GRAY&LEWIS
LAND USE PLANNERS

LOCAL STRUCTURE PLAN

LOTS 1, 3 & 128 SOUTH WESTERN HIGHWAY, BYFORD

August 2012
(Version 6 - May 2014)

LOCAL STRUCTURE PLAN

LOTS 1, 3 & 128 SOUTH WESTERN HIGHWAY, BYFORD

PREPARED BY

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Planning Consultants
Suite 5, 2 Hardy Street
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in association with

PORTER CONSULTING ENGINEERS;
GHD PTY LTD; and
LANDFORM RESEARCH

ON BEHALF OF URBAN SOLUTIONS.

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FIGURES

APPENDICES

Document Status

Version	***Purpose of Document***	***Original***	***Review***
Version 1	Draft for comment	October 2010	RT & GL
Version 2	Draft for advertising (incorporating responses/modifications required by SJ Shire)	September 2011	RT & GL
Version 3	Incorporate modifications required by SJ Shire at OCM 14 May 2012	July 2012	RT & GL
Version 4	LSP Map modified at request of Shire Officers to deviate entry road around vegetation on northern boundary of Lot 128.	August 2012	RT & GL
Version 5	LSP Map and Part One text modified as per Shire advice	January 2013	RT & GL
Version 6	Incorporate modifications required by WAPC in accordance with their letter dated 15 May 2014.	May 2014	RT & GL

LOCAL STRUCTURE PLAN - LOTS 1, 3 & 128 SOUTH WESTERN HIGHWAY, BYFORD
August 2012 (Version 6 - May 2014)

PART 1

Statutory Section

CERTIFIED THAT STRUCTURE PLAN ……..

WAS ADOPTED BY

RESOLUTION OF THE

WESTERN AUSTRALIAN PLANNING COMMISSION

ON……

…….
Chairperson,
Western Australian Planning Commission

AND BY

RESOLUTION OF THE COUNCIL
OF THE

SHIRE OF SERPENTINE-JARRAHDALE ON

……..……

AND THE SEAL OF THE MUNICIPALITY WAS PURSUANT

TO THE COUNCIL'S RESOLUTION HEREUNTO AFFIXED

IN THE PRESENCE OF:

…….
President, Shire of Serpentine-Jarrahdale

…….
Chief Executive Officer,
Shire of Serpentine-Jarrahdale

RECORD OF AMENDMENTS MADE TO THE AGREED STRUCTURE PLAN

Amendment No.	Description of Amendment	WAPC Adopted	Council Adopted

1.0 THE STATUTORY PLANNING

1.1 THIS STRUCTURE PLAN AREA

This Local Structure Plan (LSP) applies to Lots 1, 3 and 128 South Western Highway/Pinebrook Road, Byford being all the land contained within the area defined as the subject land on the LSP.

1.2 STRUCTURE PLAN CONTENT

The Structure Plan comprises:

- Statutory Section (Part 1)
- Explanatory Report and Elements of the Structure Plan (Part 2)
- Appendices – Detailed Technical Reports

1.3 INTERPRETATION

The words and expressions used in this Structure Plan shall have the respective meanings given to them in the Scheme, or where not defined in the Scheme, as set out hereunder:

'The Scheme' shall mean the Shire of Serpentine Jarrahdale Town Planning Scheme No. 2 (as amended) or such amendments or modifications thereto that may be current. 'The Structure Plan' shall mean the Local Structure Plan (LSP).

The adopted Structure Plan includes the Structure Plan map **(FIGURE 1)** and the Part 1 – Statutory Section. All other documentation contained within the Structure Plan Report is for background or explanatory purposes only and does not form part of the adopted Structure Plan.

1.4 OPERATION DATE

The Structure Plan shall come into operation on the date it is adopted by Local Government pursuant with sub-clause 5.18.6.1 of the Scheme.

1.5 RELATIONSHIP WITH THE SCHEME

Pursuant with sub-clause 5.18.6.2 of the Scheme the provisions, standards and requirements specified within Part 1 of the Structure Plan shall have the same force and effect as if it were a provision, standard or requirement of the Scheme. Part 2 of this Structure Plan is for explanatory purposes only, in order to provide a descriptive analysis of the Structure Plan.

In the event of there being any inconsistencies or conflicts 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 will prevail.

2.0 OBJECTIVES

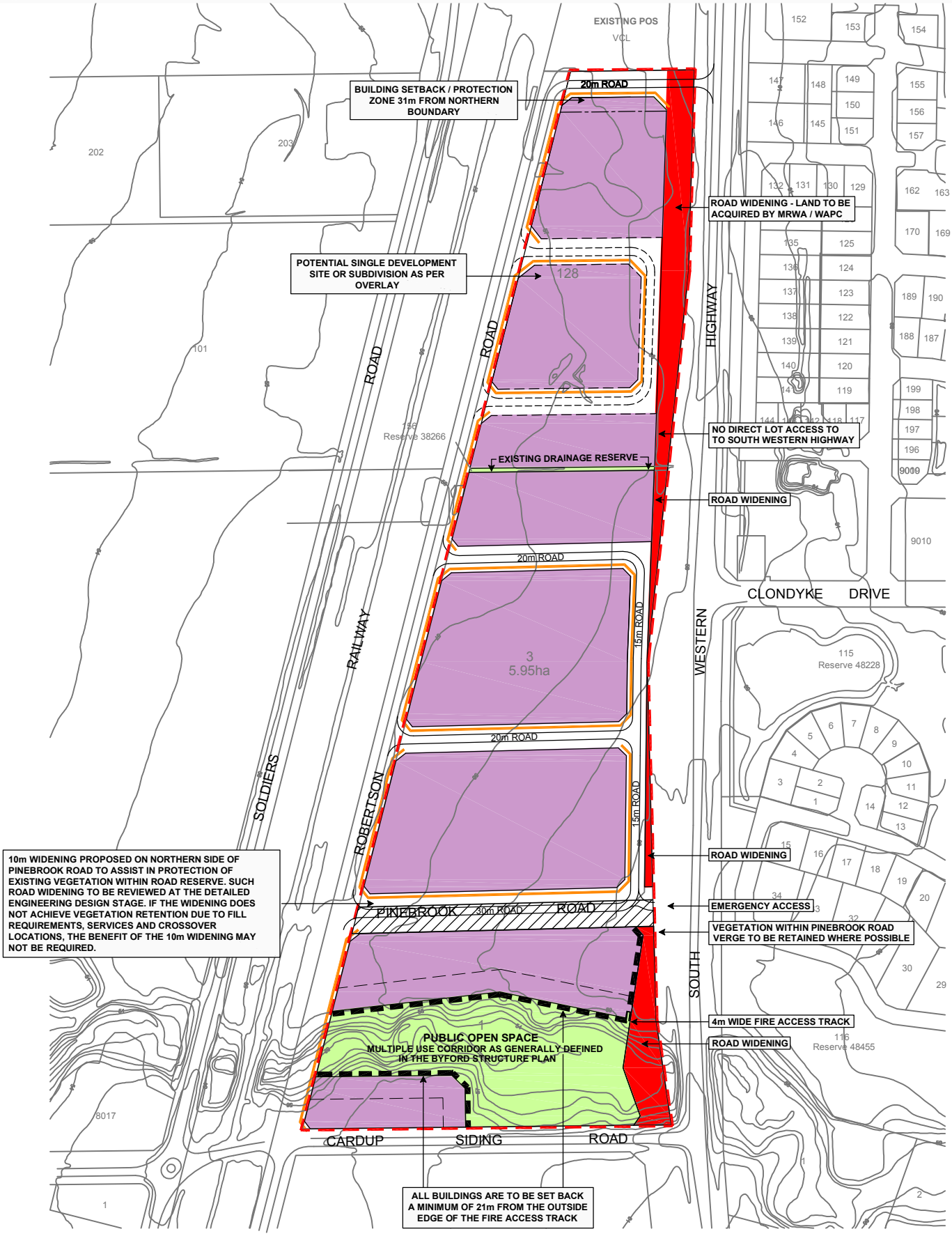
The objectives of this Local Structure Plan are to:

i) Progress planning, design and development of the Structure Plan area in the context of the principles and design parameters established by the Byford Structure Plan 2005 (as amended), Byford Townsite Drainage and Water Management Plan, The Local Water Management Strategy for the subject land and other relevant Shire of Serpentine-Jarrahdale strategies or policies;

ii) Retain where possible, significant remnant vegetation in road reserves and Public Open Space;

iii) Establish a multiple-use corridor over the Cardup Brook in accordance with the requirements of the Byford Structure Plan 2005 (as amended);

iv) Provide a vibrant and active Mixed Business Centre generally in accordance with the Byford Structure Plan 2005 (as amended), that compliments and not undermines the Byford Town Centre;



LEGEND:
LOCAL SCHEME RESERVES

- Primary Regional Road
- Local Roads
- Public Open Space and Drainage

ZONES

- Mixed Business

OTHER

- Local Structure Plan Boundary
- Footpath / Dual Use Path Network
- Existing Pinebrook Road Reserve (20m)
- Denotes Fire Access Track

NOTE

- Road Reserve widths are indicative only and are subject to change
- Distances and areas subject to survey
- Road carriageways diagrammatic only
- Minimum lot size 1000m^2
- LDP required for all development on Lot 1
- All development subject to bushfire risk and threat analysis

LOCAL STRUCTURE PLAN
LOTS 1, 3 & 128 SOUTH WESTERN HIGHWAY
BYFORD
VERSION 6 - MAY 2014

JOB REF: 100634 DATE: 6th MAY 2014

N

0 50m

SCALE 1:4000 @ A4

FIGURE 1

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Create a connected road network with shared use pathways that relates strongly to the adjacent residential areas; and

v) Create a street block layout that will facilitate passive solar lot orientation.

3.0 OPERATION OF THE STRUCTURE PLAN

The subdivision and development of land within the Structure Plan area is to generally be in accordance with the Structure Plan. Matters of detailed design (i.e. lot access, and detailed intersection design) can be considered and refined at the subdivision stage. Significant variations in design or land use will require amendments to the Structure Plan, in accordance with the provisions clause 5.18 of the Scheme.

3.1 LOCAL DEVELOPMENT PLANS

A Local Development Plan (LDP) is to be prepared and approved for the land south of Pinebrook Road, including the widened Pinebrook Road reserve, prior to any subdivision of development of Lot 1 being supported. Items that would be required to be considered as part of the LDP are to be specified and include land uses sensitive to the open space and creek line; location of vehicle crossovers along Pinebrook Road; retention of vegetation and location of service corridors within Pinebrook Road reserve; and additional requirements such as parking and landscaping.

FOOTNOTE: Local Development Plans and Detailed Area Plans are considered to be one and the same for the purposes of applying Clause 5.18.5 of the Scheme.

4.0 STRUCTURE PLAN MAP

The Structure Plan Map outlines the planned pattern of development for the Structure Plan area.

5.0 ZONES

5.1 MIXED BUSINESS ZONE

(a) The provisions standards and requirements of the subject site shall be in accordance with those applicable to the 'Mixed Business' zone as detailed within the Shire's Local Planning Policy No. 19 *Byford Development Requirements.*

(b) Residential uses are not permitted.

(c) The establishment of a Caretaker's Dwelling is only permitted where it is incidental to a predominant non-residential use on the land.

6.0 STRATEGIES AND PLANS

Prior to the commencement of development, the Shire will require the preparation and approval of the following strategies and plans, listed below:

6.1 LOCAL WATER MANAGEMENT STRATEGY

A Local Water Management Strategy shall be prepared and approved as part of the Local Structure Plan in accordance with the principles and objectives of the Byford Townsite Drainage and Water Management Plan.

6.2 LANDSCAPE MANAGEMENT PLAN

A Landscape Management Plan is to be prepared as a requirement of a condition of subdivision or development approval for any land abutting the Multiple Use Corridor. The extent of the Landscape Management plan will be at the discretion of the Director of Planning. The Landscape Management Plan shall, (if necessary), consider matters of fire management.

6.3 FIRE & EMERGENCY MANAGEMENT PLAN

A Fire and Emergency Management Plan is to be prepared, approved and implemented prior to subdivision.

6.4 DESIGN GUIDELINES

Design Guidelines to be prepared, advertised and adopted, as a Local Planning Policy, prior to any subdivision or development.

The Design Guidelines to address, but not limited to, the following:

- Building scale;
- Materials and colours;
- Car parking and access arrangements;
- Landscaping treatments;
- Location of storage areas;
- Lighting; and
- Signage.

6.5 TRAFFIC

The road network and access points shall be provided as per the access strategy (CAD Ref 201132-0079) within Part 2. The intersection treatment recommended by the Traffic Impact Assessment (undertaken by Porters dated 12/3/2014) has not been agreed/approved and further assessment is required which should undertake holistic network analysis to determine the appropriate and ultimate treatments at the following intersections:

- Nettleton Road/South Western Highway;
- Road A/South Western Highway;
- Clondyke Drive/ South Western Highway; and
- Kiln Road/South Western Highway.

The treatment(s) of the intersections are subject to further discussion and approval of Main Roads Western Australia (MRWA). This information may be required to be submitted as part of any future subdivision applications or as a condition of subdivision.

LOCAL STRUCTURE PLAN - LOTS 1, 3 & 128 SOUTH WESTERN HIGHWAY, BYFORD
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PART 2

Explanatory Section

LOCAL STRUCTURE PLAN - LOTS 1, 3 & 128 SOUTH WESTERN HIGHWAY, BYFORD
August 2012 (Version 6 - May 2014)

1.0 INTRODUCTION

This Local Structure Plan has been prepared to guide the subdivision and development of Lots 1, 3 and 128 South Western Highway, Byford.

The Local Structure Plan aims to create a Mixed Business development in line with Serpentine Jarrahdale Shire's vision for the area, as set out in the Byford Structure Plan. Accordingly, the Local Structure Plan:

- provides a range of lot sizes for Mixed Business activities;
- incorporates Cardup Brook into a Multiple Use Corridor; and
- incorporates best practice stormwater management principles into the proposed subdivision design and development.

This report provides a descriptive analysis of the Local Structure Plan, including site description, the existing statutory planning framework, opportunities and constraints, a description of the Local Structure Plan and the proposed implementation.

Lot 3 adjacent to Pinebrook Road

LOCAL STRUCTURE PLAN - LOTS 1, 3 & 128 SOUTH WESTERN HIGHWAY, BYFORD
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2.0 SITE DESCRIPTION

2.1 LOCATION

The subject land is located approximately 35 km south-east of the Perth city centre and approximately 10 km south of Armadale - **Figure 1- Regional Context Plan**.

The site is approximately 1.5 km south west of the Byford town centre between South Western Highway, and the Perth Bunbury Railway. Robertson Road is located on the western boundary and Cardup Siding Road on the southern boundary. Pinebrook Road (unmade) separates Lot 1 form Lot 3 – **Figure 2 – Locality Plan.**

The land comprises three allotments, being Lots 1, 3 and 128 South Western Highway, Byford. They have the following land areas:

- Lot 1 - 3.7647 ha;
- Lot 3 – 5.9573 ha; and
- Lot 128 – 3.7614 ha.

The site has a total area of approximately 13.18 ha.

The site is legally described as Lot 1 on Diagram 36702 comprised in Certificate of Title Volume 146 Folio 112A; Lot 3 on Diagram 62449 comprised in Certificate of Title Volume 1626 Folio 809; and Lot 128 on Deposited Plan 156237 in Certificate of Title 258 190A. Copies of the Certificates of Title are included in **Appendix 1**.

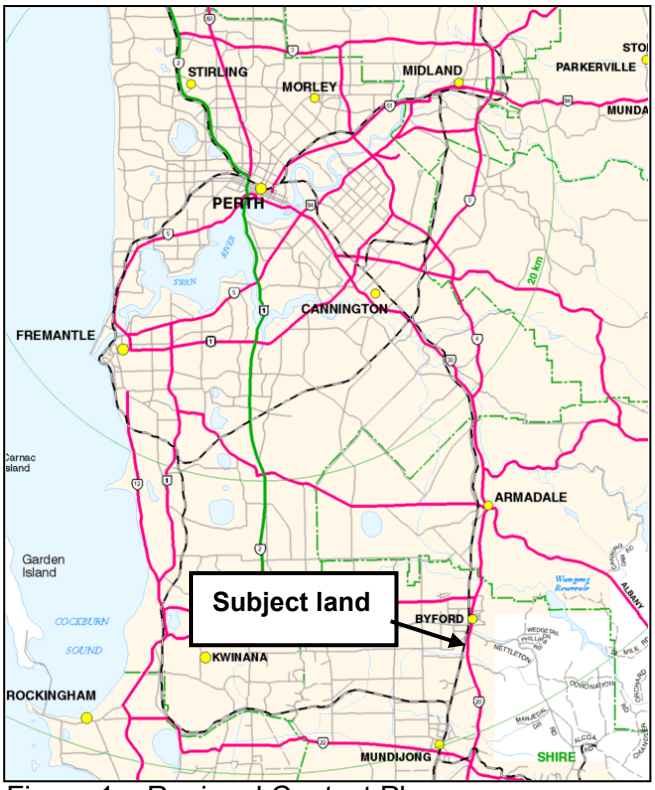

Figure 1 – Regional Context Plan

2.2 EXISTING LAND USES

The site has been extensively cleared and was previously used for grazing.

There is no infrastructure or buildings on Lots 3 and 128 - **Figure 3 - Aerial Photograph.**

There is a large residence and associated outbuildings located on Lot 1 near the corner of Pinebrook Road and Robertson Road.


Cleared land on Lot 1, on northern side of Cardup Siding Road

LOCALITY PLAN - FIGURE 2

LOCAL STRUCTURE PLAN

REDGUM BROOK ESTATE - NORTH OF OAKLANDS DRAIN
LOTS 1, 3 & 128 SOUTH WESTERN HIGHWAY
BYFORD

LOCAL STRUCTURE PLAN AREA
BYFORD STRUCTURE PLAN AREA

N

0 500m

SCALE 1:30 000 @ A4

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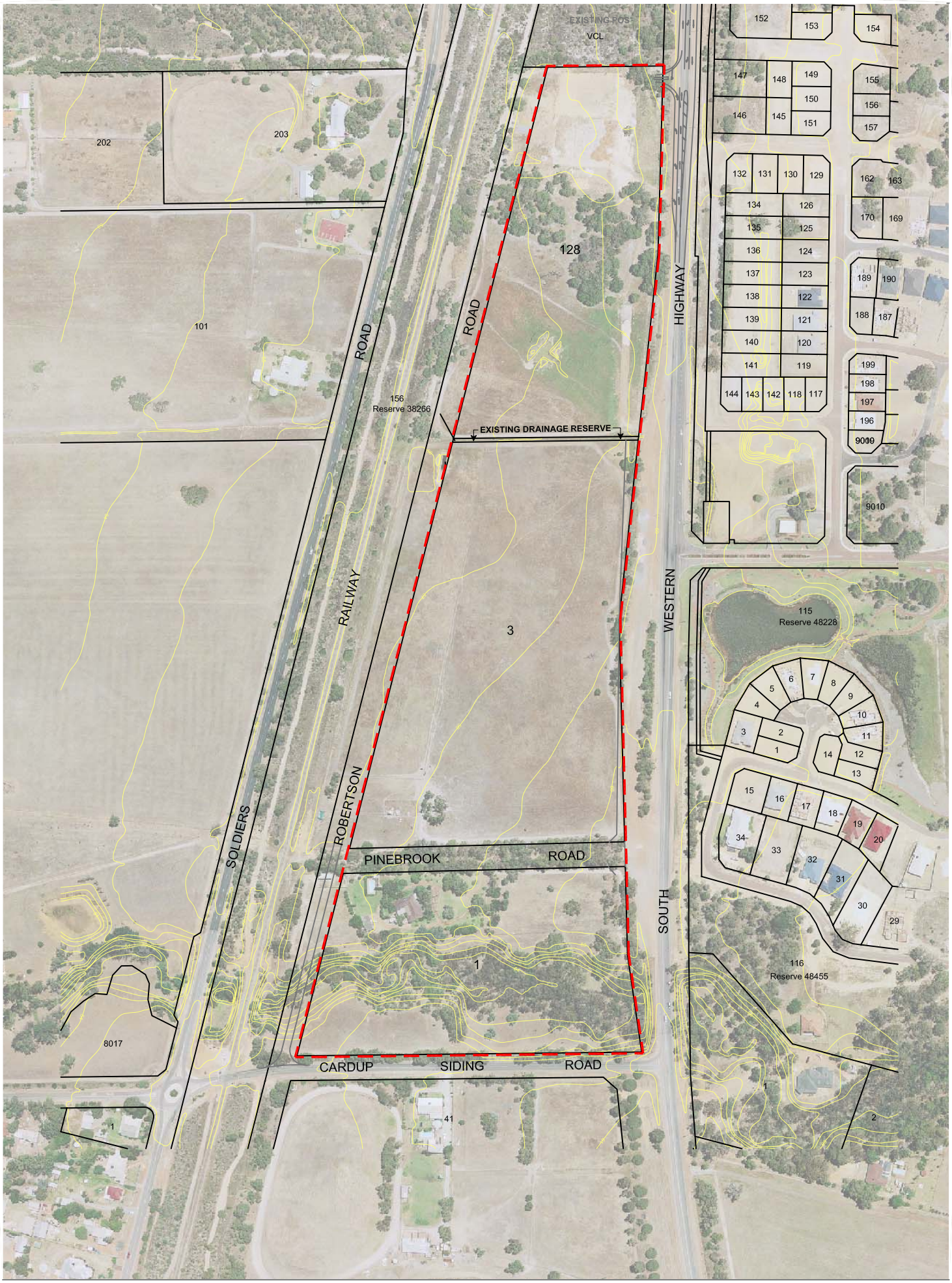
JOB REFERENCE: 100634 13th MARCH 2010



AERIAL PHOTO - FIGURE 3

LOCAL STRUCTURE PLAN
LOTS 1, 3 & 128 SOUTH WESTERN HIGHWAY
BYFORD

LEGEND:
Subject Land

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0 50m
SCALE 1:4000 @ A4

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3.0 EXISTING STATUTORY PLANNING FRAMEWORK

3.1 METROPOLITAN REGION SCHEME

The site is zoned 'Urban' under the Metropolitan Region Scheme (MRS). Land adjacent to the western boundary of the site is reserved under the MRS as 'Railway'. The property directly adjoins the northern boundary of Lot 128 is zoned Rural. South Western Highway adjacent to the eastern boundary of the site is reserved as 'Primary Regional Roads' – **Figure 4 – Extract Metropolitan Region Scheme Zoning Plan**.

3.2 SHIRE OF SERPENTINE JARRAHDALE TOWN PLANNING SCHEME NO. 2

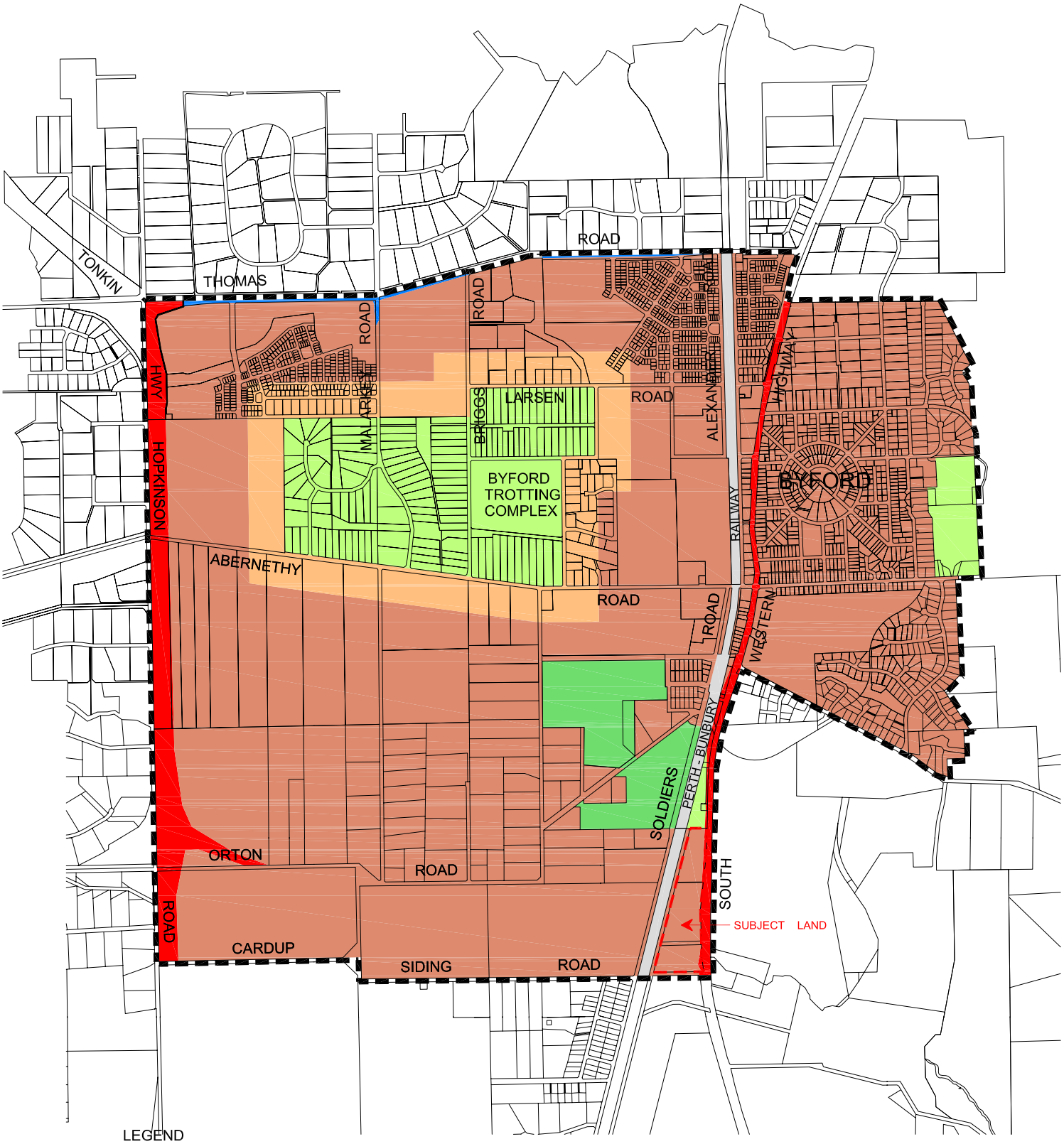
The site is zoned 'Urban Development' under the Shire of Serpentine-Jarrahdale Town Planning Scheme No. 2 (TPS 2) - **Figure 5 – Extract TPS 2 Zoning Plan.**

TPS 2 states that:

The purpose of the Urban Development zone is to provide for orderly planning of large areas of land in a locally integrated manner and within a regional context, whilst retaining flexibility to review planning with changing circumstances.

