded the linear shrinkage from TP13 in calculations for the site classification.

It must be noted that the 1.0m of controlled sand fill is required to meet site classification requirements. Other factors such as environmental and flooding requirements may require the thickness of the sand fill to be greater than this.

The above classification requires that the topsoil on the site be stripped, the excavated subgrade is proof rolled and replaced with controlled sand fill. Earthworks should be in accordance with AS3798-1996 and Section 8.7 of this report.

AS2870 indicates that sites with a classification of Class S can be expected to experience surface movement due to shrink/swell of the clayey material of up to ±20mm. Although this can be reduced by installing and maintaining measured (as outlined below) to reduce moisture variation, it is expected that a significant component of the shrink/swell movement may still occur. This movement is expected to be greater than settlement due to loading or during construction.

8.2.1 Protection of Footings From Moisture Changes

Standard footings are likely to be influenced significantly by the reactivity of the underlying clayey materials. It is important that these clays be protected from significant changes in their moisture content regimes. Otherwise, significant ground movements that are not able to be accommodated by the structure may take place.

It is recommended that no large native trees be planted any closer to the footings than their likely mature height. If trees are to be planted close to footings, (and this practice is not recommended) then regular pruning of the trees will limit their root growth and reduce their water intake.

The Water Authority of Western Australia provides advice on suitable species to plant in the vicinity of services and foundations and recommends minimum planting distances from structures.

Purchasers should be provided with a copy of the CSIRO Information Sheet on foundation maintenance (see Appendix C).

8.3 Groundwater

Prior to discussing conditions within Lot 2, Byford, it is relevant to have an understanding of the factors which influence groundwater levels. Groundwater levels on a particular site are influenced by several factors including:

- Regional groundwater levels;
- Local Geology;
- Rainfall;
- Local and Regional Drainage;
- Changes in land use;
- Groundwater extraction.

Rainfall has a major effect on groundwater levels particularly in areas where sand overlies less permeable sandy clays. There is potential for development of perched groundwater tables following periods of rainfall. Ground water levels in general will also be higher at the start of the spring compared to the start of the winter months.

The construction of regional drainage, such as Beenyup Brook is likely to have influenced groundwater levels on this site. This drain will lower groundwater levels close to the Brook and may cause a local reversal of the regional hydraulic gradient. Subsoil drainage to be installed in subdivisions may have some effect on this site.

The process of urbanisation can affect groundwater levels. Trees are effective pumps removing groundwater. Clearing has the effect of raising groundwater levels. Similarly road paving and house construction removes a portion of the soil surface from which evaporation can take place. Whether or not roof runoff is piped off site will also have an effect.

From the client supplied data it is apparent that the AAMGL is at or close to the natural surface for a large area of the site.

8.4 Subsoil Drains

The provided AAMGL value, while relevant to setting levels for subsoil drains, does not allow for the effects on groundwater levels of urbanisation or the possibility of a return to heavier rainfall. If the levels described in Section 8.3 of this report are adopted, then subsoil drains must be provided along both sides of all roads as well as providing Lot connections for roof runoff. It is important that non-woven geo-textiles are used for subsoil drainage as woven textiles can easily block due to their interaction with iron in the water. The subsoil drainage should be placed no higher than at the existing surface level, once the site has been stripped of topsoil. It is recommended that further advice be sought from JDA in regard to the need of subsoil drains along lot boundaries.

It must be noted that groundwater levels may not be the controlling factor for development level at all locations in this project. Lots and roads will need to be above flood levels of the Beenyup Brook and internal drains. Drainage pipes and subsoil drains will need to have sufficient grade for self cleansing velocities.

The high level of AAMGL, coupled with the clayey soils within the site anticipated to be relatively impermeable, means that storm water disposal through soakwells or drainage basins are not suitable on site.

8.5 Retention Systems

Earth retaining structures should be designed in accordance with the requirements of AS 4678-2002.

8.5.1 Design Parameters and Recommendations

Clayey soil material at the site forms part of the Guildford formation, and is not recommended for use as retaining wall backfill, due to the risk of significant ground movements (shrinkage and swelling) associated with changes in the soil water content. The low permeability of clayey soil material at this site also increases the likelihood of groundwater containment behind the retaining wall, thus adding additional hydrostatic pressure on the retaining wall.

However, should the clayey material be used for site earthworks (and this practice is not recommended), it should not be used as backfill within a distance from any retaining walls, equal to half the retained height of the wall. Instead, free draining sand should be placed in that zone.

Only excavated clean, free draining sand material or imported cohesionless sand fill, that satisfy specifications stipulated in Section 8.7.9, is recommended for use as retaining wall backfill. The soil parameters recommended for the design of the retaining walls are presented in Table 5.

Table 5 - Soil Parameters Recommended for Retaining Wall Design

Soil Type	Effective Cohesion (c', kPa)	Friction Angle, (ϕ' degrees)	Unit Weight (γ kN/m^3)	Active Pressure K_a	At Rest K_o	Passive Pressure K_p
Sand/ Backfill	-	33	18	0.30	0.46	3.3

Key: c' denotes undrained cohesion (kPa).

ϕ' denotes undrained friction angle (degrees)

γ dry unit weight

K_a fully mobilised coefficient of active earth pressure for horizontal ground surface

K_p fully mobilised coefficient of passive earth pressure for horizontal ground surface

K_o at rest earth pressure coefficient for horizontal ground surface

It is recommended that drainage be installed behind each retaining wall in accordance with AS 4678-2002 to collect perched groundwater from the surface of the clayey soils and any groundwater from within the permeable sand fill layers retained behind the wall. The drains should have a minimum 2% fall to a drainage point.

Without drainage provisions, any groundwater build-up behind the retaining walls will provide an additional surcharge to the retaining wall and may cause softening of the natural clayey soils underlying the sand backfill layer, resulting in a loss of bearing capacity and increased settlement of the retained ground.

It is recommended that the At Rest (Ko) Pressure be adopted in retaining wall design, if the walls are to be constructed as structural walls, or if the walls are to be incorporated into the residential structure (ie supporting part of the structure).

8.6 Flexible Pavements

It is assumed that the proposed road alignments do not involve any significant cuts or placements of fill (ie greater than 0.5m). The subgrade materials are therefore likely to comprise of sandy/gravely materials.

8.6.1 General

It is important to note that the following advice is based on a subgrade CBR of 12% and a minimum of 0.5m of non reactive sand/gravel overlying the clayey material. The advice provided in the earlier report (Ref: GEOTHERD08278AC-AA) based on a CBR of 3% should still be relevant provided that the advice on subsoil drainage (Section 8.6.7) is applied.

Where the thickness of non reactive sand/gravel cover over clay is less than 0.5m, the clay should be boxed out, such that at least 0.5m thickness of sand/gravel is provided, separating the road base from the clay layer.

Problems associated with constructing pavements on clayey soils of the Guildford Formation can include weakening of the materials with trafficking, unless a wearing layer of cohesionless material or crushed limestone is placed over the clay surface.

The excavation subgrade should be proof compacted to not less than 96% Maximum Modified Dry Density Ratio (MMDDR) in accordance with recommendations contained in Section 8.7.8. The placement and compaction of the cohesionless material should be performed in accordance with the recommendations contained in Sections 8.7.7 and 8.7.8.

Soft/wet areas in the subgrade should be excavated and replaced with crushed limestone.

If construction is performed during the wetter periods of the year, the proof compaction should be assessed by the Supervising Engineer at the time the work is carried out.

8.6.2 Preliminary Californian Bearing Ratio

It is important to note that no Californian Bearing Ratio (CBR) testing was carried out on the subgrade soils as part of the investigation for this site. It is therefore recommended that CBR testing be carried out prior to pavement construction to confirm the subgrade CBR. Based on previous experience of the encountered ground conditions at this site, a preliminary design CBR of 12% has been assumed for the sandy subgrade over the Guildford Formation. As noted above, a minimum thickness of 0.5m of non reactive sand/gravel should be present above the clayey material. This 0.5m does not form part of the pavement profile.

8.6.3 Design Traffic

Information provided by Wood & Grieve Engineers indicates that a design life of 40 years should be adopted for the proposed local access streets and local distributor streets.

Thel Design Traffic Load (DTL) has been estimated as 1×10^5 Equivalent Standard Axles (ESA) for local access streets with buses, and 1.3×10^5 ESA at intersections (allows for breaking, accelerating, turning forces), as suggested in ARRB (2005) “Sealed Local Roads Manual”.

8.6.4 Preliminary Pavement Thickness Design

The following preliminary pavement thickness requirements have been assessed:

Local Access Streets with Buses (Except Intersections):

- Surface: 30mm thickness of dense graded asphalt (10mm nominal size)
  Tack coat
  10mm primer seal
  Prime (50:50 Bitumen:MC Cutting Oil)
- Base Course: 100mm thickness of crushed granite rock base material compacted to 98% MMDDR (Minimum Soaked CBR 80%)
- Sub Base Course: 150mm thickness of crushed limestone compacted to 95% MMDDR (Minimum Soaked CBR 60%)

- Subgrade: 300mm thickness of sand/gravel compacted to 96% MMDDR (Minimum Soaked CBR 12%)

Local Access Streets with Buses (At Intersections and Roundabouts):

- Surface: 30mm thickness of dense graded asphalt (10mm nominal size)

  Tack coat

  10mm primer seal

  Prime (50:50 Bitumen:MC Cutting Oil)
- Base Course: 110mm thickness of crushed granite rock base material compacted to 98% MMDDR (Minimum Soaked CBR 80%)
- Sub Base Course: 150mm thickness of crushed limestone compacted to 95% MMDDR (Minimum Soaked CBR 60%)
- Subgrade: 300mm thickness of sand/gravel compacted to 96% MMDDR (Minimum Soaked CBR 12%)

Thickness requirements for the local access streets with buses are based on 90% design reliability, (ARRB, (2005)).

It is important to note that CBR testing of the subgrade materials was not carried out as part of this work and therefore the pavement design provided can only be considered as preliminary until CBR testing is carried out to confirm the suitability of the design.

8.6.5 Pavement Materials

Pavement materials should conform to the “Guide to the Selection and Use of Naturally Occurring Materials as Base and Sub Base” jointly published by Main Roads Western Australia and Australian Geomechanics Society (2002).

8.6.6 Road Construction

The following method should be undertaken in the construction of the roads:

- Strip and separately stockpile the top 100-150mm of Topsoil in the area.
- If the minimum depth of the sand overlying clay is less than the minimum required 500mm, the clay should be boxed out, such that at least 0.5m thickness of sand/gravel is provided
- Install subsoil drainage a minimum of 0.5m below the sub-base level of the road.
- Compaction and placement of the road material can then be undertaken.

8.6.7 Subsoil Drains

It is judged that the AAMGL for the proposed site could reach the surface level. Therefore, subsoil drainage should be provided to lower the groundwater table and to drain any infiltrated water in the pavement layers. Slotted Pipes in subsoil drainage such as corrugated plastic, smooth plastic, UPVC, concrete, fibre-reinforced concrete or perforated corrugated steel can be installed. The outlets should be lead into table drains or into pits for discharge into the stormwater system. Outlets into the pits should be located above the hydraulic grade line of the stormwater system to avoid backflow into the subsoil drainage system.

The invert of subsoil drains needs to be sufficiently deep, and spacing (to other side of the road formation) sufficiently close, that adequate clearance can be maintained between the underside of the base coarse, and the soil zone wetted by capillary rises. If a minimum clearance between invert of drain and underside of sub base course of 0.5m cannot be maintained, then it may be necessary to raise the elevation of the road formation.

Based on the above for roads that are perpendicular to the surface contours, subsoil drains must be provided along both sides of all roads. Drainage pipes and subsoil drains will need to have sufficient grade for self cleansing velocities. For roads that are parallel to the slope of the site, the subgrade can be graded one way, and only one subsoil drain (which will be located on the uphill side of the road) will be sufficient. For roads that are at or close to existing levels, subsoil drains on both sides of the road will be required.

8.7 Earthworks

8.7.1 General

Earthworks should be carried out in accordance with the principles set out in AS3798-1996.

It is recommended that the earthworks be performed during the drier period of the year to avoid possible construction problems associated with perched groundwater on the clayey materials. If construction proceeds during the wetter parts of the year, the clayey materials may soften and be difficult to moisture condition and compact.

8.7.2 Removal of Topsoil and Uncontrolled Fill

All organic materials and uncontrolled fill should be stripped and stockpiled separately.

The investigation intersected topsoil material to depths varying from 0 m to 0.15 m. Variations in this depth are present over the site. The topsoil is not suitable for use as structural filling. It is only suitable for landscaping purposes.

The underlying sand fill may be reused, provided it complies with the cohesionless sand fill specifications provided in Section 8.7.9. in order to comply with this

8.7.3 Proof Compaction

Assuming the site is developed as a whole, after the site has been stripped to the satisfaction of the Supervising Engineer, the site should be proof compacted using a medium weight, self-propelled, smooth drum vibrating roller, capable of operating in variable frequency modes. A Dynamic CA 252D, or equivalent, is recommended.

The following proof compaction procedure is recommended:

- The entire site should be given a minimum of 4 passes with the roller operating in the low frequency/high amplitude mode. A pass should include a minimum overlap of 20%.
- The site should then be given an additional minimum of 4 passes with the roller operating in the high frequency/low amplitude mode.
- All weak areas, that deform excessively under rolling, should be removed and replaced with clean sand fill.
- On completion of vibratory rolling, 2 passes of the site should be made with the roller operating in a static mode. This will compact the sands in the upper 300mm that were disturbed by cyclic mobility.

It is recommended that the proof compaction be monitored by an Engineer experienced in earthworks. Should the proof compaction be performed during the wetter part of the year, it is recommended that a geotechnical engineer be contracted to advise on the need for proof compaction.

8.7.4 Excavation Characteristics

Excavation characteristics have been assessed based on site observations during fieldwork are expected to be as follows:

Table 6 - Excavation Characteristics for 20 Tonne Excavator/Dozer

Layer	Description	Ease of Excavation
1	Topsoil/Sand	Easy - Fair
2	Sandy Clay/ Sandy Gravel	Fair - Hard

It is recommended that a rock bucket (excavator bucket with forked teeth) is used to aid in excavating through the hardened clay materials.

Trafficability problems for construction equipment may occur during wetter months when the clayey materials may soften and bogging of equipment may become a problem.

8.7.5 Indicative Bulking and Shrinkage Factors

The following indicative bulking and shrinkage have been assessed for the relevant soils encountered in the test pits.

Table 7 – Indicative Bulking and Shrinkage Factors

Material	Bulking Factor	Shrinkage Factor
Sand	1.05	0.89
Clay and Gravel	1.35	-
Sand and Gravel	1.15	-

It is important to note the values given in the table above are indicative only and cannot be relied upon as no laboratory testing has been carried out to confirm these values.

8.7.6 Dewatering

Dewatering using a combination of spears and sumps will be required if excavation of trenches is performed in the wetter months.

Attention is drawn to the special difficulties of dewatering in the Guildford Formation. Overall permeability in the horizontal direction (dictated by sand beds) can be orders of magnitude greater than vertical permeability (constrained by clay beds). Dewatering of the Guildford Formation may therefore require draining a number of water yielding layers separated by impermeable layers.

A risk exists in dewatering using trench sumps that deeper water yielding horizons separated from the excavation floor by impermeable clay, will not be adequately depressurised. The trench floor may heave if the upward pressure of water in the deeper horizon exceeds the pressure due to the effective weight of the remaining soil. The risk of heave is accentuated, the wider the area that is being excavated.

8.7.7 Suitability of Excavated Materials for Use as Fill

Sand excavated from site may be used as structural fill.

Topsoil may be used as fill in landscape areas but should not be used as structural fill.

8.7.8 Compaction Requirements

Sand complying with the recommendation contained in Section 8.7.9 should be compacted to achieve a Minimum Dry Density Ratio of at least 95% of Maximum Modified Dry Density compaction test. As a guide the fill should be compacted to achieve a penetration resistance (Perth Sand Penetrometer) of not less than 7 blows/300mm for the test interval 150mm to 450mm, not less than 10 blows/300mm for the test interval 450mm to 750mm and not less than 12 blows/300mm for the test interval 750mm to 1050mm. Sands containing 5-12% fines will need to be correlated to the Perth Sand Penetrometer test.

Clay complying with the recommendations contained in Section 8.7.10 should be compacted to achieve a Minimum Dry Density Ratio of at least 95% of the Modified Maximum Dry Density. Confirmation that this density has been achieved will require Nuclear Densometer testing and 1:1 laboratory testing.

8.7.9 Cohesionless Sand Structural Filling

For this study, cohesionless structural sand fill has been defined as fill satisfying the following criteria:

- The sand shall be clean, cohesionless, free draining and free of all silty, organic or any other deleterious inclusions.
- Containing less than (5%) by weight of soil fractions finer than 0.075mm.
- Having a plasticity index equal to 0%, (i.e. non plastic).

It is recommended that a 25 kg representative sample(s) of the proposed structural fill be delivered to a NATA registered soils laboratory for testing at least one week before approval is required. It is unlikely that the overlying in-situ sand will comply with these requirements due to the fines content.

8.7.10 Cohesive Structural Fill

For this study, cohesive structural fill has been defined as fill satisfying the following criteria:

i Containing between 12% and 36% by weight, of fractions finer than 0.075mm.

ii Having a plasticity index in the range of 24% to 28%.

The liquid limit of the fill shall not exceed 53%.

The plasticity index of the fill shall not exceed 28%.

The linear shrinkage of the fill shall not exceed 11%.

It should be noted that if cohesive fill is to be adopted, it may affect the site classification.

8.8 Construction Considerations

8.8.1 General

There are a number of activities that must be undertaken during construction to ensure compliance with design and to ensure the smooth running of the project. The following activities should be carried out during the contract.

It is recommended that the construction be performed during the drier period of the year to avoid possible construction problems associated with perched groundwater on the clayey materials. If construction proceeds during the wetter parts of the year, the clayey materials may soften and be difficult to moisture condition and compact.

8.8.2 Site Drainage and Erosion Control

Runoff from upslope of the site should be collected and diverted away from the structures. The finished surface level of the site should be graded with falls away from the structures and their foundations. This will minimise the incidence of water ponding around the footings.

Erosion control measures as set out in the “Erosion and Sediment Control Manual for the Darling Range, Perth Western Australia (2001)” should be adopted.

8.8.3 Preparation of Footing Bases in Sands

All sands disturbed in the bases of footing excavations should be compacted. Any uncontrolled fill must be excavated and replaced.

The bases of all footings excavations in clean sands should be compacted to achieve a minimum blow count of 7 for each 300mm penetration of the Perth Sand Penetrometer test, AS 1289.6.3.3.

Where the sand contains more than 5% fines, the Perth Sand Penetrometer can be used for compaction control provided a correlation is first carried out to assess the number of blows required per 300mm to achieve 95% of Maximum Modified Dry Density (MMDD).

A minimum of 3 Perth Sand Penetrometer tests should be carried out in the base of each footing excavation.

To facilitate compaction, the groundwater should not be any closer than 1m to the base of the footing excavation.

8.8.4 Mixed Use Developments

The site has been classified based upon AS2870-1996 and as such is suitable only for buildings that are covered in AS2870. The construction of mixed use type developments that differ from those described in AS2870-1996 (eg higher than three storeys, buildings with basements, etc) will require a site specific investigation. Coffey would be willing and able to provide a site specific investigation if required.

9 IMPORTANT INFORMATION ABOUT YOUR COFFEY REPORT

The reader's attention is drawn to the important information about this report which follows the main text.

10 REFERENCES

The following standards and references were used in the preparation of this report.

AS 1170.4-1993 Minimum Design Loads on Structures Part 4: Earthquake Loads.

AS 1289 Method of Testing Soils For Engineering Purposes.

AS 1726-1993 SAA Geotechnical Site Investigations.

AS 2870-1996 Residential Slabs and Footings.

AS 3798-1996 Guidelines on Earthworks for Commercial and Residential Developments

AS 4133.0-1993 Methods of Testing Rocks for Engineering Purposes.

AS 4678-2002 Earth Retaining Structures

Kay J N (1990) “Use of the Liquid Limit for Characterisation of Expansive Soil Sites” CE 32 N0 3 IE Aust

Main Roads Western Australia (1998)”Procedure for Thickness Design of Flexible Pavements”. Engineering Road Note No. 9 (1988),

Main Roads Western Australia and Australian Geomechanics Society (2002) “ A Guide to the Selection and Use of Naturally Occurring Materials as Base and Sub Base in Roads in Western Australia”

NAVFAC (1975) “Soil Mechanics Manual”.

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SPECIALISTS MANAGING THE EARTH

Important information about your **Coffey** Report

As a client of Coffey you should know that site subsurface conditions cause more construction problems than any other factor. These notes have been prepared by Coffey to help you interpret and understand the limitations of your report.

Your report is based on project specific criteria

Your report has been developed on the basis of your unique project specific requirements as understood by Coffey and applies only to the site investigated. Project criteria typically include the general nature of the project; its size and configuration; the location of any structures on the site; other site improvements; the presence of underground utilities; and the additional risk imposed by scope-of-service limitations imposed by the client. Your report should not be used if there are any changes to the project without first asking Coffey to assess how factors that changed subsequent to the date of the report affect the report's recommendations. Coffey cannot accept responsibility for problems that may occur due to changed factors if they are not consulted.

Subsurface conditions can change

Subsurface conditions are created by natural processes and the activity of man. For example, water levels can vary with time, fill may be placed on a site and pollutants may migrate with time. Because a report is based on conditions which existed at the time of subsurface exploration, decisions should not be based on a report whose adequacy may have been affected by time. Consult Coffey to be advised how time may have impacted on the project.

Interpretation of factual data

Site assessment identifies actual subsurface conditions only at those points where samples are taken and when they are taken. Data derived from literature and external data source review, sampling and subsequent laboratory testing are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact on the proposed development and recommended actions. Actual conditions may differ from those inferred to exist, because no professional, no matter how qualified, can reveal what is hidden by earth, rock and time. The actual interface between materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but steps can be taken to reduce the impact of unexpected conditions. For this reason, owners should retain the services of Coffey through the development stage, to identify variances, conduct additional tests if required, and recommend solutions to problems encountered on site.

Your report will only give preliminary recommendations

Your report is based on the assumption that the site conditions as revealed through selective point sampling are indicative of actual conditions throughout an area. This assumption cannot be substantiated until project implementation has commenced and therefore your report recommendations can only be regarded as preliminary. Only Coffey, who prepared the report, is fully familiar with the background information needed to assess whether or not the report's recommendations are valid and whether or not changes should be considered as the project develops. If another party undertakes the implementation of the recommendations of this report there is a risk that the report will be misinterpreted and Coffey cannot be held responsible for such misinterpretation.

Your report is prepared for specific purposes and persons

To avoid misuse of the information contained in your report it is recommended that you confer with Coffey before passing your report on to another party who may not be familiar with the background and the purpose of the report. Your report should not be applied to any project other than that originally specified at the time the report was issued.

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Important information about your **Coffey** Report

Interpretation by other design professionals

Costly problems can occur when other design professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, retain Coffey to work with other project design professionals who are affected by the report. Have Coffey explain the report implications to design professionals affected by them and then review plans and specifications produced to see how they incorporate the report findings.

Data should not be separated from the report*

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way.

Logs, figures, drawings, etc. are customarily included in our reports and are developed by scientists, engineers or geologists based on their interpretation of field logs (assembled by field personnel) and laboratory evaluation of field samples. These logs etc. should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

Geoenvironmental concerns are not at issue

Your report is not likely to relate any findings, conclusions, or recommendations about the potential for hazardous materials existing at the site unless specifically required to do so by the client. Specialist equipment, techniques, and personnel are used to perform a geoenvironmental assessment.
Contamination can create major health, safety and environmental risks. If you have no information about the potential for your site to be contaminated or create an environmental hazard, you are advised to contact Coffey for information relating to geoenvironmental issues.

Rely on Coffey for additional assistance

Coffey is familiar with a variety of techniques and approaches that can be used to help reduce risks for all parties to a project, from design to construction. It is common that not all approaches will be necessarily dealt with in your site assessment report due to concepts proposed at that time. As the project progresses through design towards construction, speak with Coffey to develop alternative approaches to problems that may be of genuine benefit both in time and cost.

Responsibility

Reporting relies on interpretation of factual information based on judgement and opinion and has a level of uncertainty attached to it, which is far less exact than the design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. To help prevent this problem, a number of clauses have been developed for use in contracts, reports and other documents. Responsibility clauses do not transfer appropriate liabilities from Coffey to other parties but are included to identify where Coffey's responsibilities begin and end. Their use is intended to help all parties involved to recognise their individual responsibilities. Read all documents from Coffey closely and do not hesitate to ask any questions you may have.

* For further information on this aspect reference should be made to "Guidelines for the Provision of Geotechnical information in Construction Contracts" published by the Institution of Engineers Australia, National headquarters, Canberra, 1987.

Figures

LEGEND

TEST PIT LOCATION

drawn	LB
approved	
date	23/4/08
scale	NOT TO SCALE
original size	A3

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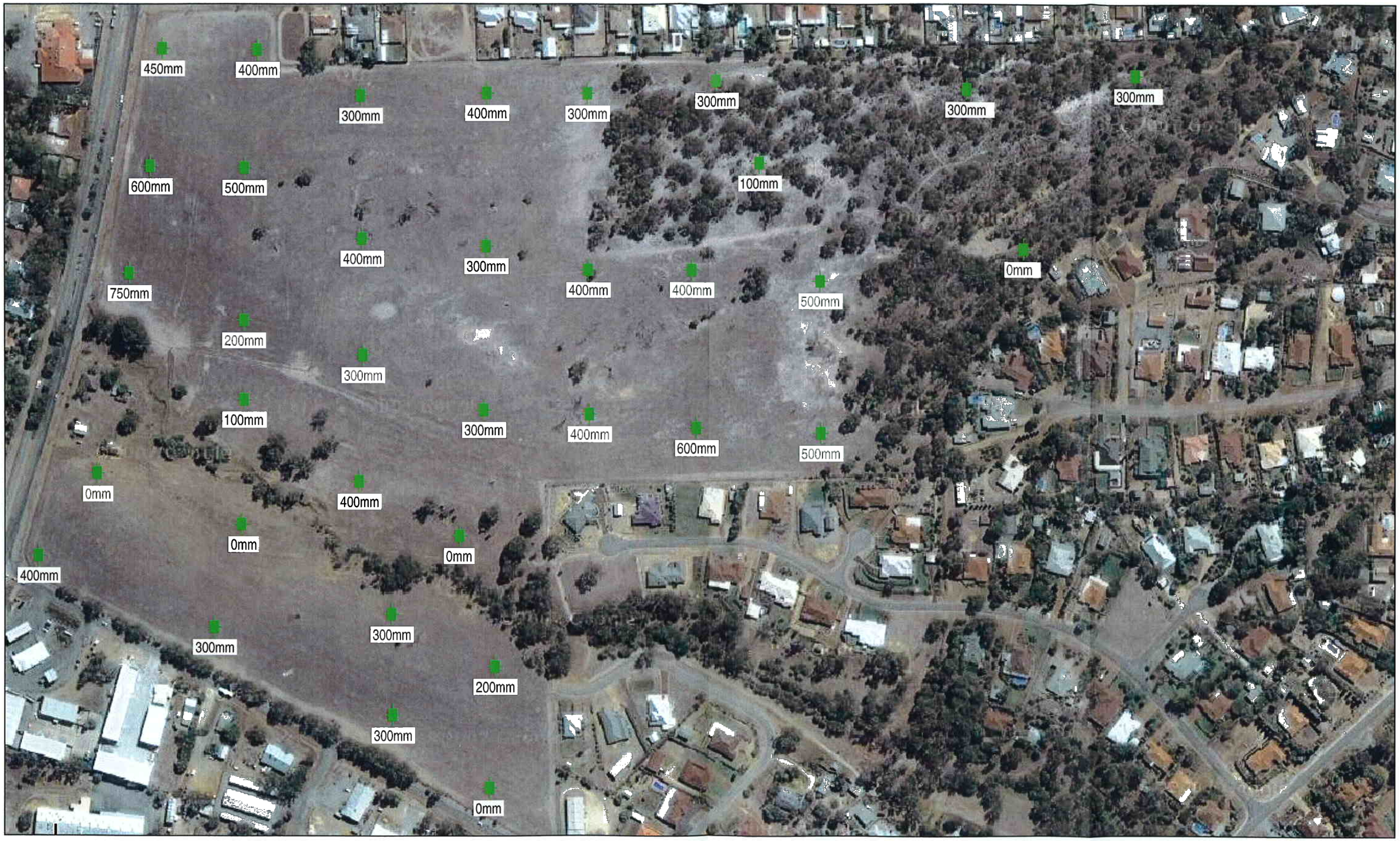
SPECIALISTS MANAGING THE EARTH

client:	WOOD & GRIEVE ENGINEERS		
project:	LOT 2 SOUTH WESTERN HIGHWAY BYFORD		
title:	TEST LOCATION PLAN		
project no:	GEOTHERD08278AC	fig no: FIGURE 1	rev:

REF:
DWG: F:\Geotechnical\HERD08000\GEOTHERD08278AC Lot 2, South Western Highway, Byford\DWG\GH8278AC FIG1.dwg



LEGEND

(500mm) DEPTH OF SAND OVERLYING CLAY

REF:
DWG: F:\Geotechnical\HERD08000\GEOTHERD08278AC Lot 2, South Western Highway, Byford\DWG\GH8278AC FIG1-2.dwg

drawn	LB
approved	
date	23/4/08
scale	NOT TO SCALE
original size	A3

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

client:	WOOD & GRIEVE ENGINEERS		
project:	LOT 2 SOUTH WESTERN HIGHWAY BYFORD		
title:	DEPTH TO CLAY		
project no:	GEOTHERD08278AC	fig no: FIGURE 2	rev:

N

Bore10
61.34

Bore4
70.94

Bore1
79.46

Bore2
74.2

Bore7
65.84

Bore11
61.06

Bore12
61.26

Bore9
63.51

Bore3
70.07

Bore5
67.12

Bore13
61.29

Bore8
64.62

Bore6
67.58

Note:
In areas where AAMGL is greater than natural surface it is assumed that the AAMGL is at natural surface. Between 0.5m-2m ponding is expected in Beenyup Brook Foreshore reserve and the and 0.6m ponding in the depression adjacent to South Western Hwy (as shown).

- Study Area
- JDA Groundwater Monitoring Bore
- Estimated AAMGL (mAHD)
- Topography (mAHD)
- AAMGL at natural surface

drawn	LB
approved	
date	23/4/08
scale	1:3000
original size	A3

coffey geotechnics
SPECIALISTS MANAGING THE EARTH

client:	WOOD & GRIEVE ENGINEERS		
project:	LOT 2 SOUTH WESTERN HIGHWAY BYFORD		
title:	SITE LOCATION PLAN		
project no: GEOTHERD08278AC	fig no: FIGURE 3	rev:	

REF:
DWG: F:\Geotechnical\HERD08000\GEOTHERD08278AC Lot 2, South Western Highway, Byford\DWG\GH8278AC FIGURE1.dwg

Appendix A

Results of Field Investigation

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Engineering Log - Excavation

		Excavation No.	TP1
		Sheet No.	1 of 1
		Project No.	GEOTHERD08278AC
Client :	Wood & Grieve Engineers	Date excavated	21/2/08
Principal :	Aspen Group	Date completed	21/2/08
Project :	Lot 2 South Western Highway, Byford	Logged by :	PW
Location :	Lot 2 South Western Highway, Byford	Checked by :	

Position : E: 406564.1, N: 6434115.3 (50 MGA94) Surface Elevation : 61.2m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information					material substance						
method	penetration (VE E F H)	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description: SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa (100 200 300 400)	structure and additional observations
BH			Not Observed		61.0	0.0			**TOPSOIL**, fine to medium, dark grey; trace of rootlets and organic content	D	L		
								SM	**SILTY SAND**, fine to coarse grained, off white; trace of fines		MD		
					60.5	0.5		GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, low plasticity, brown; sand, medium to fine grained	M	St		
					60.0	1.0							
					59.5	1.5							
					59.0	2.0			EXCAVATION TP1 TERMINATED AT 2.00 m				
					58.5	2.5							
					58.0	3.0							
					57.5	3.5							

COFFEY_02.GLB Log EXCAVATION GH08278AC - EXCAVATION.GPJ <<DrawingFile>> 29/04/2008 09:41

method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration
VE E F H VH

water
- 10 Oct., 73 Water Level on Date shown
- water inflow
- water outflow

samples & field tests
- U50 - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- E - Environmental Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa)
- PBT - Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
- D - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

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Engineering Log - Excavation

Excavation No.	TP2
Sheet No.	1 of 1
Project No.	GEOTHERD08278AC
Date excavated	21/2/08
Date completed	21/2/08
Logged by :	PW
Checked by :	

Client : *Wood & Grieve Engineers*

Principal : *Aspen Group*

Project : *Lot 2 South Western Highway, Byford*

Location : *Lot 2 South Western Highway, Byford*

Position : E: 406481.5, N: 6434163.8 (50 MGA94) Surface Elevation : 61.8m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	penetration (VE E F H VH)	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description: SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa (100 200 300 400)	structure and additional observations
			Not Observed	B	61.5	0.0			**TOPSOIL**, fine to medium, dark grey; trace of rootlets, organics and fines	D	L		
						0.5		GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, low plasticity, brown; sand, medium to fine grained	M	St		
					61.0	1.0							
					60.5	1.5							
					60.0	2.0							
					59.5	2.5			EXCAVATION TP2 TERMINATED AT 2.30 m				
					59.0	3.0							
					58.5	3.5							
					58.0								

COFFEY_02.GLB Log EXCAVATION GH08278AC - EXCAVATION.GPJ <<DrawingFile>> 29/04/2008 09:45

method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration (VE E F H VH)

water
- 10 Oct., 73 Water Level on Date shown
- water inflow
- water outflow

samples & field tests
- U50 - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- E - Environmental Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
- PBT - Plate Bearing Test

classification symbols & soil description Based on Unified Classification System

moisture
- D - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

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Engineering Log - Excavation

		Excavation No.	TP3
		Sheet No.	1 of 1
		Project No.	GEOTHERD08278AC
Client :	Wood & Grieve Engineers	Date excavated	21/2/08
Principal :	Aspen Group	Date completed	21/2/08
Project :	Lot 2 South Western Highway, Byford	Logged by :	PW
Location :	Lot 2 South Western Highway, Byford	Checked by :	

Position :
Surface Elevation : 62m (AHD)
Equipment type : Backhoe
Method :
Excavation dimensions :

excavation information | **material substance**

method	penetration (VE E F H)	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components)	moisture condition	consistency / relative density	hand penetrometer kPa (100 200 300 400)	structure and additional observations
			Not Observed		62.0	0.0			**TOPSOIL**, fine to medium, dark grey; trace of rootlets and organic content	D	L		
								GC	**SANDY CLAYEY GRAVEL**, low plasticity, brown; sand, medium to fine grained	M	St		
					61.5	0.5							
					61.0	1.0							
					60.5	1.5							
					60.0	2.0			EXCAVATION TP3 TERMINATED AT 1.90 m				
					59.5	2.5							
					59.0	3.0							
					58.5	3.5							

COFFEY_02.GLB Log EXCAVATION GH08278AC - EXCAVATION.GPJ <<DrawingFile>> 29/04/2008 09:48

method
N Natural Exposure
X Existing Excavation
BH Backhoe Bucket
B Bulldozer Blade
R Ripper
E Excavator

support
T Timbering

penetration
VE E F H VH

water
10 Oct., 73 Water Level on Date shown
water inflow
water outflow

samples & field tests
U50 - Undisturbed Sample 50mm diameter
U63 - Undisturbed Sample 63mm diameter
D - Disturbed Sample
B - Bulk Disturbed Sample
E - Environmental Sample
MC - Moisture Content
HP - Hand Penetrometer (UCS kPa)
VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT - Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
D - Dry
M - Moist
W - Wet
W_P - Plastic Limit
W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

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Engineering Log - Excavation

		Excavation No.	TP4
		Sheet No.	1 of 1
		Project No.	GEOTHERD08278AC
Client :	Wood & Grieve Engineers	Date excavated	21/2/08
Principal :	Aspen Group	Date completed	21/2/08
Project :	Lot 2 South Western Highway, Byford	Logged by :	PW
Location :	Lot 2 South Western Highway, Byford	Checked by :	

Position : E: 406651.6, N: 6434078.7 (50 MGA94) Surface Elevation : 62.8m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	penetration	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description: SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa	structure and additional observations
BH	VE E F H		Not Observed	B	62.5	0.0			**TOPSOIL**, fine to medium, grey; trace rootlets	D	L	100 200 300 400	
								SM	**SILTY SAND**, fine to medium grained, off white; trace of gravel, medium to fine grained; trace of fines		MD		
					62.0	0.5		GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, low plasticity, brown; sand, medium to fine grained; in top 200mm	M	St		
					61.5	1.0							
					61.0	1.5							
					60.5	2.0			EXCAVATION TP4 TERMINATED AT 2.10 m				
					60.0	2.5							
					59.5	3.0							
					59.0	3.5							

COFFEY_02.GLB Log EXCAVATION GH08278AC - EXCAVATION.GPJ <<DrawingFile>> 29/04/2008 09:51

method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration

VE E F H VH

water

10 Oct., 73 Water Level on Date shown
water inflow
water outflow

samples & field tests
- U50 - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- E - Environmental Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa)
- PBT - Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
- D - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

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Engineering Log - Excavation

		Excavation No.	TP5
		Sheet No.	1 of 1
		Project No.	GEOTHERD08278AC
Client :	Wood & Grieve Engineers	Date excavated	21/2/08
Principal :	Aspen Group	Date completed	21/2/08
Project :	Lot 2 South Western Highway, Byford	Logged by :	PW
Location :	Lot 2 South Western Highway, Byford	Checked by :	

Position : E: 406774.7, N: 6434002.5 (50 MGA94) Surface Elevation : 65.4m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	penetration (VE E F H)	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components)	moisture condition	consistency / relative density	hand penetrometer kPa (100 200 300 400)	structure and additional observations
			Not Observed		65.0	0.0			**TOPSOIL**, fine to medium, grey; trace of rootlets	D	L		
								SM	**SILTY SAND**, fine to medium grained, off white; trace of gravel, medium to fine grained		L		
					64.5	0.5		GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, low plasticity, brown; sand, medium to fine grained	M	St		
					64.0	1.0							
					63.5	1.5							
					63.0	2.0			EXCAVATION TP5 TERMINATED AT 2.30 m				
					62.5	2.5							
					62.0	3.0							
					61.5	3.5							

COFFEY_02.GLB Log EXCAVATION GH08278AC - EXCAVATION.GPJ <<DrawingFile>> 29/04/2008 09:51

method
N Natural Exposure
X Existing Excavation
BH Backhoe Bucket
B Bulldozer Blade
R Ripper
E Excavator

support
T Timbering

penetration
VE E F H

water
10 Oct., 73 Water Level on Date shown
water inflow
water outflow

samples & field tests
U50 - Undisturbed Sample 50mm diameter
U63 - Undisturbed Sample 63mm diameter
D - Disturbed Sample
B - Bulk Disturbed Sample
E - Environmental Sample
MC - Moisture Content
HP - Hand Penetrometer (UCS kPa)
VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa)
PBT - Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
D - Dry
M - Moist
W - Wet
W_P - Plastic Limit
W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

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Engineering Log - Excavation

Excavation No.	TP6
Sheet No.	1 of 1
Project No.	GEOTHERD08278AC
Client :	Wood & Grieve Engineers
Principal :	Aspen Group
Project :	Lot 2 South Western Highway, Byford
Location :	Lot 2 South Western Highway, Byford
Date excavated	21/2/08
Date completed	21/2/08
Logged by :	PW
Checked by :	

Position : E: 406810.3, N: 6434063.3 (50 MGA94) Surface Elevation : 65m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	penetration (VE E F H)	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components)	moisture condition	consistency / relative density	hand penetrometer kPa (100 200 300 400)	structure and additional observations
			Not Observed		65.0	0.0			**TOPSOIL**, fine to medium, grey; trace rootlets	D	MD		
								SM	**SILTY SAND**, fine to coarse grained, off white; trace of gravel, medium to fine grained		MD		
					64.5	0.5		GP-GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, low plasticity, brown; sand, medium to fine grained	M	St - VSt		
					64.0	1.0							
					63.5	1.5							
					63.0	2.0							
									EXCAVATION TP6 TERMINATED AT 2.20 m				
					62.5	2.5							
					62.0	3.0							
					61.5	3.5							

COFFEY_02.GLB Log EXCAVATION GH08278AC - EXCAVATION.GPJ <<DrawingFile>> 29/04/2008 09:51

method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration
VE E F H

water
- 10 Oct., 73 Water Level on Date shown
- water inflow
- water outflow

samples & field tests
- U50 - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- E - Environmental Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa)
- PBT - Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
- D - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

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Engineering Log - Excavation

Excavation No.	TP7
Sheet No.	1 of 1
Project No.	GEOTHERD08278AC
Date excavated	21/2/08
Date completed	21/2/08
Logged by :	PW
Checked by :	

Client : *Wood & Grieve Engineers*

Principal : *Aspen Group*

Project : *Lot 2 South Western Highway, Byford*

Location : *Lot 2 South Western Highway, Byford*

Position : E: 406875.3, N: 6434096 (50 MGA94) Surface Elevation : 66.8m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	VE E F H penetration	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description: SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa 100 200 300 400	structure and additional observations
BH			Not Observed		66.5	0.0			**TOPSOIL**, fine to medium, grey; trace of rootlets	D	MD		
								SM	**SILTY SAND**, fine to coarse grained, off white; trace of gravel, medium to fine grained		MD		
					66.0	0.5		GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, low plasticity, brown; sand, medium to fine grained	M	St - VSt		
					65.5	1.0							
					65.0	1.5							
					64.5	2.0							
					64.0	2.5			EXCAVATION TP7 TERMINATED AT 2.30 m				
					63.5	3.0							
					63.0	3.5							

COFFEY_02.GLB Log EXCAVATION GH08278AC - EXCAVATION.GPJ <<DrawingFile>> 29/04/2008 09:51

method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration
VE E F H VH

water
- 10 Oct., 73 Water Level on Date shown
- water inflow
- water outflow

samples & field tests
- U50 - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- E - Environmental Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa)
- PBT - Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
- D - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

coffey geotechnics

Engineering Log - Excavation

		Excavation No.	TP8
		Sheet No.	1 of 1
		Project No.	GEOTHERD08278AC
Client :	Wood & Grieve Engineers	Date excavated	21/2/08
Principal :	Aspen Group	Date completed	21/2/08
Project :	Lot 2 South Western Highway, Byford	Logged by :	PW
Location :	Lot 2 South Western Highway, Byford	Checked by :	

Position : E: 406869.8, N: 66133959 (50 MGA94) Surface Elevation : 67.2m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	penetration	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description: SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa	structure and additional observations
BH	VE E F H VH		Not Observed		67.0	0.0			**TOPSOIL**, fine to medium, grey; trace of rootlets and fines	D	MD		
					66.5	0.5		GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, low plasticity, brown; sand, medium to fine grained	M	St - VSt		
					66.0	1.0							
					65.5	1.5							
					65.0	2.0			EXCAVATION TP8 TERMINATED AT 2.20 m				
					64.5	2.5							
					64.0	3.0							
					63.5	3.5							

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method
N Natural Exposure
X Existing Excavation
BH Backhoe Bucket
B Bulldozer Blade
R Ripper
E Excavator

support
T Timbering

penetration
VE E F H VH

water
10 Oct., 73 Water Level on Date shown
water inflow
water outflow

samples & field tests
U50 - Undisturbed Sample 50mm diameter
U63 - Undisturbed Sample 63mm diameter
D - Disturbed Sample
B - Bulk Disturbed Sample
E - Environmental Sample
MC - Moisture Content
HP - Hand Penetrometer (UCS kPa)
VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT - Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
D - Dry
M - Moist
W - Wet
W_P - Plastic Limit
W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

coffey geotechnics

Engineering Log - Excavation

		Excavation No.	*TP9*
		Sheet No.	1 of 1
		Project No.	*GEOTHERD08278AC*
Client :	*Wood & Grieve Engineers*	Date excavated	*21/2/08*
Principal :	*Aspen Group*	Date completed	*21/2/08*
Project :	*Lot 2 South Western Highway, Byford*	Logged by :	*PW*
Location :	*Lot 2 South Western Highway, Byford*	Checked by :	

Position : E: 406693.8, N: 6434228 (50 MGA94) Surface Elevation : 63m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	penetration (VE E F H)	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components)	moisture condition	consistency / relative density	hand penetrometer kPa (100 200 300 400)	structure and additional observations
BH			Not Observed	B	63.0	0.0			**TOPSOIL**, fine to medium, grey; trace of rootlets and fines	D	MD		
								SM	**SILTY SAND**, fine to coarse grained, off white; trace of gravel, medium to fine grained		MD		
								GP-GC	**SANDY GRAVEL**, fine to medium grained, off white; sand, medium to fine grained				
					62.5	0.5		GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, medium plasticity, brown; sand, medium to fine grained	M	St - VSt		
					62.0	1.0							
					61.5	1.5							
					61.0	2.0			EXCAVATION TP9 TERMINATED AT 2.00 m				
					60.5	2.5							
					60.0	3.0							
					59.5	3.5							

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method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration (VE E F H VH)

water
- 10 Oct., 73 Water Level on Date shown
- water inflow
- water outflow

samples & field tests
- U50 - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- E - Environmental Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa)
- PBT - Plate Bearing Test

classification symbols & soil description Based on Unified Classification System

moisture
- D - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

coffey geotechnics

Engineering Log - Excavation

		Excavation No.	TP10
		Sheet No.	1 of 1
		Project No.	GEOTHERD08278AC
Client :	Wood & Grieve Engineers	Date excavated	21/2/08
Principal :	Aspen Group	Date completed	21/2/08
Project :	Lot 2 South Western Highway, Byford	Logged by :	PW
Location :	Lot 2 South Western Highway, Byford	Checked by :	

Position : E: 406694.4, N: 6434295.6 (50 MGA94) Surface Elevation : 62.8m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	VE penetration E F H	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description: SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa 100 200 300 400	structure and additional observations
BH			Not Observed		62.5	0.0			**TOPSOIL**, fine to medium, grey; trace of rootlets	D	MD		
								SM	**SILTY SAND**, fine to coarse grained, off white; trace of gravel, medium to fine grained		MD		
					62.0	0.5		GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, low plasticity, brown mottled grey; sand, medium to fine grained	M	St		
					61.5	1.0							
					61.0	1.5							
					60.5	2.0			EXCAVATION TP10 TERMINATED AT 2.20 m				
					60.0	2.5							
					59.5	3.0							
					59.0	3.5							

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method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration VE E F H VH

water
- 10 Oct., 73 Water Level on Dete shown
- water inflow
- water outflow

samples & field tests
- U50 - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- E - Environmental Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
- PBT - Plate Bearing Test

classification symbols & soil description Based on Unified Classification System

moisture
- D - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

coffey geotechnics

Engineering Log - Excavation

		Excavation No.	TP11
		Sheet No.	1 of 1
		Project No.	GEOTHERD08278AC
Client :	Wood & Grieve Engineers	Date excavated	21/2/08
Principal :	Aspen Group	Date completed	21/2/08
Project :	Lot 2 South Western Highway, Byford	Logged by :	PW
Location :	Lot 2 South Western Highway, Byford	Checked by :	

Position : E: 406713.4, N: 6434404.5 (50 MGA94) Surface Elevation : 62.6m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	penetration (VE E F H)	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description: SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa (100 200 300 400)	structure and additional observations
			Not Observed		62.5	0.0			**TOPSOIL**, fine to medium, grey; trace of rootlets	D	MD		
								SM	**SILTY SAND**, fine to coarse grained, off white; trace of gravel, medium to fine grained		MD		
					62.0	0.5		GP-GC	**SANDY GRAVEL**, fine to medium grained, off white; sand, medium to fine grained				
					61.5	1.0		GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, low plasticity, brown; sand, medium to fine grained	M	VSt		
					61.0	1.5			....trace medium to fine grained gravel				
					60.5	2.0							
					60.0	2.5			EXCAVATION TP11 TERMINATED AT 2.30 m				
					59.5	3.0							
					59.0	3.5							

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method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration (VE E F H VH)

water
- 10 Oct., 73 Water Level on Date shown
- water inflow
- water outflow

samples & field tests
- U50 - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- E - Environmental Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
- PBT - Plate Bearing Test

classification symbols & soil description
Based on Unified Classificetion System

moisture
- D - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

coffey geotechnics

Engineering Log - Excavation

		Excavation No.	TP12
		Sheet No.	1 of 1
		Project No.	GEOTHERD08278AC
Client :	Wood & Grieve Engineers	Date excavated	21/2/08
Principal :	Aspen Group	Date completed	21/2/08
Project :	Lot 2 South Western Highway, Byford	Logged by :	PW
Location :	Lot 2 South Western Highway, Byford	Checked by :	

Position : E: 4067169, N: 6434492.8 (50 MGA94) Surface Elevation : 62.8m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	penetration	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components)	moisture condition	consistency / relative density	hand penetrometer kPa	structure and additional observations
BH	VE E F H		Not Observed	B	62.5	0.0			**TOPSOIL**, fine to medium, grey; trace of rootlets	D	MD	100 200 300 400	
								SM	**SILTY SAND**, fine to coarse grained, off white; trace of gravel, medium to fine grained		MD		
						0.5		GP-GC	**SANDY GRAVEL**, fine to medium grained, off white; sand, medium to fine grained; trace of low plasticity fines				
					62.0	1.0		GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, low plasticity, brown; sand, medium to fine grained ....trace medium to fine grained gravel	D - M	VSt		
					61.5	1.5							
					61.0	2.0							
					60.5	2.5			EXCAVATION TP12 TERMINATED AT 2.30 m				
					60.0	3.0							
					59.5	3.5							
					59.0								

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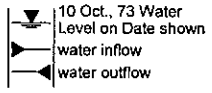
method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration

water



samples & field tests
- U50 - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- E - Environmental Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPe)
- VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa)
- PBT - Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
- D - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

coffey geotechnics

Engineering Log - Excavation

Excavation No.	TP13
Sheet No.	1 of 1
Project No.	GEOTHERD08278AC
Date excavated	21/2/08
Date completed	21/2/08
Logged by :	PW
Checked by :	

Client : *Wood & Grieve Engineers*

Principal : *Aspen Group*

Project : *Lot 2 South Western Highway, Byford*

Location : *Lot 2 South Western Highway, Byford*

Position : E: 406642.6, N: 6434477.5 (50 MGA94) Surface Elevation : 60.4m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	penetration	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components)	moisture condition	consistency / relative density	hand penetrometer kPa	structure and additional observations
BH	VE E F H		Not Observed	B	60.0	0.0			**TOPSOIL**, fine to medium, grey; trace of rootlets	D	MD	100 200 300 400	
								SM	**SILTY SAND**, fine to coarse grained, off white; trace of gravel, medium to fine grained		MD		
						0.5		GP-GC	**SANDY GRAVEL**, fine to medium grained, white; sand, medium to fine grained				
					59.5	1.0		GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, medium plasticity, brown; sand, medium to fine grained	D - M	VSt		
					59.0	1.5			....trace medium to fine grained gravel				
					58.5	2.0							
					58.0	2.5			EXCAVATION TP13 TERMINATED AT 2.20 m				
					57.5	3.0							
					57.0	3.5							
					56.5								

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method
N Natural Exposure
X Existing Excavation
BH Backhoe Bucket
B Bulldozer Blade
R Ripper
E Excavator

support
T Timbering

penetration
VE E F H VH

water
10 Oct., 73 Water Level on Date shown
water inflow
water outflow

samples & field tests
U50 - Undisturbed Sample 50mm diameter
U63 - Undisturbed Sample 63mm diameter
D - Disturbed Sample
B - Bulk Disturbed Sample
E - Environmental Sample
MC - Moisture Content
HP - Hand Penetrometer (UCS kPa)
VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa)
PBT - Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
D - Dry
M - Moist
W - Wet
W_P - Plastic Limit
W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

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Engineering Log - Excavation

Excavation No.	TP14
Sheet No.	1 of 1
Project No.	GEOTHERD08278AC
Client :	Wood & Grieve Engineers
Principal :	Aspen Group
Project :	Lot 2 South Western Highway, Byford
Location :	Lot 2 South Western Highway, Byford
Date excavated	21/2/08
Date completed	21/2/08
Logged by :	PW
Checked by :	

Position : E: 406621.8, N: 643449.1 (50 MGA94) Surface Elevation : 60.6m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	penetration	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description: SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa	structure and additional observations
BH	VE E F H		21/02/08		60.5	0.0			**TOPSOIL**, fine to medium, grey; trace of rootlets	D	MD	100 200 300 400	
								SM	**SILTY SAND**, fine to coarse grained, off white; trace of gravel, medium to fine grained		MD		
					60.0	0.5		GP-GC	**SANDY GRAVEL**, fine to medium grained, off white; sand, medium to fine grained				
					59.5	1.0		GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, low plasticity, pale brown; sand, medium to fine grained	M	St - VSt		
					59.0	1.5			....trace medium to fine grained gravel				
					58.5	2.0							
					58.0	2.5			EXCAVATION TP14 TERMINATED AT 2.40 m				
					57.5	3.0							
					57.0	3.5							

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method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration

VE E F H

water
- 10 Oct., 73 Water Level on Date shown
- water inflow
- water outflow

samples & field tests
- U50 - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- E - Environmental Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa)
- PBT - Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
- D - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

coffey geotechnics

Engineering Log - Excavation

Excavation No.	TP15
Sheet No.	1 of 1
Project No.	GEOTHERD08278AC
Date excavated	21/2/08
Date completed	21/2/08
Logged by :	PW
Checked by :	

Client : *Wood & Grieve Engineers*

Principal : *Aspen Group*

Project : *Lot 2 South Western Highway, Byford*

Location : *Lot 2 South Western Highway, Byford*

Position : E: 406603.5, N: 6434318 (50 MGA94) Surface Elevation : 60.8m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	penetration	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components)	moisture condition	consistency / relative density	hand penetrometer kPa	structure and additional observations
BH	VE E F H		Not Observed	B	60.5	0.0			**TOPSOIL**, fine to medium, grey; trace rootlets	D - M	MD	100 200 300 400	
								SM	**SILTY SAND**, fine to coarse grained, off white; trace of gravel, medium to fine grained; trace of fines		MD		
					60.0	0.5		GP-GC	**SANDY GRAVEL**, fine to medium grained, off white; sand, medium to fine grained; trace of low plasticity fines				
					59.5	1.0		GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, low plasticity, brown; sand, medium to fine grained	M	St - VSt		
					59.0	1.5			....trace medium to fine grained gravel				
					58.5	2.0			EXCAVATION TP15 TERMINATED AT 2.30 m				
					58.0	2.5							
					57.5	3.0							
					57.0	3.5							

method
N Natural Exposure
X Existing Excavation
BH Backhoe Bucket
B Bulldozer Blade
R Ripper
E Excavator

support
T Timbering

penetration VE E F H VH

water
10 Oct., 73 Water Level on Date shown
water inflow
water outflow

samples & field tests
U50 - Undisturbed Sample 50mm diameter
U63 - Undisturbed Sample 63mm diameter
D - Disturbed Sample
B - Bulk Disturbed Sample
E - Environmental Sample
MC - Moisture Content
HP - Hand Penetrometer (UCS kPa)
VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa)
PBT - Plate Bearing Test

classification symbols & soil description Based on Unified Classification System

moisture
D - Dry
M - Moist
W - Wet
W_P - Plastic Limit
W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

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Engineering Log - Excavation

		Excavation No.	TP16
		Sheet No.	1 of 1
		Project No.	GEOTHERD08278AC
Client :	Wood & Grieve Engineers	Date excavated	21/2/08
Principal :	Aspen Group	Date completed	21/2/08
Project :	Lot 2 South Western Highway, Byford	Logged by :	PW
Location :	Lot 2 South Western Highway, Byford	Checked by :	

Position : E: 406775, N: 6434186.8 (50 MGA94) Surface Elevation : 64.8m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	penetration	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description: SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components	moisture condition	consistency / relative density	hand penetrometer 100 200 300 400 kPa	structure end additional observations
BH	VE E F H		Not Observed		64.5	0.0			**TOPSOIL**, fine to medium, grey; trace rootlets	D	MD		
								SM	**SILTY SAND**, fine to medium grained, off white; trace of gravel, medium to fine grained	D - M	MD		
						0.5		GP-GC	**SANDY GRAVEL**, fine to medium grained, off white; sand, medium to fine grained				
					64.0			GC	**SANDY CLAYEY CLAY**, fine to medium, low plasticity, brown; sand, medium to fine grained		St - VSt		
						1.0			....trace medium to fine grained gravel				
					63.5								
					63.0	1.5							
						2.0							
					62.5								
						2.5			EXCAVATION TP16 TERMINATED AT 2.40 m				
					62.0								
						3.0							
					61.5								
						3.5							
					61.0								

COFFEY_02.GLB Log EXCAVATION GH08278AC - EXCAVATION.GPJ <<DrawingFile>> 29/04/2008 11:12

method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration VE E F H VH

water
- 10 Oct., 73 Water Level on Date shown
- water inflow
- water outflow

samples & field tests
- U50 - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- E - Environmental Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
- PBT - Plate Bearing Test

classification symbols & soil description Based on Unified Classification System

moisture
- D - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

coffey geotechnics

Engineering Log - Excavation

		Excavation No.	TP17
		Sheet No.	1 of 1
		Project No.	GEOTHERD08278AC
Client :	Wood & Grieve Engineers	Date excavated	21/2/08
Principal :	Aspen Group	Date completed	21/2/08
Project :	Lot 2 South Western Highway, Byford	Logged by :	PW
Location :	Lot 2 South Western Highway, Byford	Checked by :	

Position : E: 406788, N: 6434257.5 (50 MGA94) Surface Elevation : 64.6m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	penetration (VE E F H)	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description: SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa (100 200 300 400)	structure and additional observations
BH			Not Observed		64.5	0.0			**TOPSOIL**, fine to medium, grey; trace rootlets	D	MD		
								SM	**SILTY SAND**, fine to medium grained, off white; trace of gravel, medium to fine grained; from depth 0.3m		MD		
								GP-GC	**SANDY GRAVEL**, fine to medium grained, off white; sand, medium to fine grained				
					64.0	0.5		GC	**SANDY CLAYEY CLAY**, fine to medium, low plasticity, brown; sand, medium to fine grained	D - M	St - VSt		
					63.5	1.0			....trace medium to fine grained gravel				
					63.0	1.5							
					62.5	2.0							
					62.0	2.5			EXCAVATION TP17 TERMINATED AT 2.30 m				
					61.5	3.0							
					61.0	3.5							

COFFEY_02.GLB Log EXCAVATION GH08278AC - EXCAVATION.GPJ <<DrawingFile>> 29/04/2008 11:13

method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration (VE E F H VH)

water
- 10 Oct., 73 Water Level on Date shown
- water inflow
- water outflow

samples & field tests
- U50 - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- E - Environmental Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa)
- PBT - Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
- D - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

coffey geotechnics

Engineering Log - Excavation

		Excavation No.	TP18
		Sheet No.	1 of 1
		Project No.	GEOTHERD08278AC
Client :	Wood & Grieve Engineers	Date excavated	21/2/08
Principal :	Aspen Group	Date completed	21/2/08
Project :	Lot 2 South Western Highway, Byford	Logged by :	PW
Location :	Lot 2 South Western Highway, Byford	Checked by :	

Position : E: 406786.2, N: 6434365.9 (50 MGA94) Surface Elevation : 64.8m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information						material substance						
method	penetration (VE E F H)	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description: SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa (100 200 300 400)	structure and additional observations
BH			Not Observed		64.5	0.0			**TOPSOIL**, fine to medium, grey; trace of rootlets	D	MD		
								SM	**SILTY SAND**, fine to medium grained, off white; trace of gravel, medium to fine grained		MD		
						0.5		GP-GC	**SANDY GRAVEL**, fine to medium grained, off white; sand, medium to fine grained				
					64.0			GC	**SANDY CLAYEY CLAY**, fine to medium, low plasticity, brown; sand, medium to fine grained	D - M	St - VSt		
						1.0			....trace medium to fine grained gravel				
					63.5								
					63.0	1.5							
						2.0			EXCAVATION TP18 TERMINATED AT 2.10 m				
					62.5	2.5							
					62.0	3.0							
					61.5	3.5							
					61.0								

COFFEY_02.GLB Log EXCAVATION GH08278AC - EXCAVATION.GPJ <<DrawingFile>> 29/04/2008 11:13

method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration
VE E F H VH

water
- 10 Oct., 73 Water Level on Date shown
- water inflow
- water outflow

samples & field tests
- U50 - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- E - Environmental Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa)
- PBT - Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
- D - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

coffey geotechnics

Engineering Log - Excavation

		Excavation No.	TP19
		Sheet No.	1 of 1
		Project No.	GEOTHERD08278AC
Client :	Wood & Grieve Engineers	Date excavated	21/2/08
Principal :	Aspen Group	Date completed	21/2/08
Project :	Lot 2 South Western Highway, Byford	Logged by :	PW
Location :	Lot 2 South Western Highway, Byford	Checked by :	

Position : E: 406785.9, N: 6434466.2 (50 MGA94) Surface Elevation : 65m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	penetration	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components)	moisture condition	consistency / relative density	hand penetrometer kPa	structure and additional observations
BH	VE E F H		Not Observed		65.0	0.0			**TOPSOIL**, fine to medium, grey; trace of rootlets	D	MD	100 200 300 400	
								SM	**SILTY SAND**, fine to coarse grained, off white; trace of gravel, medium to fine grained		MD		
								GP-GC	**SANDY GRAVEL**, fine to medium grained, off white; sand, medium to fine grained				
					64.5	0.5		GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, low plasticity, brown; sand, medium to fine grained		VSt		
					64.0	1.0							
					63.5	1.5			....trace of medium to fine grained gravel	M	St - VSt		
					63.0	2.0							
									EXCAVATION TP19 TERMINATED AT 2.10 m				
					62.5	2.5							
					62.0	3.0							
					61.5	3.5							

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method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration

VE E F H VH

water

10 Oct., 73 Water Level on Date shown
water inflow
water outflow

samples & field tests
- U50 - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- E - Environmental Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
- PBT - Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
- D - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

coffey geotechnics

Engineering Log - Excavation

Excavation No.	TP20
Sheet No.	1 of 1
Project No.	GEOTHERD08278AC
Date excavated	21/2/08
Date completed	21/2/08
Logged by :	PW
Checked by :	

Client : *Wood & Grieve Engineers*

Principal : *Aspen Group*

Project : *Lot 2 South Western Highway, Byford*

Location : *Lot 2 South Western Highway, Byford*

Position : E: 406880.2, N: 6434481.3 (50 MGA94) Surface Elevation : 67.6m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information						material substance						
method	penetration (VE E F H)	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description: SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa (100 200 300 400)	structure and additional observations
BH			Not Observed		67.5	0.0			**TOPSOIL**, fine to medium, grey; trace rootlets	D	MD		
								SM	**SILTY SAND**, fine to coarse grained, off white; trace of gravel, medium to fine grained		MD		
								GP-GC	**SANDY GRAVEL**, fine to medium grained, off white; sand, medium to fine grained				
					67.0	0.5		GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, low plasticity, brown; sand, medium to fine grained	D - M	VSt		
					66.5	1.0			....trace medium to fine grained gravel				
					66.0	1.5							
					65.5	2.0							
					65.0	2.5			EXCAVATION TP20 TERMINATED AT 2.20 m				
					64.5	3.0							
					64.0	3.5							

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method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration (VE E F H VH)

water
- 10 Oct., 73 Water Level on Date shown
- water inflow
- water outflow

samples & field tests
- U50 - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- E - Environmental Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa)
- PBT - Plate Bearing Test

classification symbols & soil description Based on Unified Classification System

moisture
- D - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

coffey geotechnics

Engineering Log - Excavation

		Excavation No.	TP21
		Sheet No.	1 of 1
		Project No.	GEOTHERD08278AC
Client :	Wood & Grieve Engineers	Date excavated	22/2/08
Principal :	Aspen Group	Date completed	22/2/08
Project :	Lot 2 South Western Highway, Byford	Logged by :	PW
Location :	Lot 2 South Western Highway, Byford	Checked by :	

Position : E: 406853.9, N: 6434365.7 (50 MGA94) Surface Elevation : 67.2m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	penetration	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description: SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa	structure and additional observations
BH	VE E F H		Not Observed		67.0	0.0			**TOPSOIL**, fine to medium, grey; trace of rootlets	D	MD	100 200 300 400	
								SM	**SILTY SAND**, fine to coarse grained, off white; trace of gravel, medium to fine grained		MD		
								GP-GC	**SANDY GRAVEL**, fine to medium grained, off white; sand, medium to fine grained				
					66.5	0.5		GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, low plasticity, brown; sand, medium to fine grained	D - M	St - VSt		
					66.0	1.0							
					65.5	1.5							
					65.0	2.0							
									EXCAVATION TP21 TERMINATED AT 2.30 m				
					64.5	2.5							
					64.0	3.0							
					63.5	3.5							

COFFEY_02.GLB Log EXCAVATION GH08278AC - EXCAVATION.GPJ <<DrawingFile>> 29/04/2008 09:46

method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration

VE E F H

water
- 10 Oct., 73 Water Level on Date shown
- water inflow
- water outflow

samples & field tests
- U50 - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- E - Environmental Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa)
- PBT - Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
- D - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

coffey geotechnics

Engineering Log - Excavation

Excavation No.	TP22
Sheet No.	1 of 1
Project No.	GEOTHERD08278AC
Client :	Wood & Grieve Engineers
Principal :	Aspen Group
Project :	Lot 2 South Western Highway, Byford
Location :	Lot 2 South Western Highway, Byford
Date excavated	21/2/08
Date completed	21/2/08
Logged by :	PW
Checked by :	

Position : E: 406868.7, N: 6434248.5 (50 MGA94) Surface Elevation : 66.4m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	penetration	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description: SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa	structure and additional observations
BH	VE E F H VH		21/02/08		66.0	0.0			**TOPSOIL**, fine to medium, grey; trace of rootlets	D	MD	100 200 300 400	
								SM	**SILTY SAND**, fine to coarse grained, off white; trace of gravel, medium to fine grained		MD		
					65.5	0.5		GP-GC	**SANDY GRAVEL**, fine to medium grained, off white; sand, medium to fine grained				
								GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, low plasticity, brown; sand, medium to fine grained	M	St - VSt		
					65.0	1.0							
					64.5	1.5							
					64.0	2.0			EXCAVATION TP22 TERMINATED AT 2.30 m				
					63.5	2.5							
					63.0	3.0							
					62.5	3.5							

COFFEY_02.GLB Log EXCAVATION GH08278AC - EXCAVATION.GPJ <<DrawingFile>> 28/04/2008 09:46

method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration

VE E F H VH

water

10 Oct., 73 Water Level on Date shown
water inflow
water outflow

samples & field tests
- U50 - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- E - Environmental Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa)
- PBT - Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
- O - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

coffey geotechnics

Engineering Log - Excavation

		Excavation No.	TP23
		Sheet No.	1 of 1
		Project No.	GEOTHERD08278AC
Client :	Wood & Grieve Engineers	Date excavated	21/2/08
Principal :	Aspen Group	Date completed	21/2/08
Project :	Lot 2 South Western Highway, Byford	Logged by :	PW
Location :	Lot 2 South Western Highway, Byford	Checked by :	

Position : E: 406867.4, N: 6434133.5 (50 MGA94) Surface Elevation : 64.2m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	penetration (VE E F H)	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description: SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa (100 200 300 400)	structure and additional observations
BH			Not Observed		64.0	0.0			**TOPSOIL**, fine to medium, grey; trace rootlets	D	MD		
						0.5		GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, low plasticity, brown; sand, medium to fine grained; with some cobbles; after depth 0.4-1.2m	D - M	St - VSt		
					63.5								
					63.0	1.0							
				B	62.5	1.5		SC	**CLAYEY SAND**, fine to coarse grained, medium plasticity, grey; trace of fines	M	VSt		
					62.0	2.0							
									EXCAVATION TP23 TERMINATED AT 2.30 m				
					61.5	2.5							
					61.0	3.0							
					60.5	3.5							

COFFEY_02.GLB Log EXCAVATION GH08278AC - EXCAVATION.GPJ <<DrawingFile>> 29/04/2008 09:46

method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration (VE E F H VH)

water
- 10 Oct., 73 Water Level on Date shown
- water inflow
- water outflow

samples & field tests
- U50 - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- E - Environmental Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
- PBT - Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
- D - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

coffey geotechnics

Engineering Log - Excavation

Excavation No.	TP24
Sheet No.	1 of 1
Project No.	GEOTHERD08278AC
Date excavated	22/2/08
Date completed	22/2/08
Logged by	PW
Checked by	

Client : *Wood & Grieve Engineers*

Principal : *Aspen Group*

Project : *Lot 2 South Western Highway, Byford*

Location : *Lot 2 South Western Highway, Byford*

Position : E: 406937.4, N: 6434220.5 (50 MGA94) Surface Elevation : 67.6m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information							material substance					
method	VE penetration E F H	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description: SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components	moisture condition	consistency / relative density	hand penetrometer 100 200 300 400 kPa	structure and additional observations
BH			22/02/08		67.5	0.0			**TOPSOIL**, fine to medium, grey; trace of rootlets	D	MD		
								SM	**SILTY SAND**, fine to coarse grained, off white; trace of gravel, medium to fine grained; from 0.4-0.6m	D - M	MD		
					67.0	0.5		GP-GC	**SANDY GRAVEL**, fine to medium grained, off white; sand, medium to fine grained				
								GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, low plasticity, brown mottled grey; sand, medium to fine grained	M	St - VSt		
					66.5	1.0							
									....trace medium to fine grained gravel				
					66.0	1.5							
					65.5	2.0							
									EXCAVATION TP24 TERMINATED AT 2.30 m				
					65.0	2.5							
					64.5	3.0							
					64.0	3.5							