Pursuant to clause 5.18 and Appendix 15 of TPS 2, a detailed Structure Plan for the whole or part of a precinct within the Byford Development Area is required to be prepared, advertised and adopted by the Council and the WAPC prior to the subdivision of the land.

A detailed Structure Plan is required to comply with the relevant provisions of the Byford Structure Plan and the Byford. Townsite Drainage and Water Management Plan, which are discussed in Section 3.5.



LEGEND

RESERVED LANDS

- PARKS AND RECREATION
- RAILWAYS

ROADS

- PRIMARY REGIONAL ROADS
- OTHER REGIONAL ROADS

ZONES

- URBAN
- URBAN DEFERRED
- RURAL

MRS ZONING - FIGURE 4

LOCAL STRUCTURE PLAN

LOTS 1, 3 & 128 SOUTH WESTERN HIGHWAY
BYFORD

LOCAL STRUCTURE PLAN AREA

BYFORD STRUCTURE PLAN AREA

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0 500m

SCALE 1:30 000 @ A4

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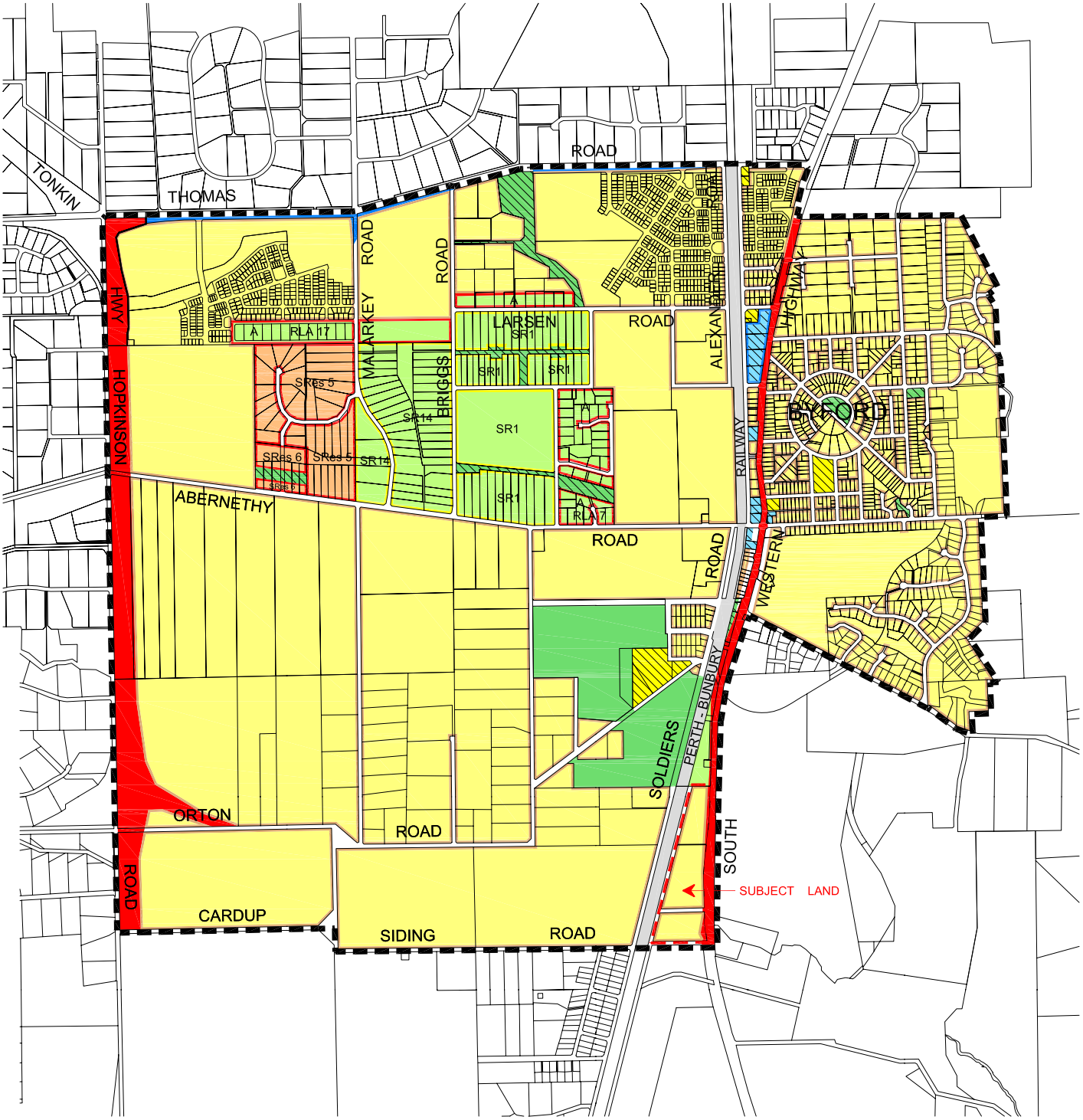

LEGEND

METROPOLITAN REGION SCHEME RESERVES
- PARKS AND RECREATION
- RAILWAYS
- PRIMARY REGIONAL ROADS
- OTHER REGIONAL ROADS

LOCAL SCHEME RESERVES
- LOCAL ROADS
- PUBLIC AND COMMUNITY PURPOSES
- PUBLIC OPEN SPACE

ZONES
- SPECIAL RESIDENTIAL
- URBAN DEVELOPMENT
- COMMERCIAL
- SHOWROOM / WAREHOUSE
- RURAL
- RURAL LIVING A
- SPECIAL RURAL

OTHER
- SRes 5 — SPECIAL RESIDENTIAL AREAS (SEE SCHEME TEXT)
- RLA 7 — RURAL LIVING A AREA (SEE SCHEME TEXT)
- SR14 — SPECIAL RURAL AREA (SEE SCHEME TEXT)

TPS No. 2 - FIGURE 5

LOCAL STRUCTURE PLAN

LOTS 1, 3 & 128 SOUTH WESTERN HIGHWAY
BYFORD

LOCAL STRUCTURE PLAN AREA
BYFORD STRUCTURE PLAN AREA

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0 500m

SCALE 1:30 000 @ A4

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3.3 STATE STRATEGIES & POLICIES

3.3.1 STATE SUSTAINABILITY STRATEGY

The State Sustainability Strategy provides an overarching framework for the State Government to respond to the sustainability agenda. The Strategy identifies the following six broad goals and 42 strategy areas intended to fulfil these goals and guide Government action towards achieving its vision for sustainable Western Australia:

- Sustainability and governance
- Contributing to global sustainability
- Sustainable natural resource management
- Sustainability and settlements
- Sustainability and community'
- Sustainability and business

The policy objectives of the State Sustainability Strategy are incorporated into the planning system through State and Local Government policy and formally applied through planning decisions.

3.3.2 STATE PLANNING STRATEGY

The State Planning Strategy (1997) was prepared by the WAPC as a whole of Government approach to guide sustainable land use planning throughout the State until 2029.

The Strategy is aimed at developing a land use planning system to help the State achieve a number of key goals. These include generating wealth, conserving and enhancing the environment and building vibrant and safe communities for the enjoyment of this and subsequent generations of Western Australians. The Strategy was last audited in 2000-2001.

The Local Structure Plan for the site is consistent with the goals and objectives of the State Planning Strategy.

3.3.3 NETWORK CITY

Network City was adopted by the Western Australian Planning Commission (WAPC) in July 2004 and endorsed by the State Government in August 2004 "as the strategy framework and the basis for local dialogue in planning for the metropolitan and Peel regions".

A draft Statement of Planning Policy: Network City, made under section 5AA of the Town Planning and Development Act 1928, was released by the WAPC for public comment in March 2006.

Network City's vision is for "a world-class sustainable city, vibrant, more compact and accessible, with a unique sense of place".

Network City identifies three principles to guide decision making:

- Enhance efficiency of urban land use and infrastructure.
- Protect and rehabilitate the environment and improve resource efficiency and energy use.
- Enhance community vitality and cohesiveness.

Network City has ten key objectives:

- Deliver urban growth management.
- Accommodate urban growth primarily within a Network City pattern, incorporating communities.
- Align transport systems and land use to optimise accessibility and amenity.
- Deliver a safe, reliable and energy efficient transport system that provides travel choice.
- Protect and enhance the natural environment, open spaces and heritage.
- Deliver for all a better quality life, building on our existing strengths.
- Plan with the communities.

- Ensure employment is created in centres.
- Deliver a city with 'urban' energy, creativity and cultural vitality.
- Provide a city plan that will be implemented, provide certainty and deliver results.

The key principles, objectives and strategies of Network City are captured in the following eight headline statements:

- Manage growth by sharing responsibility between industry, communities and government.
- Plan with communities.
- Nurture the environment.
- Make fuller use of urban land.
- Encourage public over private transport.
- Strengthen local sense of place.
- Development strategies which deliver local jobs.
- Provide affordable housing.

The subject land is identified in the Network City Framework plan within an area where "future communities will be designed around networks and centres".

3.3.4 DIRECTIONS 2031 DRAFT SPATIAL FRAMEWORK FOR PERTH AND PEEL (2009)

Directions 2031 is a spatial framework that builds on the principles identified under Network City. It is a high-level strategic plan that establishes a vision for the future growth of the Perth and Peel region, and provides a framework to guide the detailed planning and delivery of housing, infrastructure and services necessary to accommodate that growth. It is estimated that by 2031 the Perth and Peel region 328,000 more dwellings to accommodate an additional 556,000 residents.

Directions 2031 recognises that for any planning vision to be successful it must be in tune with the aspirations of both residents and businesses.

The planned growth of the outer suburbs (already anticipated in the metropolitan and Peel region planning schemes can meet the needs of most people seeking new and affordable accommodation in more peaceful suburban surroundings through a 'connected' growth strategy.

The Local Structure Plan proposed for the subject land embraces the principles of Network City and Directions 2031 in that it provides for the key principles and objectives as listed above, including the development of land that is identified for urban development in the MRS and TPS 2, a local sense of place that nurtures the environment, and a range of employment generating activities.

The objectives of Network City and Directions 2031 are reflected in the Local Structure Plan and addressed throughout Section 4 of this report.

3.3.5 LIVEABLE NEIGHBOURHOODS

Liveable Neighbourhoods Edition 3 (LN 3) was prepared by the WAPC to implement the objectives of the State Planning Strategy and deliver the strategies and actions of Network City. As an operational policy of the WAPC, LN3 guides the design and assessment of structure plans (regional, district and local), subdivision and development for new urban areas.

Its aims include promoting:

- the design of walkable neighbourhoods;
- places that offer community and a sense of place;
- mixed business and active streets;
- accessible and sustainable parks;
- energy efficient design; and
- a variety of lot sizes and housing types.

The key initiatives of LN 3 are covered under eight design elements:

- community design;
- movement network;
- lot layout;
- public parkland;
- urban water management;
- utilities;
- activity centres and employment;
- schools.

The implementation of each of these elements and the fulfilment of the overall principles of LN will be fundamental to ensuring that development of the site and the wider Byford urban area occurs in a thoughtful and sustainable manner. Application of the LN principles is therefore to all levels of planning for the site, from local structure planning through to detailed lot and building design.

3.3.6 SOUTH-EAST CORRIDOR STRUCTURE PLAN (SOUTH OF ARMADALE)

The South-East Corridor Structure Plan for the area south of Armadale was released in 1996 to ensure a comprehensive approach to planning and development in the southern part of the South-East Corridor and to guide more detailed local planning for the area. The plan identified a proposed urban expansion area around Byford, including the subject site.

3.4 SHIRE OF SERPENTINE JARRAHDALE STRATEGIES & POLICIES

3.4.1 BYFORD STRUCTURE PLAN

The subject site is located within the Byford Structure Plan (BSP) area – **Figure 6 - Byford Structure Plan**.

The BSP was adopted by the Council and the WAPC in 2005 to guide the development of land in the Byford area for urban purposes. The BSP was prepared in response to continued pressure from landowners within the study area to develop their land. It expands on the principles of the South East Corridor Structure Plan and sets out a neighbourhood structure for the Byford area.

The BSP aims to accommodate future urban growth while maintaining the area's identity and lifestyle. The BSP identifies the following as the main elements in achieving this vision:

- Sustainable and best management practices for urban stormwater management;
- Creation of urban nodes, town centre and neighbourhood centres to facilitate community formation and strong local identity;
- Improved landscape elements;
- Legible and robust street layout to encourage walking and cycling as alternatives to driving.

The BSP as adopted by the Council and WAPC in 2005 identified the following uses in respect to the subject site:

- Lots 1, 3 & 128 are identified as Mixed Business with the exception of a Multiple Use Corridor (MUC) over the portion of Cardup Brook through Lot 1;
- A Rural zoning between Cardup Siding Road and the MUC;
- An area of 'Landscape Sensitivity' (remnant vegetation) was also identified on Lot 128; and
- Lots 1 and 3 were also the subject of a Notation B, 'Land subject to further study – planning to be finalized subject to resolution of alignment of Orton Road.

Shire staff subsequently reviewed the 2005 BSP to address inconsistencies and deficiencies. On 1 September 2006, the Council adopted a draft 'Byford District Structure Plan 2006' for public comment. This draft 2006 District Structure Plan was considered for final approval at a Special Council meeting on 13 February 2007.

SJS TRIM - IN14/10387

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 BUFFER LIMITED 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 BOTH TOWN CENTRE DISTRICT DISTRIBUTOR INTEGRATOR 'B' ROAD AND LARSEN ROAD TO BE REVIEWED AS PART OF FURTHER DETAILED STRUCTURE PLANNING
4. GARDUP BROOK FORESHORE RESERVE: MINIMUM WIDTH 50 METRES FINAL WIDTH SUBJECT TO DETAILED INVESTIGATION, LAND TO BE CEDED FREE OF COST UPON SUBDIVISION IN ACCORDANCE WITH WESTERN AUSTRALIAN PLANNING COMMISSION 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 ENSURE 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 6.9% 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 DOUBLE 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 OR OTHERWISE SUCH LAND ABUTS LAND CLASSIFIED RURAL RESIDENTIAL, AN APPROPRIATE LOWER DENSITY 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 OF 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 STRUCTURE PLAN IS TO INCLUDE AN INVESTIGATION INTO INCREASED RESIDENTIAL DENSITIES WITHIN THE 800 METRE WALKABLE CATCHMENT AND ITS RELATIONSHIP WITH TRANSIT ORIENTATED 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 WITHIN THE 800 METRE WALKABLE CATCHMENT OF THE TOWN CENTRE WILL BE SUBJECT TO A SEPARATE MODIFICATION TO THE MSP 2006 AND COMMUNITY CONSULTATION.
18. THE EXISTING WATERWAY WILL BE SUBJECT TO WATER SENSITIVE URBAN DESIGN PRINCIPLES AT THE DETAILED PLANNING AND 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 / 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 CONSULTATION 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 CONSULTATION 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 STRUCTURE 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 SHIRE'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 (R2.5-R5)
- RESIDENTIAL (R30)
- RESIDENTIAL (R30-R60)
- LAND SUBJECT TO FURTHER STUDY. SEE NOTES 25 & 29 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
- EXISTING 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

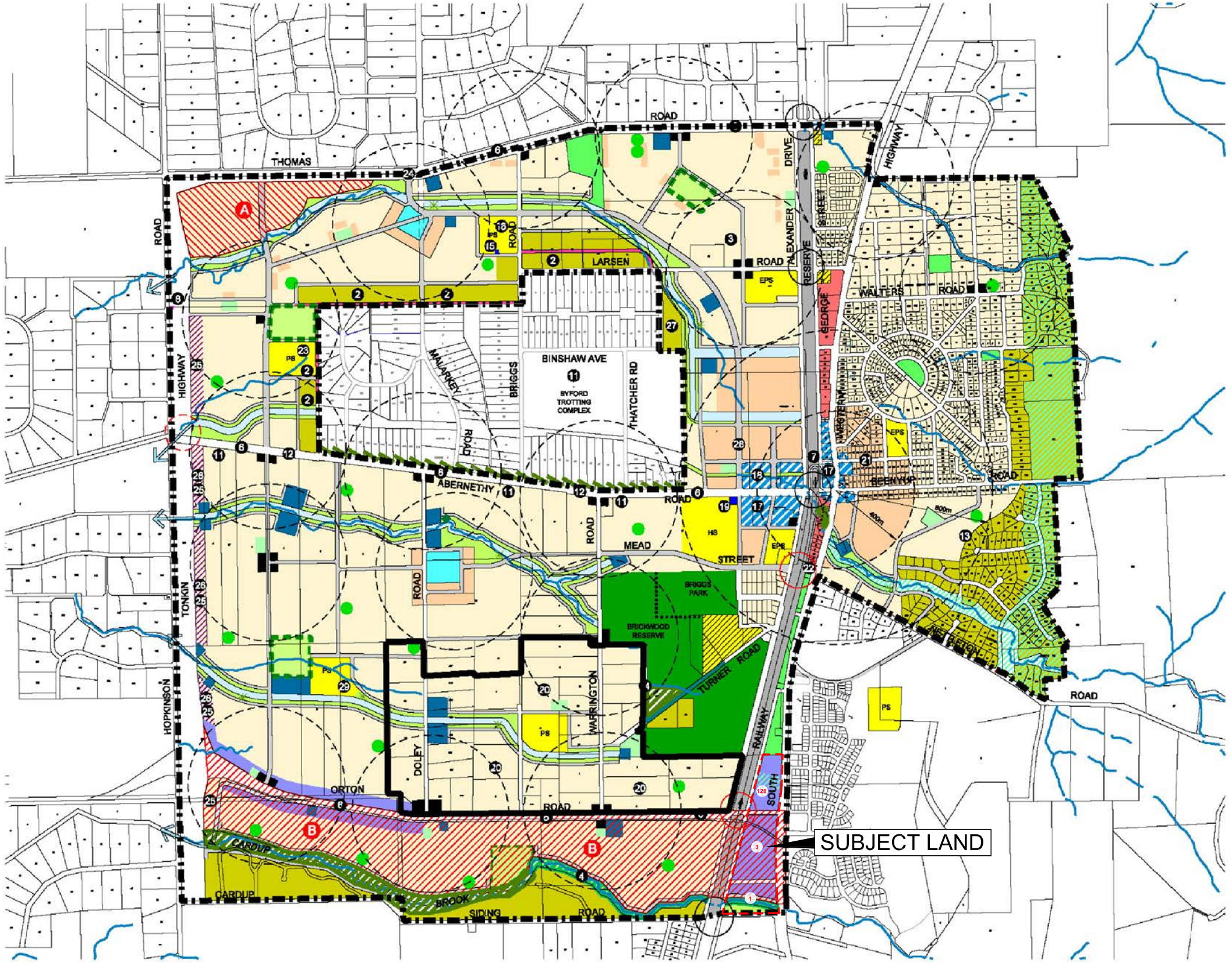


FIGURE 6

PROJECT

Byford Structure Plan

Adopted by Council (Original) - 22nd AUG 2005
Adopted by Council (Review No.1) - 13th FEB 2007

CLIENT		DATE
SHIRE OF SERPENTINE - JARRAHDALE		9/7/2008
PLAN NUMBER	SCALE	PROJECTION
02/128/001G-struct	1:10,000 @ A1	MGA 94
DESIGNED BY	CHECKED BY	DRAWN BY
KN	ST	YH

200m 0 200 400 600m

ALL AREAS AND DIMENSIONS DERIVED ARE SUBJECT TO DETAIL SURVEY.

TAYLOR BURRELL BARNETT
Town Planning and Design
187 Roberts Road Subiaco
Western Australia 6008
Telephone: (08) 9382 2911
Facsimile: (08) 9382 4586
admin@tbbplanning.com.au

However, Council resolved not to proceed with the 2006 District Structure Plan, and instead adopted minor modifications to the 2005 BSP as set out below:

- Include a notation on the Plan to require the preparation and implementation of a Bicycle and Pedestrian Plan for each Local Structure Plan in accordance with the Shire's Bicycle and Pedestrian Master Plan.
- Include a notation on the plan requiring Local Structure Plans to be prepared, approved and adopted across the entire Development Area.
- Include a notation on the Plan to require the provision of land for community purposes in accordance with Council's Community Services and Facilities Plan.
- Prior to the completion of the Department of Water Regional Drainage study and the review of the Parsons Brinkerhoff Byford Urban Stormwater Management Strategy, areas of land are to be set aside in each sub-catchment for drainage in accordance with the Water Corporation's requirements.
- Detailed Area Plans are require 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.

In November 2007, the WAPC considered the amendments adopted by the Council and endorsed the modified BSP.

The Council has recently resolved to remove the red hatching and the Notation B relating to the additional further studies in respect to the Orton Road alignment.

Section 4 of this report describes how the proposed Local Structure Plan for Lots 1, 3 and 128 South Western Highway is consistent with the Byford Structure Plan.

3.4.2 BYFORD URBAN STORM WATER MANAGEMENT STRATEGY

The Byford Urban Stormwater Management Strategy (BUSMS) was adopted by Council in September 2003 and is integral to the implementation of the BSP. The Strategy addresses stormwater management issues for the Byford area and provides a framework for more site-specific water management plans. The Strategy sets out how water quality and quantity should be managed in accordance with water sensitive urban design principles. The Local Structure Plan has been prepare in accordance with the requirements of BUSMS, as described in Section 4 and **Appendix 2**.

3.4.3 DEPARTMENT OF WATER AND BYFORD TOWNSITE DRAINAGE AND WATER MANAGEMENT PLAN

This Department of Water's Byford Townsite Drainage and Water Management Plan (BTDWMP) was released in September 2008. The BTDWMP provides guidance for the Shire, WAPC, land developers and other State agencies about water management issue to help development proceed within the Byford Townsite area. The BTDWMP assists in integrating land and water planning as required by State Planning Policy 2.9 and Better Urban Water Management guidelines. Local structure plans and subdivision plans prepared for areas of proposed new development must demonstrate compliance with the strategies, objectives and design criteria detailed in the BTDWMP.

The Local Structure Plan has been prepared in accordance with the requirements of the BTDWMP, as described in Section 4 and **Appendix 2**.

3.4.4. DEVELOPMENT CONTRIBUTIONS

Clause 5.19 of TPS 2 and the BSP provide for the preparation of a Development Contribution Plan for the BSP area. Such a plan typically includes cost-sharing arrangements for district level infrastructure such as arterial roads, public open space and associated facilities, including administration costs. The Shire has engaged consultants to prepare a Development Contribution Plan for the BSP, however this is yet to be finalised and formally implemented. The contribution arrangement is being progressed through Amendment 150 to TPS 2. It is expected that the Developer Contribution Plan will be advertised mid 2010. Once finalised, the Development Contribution Plan is expected to be implemented by way of an Amendment to TPS 2. In the absence of an endorsed Development Contribution Plan, clause 5.19.1.5 of TPS 2 provides for Council to reach negotiated agreements with developers in respect to contributions as part of the local structure planning process.

In addition, the Shire is also currently preparing a draft Community Facilities and Services Plan to guide the sustainable development of community facilities and services to the year 2020. Such facilities might include recreation facilities, local libraries, and a new administration centre for the Shire. The plan will include a strategy for a shared funding partnership between Council, land developers, the community and other government and non-government agencies. The draft plan was advertised for community comment in July-August 2008 and the Shire is currently considering submissions.

The developer of the site will liaise with the Shire in respect to contributions required under these plans during the subdivision approval process.

3.4.5 LOCAL PLANNING POLICIES

The following local planning policies have been adopted by Council and are relevant to the proposed Local Structure Plan for the site.

LPP2 SUBDIVISION WITHIN THE BYFORD STRUCTURE AREA

Local planning policy LPP2 states that Council will not support any subdivision proposals within the Byford Structure Plan are unless a detailed structure plan has been prepared for the particular precinct.

LPP6 WATER SENSITIVE DESIGN

This local planning policy seeks to ensure that water sensitive design best management practices are incorporated in structure plans, subdivisions and developments.

The policy also aims to develop a network of Multiple Use Corridors, which form the major spines of the stormwater management and wildlife corridor systems throughout the Shire, integrating water quantity and quality management, nature conservation and ecological function, and recreational and educational opportunities.

The policy requires the preparation of a Stormwater Management Plan consistent with the BUSMS prior to Council considering a subdivision application in the Byford Structure Plan area.

This report demonstrates how the proposed subdivision and development of the site will comply with Council's local planning policy for water sensitive urban design. A Local Water Management Strategy for the Local Structure Plan area is included in **Appendix 2**.