COFFEY_02.GLB Log EXCAVATION GH08278AC - EXCAVATION.GPJ <<DrawingFile>> 29/04/2008 09:47

method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration
VE E F H VH

water
- 10 Oct., 73 Water Level on Date shown
- water inflow
- water outflow

samples & field tests
- U50 - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- E - Environmental Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
- PBT - Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
- D - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

coffey geotechnics

Engineering Log - Excavation

		Excavation No.	TP25
		Sheet No.	1 of 1
		Project No.	GEOTHERD08278AC
Client :	Wood & Grieve Engineers	Date excavated	22/2/08
Principal :	Aspen Group	Date completed	22/2/08
Project :	Lot 2 South Western Highway, Byford	Logged by :	PW
Location :	Lot 2 South Western Highway, Byford	Checked by :	

Position : E: 406953.5, N: 6434358.5 (50 MGA94) Surface Elevation : 69.8m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	penetration (VE E F H VH)	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components)	moisture condition	consistency / relative density	hand penetrometer kPa (100 200 300 400)	structure and additional observations
BH			Not Observed		69.5	0.0			**TOPSOIL**, fine to medium, grey; trace rootlets	D	MD		
								SM	**SILTY SAND**, fine to coarse grained, off white; trace of gravel, medium to fine grained; trace of tree roots		MD		
						0.5		GP-GC	**SANDY GRAVEL**, fine to medium grained, off white; sand, medium to fine grained; trace of tree roots				
					69.0			GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, low plasticity, brown mottled grey; sand, medium to fine grained	D - M	St - VSt		
					68.5	1.0			....trace medium to fine grained gravel				
					68.0	1.5							
					67.5	2.0			EXCAVATION TP25 TERMINATED AT 2.30 m				
					67.0	2.5							
					66.5	3.0							
					66.0	3.5							

method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration (VE E F H VH)

water
- 10 Oct., 73 Water Level on Date shown
- water inflow
- water outflow

samples & field tests
- U50 - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- E - Environmental Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa)
- PBT - Plate Bearing Test

classification symbols & soil description Based on Unified Classification System

moisture
- D - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

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Engineering Log - Excavation

		Excavation No.	TP26
		Sheet No.	1 of 1
		Project No.	GEOTHERD08278AC
Client :	Wood & Grieve Engineers	Date excavated	22/2/08
Principal :	Aspen Group	Date completed	22/2/08
Project :	Lot 2 South Western Highway, Byford	Logged by :	PW
Location :	Lot 2 South Western Highway, Byford	Checked by :	

Position : E: 406967.1, N: 6434488.6 (50 MGA94) Surface Elevation : 70.2m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	penetration	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components)	moisture condition	consistency / relative density	hand penetrometer kPa	structure and additional observations
BH	VE E F H		Not Observed		70.0	0.0			**TOPSOIL**, fine to medium, grey; trace rootlets	D	MD	100 200 300 400	
								SM	**SILTY SAND**, fine to coarse grained, off white; with some gravel, medium to fine grained; trace of tree roots		MD		
								GP-GC	**SANDY GRAVEL**, fine to medium grained, off white; sand, medium to fine grained; trace of tree roots				
					69.5	0.5		GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, low plasticity, brown mottled grey; sand, medium to fine grained	D - M	St - VSt		
					69.0	1.0			....trace medium to fine grained gravel				
					68.5	1.5							
					68.0	2.0							
					67.5	2.5			EXCAVATION TP26 TERMINATED AT 2.30 m				
					67.0	3.0							
					66.5	3.5							

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method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration

VE E F H

water
- 10 Oct., 73 Water Level on Date shown
- water inflow
- water outflow

samples & field tests
- U50 - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- E - Environmental Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa)
- PBT - Plate Bearing Test

classification symbols & soil description Based on Unified Classification System

moisture
- D - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

coffey geotechnics

Engineering Log - Excavation

		Excavation No.	TP27
		Sheet No.	1 of 1
		Project No.	GEOTHERD08278AC
Client :	Wood & Grieve Engineers	Date excavated	22/2/08
Principal :	Aspen Group	Date completed	22/2/08
Project :	Lot 2 South Western Highway, Byford	Logged by :	PW
Location :	Lot 2 South Western Highway, Byford	Checked by :	

Position : E: 407062.7, N: 6434498.2 (50 MGA94) Surface Elevation : 73.8m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	penetration (VE E F H)	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components)	moisture condition	consistency / relative density	hand penetrometer kPa (100 200 300 400)	structure and additional observations
BH			Not Observed		73.5	0.0			**TOPSOIL**, fine to medium, grey; trace of rootlets	D	MD		
								SM	**SILTY SAND**, fine to coarse grained, off white; trace of gravel, medium to fine grained		MD		
					73.0	0.5		GP-GC	**SANDY GRAVEL**, fine to medium grained, off white; sand, medium to fine grained				
								GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, low plasticity, brown mottled grey; sand, medium to fine grained	D - M	St - VSt		
					72.5	1.0			....no gravel				
					72.0	1.5							
					71.5	2.0			EXCAVATION TP27 TERMINATED AT 2.30 m				
					71.0	2.5							
					70.5	3.0							
					70.0	3.5							

method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration (VE E F H)

water
- 10 Oct., 73 Water Level on Date shown
- water inflow
- water outflow

samples & field tests
- U50 - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- E - Environmental Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa)
- PBT - Plate Bearing Test

classification symbols & soil description Based on Unified Classification System

moisture
- D - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

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Engineering Log - Excavation

		Excavation No.	TP28
		Sheet No.	1 of 1
		Project No.	GEOTHERD08278AC
Client :	Wood & Grieve Engineers	Date excavated	22/2/08
Principal :	Aspen Group	Date completed	22/2/08
Project :	Lot 2 South Western Highway, Byford	Logged by :	PW
Location :	Lot 2 South Western Highway, Byford	Checked by :	

Position : E: 407172.5, N: 6434505.1 (50 MGA94) Surface Elevation : 78.2m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	penetration	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description: SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa	structure and additional observations
BH	VE E F H		Not Observed		78.0	0.0			**TOPSOIL**, fine to medium, grey; trace rootlets	D	MD	100 200 300 400	
								SM	**SILTY SAND**, fine to coarse grained, off white; trace of gravel, medium to fine grained		MD		
								GP-GC	**SANDY GRAVEL**, fine to medium grained, off white; sand, medium to fine grained				
					77.5	0.5		GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, low plasticity, brown mottled grey; sand, medium to fine grained	D - M	St - VSt		
						1.0			....trace medium to fine grained gravel				
					77.0								
						1.5							
					76.5								
						2.0							
					76.0				EXCAVATION TP28 TERMINATED AT 2.20 m				
						2.5							
					75.5								
						3.0							
					75.0								
						3.5							
					74.5								

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method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration

VE E F H VH

water

10 Oct., 73 Water Level on Date shown
water inflow
water outflow

samples & field tests
- U50 - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- E - Environmental Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
- PBT - Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
- D - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

coffey geotechnics

Engineering Log - Excavation

Excavation No.	TP29
Sheet No.	1 of 1
Project No.	GEOTHERD08278AC
Date excavated	22/2/08
Date completed	22/2/08
Logged by :	PW
Checked by :	

Client : *Wood & Grieve Engineers*

Principal : *Aspen Group*

Project : *Lot 2 South Western Highway, Byford*

Location : *Lot 2 South Western Highway, Byford*

Position : E: 407302, N: 6434510.3 (50 MGA94) Surface Elevation : 84.6m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	penetration	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components)	moisture condition	consistency / relative density	hand penetrometer 100 200 300 400 kPa	structure and additional observations
BH	VE E F H		Not Observed		84.5	0.0			**TOPSOIL**, fine to medium, grey; trace of organic material and rootlets	D	MD		
								SM	**SILTY SAND**, fine to coarse grained, off white; trace of gravel, medium to fine grained; trace of tree roots		MD		
					84.0	0.5		GP-GC	**SANDY GRAVEL**, fine to medium grained, off white; sand, medium to fine grained; trace of cobbles, medium to fine grained; trace of tree roots				
								GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, low plasticity, brown; sand, medium to fine grained; trace of cobbles to depth 1.2m	D - M	St - VSt		
					83.5	1.0							
					83.0	1.5							
					82.5	2.0							
									EXCAVATION TP29 TERMINATED AT 2.20 m				
					82.0	2.5							
					81.5	3.0							
					81.0	3.5							

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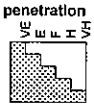
method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration



water

10 Oct., 73 Water Level on Date shown
water inflow
water outflow

samples & field tests
- U50 - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- E - Environmental Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
- PBT - Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
- D - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

coffey geotechnics

Engineering Log - Excavation

		Excavation No.	TP30
		Sheet No.	1 of 1
		Project No.	GEOTHERD08278AC
Client :	Wood & Grieve Engineers	Date excavated	22/2/08
Principal :	Aspen Group	Date completed	22/2/08
Project :	Lot 2 South Western Highway, Byford	Logged by :	PW
Location :	Lot 2 South Western Highway, Byford	Checked by :	

Position : E: 407049.8, N: 6434350.5 (50 MGA94) Surface Elevation : 71.8m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	VE penetration E F H	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description: SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components	moisture condition	consistency / relative density	hand penetrometer 100 200 300 400 kPa	structure and additional observations
BH			Not Observed		71.5	0.0			**TOPSOIL**, fine to medium, grey; trace of rootlets	D	MD		
								SM	**SILTY SAND**, fine to coarse grained, off white; trace of gravel, medium to fine grained		MD		
						0.5		GP-GC	**SANDY GRAVEL**, fine to medium grained, off white; sand, medium to fine grained				
					71.0			GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, low plasticity, brown mottled grey; sand, medium to fine grained	D - M	St - VSt		
					70.5	1.0			....trace of medium to fine grained gravel				
					70.0	1.5							
					69.5	2.0			EXCAVATION TP30 TERMINATED AT 2.30 m				
					69.0	2.5							
					68.5	3.0							
					68.0	3.5							

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method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration

VE W E I VH

water

10 Oct., 73 Water Level on Date shown
water inflow
water outflow

samples & field tests
- U50 - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- E - Environmental Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa)
- PBT - Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
- D - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

coffey geotechnics

Engineering Log - Excavation

Excavation No.	TP31
Sheet No.	1 of 1
Project No.	GEOTHERD08278AC
Date excavated	22/2/08
Date completed	22/2/08
Logged by :	PW
Checked by :	

Client : *Wood & Grieve Engineers*

Principal : *Aspen Group*

Project : *Lot 2 South Western Highway, Byford*

Location : *Lot 2 South Western Highway, Byford*

Position : E: 407057.6, N: 6434212 (50 MGA94) Surface Elevation : 70.2m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	penetration	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components)	moisture condition	consistency / relative density	hand penetrometer kPa	structure and additional observations
BH	VE E F H		Not Observed		70.0	0.0			**TOPSOIL**, fine to medium, grey; trace of rootlets	D	MD	100 200 300 400	
						0.5		SM	**SILTY SAND**, fine to coarse grained, off white; trace of gravel, medium to fine grained	D - M	MD		
					69.5			GP-GC	**SANDY GRAVEL**, fine to medium grained, off white; sand, medium to fine grained				
						1.0		GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, low plasticity, brown mottled grey; sand, medium to fine grained	M	St - VSt		
					69.0								
						1.5							
					68.5								
						2.0							
					68.0								
						2.5			EXCAVATION TP31 TERMINATED AT 2.40 m				
					67.5								
						3.0							
					67.0								
						3.5							
					66.5								

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method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration
VE E F H VH

water
- 10 Oct., 73 Water Level on Date shown
- water inflow
- water outflow

samples & field tests
- U50 - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- E - Environmental Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa)
- PBT - Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
- D - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

coffey geotechnics

Engineering Log - Excavation

		Excavation No.	TP32
		Sheet No.	1 of 1
		Project No.	GEOTHERD08278AC
Client :	Wood & Grieve Engineers	Date excavated	22/2/08
Principal :	Aspen Group	Date completed	22/2/08
Project :	Lot 2 South Western Highway, Byford	Logged by :	PW
Location :	Lot 2 South Western Highway, Byford	Checked by :	

Position : E: 407169.5, N: 6434218.9 (50 MGA94) Surface Elevation : 73.6m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	penetration (VE E F H)	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components)	moisture condition	consistency / relative density	hand penetrometer kPa (100 200 300 400)	structure and additional observations
BH			Not Observed		73.5	0.0			TOPSOIL, fine to medium, grey; trace of rootlets	D	MD		
								SM	SILTY SAND, fine to coarse grained, off white; trace of gravel, medium to fine grained		MD		
					73.0	0.5		GP-GC	SANDY GRAVEL, fine to medium grained, off white; sand, medium to fine grained				
					72.5	1.0		GC	SANDY CLAYEY GRAVEL, fine to medium grained, low plasticity, brown mottled grey; sand, medium to fine grained ....trace of medium to fine grained gravel	D - M	St - VSt		
					72.0	1.5							
					71.5	2.0							
					71.0	2.5			EXCAVATION TP32 TERMINATED AT 2.30 m				
					70.5	3.0							
					70.0	3.5							

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method
N Natural Exposure
X Existing Excavation
BH Backhoe Bucket
B Bulldozer Blade
R Ripper
E Excavator

support
T Timbering

penetration
VE E F H VH

water
10 Oct., 73 Water Level on Date shown
water inflow
water outflow

samples & field tests
U50 - Undisturbed Sample 50mm diameter
U63 - Undisturbed Sample 63mm diameter
D - Disturbed Sample
B - Bulk Disturbed Sample
E - Environmental Sample
MC - Moisture Content
HP - Hand Penetrometer (UCS kPa)
VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
PBT - Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
D - Dry
M - Moist
W - Wet
W_P - Plastic Limit
W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

coffey geotechnics

Engineering Log - Excavation

Excavation No.	TP33
Sheet No.	1 of 1
Project No.	GEOTHERD08278AC
Client :	Wood & Grieve Engineers
Principal :	Aspen Group
Project :	Lot 2 South Western Highway, Byford
Location :	Lot 2 South Western Highway, Byford
Date excavated	22/2/08
Date completed	22/2/08
Logged by :	PW
Checked by :	

Position : E: 407194.8, N: 6434389 (50 MGA94) Surface Elevation : 75m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	VE E F H penetration	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description: SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa 100 200 300 400	structure and additional observations
BH			Not Observed		75.0	0.0			**TOPSOIL**, fine to medium, grey; trace of rootlets	D	MD		
								SM	**SILTY SAND**, fine to coarse grained, off white; trace of gravel, medium to fine grained; trace of roots		MD		
					74.5	0.5		GP-GC	**SANDY GRAVEL**, fine to medium grained, off white; sand, medium to fine grained				
					74.0	1.0		GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, low plasticity, brown mottled grey; sand, medium to fine grained	D - M	St - VSt		
					73.5	1.5			....trace medium to fine grained gravel				
					73.0	2.0			EXCAVATION TP33 TERMINATED AT 2.20 m				
					72.5	2.5							
					72.0	3.0							
					71.5	3.5							

COFFEY_02.GLB Log EXCAVATION GH08278AC - EXCAVATION.GPJ <<DrawingFile>> 29/04/2008 09:50

method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration

water

samples & field tests
- U50 - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- E - Environmental Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
- PBT - Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
- D - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

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Engineering Log - Excavation

Excavation No.	TP34
Sheet No.	1 of 1
Project No.	GEOTHERD08278AC
Date excavated	22/2/08
Date completed	22/2/08
Logged by	PW
Checked by	

Client : *Wood & Grieve Engineers*

Principal : *Aspen Group*

Project : *Lot 2 South Western Highway, Byford*

Location : *Lot 2 South Western Highway, Byford*

Position : E: 407303.9, N: 6434363.6 (50 MGA94) Surface Elevation : 80.8m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	penetration (VE E F H)	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description: SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components	moisture condition	consistency / relative density	hand penetrometer kPa (100 200 300 400)	structure and additional observations
BH			Not Observed	B	80.5	0.0			**TOPSOIL**, fine to medium, grey; trace of rootlets	D	MD		
								GP-GC	**SANDY GRAVEL**, fine to medium grained, low plasticity, off white; sand, medium to fine grained; trace of tree roots and fines		D		
					80.0	0.5			....becoming brown				
					79.5	1.0							
					79.0	1.5		GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, low plasticity, brown; sand, medium to fine grained		St - VSt		
					78.5	2.0			EXCAVATION TP34 TERMINATED AT 2.20 m				
					78.0	2.5							
					77.5	3.0							
					77.0	3.5							

COFFEY_02.GLB Log EXCAVATION GH08278AC - EXCAVATION.GPJ <<DrawingFile>> 29/04/2008 09:50

method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration (VE E F H VH)

water
- 10 Oct., 73 Water Level on Date shown
- water inflow
- water outflow

samples & field tests
- U50 - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- D - Disturbed Sample
- B - Bulk Disturbed Sample
- E - Environmental Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remoulded (uncorrected kPa)
- PBT - Plate Bearing Test

classification symbols & soil description Based on Unified Classification System

moisture
- D - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

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Engineering Log - Excavation

Excavation No.	TP35
Sheet No.	1 of 1
Project No.	GEOTHERD08278AC
Client :	Wood & Grieve Engineers
Principal :	Aspen Group
Project :	Lot 2 South Western Highway, Byford
Location :	Lot 2 South Western Highway, Byford
Date excavated	22/2/08
Date completed	22/2/08
Logged by :	PW
Checked by :	

Position : E: 407122.1, N: 6434442.9 (50 MGA94) Surface Elevation : 74m (AHD)

Equipment type : Backhoe Method : Excavation dimensions :

excavation information | **material substance**

method	penetration	support	ground water	samples & field tests	RL (m)	depth (m)	graphic log	classification symbol	material description (SOIL TYPE, Plasticity or Particle Characteristic, Colour, Secondary and Minor Components)	moisture condition	consistency / relative density	hand penetrometer kPa	structure and additional observations
BH	VE E F H		Not Observed	B	74.0	0.0			**TOPSOIL**, fine to medium, grey; trace of rootlets and organic material	D	MD	100 200 300 400	
								SM	**SILTY SAND**, fine to medium grained, off white; with some gravel, meduim to fine grained; trace of tree roots		D		
					73.5	0.5		GP-GC	**SANDY CLAYEY GRAVEL**, fine to medium grained, off white; sand, medium to fine grained; with low plasticity fines				
					73.0	1.0							
					72.5	1.5							
					72.0	2.0							
									EXCAVATION TP35 TERMINATED AT 2.10 m				
					71.5	2.5							
					71.0	3.0							
					70.5	3.5							

method
- N Natural Exposure
- X Existing Excavation
- BH Backhoe Bucket
- B Bulldozer Blade
- R Ripper
- E Excavator

support
- T Timbering

penetration

VE E F H VH

water

10 Oct., 73 Water Level on Date shown
water inflow
water outflow

samples & field tests
- U50 - Undisturbed Sample 50mm diameter
- U63 - Undisturbed Sample 63mm diameter
- O - Disturbed Sample
- B - Bulk Disturbed Sample
- E - Environmental Sample
- MC - Moisture Content
- HP - Hand Penetrometer (UCS kPa)
- VS - Vane Shear; P-Peak, R-Remouded (uncorrected kPa)
- PBT - Plate Bearing Test

classification symbols & soil description
Based on Unified Classification System

moisture
- D - Dry
- M - Moist
- W - Wet
- W_P - Plastic Limit
- W_L - Liquid Limit

consistency / relative density

VS	- Very Soft
S	- Soft
F	- Firm
St	- Stiff
VSt	- Very Stiff
H	- Hard
VL	- Very Loose
L	- Loose
MD	- Medium Dense
D	- Dense
VD	- Very Dense

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Appendix B

Results of Laboratory Testing

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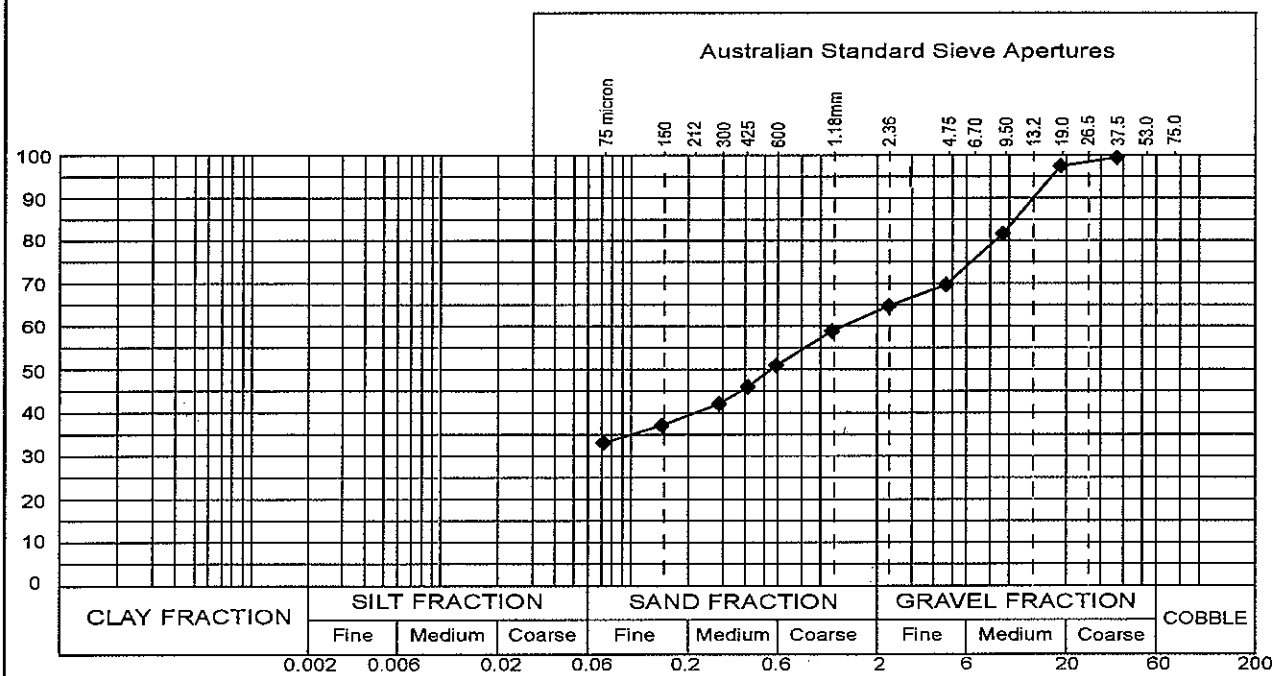
TEST CERTIFICATE

Client: Coffey Geotechnics-GEOTHERD08278AC **Report No.:** HERD08S-02133
Principal: Aspen Group
Project: Lot 2, Byford **Job No.:** LABTHERD00446AA
Location: Lot 2, South Western Highway, Byford
Sample ID: TP2@2.0-2.3m **Date Tested:** 7/04/2008

Particle Size Distribution & Atterberg Limits of a Soil

Partcle Size Distribution (AS1289 3.6.1)				**Atterberg Limits** (AS1289 3.1.2, 3.2.1, 3.3.1, 3.4.1)	
Sieve Size	% Passing	Sieve Size	% Passing	**Moisture Content** (AS1289 2.1.1)	
150.0mm		1.18 mm	59	Liquid Limit (%)	35
75.0mm		600 micron	51	Plastic Limit (%)	18
37.5 mm	100	425 micron	46	Plasticity Index (%)	17
19.0 mm	98	300 micron	42	Linear Shrinkage (%)	11
9.50 mm	82	150 micron	37	Nature Of Shrinkage	Crumbing
4.75 mm	70	75 micron	33	Sample History	Air Dried
2.36mm	65			Preparation Method	Dry Sieved
				Moisture Content (%)	12.8



Remarks: Sampling Method/s - Submitted by client

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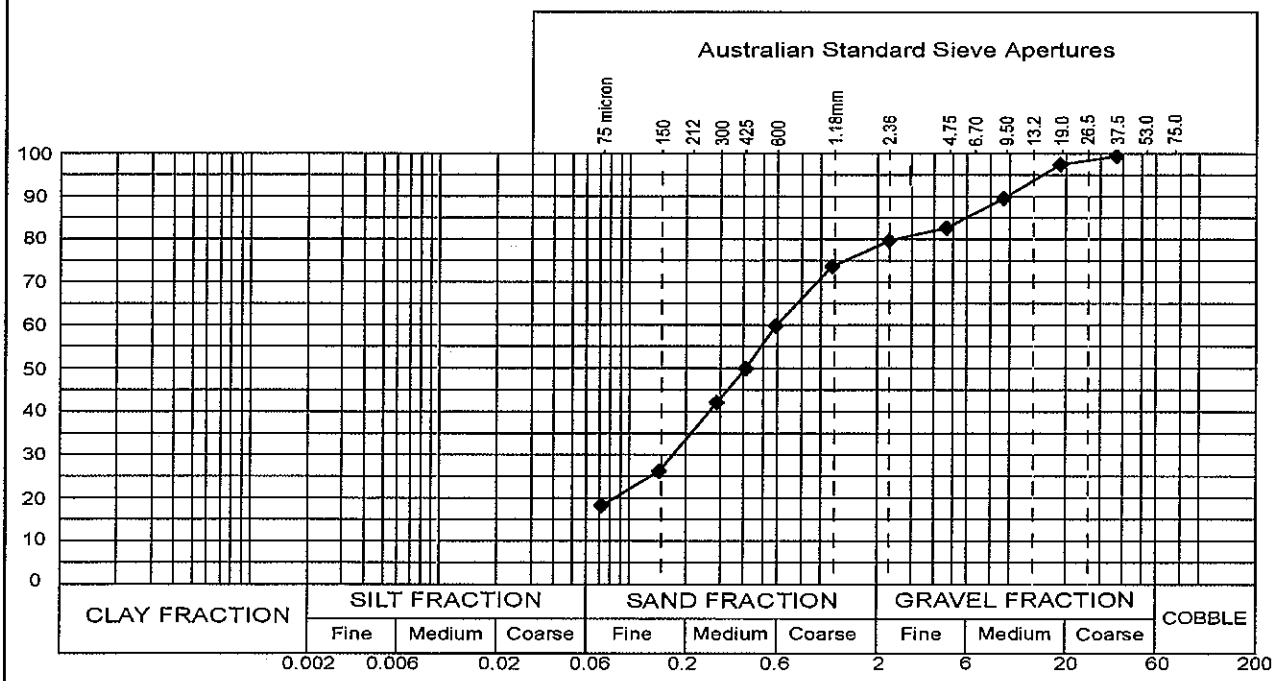
Client: Coffey Geotechnics-GEOTHERD08278AC **Report No.:** HERD08S-02134
Principal: Aspen Group
Project: Lot 2, Byford **Job No.:** LABTHERD00446AA
Location: Lot 2, South Western Highway, Byford
Sample ID: TP4@0.3-0.5m **Date Tested:** 7/04/2008

Particle Size Distribution & Atterberg Limits of a Soil

Partcle Size Distribution (AS1289 3.6.1)				**Atterberg Limits** (AS1289 3.1.2, 3.2.1, 3.3.1, 3.4.1)	
Sieve Size	% Passing	Sieve Size	% Passing	**Moisture Content** (AS1289 2.1.1)	
150.0mm		1.18 mm	74	Liquid Limit (%)	slips in cup
75.0mm		600 micron	60	Plastic Limit (%)	Not Obtainable
37.5 mm	100	425 micron	50	Plasticity Index (%)	Non Plastic
19.0 mm	98	300 micron	42	Linear Shrinkage (%)	-
9.50 mm	90	150 micron	26	Nature Of Shrinkage	-
4.75 mm	83	75 micron	18	Sample History	-
2.36mm	80			Preparation Method	-
				Moisture Content (%)	3.2



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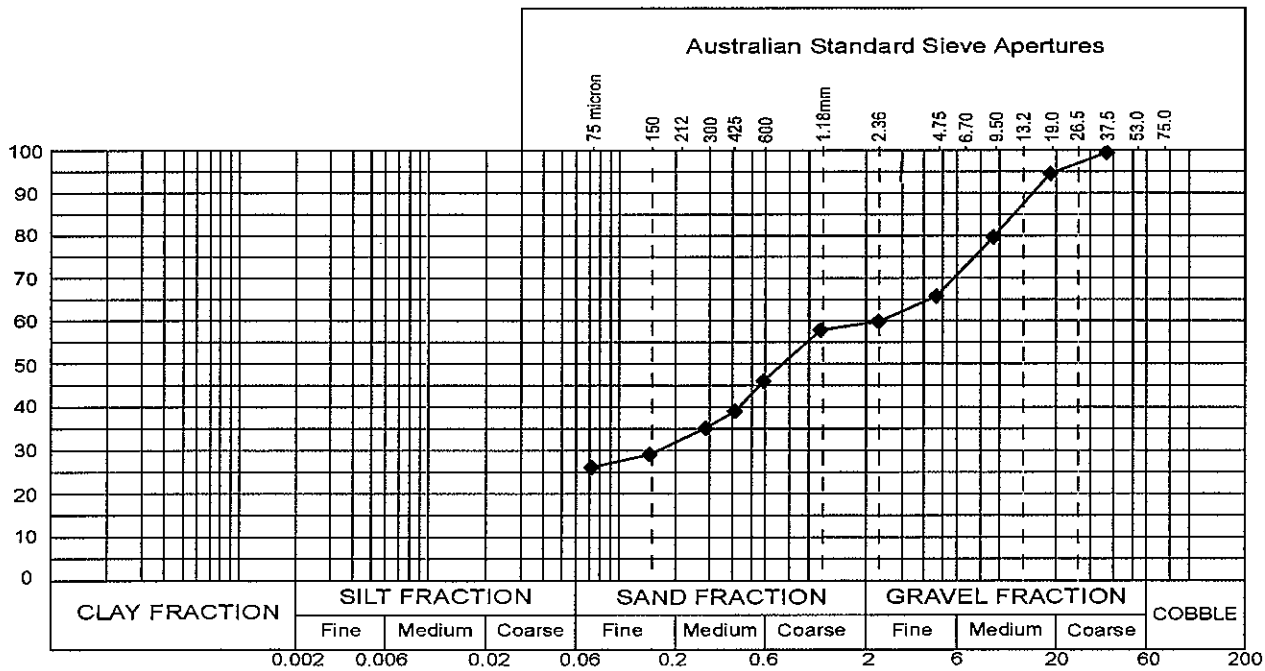
Client: Coffey Geotechnics-GEOTHERD08278AC **Report No.:** HERD08S-02135
Principal: Aspen Group
Project: Lot 2, Byford **Job No.:** LABTHERD00446AA
Location: Lot 2, South Western Highway, Byford
Sample ID: TP9@1.7-2.0m **Date Tested:** 8/04/2008

Particle Size Distribution & Atterberg Limits of a Soil

Partcle Size Distribution (AS1289 3.6.1)				**Atterberg Limits** (AS1289 3.1.2, 3.2.1, 3.3.1, 3.4.1)	
Sieve Size	% Passing	Sieve Size	% Passing	**Moisture Content** (AS1289 2.1.1)	
150.0mm		1.18 mm	58	Liquid Limit (%)	42
75.0mm		600 micron	46	Plastic Limit (%)	18
37.5 mm	100	425 micron	39	Plasticity Index (%)	24
19.0 mm	95	300 micron	35	Linear Shrinkage (%)	12
9.50 mm	80	150 micron	29	Nature Of Shrinkage	Flat
4.75 mm	66	75 micron	26	Sample History	Air Dried
2.36mm	60			Preparation Method	Dry Sieved
				Moisture Content (%)	12.3



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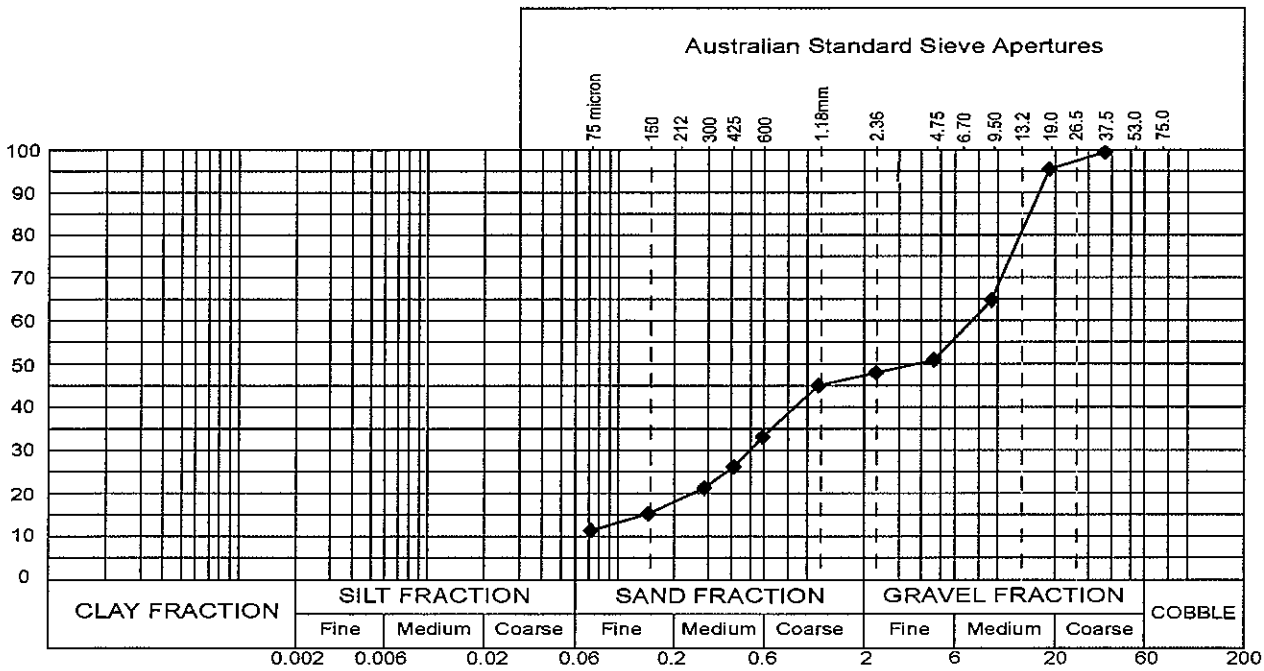
Client: Coffey Geotechnics-GEOTHERD08278AC **Report No.:** HERD08S-02136
Principal: Aspen Group
Project: Lot 2, Byford **Job No.:** LABTHERD00446AA
Location: Lot 2, South Western Highway, Byford
Sample ID: TP12@0.4-0.6m **Date Tested:** 8/04/2008

Particle Size Distribution & Atterberg Limits of a Soil

Partcle Size Distribution (AS1289 3.6.1)				**Atterberg Limits** (AS1289 3.1.2, 3.2.1, 3.3.1, 3.4.1)	
Sieve Size	% Passing	Sieve Size	% Passing	**Moisture Content** (AS1289 2.1.1)	
150.0mm		1.18 mm	45	Liquid Limit (%)	21
75.0mm		600 micron	33	Plastic Limit (%)	11
37.5 mm	100	425 micron	26	Plasticity Index (%)	10
19.0 mm	96	300 micron	21	Linear Shrinkage (%)	4
9.50 mm	65	150 micron	15	Nature Of Shrinkage	Flat
4.75 mm	51	75 micron	11	Sample History	Air Dried
2.36mm	48			Preparation Method	Dry Sieved
				Moisture Content (%)	5.0