LPP9 MULTIPLE USE TRAILS WITHIN THE SHIRE OF SERPENTINE JARRAHDALE

This planning policy aims to "implement Council's vision to provide a trails network that expands on the existing rails, and interlinks suburbs and communities". The policy encourages the incorporation of recreational trails within Multiple Use Corridors where possible. The policy includes specifications for the construction of trails within the State. The Multiple Use Corridor within Lot 1 will be provided in accordance with this policy, in consultation with Council staff.

LPP19 BYFORD STRUCTURE PLAN AREA DEVELOPMENT REQUIREMENTS

This policy sets out the permissibility of various land uses and the development requirements within the zones contained in the BSP. The policy makes provision for a local structure plan to set out the development standards for a particular site.

LOCAL STRUCTURE PLAN - LOTS 1, 3 & 128 SOUTH WESTERN HIGHWAY, BYFORD
August 2012 (Version 6 - May 2014)

4.0 SITE ANALYSIS ASSESSMENT – OPPORTUNITIES AND CONSTRAINTS

The following section identifies the existing conditions of the Local Structure Plan area, and the key opportunities and constraints for development.

4.1. TOPOGRAPHY & SURFACE HYDROLOGY

The development area occurs along the foot of the Darling Scarp, where the Scarp begins to spread out through colluvial processes to form the Swan Coastal Plan. The topography is characterised by a relatively flat palusplain (seasonally waterlogged land) varying between 60m AHD along the eastern boundary to approximately 55m AHD along the western boundary.

4.2 HYDROGEOLOGY

The Byford area is known to experience regular water logging in the low-lying areas to the west of the study area. This inundation is due to a combination of persistent winter rainfall elevating the shallow water table, which rises to the surface and inundates vast areas of the flat terrain, and poor drainage.

There are several local depressions east and west of South Western Highway within and adjacent to Lots 3 and 128, which result in local perching of surface water after a large rainfall event.

There is also a stream (Cardup Brook) which passes directly through the study area at the southern end in Lot 1.

There is potential for areas within the study area to receive additional floodwater from outside their natural catchment by overtopping of drains and watercourses.

Groundwater levels across the study area are typically shallow, varying between 0m – 6m below natural surface level.

Lots 1, 3 and 128 are predominantly designated as a Multiple Use Wetland (MUW). A small portion of the southern end of the site is designated as a Resource Enhancement Wetland (REW) which is associated with Cardup Brook.

In general, MUW are totally or mostly cleared, and are used for agricultural purposes. These wetlands still serve hydrological functions, such as groundwater recharge and flood mitigation, but do not have any specific management objectives.

4.3 SOILS/GEOTECHNICAL

The soils of the study area are generally related to the Yogannup Formation.

The dominant soil types are gravely yellow clay sands, which occur across the majority of the site. They are yellow and more sandy and gravely in the surface horizons, but more clayey at depth.

A number of small creeks drain across the site from the Scarp, petering out in sands on the Swan Coastal Plain. The most significant of these is Cardup Brook which forms a small valley in the southern edge of the site.

Surface water collects to form seasonally wet soils in several low areas west of South Western Highway, due to road and surface water drainage.

The flows in the creeks only occur in winter and following response to storm events.

Surface water collects in several low areas forming local temporary perching of surface water in winter.

A detailed Local Water Management Strategy (LWMS) has been undertaken over the site by GHD and is included in **Appendix 2**.

4.4 VEGETATION

A flora and vegetation assessment of the site has been undertaken by Landform Assessment – **Appendix 3.**

- *Vegetation Assessment*

  The subject land originally comprised vegetation of the Guildford Vegetation Complex, of which only 5% remains. This vegetation is typified by that contained in the adjoining Brickwood Reserve that abuts the north western corner of the site. The Brickwood Reserve vegetation is listed as Bush Forever Site 350.

Brickwood Reserve – Bush Forever Site 350 - on northern boundary of Lot 128.

Past clearing practices have removed most indigenous species, with the best nomination for the remnant vegetation is altered to significantly degraded Floristic Community 3a, *Eucalyptus calophylla – Kingia australis* woodlands on heavy soils.

The best representation of this is the small area in the extreme north eastern corner of the site. The only other remnant of this community is scattered remnants along the road verges, outside the study site.

The vegetation along Pinebrook Road is also a remnant of Community Type 3a.

All other vegetation is so altered and consisting of regrowth that, whilst it might originally have been part of the same community Type, it can no longer be considered so.

Vegetation along Pinebrook Road.

- *Significant Flora*

  No Declared Rare, Priority Species or Significant flora was identified during the vegetation assessments.

  The vegetation along Cardup Brook is listed as Bush Forever Site 271. The riparian vegetation is classified as Wetlands 62 and 23-V1 associated with Cardup Brook. Whilst these vegetated sites are classified as Conservation Category wetlands, they are coincident with the remnant vegetation.

  The alignment of Cardup Brook is listed as Bushforever and represents a more significant community asset than the small discontinuous vegetation remnants of the regrowth Marri trees on Lot 128. Therefore, in order to protect the community assets for biodiversity, the landholders have elected to place Cardup Brook and its banks within POS. The vegetation within this area of POS is degraded and could benefit from additional planting.

All other areas of remnant vegetation are either too small and/or too degraded to have a high significance for retention.

Degraded remnant trees on Lot 128.

- *Vegetation within Lot 128*

  The vegetation in the northern portion of the Structure Plan area (contained within Lot 128), is identified as "Completely Degraded" in Bushforever 2000.

  The vegetation consists of a stand of *Eucalyptus calophylla* which is regrowth Marri forming parkland pasture. The trees are generally not very old, and with almost no understorey, do not represent significant vegetation, but rather seeded regrowth of a generally young age of 20 – 30 years. This vegetation does not justify a classification other than parkland pasture.

  As such, there is little merit in retaining the remnant trees in this area of the site. The requirement to fill the land by approximately 1.0m will mean that it is unlikely that these trees will survive in any event.

- *Vegetation Along Pinebrook Road*

  The vegetation along Pinebrook Road has been identified in Bushforever 2000 as being in "Good Condition".

  There is considered to be no viable alternative option that would successfully retain the vegetation along Pinebrook Road. Every endeavour will be made to retain the vegetation where possible during development of the site.

4.5 FAUNA

Vegetation on site will be providing some habitats for birds and other small fauna, but with its sparseness on the low ridge the number of fauna species is likely to be significantly restricted.

4.6 CONSERVATION AND HERITAGE VALUES

4.6.1 BUSH FOREVER

No parts of the property are covered under Bush Forever provisions.

Along the western boundary of the development site is Bush Forever Site 321 – which runs along the railway corridor.

4.6.2 ABORIGINAL HERITAGE

The *Aboriginal Heritage Act 1972* is the Western Australian legislation in place to protect places and objects customarily used by, or traditional to, the original inhabitants of Australia. Such places and objects are maintained in a register under the Act, however, all sites are protected under the Act whether or not they have been registered. The Act is administered by the Department of Aboriginal Affairs (DIA).

A search using the DIA Aboriginal Inquiry System indicates that there is one listed heritage site within the development area. Cardup Brook, which flows through the lower section of the site is listed as a mythical site (site ID 16108).

4.7 CONTAMINATION

The Department of Environment and Conservation's Contaminated Sites Database was searched to identify potentially contaminated sites within 2km radius of the property.

The search indicated that the subject land is not categorized as either 'contaminated', 'potentially contaminated' or 'remediated for

restricted use' in the Contaminated Sites Database.

4.8 ACID SULFATE SOILS

Acid Sulfate Soil (ASS) risk areas for the Perth Metropolitan Area have been mapped by the DEC and WAPC. These maps indicate that the soils within the development area generally present no risk of actual acid sulfate soils (AASS) or potential acid sulfate soils (PASS) occurring generally at greater than 3 m depth.

Along the southern boundary of Cardup Brook and also along the north western boundary at Soldiers Road there are regions of low to moderate risk of AASS or PASS occurring generally at greater than 3m depth. These areas are associated with the natural waterways that pass through the study area.

4.9 LAND USE

The subject site has been extensively cleared and used for pasture for many years. There is a single dwelling on Lot 1, with portion of the land being used for the agistment of horses.

Dwelling on Lot 1.

Horse agistment on Lot 1

As described in Section 3, the Shire of Serpentine-Jarrahdale TPS No. 2 identifies the site for Urban Development. The Byford Structure Plan identifies the site as Mixed Business.

The site abuts South Western Highway to the east, with a proposed future road widening affecting Lots 3 and 128.

The site abuts Robertson Road and the Railway Reserve to the west. An area of public open space abuts the northern boundary.

'Byford by the Scarp' residential estate lies to the east of the site, on the eastern side of South Western Highway.

Land to the south is zoned Rural.

'Byford by the Scarp' residential estate.

4.10 ROADS

The site currently has frontages to South Western Highway, Robertson Road, Cardup Siding Road and Pinebrook Road.

There are no footpaths or cycle facilities along South Western Highway.

4.10.1 SOUTH WESTERN HIGHWAY

The section of South Western Highway fronting the development area is an undivided two-way single carriageway rural highway that is classified as a District Distributor A under Main Roads WA Functional Road Hierarchy. South Western Highway is also a Freight Route carrying heavy haulage vehicles.

There is provision for road widening in the proposed Structure Plan for the construction of a future dual carriageway.

4.10.2 CARDUP SIDING ROAD

Cardup Siding Road is an undivided single carriageway unkerbed rural standard road with a single lane in each direction. It is classified as a Local Access Road.

Cardup Siding Road near intersection with South Western Highway – looking north west.

4.10.3 PINEBROOK ROAD

Pinebrook Road is an undivided narrow single carriageway two-way unsealed rural road. It provides access to the single residential dwelling on Lot 1.

Pinebrook Road.

4.10.4 ROBERTSON ROAD

The Robertson Road reserve abutting the western boundary of the site is an unconstructed road. This future road, when constructed, will likely be classified as a Local Access Road.

4.11 PUBLIC TRANSPORT

The nearest Transperth bus service routes are No.s 251, 252 and 253 which travel north-south along South Western Highway until reaching Abernethy Road where they diverge to travel along Soldiers Road.

The nearest stop on theses routes is located on Soldiers Road south of Bateman Street where a bus Terminus is located on the eastern side of the road.

4.12 SERVICES

4.12.1 DRAINAGE

There are several local depressions east and west of South Western Highway within and adjacent to Lots 3 and 128, which result in

local perching of surface water after a large rainfall event.

The whole site will be filled by up to one metre and sub soil drains will be installed where required to address the groundwater seepage. This will be addressed at the UWMP/subdivision design stage.

There is an existing open drain running through a Water Corporation drainage reserve between Lots 3 and 128. This open drain is connected to the eastern side of South Western Highway through two 600mm pipes located under the Highway.

Existing drainage culvert from South Western Highway drain into drainage reserve between Lots 3 and 128.

There is also a natural stream – Cardup Brook, which passes directly through the study area at the southern end in Lot 1.

There is potential for areas within the study area to receive additional floodwater from outside their natural catchment by overtopping of drains and watercourses.

These drainage matters are addressed further in the Local Water Management Strategy - **Appendix 2**.

4.12.2 SEWER

No gravity sewer exists in the immediate vicinity of this development. Water Corporation advises that any development of Lot 3 South Western Highway is dependent upon the construction of the pump station near Tonkin Highway and connecting sewers.

The construction of the sewer pump station is now underway, however, it could be some time before the gravity mains are extended across to service Byford by the Scarp, and in turn, Lots 1, 3 and 128.

4.12.3 POWER

The existing Western Power distribution infrastructure in the vicinity of the subject land comprises of aerial power lines. There is no existing underground power in the vicinity.

4.12.4 WATER SUPPLY

Water reticulation is available in both South Western Highway and Pinebrook Road, with an existing 200mm diameter water main located in the northern verge of Pinebrook Road and the eastern verge of Forrest Street.

4.12.5 TELEPHONE

An existing local telecommunications network exists in the vicinity of the proposed development.

4.12.6 GAS

A High Pressure Gas main is located in South Western Highway on the eastern verge.

LOCAL STRUCTURE PLAN - LOTS 1, 3 & 128 SOUTH WESTERN HIGHWAY, BYFORD
August 2012 (Version 6 - May 2014)

5.0 LOCAL STRUCTURE PLAN

5.1 INTRODUCTION

This section describes the proposed Local Structure Plan, including the proposed indicative lot pattern, major land uses, road network and major infrastructure. It also addresses the compliance of the Local Structure Plan with the State and local planning framework, in particular the Byford Structure Plan.

The proposed Local Structure Plan is shown in **Figure 7.**

"Completely degraded" remnant trees on Lot 128.

5.2 COMPLIANCE WITH BYFORD STRUCTURE PLAN

The Local Structure Plan has been prepared generally in accordance with the Byford Structure Plan.

In respect to Advice Note B on the Byford Structure Plan (Section 3.5.1), the Shire has resolved to remove Notation B.

The Local Structure Plan does vary slightly from the Byford Structure Plan in respect to the inclusion of the land south of Cardup Brook as Mixed Business (as opposed to Rural).

In this regard, it is noted that the Shire is preparing the rezoning of land south of Cardup Siding Road to Industrial and it would be incompatible to retain a narrow band of rural land north of Cardup Siding Road. Furthermore, that portion of land is now zoned Urban Development.

The area on Lot 128 identified as "landscape sensitivity" on the Byford Structure Plan is composed of vegetation described in the Vegetation Assessment as "completely degraded", and as such, is not proposed to be retained. It is too degraded to be classified as Floristic Community 3a.

5.3 PROPOSED LOCAL ROAD STRUCTURE AND INDICATIVE LOT PATTERN

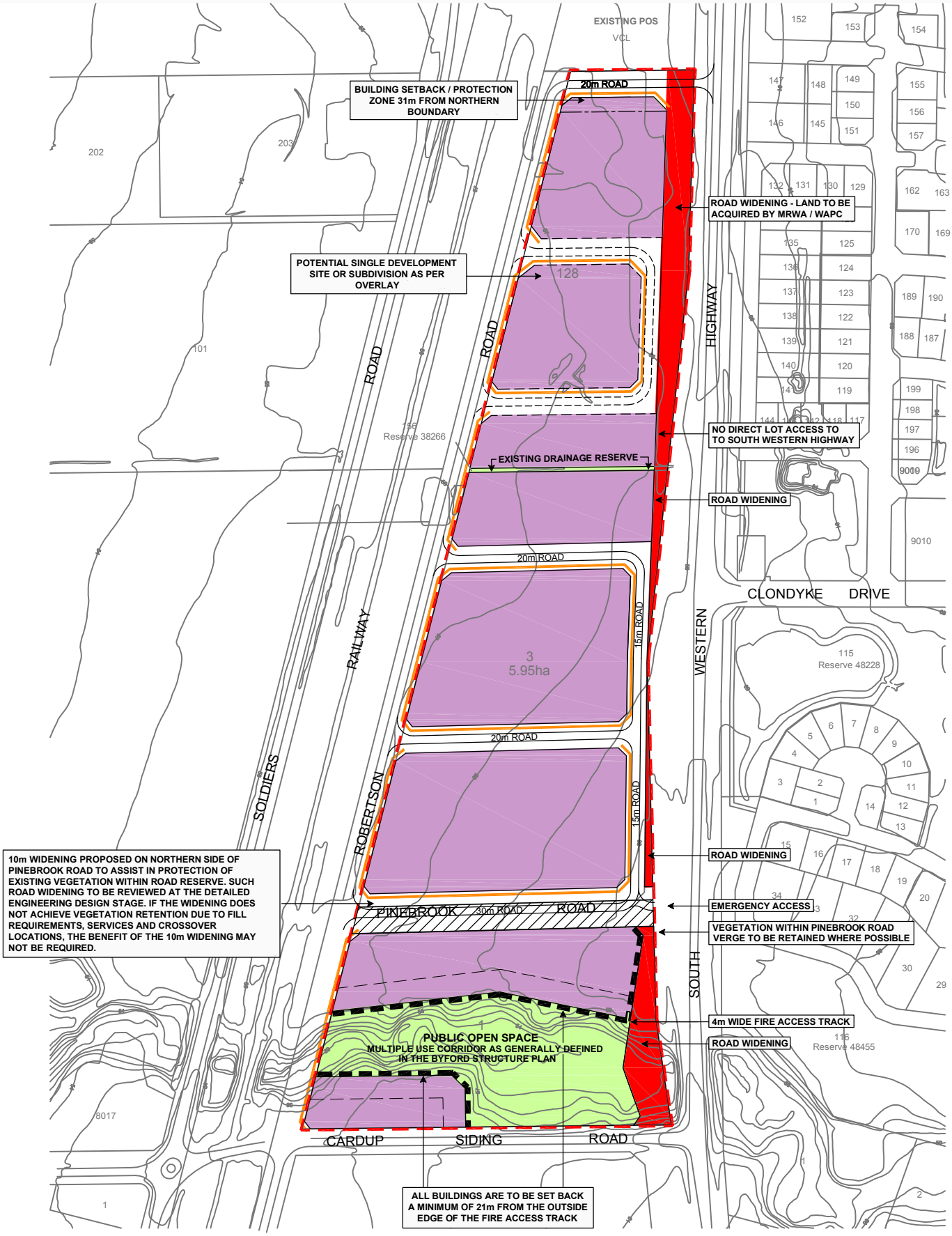
The proposed indicative lot layout is shown on the Local Structure Plan **Figure 7**. The local road structure and lot layout is largely influenced by the location of the following:

- MRS reserve for the South Western highway, including proposed widening; and
- Multiple Use Corridor, incorporating Cardup Brook through Lot 1.

In addition, the proposed lot layout is influenced by the road network, which is designed to limit through traffic and provide strong vehicle, pedestrian, cycle and visual links.

As required by *Liveable Neighbourhoods* and the BSP the proposed lot layout optimises north-south and east-west orientation of lots to facilitate building designs that enjoy the benefits of passive solar access.

A variety of lot sizes are proposed to accommodate a range of Mixed Business/commercial uses.



LEGEND:
LOCAL SCHEME RESERVES

- Primary Regional Road
- Local Roads
- Public Open Space and Drainage

ZONES

- Mixed Business

OTHER

- Local Structure Plan Boundary
- Footpath / Dual Use Path Network
- Existing Pinebrook Road Reserve (20m)
- Denotes Fire Access Track

NOTE

- Road Reserve widths are indicative only and are subject to change
- Distances and areas subject to survey
- Road carriageways diagrammatic only
- Minimum lot size 1000m²
- LDP required for all development on Lot 1
- All development subject to bushfire risk and threat analysis

LOCAL STRUCTURE PLAN
LOTS 1, 3 & 128 SOUTH WESTERN HIGHWAY
BYFORD
VERSION 6 - MAY 2014

JOB REF: 100634 DATE: 6th MAY 2014

N
0 50m
SCALE 1:4000 @ A4

FIGURE 7

GRAY & LEWIS
LAND USE PLANNERS
Suite 5, 2 Hardy Street
South Perth, WA 6151
T (08) 9474 1722
F (08) 9474 1172
perth@graylewis.com.au

5.4. MULTIPLE USE CORRIDOR

The Local Structure Plan proposes to incorporate Cardup Brook and associated vegetation within a Multiple Use Corridor (MUC) in accordance with the requirements of the BSP and local planning policies.

The MUC will continue to provide a drainage function as well as providing public open space. The proposed dimensions of the MUC accord with the typical cross sections set out in the BSP and includes the retention of riparian vegetation.

As noted in the Local Water Management Strategy for the Local Structure Plan area (Appendix 2), the MUC complies with the requirements of the Byford Urban Stormwater Management Strategy and the Shire's Subdivision Design Guidance document.

Detailed design of the MUC will enhance the ecological function of Cardup Brook as a green corridor. This will include replanting and reseeding with local provenance stock.

A 4.0 m wide strategic firebreak will be constructed adjacent to the mixed business lots, as shown on the Local Structure Plan map, in accordance with Shire specifications.

5.5 PUBLIC OPEN SPACE

In accordance with WAPC policy, public open space is not required to be provided for non-residential uses.

5.6 ROAD NETWORK – TRAFFIC ANALYSIS

The Local Structure Plan establishes a highly interconnected road network that provides choice, reducing vehicle flows on individual routes and strong visual, pedestrian and cycle links to the Multiple Use Corridor, and east-west linkages beyond the Structure Plan area.

The traffic analysis prepared by Porter Consulting Engineers (Appendix 4) confirms the above design objectives via the projected traffic volumes.

An indicative road hierarchy based on *Liveable Neighbourhoods* road classifications is shown on the Structure Plan Map. The road layout is indicative only and is subject to detailed planning at the time of subdivision and development.

Vehicle access to the proposed Mixed Business development will be via:

- A new road which will be created at the northern end of the site, connecting with the presently unmade Robertson Road and South Western Highway; and
- An Emergency Access from Pinebrook Road onto South Western Highway.

The proposed Structure Plan for the development of the total land area requires the construction of an internal road network servicing the created subdivided lots. External access to the internal road network requires commotion with South Western Highway.

The Shire has advised that the proposed future Orton Road extension will now not proceed. As the road will not be constructed and the future road reserve alignment is not acceptable to MRWA, access to South Western Highway via a future Orton Road is not available to this site.

Discussions with MRWA on alterative options for access to the site has resulted in the advice that only a single main access point from the land development site will be permitted onto South Western Highway. Further, MRWA advises that access must be located at the most northern end of the development, i.e. at the northern end of Lot 128. In this position, it is at an approximate mid-distance between the existing Clondyke Drive intersection and a proposed future Wilaring Street intersection. MRWA advises that the resulting 400 metre separation distance between each intersection will be acceptable.

A single point of access to a commercial subdivision is not considered appropriate for reasons of safety for evacuation. Accordingly, MRWA has suggested that a secondary access for Emergency use only form Pinebrook Road onto South Western Highway is acceptable.

Internal roads will comply with Council standards. Footpaths will be provided on at least one side of all roads, as required by *Liveable Neighbourhoods*. Parking embayments will be provided on roads abutting public open space.

The final subdivision design and landscape master plan for the site will address the requirements of the Shire's Bicycle and Pedestrian Master Plan, which is currently being prepared.

5.7 LANDSCAPE AND VEGETATION MANAGEMENT PLAN

A Landscape and Vegetation Management Plan will be developed for the Local Structure Plan area prior to subdivision or development. Such plan will address (but not be limited to) the following matters:

(i) the provision of appropriate native and indigenous street trees along all local roads within the Structure Plan area, and at a density of no less than one per lot; and

(ii) revegetation of drainage areas and multiple use corridor with appropriate indigenous native species.

5.8 FIRE MANAGEMENT PLAN

A Preliminary Fire Management Plan has been prepared by FirePlan WA – refer Appendix 5.

The site is generally cleared, except for an area along the section of Cardup Brook and a small section in the northern third of the site (on Lot 128).

These two areas would be rated as "extreme" with the remainder of the site rated as "low". The adjoining area to the north of Lot 128 is rated as "extreme", to the east is residential, to the south is cleared rural land and to the west is currently rural land which is proposed to be developed as residential.

The proposed access for the development allows for two access/egress points which complies with *Planning for Bushfire Protection.*

A more detailed Fire Management Plan will be prepared as a condition of subdivision.

5.9 MAJOR INFRASTRUCTURE

5.9.1 EARTHWORKS

Some clearing of the site has been allowed for the subdivision area for the removal of topsoil and clearing through the road reserves.

The extent of the fill to the site is based on the geotechnical report and achieving the minimum Class S for the site, which required 700mm of fill across the development.

5.9.2 ROADS

All proposed road reserve widths are 20m except for two small sections of service roads adjacent to South Western Highway which are 15m wide. It is common practice where road reserves interface for the verge to 'overlap'. Effectively, the road reserve for South Western Highway becomes 15m wider to accommodate the 7.4m verge on the western side.

The other 20m wide road reserves are consistent with road planning policy for Mixed Business/Service Commercial uses to accommodate a standard 7.4m wide pavement.

It is not an industrial development where wider road reserves may be required to accommodate heavy haulage vehicles.

5.9.3 DRAINAGE

A comprehensive drainage strategy is included in the Local Water Management Strategy (Appendix 2). The proposed strategy is consistent with the requirements of the Byford Urban Stormwater Management Strategy and the 2005 Developer Guidelines by Parsons Brinkerhoff, the Byford Subdivision Guidance document and the

Department of Water's Byford Townsite Drainage and Water Management Plan.

Within the proposed development, runoff will be directed to both a pit and pipe network and a proposed bioretention swale located parallel to Robertson Road.

Bioretention swales along South Western Highway are also planned. Drainage swales will be provided to the north-south roads with single sided development.

The proposed bioretention swales will provide sufficient retention to avoid the necessity of constructing detention/infiltration basins within the development. They will be vegetated to enhance contaminant removal.

5.9.4 POWER

Power supply will be extended throughout the subdivision. All aerial lines will be relocated underground under the WAPC approval requirements.

5.9.5 WATER SUPPLY

Water infrastructure will be required through the provision of a 150mm water service. The Water Corporation has advised that they would require water to be connected to the existing systems in Pinebrook Road and South Western Highway.

The connection to the existing water main in South Western Highway will require boring under the road.

5.9.6 SEWER

As outlined in Section 4.12.4 the Water Corporation will require the pump station near Tonkin Highway and the associated sewer to be constructed prior to Lots 1, 3 & 128 being developed. This will limit the timing of the proposed development until this infrastructure is available.

5.9.7 GAS

Gas services will be extended from the existing High Pressure Gas main located in South Western Highway on the eastern verge.

5.9.8 TELEPHONE

The Telstra network will be extended into the development area.

5.9.9 FOOTPATHS

The provision of a 1.8m footpath along the new subdivisional roads has been indicated on the Local Structure Plan, however will be confirmed at the subdivision application stage.