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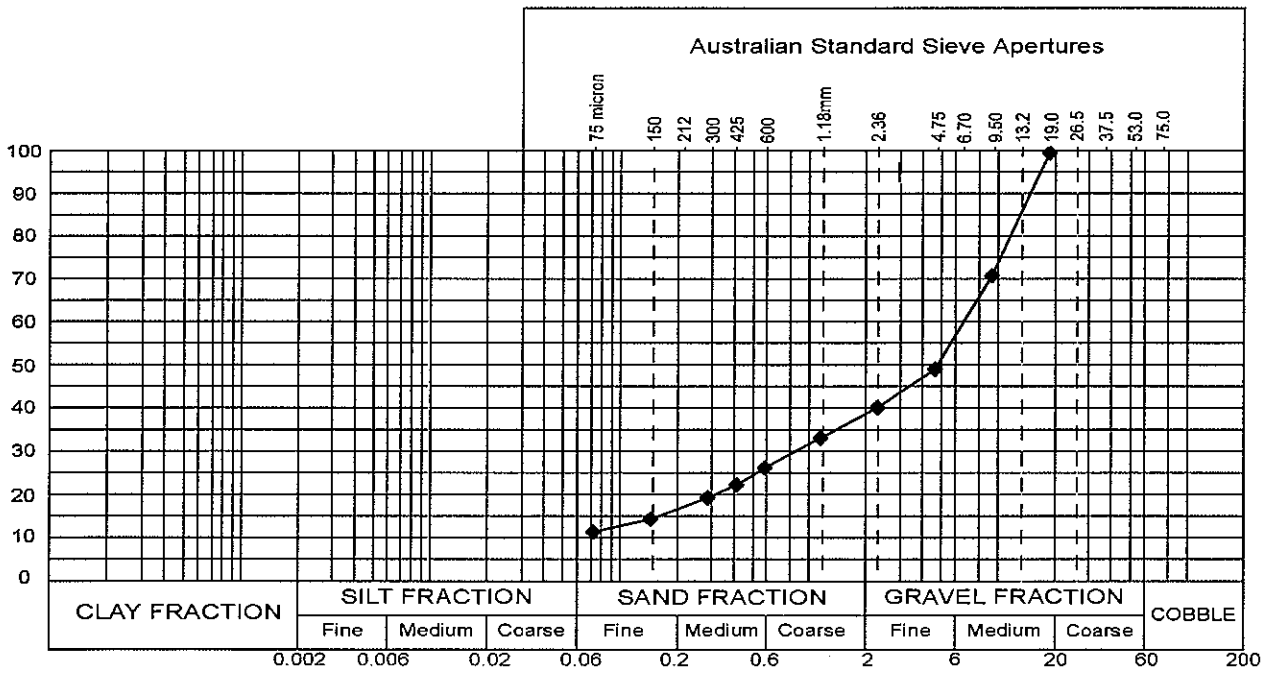
TEST CERTIFICATE

Client: Coffey Geotechnics-GEOTHERD08278AC **Report No.:** HERD08S-02137
Principal: Aspen Group
Project: Lot 2, Byford **Job No.:** LABTHERD00446AA
Location: Lot 2, South Western Highway, Byford
Sample ID: TP13@0.9-1.2m **Date Tested:** 8/04/2008

Particle Size Distribution & Atterberg Limits of a Soil

Partcle Size Distribution (AS1289 3.6.1)				**Atterberg Limits** (AS1289 3.1.2, 3.2.1, 3.3.1, 3.4.1)	
Sieve Size	% Passing	Sieve Size	% Passing	**Moisture Content** (AS1289 2.1.1)	
150.0mm		1.18 mm	33	Liquid Limit (%)	38
75.0mm		600 micron	26	Plastic Limit (%)	16
37.5 mm		425 micron	22	Plasticity Index (%)	22
19.0 mm	100	300 micron	19	Linear Shrinkage (%)	28
9.50 mm	71	150 micron	14	Nature Of Shrinkage	Crumbing
4.75 mm	49	75 micron	11	Sample History	Air Dried
2.36mm	40			Preparation Method	Dry Sieved
				Moisture Content (%)	9.2



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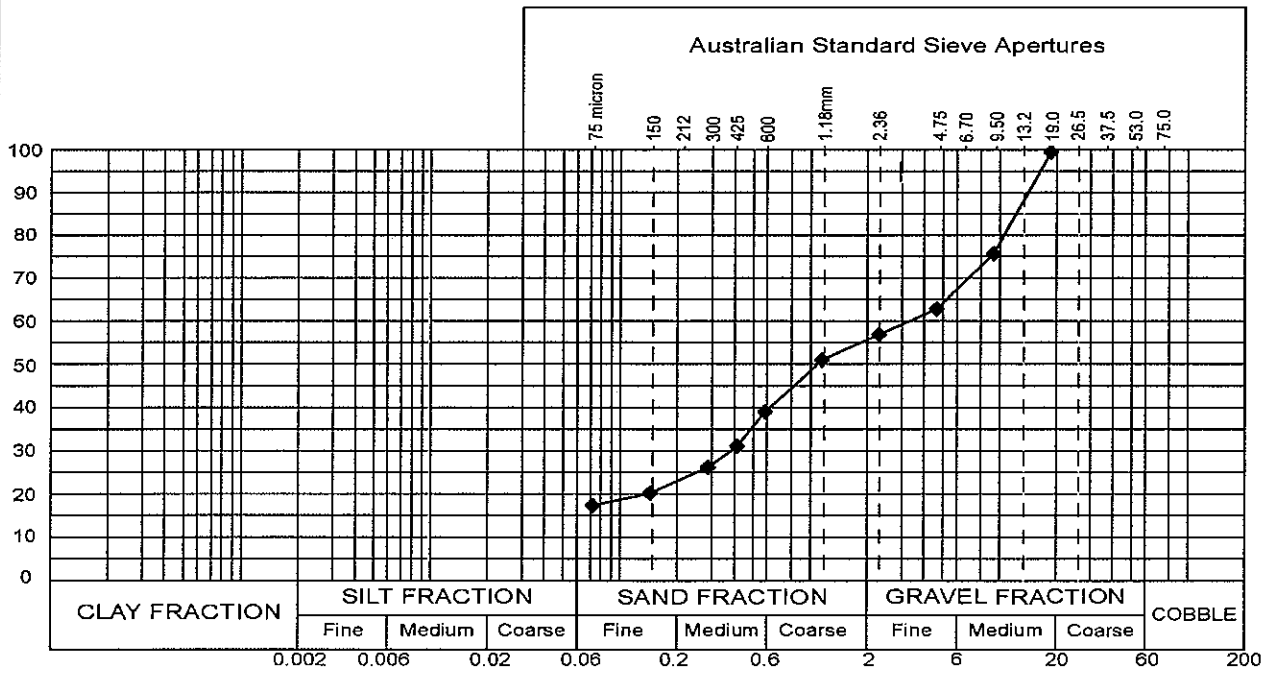
TEST CERTIFICATE

Client: Coffey Geotechnics-GEOTHERD08278AC **Report No.:** HERD08S-02138
Principal: Aspen Group
Project: Lot 2, Byford **Job No.:** LABTHERD00446AA
Location: Lot 2, South Western Highway, Byford
Sample ID: TP15@0.6-0.9m **Date Tested:** 8/04/2008

Particle Size Distribution & Atterberg Limits of a Soil

Partcle Size Distribution (AS1289 3.6.1)				**Atterberg Limits** (AS1289 3.1.2, 3.2.1, 3.3.1, 3.4.1)	
Sieve Size	% Passing	Sieve Size	% Passing	**Moisture Content** (AS1289 2.1.1)	
150.0mm		1.18 mm	51	Liquid Limit (%)	29
75.0mm		600 micron	39	Plastic Limit (%)	13
37.5 mm		425 micron	31	Plasticity Index (%)	16
19.0 mm	100	300 micron	26	Linear Shrinkage (%)	8
9.50 mm	76	150 micron	20	Nature Of Shrinkage	Flat
4.75 mm	63	75 micron	17	Sample History	Air Dried
2.36mm	57			Preparation Method	Dry Sieved
				Moisture Content (%)	8.7



Remarks: Sampling Method/s - Submitted by client

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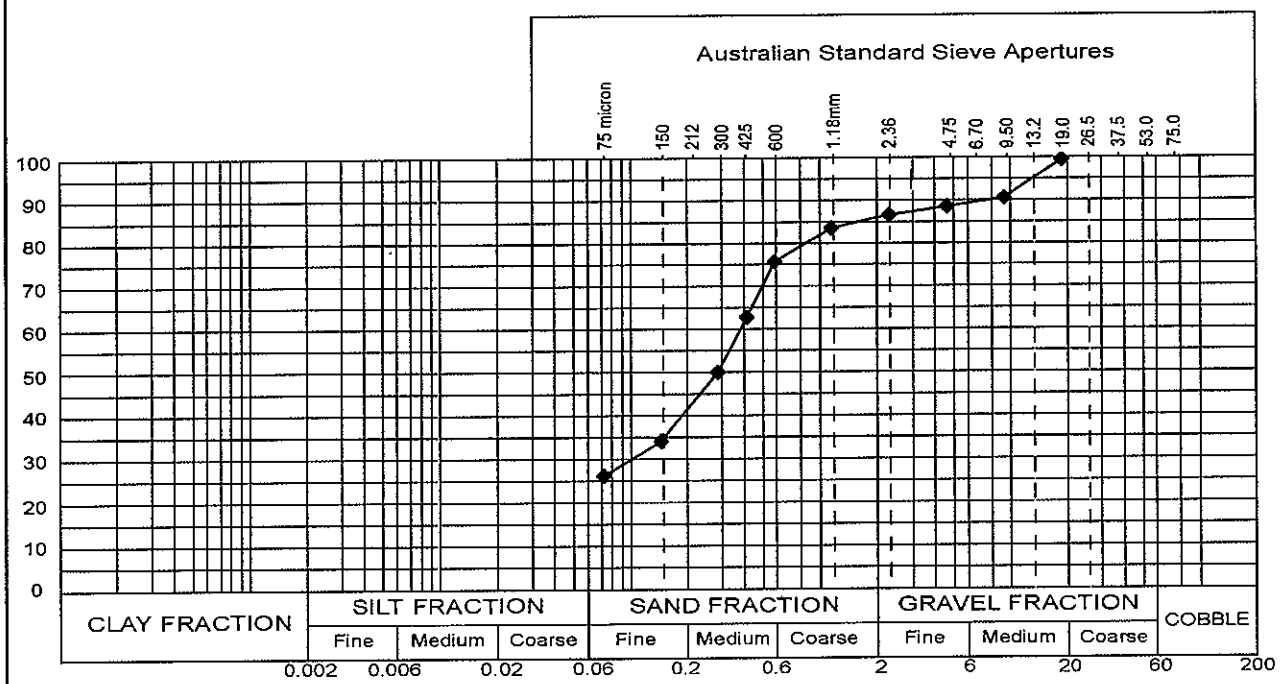
TEST CERTIFICATE

Client: Coffey Geotechnics-GEOTHERD08278AC **Report No.:** HERD08S-02139
Principal: Aspen Group
Project: Lot 2, Byford **Job No.:** LABTHERD00446AA
Location: Lot 2, South Western Highway, Byford
Sample ID: TP23@1.8-2.1m **Date Tested:** 8/04/2008

Particle Size Distribution & Atterberg Limits of a Soil

Partcle Size Distribution (AS1289 3.6.1)				**Atterberg Limits** (AS1289 3.1.2, 3.2.1, 3.3.1, 3.4.1)	
Sieve Size	% Passing	Sieve Size	% Passing	**Moisture Content** (AS1289 2.1.1)	
150.0mm		1.18 mm	84	Liquid Limit (%)	27
75.0mm		600 micron	76	Plastic Limit (%)	14
37.5 mm		425 micron	63	Plasticity Index (%)	13
19.0 mm	100	300 micron	50	Linear Shrinkage (%)	7
9.50 mm	91	150 micron	34	Nature Of Shrinkage	Curling
4.75 mm	89	75 micron	26	Sample History	Air Dried
2.36mm	87			Preparation Method	Dry Sieved
				Moisture Content (%)	12.8



Remarks: Sampling Method/s - Submitted by client

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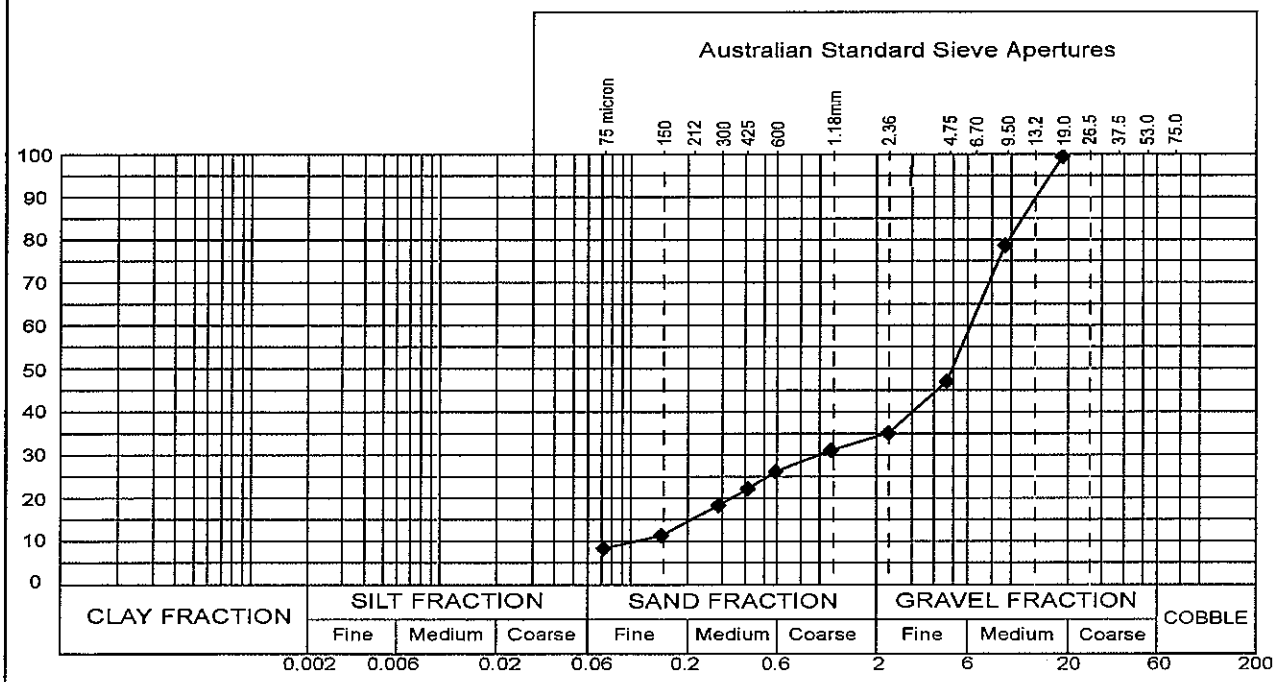
TEST CERTIFICATE

Client: Coffey Geotechnics-GEOTHERD08278AC **Report No.:** HERD08S-02140
Principal: Aspen Group
Project: Lot 2, Byford **Job No.:** LABTHERD00446AA
Location: Lot 2, South Western Highway, Byford
Sample ID: TP34@1.0-1.2m **Date Tested:** 8/04/2008

Particle Size Distribution & Atterberg Limits of a Soil

Partcle Size Distribution (AS1289 3.6.1)				**Atterberg Limits** (AS1289 3.1.2, 3.2.1, 3.3.1, 3.4.1)	
Sieve Size	% Passing	Sieve Size	% Passing	**Moisture Content** (AS1289 2.1.1)	
150.0mm		1.18 mm	31	Liquid Limit (%)	22
75.0mm		600 micron	26	Plastic Limit (%)	16
37.5 mm		425 micron	22	Plasticity Index (%)	6
19.0 mm	100	300 micron	18	Linear Shrinkage (%)	3
9.50 mm	79	150 micron	11	Nature Of Shrinkage	Crumbing
4.75 mm	47	75 micron	8	Sample History	Air Dried
2.36mm	35			Preparation Method	Dry Sieved
				Moisture Content (%)	7.3



Remarks: Sampling Method/s - Submitted by client

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Approved Signatory: B Truslove
B Truslove
Date: 16/04/2008
NATA Acc. Laboratory No 431

From No. AS1289.3.6.1&3.1.2&2.1.1, Issue 1, Rev 0, 18.02.08

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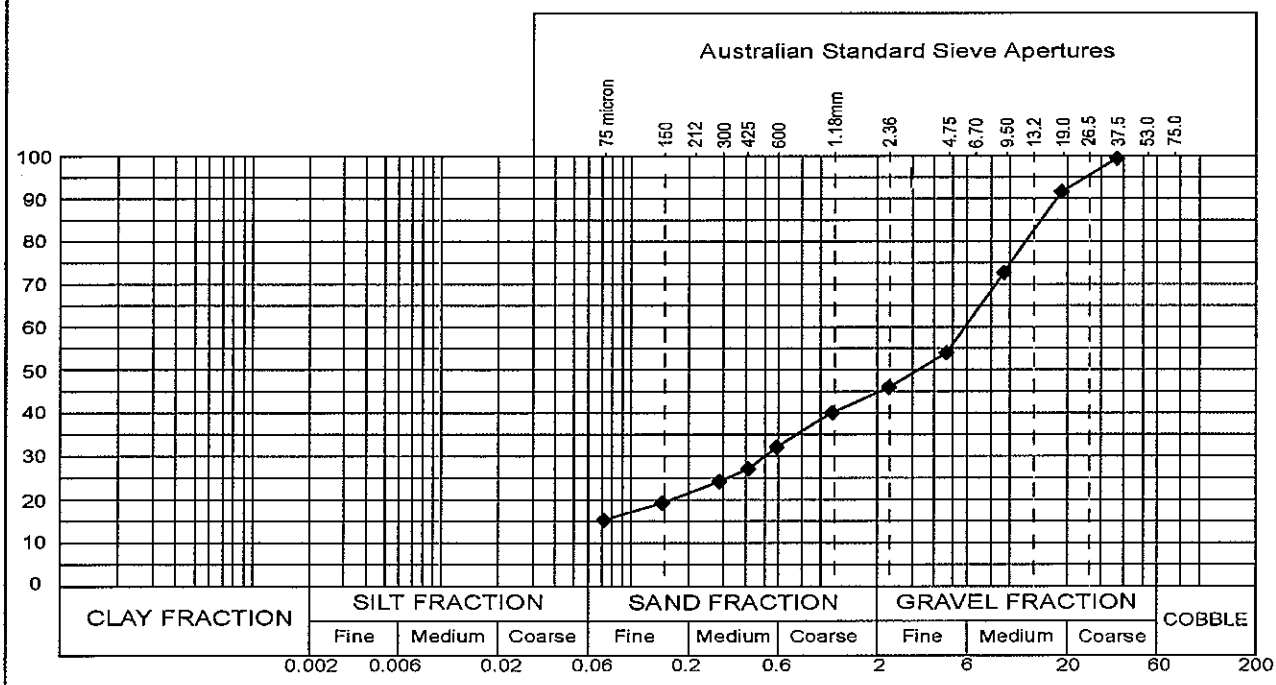
TEST CERTIFICATE

Client: Coffey Geotechnics-GEOTHERD08278AC **Report No.:** HERD08S-02141
Principal: Aspen Group
Project: Lot 2, Byford **Job No.:** LABTHERD00446AA
Location: Lot 2, South Western Highway, Byford
Sample ID: TP35@1.5-1.8m **Date Tested:** 8/04/2008

Particle Size Distribution & Atterberg Limits of a Soil

Partcle Size Distribution (AS1289 3.6.1)				**Atterberg Limits** (AS1289 3.1.2, 3.2.1, 3.3.1, 3.4.1)	
Sieve Size	% Passing	Sieve Size	% Passing	**Moisture Content** (AS1289 2.1.1)	
150.0mm		1.18 mm	40	Liquid Limit (%)	31
75.0mm		600 micron	32	Plastic Limit (%)	15
37.5 mm	100	425 micron	27	Plasticity Index (%)	16
19.0 mm	92	300 micron	24	Linear Shrinkage (%)	8
9.50 mm	73	150 micron	19	Nature Of Shrinkage	Crumbing
4.75 mm	54	75 micron	15	Sample History	Air Dried
2.36mm	46			Preparation Method	Dry Sieved
				Moisture Content (%)	7.3



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Appendix C

CSIRO Information Sheet

Foundation Maintenance and Footing Performance:
A Homeowner's Guide

CSIRO

BTF 18
replaces
Information
Sheet 10/91

Buildings can and often do move. This movement can be up, down, lateral or rotational. The fundamental cause of movement in buildings can usually be related to one or more problems in the foundation soil. It is important for the homeowner to identify the soil type in order to ascertain the measures that should be put in place in order to ensure that problems in the foundation soil can be prevented, thus protecting against building movement.

This Building Technology File is designed to identify causes of soil-related building movement, and to suggest methods of prevention of resultant cracking in buildings.

Soil Types

The types of soils usually present under the topsoil in land zoned for residential buildings can be split into two approximate groups – granular and clay. Quite often, foundation soil is a mixture of both types. The general problems associated with soils having granular content are usually caused by erosion. Clay soils are subject to saturation and swell/shrink problems.

Classifications for a given area can generally be obtained by application to the local authority, but these are sometimes unreliable and if there is doubt, a geotechnical report should be commissioned. As most buildings suffering movement problems are founded on clay soils, there is an emphasis on classification of soils according to the amount of swell and shrinkage they experience with variations of water content. The table below is Table 2.1 from AS 2870, the Residential Slab and Footing Code.

Causes of Movement

Settlement due to construction

There are two types of settlement that occur as a result of construction:

- Immediate settlement occurs when a building is first placed on its foundation soil, as a result of compaction of the soil under the weight of the structure. The cohesive quality of clay soil mitigates against this, but granular (particularly sandy) soil is susceptible.
- Consolidation settlement is a feature of clay soil and may take place because of the expulsion of moisture from the soil or because of the soil's lack of resistance to local compressive or shear stresses. This will usually take place during the first few months after construction, but has been known to take many years in exceptional cases.

These problems are the province of the builder and should be taken into consideration as part of the preparation of the site for construction. Building Technology File 19 (BTF 19) deals with these problems.

Erosion

All soils are prone to erosion, but sandy soil is particularly susceptible to being washed away. Even clay with a sand component of say 10% or more can suffer from erosion.

Saturation

This is particularly a problem in clay soils. Saturation creates a bog-like suspension of the soil that causes it to lose virtually all of its bearing capacity. To a lesser degree, sand is affected by saturation because saturated sand may undergo a reduction in volume – particularly imported sand fill for bedding and blinding layers. However, this usually occurs as immediate settlement and should normally be the province of the builder.

Seasonal swelling and shrinkage of soil

All clays react to the presence of water by slowly absorbing it, making the soil increase in volume (see table below). The degree of increase varies considerably between different clays, as does the degree of decrease during the subsequent drying out caused by fair weather periods. Because of the low absorption and expulsion rate, this phenomenon will not usually be noticeable unless there are prolonged rainy or dry periods, usually of weeks or months, depending on the land and soil characteristics.

The swelling of soil creates an upward force on the footings of the building, and shrinkage creates subsidence that takes away the support needed by the footing to retain equilibrium.

Shear failure

This phenomenon occurs when the foundation soil does not have sufficient strength to support the weight of the footing. There are two major post-construction causes:

- Significant load increase.
- Reduction of lateral support of the soil under the footing due to erosion or excavation.
- In clay soil, shear failure can be caused by saturation of the soil adjacent to or under the footing.

GENERAL DEFINITIONS OF SITE CLASSES

Class	Foundation
A	Most sand and rock sites with little or no ground movement from moisture changes
S	Slightly reactive clay sites with only slight ground movement from moisture changes
M	Moderately reactive clay or silt sites, which can experience moderate ground movement from moisture changes
H	Highly reactive clay sites, which can experience high ground movement from moisture changes
E	Extremely reactive sites, which can experience extreme ground movement from moisture changes
A to P	Filled sites
P	Sites which include soft soils, such as soft clay or silt or loose sands; landslip; mine subsidence; collapsing soils; soils subject to erosion; reactive sites subject to abnormal moisture conditions or sites which cannot be classified otherwise

Tree root growth
Trees and shrubs that are allowed to grow in the vicinity of footings can cause foundation soil movement in two ways:

- Roots that grow under footings may increase in cross-sectional size, exerting upward pressure on footings.
- Roots in the vicinity of footings will absorb much of the moisture in the foundation soil, causing shrinkage or subsidence.

Unevenness of Movement

The types of ground movement described above usually occur unevenly throughout the building's foundation soil. Settlement due to construction tends to be uneven because of:

- Differing compaction of foundation soil prior to construction.
- Differing moisture content of foundation soil prior to construction.

Movement due to non-construction causes is usually more uneven still. Erosion can undermine a footing that traverses the flow or can create the conditions for shear failure by eroding soil adjacent to a footing that runs in the same direction as the flow.

Saturation of clay foundation soil may occur where subfloor walls create a dam that makes water pond. It can also occur wherever there is a source of water near footings in clay soil. This leads to a severe reduction in the strength of the soil which may create local shear failure.

Seasonal swelling and shrinkage of clay soil affects the perimeter of the building first, then gradually spreads to the inrerior. The swelling process will usually begin at the uphill extreme of the building, or on the weather side where the land is flat. Swelling gradually reaches the inrerior soil as absorption continues. Shrinkage usually begins where the sun's heat is greatest.

Effects of Uneven Soil Movement on Structures

Erosion and saturation
Erosion removes the support from under footings, tending to create subsidence of the part of the structure under which it occurs. Brickwork walls will resist the stress created by this removal of support by bridging the gap or cantilevering until the bricks or the mortar bedding fail. Older masonry has little resistance. Evidence of failure varies according to circumstances and symproms may include:

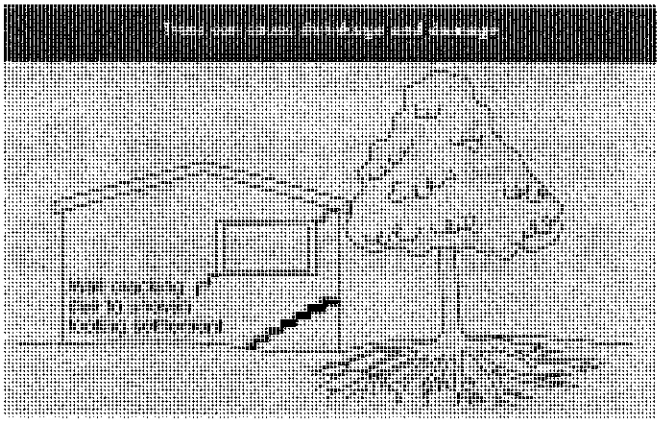
- Step cracking in the mortar beds in the body of the wall or above/below openings such as doors or windows.
- Vertical cracking in the bricks (usually but not necessarily in line with the vertical beds or perpends).

Isolated piers affected by erosion or saturation of foundations will evenrually lose contact with the bearers they support and may tilt or fall over. The floors that have lost this support will become bouncy, sometimes rattling ornaments etc.

Seasonal swelling/shrinkage in clay
Swelling foundation soil due to rainy periods first lifts the most exposed extremities of the footing system, then the remainder of the perimeter footings while gradually permeating inside the building footprint to lift internal footings. This swelling first tends to create a dish effect, because the external footings are pushed higher than the internal ones.

The first noticeable symptom may be that the floor appears slightly dished. This is often accompanied by some doors binding on the floor or the door head, together with some cracking of cornice mirres. In buildings with timber flooring supported by bearers and joists, the floor can be bouncy. Externally there may be visible dishing of the hip or ridge lines.

As the moisture absorption process completes its journey to the innermost areas of the building, the inrernal footings will rise. If the spread of moisture is roughly even, it may be rhat the symptoms will temporarily disappear, but it is more likely that swelling will be uneven, creating a difference rather than a disappearance in symptoms. In buildings with timber flooring supported by bearers and joists, the isolated piers will rise more easily than the strip footings or piers under walls, creating noticeable doming of flooring.



As the weather pattern changes and the soil begins to dry out, the external footings will be first affected, beginning with the locations where the sun's effect is strongest. This has the effect of lowering the external footings. The doming is accentuated and cracking reduces or disappears where it occurred because of dishing, but other cracks open up. The roof lines may become convex.

Doming and dishing are also affected by weather in other ways. In areas where warm, wet summers and cooler dry winters prevail, water migration tends to be toward the interior and doming will be accentuated, whereas where summers are dry and winters are cold and wet, migration tends to be toward the exterior and the underlying propensity is toward dishing.

Movement caused by tree roots
In general, growing roots will exert an upward pressure on footings, whereas soil subject to drying because of tree or shrub roots will tend to remove support from under footings by inducing shrinkage.

Complications caused by the structure itself
Most forces rhat the soil causes to be exerted on structures are vertical – i.e. either up or down. However, because these forces are seldom spread evenly around the footings, and because the building resists uneven movement because of its rigidity, forces are exerted from one part of the building to another. The net result of all these forces is usually rotational. This resultant force often complicates the diagnosis because the visible symptoms do not simply reflect the original cause. A common symptom is binding of doors on the vertical member of the frame.

Effects on full masonry structures
Brickwork will resist cracking where it can. It will attempt to span areas that lose support because of subsided foundations or raised points. It is therefore usual to see cracking at weak points, such as openings for windows or doors.

In the event of construction settlement, cracking will usually remain unchanged after the process of settlement has ceased.

With local shear or erosion, cracking will usually continue to develop until the original cause has been remedied, or until the subsidence has completely neutralised the affected portion of footing and the structure has stabilised on other footings that remain effective.

In the case of swell/shrink effects, the brickwork will in some cases return ro its original position after completion of a cycle, however it is more likely that the rotational effect will not be exactly reversed, and it is also usual that brickwork will settle in its new position and will resist the forces trying to return it ro its original posirion. This means that in a case where swelling takes place after construction and cracking occurs, the cracking is likely to at least partly remain after the shrink segment of the cycle is complete. Thus, each time the cycle is repeated, the likelihood is that the cracking will become wider until the sections of brickwork become virtually independent.

With repeared cycles, once the cracking is established, if there is no other complication, it is normal for the incidence of cracking to stabilise, as the building has the articulation it needs to cope with the problem. This is by no means always the case, however, and monitoring of cracks in walls and floors should always be treated seriously.

Upheaval caused by growth of tree roots under footings is not a simple vertical shear stress. There is a tendency for the root to also exert lateral forces that attempt to separate sections of brickwork after initial cracking has occurred.

The normal structural arrangement is that the inner leaf of brickwork in the external walls and at least some of the internal walls (depending on the roof type) comprise the load-bearing structure on which any upper floors, ceilings and the roof are supported. In these cases, it is internally visible cracking that should be the main focus of attention, however there are a few examples of dwellings whose external leaf of masonry plays some supporting role, so this should be checked if there is any doubt. In any case, externally visible cracking is important as a guide to stresses on the structure generally, and it should also be remembered that the external walls must be capable of supporting themselves.

Effects on framed structures
Timber or steel framed buildings are less likely to exhibit cracking due to swell/shrink than masonry buildings because of their flexihility. Also, the doming/dishing effects tend to be lower because of the lighter weight of walls. The main risks to framed buildings are encountered because of the isolated pier footings used under walls. Where erosion or saturation cause a footing to fall away, this can double the span which a wall must bridge. This additional stress can create cracking in wall linings, particularly where there is a weak point in the structure caused by a door or window opening. It is, however, unlikely that framed structures will be so stressed as to suffer serious damage without first exhibiting some or all of the above symptoms for a considerable period. The same warning period should apply in the case of upheaval. It should he noted, however, that where framed buildings are supported by strip footings there is only one leaf of brickwork and therefore the externally visible walls are the supporting structure for the building. In this case, the subfloor masonry walls can be expected to behave as full brickwork walls.

Effects on brick veneer structures
Because the load-bearing structure of a brick veneer building is the frame that makes up the interior leaf of the external walls plus perhaps the internal walls, depending on the type of roof, the building can be expected to behave as a framed structure, except that the external masonry will behave in a similar way to the external leaf of a full masonry structure.

Water Service and Drainage

Where a water service pipe, a sewer or stormwater drainage pipe is in the vicinity of a building, a water leak can cause erosion, swelling or saturation of susceptible soil. Even a minuscule leak can be enough to saturate a clay foundation. A leaking tap near a building can have the same effect. In addition, trenches containing pipes can become watercourses even though backfilled, particularly where broken rubble is used as fill. Water that runs along these trenches can be responsible for serious erosion, interstrata seepage into subfloor areas and saturation.

Pipe leakage and trench water flows also encourage tree and shrub roots to the source of water, complicating and exacerbating the problem.
Poor roof plumbing can result in large volumes of rainwater being concentrated in a small area of soil:

- Incorrect falls in roof guttering may result in overflows, as may gutters blocked with leaves etc.
- Corroded guttering or downpipes can spill water to ground.
- Downpipes not positively connected to a proper stormwater collection system will direct a concentration of water to soil that is directly adjacent to footings, sometimes causing large-scale problems such as erosion, saturation and migration of water under the building.

Seriousness of Cracking

In general, most cracking found in masonry walls is a cosmetic nuisance only and can be kept in repair or even ignored. The table below is a reproduction of Table C1 of AS 2870.

AS 2870 also publishes figures relating to cracking in concrete floors, however because wall cracking will usually reach the critical point significantly earlier than cracking in slabs, this table is not reproduced here.

Prevention/Cure

Plumbing
Where building movement is caused by water service, roof plumbing, sewer or stormwater failure, the remedy is to repair the problem. It is prudent, however, to consider also rerouting pipes away from the building where possible, and relocating taps to positions where any leakage will not direct water to the building vicinity. Even where gully traps are present, there is sometimes sufficient spill to create erosion or saturation, particularly in modern installations using smaller diameter PVC fixtures. Indeed, some gully traps are not situated directly under the taps that are installed to charge them, with the result that water from the tap may enter the backfilled trench that houses the sewer piping. If the trench has been poorly backfilled, the water will either pond or flow along the bottom of the trench. As these trenches usually run alongside the footings and can be at a similar depth, it is not hard to see how any water that is thus directed into a trench can easily affect the foundation's ability to support footings or even gain entry to the subfloor area.

Ground drainage
In all soils there is the capacity for water to travel on the surface and below it. Surface water flows can be established by inspection during and after heavy or prolonged rain. If necessary, a grated drain system connected to the stormwater collection system is usually an easy solution.

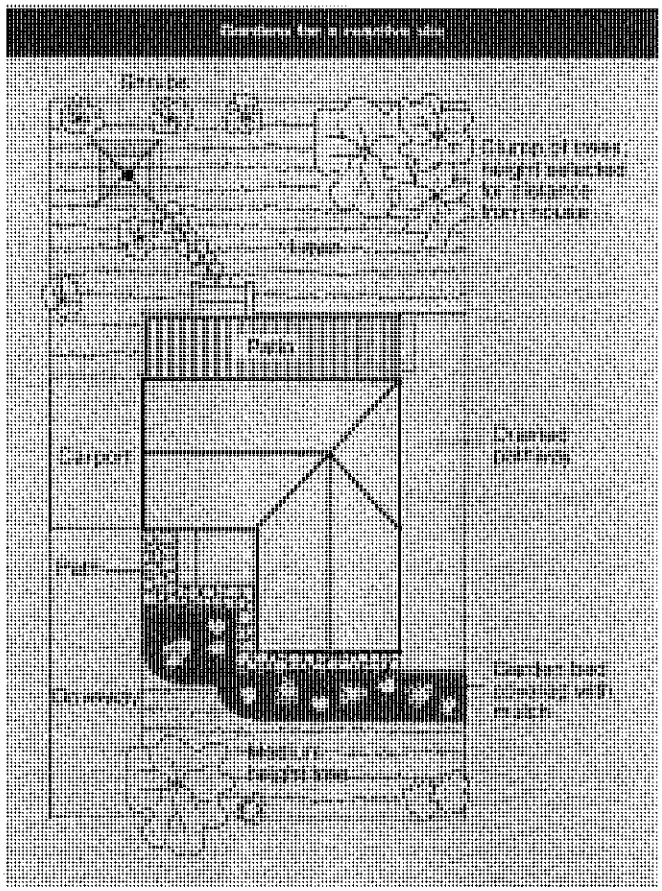
It is, however, sometimes necessary when attempting to prevent water migration that testing be carried out to establish watertable height and subsoil water flows. This subject is referred to in BTF 19 and may properly be regarded as an area for an expert consultant.

Protection of the building perimeter
It is essential to remember that the soil that affects footings extends well beyond the actual building line. Watering of garden plants, shrubs and trees causes some of the most serious water problems.

For this reason, particularly where problems exist or are likely to occur, it is recommended that an apron of paving be installed around as much of the building perimeter as necessary. This paving

CLASSIFICATION OF DAMAGE WITH REFERENCE TO WALLS

Description of typical damage and required repair	Approximate crack width limit (see Note 3)	Damage category
Hairline cracks	<0.1 mm	0
Fine cracks which do not need repair	<1 mm	1
Cracks noticeable but easily filled. Doors and windows stick slightly	<5 mm	2
Cracks can be repaired and possibly a small amount of wall will need to be replaced. Doors and windows stick. Service pipes can fracture. Weathertightness often impaired	5–15 mm (or a number of cracks 3 mm or more in one group)	3
Extensive repair work involving breaking-out and replacing sections of walls, especially over doors and windows. Window and door frames distort. Walls lean or bulge noticeably, some loss of bearing in beams. Service pipes disrupted	15–25 mm but also depend on number of cracks	4



should extend outwards a minimum of 900 mm (more in highly reactive soil) and should have a minimum fall away from the building of 1:60. The finished paving should be no less than 100 mm below brick vent bases.

It is prudent to relocate drainage pipes away from this paving, if possible, to avoid complications from future leakage. If this is not practical, earthenware pipes should be replaced by PVC and backfilling should be of the same soil type as the surrounding soil and compacted to the same density.

Except in areas where freezing of water is an issue, it is wise to remove taps in the building area and relocate them well away from the building – preferably not uphill from it (see BTF 19).

It may be desirable to install a grated drain at the outside edge of the paving on the uphill side of the building. If subsoil drainage is needed this can be installed under the surface drain.

Condensation

In buildings with a subfloor void such as where bearers and joists support flooring, insufficient ventilation creates ideal conditions for condensarion, particularly where there is little clearance between the floor and the ground. Condensation adds to the moisture already present in the subfloor and significantly slows the process of drying out. Installation of an adequate subfloor ventilation system, either natural or mechanical, is desirable.

Warning: Although this Building Technology File deals with cracking in buildings, it should be said that subfloor moisture can result in the development of other problems, notably:

- Water that is transmitted into masonry, metal or timber building elements causes damage and/or decay to those elements.
- High subfloor humidity and moisture content create an ideal environment for various pests, including termites and spiders.
- Where higb moisture levels are transmitted to the flooring and walls, an increase in the dust mite count can ensue within the living areas. Dust mites, as well as dampness in general, can be a healrh hazard to inhabitants, particularly those who are abnormally susceptible to respiratory ailments.

The garden

The ideal vegetation layout is to have lawn or plants that require only light watering immediately adjacent to the drainage or paving edge, then more demanding plants, shrubs and trees spread out in that order.

Overwatering due to misuse of automatic watering systems is a common cause of saturation and water migration under footings. If it is necessary to use these systems, it is important to remove garden beds to a completely safe distance from buildings.

Existing trees

Where a tree is causing a problem of soil drying or there is the existence or rhreat of upheaval of footings, if the offending roots are subsidiary and their removal will not significantly damage the tree, they should be severed and a concrete or metal barrier placed vertically in the soil to prevent future root growth in the direction of the building. If it is not possible to remove the relevant roots without damage to the tree, an application to remove the tree should be made to the local authority. A prudent plan is to transplant likely offenders before they become a problem.

Information on trees, plants and shrubs

State departments overseeing agriculture can give information regarding root patterns, volume of water needed and safe distance from buildings of most species. Botanic gardens are also sources of information. For information on plant roots and drains, see Building Technology File 17.

Excavation

Excavation around footings must be properly engineered. Soil supporting footings can only be safely excavated at an angle that allows the soil under the footing to remain stable. This angle is called the angle of repose (or friction) and varies significantly between soil types and conditions. Removal of soil within the angle of repose will cause subsidence.

Remediation

Where erosion has occurred that has washed away soil adjacent to footings, soil of the same classification should be introduced and compacted to the same density. Where footings have been undermined, augmentation or other specialist work may be required. Remediation of footings and foundations is generally the realm of a specialist consultant.

Where isolated footings rise and fall because of swell/shrink effect, the homeowner may be tempted to alleviate floor bounce by filling the gap that has appeared between the bearer and the pier with blocking. The danger here is that when the next swell segment of the cycle occurs, the extra blocking will push the floor up into an accentuated dome and may also cause local shear failure in the soil. If it is necessary to use blocking, it should be by a pair of fine wedges and monitoring should be carried out fortnightly.

This BTF was prepared by John Lewer FAIB, MIAMA, Partner, Construction Diagnosis.

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Tree Assessments for Lot 2 Nettleton Road, Byford For Plan E

May 2013

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SJS TRIM - IN15/13980

TABLE OF CONTENTS

BRIEF:

Plan E has commissioned this consultant to carry out tree assessments of 8 trees within the development known as Lot 2 Nettleton Road, Byford. The purpose of the report is to assess trees which will be affected by the installation of a new road on the northern side of the trees. The road is to be raised approximately 0.5m above the natural grade and battered down towards the trees. The survey is to assess the current health and condition of the trees as it has been some time since they have been previously inspected. The assessment is to include the closest proximity allowed for the road to be installed adjacent the trees.

The inspection consisted of several parts.

- Examination, observation and documenting the trees.
- Provide an itemised list of tree details and recommendations.
- Photograph each tree.

This consultant confirms that the site inspections were carried out on 27th of May 2013.

FORM AND APPROACH:

This consultant used the preliminary subdivision concept map to find the trees which displayed the trees locations and tree numbers.

Below are the definitions for the captured information provided.

Botanical name Information:
Botanical names are listed detailing the generic name followed by the specific epithet. The variety is named where applicable.

Tree Age:
Tree age is based on the age of the tree that would be considered typical for the species in the general area. It is not based on the health of the tree.

Juvenile
The tree has recently been planted or self-sown (within the last 3 – 5 years).

Semi mature
The tree has become established in the site and may be approaching its expected mature size. If correctly maintained the specimen will continue to grow to maturity.

Mature
Usually the tree will have reached the expected size for the species in the site.

Post mature
The tree has passed the mature stage of its life and is characterized by both a very slow growth rate and by intolerance to disturbances. The post-mature tree has limited energy reserves to fight invading diseases and insects, especially pruning wounds. Removal of live tissue is something to avoid.

Severe decline

The tree is in its final stages of life, the tree is beginning to lose its ability to defend itself. It is at this stage that the tree becomes susceptible to pests and disease. The tree will be assessed for hazards and may require reduction pruning or removal.

Note
It is important to note that tree age is not directly related to tree health. For example: It is possible for a young tree to have very poor health and a mature tree to have good health.

Tree health:

Good
The tree is demonstrating good or exceptional growth for the species. The tree should exhibit a full canopy of foliage, and have only minor pest or diseases problems. Foliage colour, size and density should be typical of a healthy specimen of that species.

Fair
The tree is in reasonable condition and growing well for the species. The tree should exhibit an adequate canopy of foliage. There may be some dead wood present in the crown, some grazing by insects or animals may be evident and/or foliage colour, size or density may be atypical for a healthy specimen of that species.

Poor
The tree is not growing to its full capacity; extension growth of the laterals may be minimal. The canopy may be thinning or sparse. Large amounts of dead wood may be evident throughout the crown. Significant pest and disease problems may be evident or symptoms of stress indicating tree decline.

Very poor
The tree appears to be in a state of decline and the canopy may be very thin and sparse. A significant volume of deadwood may be present in the canopy or pest and disease problems may be causing a severe decline in tree health.

Dead
The tree is dead.

Tree structure:

Each tree surveyed was examined in detail to ascertain its overall structural condition.

The assessed tree was then placed into one of five categories:

- *Good:* The tree has a well-defined and balanced crown. Branch unions appear to be strong, with no defects evident in the trunk or the branches. Major limbs are well defined. The tree would be considered a good example of the species. Probability of significant failure is highly unlikely.

- *Fair:* The tree has some minor problems in the structure of the crown. The crown may be slightly out of balance, and some branch unions or branches may be exhibiting minor structural faults. If the tree is single trunked, this may be on a slight lean or be exhibiting minor defects. Probability of significant failure is low.

- *Poor:* The tree may have a poorly structured crown. The crown may be unbalanced or exhibit large gaps. Major limbs may not be well defined. Branches may be rubbing or crossing over. Branch unions may be poor or faulty at the point of attachment. The tree may have suffered major root damage. Probability of significant failure is moderate.

- *Very Poor:* The tree has a poorly structured crown. The crown is unbalanced or exhibits large gaps. Major limbs are not well defined. Branch unions may be poor or faulty at the point of attachment. A section of the tree has failed or is in imminent danger of failure. Active failure may be present or failure is probable in the immediate future.

- *Has Failed:* A significant section of the tree or the whole tree has failed.

TPZ – Tree Protection zone

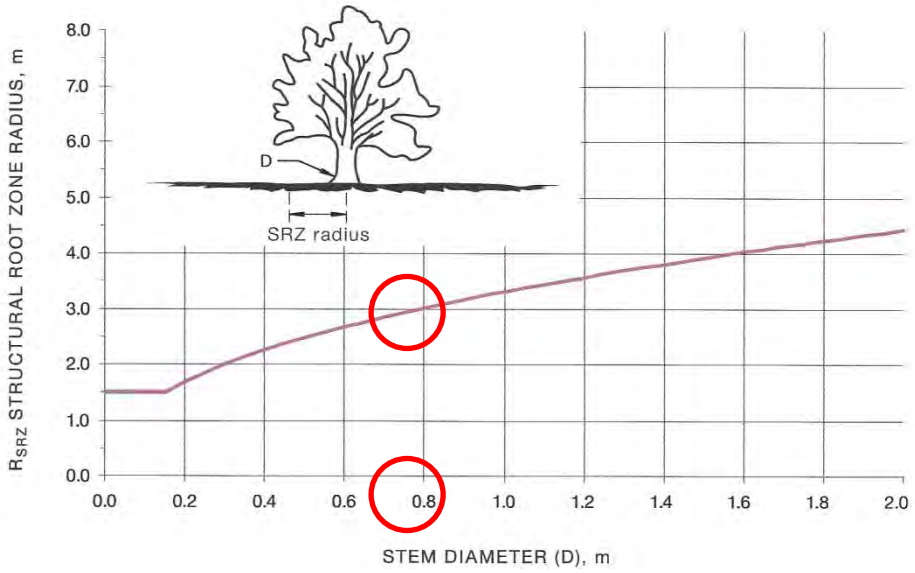
As per the Australian Standards AS 4970-2009 *Protection of trees on development sites* the tree protection zone (TPZ) is the principal means of protecting trees on development sites. The TPZ is a combination of the root area and crown area requiring protection. It is an area isolated from construction disturbance, so that the tree remains viable.

The radius of the TPZ is calculated for each tree by multiplying its DBH x 12.
E.g DBH is 0.5m x 12 = 6m radius (TPZ = 6m measured from the centre of the trunk at ground level.)
If the proposed encroachment is greater than 10% into the TPZ or SRZ the project Arborist must demonstrate that the tree(s) would remain viable. Once the design is completed the project Arborist may need to re-inspect selected trees to ensure the trees are adequately protected. The purpose of this is to determine the potential impact on trees proposed to be retained.

SRZ – Structural Root zone

This consultant advises that a structural root zone area of a tree is required for tree stability. Using Australian Standards AS 4970-2009 *Protection of trees on development sites* the structural root zone area can be calculated when major encroachment into a TPZ is proposed. An indicative SRZ radius can be determined from the trunk diameter measured immediately above the buttress using the following formula. SRZ radius = $(D \times 50)^{0.42} \times 0.64$ or using the following guide from AS 4970-2009. E.g Diameter at root flare is 0.8m (red circle) and using the graph below a 3m SRZ radius is required. This is measured from the centre of the trunk at ground level.

A1



The curve can be expressed by the following formula:

$R_{SRZ} = (D \times 50)^{0.42} \times 0.64$

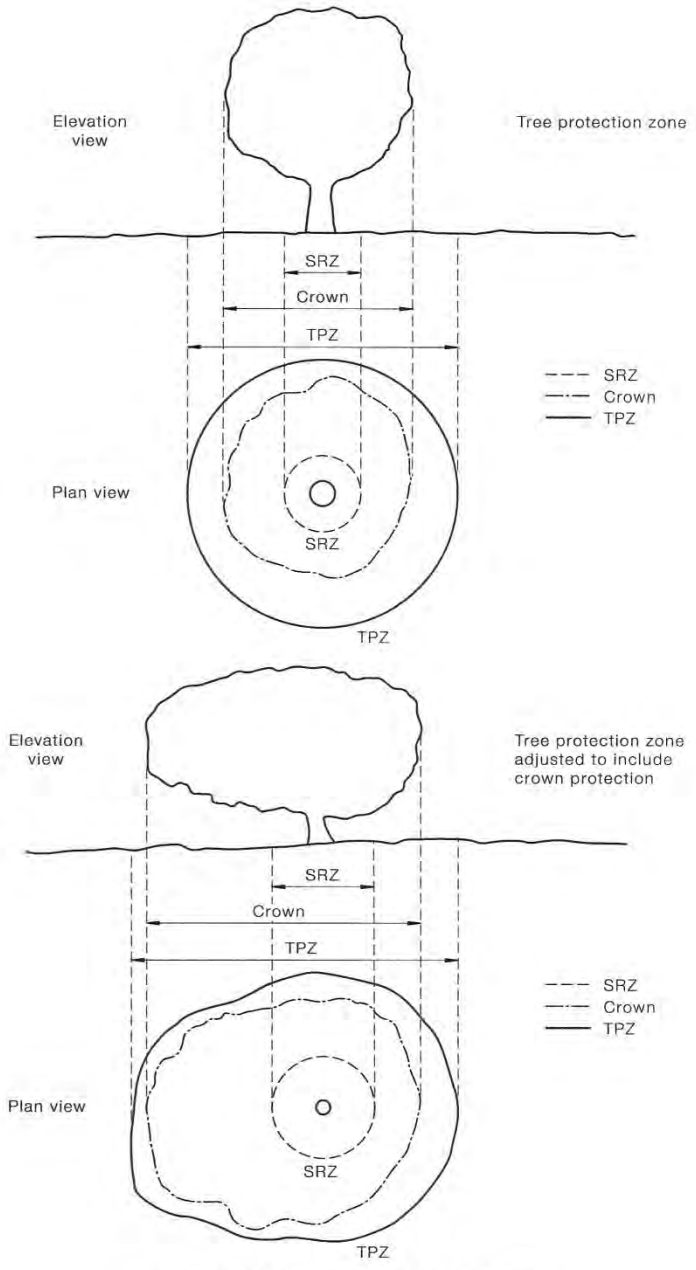
NOTES:

1 R_{SRZ} is the calculated structural root zone radius (SRZ radius).
2 D is the stem diameter measured immediately above root buttress.
3 The R_{SRZ} for trees less than 0.15 m diameter is 1.5 m.
4 The R_{SRZ} formula and graph do not apply to palms, other monocots, cycads and tree ferns.
5 This does not apply to trees with an asymmetrical root plate.

FIGURE 1 STRUCTURAL ROOT ZONE CALCULATION

The SRZ is only required to be used when major encroachment into a TPZ is proposed. The SRZ radius is not a calculation in which all roots outside the SRZ radius can be severed otherwise to do so will cause the tree to become structurally unstable and a high risk of whole tree failure. Encroachment within the TPZ and SRZ which may adversely affect root systems requires approval from the Project Arborist to ensure the tree remains structurally stable.

Below is a diagram of an indicative tree protection zone



NOTE: Refer to Clause 3.2 for calculation of TPZ.

FIGURE 2 INDICATIVE TREE PROTECTION ZONE

Limitation of liability

Trees can be managed, but they cannot be controlled. To live or work near a tree involves a degree of risk.

This report only covers identifiable defects present at the time of inspection. Paperbark Technologies accepts no responsibility and cannot be held liable for any structural defect or unforeseen event/situation or adverse weather conditions that may occur after the time of inspection.

Paperbark Technologies cannot guarantee that the tree/s contained within this report will be structurally sound under all circumstances, and is not able to detect every condition that may possibly lead to the structural failure of a tree. Paperbark Technologies cannot guarantee that the recommendations made will categorically result in the tree being made safe.

Unless specifically mentioned this report will only be concerned with above ground inspections, as such all observations have been visually assessed from ground level. Trees are living organisms and as such cannot be classified as safe under any circumstances. Trees fail in ways that the arboriculture industry does not fully understand.

The recommendations are made on the basis of what can be reasonably identified at the time of inspection therefore Paperbark Technologies accepts no liability for any recommendations made.

All care has been taken to obtain information from reliable sources, however Paperbark Technologies can neither guarantee or be responsible for the accuracy of information provided by others.

In the event that Paperbark Technologies recommends re-inspection of trees at varying intervals, it is this client's responsibility to make arrangements with Paperbark Technologies to conduct the re-inspection.

Tree Survey Details over leaf.

Tree number	Species	Health & condition	SRZ radius (m)	Recommendations
800	*Eucalyptus wandoo*	This specimen was found to be in fair health however displayed poor structural condition due to major trunk decay within the twin stem formation. The canopy consisted of a high amount of deadwood with large sections of decay within the upper branches. Looking at the Kerb and batter survey pegs this tree is within very close proximity to the future road with the canopy extending significantly over the proposed roadway and is not recommended to be retained based upon safety grounds.	Not applicable	Remove tree based upon future safety grounds
801	*Eucalyptus wandoo*	This specimen was found to be in fair health and condition displaying a large amount of deadwood, termites and decay at the base of the trunk. This tree has experienced previous limb failures resulting in jagged branch stubs and the stubs are now displaying significant decay extending within the branches and trunk. This tree is leaning in a southerly direction and as the roadway will be installed on the northern side of the tree it is recommended to include a combination of SRZ and TPZ in the distance away from the trunk due to potential root damage on the northern side which may cause the tree to become structurally unstable.	6.12m radius	Carry out deadwood pruning within the canopy. Remove deadwood back to source. Treat tree for termites. Retain a combined SRZ & TPZ of 6.1m around the tree with no root disturbance within this radius.

802	*Eucalyptus wandoo*	This specimen was found to be in fair health and poor structural condition due to multiple limb failures and inverted jagged wounds. There was a large amount of deadwood held within the canopy which is recommended to be cleanly pruned. Once pruning is carried out there may not be much of this canopy left however the tree is within a cluster of other trees and will still provide amenity and habitat to the surrounding streetscape.	3.6m radius	Carry out deadwood pruning and clean up all jagged branch stubs to source. Retain a combined SRZ & TPZ of 3.6m around the tree
803	*Eucalyptus wandoo*	This specimen displayed a central column of decay with active termites and epicormic growth development. The canopy which consisted of epicormic growth is weakly attached and is prone to a high risk of future fracture and failure. This specimen is not worthy of retention based upon future safety grounds.	Not applicable	Remove tree based upon future safety grounds
804	*Eucalyptus wandoo*	This tree was found to be in fair health and fair structural condition displaying sporadic limb failures and a high amount of deadwood. This specimen is one of the best trees out of these 8 specimens and is suitable for retention using a combination of SRZ and TPZ.	5.4m radius	Retain tree with 5.4m radius of undisturbed soil around the base. It is recommended to remove all deadwood based upon safety grounds.
805	*Eucalyptus wandoo*	This specimen was found to be in fair health displaying poor structure due to sporadic limb failures and a large amount of deadwood held within the canopy. This specimen is suitable to retain after remedial tree surgery works.	4.5m radius	Retain the tree with a 4.5m radius of undisturbed soil. Carry out deadwood pruning and cleanly prune all jagged branch stubs.
806	*Eucalyptus wandoo*	This tree was found to be in poor health and condition due to a high amount of dead material within the canopy. Much of the canopy consists of epicormic growth due to suppression by the adjacent trees. It is suitable to retain after dead wood pruning.	2.7m radius	Retain the tree with a 2.7m radius of undisturbed soil. Carry out deadwood pruning and cleanly prune all jagged branch stubs.

807	*Eucalyptus wandoo*	This specimen was found to be in good health and displays fair structural condition. It displayed a large amount of parrot browsing damage on the main trunk and upper branches with bird nests and hollows visible. The base of the trunk displayed a decayed section on the west side with evidence of termite mud colonies. The canopy held a large amount of dead wood and evidence of previous limb failures. This specimen is considered to be one of the better trees out of this grouping and is recommended to have remedial tree surgery works and termite treatment carried out. It is recommended to retain a combined TPZ and SRZ radius around this tree to ensure the tree retains its health and vitality and reduce the risk of limb failure onto the new roadway.	8m radius	Retain the tree with an 8m radius of undisturbed soil. Carry out deadwood pruning, cleanly prune all jagged branch stubs to source and carry out termite treatment.

Summary of findings

This consultant's inspection of the trees within Lot 2 Nettleton Road, Byford revealed that they were predominantly in fair health however displayed a high amount of dead material and decay within trunks and upper limbs due to years of neglect.

The tree survey revealed that of the 8 trees inspected:

- 2 trees require removal due to poor structural condition with major decay & deadwood.
- The remainder of the trees can be retained once remedial tree surgery works are carried out.

This consultant advises that the edge of the battering which is to extend from the proposed road level down towards the trees is recommended to end at the recommended TPZ & SRZ radius nominated against each tree. This is to ensure that the trees root zone remains predominantly intact and the canopy of the trees is not significantly extending over the roadway.

All pruning works are to be carried out by suitably qualified Arborist's to ensure the trees are correctly managed.

Trenching within the recommended SRZ & TPZ of trees is not recommended as it will cause structural stability issues and render the tree a high level of risk to the surrounding targets.

To reduce the effects that re-development can have upon the health of retained trees, suitable forms of protection are required together with the steps necessary to limit deterioration of those species left standing on the development site.

This consultant confirms that there is clear evidence that mature trees are more sensitive to contractor pressure than young and semi-mature specimens, where the younger trees are able to compensate and adapt to new ground conditions by producing new roots. However, although younger trees can exhibit a remarkable tolerance to the adverse effects of building operations and site alterations, this is conditional upon the location and extent of works carried out within the root zone of the tree and therefore the extent of primary root removal.

As with predominantly most trees they store vast amounts of carbohydrate in their root system, subsequently when major roots are severed the tree is unable to replenish its depleted energy levels, which gradually results in the decline of the canopy and often the death of the tree, with such symptoms often not evident until some years later.
Therefore there must be clear recommendations to alleviate detrimental tree damage from the commencement through to the completion of the development, with the recommendations enforced and clearly understood by all contractor staff.

The future management, maintenance and condition of the trees have a considerable bearing on their location, with safety to property and persons the main priority. It is therefore recommended that each tree be re-inspected annually to ensure that the trees remain healthy and in a structurally sound condition with a level of risk that is acceptable to property and to persons.

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References

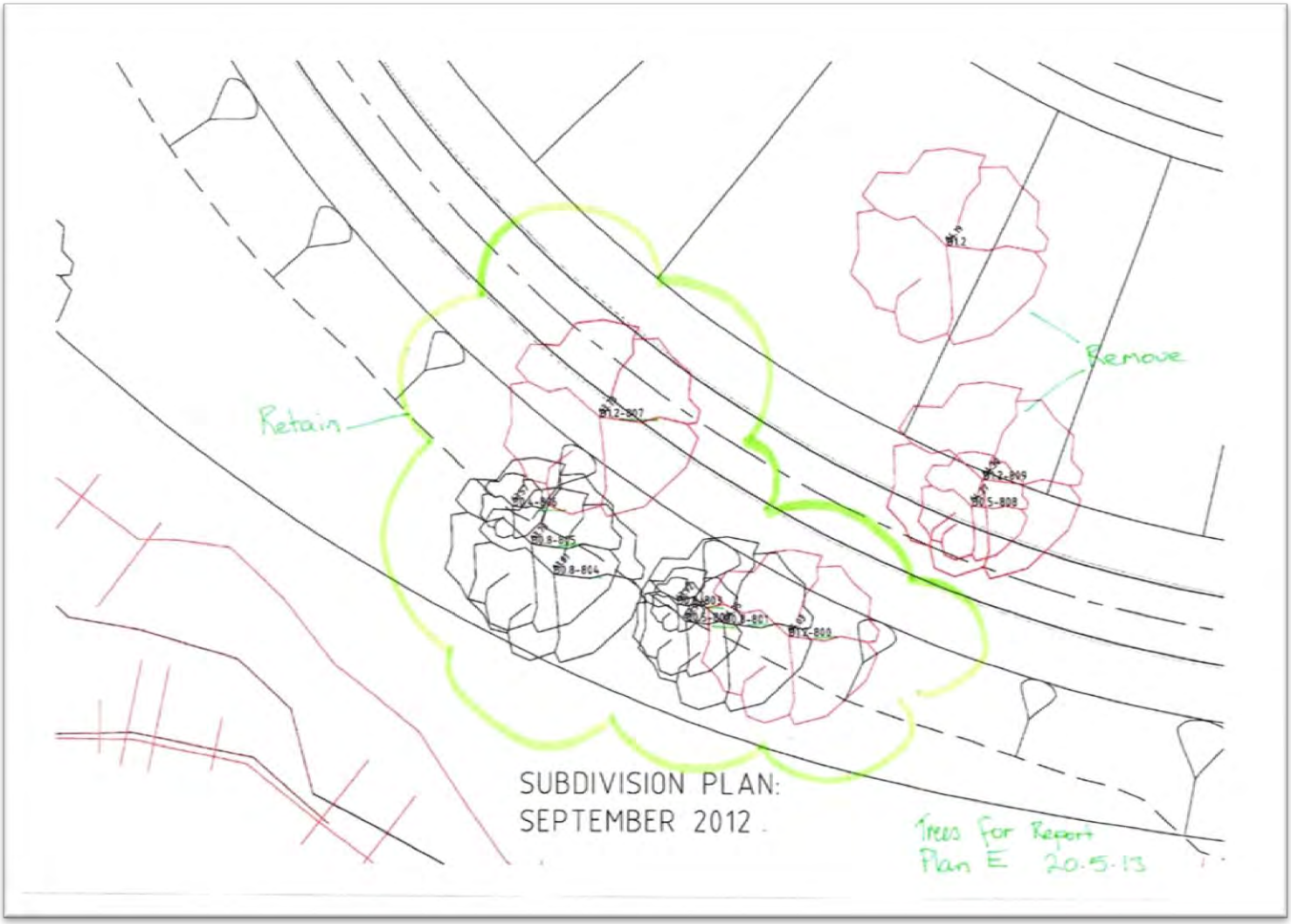
Mattheck, C & Breloer H, (1994) *The body language of trees, a handbook for failure analysis.* London TSO (The Stationery Office)

Lonsdale David, (1999) *Principles of Tree Hazard Assessment and Management.* London TSO (The Stationery Office).

Hayes, Ed (2007) *Evaluating Tree Defects, second edition.* Safetrees Rochester.

Australian Standards 4970-2009 *Protection of trees on development sites.*

Aerial plan of the trees in question



Photos of trees 800 – 807

Tree 800

Tree 800 displaying significant decay within twin stem formation.

Tree 801

Tree 803

Tree 802

Tree 807

Tree 807 showing basal decay & termites

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ABN 44 981 725 498
Knightside Nominees Pty Ltd

26 August 2013

Ken Haustead

Cedar Woods Properties Limited
PO Box 788
WEST PERTH WA 6872

Dear Ken,

RE: Lot 2 Nettleton Road, Byford – Retained Vegetation Advice

Following is our assessment of the modified configuration of the retained vegetation in the north-east corner of the Lot 2 Nettleton Road, Byford development site.

A flora and vegetation survey of Lot 2 was undertaken in 2007 (ENV, 2007). The vegetation in the eastern part of the lot was mapped as one vegetation type, a Marri/Jarrah Woodland or specifically a "Woodland of *Corymbia calophylla* and *Eucalyptus marginata* over *Hibbertia hypericoides, Mesomelaena tetragona* and *Desmocladus flexuosus"*.

The condition of the Marri/Jarrah woodland was rated by ENV as Good for the eastern half of the stand of woodland and Degraded for the western and southern portion. A site inspection undertaken by myself on 18 February confirmed the general description and condition rating of the vegetation. No significant flora or vegetation communities were recorded on the site.

In 2008 the Shire of Serpentine-Jarrahdale released its Local Biodiversity Strategy. The Strategy identified 6,333ha of Local Natural Areas to be retained and managed to protect the biodiversity values within the Shire. The majority of the Local Natural Areas was on private property. The Marri/Jarrah woodland on Lot 2 was considered a Local Natural Area identified under the Local Biodiversity Strategy.

The Indicative Development Concept Plan for Lot 2 prepared by the Aspen Group identified a 3ha portion of the Marri/Jarrah Woodland for retention. The retained area was triangular in shape and in the north-east corner of the lot (Attachment 1). The 3ha area included a road connecting the future development on Lot 2 with Beenyup Road. The road effectively would have reduced the conservation area to less than 3ha, taking into account the area of the road and verges, and would have split the area into two separate conservation areas.

A Preliminary Subdivision Concept prepared for the lot by the new owners, Cedar Woods, also proposed to retain a 3ha portion of the Marri/Jarrah Woodland although with a different

configuration (Attachment 2). The Subdivision Concept plan does not include a connecting road within the 3ha portion and consolidates the conservation area into one land parcel.

A comparison of the two different 3ha retained vegetation configurations can be made using the Perth Biodiversity Project Natural Area Initial Assessment (NAIA) tool which assists in determining the viability of a local natural area. The results of the NAIA are shown in Attachment 3 and are summarised below.

Size

Both configurations are between 1ha and 4ha and therefore score 2 on the NAIA.

Shape

The symmetrical triangular shape of the Development Concept Plan configuration scores a 3 while the slightly more irregular shape of the Preliminary Subdivision Concept with few indentations scores 2.5. It should be noted, however, that the Development Concept Plan configuration is really two areas separated by a road.

Perimeter to Area Ratio

The slightly more regular shape of the triangle in the Development Concept Plan configuration has a slightly lower perimeter to area ratio (0.026) than the slightly more irregular shape of the Preliminary Subdivision Concept (0.035), however the numbers both score 2 as they are between 0.02 and 0.04. A lower perimeter to area ratio is preferred in reserve design. The perimeter to area ratio is a measure of the potential extent of impacts from edge effects such as weed invasion extending into the reserve. The score for the Development Concept Plan therefore is slightly overestimated as this plan has a proposed road running through the north-west portion linking the future development with Beenyup Road. The impact of a road passing through the 3ha conservation area would increase the possibility of weed spreading into more of the area than just from the perimeter.

Vegetation Condition

The vegetation condition in the Development Concept Plan configuration is nearly all rated as Good which scores 3.98 in the NAIA. The vegetation in the Preliminary Subdivision Concept configuration retains about 75% Good and 25% Degraded therefore the score of 3.5 is slightly lower. Both scores are similar in comparison to the maximum score for this category which is 10. The score of 360 given in the ENV (2008) assessment of the NAIA has been incorrectly applied and has therefore not allowed a total score to be tallied. The ENV score should have been 3.6.

Connectivity

Both configurations are not part of a Regional Ecological Linkage but are within 500m of two protected natural areas having an area greater than 4ha, therefore a score of 1.5 applies.

Total Score

The total score for the Development Concept Plan configuration is 12.48.

The total score for the Preliminary Subdivision Concept configuration is 11.5.

Both scores are just under the accepted target of 14.0 for a local natural area to be viable to protect conservation values.

In terms of the conservation values that the 3.0ha local natural area is protecting there is very little difference between the two configurations as summarised below:

- Both areas protect the same vegetation type;
- The vegetation type is not a Threatened or Priority Ecological Community;
- Both areas do not contain any significant flora species;
- The condition of the vegetation is slightly better in the Development Concept Plan configuration but the rating of Good is quite low on the vegetation condition scale with Pristine, Excellent and Very Good scales rated higher; and
- Both areas protect fauna values on the site with the retention of Marri and Jarrah trees for Black Cockatoo habitat.

However, an important difference between the two configurations is the inclusion of a through road in the triangular Development Concept Plan while the Subdivision Concept does not have any such road. As stated above, the impact of a road traversing the conservation area is likely to result in greater weed infestation within the vegetated area. The through road would also likely result in greater impacts on fauna, through road kill, than the configuration without the road. The through road is also likely to increase the requirement for fencing around the reserve as well as either side of the road thereby reducing the connectivity between the two halves divided by the road.

In conclusion, our comparison of the two different 3ha retained vegetation configurations indicates there is very little difference in the conservation values protected in each configuration or in the viability of the areas as conservation reserves. Given that there are few significant conservation values in the 3.0ha areas, the low viability score is not considered a problem. The primary difference between the two configurations is the deletion of the through road between the future development and Beenyup Road in the Subdivision Concept configuration which is considered a better management option for the retained 3ha of vegetation on the site and will result in an effective area of 3ha being retained.

Please contact me if you require any clarification of this advice.

Yours sincerely

Paul van der Moezel
Managing Director

References

ENV (2007). *Flora and Vegetation Survey of Lot 2 South West Highway, Byford.* Unpublished report prepared for the Aspen Group.

ENV (2008). *An Assessment of Remnant Vegetation at Lot 2 Nettleton Road*. Unpublished report prepared for the Aspen Group.