LOCAL STRUCTURE PLAN - LOTS 1, 3 & 128 SOUTH WESTERN HIGHWAY, BYFORD
August 2012 (Version 6 - May 2014)

6.0 IMPLEMENTATION

The owners intend to proceed with obtaining subdivision approval as soon as the Local Structure Plan is approved. Subdivision works are proposed to commence in early 2012 and are likely to be staged over a two to three year period.

As discussed in Section 3.5.4, the Shire is currently preparing developer contribution plans for the funding of infrastructure and facilities in the Byford Structure Plan area. Developer contributions will be negotiated with Council through the Local Structure Plan process.

LOCAL STRUCTURE PLAN - LOTS 1, 3 & 128 SOUTH WESTERN HIGHWAY, BYFORD
August 2012 (Version 6 - May 2014)

REFERENCES

Department of Environment (DoE) 2004, Perth Groundwater Atlas, Second Edition. ISBN: 1 920947 78 7

Department of Environment (DoE) 2006. Draft Identification and Investigation of Acid Sulfate Soils. Acid Sulfate Soil Guideline Series. Prepared by the Land and Water Quality Branch of the DoE May 2006.

Department of indigenous Affairs 2006. Aboriginal Heritage Sites Register. Accessed November 2006 http://www.dia.wa.gov.au/heritage_Sites_Register.aspx

Department of Water (DoW) 2006. Perth Ground Water Atlas online mapping tool. Accessed November 2006 http://portal.water.wa.gov.au/portal/page/portal/dow/information/DATA/groundwater_atlas

Government of Western Australia 2000. Bush Forever – A Directory of Bush Forever Sites. Government of Western Australia.

Appendix 1

Certificates of Title

REGISTER NUMBER	
1/D36702	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
3	3/4/2008

WESTERN AUSTRALIA

RECORD OF CERTIFICATE OF TITLE

UNDER THE TRANSFER OF LAND ACT 1893

VOLUME 146 FOLIO 112A

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

LAND DESCRIPTION:

LOT 1 ON DIAGRAM 36702

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

BYFORD INDUSTRIAL HOLDINGS PTY LTD OF POST OFFICE BOX 508, KELMSCOTT
(T K545570) REGISTERED 26 MARCH 2008

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

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

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

STATEMENTS:

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

SKETCH OF LAND:	146-112A (1/D36702).
PREVIOUS TITLE:	1057-724.
PROPERTY STREET ADDRESS:	15 PINEBROOK RD, BYFORD.
LOCAL GOVERNMENT AREA:	SHIRE OF SERPENTINE-JARRAHDALE.

WESTERN AUSTRALIA

REGISTER NUMBER	
3/D62449	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
1	21/9/2007

RECORD OF CERTIFICATE OF TITLE

VOLUME 1626 FOLIO 809

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

LAND DESCRIPTION:

LOT 3 ON DIAGRAM 62449

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

COLLI NOMINEES PTY LTD
DIVINITAS PTY LTD
GER PTY LTD
ALL OF PO BOX 80, MUNDIJONG
AS TENANTS IN COMMON IN EQUAL SHARES

(T K331074) REGISTERED 4 SEPTEMBER 2007

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

1. K331075 MORTGAGE TO NATIONAL AUSTRALIA BANK LTD REGISTERED 4.9.2007.

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:	1626-809 (3/D62449).
PREVIOUS TITLE:	146-111A.
PROPERTY STREET ADDRESS:	NO STREET ADDRESS INFORMATION AVAILABLE.
LOCAL GOVERNMENT AREA:	SHIRE OF SERPENTINE-JARRAHDALE.

REGISTER NUMBER	
128/DP156237	
DUPLICATE EDITION	DATE DUPLICATE ISSUED
2	9/1/2009

WESTERN AUSTRALIA

RECORD OF CERTIFICATE OF TITLE

VOLUME 258 FOLIO 190A

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 128 ON DEPOSITED PLAN 156237

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

AUSWIDE INTERNATIONAL INVESTMENTS (CARDUP) PTY LTD OF 2898 ALBANY HIGHWAY, KELMSCOTT
(T K791910) REGISTERED 4 DECEMBER 2008

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

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

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

STATEMENTS:

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

SKETCH OF LAND:	258-190A (128/DP156237).
PREVIOUS TITLE:	1057-724.
PROPERTY STREET ADDRESS:	NO STREET ADDRESS INFORMATION AVAILABLE.
LOCAL GOVERNMENT AREA:	SHIRE OF SERPENTINE-JARRAHDALE.

NOTE 1: A000001A LAND PARCEL IDENTIFIER OF SERPENTINE AGRICULTURAL AREA LOT 128 (OR THE PART THEREOF) ON SUPERSEDED PAPER CERTIFICATE OF TITLE CHANGED TO LOT 128 ON DEPOSITED PLAN 156237 ON 23-APR-02 TO ENABLE ISSUE OF A DIGITAL CERTIFICATE OF TITLE.

NOTE 2: THE ABOVE NOTE MAY NOT BE SHOWN ON THE SUPERSEDED PAPER CERTIFICATE OF TITLE OR ON THE CURRENT EDITION OF DUPLICATE CERTIFICATE OF TITLE.

Appendix 2

Local Water Management Strategy
July 2012

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Urban Solutions

Report for Lots 1, 3 and 128 South West Highway, Byford

Local Water Management Strategy

July 2012

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

SJS TRIM - IN14/10387

Contents

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Appendices

1. Introduction

GHD Pty Ltd was commissioned by Urban Solutions and Clark Property Group to prepare a Local Water Management Strategy (LWMS) for the proposed industrial estate on Lots 1, 3, and 128 South Western Highway, Byford ('the development').

Lots 1, 3 and 128 on South Western Highway, Byford is a 13.5 ha site within the Shire of Serpentine-Jarrahdale, approximately 32 km south-east of Perth (Figure 1).

This Local Water Management Strategy for the development has been prepared in accordance with *Better Urban Water Management* (Western Australia Planning Commission (WAPC), 2008) which provides a model for developers to address water related management issues at the various stages of planning and presents interim water related design objectives for water conservation, groundwater and stormwater. This LWMS sets objectives which are consistent with the Department of Water's (DoW) current position on *Urban Stormwater Management in Western Australia*.

1.1 Total water cycle management - principles and objectives

Total water cycle management, also referred to as integrated water cycle management, 'recognises that water supply, stormwater and sewage services are interrelated components of catchment systems and therefore must be dealt with using a holistic water management approach that reflects the principles of ecological sustainability' (DoW 2004-07, *Stormwater management manual for Western Australia*).

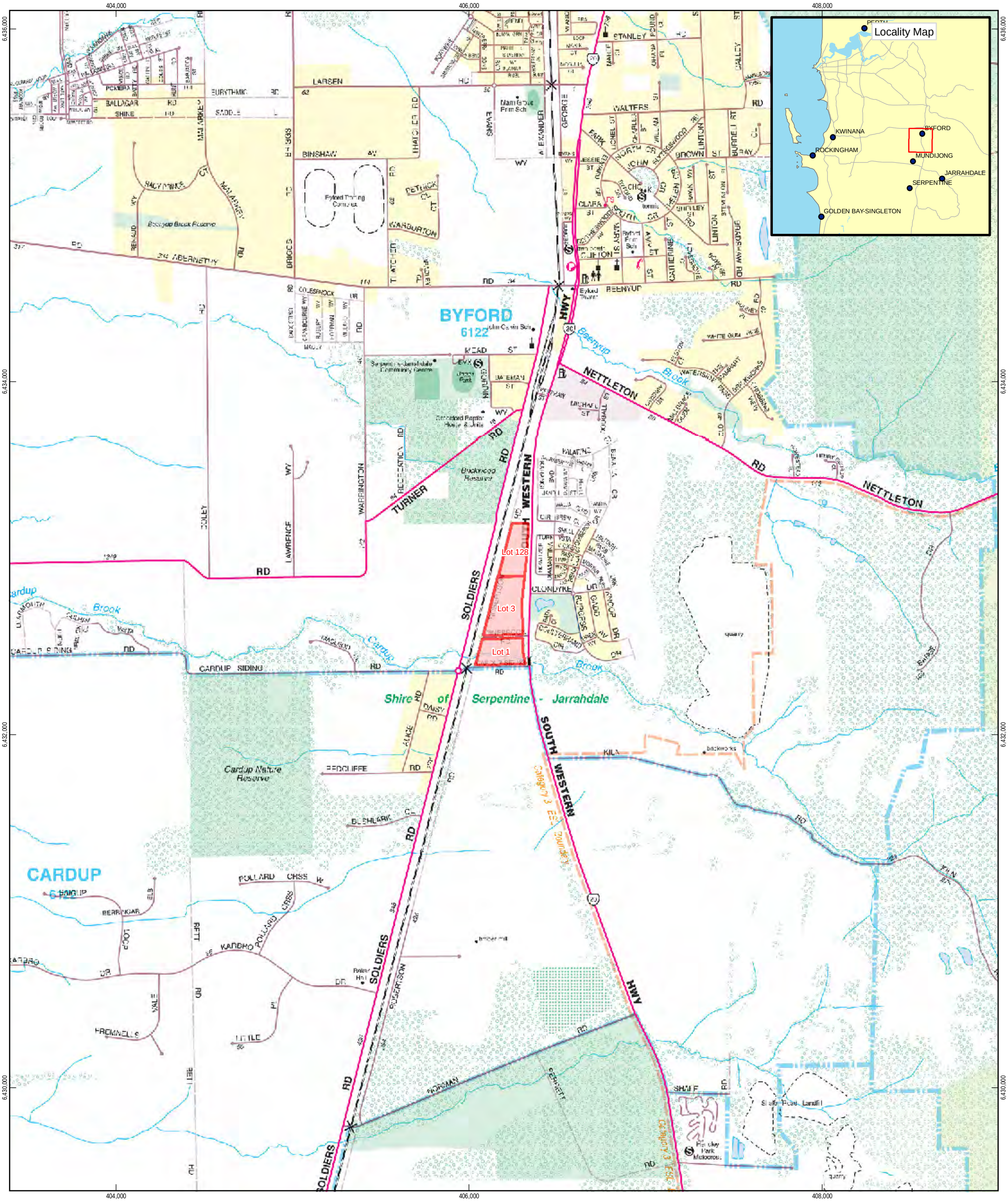
The *State Planning Policy 2.9: Water Resources* (WAPC, 2004) outlines the key principles of integrated water cycle management as:

- Consideration of all water resources, including wastewater in water planning;
- Integration of water and land use planning;
- The sustainable and equitable use of all water sources, having consideration of the needs of all water users, including the community, industry and the environment;
- Integration of human water use and natural water processes; and
- A whole of catchment integration of natural resource use and management.

The principles and objectives for managing urban water as stated in *the Stormwater Manual for Western Australia* (DoW, 2004-07) are as follows:

- Water Quality: to maintain or improve the surface and groundwater quality within the Development Areas relative to predevelopment conditions.
- Water Quantity: to maintain the total water cycle balance within the Development Areas relative to the pre - development conditions.
- Water Conservation: to maximise the reuse of stormwater.
- Ecosystem Health: to retain natural drainage systems and protect ecosystem health.

- Economic Viability: to implement stormwater management systems that are economically viable in the long term.
- Public Health: to minimise the public risk, including risk from injury or loss of life, to the community.
- Protection of Property: to protect the built environment from flooding and waterlogging.
- Social Values: to ensure that social, aesthetic and cultural values are recognised and maintained when managing stormwater.
- Development: to ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles.



LEGEND

Study Area

1:20,000 (at A3)

0 100 200 400 600 800 1,000

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 50

N

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Urban Solutions

Urban Solutions
Byford Lots 1, 3 and 128 LWMS

Job Number 61-24146
Revision A
Date 11 OCT 2010

Groundwater Monitoring Report

Figure 1

G:\61\24146\GIS\mxds\superseded\6124146_G001_RevA.mxd

GHD House, 239 Adelaide Terrace Perth WA 6004 **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au

Data Source: GHD: Study Area - 20090929; GA: 250k Topo Data (series 3) - 2006; Landgate: Streetsmart Directory - 2009. Created by: wdavis, sismail, RLow

1.2 Planning framework

The planning framework for land and water planning is illustrated in Figure 2. The LWMS demonstrates how water resources can be considered in the land use planning system and to ensure consistency with *State Planning Policy 2.9 Water Resources* (WAPC, 2004).

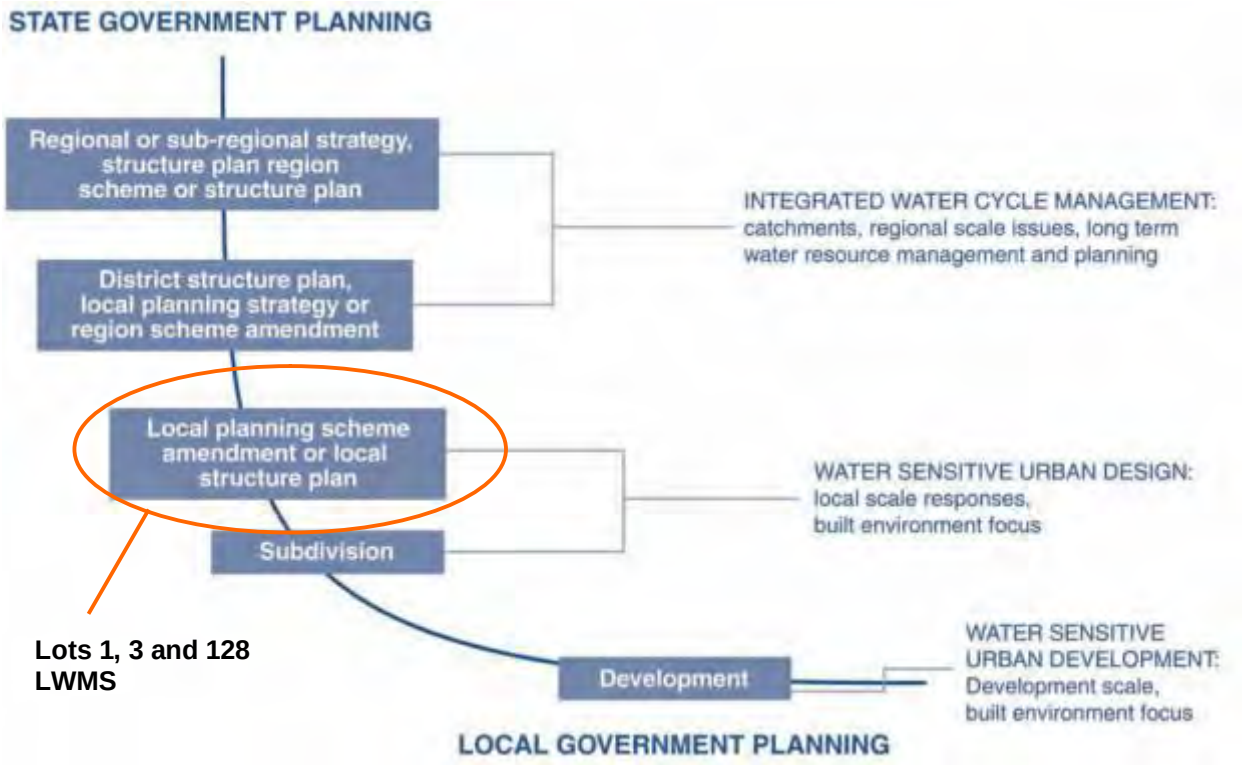

Figure 2 Planning framework for integrating the drainage planning with land planning

SOURCE: WAPC, 2008

1.3 Previous studies

A number of studies within the Byford locality have been conducted. Information presenting in those documents have been drawn upon in the creation of this LWMS.

- *Byford Townsite Drainage and Water Management Plan* (GHD and DoW, 2008) presents a Drainage and Water Management Plan (DWMP) to address water issues in proposed development areas.
- *Local Scale Groundwater Modelling of Byford* (CyMod Systems, 2007) for the DoW to assess any impacts from variations in climate or planned development in the study area.
- *Byford Floodplain Management Strategy* (SKM, 2007). Prepared for the Department of Water. A floodplain management study including two-dimensional flood modelling has been completed by SKM (2007) for DoW. A high resolution

digital elevation model, created to assist flood modelling, has been made available as part of the surface water modelling outputs to supplement Landgate information.

Environmental water requirements of groundwater dependent ecosystems have not yet been published for this area.

2. Proposed development

2.1 District structure plan

The *Byford District Structure Plan* (Taylor Burrell Barnett, 2005) (DSP) outlines the Shire of Serpentine Jarrahdale's proposed planning framework for future subdivision and development/ redevelopment of the town centre and the surrounding rural residential area including the areas available for surface drainage infrastructure and corridors. There is flexibility within the DSP on the types of best management practices that may be used for surface and groundwater quantity and quality management. Much of the proposed development is residential with mixed business and a multiple use corridor in the south of the development.

The *Byford Urban Stormwater Management Strategy* (BUSMS) was prepared by Parsons Brinkerhoff in 2003 which defined drainage corridors and proposed drainage basin locations. The BUSMS has been superseded by the *Byford Townsite DWMP* (DoW, 2008) which has been prepared to comply with the current water planning framework (Figure 2). The Byford DWMP involved further hydrologic and hydraulic modelling to minimise the flooding risk and defines the areas required for stormwater drainage infrastructure and promotes best practice in water management. The DSP has been amended to reflect the implementation of the Byford DWMP.

2.2 Local structure plan

The Gray and Lewis Local Structure Plan for the proposed industrial estate on Lots 1, 3, and 128 South Western Highway outlines the expected development of the industrial estate. The Local Structure Plan sets a typical lot size of 1000-1500 m^2. 20m wide roads have been designed to accommodate larger vehicles that are expected to frequent the area.

Existing drainage reserves have been retained and a multiple use corridor as described in the Byford Structure plan has been designed within Lot 1.

3. Design criteria

The design criteria adopted for this LWMS have been based on the design objectives outlined in *Better Urban Water Management* (WAPC, 2008) and key design criteria outlined in the *Byford Townsite DWMP* (GHD and DoW, 2008). This criteria is summarised in the sections below.

3.1 Water conservation

The overall intention of this LWMS is to achieve the sustainable management of all aspects of the water cycle within the development Specifically, the objectives for integrated urban water management for the development are:

- Substitute drinking quality water with fit-for-purpose water for non-drinking water uses. The *State Water Strategy* (Government of Western Australia, 2003) sets a target of 20% reuse by 2012. The development aims to reduce the use of scheme water by providing an alternative fit for purpose water supply for non-drinking use.

3.2 Water quantity management

The post development annual discharge volumes and peak flows are to be maintained relative to pre-development conditions, unless otherwise established through determination of ecological water requirements for sensitive environments. To achieve the above principle the following criteria will be applied:

- *Ecological protection* - For the critical one year average recurrence interval (ARI) event, the post development discharge volume and peak flow rates shall be maintained relative to pre - development conditions in all parts of the catchment. Where there are identified impacts on significant ecosystems, maintain or restore desirable environmental flows and/or hydrological cycles as specified by DoW.
- *Flood Management* - Manage the catchment runoff for up to the 1 in 100 year ARI event in the development area to pre - development peak flows, unless otherwise indicated in an approved strategy or as negotiated with the relevant drainage service provider.
- *Protect infrastructure and assets from inundation and flooding* - Urban development usually results in the removal of significant areas of vegetation and replacement of permeable areas with buildings, roads and paved areas. This results in increased volumes and flows of surface runoff, which has the potential to cause flooding and inundation.

3.3 Water quality management

Maintain surface and groundwater quality at pre-development levels (winter concentrations) and if possible, improve the quality of water leaving the development area to maintain and restore ecological systems in the sub catchment in which the

development is located. To achieve the above principle the following criteria will be applied:

- If the pollutant outputs of development (measured or modelled concentrations) exceed catchment ambient conditions, the proponent shall achieve water quality improvements in the development area or, alternatively, arrange equivalent water quality improvement offsets inside the catchment. If these conditions have not been determined, the development should meet relevant water quality guidelines stipulated in the *National water quality management strategy* (ANZECC and ARMCANZ, 2000).
- Ensure that all runoff contained in the drainage infrastructure network receives treatment prior to discharge to a receiving environment consistent with the *Stormwater management manual* (DoW, 2004-2007).
- All outflows from subsoils should receive treatment prior to discharge to the stormwater system.
- Protect groundwater as a resource.

3.4 Commitment to best management practice

In order to meet the design criteria of reductions in total phosphorus, total nitrogen, total suspended solids and gross pollutants as compared to developments in which water treatment is not undertaken, it is necessary to use a combination of best management practice strategies. In addition, best management practice strategies reduce risks of flooding on housing and infrastructure while maximising the potential for stormwater to be treated as a resource.

The hierarchy of best management practice principles is as follows:

- Implement controls at or near the source to prevent pollutants entering the system and/or treat stormwater.
- Install in-transit measures to treat stormwater and mitigate pollutants that have entered the conveyance system.
- Implement end-of-pipe controls to treat stormwater, addressing any remaining pollutants prior to discharging to receiving environments.

4. Pre-development environment

4.1 Climate, rainfall and evaporation

The nearest meteorological station which records rainfall, temperature and evaporation to the development is the Medina Research Centre weather station (station number 009194). This station is located approximately 20 km west of the development. The climate for the area is characterised by hot, dry summers, and cool wet winters (Figure 3). Evaporation is at its peak during the summer months and at its lowest during the winter months (Figure 4). Detailed climatic data is presented in Appendix A.

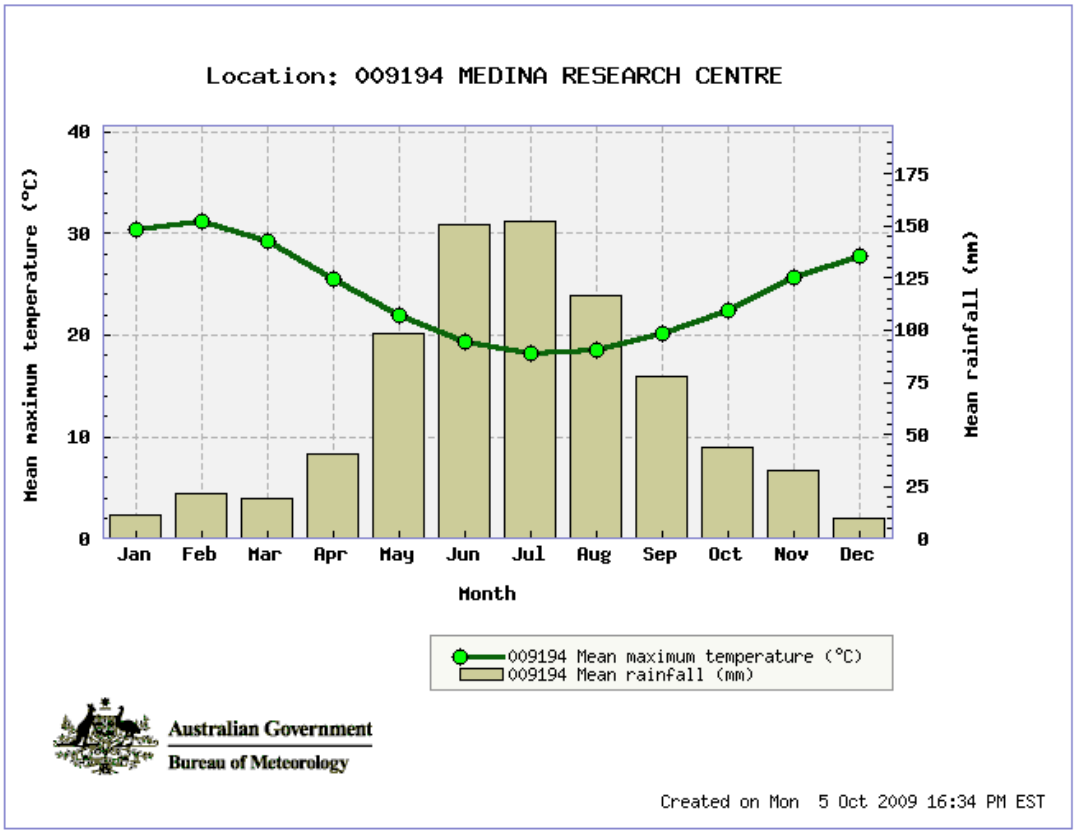

Figure 3 Mean maximum temperature and mean rainfall for the Medina Research Centre weather station (BOM, 2009)

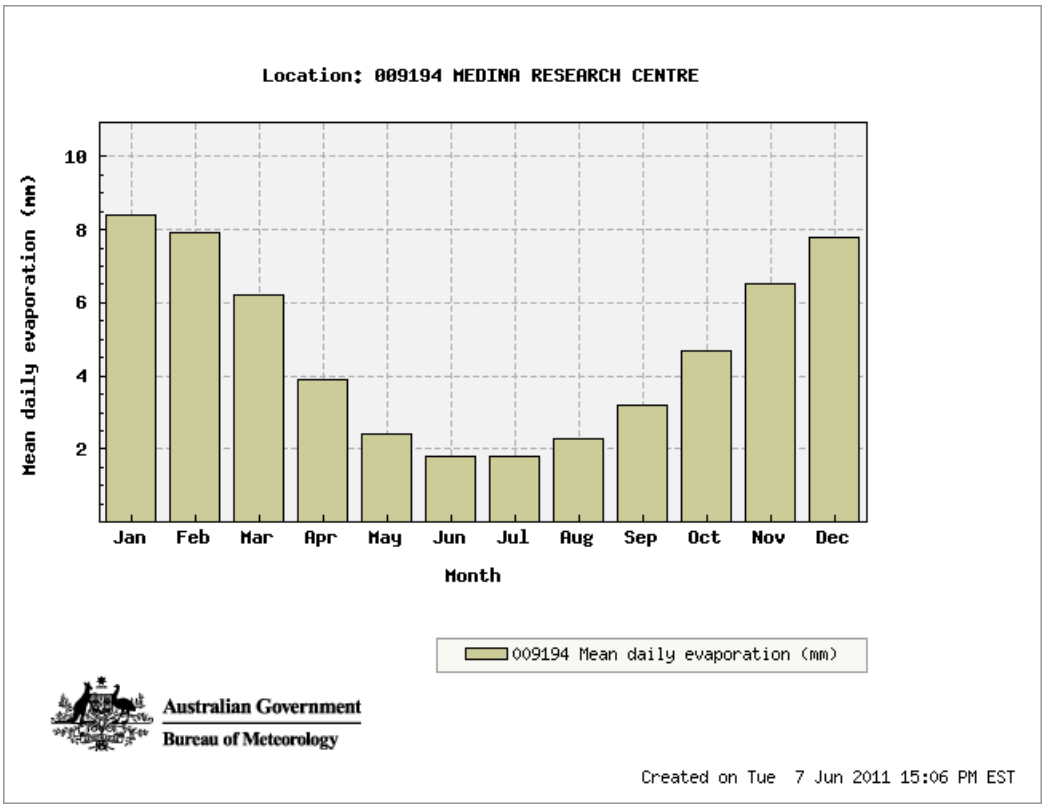

Figure 4 Mean daily evaporation for the Medina Research Centre (BOM, 2009)

4.2 Topography, Geology and Soils

The development area occurs along the foot of the Darling Scrap, where the Scarp begins to spread out through colluvial processes to form the Swan Coastal Plain.