Attachments

1 Indicative Development Concept Plan
2 Preliminary Subdivision Concept
3 Natural Area Initial Assessment Summaries

Attachment 1

LEGEND

- SUBJECT LAND
- POTENTIAL VISITOR PARKING
- PEDESTRIAN CIRCUIT (supplements road pavement)
- SECURITY FENCE/ACCESS GATE
- DWELLING SETBACK LINE (as detailed in Risk Management Plan)

NOTES

1. Drainage Detention
2. Rehabilitation and enhancement to Beenyup Brook Corridor.
3. Large lot interface with existing residential.
4. Caravan Storage.
5. Potential emergency access/egress.
6. Linear open space and drainage corridor.
7. Landscape buffer incorporating Dual Use Path and landscaping treatment to address risk management report outcomes.
8. Identified trees for retention.
9. Community Centre
10. Arborway - High amenity entry statement and pedestrian spine.
11. Vegetation protection zone(land area -3ha)

INDICATIVE DEVELOPMENT CONCEPT PLAN
Lot 2 Nettleton Road, Byford
An Aspen Group Project

s: NTS
d: Oct 2009
j: 07/067

plan 02

Attachment 2

LEGEND	
	TOTAL APPLICATION AREA (32.288ha)
	ANTICIPATED FOR DRAINAGE CONNECTIONS

LOT YIELD			LOT AREA	
Size	No. Lots	% Total Lots	Average Size	% of Total Area
200m² - 249m²	24	6.70%	240m²	3.62%
250m² - 299m²	29	8.10%	269m²	4.90%
300m² - 349m²	13	3.63%	324m²	2.64%
350m² - 449m²	108	30.17%	387m²	26.27%
450m² - 499m²	83	23.18%	459m²	23.93%
500m² - 599m²	52	14.53%	533m²	17.42%
600m² - 1259m²	47	13.13%	645m²	19.04%
1260m²+	2	0.56%	1743m²	2.19%
Total Number of Lots	**358**			

Minimum Lot Size 240m²
Maximum Lot Size 2210m²
Average Lot Size 445m²
Total Lot Area 15.9375ha

PRELIMINARY SUBDIVISION CONCEPT
Lot 2 Nettleton Road, Byford
Prepared for Cedar Woods

DRAFT

0m 15 30 45m
s: 1:3000@A3
1:1500@A1
d: 17 Jan 2013
p: 07/067/033A

Taylor Burrell Barnett Town Planning and Design
187 Roberts Road Subiaco Western Australia 6008
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Attachment 3

Initial Assessment Summary

Name of area Preliminary Subdivision Concept Configuration

VIABILITY ESTIMATE			
Viability Factor	**Category**		**Score**
Size	Greater than 20 ha		5
	Greater than 10 ha less than 20 ha		4
	Greater than 4 ha less than 10 ha		3
	Greater than 1 ha less than 4 ha		(2)
	Less than 1 ha		1
Shape	Circle, square or squat rectangle		3.5
	Oval, rectangle or symmetrical triangle		3
	Irregular shape with few indentations		(2.5)
	Irregular shape with many indentations		2
	Long thin shape with large proportion of area greater than 50 m wide		1.5
	Long thin shape with large proportion of area less than 50 m wide		1
Perimeter to area ratio	Less than 0.01		4
	Greater than 0.01 less than 0.02		3
	Greater than 0.02 less than 0.04		(2) 0.035
	Greater than 0.04		1
Vegetation condition NB: based on Keighery (1994) condition scale	Pristine	10 x % =	
	Excellent	8 x % =	
	Very Good	6 x % =	
	Good	4 x 75 % = 3	
	Degraded	2 x 25 % = 0.5	
	Completely Degraded	0 x % =	
		Total calculated score =	(3.5)
Connectivity	**A.** Forms part of a Regional Ecological Linkage and is contiguous with a protected natural area greater than 4ha		5
	B. Not part of a Regional Ecological Linkage but contiguous with a protected natural area greater than 4ha		4.5
	C. Forms part of a Regional Ecological Linkage and is within 500 m of more than 4 protected natural areas having an area greater than 4 ha		4
	D. Not part of a Regional Ecological Linkage but within 500 m of more than 4 protected natural areas having an area greater than 4 ha		3.5
	E. Forms part of a Regional Ecological Linkage and is within 500 m of 3 or 4 protected natural areas having an area greater than 4 ha		3
	F. Not part of a Regional Ecological Linkage but within 500 m of 3 or 4 protected natural areas having an area greater than 4 ha		2.5
	G. Forms part of a Regional Ecological Linkage and is within 500 m of 2 protected natural areas having an area greater than 4 ha		2
	H. Not part of a Regional Ecological Linkage but within 500 m of 2 protected natural areas having an area greater than 4 ha		(1.5)
	I. Forms part of a Regional Ecological Linkage and is within 500 m of 1 protected natural area having an area greater than 4 ha		1
	J. Not part of a Regional Ecological Linkage but within 500 m of 1 protected natural area having an area greater than 4 ha		0.5
	K. Forms part of a Regional Ecological Linkage but is not within 500 m of any protected natural areas having an area greater than 4 ha		0.25
TOTAL SCORE (Viability Estimate)			

TOTAL 11.5

Initial Assessment Summary

Name of area Development Concept Plan Configuration

VIABILITY ESTIMATE			
Viability Factor	**Category**		**Score**
Size	Greater than 20 ha		5
	Greater than 10 ha less than 20 ha		4
	Greater than 4 ha less than 10 ha		3
	Greater than 1 ha less than 4 ha		(2)
	Less than 1 ha		1
Shape	Circle, square or squat rectangle		3.5
	Oval, rectangle or symmetrical triangle		(3)
	Irregular shape with few indentations		2.5
	Irregular shape with many indentations		2
	Long thin shape with large proportion of area greater than 50 m wide		1.5
	Long thin shape with large proportion of area less than 50 m wide		1
Perimeter to area ratio	Less than 0.01		4
	Greater than 0.01 less than 0.02		3
	Greater than 0.02 less than 0.04		(2) 0.026
	Greater than 0.04		1
Vegetation condition NB: based on Keighery (1994) condition scale	Pristine	10 x % =	
	Excellent	8 x % =	
	Very Good	6 x % =	
	Good	4 x 99 % = 3.96	
	Degraded	2 x 1 % = 0.02	
	Completely Degraded	0 x % =	
		Total calculated score =	(3.98)
Connectivity	**A.** Forms part of a Regional Ecological Linkage and is contiguous with a protected natural area greater than 4ha		5
	B. Not part of a Regional Ecological Linkage but contiguous with a protected natural area greater than 4ha		4.5
	C. Forms part of a Regional Ecological Linkage and is within 500 m of more than 4 protected natural areas having an area greater than 4 ha		4
	D. Not part of a Regional Ecological Linkage but within 500 m of more than 4 protected natural areas having an area greater than 4 ha		3.5
	E. Forms part of a Regional Ecological Linkage and is within 500 m of 3 or 4 protected natural areas having an area greater than 4 ha		3
	F. Not part of a Regional Ecological Linkage but within 500 m of 3 or 4 protected natural areas having an area greater than 4 ha		2.5
	G. Forms part of a Regional Ecological Linkage and is within 500 m of 2 protected natural areas having an area greater than 4 ha		2
	H. Not part of a Regional Ecological Linkage but within 500 m of 2 protected natural areas having an area greater than 4 ha		(1.5)
	I. Forms part of a Regional Ecological Linkage and is within 500 m of 1 protected natural area having an area greater than 4 ha		1
	J. Not part of a Regional Ecological Linkage but within 500 m of 1 protected natural area having an area greater than 4 ha		0.5
	K. Forms part of a Regional Ecological Linkage but is not within 500 m of any protected natural areas having an area greater than 4 ha		0.25
TOTAL SCORE (Viability Estimate)			

TOTAL 12.48

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Environmental Noise Assessment

Lot 2 Nettletone Road, Byford

Reference: 13032388-01.docx

Prepared for:
Cedar Woods

Member Firm of Association of Australian Acoustical Consultants

Report: 13032388-01.docx

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Prepared By:	Terry George 
Position:	Project Director
Date:	4 October 2013

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Appendices

1 INTRODUCTION

In 2007, Lloyd George Acoustics assessed noise levels from an industrial estate on the south side of Nettleton Road in Byford to a proposed subdivision on the north side of Nettleton Road. At that stage, the residential subdivision did not proceed and is now under different ownership. At the request of Cedar Woods and due to the age of the previous assessment, noise from the industrial estate has been reassessed by way of updated measurements and incorporating the latest proposed subdivision plan.

Figure 1-1 below provides the general site locality with *Figure 1-2* providing the draft subdivision plan.

Figure 1-1 Site Locality

Figure 1-2 Draft Subdivision Plan and Earthworks

To the north, west and east of the site are existing residences, with South Western Highway being to the immediate west. According to Map 02 of the Shire of Serpentine-Jarrahdale Town Planning Scheme No.2, the subject site and surrounding land is zoned Urban Development. Interestingly, this zoning is also shown for the land on the south side of Nettleton Road. The actual land use for that land, bound by Nettleton Road, South Western Highway and Wilaring Street is considered to be light industrial.

Noise from the light industrial area is required to comply with the prescribed standards of the *Environmental Protection (Noise) Regulations 1997* and the onus of achieving this compliance is on the noise emitter. For instance, Section 79 of the *Environmental Protection Act 1986* states:

> *"A person who … causes or allows to be used any equipment in such a way as to cause … unreasonable noise from those premises commits an offence."*

This report considers the existing industrial noise levels to the existing residences and also these same noise levels to the proposed subdivision.

Appendix C contains a description of some of the terminology used throughout this report.

2 CRITERIA

Environmental noise in Western Australia is governed by the *Environmental Protection Act 1986*, through the *Environmental Protection (Noise) Regulations 1997* (the Regulations).

Regulation 7 defines the prescribed standard for noise emissions as follows:

"7. (1) Noise emitted from any premises or public place when received at other premises –

(a) Must not cause or significantly contribute to, a level of noise which exceeds the assigned level in respect of noise received at premises of that kind; and

(b) Must be free of –

i. Tonality;

ii. Impulsiveness; and

iii. Modulation".

A "…noise emission is taken to *significantly contribute to* a level of noise if the noise emission exceeds a value which is 5 dB below the assigned level…"

Tonality, impulsiveness and modulation are defined in Regulation 9. Noise is to be taken to be free of these characteristics if:

(a) The characteristics cannot be reasonably and practicably removed by techniques other than attenuating the overall level of noise emission; and

(b) The noise emission complies with the standard after the adjustments of *Table 2-1* are made to the noise emission as measured at the point of reception.

Table 2-1 Adjustments for Intrusive Characteristics

Tonality	Modulation	Impulsiveness
+ 5dB	+ 5dB	+ 10dB

Note: The above are cumulative to a maximum of 15dB.

The baseline assigned levels (prescribed standards) are specified in Regulation 8 and are shown in *Table 2-2*.

Table 2-2 Baseline Assigned Noise Levels

Premises Receiving Noise	Time Of Day	Assigned Level (dB)		
		L_{A10}	L_{A1}	L_{Amax}
Noise Sensitive[1]	0700 to 1900 hours Monday to Saturday (Day)	45 + influencing factor	55 + influencing factor	65 + influencing factor
	0900 to 1900 hours Sunday and public holidays (Sunday)	40 + influencing factor	50 + influencing factor	65 + influencing factor
	1900 to 2200 hours all days (Evening)	40 + influencing factor	50 + influencing factor	55 + influencing factor
	2200 hours on any day to 0700 hours Monday to Saturday and 0900 hours Sunday and public holidays (Night)	35 + influencing factor	45 + influencing factor	55 + influencing factor
Noise Sensitive[2]	All hours	60	75	80

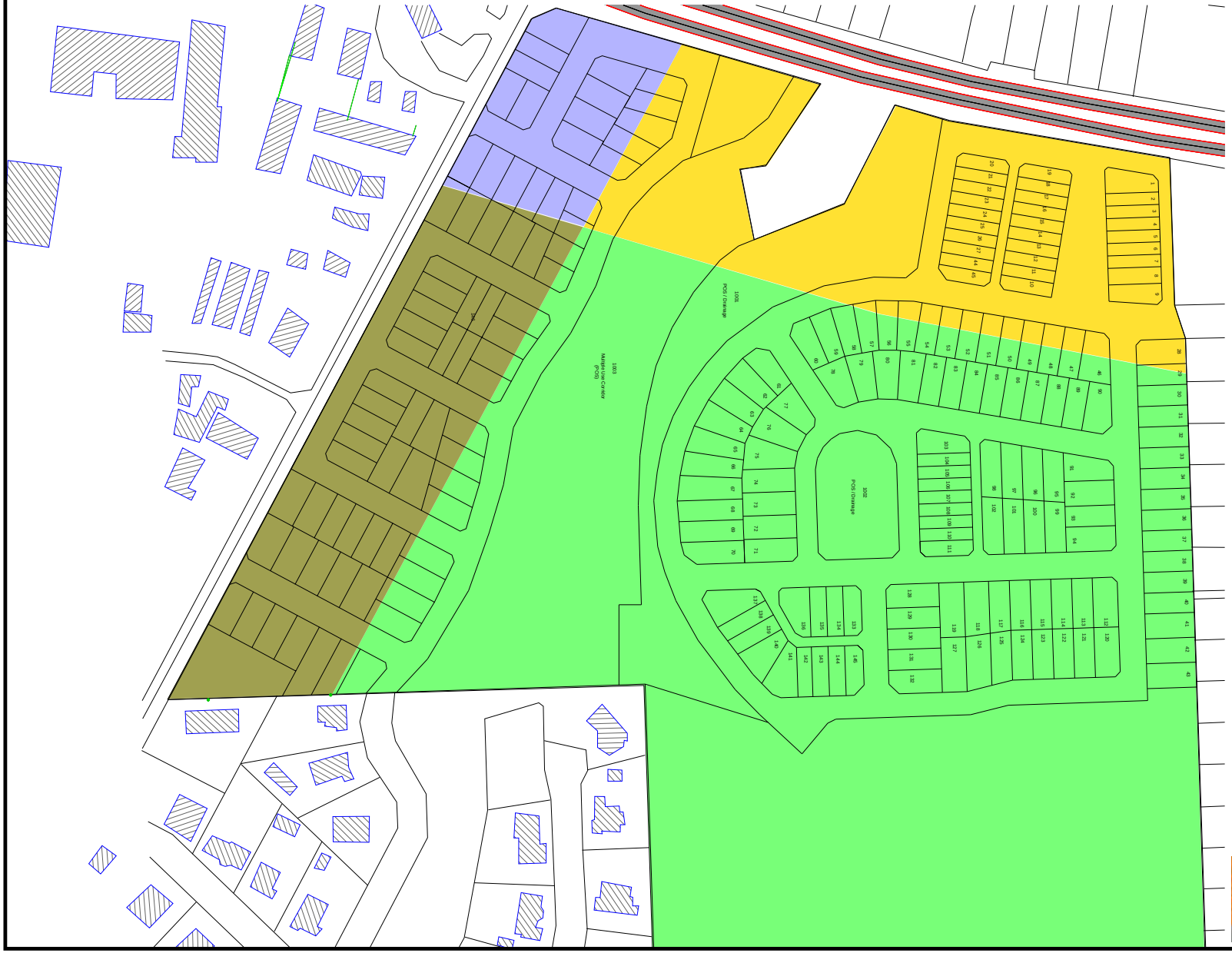
1. Applies within 15 metres of a building associated with a noise sensitive use, as defined in Schedule 1, Part C.
2. Applies at a noise sensitive premises greater than 15 metres from a building with a noise sensitive use.

The influencing factor varies across the site. For instance, residences within 100 metres of South Western Highway would receive a transport factor of + 6 dB. This reduces to 2 dB where residences are between 100 metres and 450 metres from South Western Highway. All residences within 450 metres will also have an influencing factor from the light industrial area, depending on the percentage of industrial land within 100 metres and 450 metres of that residence. The different influencing factors are shown on *Figure 2-1*.

Lot 2 Nettleton Road Proposed Subdivision

Influencing Factors for Assigned Noise Levels of Regulations

Figure 2-1



Signs and symbols

- Road Source
- Road Surface
- Building
- IF = 0
- IF = 2
- IF = 5
- IF = 6
- IF = 9

4 October 2013

Length Scale 1:3500

0 20 40 80 120 160 m

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The highest total influencing factor is + 9 dB so as an example for these residences, the assigned L_{A1} daytime noise level would be 64 dB L_{A1} and during the night, the L_{A10} assigned noise level would be 44 dB L_{A10}.

3 METHODOLOGY

3.1 Site Measurements

Under the Regulations, there are certain requirements that must be satisfied when undertaking measurements and are defined in Regulations 19, 20, 22 and 23 and Schedule 4. In undertaking the measurements, these have been satisfied, specifically noting the following:

- The sound level meter used was:
    - Bruel & Kjaer Type 2260 Observer (S/N: 2508199);
- All equipment holds current laboratory certificates of calibration that are available upon request. The equipment was also field calibrated before and after the Event and found to be within +/- 0.5 dB.
- Each microphone was fitted with a standard wind screen.
- The microphone was at least 1.2 metres above ground level and at least 3.0 metres from reflecting facades (other than the ground plane).

Measurements were recorded during the day on 10 June 2013 between 11.00am and 1.30pm. During the night, measurements were recorded on 18 June 2013 between 10.00pm and 11.30pm. Weather data during the night measurements were obtained from the Bureau of Meteorology's Champion Lakes site and were recorded at:

- Temperature 10°C
- Humidity 90%
- Wind Speed 3.6m/s
- Wind Direction South-Easterly

The above conditions are considered to represent the worst-case in terms of noise propagation.

During the day, background noise from road traffic dominates the noise levels. At night, road traffic is sporadic so its influence can be minimised on noise measurements. Noise from fauna is present during the day and night.

Measurements were recorded at a number of locations on the southern boundary of the subject site as well as measurements closer to the noise sources of interest. These measurements were then used to calibrate the noise model and assess the noise levels over the site and existing residences.

3.2 Noise Modelling

Computer modelling has been used to support the hand held measurements. The advantage of modelling is that it is not affected by background noise sources.

The software used was *SoundPLAN 7.2* with the CONCAWE algorithms selected. These algorithms have been selected as they are one of the few that include the influence of wind and atmospheric stability. Input data required in the model are:

- Meteorological Information;
- Topographical data;
- Ground Absorption; and
- Source sound power levels.

3.2.1 Meteorological Information

Meteorological information utilised (*Table 3-1)* is based on that specified in the *draft EPA Guidance for the Assessment of Environmental Factors No.8 Environmental Noise*. These conditions are considered the worst-case for noise propagation. At wind speeds greater than those shown above, sound propagation may be further enhanced, however background noise from the wind itself and from local vegetation is likely to be elevated and dominate the ambient noise levels.

Table 3-1 Modelling Meteorological Conditions

Parameter	Night (1900-0700)	Day (0700-1900)
Temperature (^{o}C)	15	20
Humidity (%)	50	50
Wind Speed (m/s)	3	4
Wind Direction*	All	All
Pasquil Stability Factor	F	E

* Note that the modelling package used allows for all wind directions to be modelled simultaneously.

Note that the above conditions approximate the typical worst-case for enhancement of sound propagation. The EPA policy is that compliance with the assigned noise levels needs to be demonstrated for 98% of the time, during the day and night periods, for the month of the year in which the worst-case weather conditions prevail. In most cases, the above conditions occur for more than 2% of the time and therefore must be satisfied.

3.2.2 Topographical Data

Topographical data was based on a combination of *GoogleEarth* as well as a site specific survey.

3.2.3 Ground Absorption

Ground absorption varies from a value of 0 to 1, with 0 being for an acoustically reflective ground (e.g. water or bitumen) and 1 for acoustically absorbent ground (e.g. grass). In this instance, a value of 0.65 has been used as an average across the study area.

3.2.4 Source Sound Levels

The sound power levels used in the modelling are provided in *Table 3-2*. How these were calculated is further discussed in *Section 4.1*. Note that as permission to enter the industrial sites was not obtained, the source descriptions are in general terms only, with only the dominant frequencies identified.

Table 3-2 Source Sound Power Levels

Description	Octave Band Centre Frequency (Hz)							Overall dB(A)
	125	250	500	1k	2k	4k	8k	
Noise from Mill – L_{A10}								
Air Release – Bottom of North Silos						65 66	66 63	**71**
Tonal Noise (1kHz) – Top of North Silos				73				**73**
Tonal Noise (160Hz) – East Mill Building	93							**93**
Mobichanics – L_{A1}								
High Pressure Air			70	74 81 81	81 82 84	86 89 87	87 86 82	**95**

4 RESULTS

4.1 Noise Monitoring

During the day, noise measurements and observations were undertaken on the southern boundary of the subject site. The locations of these measurements were:

- Opposite the Caltex Service Station and Carwash
- Opposite Byford Plasterboard Premises
- Opposite Dougall Street
- Intersection of Dougall and Michael Streets.

The results of the daytime measurements and observations are summarised below in *Table 4-1*. For the most part, there is minimal noise coming from each industry, with the main exception being the Mill. Intermittent noise was observed from Mobichanics, located on the southeast corner of Dougall Street and Nettleton Road.

Table 4-1 Summary of Day Noise Measurements and Observations

Location	Comments	Noise Levels
Opposite Caltex Service Station & Carwash	Carwash not in use during observation period. Only audible noise from service station is from car engines moving. These are exempt from Regulations. Dominant noise is from road traffic on Nettleton Road.	Noise levels recorded were: - 48 dB L_{A90} - 61 dB L_{A10} - 71 dB L_{A1} - 75 dB L_{Amax} These are not assessed against the Regulations, as they are associated with road traffic.
Opposite Byford Plasterboard	No noise from these premises. Ambient noise dominated by road traffic.	-
Opposite Dougall Street	Measured noise with road traffic and with less road traffic influence. Constant tonal noise at 160Hz audible.	With traffic noise levels: - 43 dB L_{A90} (34 dB(A) at 160 Hz) - 56 dB L_{A10} - 64 dB L_{A1} - 68 dB L_{Amax} Without traffic noise levels: - 44 dB L_{A90} (37 dB(A) at 160 Hz) - 46 dB L_{A10} (39 dB(A) at 160 Hz) - 50 dB L_{A1} / 59 dB L_{A1} from Mobichanics - 48 dB L_{Amax}
Intersection of Dougall and Michael Streets	Tonal noise at 160Hz prominent. Likely to be coming from the mill.	-

The results of the night measurements and observations are summarised below in *Table 4-2*. These measurements are more useful in that there is significantly less road traffic around and therefore noise from the Mill, which is a 24-hour operation and the main noise emitter, is more accurately quantified.

Table 4-2 Summary of Night Measurements and Observations

Location	Comments	Noise Levels
Opposite Caltex Service Station & Carwash	Carwash not in use during observation period. Only audible noise from service station is from car engines moving and some conversational noise. Traffic, crickets and frogs are significant. Tonal noise and air release noise audible, identified as coming from the north silos at the Mill.	Noise levels are typically 39 dB(A) with tonality at 160 Hz and 1 kHz at levels of 32 dB(A) and 33 dB(A) respectively.
Opposite Byford Plasterboard	No noise from these premises. Ambient noise dominated by road traffic and the mill as described above.	Noise levels are typically 42 dB(A) with tonality at 160 Hz and 1 kHz at levels of 35 dB(A) and 36 dB(A) respectively.
Opposite Dougall Street	Both road traffic and frogs are dominant at this location. Tonal noise at 160Hz strongest here.	Noise levels are typically 41 dB(A) with tonality at 160 Hz and 1 kHz at levels of 37 dB(A) and 34 dB(A) respectively.
Intersection of Dougall and Michael Streets	Tonal noise at 160Hz prominent from Mill.	Noise levels are typically 55 dB(A) with tonality at 160 Hz at a level of 54 dB(A)
Carpark south of carwash and north of Mill	Tonal noise at 1kHz and air release noise from Mill dominant.	Noise levels are typically 45 dB(A) with tonality at 160 Hz at a level of 36 dB(A) and at 1kHz a level of 42 dB(A).

4.2 Noise Modelling

The results of the measurements were used to calculate the sound power levels of the significant noise sources for the critical periods of day L_{A1} and night L_{A10}. The sound power levels were incorporated into the noise model and calibrated for accuracy. The model was then run so as to predict the noise levels to existing residences as shown in *Figures 4-1 and 4-2* and summarised in *Table 4-3*.

Table 4-3 Summary of Noise Modelling to Existing Residences

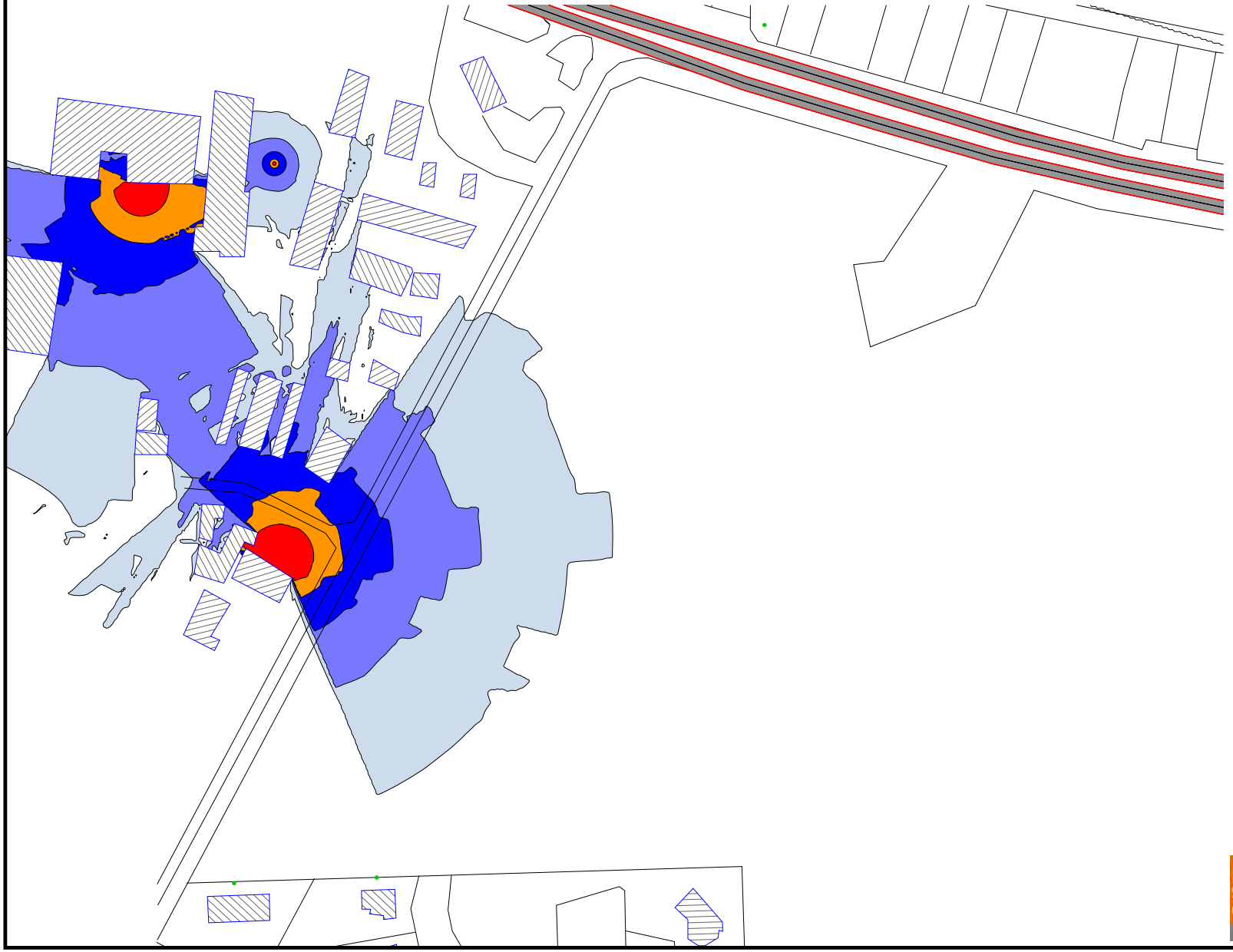
Location	Scenario	
	Day dB L_{A1}	Night dB L_{A10}
South Western Highway Residence	40	35
Nettleton Road Residence	42	41

The model was then updated to incorporate the proposed dwellings associated with the subdivision and the model then re-run. The results of this modelling is shown on *Figures 4-3 and 4-4*. For the worst-case scenario of L_{A10} night, the predicted noise level is up to 41 dB L_{A10} at residences fronting Nettleton Road and 32 dB L_{A10} at residences on the circular road where the assigned level reduces. At the closest residences, the L_{A1} noise level is calculated to be 58 dB L_{A1}.

Lot 2 Nettleton Road Proposed Subdivision

LA1 Day Noise Level Contours

Figure 4-1



Noise levels
LA1 dB

	< 50
50 <=	< 55
55 <=	< 60
60 <=	< 65
65 <=	< 70
70 <=	

Signs and symbols

- Road Source
- Road Surface
- Building
- Receiver

3 July 2013

Length Scale 1:3000

0 15 30 60 90 120 m

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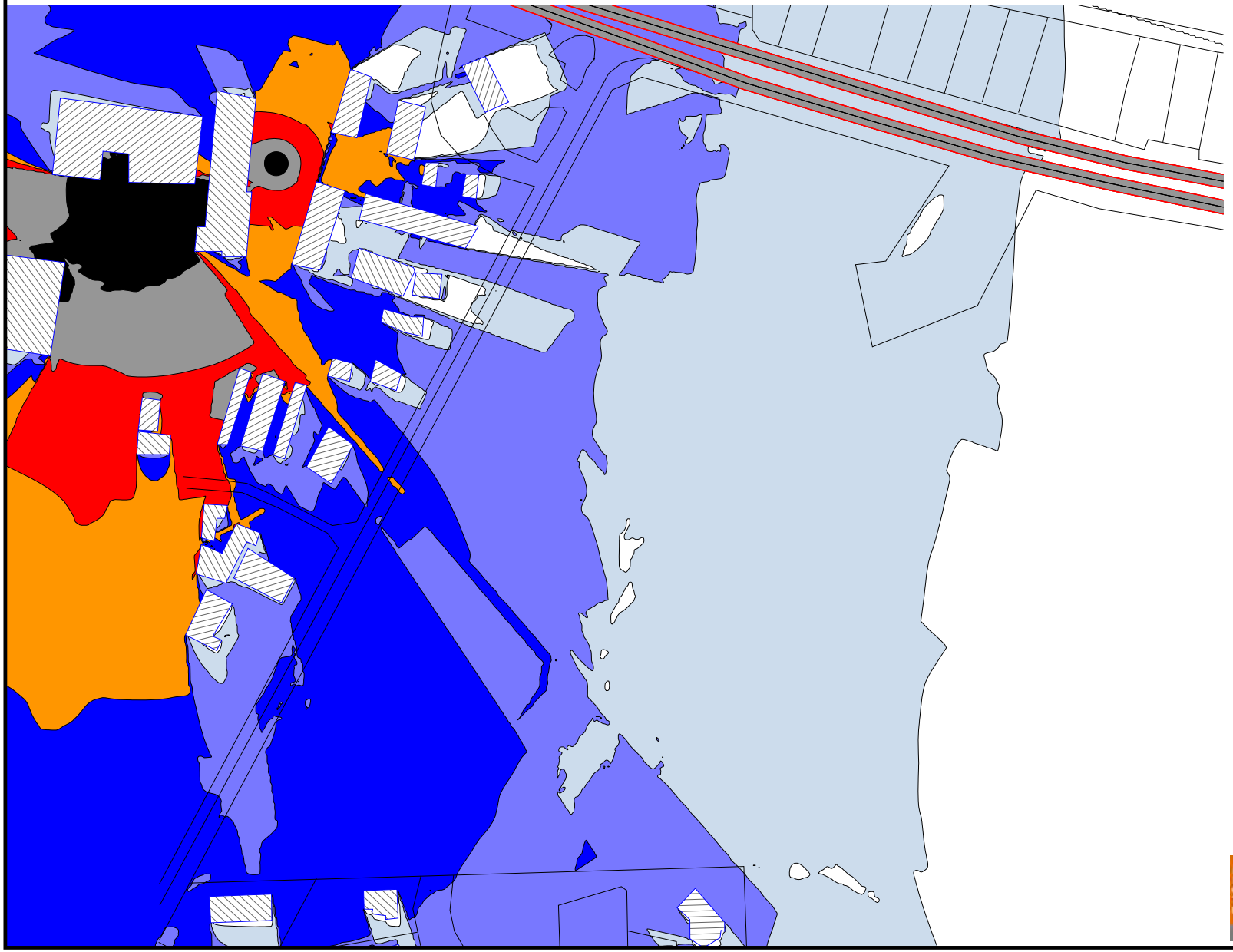
Lot 2 Nettleton Road Proposed Subdivision

LA10 Night Noise Level Contours

Figure 4-2



Noise levels
LA10 dB

	< 30
30 <=	< 35
35 <=	< 40
40 <=	< 45
45 <=	< 50
50 <=	< 55
55 <=	< 60
60 <=	

Signs and symbols

- Road Source
- Road Surface
- Building

3 July 2013

Length Scale 1:3000

0 15 30 60 90 120 m

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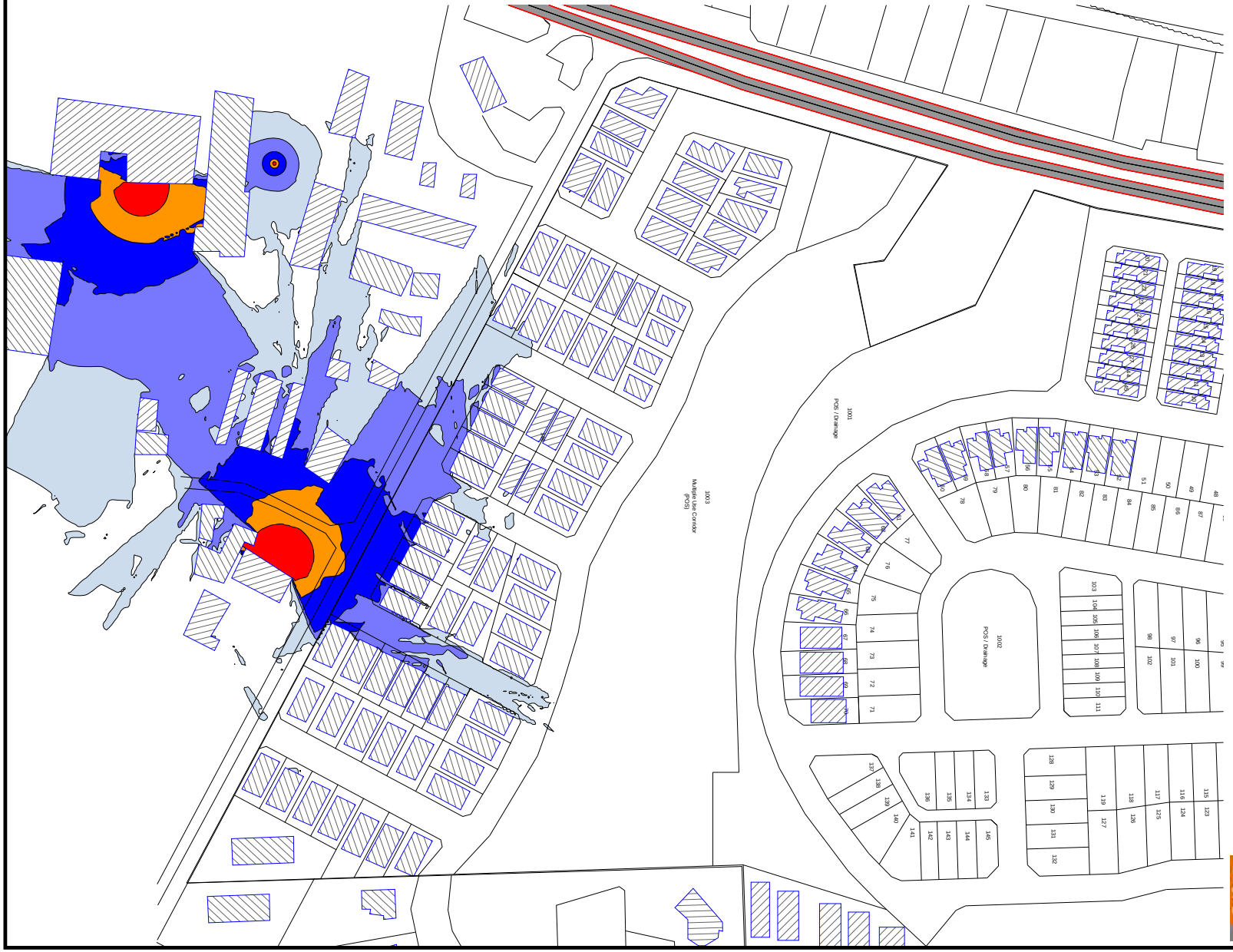
Lot 2 Nettleton Road Proposed Subdivision