The topography is characterised by a relatively flat palusplain (seasonally waterlogged land) varying between 60 m AHD along the eastern boundary to approximately 55m AHD along the western boundary.

The Douglas Partners Geotechnical Investigation (2007, Appendix E) found that Ground conditions encountered beneath the site generally comprised grey-brown slightly gravelly clayey sand overlying orange brown mottled grey brown clayey sandy material with a variable amount of gravel. The majority of the soils within the study are a composition of gravelly sandy clay, variable in nature with lenses of silt, gravel and quartz sand of colluvial origin. Along the northern boundary a pocket of white to pale grey fine to medium-grained sand occurs at the surface becoming yellow at depth. Along the southern boundary adjacent to Cardup Brook the soil is classified as clayey sandy silt pale brown in colour with low cohesion and of alluvial origin.

406,000 406,300 406,600

6,433,200 6,432,900 6,432,600 6,432,300

Lot 128

Lot 3

Lot 1

Drainage Easement

WALJA BEND
KARANGI CIR
BREN CL
HOWITZER TURN
DIAMANTINA BVD
LIMPET WAY
ENFIELD ELB
BENALLA CR
CLONDYKE DR
BURGESS DR
RATH CL
COULTERHAND CIR
SOLDIERS RD
ROBERTSON RD
SOUTH WESTERN HWY
CARDUP SIDING RD

LEGEND

- Overland Flowpath (GHD)
- Contour (0.5m) (GHD)
- Hydrography (DoW)
- Existing Culverts (GHD)
- Cadastre
- Study Area

Elevation (m)
High : 92
Low : 42

1:3,000 (at A3)
0 15 30 60 90 120 150
Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 50

N

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Urban Solutions
Byford Lots 1, 3 and 128 LWMS

Job Number 61-24146
Revision A
Date 11 OCT 2010

Topography and Drainage

Figure 5

G:\61\24146\GIS\mxds\6124146_G009_RevA.mxd

GHD House, 239 Adelaide Terrace Perth WA 6004 **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au

Data Source: Landgate: Hydrography, Contours - 20100204, Cadastre - 20090925; GHD: Study Area - 20090929, Elevation (m) - 20101012, Contour (0.5) - 20100201, Overland Flowpath - 20100309. Created by: sismail, RLow

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4.3 Acid Sulphate soils

Acid Sulphate Soils (ASS) are naturally occurring soils containing iron sulphides. These soils are typically benign within the anaerobic environment of their formation. However, when they become oxidised through various disturbances such as development, acidic soil, surface water and groundwater can result. Resultant sulphuric acid solubilises contaminants including heavy metals, potentially releasing lead, aluminium, iron, and arsenic into groundwater.

The main environmental indicator of ASS is shallow groundwater and/or waterlogging of laterites and sands, which may have generated sulphuric conditions, which lead to acid sulphate soils.

ASS risk mapping conducted by the Department of Environment and Conservation (DEC) indicates that the soils within the LWMS area to the west of the South Western Highway generally present no risk of actual acid sulfate soils (AASS) or potential acid sulfate soils (PASS) occurring generally at greater than 3 m depth. Along the southern boundary adjacent to Cardup Brook and also along the north western boundary at Solider's Road there is are regions of low to moderate risk of AASS or PASS occurring generally at greater than 3 m depth. These areas are associated with the natural waterways that pass through the study area Figure 6.

406,000 406,300 406,600

6,433,200 6,432,900 6,432,600 6,432,300

Lot 128 Lot 128
Lot 0 Lot 0
Lot 3 Lot 3
Lot 1 Lot 1

KARANGI CIR
WALJA BEND
BREN CL
QUIBERON LINK
SHELL VSTA
HOWITZER TURN
SOUTH WESTERN HWY
VICKERS PASS
DIAMANTINA BVD
LIMPET WAY
MORTAR PASS
BENALLA CR
BOFORS LANE
ENFIELD ELB
CLONDYKE DR
ROBERTSON RD
SOLDIERS RD
BURGESS DR
GADD AV
RATH CL
UREN WAY
COULTERHAND CIR
PINEBROOK RD
CARDUP SIDING RD

LEGEND

Study Area
Cadastre

Acid Sulfate Soils Risk Map

No Known ASS disturbance risk (<3m from surface)
High to moderate ASS disturbance risk (<3m from surface)
Moderate to low ASS disturbance risk (<3m from surface)

1:3,317 (at A3)
0 15 30 60 90 120 150
Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 50

N

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Urban Solutions
Byford Lots 1, 3 and 128 LWMS

Job Number	61-24146
Revision	0
Date	21 OCT 2010

Acid Sulfate Soils Risk Map

Figure 6

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Data Source: Landgate: Metro Central - 2009 Mosaic; GHD: Study Area - 20090925; DEC: Acid Sulfate Soils Risk Map (Swan Coastal Plain) - 20100125; Landgate: Cadastre - 20090929. Created by: sismail, RLow

4.4 Land use

4.4.1 Existing land use

The current land use within Lots 1, 3 and 128 is rural. The development is bordered by the South Western Hwy to the east, the proposed Robertson to the west and Cardup Siding road to the south. Cardup Creek runs from east to west through the centre of Lot 1.

Land use surrounding the development is a mix of developing residential and existing rural; with public open space as remanent bushland occurring along the northern boundary.

4.4.2 Proposed land use

The proposed land use for Lots 1, 3 and 128 is mixed business. Although actual businesses are yet to be finalised, investigations for the site are based on the site being a combination of light industrial and commercial lots.

A multiple use corridor will accommodate Cardup Brook which runs through the centre of Lot 1 between the proposed Pinebrook Road and the existing Cardup Siding Road.

4.5 Aboriginal heritage

A search of the Department of Indigenous Affairs Aboriginal Heritage Inquiry System indicates that there is one listed heritage site within the development. Cardup Brook which flows through the lower section of the development is listed as a mythological site (site ID 16108).

4.6 Reserves, conservation areas and environmentally sensitive areas

4.6.1 Bush forever

Along the western boundary of the development is Bush Forever site #350 which runs along the rail corridor.

4.6.2 Geomorphic wetlands

Lots 1, 3 and 128 are predominately designated as a Multiple Use Wetland (MUW). A small portion of the southern end of the site is designated as a Resource Enhancement Wetland (REW) which is expected to be associated with the Cardup Brook.

In general, MUW are totally or mostly cleared, and are used for agricultural purposes. These wetlands still serve hydrological functions, such as groundwater recharge and flood mitigation, but do not have any specific management objectives.

4.6.3 Threatened Ecological Communities

Seven buffer zones for threatened ecological communities exist within the development area (Figure 7). Four different communities are represented in those seven buffer zones (Table 1).

Table 1 Threatened Ecological Community names and category of threat

Site ID	Community ID	Community name	Category of threat
BRICK01	SCP3a	Eucalyptus calophylla - Kingia australis woodlands on heavy soils, Swan Coastal Plain	Critically Endangered
BRICK02	SCP20b	Banksia attenuata and/or Eucalyptus marginata woodlands of the eastern side of the Swan Coastal Plain	Endangered
BRICK03	SCP3a	Eucalyptus calophylla - Kingia australis woodlands on heavy soils, Swan Coastal Plain	Critically Endangered
BRICK04	SCP09	Dense shrublands on clay flats	Vulnerable
MYBYFORD03	SCP3c	Eucalyptus calophylla - Xanthorrhoea preissii woodlands and shrublands, Swan Coastal Plain	Critically Endangered
MYBYFORD04	SCP3a	Eucalyptus calophylla - Kingia australis woodlands on heavy soils, Swan Coastal Plain	Critically Endangered
MYBYFORD08	SCP02	Southern wet shrublands, Swan Coastal Plain	Endangered

4.6.4 Significant Flora

No Declared Rare Flora pursuant to the *Wildlife Conservation Act 1950* has been recorded within the proposed study area.

405,000 406,000 407,000

6,434,000 6,433,000 6,432,000

Nettleton Road Isolated Finds
Nettleton Road Isolated Finds
Nettleton Road 2-06
Nettleton Road 1-06
Nettleton Road 19-09-07/001
Nettleton Road Isolated Finds
Nettleton Road 19-09-07/003
Nettleton Road Isolated Finds
Beenyup Brook
Nettleton Road 19-09-07/002
NETTLETON RD
Byford Village Isolated Finds
TURNER RD
BYFORD 06
BYFORD 10
BYFORD 09
BYFORD 07
BYFORD 11
BYFORD 01
SOUTH WESTERN HWY
WARRINGTON RD
Lot 128
BYFORD 02
BYFORD 03
ORTON RD
BYFORD 05
BYFORD 08
BYFORD 04
Byford Archaeological Survey 001
Lot 0
Lot 3
BYFORD 18
BYFORD 17
BYFORD 15
BYFORD 19
Lot 1
CARDUP BROOK
BYFORD 12
BYFORD 16
BYFORD 14
BYFORD 13
BAS/ISO - 002
Cardup Nature Reserve
SOLDIERS RD

405,000 406,000 407,000

LEGEND

- Study Area
- DEC Estate
- Environmentally Sensitive Area
- Aboriginal Heritage Sites

Geomorphic Wetlands (DEC)

- Conservation
- Resource Enhancement
- Multiple Use
- Not Assessed

1:10,000 (at A3)

0 50 100 200 300 400 500

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 50

N

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Byford Lots 1, 3 and 128 LWMS

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Revision	0
Date	22 OCT 2010

Environmental Constraints

Figure 7

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Data Source: GHD: Study Area - 20090929; DIA: Aboriginal Sites - 20091125; DEC: DEC Estate - 200904, Geomorphic Wetland (Swan Coastal Plain) - 20090805, Environmetally Sensitive Area - 20090812; Landgate: Metro Central - 2009 Mosaic. Created by: sismail, RLow

4.7 Surface water

The Byford area is known to experience regular water logging in the low-lying areas to the west of the study area. This inundation is due to a combination of persistent winter rainfall elevating the shallow water table, which rises to the surface and inundates vast areas of the flat terrain, and poor drainage.

There are several local depressions east and west of the South Western Highway within and adjacent to lot 3 and 158, which result in local perching of surface water after a large rainfall event.

There is also a natural stream (Cardup Brook) which passes directly through the study area at the southern end in Lot 1.

There is potential for areas within the study area to receive additional flood water from outside their natural catchment by overtopping of drains and watercourses.

Table 2 outlines the 10 and 100 year peak flows at locations surrounding Lots 1, 3 and 128 as modelled in the DMWP.

Table 2 Pre Development Peak Flows and Levels from DWMP

Location	5 Year ARI Peak Flows (m^3/s)	5 Year ARI Peak Levels (m AHD)	100 Year ARI Peak Flows (m^3/s)	100 Year ARI Peak Levels (m AHD)
Drain between Lots 3 and 128, at South West Highway	2.75	60.12	7.02	60.18
Drain between Lots 3 and 128, at Railway	2.75	57.03	7.02	57.10
Cardup Brook at South West Hwy	6.66	55.12	24.95	57.15
Cardup Brook at Railway	6.66	54.10	12.21	57.15

4.7.1 Surface water quality

Limited surface water quality data is available within the Byford area. The S*napshot survey of the Serpentine, Murray and Harvey catchments of the Peel-Harvey Estuary* (Pedretti *et al*., 2002) included 10 sites within the Byford catchment. Samples were recorded for October 2001 and September 2002, but were only reported for 2002.

Four sites were located in Oaklands drain, one at Hopkinson Road and one on each of the three upstream branches. There were two sites on the Cardup Brook, one at Hopkinson Road and one close to the railway. Beenyup Brook was also served by two sites, again at Hopkinson Road, and close to the railway. The two remaining sites were at the Hopkinson Road end of two of the minor drains between Beenyup Brook and Cardup Brook.

Total phosphorous (TP) concentrations recorded at most of the sites in the Byford catchment were below 0.065 mg/L. Although the downstream end of Beenyup Brook recorded TP concentrations in the range 0.065 mg/L – 0.20 mg/L and the downstream ends of both of the minor drains recorded TP concentrations greater than 0.20 mg/L.

Total nitrogen (TN) concentrations recorded in two of the upstream branches of Oaklands drain were below 1.2 mg/L. TN concentrations in the third branch and the downstream end were in the range 1.2 mg/L – 3.0 mg/L. Beenyup Brook was also below 1.2 mg/L upstream, but was greater than 3.0 mg/L at its downstream location. In Cardup Brook, this trend was reversed with TN concentrations greater than 3.0 mg/L recorded upstream and less than 1.2 mg/L downstream. One of the minor drains was in the range 1.2 mg/L – 3.0 mg/L and the other was greater than 3.0 mg/L.

Pre- development monitoring conducted by GHD showed nutrient concentrations were indeed high for all quarterly monitoring events. TN concentrations were very high for within the centre of the site, comprised primarily of nitrate-N and total organic-N. TP was also high across the study area.

4.8 Groundwater

4.8.1 Groundwater Levels and Flows

Geotechnical and groundwater investigations have previously been undertaken by Parsons - Brinkerhoff (PB) (2003) as part of the *Byford urban stormwater management strategy* and separately by the Water Corporation. Results from field measurements indicate that groundwater levels are typically shallow across the study area, varying between 0 m – 6 m below natural surface level. For example 1km north of the study area near Beenyup Brook, DoW data indicate groundwater varies between 1 m – 5.4 m below natural surface level.

There are approximately 100 private groundwater bores in the greater Byford region, the majority of which target groundwater in sand lenses at the base of the Guildford clay at 17.5 m – 25 m below natural surface level. Due to the local geology, the groundwater in the study area is often perched during the winter months.

ARWC monitoring bore No. 61414007 located to the east of the study area recorded a groundwater level of between 0.7 m and 3.5 m below ground level over a period of 3 years from November 1996. Only one long term monitoring bore exists within the Byford region (T170, ARCW No. 61410153) located approximately 4km north west of the study area which shows a steady decrease in average groundwater levels since 1995.

Groundwater modelling has also been completed by CyMod Systems (2007) for DoW to assess any impacts from variations in climate or planned development in the Byford area. The groundwater model was run for three scenarios:

- No development under average rainfall conditions (current climate);
- Proposed development under average conditions; and

- Proposed development under wet rainfall conditions. Dry conditions were not selected as a post-development groundwater model.

Further information regarding the selection of pre- and post-development model scenarios and the construction and calibration of the groundwater model may be gained by requesting a copy of the *Groundwater modelling report* (CyMod Systems, 2007) from the DoW. The model is not at a scale appropriate for determining local groundwater levels and has been disregarded for the subject study.

The *Byford townsite drainage and water management strategy* (GHD and DoW, 2008) suggests that historical groundwater levels may be used as a basis for groundwater design objectives, given the overall downward trend in groundwater levels after 1995 due to the combination of abstraction of groundwater from bores and decreased rainfall.

GHD has undertaken groundwater level monitoring during between 2009, as detailed in the attached Monitoring Report (Appendix D). Results of this monitoring have been combined with local WIN bore data to estimate the Maximum Groundwater Level (MGL) at the site. A number of WIN bore data sites were used to calibrate the site monitoring data, and to fill spatial gaps in the data. Only data in the last 30-years was used in the analysis. As shown in Figure 8, MGL ranges from surface level to approximately 1.3m deep.

4.8.2 Groundwater quality

Groundwater quality data is available from a number of recent investigations. The *Byford urban stormwater management strategy* (PB, 2008) stated that shallow groundwater quality monitoring shows low levels of TP and very small concentrations of ortho-phosphorous in the groundwater. TN concentrations were moderate, with moderate concentrations of nitrate and nitrite. The report states that although these concentrations exceed relevant water quality guidelines, these concentrations are relatively low compared to other typical sites on the Swan Coastal Plain with historically pastoral or horticultural land uses.

Salinity of groundwater within the Byford region, CyMod Systems (2007) found that the surface superficial groundwater to be generally fresh or slightly brackish, whilst the groundwater of the Leederville aquifer is generally fresh (<1000 mg/L TDS).

GHD has undertaken pre-development groundwater quality modelling, the results of which are attached in Appendix D.

406,000 406,300 406,600

6,433,200 6,432,900 6,432,600

BH03 BH02 BH01

Lot 128 Lot 3 Lot 1

KARANGI CIR WALJA BEND BREN CL QUIBERON LINK SHELL VSTA VICKERS PASS HOWITZER TURN SOUTH WESTERN HWY DIAMANTINA BVD ENFIELD ELB LIMPET WAY BENALLA CR CLONDYKE DR BURGESS DR RATH CL COULTERHAND CIR

ROBERTSON RD SOLDIERS RD PINEBROOK RD CARDUP SIDING RD

17 SES21 CP 3 BORE LOT 16 SOLDIERS RD SERPENTINE RIVER SR18065 4

LEGEND

- Monitoring Bores
- WIN Bores
- Study Area
- Hydrography (DoW)
- Interpolated Maximum Groundwater Level (1m) (GHD)
- Contour (0.5m) (GHD)

Depth to MGL (m) (GHD)

- Surface Ponding
- 0 - 1.2m
- >1.2

1:3,000 (at A3)

0 15 30 60 90 120 150

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 50

N

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Byford Lots 1, 3 and 128 LWMS

Job Number 61-24146
Revision B
Date 12 OCT 2010

Groundwater and Monitoring Bores

Figure 8

G:\61\24146\GIS\mxds\6124146_G0013_Fig8_RevB.mxd

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Data Source: Landgate: Hydrography, Contours - 20100204; DoW: WIN Bores - 20080708; Landgate: Metro Central - 2009 Mosaic; GHD: Study Area - 20090925, Contour (0.5m) - 20100201, Interpolated Maximum Groundwater Level - 20100303, Groundwater Depth - 20100304, Monitoring Bore - 20100305. Created by: sismail, mbusbridge, RLow

SJS TRIM - IN14/10387

5. Water use sustainability initiative

To achieve the objectives of the Western Australian *State Water Strategy*, it will be necessary to be efficient in the use of water, and to use water that is fit-for-purpose.

5.1 Water conservation and efficiency

5.1.1 Buildings

The following water efficiency measures will apply to new buildings in this development:

- Conditions of Sale will include a clause requiring irrigation is installed according to Irrigation WA standards; and
- Conditions of Sale will include a clause mandating the use of rain sensors to irrigation systems.

The above water efficiency measures are expected to reduce water use.

5.1.2 Public Open Space and Gardens

There are no public open space (POS) areas within this development.

Irrigation requirements for gardens can be reduced by using subsurface irrigation, soil conditioners, wetting agents, mulches and adopting xeriscaping techniques.

5.2 Fit-For-Purpose

In conjunction with water efficiency measures supplying fit-for-purpose water can also reduce the demand for potable (drinking) water. That is substituting drinking water quality water where it is not required. Potential non-drinking water uses are:

- **Internal non drinking water**: non-drinking water uses inside buildings are toilet flushing, cold water inlet to washing machines, industrial processes; and
- **Irrigation**: private landscaping within the development and Public Open Space irrigation (including schools) outside the development.

Potential alternate sources of fit-for-purpose water include groundwater bores and rainwater tanks.

Ground water can be used for industrial irrigation, and abstraction licenses are available within the study area. Groundwater abstraction is considered to be the easiest and usually most cost effective method of providing an alternative to scheme water for irrigation.

Rainwater tanks can make reduction on scheme water demands and would also perform a role in stormwater detention. With proper maintenance and operation of roof catchment and rainwater tank systems, roof runoff is likely to meet Class A quality and can provide an alternative to internal non drinking water use such as toilet flushing and

industrial processes such as machine cooling. The use of roof runoff at the lot scale is not subject to regulation other than the requirement for an application to Local Government for a Building License. It is proposed to provide information packs to purchasers, outlining:

- Advantages of bore and/or rainwater tank installation;
- How to get a garden bore and/or rainwater tank installed; and
- A list of qualified installers.

With non potable water comprising a significant proportion of water use within an industrial setting the use of groundwater bores and/or rainwater tanks is expected to reduce the potable water demand to meet the State Water Strategy.

6. Strategy and Design

6.1 Floodplain management

Recommendations for floodplain management are presented in the *Floodplain management strategy* (SKM, 2007). This study developed two-dimensional modelling of the Byford catchment and resulted in the identification of floodway and flood fringe areas. The proposed *Floodplain management plan* (SKM, 2007) includes structural and non-structural measures for flood mitigation focused on managing potential flooding impacts on the site and to the immediate neighbouring land and drainage infrastructure.

6.1.1 Flood mitigation measures

Flood mitigation measures are focused on correct planning for appropriate land use in the structure plan areas and setting aside the land required for floodplain inundation depths. Existing and developed scenarios were presented within the *Floodplain management strategy* (SKM, 2007). The 'developed' case includes raised ground levels within subdivisions but no other modifications, such as waterway realignments or new or modified road crossings.

Relevant planning measures recommended by the *Flood plain management strategy* (SKM, 2007) are:

- New industrial or commercial premises will have lot levels elevated 500 mm above the 100 year annual recurrence interval flood level.
- Major arterial roads with immunity to the 100-year annual recurrence interval flood level that access new residential areas and can provide egress to emergency services must be identified. Other residential streets will be designed to be serviceable up to the five-year annual recurrence interval flood event.

Referring to Table 2, flooding at Cardup Brook requires lot levels to be a minimum of 57.65m AHD, whilst the drain between existing lots 3 and 128 will requires a finished lot level of 57.60m AHD.

6.2 Stormwater quantity

6.2.1 Proposed stormwater management strategy

Surface water quantity management is not only restricted to preventing runoff from increasing due to development, but must also manage the maintenance or even restoration of desirable environmental flows and/or hydrological cycles where potential impacts on significant ecosystems such as wetlands are identified.

The proposed stormwater management strategy employs the following measures for the following events:

1 year ARI event

- Roofs will be connected to soakwells sized for the 1-year ARI 1-hour event, and where adopted, rainwater tanks
- The remainder of lots will drain to soakwells or on-site detention structures.
- Road runoff will be infiltrated as close to source as practicable with all pit and pipe networks ending at the bioretention swale running parallel to Robertson Road.

10 year ARI event

- Surface flows generated in excess of the 1 year ARI event will be infiltrated as close to source as practicable using water sensitive urban design measures such as bioretention swales and soakwells.
- Roof runoff exceeding the soakwell capacity and bioretention swale infiltration zones will be conveyed overland to the roadside pit and pipe network and then to the bioretention swale Running parallel to Robertson Road.

100 year ARI event

- Surface flows generated in the 100 year ARI event will follow overland flow paths to the pit and pipe network and the Robertson Road swale. Storage provided in the bioretention swales will detain flows to pre-development discharge rates.

6.2.2 Stormwater rates and volumes

Flows generated within Lots 1, 3 and 128 were assessed in the 1, 10 and 100 year ARI event. Required storages to detain flows generated within these events were also assessed. In undertaking this task, the study area was divided into five predevelopment sub catchments and eleven post development subcatchments and the hydrology was assessed on a sub catchment basis. The pre and post development hydrology was calculated in DRAINS v2011.09 using an ILSAX hydrologic model. Results are presented in Table 3 and Table 4.

Table 3 Pre development flows for Lots 1, 3 and 128 Byford

Catchment Name	Area (ha)	Flows (m^3/s)		
		1 Year	10 Year	100 year
Lot 1 South	4.23	0.00	0.10	0.41
Lot 1 North	4.23	0.02	0.14	0.47
Lot 3 South	3.30	0.00	0.10	0.40
Lot 3 North	2.81	0.00	0.12	0.49
Lot 128	3.85	0.00	0.09	0.38

Table 4 Required storages to maintain pre development flows for Lots 1, 3 and 128 Byford

Catchment	Area (ha)	Required Storage (m^3)		
		1 Year ARI	10 Year ARI	100 Year ARI
Lot 1	4.23	89	209	336
Lot 3 South	3.30	23	118	345
Lot 3 North	2.81	103	307	564
Lot 128	3.85	105	336	700

Table 5 Pre and mitigated post development flows for Lots 1, 3 and 128 Byford

Catchment Name	Area (ha)	Scenario	Flows (m^3/s)		
			1 Year	10 Year	100 year
Full site	14.1	Pre Dev.	0.02	0.55	2.15
		Post Dev.	0.00	0.36	1.65

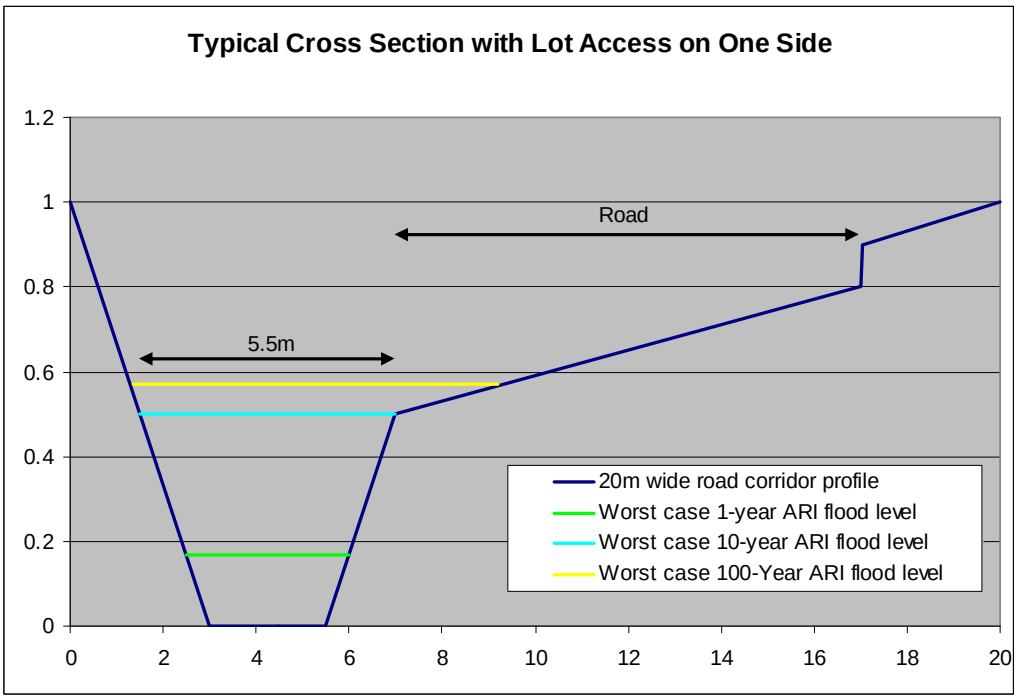
The discharge from Lot 1 south is not detained, however the total site discharge is maintained to pre-development rates by Detention provided in swales, particularly the swale along Robertson Road.

Referring to the Byford Townsite DWMP (GHD and DoW, 2008), the recommended detention storage for the catchments covering the subject site in a 100-year ARI event is approximately 250 m^3/Ha. For the subject site, this equates to approximately 3500 m^3 of storage. However, in comparison to Table 4, 1945 m^3 has been estimated. The difference is attributed to higher pre-development flow rate estimates in this investigation.

6.2.3 Road Runoff and Bioretention Swales

The lots within Lots 1, 3 and 128 Byford are serviced by a network of roads within 20-m wide road corridors. Runoff will be directed to both a pit and pipe network and a proposed Bioretention swale located parallel to Robertson Road. Bioretention swales along the South Western Highway are also planned with the typical cross section shown in Figure 9.

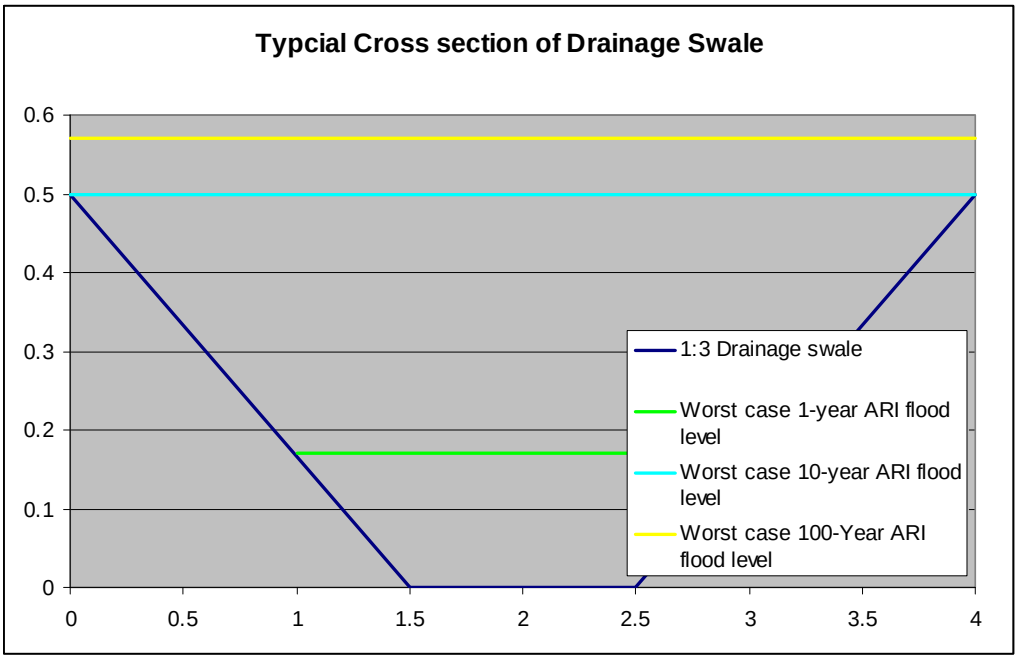
Figure 9 Typical Cross Section with Lot Access on One Side



Due to the low relief over the study area, flush kerbing or broken is recommended.

The proposed bioretention swales along both Robertson Road and South Western Highway will provide sufficient retention to avoid the necessity of constructing detention/ infiltration basins within the development. This swale will be designed with minimum 1:3 sides and a minimum depth of 0.5 m with a minimum base width of 1 m will retain sufficient stormwater volumes to retain the 100 year ARI event, as demonstrated in Table 3 and Figure 9.

Figure 10 Swale cross section



Drainage swales will be vegetated to enhance contaminant removal. Stormwater flows not retained within the 100 year ARI event will discharge to the swale along Robertson Road. Stone pitching will be used at the outlet of each pipe draining to the swale to minimize erosion at drainage entry points.

406,000 406,250 406,500

6,433,000 6,432,750 6,432,500

57.05m AHD 58.51m AHD
128N
56.65m AHD 58.04m AHD
128A
128B
128SB
128SA
56.5m AHD 57.97m AHD
56.5m AHD 57.76m AHD
56.5m AHD 58.19m AHD
3NA
3NB
56.94m AHD 59.06m AHD
3SB
3SA
1N
57.11m AHD 59.73m AHD
1S

SOLDIERS RD
ROBERTSON RD
HOWITZER TURN
SOUTH WESTERN HWY
BREN CL
SHELL VSTA
VICKERS PASS
LIMPET WAY
DIAMANTINA BVD
ENFIELD ELB
CLONDYKE DR
RATH CL
COULTERHAND CIR
PINEBROOK RD
CARDUP SIDING RD

Hydraulics of Robertson Road Crossing to be designed at a later date

LEGEND

- Minimum Invert Levels
- Hydrography
- Existing Culverts
- Proposed Culverts
- Proposed Swales
- Subsoil Pipe
- Pipe and Pit
- 100y ARI Flow Path
- Study Area
- Catchments
- 100y ARI Flood Extents (GHD)
- Lots 1, 3 and 128
- Cadastre

Notes:
Drainage invert levels and top water levels subject to civil design at UWMP stage

1:2,500 (at A3)
0 12.5 25 50 75 100 125
Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 50

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Byford Lots 1, 3 and 128 LWMS

Job Number	61-24146
Revision	4
Date	19 May 2011

Stormwater Management Strategy

Figure 11

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Data Source: DoW : Hydrography - 04/02/2010; GHD: Study Area - 25/09/2009, Catchment - 02/02/2010, 100 yr ARI Flow path - 09/03/2010, Existing Culverts - 08/10/2010, Proposed Culverts - 08/10/2010, Proposed Swales - 08/10/2010, Minimum Invert Levels - 08/10/2010, Subsoil Pipe - 12/05/2010, Pipe and Pit - 12/05/2010; Landgate: Cadastre (LGATE-068) - 25/09/2009, Jarrahdale 2010 - 12/05/2011. Created by: sismail, RLow, MG

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6.3 Surface Water Quality Management and Best Management Practices

It is proposed to adopt Water Sensitive Urban Design (WSUD) and Best Management Practices (BMPs) promoting retention, infiltration and treatment of events up to the 1-year ARI events, in accordance with the *Stormwater Management Manual for Western Australia* (DoW, 2004- 2007).

6.3.1 Structural measures

The key structural elements to be incorporated into the design of subdivisions within the study area are:

- Soakwells: Soakwells, enhanced with amended soils, will detain, infiltrate, and treat stormwater on-site;
- Bioretention swales: Where shown on the engineers drawings, biofiltration systems in the form of vegetated swales will be incorporated along Robertson Road and South West Highway.

Soakwells will be sized as a volume based on appropriate ARI calculations. An appropriate guide for the sizing of soakwells can be found in Chapter 9 of Department of Water's Stormwater Management Manual for Western Australia (2007) under the heading 'Infiltration Systems', which describes in detail how to size soakwells. To increase the treatment effectiveness and infiltration capacity of the soakwells, it is proposed to over excavate soakwell pits, and line them with an amended treatment media, such as loamy sand.

According to the *WSUD Engineering Procedures: Stormwater* design process, a bioretention system, which represents 2% of the total impervious area, provides optimal treatment and land use efficiencies. Referring to the engineering drawings, the proposed bioretention system exceeds this minimum requirement.

6.3.2 Non Structural Measures

The following non-structural measure is proposed:

- Sediment and erosion control measures during construction;

To ensure that the bioretention swales perform well, look attractive, require low maintenance, and to extend their design life, it is important to choose appropriate plant species for the construction of the swale. Table 6 lists the recommended species for use in the proposed bioretention swales, so that the vegetation

- Is suitable next to roads;
- Is suitable for prevailing soils and climate;
- Is able to absorb nutrients;
- Is able to meet hydraulic requirements;
- Is able to undergo periodic inundation, if required;

- Is able to withstand drought;
- Is a local representation of plant species;
- Has a suitable root structure and behaviour;
- Is a suitable size; and
- Has a visual appeal.

Additional information about the species and their suitability for use is provided in Appendix B.

Table 6 Recommended plant species for bioretention swales

Botanical Name		Common Name
Baumea	juncea	
Dianela	revoluta	Little Rev
Ficinia	nodosa	Knotted club rush
Juncus	holoschoenus	Jointleaf rush
Juncus	pallidus	Pale rush
Juncus	subsecundus	Finger rush
Lepidosperma	longitudinale	
Lepidosperma	tetraquetrum	
Lomandra	brittanii	
Lomandra	caespitosa	
Lomandra	hermaphrodita	
Lomandra	integra	
Lomandra	micrantha	
Lomandra	nigricans	
Lomandra	odora	
Lomandra	preissii	
Lomandra	purpurea	
Lomandra	sericea	
Lomandra	sonderi	
Lomandra	suaveolens	

7. Groundwater management strategy

7.1 Design Criteria

The following key groundwater design criteria were set in the DWMP:

- Where a perched water table exists or the predicted maximum groundwater level is at or within 1.2 m of the natural ground level, the importation of clean fill and/or the provision of sub-surface drainage will be required to ensure that adequate separation of building floor slabs from groundwater is achieved. In such instances, the sub-surface drainage will need to be placed at or above the approved controlled groundwater level.
- The bio-retention system and drainage inverts are set at or above controlled groundwater level although existing inverts below the level may remain.
- Subsurface drainage is to be installed at or above controlled groundwater level.
- Subsurface drainage must be designed with free-draining outlets.
- Development will ensure finished lot levels at a minimum of 0.8 m above the phreatic line.
- The clean fill imported onto the site is to incorporate a band of material that will reduce phosphorus export via soil leaching, whilst also meeting soil permeability and soil compaction criteria specified by the local government authority.

7.2 Glossary of Groundwater Terms

In relation to the key design criteria, the following definitions apply.

Controlled groundwater level

Controlled groundwater level is a groundwater level endorsed by DoW. Sub-surface drainage may not be installed below the controlled groundwater level.

The actual level selected will vary according to availability of data and/or modelling results. Commonly, when a modelling approach is used, the rainfall record for a year with close to average rainfall for the current climate is run and the winter maximum groundwater level for this scenario becomes the controlled groundwater level.

Alternatively, where a historical groundwater record is available, the average of recorded maxima for a selected period of records that is representative of the current climate may be chosen.

Maximum Groundwater Level

Maximum groundwater level is a groundwater level endorsed by the DoW. The actual level selected will vary according to availability of data and/or modelling results, but is commonly the maximum recorded groundwater level for a high rainfall condition.

Developments will be required to make the development surface level 1.2 m above the maximum groundwater level, if subsurface drainage is not installed, in accordance with the DWMP.

Phreatic Line

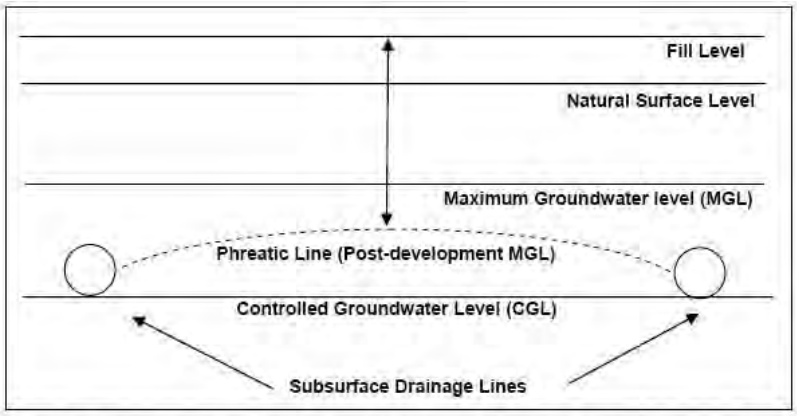
The phreatic line is the modified (post development) maximum groundwater level following the installation of subsurface drainage and is in fact an arc in between subsurface drainage lines, as indicated in Figure .

When subsurface drainage is installed the phreatic line becomes the level from which building floor level clearance to groundwater is measured.

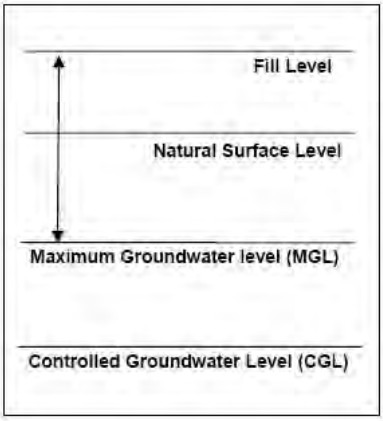
7.3 Design Solutions

Examples of different ways in which the groundwater clearance and subsurface drainage criteria may be met under different conditions are presented below in Figure . Case 1: The natural surface is less than 1.2 m above maximum groundwater level. Subsurface drainage is installed at controlled groundwater level to control the maximum groundwater level. However, because the natural surface is less than 1.2 m above the resultant phreatic line, some additional fill has also been provided to meet the minimum clearance requirement.

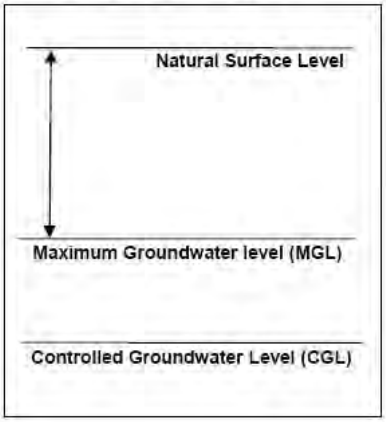
Figure 11B Meeting the groundwater clearance and subsurface drainage criteria



Case 2: The natural surface is less than 1.2 m above maximum groundwater level. Fill is provided to meet the minimum clearance requirement.



Case 3: The natural surface is greater than 1.2 m above maximum groundwater level. No fill or subsurface drainage is required to meet the minimum clearance requirement.



7.4 Groundwater Quantity Management

Manage groundwater levels to protect infrastructure and assets

Where a perched water table exists or the predicted maximum groundwater level is at or within 1.2 m of the natural ground level, the importation of clean fill and/or the provision of sub-surface drainage will be required to ensure that adequate separation of building floor slabs from groundwater is achieved. In such instances, the sub-surface drainage will need to be placed at or above the approved controlled groundwater level, as indicated in Figure 8. Development will ensure finished lot levels at a minimum of 0.8 m above the phreatic line.

The controlled groundwater level will be set through the use of swales and subsoil drains as described in section 6.2.3. The swale and subsoil drain inverts are set at or above controlled groundwater level, which in this case is either the MGL or surface level (if groundwater is at surface).. Fill will be used to meet the required level of separation and ensure a finished floor level 0.8 m above the phreatic line.

The drainage inverts are set at or above controlled groundwater level although existing inverts below the level may remain.

Clean fill imported onto the site must meet soil permeability and soil compaction criteria specified in the geotechnical investigation, or by the Shire.

Maintain groundwater regimes for the protection of groundwater-dependent ecosystems

It has been identified that localised perching of groundwater is quite extensive within the LWMS study area. Nearby groundwater-dependent ecosystems that are reliant on this seasonal perched groundwater. The subsoil drainage and fill requirements listed above will help protect these systems from changes to the natural groundwater hydrologic cycle.

7.5 Groundwater Quality

The environmental values of groundwater within, and surrounding, the study area must be upheld.

To ensure that the existing groundwater quality is maintained, the quality of the stormwater infiltration to groundwater will be maximised through the adoption of the WSUD and BMPs discussed in section 6.3. Furthermore, groundwater monitoring, as discussed in the next chapter, will ensure the protection of groundwater quality post-development.

406,000 406,300 406,600

6,433,200 6,432,900 6,432,600

JANDU ST
WALJA BEND
BREN CL
SHELL VSTA
VICKERS PASS
LIMPET WAY
CLONDYKE DR
PINEBROOK RD
CARDUP SIDING RD
ROBERTSON RD
SOLDIERS RD
KARANGI CIR
HOWITZER TURN
SOUTH WESTERN HWY
DIAMANTINA BVD
ENFIELD ELB
BENALLA CR
QUIBERON LINK
BURGESS DR
RATH CL
COULTERHAND CIR

BH03
BH02
BH01
BORE
LOT 16 SOLDIERS RD
SERPENTINE RIVER
SES21
SR18065
CP 3

Lot 128
Lot 3
Lot 1

55 56 57 58 59 60 61 62 63 17

LEGEND

- Monitoring Bores
- WIN Bores
- Hydrography
- Interpolated Maximum Groundwater Level (1m)
- GHD Proposed Subsoils
- Proposed Swales (GHD)
- Proposed Lot Layout
- Study Area

1:3,000 (at A3)
0 15 30 60 90 120 150
Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 50

N

GHD
CLIENTS | PEOPLE | PERFORMANCE

Urban Solutions

Urban Solutions
Byford Lots 1, 3 and 128 LWMS

Job Number	61-24146
Revision	2
Date	11 MAY 2011

Groundwater Management Strategy

Figure 12

G:\61\24146\GIS\mxds\6124146_G0016_Fig12_Rev2.mxd

GHD House, 239 Adelaide Terrace Perth WA 6004 **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au

Data Source: Landgate: Hydrography- 20100204, Metro Central - 2009 Mosaic; DoW: WIN Bores - 20080708; GHD: Study Area - 20090925, Interpolated Maximum Groundwater Level - 20100303, Monitoring Bore - 20100305, Proposed Swales- 2010, Proposed subsoils- 2010; Porter: Proposed lot layout- Jan 2010. Created by: cwilson, mdalton2

8. Monitoring

The Shire of Serpentine Jarrahdale are preparing proposals for a regional surface water quality and sediment monitoring program to be undertaken within the Byford Structure Plan locality. To ensure consistency throughout the Byford Structure Plan area, in which this development is located, it is proposed that a post development monitoring program be adopted.

8.1 Pre-development monitoring program

Refer to Appendix D.

8.2 Recommended post-development monitoring program

In addition to pre-development monitoring, post development monitoring is also required. Ideally, the post-development monitoring program will be a continuation of the pre-development program. The following is the recommended post-development monitoring program.

To assess the impacts of the development on water quality within the development area, surface water samples will be collected monthly during the winter (June, July and August if the drain is flowing) at locations to be specified in the Urban Water Management Plans. Groundwater samples will be collected quarterly in the months of January, April, July and October from a network of monitoring bores providing a suitable spatial representation of the study area. Samples will be analysed for the following in situ water quality parameters:

- Temperature
- Electric Conductivity (E Cond)
- pH
- Salinity
- Dissolved Oxygen (DO)
- Oxidation Reduction Potential (Eh)
- Total Dissolved Solids (TDS)

In addition samples will be laboratory analysed for the following parameters:

- pH, Electrical Conductivity, Total Dissolved Solids;
- Nutrients (Total Nitrogen, Nitrate-N, Nitrite-N, Ammonia-N, Total Phosphorus, Filterable Reactive Phosphorus); and
- Total heavy metals (Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb), Nickel (Ni), Zinc (Zn) and Mercury (Hg)).

A summary of an example of a surface water and groundwater monitoring program is presented in Table 7 below.

Table 7 Monitoring programme summary

	Sites	Frequency	Parameters
Surface water	Developments inflow and outflow locations Detention storages inflow and outflow	Site specific	◗ Flows ◗ Water levels
		Monthly during the winter (June, July and August if the drain is flowing)	◗ **In-situ** pH, EC. DO, Eh, TDS and temperature. ◗ **Unfiltered sample**: pH, EC, TN, FRP, TKN, ammonia, TP, heavy metals (As, Cd, Cr, Cu, Pb, Ni, Zn, Hg) ◗ **Filtered sample**: nitrate/nitrite and PO_4,
Groundwater	Existing network of monitoring bores	Monthly	◗ Water level
		Quarterly (typically Jan, Apr, July, Oct)	◗ **In-situ** pH, EC, DO, Eh, TDS and temperature. ◗ **Unfiltered sample**: pH, EC, TN, FRP, TKN, ammonia, TP, heavy metals (As, Cd, Cr, Cu, Pb, Ni, Zn, Hg). ◗ **Filtered sample**: nitrate/nitrite and PO_4

8.3 Reporting

The Developer will prepare an annual water quality report for each year of monitoring, which will be presented to the Shire and DoW. This report will summarise the results from the years sampling and include a qualitative review of the performance of the drainage and water management system.

Reporting and Monitoring shall be in accordance with ANZECC and the DoW QA/QC systems to allow inclusion into DoW's WIN database.

8.4 Contingency Action Plan

A contingency action plan is a plan that sets out what is to be done when the monitoring results reach a certain trigger value. The plan identifies what the trigger values are, what is to be done, and by whom. Stakeholders include the developers, land owners, DoW, and the Shire of Serpentine-Jarrahdale.

ANZECC guidelines recommend that trigger values be calculated on either the 80th percentile of monitored results for a moderate level of protection, however considering the limited availability of water quality data it is not possible to determine a trigger value based on this percentile. It is therefore proposed to adopt the monitored worst case value as the trigger to limit any further water quality degradation from its current state. As such, trigger values have been developed as presented in Table 8. Heavy metal

concentrations measured for this pre-development groundwater study were from unfiltered samples as described in the *Byford District Water Management Plan* (DoW 2008).

Should the trigger levels be exceeded in two consecutive monitoring events a meeting is to be held between the developers, DoW, and the Shire to discuss likely causes (based on the constituent profile) and appropriate ways forward, as presented in Table 9..

Table 8 Trigger Values for Water Quality

	Units	Trigger Value
Nutrients		
Filterable reactive phosphate	mg/L	2.52
Total Nitrogen*	mg/L	23.6
Total Phosphorus	mg/L	2.52
Oxides of nitrogen	mg/L	13.2
Ammonia	mg/L	0.36
Total Kjeldahl nitrogen	mg/L	12.4
Metals (Total Heavy Metal Concentrations)		
Arsenic	mg/L	0.002
Cadmium	mg/L	0.004
Chromium	mg/L	0.227
Copper	mg/L	0.326
Lead	mg/L	0.249
Mercury	mg/L	0.0002
Nickel	mg/L	0.099
Zinc	mg/L	0.175
Other		
Electrical conductivity (EC) [a]	uS/cm	2400
Dissolved oxygen	ppm	1.31
pH	-	5.0-8.0

	Units	Trigger Value
Total suspended solids	ppm	5000

Notes:

a: Lower EC values are typically associated with rainfall events. During summer, higher values are common due to water being lost to evaporation.

Table 9 Contingency Action Matrix

Suspected Cause	Possible Solutions
Over use of fertiliser	Community engagement on appropriate use of fertiliser
Sedimentation from construction erosion	Control of erosion by contractors
Green waste	Community engagement on the appropriate collection and disposal of green waste; Implement street sweeping
Spills	Referral to EPA
Failure of WSUD devices	Repair and/or maintenance of WSUD devices
Other	As appropriate

9. Implementation

9.1 Developer commitments

The developer is committed to the roles detailed ion the report and outlined in Table 10.

9.2 Roles and responsibilities

Table 10 outlines the roles and responsibilities for the actions recommended in this LWMS.