LA1 Day Noise Level Contours with Subdivision

Figure 4-3



Noise levels
LA1 dB

	< 50
50 <=	< 55
55 <=	< 60
60 <=	< 65
65 <=	< 70
70 <=	

Signs and symbols

- Road Source
- Road Surface
- Building

4 October 2013

Length Scale 1:3000

0 15 30 60 90 120 m

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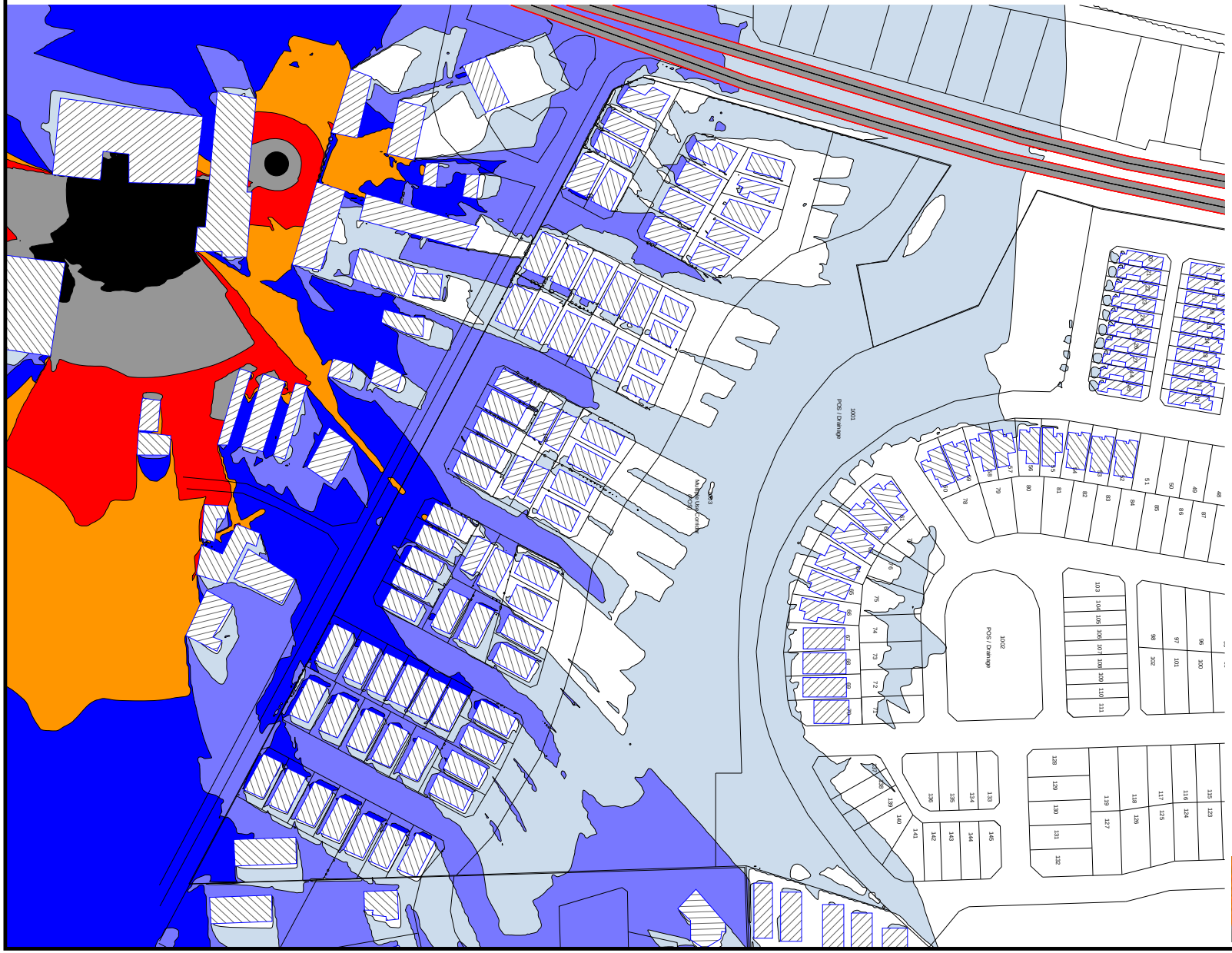
Lot 2 Nettleton Road Proposed Subdivision

LA10 Night Noise Level Contours With Subdivision

Figure 4-4



Noise levels
LA10 dB

	< 30
30 <=	< 35
35 <=	< 40
40 <=	< 45
45 <=	< 50
50 <=	< 55
55 <=	< 60
60 <=	

Signs and symbols

- Road Source
- Road Surface
- Building

4 October 2013

Length Scale 1:3000

0 15 30 60 90 120 m

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5 ASSESSMENT

The calculated existing noise levels to the existing houses are a worst-case of 40 dB L_{A1} and 39 dB L_{A10} for the Nettleton Road residences. Daytime noise levels are unlikely to be subject to any adjustments due to background noise masking the noise of interest. During the night however, noise is considered tonal and would therefore be adjusted to 44 dB L_{A10}. The assigned noise level at this time at these residences is 40 dB L_{A10} and therefore noise levels from the Mill currently exceed by 4 dB.

At future houses, the predicted noise level is up to 41 dB L_{A10} where residences front Nettleton Road. The noise would be considered tonal and subject to a + 5 dB adjustment so that the assigned level of 40 dB L_{A10} would be exceeded by 6 dB. At the proposed houses on the circular road, the predicted noise level is 32 dB L_{A10} and again would be adjusted to 37 dB L_{A10} for tonality, which would comply (marginally) with the assigned noise level of 37 dB L_{A10}. The predicted L_{A1} noise level at the closest houses is up to 58 dB L_{A1} compared to the daytime assigned noise level of 60 dB L_{A1} and therefore compliant.

As discussed in *Section 1*, the onus of complying with the prescribed standards of the *Environmental Protection (Noise) Regulations 1997* is on the noise emitter. This report has shown that noise from the Mill exceeds at existing houses by up to 4 dB and at future houses by up to 6 dB. It is recommended that the Mill be notified of these exceedances and undertake investigations to determine the source of the noises, particularly the 160 Hz tone and to a lesser extent the 1kHz tone, and undertake noise control.

Appendix A

Terminology

The following is an explanation of the terminology used throughout this report.

Decibel (dB)
The decibel is the unit that describes the sound pressure and sound power levels of a noise source. It is a logarithmic scale referenced to the threshold of hearing.

A-Weighting
An A-weighted noise level has been filtered in such a way as to represent the way in which the human ear perceives sound. This weighting reflects the fact that the human ear is not as sensitive to lower frequencies as it is to higher frequencies. An A-weighted sound level is described as L_A dB.

Sound Power Level (L_w)
Under normal conditions, a given sound source will radiate the same amount of energy, irrespective of its surroundings, being the sound power level. This is similar to a 1kW electric heater always radiating 1kW of heat. The sound power level of a noise source cannot be directly measured using a sound level meter but is calculated based on measured sound pressure levels at known distances. Noise modelling incorporates source sound power levels as part of the input data.

Sound Pressure Level (L_p)
The sound pressure level of a noise source is dependent upon its surroundings, being influenced by distance, ground absorption, topography, meteorological conditions etc and is what the human ear actually hears. Using the electric heater analogy above, the heat will vary depending upon where the heater is located, just as the sound pressure level will vary depending on the surroundings. Noise modelling predicts the sound pressure level from the sound power levels taking into account ground absorption, barrier effects, distance etc.

L_{ASlow}
This is the noise level in decibels, obtained using the A frequency weighting and the S time weighting as specified in AS1259.1-1990. Unless assessing modulation, all measurements use the slow time weighting characteristic.

L_{AFast}
This is the noise level in decibels, obtained using the A frequency weighting and the F time weighting as specified in AS1259.1-1990. This is used when assessing the presence of modulation only.

L_{APeak}
This is the maximum reading in decibels using the A frequency weighting and P time weighting AS1259.1-1990.

L_{Amax}
An L_{Amax} level is the maximum A-weighted noise level during a particular measurement.

L_{A1}
An L_{A1} level is the A-weighted noise level which is exceeded for one percent of the measurement period and is considered to represent the average of the maximum noise levels measured.

L_{A10}
An L_{A10} level is the A-weighted noise level which is exceeded for 10 percent of the measurement period and is considered to represent the "*intrusive*" noise level.

L_{Aeq}
The equivalent steady state A-weighted sound level ("equal energy") in decibels which, in a specified time period, contains the same acoustic energy as the time-varying level during the same period. It is considered to represent the "average" noise level.

L_{A90}
An L_{A90} level is the A-weighted noise level which is exceeded for 90 percent of the measurement period and is considered to represent the "*background*" noise level.

One-Third-Octave Band
Means a band of frequencies spanning one-third of an octave and having a centre frequency between 25 Hz and 20 000 Hz inclusive.

L_{Amax} assigned level
Means an assigned level which, measured as a $L_{A\ Slow}$ value, is not to be exceeded at any time.

L_{A1} assigned level
Means an assigned level which, measured as a $L_{A\ Slow}$ value, is not to be exceeded for more than 1% of the representative assessment period.

L_{A10} assigned level
Means an assigned level which, measured as a $L_{A\ Slow}$ value, is not to be exceeded for more than 10% of the representative assessment period.

Tonal Noise
A tonal noise source can be described as a source that has a distinctive noise emission in one or more frequencies. An example would be whining or droning. The quantitative definition of tonality is:

the presence in the noise emission of tonal characteristics where the difference between -

(a) the A-weighted sound pressure level in any one-third octave band; and

(b) the arithmetic average of the A-weighted sound pressure levels in the 2 adjacent one-third octave bands,

is greater than 3 dB when the sound pressure levels are determined as $L_{Aeq,T}$ levels where the time period T is greater than 10% of the representative assessment period, or greater than 8 dB at any time when the sound pressure levels are determined as $L_{A\ Slow}$ levels.

This is relatively common in most noise sources.

Modulating Noise
A modulating source is regular, cyclic and audible and is present for at least 10% of the measurement period. The quantitative definition of modulation is:

a variation in the emission of noise that —

(a) is more than 3 dB $L_{A\ Fast}$ or is more than 3 dB $L_{A\ Fast}$ in any one-third octave band;

(b) is present for at least 10% of the representative.

Impulsive Noise
An impulsive noise source has a short-term banging, clunking or explosive sound. The quantitative definition of impulsiveness is:

a variation in the emission of a noise where the difference between $L_{A\ peak}$ and $L_{A\ Max\ slow}$ is more than 15 dB when determined for a single representative event;

Major Road
Is a road with an estimated average daily traffic count of more than 15,000 vehicles.

Secondary / Minor Road
Is a road with an estimated average daily traffic count of between 6,000 and 15,000 vehicles.

Influencing Factor (IF)

$$= \frac{1}{10}(\%\ \text{Type A}_{100} + \%\ \text{Type A}_{450}) + \frac{1}{20}(\%\ \text{Type B}_{100} + \%\ \text{Type B}_{450})$$

where:

$\%\ \text{Type A}_{100}$ = the percentage of industrial land within a100m radius of the premises receiving the noise

$\%\ \text{TypeA}_{450}$ = the percentage of industrial land within a 450m radius of the premises receiving the noise

$\%\ \text{Type B}_{100}$ = the percentage of commercial land within a100m radius of the premises receiving the noise

$\%\ \text{TypeB}_{450}$ = the percentage of commercial land within a 450m radius of the premises receiving the noise

+ Traffic Factor (maximum of 6 dB)

= 2 for each secondary road within 100m

= 2 for each major road within 450m

= 6 for each major road within 100m

Representative Assessment Period
Means a period of time not less than 15 minutes, and not exceeding four hours, determined by an inspector or authorised person to be appropriate for the assessment of a noise emission, having regard to the type and nature of the noise emission.

Background Noise
Background noise or residual noise is the noise level from sources other than the source of concern. When measuring environmental noise, residual sound is often a problem. One reason is that regulations often require that the noise from different types of sources be dealt with separately. This separation, e.g. of traffic noise from industrial noise, is often difficult to accomplish in practice. Another reason is that the measurements are normally carried out outdoors. Wind-induced noise, directly on the microphone and indirectly on trees, buildings, etc., may also affect the result. The character of these noise sources can make it difficult or even impossible to carry out any corrections.

Ambient Noise
Means the level of noise from all sources, including background noise from near and far and the source of interest.

Specific Noise
Relates to the component of the ambient noise that is of interest. This can be referred to as the noise of concern or the noise of interest.

Peak Component Particle Velocity (PCPV)

The maximum instantaneous velocity in mm/s of a particle at a point during a given time interval and in one of the three orthogonal directions (x, y or z) measured as a peak response. Peak velocity is normally used for the assessment of structural damage from vibration.

Peak Particle Velocity (PPV)

The maximum instantaneous velocity in mm/s of a particle at a point during a given time interval and is the vector sum of the PCPV for the x, y and z directions measured as a peak response. Peak velocity is normally used for the assessment of structural damage from vibration.

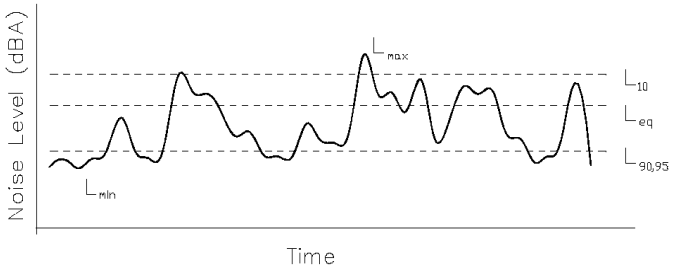
RMS Component Particle Velocity (PCPV)

The maximum instantaneous velocity in mm/s of a particle at a point during a given time interval and in one of the three orthogonal directions (x, y or z) measured as a root mean square (rms) response. RMS velocity is normally used for the assessment of human annoyance from vibration.

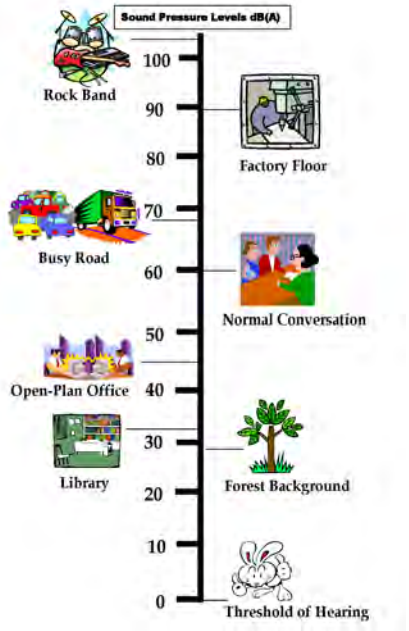
Peak Particle Velocity (PPV)

The maximum instantaneous velocity in mm/s of a particle at a point during a given time interval and is the vector sum of the PCPV for the x, y and z directions measured as a root mean square (rms) response. RMS velocity is normally used for the assessment of human annoyance from vibration.

Chart of Noise Level Descriptors



Typical Noise Levels



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Transportation Noise Assessment

Lot 2 Nettleton Road, Byford – Stage 1

Reference: 13032388-02.docx

Prepared for:
Cedar Woods

Member Firm of Association of Australian Acoustical Consultants

Report: 13032388-02.docx

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Position:	Project Director
Date:	3 September 2013

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Appendices

1 INTRODUCTION

Cedar Woods are proposing to develop Lot 2 Nettleton Road, with this report addressing the noise impacts from South Western Highway road traffic to Stage 1 of the proposed subdivision. *Figure 1-1* provides the general locality of Lot 2 with *Figure 1-2* providing the subdivision layout and finished lot levels of Stage 1.

Figure 1-1 Lot 2 General Locality

Figure 1-2 Lot 2 Stage 1 Subdivision

Appendix B contains a description of some of the terminology used throughout this report.

2 CRITERIA

The criteria relevant to this assessment is the *State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning* (hereafter referred to as the Policy) produced by the Western Australian Planning Commission (WAPC). The objectives in the Policy are to:

- Protect people from unreasonable levels of transport noise by establishing a standardised set of criteria to be used in the assessment of proposals;
- Protect major transport corridors and freight operations from incompatible urban encroachment;
- Encourage best practice design and construction standards for new development proposals and new or redevelopment transport infrastructure proposals;
- Facilitate the development and operation of an efficient freight network; and
- Facilitate the strategic co-location of freight handling facilities.

The Policy's outdoor noise criteria are shown below in *Table 2-1*. These criteria applying at any point 1-metre from a habitable façade of a noise sensitive premises and in one outdoor living area.

Table 2-1 Outdoor Noise Criteria

Period	Target	Limit
Day (6am to 10pm)	55 dB $L_{Aeq(Day)}$	60 dB $L_{Aeq(Day)}$
Night (10pm to 6am)	50 dB $L_{Aeq(Night)}$	55 dB $L_{Aeq(Night)}$

Note: The 5 dB difference between the target and limit is referred to as the margin.

In the application of these outdoor noise criteria to new noise sensitive developments, the objectives of this Policy is to achieve -

- acceptable indoor noise levels in noise-sensitive areas (e.g. bedrooms and living rooms of houses); and
- a 'reasonable' degree of acoustic amenity in at least one outdoor living area on each residential lot.

If a noise sensitive development takes place in an area where outdoor noise levels will meet the *target*, no further measures are required under this policy.

In areas where the *target* is exceeded, but noise levels are likely to be within the 5 dB margin (i.e. less than the *limit*), mitigation measures should be implemented by the developer with a view to achieving the *target* levels in at least one outdoor living area on each residential lot. Where indoor spaces are planned to be facing any outdoor area in the *margin*, mitigation measures should be implemented to achieve acceptable indoor noise levels in those spaces.

In areas where the *limit* is exceeded (i.e. above $L_{Aeq(Day)}$ of 60dB(A) or $L_{Aeq(Night)}$ of 55dB(A)), a detailed noise assessment is to be undertaken. Customised noise mitigation measures should be implemented with a view to achieving the *target* in at least one outdoor living area on each

residential lot, or if this is not practicable, within the *margin*. Where indoor spaces are planned to be facing outdoor areas that are above the *target*, mitigation measures should be implemented to achieve acceptable indoor noise levels in those spaces.

3 METHODOLOGY

Noise measurements and modelling have been undertaken in accordance with the requirements of the Policy as described below in *Sections 3.1 and 3.2*.

3.1 Site Measurements

Work on this landholding originally commenced in 2007 for the previous landholder. Monitoring was undertaken at that time (10 September to 20 September 2007) to:

- Quantify the existing noise levels;
- Determine the differences between different acoustic parameters ($L_{A10,18hour}$, $L_{Aeq(Day)}$ and $L_{Aeq(Night)}$); and
- Calibrate the noise model for existing conditions.

Although the noise logging is a number of years old, it is still valid for calibrating the model against traffic volumes at that time.

The instrument used was an ARL Type 316 noise data logger, located near the dwelling on the lot, which has since been demolished (refer *Figure 3-1*). The logger was programmed to record hourly L_{A1}, L_{A10}, L_{A90}, and L_{Aeq} levels. This instrument complies with the instrumentation requirements of *Australian Standard 2702-1984 Acoustics – Methods for the Measurement of Road Traffic Noise*. The logger was field calibrated before and after the measurement session and found to be accurate to within +/- 1 dB. Lloyd George Acoustics also holds current laboratory calibration certificate for the loggers.

Figure 3-1 Locality of Noise Logger Alongside South Western Highway

The noise data collected was verified by inspection and professional judgement. Where hourly data was considered atypical, an estimated value was inserted and highlighted by bold italic lettering.

3.2 Noise Modelling

The computer programme *SoundPLAN 7.2* was utilised incorporating the *Calculation of Road Traffic Noise* (CoRTN) algorithms, modified to reflect Australian conditions. The modifications included the following:

- Vehicles were separated into heavy (Austroads Class 3 upwards) and non-heavy (Austroads Classes 1 & 2) with non-heavy vehicles having a source height of 0.5 metres above road level and heavy vehicles having two sources, at heights of 1.5 metres and 3.6 metres above road level, to represent the engine and exhaust respectively. By splitting the noise source into three, allows for less barrier attenuation for high level sources where barriers are to be considered. Note that corrections are applied to the exhaust of –8.0 dB (based on Transportation Noise Reference Book, Paul Nelson, 1987) and to the engine source of –0.8 dB, so as to provide consistent results with the CoRTN algorithms for the no barrier scenario;
- An adjustment of –1.7 dB has been applied to the predicted levels based on the findings of An Evaluation of the U.K. DoE Traffic Noise Prediction; Australian Road Research Board, Report 122 ARRB – NAASRA Planning Group 1982.

Predictions are made at heights of 1.4 metres above ground floor level and at 1.0 metre from an assumed building façade (resulting in a + 2.5 dB correction due to reflected noise).

Various input data are included in the modelling such as ground topography, road design, traffic volumes etc. These model inputs are discussed below.

3.2.1 Ground Topography, Road Design & Cadastral Data

Topographical data was based on that provided by JDSi including the existing topography as well as the finished lot levels for Stage 1.

Buildings have also been included as these can provide barrier attenuation when located between a source and receiver, in much the same way as a hill or wall provides noise shielding. All buildings are assumed to be single storey with a height of 3.5 metres.

3.2.2 Traffic Data

Traffic data includes:

- Road Surface – The noise relationship between different road surface types is shown in *Table 3-1*.

Table 3-1 Noise Relationship Between Different Road Surfaces

Road Surfaces						
Chip Seal			Asphalt			
14mm	10mm	5mm	Dense Graded	Novachip	Stone Mastic	Open Graded
+3.5 dB	+2.5 dB	+1.5 dB	0.0 dB	-0.2 dB	-1.0 dB	-2.5 dB

The existing and future road surfaces are assumed to be unchanged.

- Vehicle Speed – The existing posted speeds in 2007 was 70km/hr and this has since been reduced to 60km/hr and therefore the latter has been assumed in future years.
- Traffic Volumes – Information used in the modelling is provided in *Table 3-2*.

Table 3-2 Traffic Information Used in the Modelling

Parameter	Scenario			
	Existing - 2007		Future - 2031	
	Northbound	Southbound	Northbound	Southbound
24 Hour Volume	6,529	6,289	15,892	15,308
18 Hour Volume[4]	6,080	5,759	14,799	14,018
% Heavy	12.2%	12.2%	8.0%	8.0%

3.2.3 Ground Attenuation

The ground attenuation has been assumed to be 0.0 (0%) for the road, 0.5 (50%) throughout the subdivision, except for the public open space, which was set to 1.00 (100%). Note 0.0 represents hard reflective surfaces such as water and 1.00 represents absorptive surfaces such as grass.

3.2.4 Parameter Conversion

The CoRTN algorithms used in the *SoundPlan* modelling package were originally developed to calculate the $L_{A10,18hour}$ noise level. The WAPC Policy however uses $L_{Aeq(Day)}$ and $L_{Aeq(Night)}$. The relationship between the parameters varies depending on the composition of traffic on the road (volumes in each period and percentage heavy vehicles).

As noise monitoring was undertaken, the relationship between the parameters is based on the results of the monitoring – refer *Section 4.1*.

4 RESULTS

4.1 Noise Monitoring

The results of the noise monitoring are summarised below in *Table 4-1* and shown graphically in *Figure 4-1*.

Table 4-1 Measured Average Noise Levels

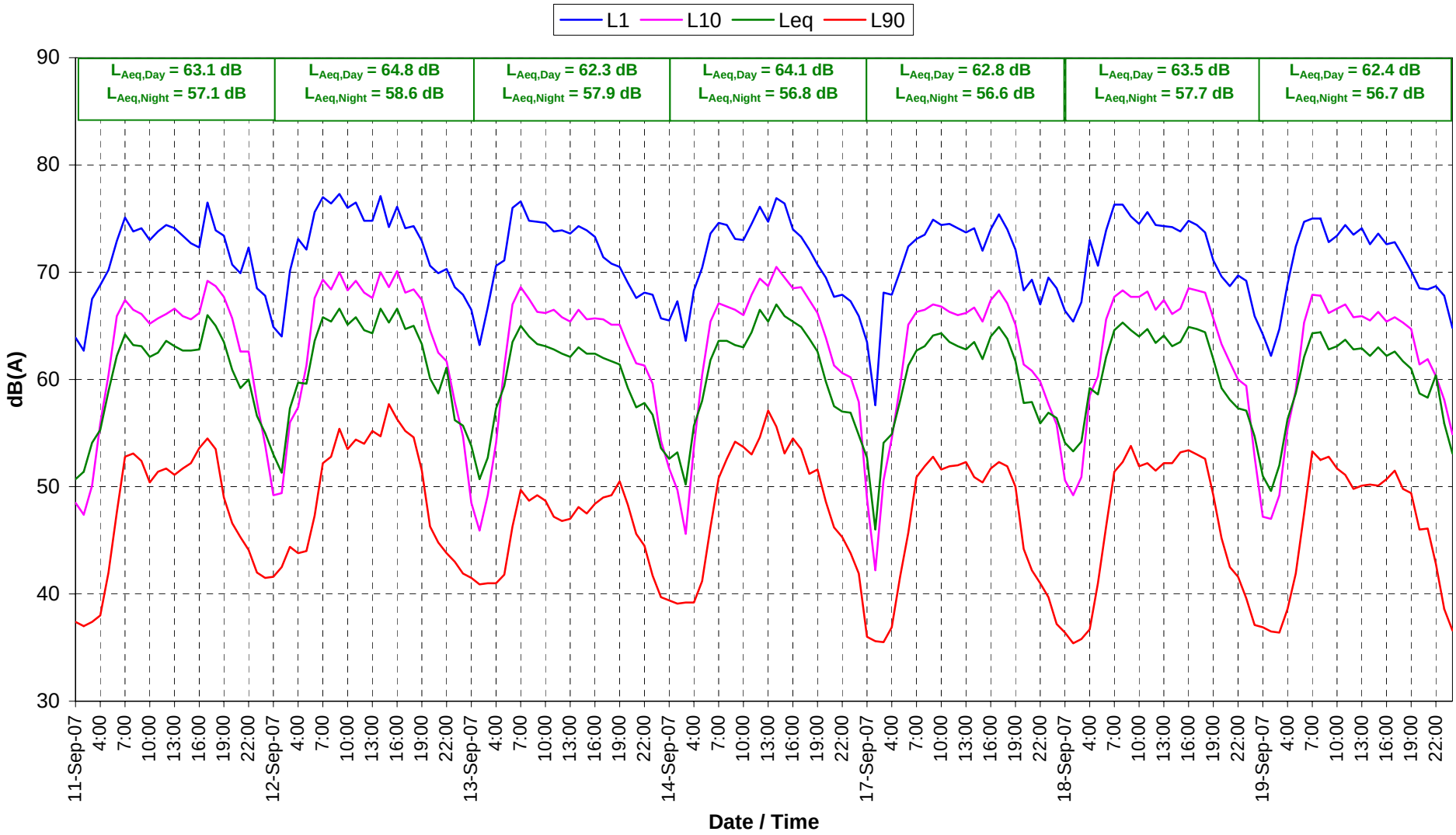
Date	Average Weekday Noise Level, dB		
	$L_{A10,18hour}$	$L_{Aeq\ (Day)}$	$L_{Aeq\ (Night)}$
11 September 2007	65.0	63.1	57.1
12 September 2007	66.4	64.8	58.6
13 September 2007	64.4	62.3	57.9
14 September 2007	65.9	64.1	56.8
17 September 2007	64.5	62.8	56.6
18 September 2007	65.2	63.5	57.7
19 September 2007	64.3	62.4	56.7
Weekday Average	**65.1**	**63.3**	**57.3**

The average differences between the weekday $L_{A10,18hour}$ and $L_{Aeq(Day)}$ is 1.8 dB and this conversion has been used in the modelling. The average differences between the weekday $L_{Aeq(Day)}$ and $L_{Aeq(Night)}$ is 5.9 dB. This same difference has been assumed to exist in future years. As such, it is the daytime noise levels that will dictate compliance since these are at least 5 dB more than night-time levels.

4.2 Noise Modelling

The noise modelling is provided in *Figure 4-2* as an $L_{Aeq(Day)}$ noise level contour plot being for the future traffic conditions including standard 1.8 metre high boundary walls. The modelling results are also provided as single point calculations in *Table 4-2*. It can be seen that predicted noise levels at the nearest houses will be above the ***target*** and therefore noise mitigation is to be considered.

Figure 4.1 - Noise Data Logging Alongside South Western Highway (Average 63.3 dB $L_{Aeq,Day}$ & 57.3 $L_{Aeq,Night}$)

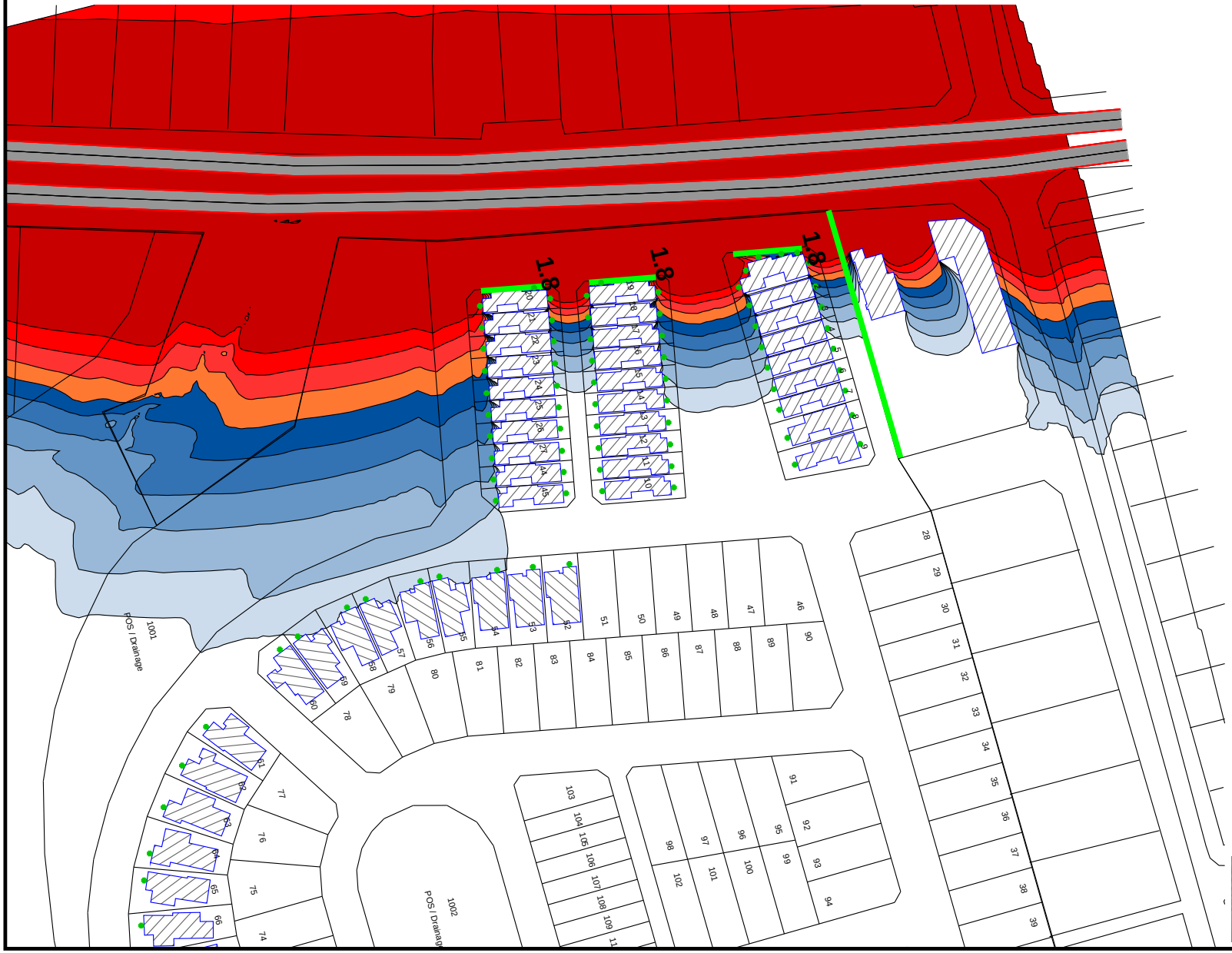


Lot 2 Nettleton Road Stage 1 Proposed Residential Subdivision

LAeq(Day) Noise Level Contours - Future 2031 Traffic Volumes

Includes 1.8m High Side Walls (Relative to Lot Level)

Figure 4.2



Noise levels
LAeq,day dB

	< 55
55 <=	< 56
56 <=	< 57
57 <=	< 58
58 <=	< 59
59 <=	< 60
60 <=	< 61
61 <=	< 62
62 <=	< 63
63 <=	

Signs and symbols

- Road Surface
- Future Dwelling
- Wall

3 September 2013

Length Scale 1:2000

0 10 20 40 60 80 m

Lloyd George Acoustics
by Terry George
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Table 4-2 Calculated Future $L_{Aeq(Day)}$ Noise Levels

Lot No.	$L_{Aeq(Day)}$ 2031 Noise Level, dB	Lot No.	$L_{Aeq(Day)}$ 2031 Noise Level, dB	Lot No.	$L_{Aeq(Day)}$ 2031 Noise Level, dB
1	63	16	57	52	53
2	60	17	59	53	54
3	59	18	60	54	56
4	57	19	63	55	56
5	56	20	63	56	56
6	55	21	62	57	56
7	55	22	61	58	56
8	54	23	60	59	55
9	53	24	60	60	55
10	52	25	59	62	53
11	53	26	58	63	52
12	54	27	58	64	51
13	54	44	57	65	50
14	55	45	57	66	49
15	56				

Note: Orange font indicates noise levels are above the limit by a maximum of 3 dB with green font indicating noise levels are within the margin.

5 ASSESSMENT

Road traffic noise levels for future dwellings in Stage 1 of Lot 2 Nettleton Road, Byford will be above the *target*. The preferred approach by the Developer is to implement architectural treatments in order to achieve satisfactory noise levels.

As such, to comply with the Policy, the following are required (refer *Figure 5-1*):

- Where residences are predicted to experience future noise levels between, and including, 61 dB and 63 dB $L_{Aeq(Day)}$ (Lots 1, 19 to 22), Package B is to be incorporated (refer *Appendix A*). Alternative constructions may be acceptable if supported by a report undertaken by a suitably qualified acoustical consultant once the lots specific building plans are available. One outdoor area will need to be provided that is shielded from the road.
- Where residences are predicted to experience future noise levels between, and including, 56 dB and 60 dB $L_{Aeq(Day)}$ (Lots 2 to 5, 15 to 18, 23 to 27, 44, 45, 54 to 58), Package A is to be incorporated (refer *Appendix A*). Alternative constructions may be acceptable if supported by a report undertaken by a suitably qualified acoustical consultant once the lots specific building plans are available. These houses are within the *margin* at worst and therefore, a reasonable acoustic amenity will be achieved in outdoor areas.
- All affected lots (Lots 1 to 5, 15 to 27, 44, 45, 54 to 58) are to have notifications on lot titles as per the Policy requirements – refer *Appendix A*.
- Where an affected lot is to be of double storey construction, specialist advice must be sort since the upper level may not receive the same level of attenuation as the ground floor that has been modelled.