Table 10 Roles and responsibilities

Role	Responsibility	Requirement and Period
Urban Water Management Plan	Developer	Developer to prepare and implement an approved UWMP prior to ground disturbing works. UWMP to address requirements of Better Urban Water Management (2008) and detail proposed civil and drainage design works.
Design and Construction of Drainage System	Developer	Hand over to Shire of Serpentine – Jarrahdale: Handover for landscape works is 2 years after successful practical completion. Civil infrastructure to have a 12-month maintenance period (period between a successful practical completion inspection and a defects inspection with written confirmation of Shire acceptance)
Non-Structural Controls: *Land use and Management*	Developer to install, inspect and maintain	Sediment and erosion control during construction in accordance with International Erosion Control Association Australasia Best Practice Guidelines[1]
Water Quality Monitoring and Reporting	Developer	Monitoring Program (Section 8). Annual reports will prepared by the Landowner to be submitted to the Shire of Serpentine – Jarrahdale and DoW for review for a period up to 3 years from practical completion.
Water Use Efficiency	Developer	Developer to provide landowners with rainwater tank and garden bore information packs

[1] http://www.austieca.com.au/

Role	Responsibility	Requirement and Period
Water Use Efficiency	Landowner	Landowner to comply with BCA requirements

10. References

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Appendix A

Detailed climatic data

Table A.11 Detailed climate data (BOM, 2009)

Statistic Element	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean maximum temperature (Degrees C)	30.3	31.2	29.2	25.5	22	19.3	18.2	18.6	20.2	22.4	25.7	27.8	24.2
Highest temperature (Degrees C)	44.9	45.8	43.3	36.5	32.9	26.2	25.8	26	30.9	35.8	40.6	45	45.8
Lowest maximum temperature (Degrees C)	20.2	19.2	18	16	12.4	11.4	12.6	12.8	14.6	14.8	13.9	19.7	11.4
Mean minimum temperature (Degrees C)	16.7	17.4	15.7	13.2	10.5	9	8.4	8	9.1	10.1	13.2	14.8	12.2
Lowest temperature (Degrees C)	4.8	6.4	4.5	2.4	2	-2	-1	-0.8	0.4	0.7	3.1	4.4	-2
Highest minimum temperature (Degrees C)	27.4	29.5	25.5	23.1	20	18.5	16.2	16.3	17	22.4	25.2	27.7	29.5
Mean daily ground minimum temperature (Degrees C)	14.2	14.9	13.3	10.3	7.8	6.4	6.3	5.9	7.2	8.3	11.4	12.5	9.9
Lowest ground temperature (Degrees C)	3.5	5.2	0.5	1	-1.2	-1.5	-2	-1.5	-0.8	-0.8	2.6	2.2	-2
Mean rainfall (mm)	11.4	21.7	19.4	40.7	98.4	150.9	152.3	117	77.1	43.4	32.7	9.4	783.5
Highest rainfall (mm)	86.2	246.5	67.4	114	226.9	250.8	248.9	170.7	130.2	108	93.2	29.4	1022.2
Lowest rainfall (mm)	0	0	1.3	2.7	34.7	28.4	76.1	42.8	33.8	7.9	5	0	513.8
Highest daily rainfall (mm)	40	230	45.8	57.8	72.8	64.4	99.4	64.6	58	57.4	39	25.2	230
Mean number of days of rain	2.5	2.3	4.8	7.8	12.5	17	18.6	16.8	14.5	9.1	6.2	3.6	115.7
Mean daily solar exposure (MJ/(m*m))	29.6	26.4	21.3	15.4	11.3	9.2	9.9	13.1	17.2	22.9	27	30.4	19.5
Mean number of clear days	18.7	17.4	15.3	12.1	8.3	7.7	7.6	8	9.2	11.5	13.8	16.6	146.2
Mean number of cloudy days	1.9	3.2	4.6	6.4	9.6	10.3	10.7	9.1	8.9	6.5	5.2	2.8	79.2
Mean daily evaporation (mm)	8.4	7.9	6.2	3.9	2.4	1.8	1.8	2.3	3.2	4.7	6.5	7.8	4.7

Appendix B

Hydrologic and Hydraulic Modelling

Methodology and Results

DRAINS results prepared 09 May, 2011 from Version 2010.08

PIT / NODE DETAILS Version 8

Name	Max HGL	Max Pond HGL	Max Surfa Flow Arrivi (cu.m/s)	Max Pond Volume (cu.m)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
HW1	59.07	1.287			-0.07	0.396	Headwall height/system capacity
N156	58.45		0				
N147	56.45		0.396				
Pit L3-Sb	0.74	2.1	0.08	3.7	1.26		None
Pit L3-Nb	0.73	2.09	0.073	3.5	1.27		None
Pit L128-B	0.68	2.07	0.048	2.5	1.32		None
Pit L128-Sl	0.7	2.08	0.06	2.9	1.3		None

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
Lot1n pre	0.017	0.017	0	11.32	43.34	12.94	AR&R 1 year, 20 minutes storm, average 31.7 mm/h, Zone 8
Lot3S pre	0	0	0	13.95	39.09	0	AR&R 1 year, 5 minutes storm, average 61 mm/h, Zone 8
Lot3N pre	0	0	0	13.34	37.77	0	AR&R 1 year, 5 minutes storm, average 61 mm/h, Zone 8
Lot128 pre	0	0	0	15.11	57.43	0	AR&R 1 year, 5 minutes storm, average 61 mm/h, Zone 8
Cat8e	1.287	1.287	0	15	30	0	AR&R 1 year, 25 minutes storm, average 27.9 mm/h, Zone 8
Cat Lot1s p	0	0	0	8.71	33.36	9.96	AR&R 1 year, 5 minutes storm, average 61 mm/h, Zone 8
Cat L3-Sb	0.08	0.042	0.061	20.88	19.14	18.18	AR&R 1 year, 1 hour storm, average 16.3 mm/h, Zone 8
Cat L3-Nb	0.073	0.041	0.056	19.34	17.96	18.18	AR&R 1 year, 1 hour storm, average 16.3 mm/h, Zone 8
Cat L128-E	0.048	0.048	0.006	7.63	8.64	8.64	AR&R 1 year, 15 minutes storm, average 37 mm/h, Zone 8
Cat L128-N	0.024	0.024	0.003	6.42	7.27	7.27	AR&R 1 year, 15 minutes storm, average 37 mm/h, Zone 8
Cat L128-S	0.022	0.022	0.009	8.79	9.96	9.96	AR&R 1 year, 25 minutes storm, average 27.9 mm/h, Zone 8
Cat L128-A	0.012	0.012	0.005	8.79	9.96	9.96	AR&R 1 year, 25 minutes storm, average 27.9 mm/h, Zone 8
Cat L3-Na	0.019	0.013	0.015	20.18	22.86	22.86	AR&R 1 year, 1 hour storm, average 16.3 mm/h, Zone 8
Cat L3-Sa	0.022	0.012	0.018	11.93	13.51	13.51	AR&R 1 year, 1 hour storm, average 16.3 mm/h, Zone 8
Cat L1-S	0	0	0	9.47	10.72	10.72	AR&R 1 year, 5 minutes storm, average 61 mm/h, Zone 8
Cat L1-N	0.132	0.046	0.112	8.91	10.09	10.09	AR&R 1 year, 1 hour storm, average 16.3 mm/h, Zone 8
Cat L128-S	0.06	0.06	0.007	7.63	8.64	8.64	AR&R 1 year, 15 minutes storm, average 37 mm/h, Zone 8

Outflow Volumes for Total Catchment (23.7 impervious + 25.3 pervious = 49.0 total ha)

Storm	Total Rainf	Total Runo	Impervious	Pervious Runoff
	cu.m	cu.m (Run	cu.m (Run	cu.m (Runoff %)
AR&R 1 ye	2488.52	635.28 (25	635.28 (52	0.00 (0.0%)
AR&R 1 ye	3696.06	1019.03 (2	1019.03 (5	0.00 (0.0%)
AR&R 1 ye	4528.29	1319.27 (2	1283.52 (5	35.75 (1.5%)
AR&R 1 ye	5172.86	1625.44 (3	1488.36 (5	137.08 (5.1%)
AR&R 1 ye	5690.96	1871.12 (3	1653.01 (6	218.10 (7.4%)
AR&R 1 ye	6143.79	2085.80 (3	1796.92 (6	288.88 (9.1%)
AR&R 1 ye	7159.6	2567.88 (3	2119.74 (6	448.13 (12.1%)
AR&R 1 ye	7979.58	2956.84 (3	2380.33 (6	576.50 (14.0%)
AR&R 1 ye	8885.24	3384.04 (3	2668.15 (6	715.89 (15.6%)
AR&R 1 ye	9624.46	3733.72 (3	2903.08 (6	830.64 (16.7%)

PIPE DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Max U/S HGL (m)	Max D/S HGL (m)	Due to Storm
Pipe121	0.891	2.3	58.655	58.449	AR&R 1 year, 25 minutes storm, average 27.9 mm/h, Zone 8
Pipe L3-Sb	0.08	1.1	0.727	0.681	AR&R 1 year, 1 hour storm, average 16.3 mm/h, Zone 8
Pipe L3-Nb	0.072	1.1	0.717	0.672	AR&R 1 year, 1 hour storm, average 16.3 mm/h, Zone 8
Pipe L128-	0.046	1	0.678	0.637	AR&R 1 year, 25 minutes storm, average 27.9 mm/h, Zone 8
Pipe L128-	0.058	1	0.697	0.654	AR&R 1 year, 25 minutes storm, average 27.9 mm/h, Zone 8

CHANNEL DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Chainage (m)	Max HGL (m)	Due to Storm
Easement	0.891	1.5			AR&R 1 year, 25 minutes storm, average 27.9 mm/h, Zone 8

OVERFLOW ROUTE DETAILS

Name	Max Q U/S	Max Q D/S	Safe Q	Max D	Max DxV	Max Width	Max V	Due to Storm
OF26	0.017	0.017	0.362	0.016	0	7.95	0.27	AR&R 1 year, 20 minutes storm, average 31.7 mm/h, Zone 8
OF27	0	0	0.362	0	0	0	0	
OF28	0	0	0.362	0	0	0	0	
OF29	0	0	0.362	0	0	0	0	
OF58	0.396	0.396	5.82	0.08	0.07	7.13	0.89	AR&R 1 year, 25 minutes storm, average 27.9 mm/h, Zone 8

OF24	0	0	0.362	0	0	0	0	
OF25	0.017	0.017	0.362	0.016	0	7.95	0.27	AR&R 1 year, 20 minutes storm, average 31.7 mm/h, Zone 8
SwaleOF	0	0	0.362	0	0	0	0	
OF L128-N	0	0	1.072	0	0	0	0	
OF L128-S	0	0	1.072	0	0	0	0	
OF L128-A	0	0	0.362	0	0	0	0	
OF L3-Na	0	0	1.072	0	0	0	0	
OF176	0	0	1.072	0	0	0	0	
OF Outlet	0	0	1.072	0	0	0	0	
OF L1-S	0	0	0.565	0	0	0	0	
OF PineRc	0	0	0.362	0	0	0	0	

DETENTION BASIN DETAILS

Name	Max WL	MaxVol	Max Q Total	Max Q Low Level	Max Q High Level
SwaleRR	-0.21	321.8	0	0	0
Sw L128-N	0.21	23.8	0	0	0
Sw L128-S	0.14	18.7	0	0	0
Sw L128-A	0.05	5.6	0	0	0
Sw L3-Na	0.01	3.9	0	0	0
Sw L3-Sa	0.12	18.1	0	0	0
Sw PineRd	0.33	134.7	0	0	0

CONTINUITY CHECK for AR&R 1 year, 1 hour storm, average 16.3 mm/h, Zone 8

Node	Inflow (cu.m)	Outflow (cu.m)	Storage Ch (cu.m)	Difference %
Lot1_Pre	21.35	21.35	0	0
Lot3S Pre	0	0	0	0
Lot3N_Pre	0	0	0	0
Lot128_pre	0	0	0	0
HW1	1909.44	1909.44	0	0
N156	1763.69	1763.69	0	0
N147	1909.44	1909.44	0	0
Lot1s pre	0	0	0	0
N162	21.35	21.35	0	0

N163	21.35	21.35	0	0
Outlet	0	0	0	0
Pit L3-Sb	190.41	190.34	0.07	0
SwaleRR	585.92	488.2	98.06	-0.1
Pit L3-Nb	175.18	175.12	0.07	0
Pit L128-B	98.05	97.98	0.06	0
Sw L128-N	46.84	46.1	0.77	0
Sw L128-S	45.06	44.93	0	0.3
Sw L128-A	24.18	24.09	0	0.4
Sw L3-Na	54.41	54.07	0	0.6
Sw L3-Sa	47.22	47.12	0	0.2
N001	0	0	0	0
N L1-S	0	0	0	0
Sw PineRd	222.16	184.48	37.8	-0.1
Pit L128-Sl	122.54	122.48	0.06	0

Run Log for Lots_1 run at 15:44:09 on 9/5/2011

No water upwelling from any pit. Freeboard was adequate at all pits.

DRAINS results prepared 09 May, 2011 from Version 2010.08

PIT / NODE DETAILS Version 8

Name	Max HGL	Max Pond HGL	Max Surfa Flow Arrivi (cu.m/s)	Max Pond Volume (cu.m)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
HW1	59.22	3.071			-0.22	2.087	Headwall height/system capacity
N156	58.47		0				
N147	56.47		2.087				
Pit L3-Sb	1.09	2.23	0.313	12.9	0.91		None
Pit L3-Nb	1.06	2.22	0.29	11.9	0.94		None
Pit L128-B	0.91	2.16	0.184	7.6	1.09		None
Pit L128-Sl	0.99	2.19	0.229	9.4	1.01		None

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
Lot1n pre	0.144	0.038	0.108	8.49	32.52	9.71	AR&R 10 year, 20 minutes storm, average 65 mm/h, Zone 8
Lot3S pre	0.098	0	0.098	16.63	46.61	0	AR&R 10 year, 45 minutes storm, average 39.3 mm/h, Zone 8
Lot3N pre	0.12	0	0.12	15.9	45.03	0	AR&R 10 year, 45 minutes storm, average 39.3 mm/h, Zone 8
Lot128 pre	0.092	0	0.092	18.01	68.48	0	AR&R 10 year, 45 minutes storm, average 39.3 mm/h, Zone 8
Cat8e	3.071	2.699	0.389	15	30	0	AR&R 10 year, 25 minutes storm, average 57 mm/h, Zone 8
Cat Lot1s p	0.1	0	0.1	10.38	39.77	11.87	AR&R 10 year, 45 minutes storm, average 39.3 mm/h, Zone 8
Cat L3-Sb	0.313	0.121	0.241	12.65	11.6	11.02	AR&R 10 year, 25 minutes storm, average 57 mm/h, Zone 8
Cat L3-Nb	0.29	0.119	0.222	11.72	10.89	11.02	AR&R 10 year, 25 minutes storm, average 57 mm/h, Zone 8
Cat L128-E	0.184	0.102	0.125	6.42	7.27	7.27	AR&R 10 year, 25 minutes storm, average 57 mm/h, Zone 8
Cat L128-N	0.098	0.051	0.066	5.4	6.12	6.12	AR&R 10 year, 25 minutes storm, average 57 mm/h, Zone 8
Cat L128-S	0.083	0.047	0.056	6.61	7.49	7.49	AR&R 10 year, 25 minutes storm, average 57 mm/h, Zone 8
Cat L128-A	0.044	0.025	0.03	6.61	7.49	7.49	AR&R 10 year, 25 minutes storm, average 57 mm/h, Zone 8
Cat L3-Na	0.072	0.036	0.059	12.23	13.85	13.85	AR&R 10 year, 25 minutes storm, average 57 mm/h, Zone 8
Cat L3-Sa	0.091	0.035	0.074	7.23	8.19	8.19	AR&R 10 year, 25 minutes storm, average 57 mm/h, Zone 8
Cat L1-S	0.279	0	0.279	9.73	11.02	11.02	AR&R 10 year, 25 minutes storm, average 57 mm/h, Zone 8
Cat L1-N	0.589	0.139	0.511	5.4	6.12	6.12	AR&R 10 year, 25 minutes storm, average 57 mm/h, Zone 8
Cat L128-S	0.229	0.128	0.156	6.42	7.27	7.27	AR&R 10 year, 25 minutes storm, average 57 mm/h, Zone 8

Outflow Volumes for Total Catchment (23.7 impervious + 25.3 pervious = 49.0 total ha)

Storm	Total Rainf	Total Runo	Impervious	Pervious Runoff
	cu.m	cu.m (Run	cu.m (Run	cu.m (Runoff %)
AR&R 10 y	5344.2	1868.14 (3	1542.81 (5	325.33 (11.8%)
AR&R 10 y	7751.13	3431.45 (4	2307.73 (6	1123.72 (28.1%)
AR&R 10 y	9423.74	4678.11 (4	2839.29 (6	1838.82 (37.8%)
AR&R 10 y	10606.81	5558.49 (5	3215.27 (6	2343.23 (42.8%)
AR&R 10 y	11626.69	6319.50 (5	3539.39 (6	2780.11 (46.3%)
AR&R 10 y	12483.4	6903.37 (5	3811.65 (6	3091.72 (48.0%)
AR&R 10 y	14429.34	8203.69 (5	4430.07 (6	3773.62 (50.6%)
AR&R 10 y	15861.26	9183.96 (5	4885.14 (6	4298.82 (52.5%)
AR&R 10 y	18284.5	10585.30 (	5655.24 (6	4930.06 (52.2%)
AR&R 10 y	20071.35	11644.87 (	6223.11 (6	5421.76 (52.3%)

PIPE DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Max U/S HGL (m)	Max D/S HGL (m)	Due to Storm
Pipe121	0.984	2.5	58.655	58.467	AR&R 10 year, 25 minutes storm, average 57 mm/h, Zone 8
Pipe L3-Sb	0.31	1.7	0.947	0.862	AR&R 10 year, 25 minutes storm, average 57 mm/h, Zone 8
Pipe L3-Nb	0.287	1.7	0.929	0.847	AR&R 10 year, 25 minutes storm, average 57 mm/h, Zone 8
Pipe L128-	0.182	1.4	0.84	0.775	AR&R 10 year, 25 minutes storm, average 57 mm/h, Zone 8
Pipe L128-	0.227	1.6	0.881	0.808	AR&R 10 year, 25 minutes storm, average 57 mm/h, Zone 8

CHANNEL DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Chainage (m)	Max HGL (m)	Due to Storm
Easement	0.984	1.5			AR&R 10 year, 25 minutes storm, average 57 mm/h, Zone 8

OVERFLOW ROUTE DETAILS

Name	Max Q U/S	Max Q D/S	Safe Q	Max D	Max DxV	Max Width	Max V	Due to Storm
OF26	0.144	0.144	0.362	0.035	0.02	15.42	0.5	AR&R 10 year, 20 minutes storm, average 65 mm/h, Zone 8
OF27	0.098	0.098	0.362	0.03	0.01	13.53	0.46	AR&R 10 year, 45 minutes storm, average 39.3 mm/h, Zone 8
OF28	0.12	0.12	0.362	0.032	0.02	14.48	0.48	AR&R 10 year, 45 minutes storm, average 39.3 mm/h, Zone 8
OF29	0.092	0.092	0.362	0.029	0.01	13.22	0.46	AR&R 10 year, 45 minutes storm, average 39.3 mm/h, Zone 8
OF58	2.087	2.087	5.82	0.182	0.28	11.16	1.51	AR&R 10 year, 25 minutes storm, average 57 mm/h, Zone 8

OF24	0.1	0.1	0.362	0.03	0.01	13.85	0.45	AR&R 10 year, 45 minutes storm, average 39.3 mm/h, Zone 8
OF25	0.551	0.551	0.362	0.059	0.04	24.24	0.72	AR&R 10 year, 20 minutes storm, average 65 mm/h, Zone 8
SwaleOF	0.181	0.181	0.362	0.038	0.02	16.68	0.53	AR&R 10 year, 1 hour storm, average 32.4 mm/h, Zone 8
OF L128-N	0	0	1.072	0	0	0	0	
OF L128-S	0	0	1.072	0	0	0	0	
OF L128-A	0	0	0.362	0	0	0	0	
OF L3-Na	0	0	1.072	0	0	0	0	
OF176	0	0	1.072	0	0	0	0	
OF Outlet	0.363	0.363	1.072	0.266	0.34	2.13	1.28	AR&R 10 year, 1 hour storm, average 32.4 mm/h, Zone 8
OF L1-S	0.279	0.279	0.565	0.115	0.12	4	1.08	AR&R 10 year, 25 minutes storm, average 57 mm/h, Zone 8
OF PineRd	0.189	0.189	0.362	0.038	0.02	16.68	0.55	AR&R 10 year, 1 hour storm, average 32.4 mm/h, Zone 8

DETENTION BASIN DETAILS

Name	Max WL	MaxVol	Max Q Total	Max Q Low Level	Max Q High Level
SwaleRR	0.08	966.2	0.181	0	0.181
Sw L128-N	0.47	79.8	0	0	0
Sw L128-S	0.36	70.2	0	0	0
Sw L128-A	0.2	31.2	0	0	0
Sw L3-Na	0.16	63.2	0	0	0
Sw L3-Sa	0.34	77.3	0	0	0
Sw PineRd	0.58	344.1	0.189	0	0.189

CONTINUITY CHECK for AR&R 10 year, 45 minutes storm, average 39.3 mm/h, Zone 8

Node	Inflow (cu.m)	Outflow (cu.m)	Storage Ch (cu.m)	Difference %
Lot1_Pre	261.12	261.12	0	0
Lot3S Pre	224.13	224.13	0	0
Lot3N_Pre	266.61	266.61	0	0
Lot128_pre	263.47	263.47	0	0
HW1	4291.4	4291.4	0	0
N156	2398.58	2398.58	0	0
N147	4291.4	4291.4	0	0
Lot1s pre	203.48	203.48	0	0
N162	1218.8	1218.8	0	0

N163	1218.8	1218.8	0	0
Outlet	587.11	587.11	0	0
Pit L3-Sb	453.46	453.39	0.06	0
SwaleRR	1365.63	881.7	484.56	0
Pit L3-Nb	415.07	415	0.06	0
Pit L128-B	221.07	221.01	0.06	0
Sw L128-N	105.61	73.58	32.09	-0.1
Sw L128-S	101.59	81.35	20.29	-0.1
Sw L128-A	54.51	54.41	0	0.2
Sw L3-Na	128.91	128.68	0	0.2
Sw L3-Sa	112.45	90.57	21.95	-0.1
N001	587.11	587.11	0	0
N L1-S	249.07	249.07	0	0
Sw PineRd	575.45	430.51	145.15	0
Pit L128-Sl	276.3	276.23	0.06	0

Run Log for Lots_1 run at 15:38:40 on 9/5/2011

No water upwelling from any pit. Freeboard was adequate at all pits.
The maximum flow exceeded the safe value in the following overflow routes: OF25

DRAINS results prepared 09 May, 2011 from Version 2010.08

PIT / NODE DETAILS Version 8

Name	Max HGL	Max Pond HGL	Max Surfa Flow Arrivi (cu.m/s)	Max Pond Volume (cu.m)	Min Freeboard (m)	Overflow (cu.m/s)	Constraint
HW1	59.39	5.874			-0.39	4.793	Headwall height/system capacity
N156	58.48		0				
N147	56.48		4.793				
Pit L3-Sb	1.35	2.3	0.736	20	0.65		None
Pit L3-Nb	1.35	2.3	0.677	20	0.65		None
Pit L128-B	1.28	2.27	0.408	16.8	0.72		None
Pit L128-Sl	1.35	2.3	0.51	20	0.65		None

SUB-CATCHMENT DETAILS

Name	Max Flow Q (cu.m/s)	Paved Max Q (cu.m/s)	Grassed Max Q (cu.m/s)	Paved Tc (min)	Grassed Tc (min)	Supp. Tc (min)	Due to Storm
Lot1n pre	0.464	0.059	0.444	7.42	28.43	8.49	AR&R 100 year, 30 minutes storm, average 91 mm/h, Zone 8
Lot3S pre	0.402	0	0.402	11.89	33.31	0	AR&R 100 year, 30 minutes storm, average 91 mm/h, Zone 8
Lot3N pre	0.491	0	0.491	11.37	32.18	0	AR&R 100 year, 30 minutes storm, average 91 mm/h, Zone 8
Lot128 pre	0.376	0	0.376	12.87	48.94	0	AR&R 100 year, 30 minutes storm, average 91 mm/h, Zone 8
Cat8e	5.874	4.793	1.167	15	30	0	AR&R 100 year, 20 minutes storm, average 117 mm/h, Zone 8
Cat Lot1s p	0.408	0	0.408	7.42	28.43	8.49	AR&R 100 year, 30 minutes storm, average 91 mm/h, Zone 8
Cat L3-Sb	0.736	0.24	0.567	8.86	8.12	7.71	AR&R 100 year, 15 minutes storm, average 139 mm/h, Zone 8
Cat L3-Nb	0.677	0.224	0.518	8.79	8.16	8.26	AR&R 100 year, 20 minutes storm, average 117 mm/h, Zone 8
Cat L128-E	0.408	0.193	0.271	4.49	5.09	5.09	AR&R 100 year, 15 minutes storm, average 139 mm/h, Zone 8
Cat L128-N	0.211	0.092	0.138	3.78	4.28	4.28	AR&R 100 year, 15 minutes storm, average 139 mm/h, Zone 8
Cat L128-S	0.184	0.089	0.123	4.63	5.24	5.24	AR&R 100 year, 15 minutes storm, average 139 mm/h, Zone 8
Cat L128-A	0.099	0.047	0.066	4.63	5.24	5.24	AR&R 100 year, 15 minutes storm, average 139 mm/h, Zone 8
Cat L3-Na	0.179	0.069	0.142	9.17	10.39	10.39	AR&R 100 year, 20 minutes storm, average 117 mm/h, Zone 8
Cat L3-Sa	0.208	0.064	0.161	5.42	6.14	6.14	AR&R 100 year, 20 minutes storm, average 117 mm/h, Zone 8
Cat L1-S	0.806	0	0.806	7.3	8.26	8.26	AR&R 100 year, 20 minutes storm, average 117 mm/h, Zone 8
Cat L1-N	1.269	0.25	1.082	3.78	4.28	4.28	AR&R 100 year, 15 minutes storm, average 139 mm/h, Zone 8
Cat L128-S	0.51	0.241	0.338	4.49	5.09	5.09	AR&R 100 year, 15 minutes storm, average 139 mm/h, Zone 8