Lot 2 Nettleton Road Stage 1 Proposed Residential Subdivision

Architectural Treatments for Future 2031 Traffic Volumes - 1.8m Boundary Walls

Figure 5_1

Signs and symbols

- Road Source
- Road Surface
- No Treatment
- Wall
- Package A
- Package B

22 August 2013

Length Scale 1:2000

0 10 20 40 60 80 m

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6 CONCLUSION

To satisfy the requirements of the *State Planning Policy 5.4 Road and Rail Transport Noise and Freight Considerations in Land Use Planning*, the following is required:

- Lots shown on *Figure 5-1* are to incorporate a notification on title and architectural treatments as described. Alternative treatment to the deemed to satisfy can be accepted if supported by a report by a suitable qualified acoustical engineer (member firm of the Association of Australian Acoustical Consultants);
- If a residence requiring notification is to be multiple storey, a report must be undertaken by a suitably qualified acoustical engineer (member firm of the Association of Australian Acoustical Consultants) to assess the impacts to the upper floor.

Appendix A

DEEMED TO SATISFY CONSTRUCTION STANDARDS

Package A: Noise levels within the *margin* – Lots 2 to 5, 15 to 18, 23 to 27, 44, 45, 54 to 58

The following noise insulation package is designed to meet the indoor noise standards for residential developments in areas where noise levels exceed the noise *target* but are within the *limit*.

Area type	Orientation	Package A measures
Indoors		
Bedrooms	Facing road/rail corridor	• 6mm (minimum) laminated glazing • Fixed, casement or awning windows with seals • No external doors • Closed eaves • No vents to outside walls/eaves • Mechanical ventilation/airconditioning[1]
	Side-on to corridor	• 6mm (minimum) laminated glazing • Closed eaves • Mechanical ventilation/airconditioning
	Away from corridor	No requirements
Living and work areas[2]	Facing corridor	• 6mm (minimum) laminated glazing • Fixed, casement or awning windows with seals • 35mm (minimum) solid core external doors with acoustic seals[3] • Sliding doors must be fitted with acoustic seals • Closed eaves • No vents to outside walls/eaves • Mechanical ventilation/airconditioning
	Side-on to corridor	• 6mm (minimum) laminated glazing • Closed eaves • Mechanical ventilation/airconditioning
	Away from corridor	No requirements
Other indoor areas	Any	No requirements

[1] See section on Mechanical ventilation/airconditioning for further details and requirements.
[2] These deemed-to-comply guidelines adopt the definitions of indoor spaces used in AS 2107-2000. A comparable description for bedrooms, living and work areas is that defined by the Building Code of Australia as a "habitable room". The Building Code of Australia may be referenced if greater clarity is needed. A living or work area can be taken to mean any "habitable room" other than a bedroom. Note that there are no noise insulation requirements for utility areas such as bathrooms. The Building Code of Australia describes these utility spaces as "non-habitable rooms".
[3] Glazing panels are acceptable in external doors facing the transport corridor. However these must meet the minimum glazing requirements.

Package B: Noise levels above the *limit* but within 3 dB – Lot 1

The following noise insulation package is designed to meet the indoor noise standards for residential developments in areas where noise levels exceed the *limit* by no more than 3 dB.

Area type	Orientation	Package B measures
Indoors		
Bedrooms	Facing or side on to South Western Highway	• 10mm (minimum) laminated glazing • Fixed, casement or awning windows with seals • No external doors • Closed eaves • No vents to outside walls/eaves • Mechanical ventilation/airconditioning[4]
	East Side of House	No requirements
Living and work areas[5]	Facing or side on to South Western Highway	• 10mm (minimum) laminated glazing • Fixed, casement or awning windows with seals • 40mm (minimum) solid core external doors with acoustic seals[6] • Sliding doors must be fitted with acoustic seals • Closed eaves • No vents to outside walls/eaves • Mechanical ventilation/airconditioning
	East Side of House	No requirements
Other indoor areas	Any	No requirements

[4] See section on Mechanical ventilation/airconditioning for further details and requirements.
[5] These deemed-to-comply guidelines adopt the definitions of indoor spaces used in AS 2107-2000. A comparable description for bedrooms, living and work areas is that defined by the Building Code of Australia as a "habitable room". The Building Code of Australia may be referenced if greater clarity is needed. A living or work area can be taken to mean any "habitable room" other than a bedroom. Note that there are no noise insulation requirements for utility areas such as bathrooms. The Building Code of Australia describes these utility spaces as "non-habitable rooms".
[6] Glazing panels are acceptable in external doors facing the transport corridor. However these must meet the minimum glazing requirements.

Package B: Noise levels within 3 dB of the *limit* – Lots 19 & 20

The following noise insulation package is designed to meet the indoor noise standards for residential developments in areas where noise levels exceed the *limit* by no more than 3 dB.

Area type	Orientation	Package B measures
Indoors		
Bedrooms	North or South Side of House	• 10mm (minimum) laminated glazing • Fixed, casement or awning windows with seals • No external doors • Closed eaves • No vents to outside walls/eaves • Mechanical ventilation/airconditioning[7]
	West Side of House	• 10mm (minimum) laminated glazing • Closed eaves • Mechanical ventilation/airconditioning
	East Side of House	No requirements
Living and work areas[8]	North or South Side of House	• 10mm (minimum) laminated glazing • Fixed, casement or awning windows with seals • 40mm (minimum) solid core external doors with acoustic seals[9] • Sliding doors must be fitted with acoustic seals • Closed eaves • No vents to outside walls/eaves • Mechanical ventilation/airconditioning
	West Side of House	• 6mm (minimum) laminated glazing • Closed eaves • Mechanical ventilation/airconditioning
	East Side of House	No requirements
Other indoor areas	Any	No requirements

[7] See section on Mechanical ventilation/airconditioning for further details and requirements.
[8] These deemed-to-comply guidelines adopt the definitions of indoor spaces used in AS 2107-2000. A comparable description for bedrooms, living and work areas is that defined by the Building Code of Australia as a "habitable room". The Building Code of Australia may be referenced if greater clarity is needed. A living or work area can be taken to mean any "habitable room" other than a bedroom. Note that there are no noise insulation requirements for utility areas such as bathrooms. The Building Code of Australia describes these utility spaces as "non-habitable rooms".
[9] Glazing panels are acceptable in external doors facing the transport corridor. However these must meet the minimum glazing requirements.

Package B: Noise levels within 3 dB of the *limit* – Lots 21 & 22

The following noise insulation package is designed to meet the indoor noise standards for residential developments in areas where noise levels exceed the *limit* by no more than 3 dB.

Area type	Orientation	Package B measures
Indoors		
Bedrooms	North or South Side of House	• 10mm (minimum) laminated glazing • Fixed, casement or awning windows with seals • No external doors • Closed eaves • No vents to outside walls/eaves • Mechanical ventilation/airconditioning[10]
	West Side of House	• 6mm (minimum) laminated glazing • Closed eaves • Mechanical ventilation/airconditioning
	East Side of House	No requirements
Living and work areas[11]	North or South Side of House	• 10mm (minimum) laminated glazing • Fixed, casement or awning windows with seals • 40mm (minimum) solid core external doors with acoustic seals[12] • Sliding doors must be fitted with acoustic seals • Closed eaves • No vents to outside walls/eaves • Mechanical ventilation/airconditioning
	West or East Side of House	No requirements
Other indoor areas	Any	No requirements

[10] See section on Mechanical ventilation/airconditioning for further details and requirements.
[11] These deemed-to-comply guidelines adopt the definitions of indoor spaces used in AS 2107-2000. A comparable description for bedrooms, living and work areas is that defined by the Building Code of Australia as a "habitable room". The Building Code of Australia may be referenced if greater clarity is needed. A living or work area can be taken to mean any "habitable room" other than a bedroom. Note that there are no noise insulation requirements for utility areas such as bathrooms. The Building Code of Australia describes these utility spaces as "non-habitable rooms".
[12] Glazing panels are acceptable in external doors facing the transport corridor. However these must meet the minimum glazing requirements.

Mechanical ventilation/airconditioning

Where outdoor noise levels are above the "target", both Packages A and B require mechanical ventilation or airconditioning to ensure that windows can remain closed in order to achieve the indoor noise standards.

In implementing Packages A and B, the following need to be observed:

- Evaporative airconditioning systems will not meet the requirements for Packages A and B because windows need to remain open;
- Refrigerative airconditioning systems need to be designed to achieve fresh air ventilation requirements;
- air inlets need to be positioned facing away from the transport corridor where practicable;
- ductwork needs to be provided with adequate silencing to prevent noise intrusion.

Notification

Notifications on certificates of title and/or advice to prospective purchasers advising of the potential for noise impacts from road and rail corridors can be effective in warning people of the potential impacts of transport noise. Such advice can also bring to the attention of prospective developers the need and opportunities to reduce the impact of noise through sensitive design and construction of buildings and the location and/or screening of outdoor living areas.

Notification should be provided to prospective purchasers, and required as a condition of subdivision (including strata subdivision) for the purposes of noise-sensitive development or planning approval involving noise-sensitive development, where external noise levels are forecast or estimated to exceed the "target" criteria as defined by the Policy. In the case of subdivision and development, conditions of approval should include a requirement for registration of a notice on title, which is provided for under section 12A of the Town Planning and Development Act and section 70A of the Transfer of Land Act. An example of a suitable notice is given below.

Notice: This property is situated in the vicinity of a transport corridor, and is currently affected, or may in the future be affected, by transport noise. Further information about transport noise, including development restrictions and noise insulation requirements for noise-affected property, are available on request from the relevant local government offices.

Appendix B

Terminology

The following is an explanation of the terminology used throughout this report.

Decibel (dB)
The decibel is the unit that describes the sound pressure and sound power levels of a noise source. It is a logarithmic scale referenced to the threshold of hearing.

A-Weighting
An A-weighted noise level has been filtered in such a way as to represent the way in which the human ear perceives sound. This weighting reflects the fact that the human ear is not as sensitive to lower frequencies as it is to higher frequencies. An A-weighted sound level is described as L_A dB.

L_1
An L_1 level is the noise level which is exceeded for 1 per cent of the measurement period and is considered to represent the average of the maximum noise levels measured.

L_{10}
An L_{10} level is the noise level which is exceeded for 10 per cent of the measurement period and is considered to represent the "*intrusive*" noise level.

L_{90}
An L_{90} level is the noise level which is exceeded for 90 per cent of the measurement period and is considered to represent the "*background*" noise level.

L_{eq}
The L_{eq} level represents the average noise energy during a measurement period.

$L_{A10,18hour}$
The $L_{A10,18\ hour}$ level is the arithmetic average of the hourly L_{A10} levels between 6.00 am and midnight. The *CoRTN* algorithms were developed to calculate this parameter.

$L_{Aeq,24hour}$
The $L_{Aeq,24\ hour}$ level is the logarithmic average of the hourly L_{Aeq} levels for a full day (from midnight to midnight).

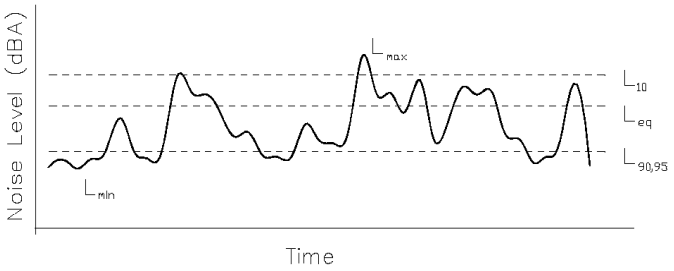
$L_{Aeq,8hour}$ / $L_{Aeq\ (Night)}$
The $L_{Aeq\ (Night)}$ level is the logarithmic average of the hourly L_{Aeq} levels from 10.00 pm to 6.00 am on the same day.

$L_{Aeq,16hour}$ / $L_{Aeq\ (Day)}$
The $L_{Aeq\ (Day)}$ level is the logarithmic average of the hourly L_{Aeq} levels from 6.00 am to 10.00 pm on the same day. This value is typically 1-3 dB less than the $L_{A10,18hour}$.

Satisfactory Design Sound Level
The level of noise that has been found to be acceptable by most people for the environment in question and also to be not intrusive.

Maximum Design Sound Level
The level of noise above which most people occupying the space start to become dissatisfied with the level of noise.

Chart of Noise Level Descriptors



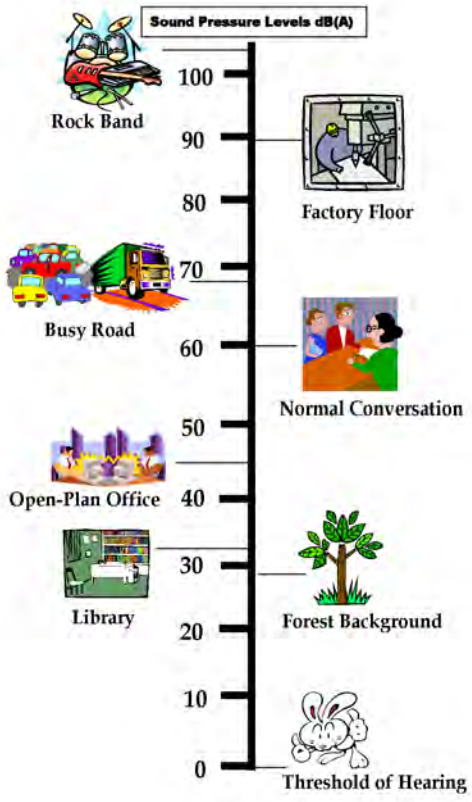
Austroads Vehicle Class

AUSTROADS Vehicle Classification System

Level 1 Length (indicative) Type	Level 2 Axles and Axle Groups Axles	Groups	Level 3 Vehicle Type Typical Description	AUSTROADS Classification Class	Parameters	Typical Configuration
			LIGHT VEHICLES			
Short up to 5.5m		1 or 2	Short Sedan, Wagon, 4WD, Utility, Light Van, Bicycle, Motorcycle, etc	1	d(1) ≤ 3.2m and axles = 2	
	3, 4 or 5	3	Short - Towing Trailer, Caravan, Boat, etc	2	groups = 3 d(1) ≥ 2.1m, d(1) ≤ 3.2m, d(2) ≥ 2.1m and axles = 3, 4 or 5	
			HEAVY VEHICLES			
Medium 5.5m to 14.5m	2	2	Two Axle Truck or Bus	3	d(1) > 3.2m and axles = 2	
	3	2	Three Axle Truck or Bus	4	axles = 3 and groups = 2	
	> 3	2	Four Axle Truck	5	axles > 3 and groups = 2	
Long 11.5m to 19.0m	3	3	Three Axle Articulated Three axle articulated vehicle, or Rigid vehicle and trailer	6	d(1) > 3.2m, axles = 3 and groups = 3	
	4	> 2	Four Axle Articulated Four axle articulated vehicle, or Rigid vehicle and trailer	7	d(2) < 2.1m or d(1) < 2.1m or d(1) > 3.2m axles = 4 and groups > 2	
	5	> 2	Five Axle Articulated Five axle articulated vehicle, or Rigid vehicle and trailer	8	d(2) < 2.1m or d(1) < 2.1m or d(1) > 3.2m axles = 5 and groups > 2	
	≥ 6	> 2	Six Axle Articulated Six axle articulated vehicle, or Rigid vehicle and trailer	9	axles = 6 and groups > 2 or axles > 6 and groups = 3	
Medium Combination 17.5m to 36.5m	> 6	4	B Double B Double, or Heavy truck and trailer	10	groups = 4 and axles > 6	
	> 6	5 or 6	Double Road Train Double road train, or Medium articulated vehicle and one dog trailer (M.A.D.)	11	groups = 5 or 6 and axles > 6	
Large Combination Over 33.0m	> 6	> 6	Triple Road Train Triple road train, or Heavy truck and three trailers	12	groups > 6 and axles > 6	

Definitions: Group: Axle group, where adjacent axles are less than 2.1m apart. Groups: Number of axle groups. Axles: Number of axles (maximum axle spacing of 10.0m). d(1): Distance between first and second axle. d(2): Distance between second and third axle.

Typical Noise Levels



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Osborne Park WA 6017

ABN 44 981 725 498
Knightside Nominees Pty Ltd

17 September 2013

Shire of Serpentine Jarrahdale
6 Paterson Street
MUNDIJONG WA 6123

Dear Louise,

RE: Nettleton Road, Byford – Bushland Management Actions

Following from our meeting on 5 September 2013 at the Serpentine-Jarrahdale Shire Offices please find following a brief outline of management proposed to be undertaken for the bushland area to be retained on Lot 2 Nettleton Road, Byford.

There are a number of Management Actions that can be commenced immediately, some that can be undertaken in the medium term (1-2 years) and others in the long term (2-3 years).

1 Immediate Actions

1.1 Weed Management

A number of weeds species have been recorded in the bushland area. The focus of weed control within the bushland area will be to control Declared Weeds, woody weeds (Flinders Range Wattle, Coast Tea Tree) and invasive species that can limit the rehabilitation of native plants. The weed species, Declared Weeds and whether they will be actively managed are outlined in the table below.

Species	Common Name	Status under the BAM Act	Requires Management
Acacia iteaphylla	Flinders Range Wattle		Yes
Arctotheca calendula	Cape Weed		Yes
Avena fatua	Wild Oats		Yes
Briza minor	Shivery Grass		No
Echium plantagineum	Paterson's Curse	Declared Pest (S22)	Yes
Ehrharta longifolia	Annual Veldt Grass		Yes
Gomphocarpus fruticosus	Cotton Bush	Declared Pest (S22)	Yes
Leptospermum laevigatum	Coast Tea-tree		Yes
Lysimachia arvensis	Pimpernel		No
Moraea flaccida	Cape Tulip	Declared Pest (S22)	Yes
Oxalis pes-caprae	Soursob		Yes
Oxalis purpurea	Largeflower Wood Sorrel		No

Species	Common Name	Status under the BAM Act	Requires Management
Romulea rosea	Guildford Grass		No
Schinus terebinthifolius	Brazilian Pepper Tree		Yes
Sparaxis bulbifera	Harlequin Flower		Yes
Trifolium arvense	Hare's Foot Clover		No
Ursinia anthemoides	Ursinia		No
Watsonia meriana var. *bulbillifera*	Watsonia		Yes

Weed management has commenced on all of Lot 2 Nettleton Road with a spraying program being implemented for the Cotton Bush on the site. Weed control can be undertaken immediately in the bushland area.

Many of the weeds in the bushland area can be controlled using a 'frog friendly' Glyphosate-based herbicide such as Roundup Biactive or similar, at the recommended rates. This will be applied twice a year just after the break of season (April to May) and in late winter to early spring. If summer rainfall is sufficient for germination herbicide will be applied at this time also.

Bulbs and corm species of the Iridaceae family have been recorded in the Bushland Area including Guildford Grass, Watsonia and Harlequin Flower species. These species are not as effectively controlled by Glyphosate. A bulb-specific herbicide containing metsulfuron-methyl will need to be applied to these infestations prior to any application of Glyphosate. Spraying should be undertaken approximately six to eight weeks after shoots have emerged, when the old bulb/corm is exhausted and the new bulb/corm is developing. This will permit enough chemical to be absorbed by the new bulb/corm to kill it. Spraying at flowering will affect flowers and seeds but not corms.

Woody species and larger species such as the Coast Tea-tree and Flinders Range Wattle will be removed by hand. The stumps then will be treated with Glyphosate.

1.2 Seed Collection

The collection of endemic seed from the remainder of the bushland can occur in the short term. This can be stored for later use in direct seeding or can be grown into tubestock for rehabilitation or landscaping within the estate.

2 Medium Term Actions

2.1 Fencing

Fencing can be established once the configuration of the bushland is determined. Temporary fencing is not likely to be able to be maintained in the short term due to the surrounding residents' likely desire to retain the kangaroo population on the site for as long as possible.

In accordance with Shire of Serpentine-Jarrahdale Local Planning Policy LPP8 Landscape Protection the fencing to be used around the Bushland Area on the southern and western boundary will be a minimum standard of pine post and ringlock wire 1.2m high similar to the photo below.

2.2 Fencing Removal

There is also some remnant fencing in the Bushland Area to be removed when the fencing is being undertaken that consists of posts and barbed wire shown in the photo below.

2.3 Firebreaks

When the fence is installed firebreaks on the western and southern boundaries will be established and the existing tracks on the northern and western boundary will be formalised to be adequate firebreaks.

2.4 Rehabilitation

2.4.1 Area to be Rehabilitated

The bushland area is 75% in Good Condition and there are some tracks within this area that would be rehabilitated, particularly those areas that are old tracks running east-west and down slope. There is 25% of the proposed bushland area that is in Degraded Condition. This area would be rehabilitated to re-introduce an understorey.

2.4.2 Soil Preparation

The soil units on the site are susceptible to sub-surface compaction and there is evidence of this occurring in tracks on the site. Soil preparation in these areas will be required prior to rehabilitation. Deep ripping is highly effective as it breaks apart a fairly typical compaction layer from traffic at 10 to 40cm depth.

The soil will be ripped where possible to 50 – 80 cm depth in late summer/ early autumn, as this is when the soil compaction layer will shatter. Riplines will follow contours and will be kept 3m outside vegetated areas. Prior to planting, riplines will be furrowed where possible. Furrows collect water, directing it to the root-zone and also help to remove hydrophobic soils if present. Furrow spoil will be hilled on the down-slope side to better trap and retain water.

In areas that are not able to be accessed by machinery, soil will be dug by manual means. Any areas with heavily compacted clay may be treated with gypsum prior to ripping.

Dieback management will be included in the rehabilitation works.

2.4.3 Rehabilitation Species List

The species lists for the rehabilitation areas are consistent with species recorded in the Bushland Area. As many of these species will be used as possible but the final species list may be affected by availability. Tubestock and seed will be sourced locally from the Perth Metropolitan Region south of the river.

Rehabilitation Species List

Strata	Species	Common Name
Trees	*Corymbia calophylla*	Marri
	Eucalyptus wandoo	White Gum
	Eucalyptus marginata	Jarrah
Shrubs	*Acacia pulchella*	Prickly Moses
	Grevillea wilsonii	Native Fuchsia
	Baeckea camphorosmae	Camphor Myrtle
	Daviesia decurrens	Prickly Bitter-pea
	Hakea lissocarpha	Honey Bush
	Hibbertia hypericoides	Yellow Buttercups
	Banksia dallanneyi	Couch Honeypot
Sub-shrubs	*Patersonia occidentalis*	Purple Flags
	Mesomelaena tetragona	Semaphore Sedge
	Kennedia prostrata	Running Postman

2.4.4 Plant Harvesting

There is potential for the sedges on the site to be harvested from areas to be cleared and transplanted into degraded areas on the site. This will be done by digging up sedges in clumps approximately 500mm wide and directly transplanting these into the Bushland Area during winter.

2.4.5 Planting

All rehabilitation will be planted in a semi-random fashion to ensure the final vegetation appears as natural as possible. Tubestock will be used in all cases, however if weed control is successful in the first 2 years some seed may be spread over areas to enhance the rehabilitated areas to a natural looking bushland.

Rehabilitation will be done over a two-year period. Tubestock will be planted in the first year and then depending on follow-up monitoring infill planting will be undertaken in the second year. Planting will be subject to the successful management of the kangaroos in the bushland area.

2.4.6 Completion Criteria

The completion criteria will be:

- 80% survival of tubestock planted in rehabilitated areas;
- Bushland area all in Good condition at completion;
- Less than 5% coverage of any weed species (1 weed per square metre);
- No Declared Weeds in the Bushland Area; and
- Implementation of the management actions outlined above.

3 Long Term Actions

3.1 Future Amenity Locations

During a site visit with Chris Portlock and Jim Jones it was discussed that amenities may be placed in the bushland area. Two identified areas will not be rehabilitated in order to provide areas in which infrastructure may be installed by the Shire of Serpentine-Jarrahdale in the future. Existing tracks that provide access to the areas from the firebreak. This is

3.2 Walking Path

A loop track using existing cleared areas could be retained to provide a walking path around the Bushland Area. Parts of this path will coincide with the fire breaks.

4 Conclusion

Immediate actions can be undertaken in the bushland area regardless of the configuration of the final subdivision. These are:

- Weeding; and
- Collection of seed.

In the medium term once the boundary of the Bushland Area is determined through the LSP approval process, Cedar Woods will:

- Fence the site;
- Establish firebreaks; and
- Commence rehabilitation in Degraded Areas.

In the long term prior to handover the amenity of the site will be enhanced by:

- Ensuring future amenities can be installed; and
- Establishing a walking path.

Please contact me if you require any clarification or further information.

Yours sincerely

Paul van der Moezel
Managaing Director

Input from Shea Hatch (Plan E)
Senior Landscape Architect

REGISTER NUMBER	
2/D35560	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
3	8/1/2010

WESTERN AUSTRALIA

RECORD OF CERTIFICATE OF TITLE

VOLUME 2007 FOLIO 85

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 2 ON DIAGRAM 35560

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

ASPEN COMMUNITIES LTD OF LEVEL 8, 256 ADELAIDE TERRACE, PERTH
(AN K659029) REGISTERED 17 JULY 2008

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

1. THE LAND THE SUBJECT OF THIS CERTIFICATE OF TITLE EXCLUDES ALL PORTIONS OF THE LOT DESCRIBED ABOVE EXCEPT THAT PORTION SHOWN IN THE SKETCH OF THE SUPERSEDED PAPER VERSION OF THIS TITLE. VOL 2007 FOL 85.
2. L185252 MORTGAGE TO BENDIGO AND ADELAIDE BANK LTD REGISTERED 23.12.2009.

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.

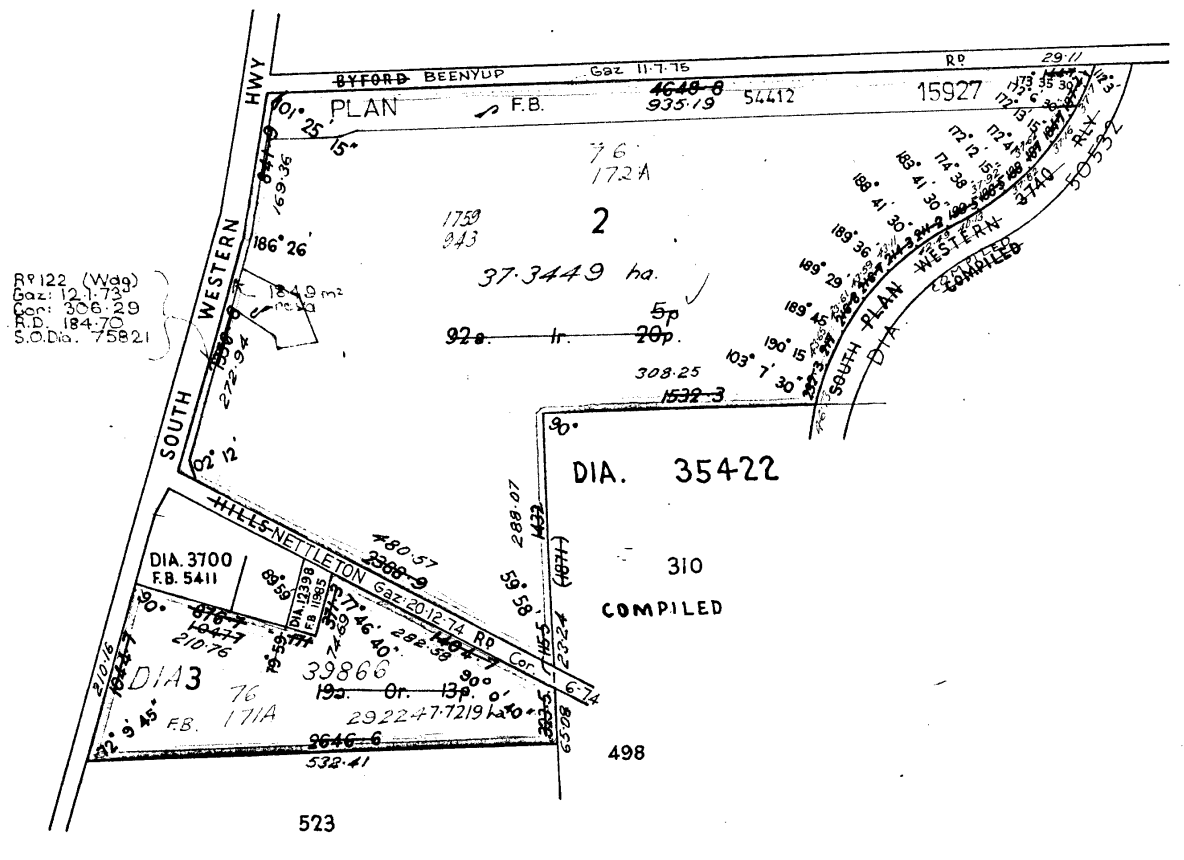
----------END OF CERTIFICATE OF TITLE----------

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: 2007-85 (2/D35560).
PREVIOUS TITLE: 1759-943.
PROPERTY STREET ADDRESS: 904 SOUTH WESTERN HWY, BYFORD.
LOCAL GOVERNMENT AREA: SHIRE OF SERPENTINE-JARRAHDALE.

Town or District.	Number of Lot or Location.	Field Book	Scale	Certificate in which Land is Vested.	Area
COCKBURN SOUND	Pt LOC. 632		1 : 7920 ~~10~~ ~~Chains to one inch.~~	Vol. 1083. Fol. 491..	~~A. R. P.~~ ~~111 - 1 - 18 TOTAL~~



COMPILED FROM L&S DIA. 46/54, O.P. 4631, L.T.O. PLAN 3740 & L.T.O. DIAS 3700 & 12398

ERIC BROOK
LICENSED SURVEYOR &
MAPPING CONSULTANT
DRAWN IN L.T.O.
R.T.

DIA 35560

CI

CERTIFICATE

I hereby certify that this survey was performed by me personally (or under my own personal supervision, inspection and field check) in strict accordance with the Licensed Surveyors (Guidance of Surveyors) Regulations, 1961.

COMPILED
Licensed Surveyor.

Date

Approved by Town Planning Board

23545

Chairman

Date 16.1.68

Approved
Inspector of Plans and Surveys

Examined KRGill Date 28.2.68
Cr. Hawks Cat Bk 2 p.76-80

On
Plan
Diagram
Index Plan ~~8927~~
PEEL 2000 22.35, 23.35
PEEL 5000 09.14

Registered
OFFICE FEE PAID $2.00
1108323 19/1/68

Diagram No.
35560

29734/9/66-2M-O Docket Dia 16893

ORIGINAL

Pre-lodgement Consultation Table

Agency	Date of Consultation	Method of Consultation	Summary of Outcome
Land owners within and adjacent to the structure plan area	2008	Advertising of existing LSP.	LSP Approval
Relevant community groups in the area			
Local government	2008	Email, phone,	Following preparation of the Flora and Vegetation (November 2007) report, consultation with the DEC confirmed the presence of a TEC and this resulted in the preparation of the Remnant Vegetation Assessment & Biodiversity Strategy (September 2009).
	29/08/2012	Telephone (Craig Wansborough, Project Manager Water Sensitive Urban Design, pers comm).	The site has an existing approved LWMS prepared by JDA Consultant Hydrologists (JDA,2009). The Shire provided advice that an Addendum to the LWMS would be appropriate to support the revised structure plan rather than resubmssion of a new LWMS. The Addendum would focus on areas of change to the approved LWMS, which would be predominately related to revised stormwater modelling outcomes. This approach was agreed by Department of Water. An Addendum to the approved LWMS was prepared by Hyd2o on this basis.
	15/10/2012	Telephone (Craig Wansborough, Project Manager Water Sensitive Urban Design, pers comm).	Confirmation the Byford Townsite Drainage and Water Management Plan (DoW, 2009) is still current and the appropriate urban water management reference document to inform planning for the site.
WAPC	2012	WAPC literature accessed via WAPC website.	Fire Management Plan has been prepared in accordance with the WAPC's *Planning for Bushfire Protection Guidelines.*
Department of Water	28/8/2012	Telephone (Brett Dunn, A/Program Manager Urban Water Management Kwinana Peel Region, pers comm).	The site has an existing approved LWMS prepared by JDA Consultant Hydrologists (JDA, 2009). Department of Water provided advice that an Addendum to the LWMS would be appropriate to support the revised structure plan rather than resubmission of a new LWMS. The Addendum would focus on areas of change to the approved LWMS, which would be predominately related to revised stormwater modelling outcomes. This approach was agreed by the Shire. An Addendum to the approved LWMS was prepared by Hyd2o on this basis.
Department of Environment and Conservation	2008	LSP advertising	DEC notes and supports the retention of native vegetation in the proposed 'Bushland Retention Area' of the LSP. However, DEC considers appropriate interface treatements, including a hard edge road, fencing and an adequate fire hazard separation zone as necessary to ensure the reserve values are protected from the potential fire hazard of nearby bushland.

Agency	Date of Consultation	Method of Consultation	Summary of Outcome
			DEC anticipates incorporation of these actions through implementation of the proposed *Bushland Management Plan* at early stages of the planning process.
Department of Education	17/10/2012	Email (Stephen Muldoon, Senior Consultant Strategic Asset Planning).	The Department advises that the development would fall within the catchment area for the Byford Primary School and that there would be no requirement for school site contributions.
Department of Indigenous Affairs	2007-2008	Archaeological and ethnographic surveys and community consultation; Section 18 Application and consultation with DIA.	Section 18 Ministerial consent to use the land received on July 15 2008.
Main Roads Western Australia			
Heritage Council			
Department of Transport			
Department of Health	2008	LSP advertising	The Department has no objection to the proposed LSP subject to all developments being connected to sewer to comply with the Government Sewerage Policy.
Public Transport Authority	2008	LSP advertising	No objection to the proposed LSP.
Environmental Protection Authority	2008	LSP advertising	No additional environmental issues to those previously considered by the EPA.
Western Power	22/08/2012	Western Power database enquiry.	Database (DFIS) confirms HV & LV infrastructure in vicinity of site. Capacity of existing network will be confirmed when development formally proceeds and a Design Information Package is received from Western Power.
Alinta Gas	05/07/2010	Telephone (Marc Stubbs, Westnet Energy).	Provided with plans of existing gas infrastructure in vicinity of site and advised proposed development can be serviced.
Water Corporation	22/08/2012	Email (Chris Grant, Water Corporation).	Indicative water and sewer pipe sizes and alignments provided by WC.
Telstra	22/08/2012	Website enquiry.	As development will realise over 100 dwellings it qualifies for servicing by NBNCo. Mapping shows site is within the NBNCo fibre footprint.
Non-government school providers			
Department for Community Development			
Department of Sports and Recreation			
Department of Agriculture and Food Western Australia			

Agency	Date of Consultation	Method of Consultation	Summary of Outcome
Fire and Emergency Services Authority	2008	LSP advertising	Fire management plan should include: • The specification for Emergency Access Way Gates; • Consdieration for the side being within the 2km Ember Attack Zone of the state forrest and the consequences of such an incident • Fire breaks to be 4m wide; • Emergency Access Way gates to be shown on the plan; and • 20m building protection zone to be indicated on the plan. The Shire is the Hazard Management Agency in this instance and would be expected to apply a condition requiring the compliance with WAPC DC 3.7 and the associated 'Planning for Bushfire Protection' document.
Any other relevant government agency as Required			