Outflow Volumes for Total Catchment (23.7 impervious + 25.3 pervious = 49.0 total ha)

Storm	Total Rainf	Total Runo	Impervious	Pervious Runoff
	cu.m	cu.m (Run	cu.m (Run	cu.m (Runoff %)
AR&R 100	9831.7	5890.41 (5	2968.94 (6	2921.47 (57.5%)
AR&R 100	14115.21	9687.37 (6	4330.25 (6	5357.12 (73.5%)
AR&R 100	17011.69	12236.12 (	5250.75 (6	6985.37 (79.5%)
AR&R 100	19092.25	14000.02 (	5911.95 (6	8088.06 (82.0%)
AR&R 100	20805.66	15370.53 (	6456.48 (6	8914.05 (83.0%)
AR&R 100	22274.3	16520.03 (	6923.21 (6	9596.82 (83.4%)
AR&R 100	25333.95	18857.77 (	7895.56 (6	10962.21 (83.8%)
AR&R 100	27414.52	20416.20 (	8556.76 (6	11859.44 (83.8%)
AR&R 100	32456.83	24407.91 (	10159.23 (	14248.69 (85.0%)
AR&R 100	36324.23	27637.40 (	11388.28 (	16249.11 (86.6%)

PIPE DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Max U/S HGL (m)	Max D/S HGL (m)	Due to Storm
Pipe121	1.081	2.5	58.74	58.525	AR&R 100 year, 20 minutes storm, average 117 mm/h, Zone 8
Pipe L3-Sb	0.467	2.1	1.14	0.946	AR&R 100 year, 5 minutes storm, average 241 mm/h, Zone 8
Pipe L3-Nb	0.467	2.1	1.14	0.946	AR&R 100 year, 10 minutes storm, average 173 mm/h, Zone 8
Pipe L128-	0.399	1.9	1.129	0.911	AR&R 100 year, 15 minutes storm, average 139 mm/h, Zone 8
Pipe L128-	0.467	2.1	1.14	0.946	AR&R 100 year, 10 minutes storm, average 173 mm/h, Zone 8

CHANNEL DETAILS

Name	Max Q (cu.m/s)	Max V (m/s)	Chainage (m)	Max HGL (m)	Due to Storm
Easement	1.081	1.5			AR&R 100 year, 20 minutes storm, average 117 mm/h, Zone 8

OVERFLOW ROUTE DETAILS

Name	Max Q U/S	Max Q D/S	Safe Q	Max D	Max DxV	Max Width	Max V	Due to Storm
OF26	0.464	0.464	10.912	0.055	0.04	22.98	0.68	AR&R 100 year, 30 minutes storm, average 91 mm/h, Zone 8
OF27	0.402	0.402	10.912	0.052	0.03	21.72	0.66	AR&R 100 year, 30 minutes storm, average 91 mm/h, Zone 8
OF28	0.491	0.491	10.912	0.056	0.04	23.3	0.7	AR&R 100 year, 30 minutes storm, average 91 mm/h, Zone 8
OF29	0.376	0.376	10.912	0.051	0.03	21.41	0.64	AR&R 100 year, 30 minutes storm, average 91 mm/h, Zone 8
OF58	4.793	4.793	5.785	0.267	0.52	14.5	1.94	AR&R 100 year, 20 minutes storm, average 117 mm/h, Zone 8

OF24	0.408	0.408	10.912	0.053	0.03	22.04	0.65	AR&R 100 year, 30 minutes storm, average 91 mm/h, Zone 8
OF25	2.141	2.141	10.912	0.099	0.11	33.32	1.09	AR&R 100 year, 30 minutes storm, average 91 mm/h, Zone 8
SwaleOF	0.93	0.93	10.912	0.073	0.06	28.94	0.82	AR&R 100 year, 1 hour storm, average 56 mm/h, Zone 8
OF L128-N	0.092	0.092	1.945	0.16	0.14	1.28	0.91	AR&R 100 year, 20 minutes storm, average 117 mm/h, Zone 8
OF L128-S	0.03	0.03	1.945	0.104	0.07	0.83	0.69	AR&R 100 year, 45 minutes storm, average 69 mm/h, Zone 8
OF L128-A	0	0	10.912	0	0	0	0	
OF L3-Na	0	0	1.945	0	0	0	0	
OF176	0.027	0.027	1.945	0.101	0.07	0.81	0.67	AR&R 100 year, 45 minutes storm, average 69 mm/h, Zone 8
OF Outlet	1.648	1.648	1.945	0.47	0.88	3.76	1.87	AR&R 100 year, 1 hour storm, average 56 mm/h, Zone 8
OF L1-S	0.806	0.806	2.481	0.174	0.28	4	1.62	AR&R 100 year, 20 minutes storm, average 117 mm/h, Zone 8
OF PineRd	0.77	0.77	10.912	0.067	0.05	27.39	0.78	AR&R 100 year, 25 minutes storm, average 102 mm/h, Zone 8

DETENTION BASIN DETAILS

Name	Max WL	MaxVol	Max Q Total	Max Q Low Level	Max Q High Level
SwaleRR	0.24	1377.7	0.93	0	0.93
Sw L128-N	0.55	102.8	0.092	0	0.092
Sw L128-S	0.52	132.5	0.03	0	0.03
Sw L128-A	0.36	70.4	0	0	0
Sw L3-Na	0.31	156.2	0	0	0
Sw L3-Sa	0.52	153.4	0.027	0	0.027
Sw PineRd	0.71	461.5	0.77	0	0.77

CONTINUITY CHECK for AR&R 100 year, 30 minutes storm, average 91 mm/h, Zone 8

Node	Inflow (cu.m)	Outflow (cu.m)	Storage Ch (cu.m)	Difference %
Lot1_Pre	762.6	762.6	0	0
Lot3S Pre	730.83	730.83	0	0
Lot3N_Pre	863.64	863.64	0	0
Lot128_pre	957.65	957.65	0	0
HW1	7742.79	7742.79	0	0
N156	2463.2	2463.2	0	0
N147	7742.79	7742.79	0	0
Lot1s pre	643.86	643.86	0	0
N162	3958.58	3958.58	0	0

N163	3958.58	3958.58	0	0
Outlet	2279.74	2279.74	0	0
Pit L3-Sb	773.42	697.31	0.06	9.8
SwaleRR	2263.82	1718.03	546.26	0
Pit L3-Nb	706.85	660.8	0.06	6.5
Pit L128-B	370.71	370.65	0.06	0
Sw L128-N	177.1	134.05	43.11	0
Sw L128-S	170.35	109.44	61	-0.1
Sw L128-A	91.41	72.03	19.43	-0.1
Sw L3-Na	219.54	182.09	37.6	-0.1
Sw L3-Sa	191.79	120.21	71.69	-0.1
N001	2279.74	2279.74	0	0
N L1-S	648.57	648.57	0	0
Sw PineRd	1005.61	853.13	152.71	0
Pit L128-Sl	463.31	463.25	0.06	0

Run Log for Lots_1 run at 15:32:16 on 9/5/2011Water was lost from the system at Pit L128-Sb, Pit L3-Nb, Pit L3-Sb.

Is this correct? If this water re-enters the system further downstream you should draw an overflow route from these locations.

No water upwelling from any pit. Freeboard was adequate at all pits.

Appendix C

Plant Species Typically Used in WA WSUD

Subject to Council requirements

Byford Lots 1, 3 & 128 - PLANT SELECTION LIST								
BOTANICAL NAME		**COMMON NAME**	**HEIGHT**	**WIDTH**	**FOUND IN STUDY AREA**	**ORNAMENTAL**	**LOCATION**	
Infiltration Basins (if used)								
Melaleuca	preissiana	Stout paperbark	6-10m	3-5m	Y		Tolerates waterlogged soils. Periodic inundation Salt Water Tolerant	Uplands
Melaleuca	rhaphiophylla	Freshwater paperbark	6m	3m	Y	Y	Wet depressions or clay flats	Levee/ Channel
Melaleuca	cuticularis	Saltwater paperbark	5m	6m		Y	tolerant to both waterlogging and in the salt air and water - Drought tolerant	
Melaleuca	lateritia	Robin redbreast bush	2.5m			Y	Fringing watercourses and in wet seasonally depressions	
Banksia	littoralis	Swamp banksia	12m				Swampy areas, does not tollerate inundation, prefers areas subject to only short winter water logging. -Deep sands and well drained soils, drought resistant	
Banksia	seminuda	River banksia	20m				Richer heavier soils along riverbanks and seasonally wet depressions	
Carex	appressa	Tall sedge	2m	0.5m			Brackish water, occur seasonally inundated or shallow permanent water	Levee
Carex	fascicularis	Tassel sedge	1.5m	1m			Fresh to brackish water. Seasonally waterlogged or partially inundated watercourses and lake margins	Levee
Carex	inversa	Knob sedge	0.1-0.15m	0.2m			seasonally wet or water logged soils and in fresh to semi saline conditions.	
Dianella	caerulea	King Alfred	0.3-0.5m			Y		
Dianela	revoluta	Little Rev	0.3-1.5m			Y	Variety of soils, laterite, granite, limestone	
Lomandra	histrix	Tropic Belle				Y		
Lomandra	longifolia	Lomandra				Y		
Juncus	caespiticius	Grassy rush	.09-.6m				Peaty Saline sand, winter depressions	
Juncus	holoschoenus	Jointleaf rush	.3-1m				Sand, swamps, creeks.	
Juncus	kraussii	Sea rush	0.8-1.5m				Saline to brackish habitats fringing watercourses and lakes, also on sea shores	Channel- Levee
Juncus	pallidus	Pale rush	2m				Common in seasonally damp areas. Max water depth 0.05m	(Levee)
Juncus	pauciflorus	Loose flower rush	1m				Permanently damp or seasonally wet soil fringing fresh watercourses	Levee
Juncus	subsecundus	Finger rush	1m		Y		Moist seasonally wet soils	Levee
Goodenia	pulchella	subsp. Coastal Plain	0.5m				Seasonally wet sites, undulating dunes	
Eucalyptus	occidentalis	Flat-topped-yate	20m	5m			Wet depressions or clay flats	Uplands
Eucalyptus	rudis	Flooded gum	25m	4m	Y		prolonged periods of flooding usually found in waterlogged areas,	
Casuarina	cunninghamiana	Casuarina	5-9m	5m		Y	Loam over granite, Eucalyptus woodlands along creek edge	
Ficinia	nodosa	Knotted club rush	1m			Y	Sands coastal dunes, winter wet depressions and fringing rivers and lke margins - Highly tolerant to salt spray and waterlogging-	
Lepidosperma	gladiatum	Coastal sword-sedge	1.5m				Perennial, found in seasonally moist or wet sands as well as dry dunes, full sun- part shade - Tolerates direct salt winds and alkaline soils.	
Bioretention Swales and Pockets (if used)								
Carex	appressa	Tall sedge	2m	0.5m			Brackish water, occur seasonally inundated or shallow permanent water	
Carex	appressa	Tassel sedge	1.5m	1m			Fresh to brackish water. Seasonally waterlogged or partially inundated watercourses and lake margins	
Carex	inversa	Knob sedge	0.1-0.15m	0.2m			seasonally wet or water logged soils and in fresh to semi saline conditions.	
Juncus	caespiticius	Grassy rush	.09-.6m				Peaty Saline sand, winter depressions	Channel- Levee
Juncus	holoschoenus	Jointleaf rush	.3-1m				Sand, swamps, creeks.	(Levee)
Juncus	kraussii	Sea rush	0.8-1.5m				Saline to brackish habitats fringing watercourses and lakes, also on sea shores	Levee
Juncus	pallidus	Pale rush	2m				Common in seasonally damp areas. Max water depth 0.05m	Levee
Juncus	pauciflorus	Loose flower rush	1m				Permanently damp or seasonally wet soil fringing fresh watercourses	
Juncus	subsecundus	Finger rush	1m		Y		Moist seasonally wet soils	
Ficinia	nodosa	Knotted club rush	1m			Y	Sands coastal dunes, winter wet depressions and fringing rivers and lke margins - Highly tolerant to salt spray and waterlogging-	
Dianella	caerulea	King Alfred	0.3-0.5m			Y		levee/ uplands
Dianela	revoluta	Little Rev	0.3-1.5m			Y	Variety of soils, laterite, granite, limestone	
Lomandra	histrix	Tropic Belle				Y		
Lomandra	longifolia	Lomandra				Y		
Lepidosperma	gladiatum	Coastal sword-sedge	1.5m				Perennial, found in seasonally moist or wet sands as well as dry dunes, full sun- part shade - Tolerates direct salt winds and alkaline soils.	

Appendix D

Groundwater Monitoring Report

GHD 2010

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Urban Solutions

Report for Byford LWMS and UWMP

Groundwater Monitoring Report

November 2010

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

Contents

Table Index

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Appendices

A Laboratory Results and Chain of Custody forms

B Tabulated Monitoring Results

C RPD summaries

1. Introduction

GHD Pty Ltd (GHD) was commissioned by Urban Solutions to undertake monitoring of groundwater for Lots 1, 3, and 128 South Western Highway, Byford (Figure 1) to support the submission of a Local Structure Plan. The study area totals 13.5 ha and is located within the Shire of Serpentine-Jarrahdale (the Shire), approximately 32 km south of Perth.

The monitoring program includes three groundwater monitoring bores distributed across the site. Groundwater levels were monitored monthly and a groundwater quality monitoring program was undertaken on a quarterly basis. This report presents the results over the July to December 2009 monitoring period with the objective of establishing pre-development groundwater quality and groundwater levels across the site.

404,000 406,000 408,000

6,436,000 6,434,000 6,432,000 6,430,000

BYFORD
6122

CARDUP
6122

Lot 128
Lot 3
Lot 1

Shire of Serpentine - Jarrahdale

Byford Trotting Complex
Marri Grove Prim Sch
Byford Prim Sch
John Calvin Sch
Byford Tavern
Serpentine-Jarrahdale Community Centre
Graceford Baptist Hostel & Units
Brickwood Reserve
Briggs Park
Cardup Nature Reserve
timber mill
brickworks
quarry
Shale Road Landfill
Hendley Park Motocross
landing ground

Beenyup Brook
Cardup Brook

Category 3 ESL Boundary

LEGEND

Study Area

1:20,000 (at A3)
0 100 200 400 600 800 1,000
Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 50

N

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Urban Solutions

Urban Solutions
Byford Lots 1, 3 and 128 LWMS/ UWMP

Locality and Study Area

Job Number	61-24146
Revision	A
Date	25 SEP 2009

Figure 1

G:\61\24146\GIS\mxds\6124146_G001_RevA.mxd

GHD House, 239 Adelaide Terrace Perth WA 6004 **T** 61 8 6222 8222 **F** 61 8 6222 8555 **E** permail@ghd.com.au **W** www.ghd.com.au

Data Source: Landgate: Streetsmart Mosaic - 2009; GHD: Study Area - 20090929. Created by: wdavis

2. Field Measurement and Sampling Methods

Groundwater level monitoring was undertaken monthly and groundwater quality monitoring undertaken quarterly for the six month period from July to December 2009. The first monitoring event took place on 20 July 2009. Monitoring sites are presented in

Figure 2. The groundwater monitoring bores were distributed throughout the site. Groundwater samples were collected in accordance with procedures specified in *Australian Standards Water Quality - Sampling* AS 5667 (1998) and Department of Environment "*Development of Sampling and Analysis Programs"* (DEP 2001).

2.1 General

The water quality meter and electronic dip meter were decontaminated between sampling locations. Samples were collected into pre-cleaned containers supplied by the laboratory, suitable for the analytes and containing appropriate preservatives where required.

Samples were kept chilled upon collection and during transport to the laboratory. Transport to the laboratory occurred on the day of sampling. Each sample was identified by means of a label that showed sample location, job number, date, time and client. All samples were tracked from collection to the laboratory with GHD's Chain of Custody forms that are attached to the final laboratory reports in Appendix A.

2.2 Groundwater Samples

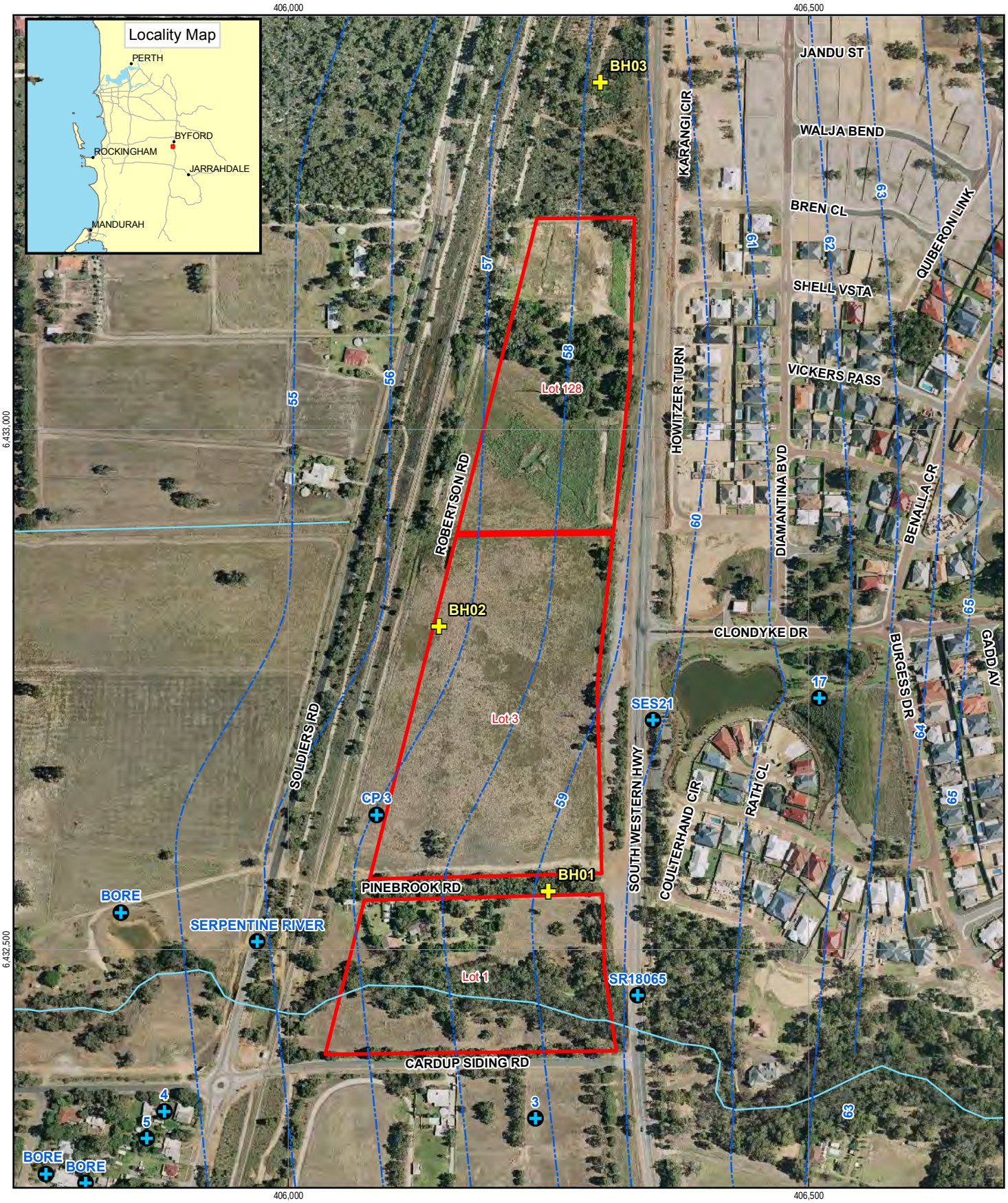
Groundwater monitoring bores were purged by removal of three times the well volume prior to sample collection to remove stagnant water and to ensure the collection of representative groundwater samples. The groundwater quality was monitored *in situ* with a water quality meter. Collection of groundwater quality samples was undertaken after field water quality meter parameters had stabilised. Purging and sampling was undertaken with a separate disposable bailer for each bore. Dedicated bailers have been left in place in the groundwater monitoring bores.

Bore BH01 was unable to be sampled during the July 2009 monitoring event because the bore was dry. During the monitoring bore installation the bore was drilled to refusal (~6 metres) and groundwater was not intercepted.

2.3 Field Measurements

Water levels were measured in all groundwater bores. Measurements were taken as 'depth to groundwater below top of casing (bTOC)' and 'total bore depth' with an electronic water level meter. A multi-parameter water quality meter (Hanna HI 9828) was used to obtain *in situ* field measurements of:

- Temperature
- Electric Conductivity (E Cond)
- pH
- Salinity
- Dissolved Oxygen (DO)
- Oxidation Reduction Potential (Eh)
- Total Dissolved Solids (TDS)



LEGEND

- Monitoring Bores
- WIN Bores
- Interpolated Maximum Groundwater Level (1m)
- Hydrography
- Study Area

DRAFT

1:5,000 (at A4)

0 25 50 100 150

Metres

Map Projection: Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia (GDA)
Grid: Map Grid of Australia 1994, Zone 50

N

GHD

CLIENTS | PEOPLE | PERFORMANCE

Urban Solutions

Urban Solutions
Byford Lots 1,3 & 128 Groundwater Monitoring

Job Number 61-24146
Revision A
Date 26 MAR 2010

Location of Monitoring Bores

Figure 2

G:\61\24146\GIS\mxds\6124146_G009_RevA.mxd

GHD House, 239 Adelaide Terrace Perth WA 6004 T 61 8 6222 8222 F 61 8 6222 8555 E permail@ghd.com.au W www.ghd.com.au

Data Source: GHD: Study Area - 20090925, Interpolated Maximum Groundwater Level - 20100303, Monitoring Bores - 20100305; Landgate: Hydrography - 20100204, Metro Central Mosaic - 2009; DoW: WIN Bores - 20080708; GA: Topo Data (Series 3) - 2006. Created by: sismail

Measurements were taken before, during, and after removal of the purge volume. Values used in discussion and in Appendix B represent those measurements taken after purging.

2.4 Laboratory Program

Groundwater samples were submitted to ALS Laboratory Group, which is accredited by the National Association of Testing Authorities (NATA), for the following analyses:

- pH, Electrical Conductivity, Total Dissolved Solids;
- Nutrients (Total Nitrogen, Nitrate-N, Nitrite-N, Ammonia-N, Total Phosphorus, Filterable Reactive Phosphorus); and
- Total heavy metals (Arsenic (Ar), Cadmium (Cd), Chromium (Cr), Copper (Cu), Lead (Pb), Nickel (Ni), Zinc (Zn) and Mercury (Hg)).

Summaries of Laboratory Analytical Results are presented in Appendix B and are discussed in Section 5.

3. Assessment Criteria

In accordance with standard practice, the selection of appropriate assessment criteria for this review is based on the beneficial use and management objectives of the water resources in the local area. For the local area of Byford, these are considered to be:

- Groundwater: aquatic ecosystems and potentially drinking water; and
- Surface water: aquatic ecosystems.

As such the following assessment levels for aquatic ecosystems were used:

- Physicochemical parameters and nutrients
  - Trigger values for lowland rivers in Southwest Australia as specified in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC and ARMCANZ 2000), hereafter referred to as the ANZECC guidelines; and
- Remaining parameters (metals and metalloids)
  - Trigger values for freshwater ecosystems with a 95% level of species protection (which generally corresponds to trigger values for slightly-moderately disturbed systems) (refer to ANZECC and ARMCANZ 2000).

These assessment criteria are tabulated and presented in Appendix B.

4. Quality Assurance

To monitor the integrity of the water sampling procedures and laboratory techniques, a field duplicate quality assurance sample was collected and submitted to the laboratory for analysis. A quantitative measure of the precision of laboratory and field procedures with field duplicates is to calculate the relative percent difference in accordance with the procedure described in AS 4482.1 (1997). According to this standard, the relative percentage difference of duplicate analyses is expected to range between 30% and 50%. However, this variation can be higher for organics and for low concentrations of analytes. Where a result was reported below the limit of reporting for one of the duplicate samples, a nominal concentration equal to the limit of reporting was adopted for calculation purposes.

RPDs for physio-chemical and nutrient analytes are presented in Table 1. The RPDs calculated for the duplicates are generally within the expected range of maximum values. Low RPDs (30% to 50%) indicate that field methodologies and laboratory procedures have not significantly affected the integrity of the laboratory results. Hence, the analytical data are of acceptable quality to draw meaningful conclusions regarding the environmental conditions of the site.

The RPDs that exceed the expected range of 30-50% have been shaded grey in Table 1. The high RPDs for Reactive P in July and Cadmium in October are likely attributed to one of the duplicates reporting a concentration below the limit of reporting. The high RPDs for ammonia-N (October 2009) raises concerns about the integrity of the sample, however the observed concentration of ammonia-N in October is much lower than previously observed in July so the sample has been retained in the analysis of the results.

Table 1 Relative Percentage Difference (RPD) analysis for each monitoring event

Monitoring event	July 2009	October 2009
Metals		
Arsenic	0.0 %	0.0 %
Cadmium	0.0 %	133.3%
Chromium (Total)	27.0 %	28.1 %
Copper	8.9 %	18.8 %
Lead	17.9 %	27.0 %
Nickel	10.6 %	14.2 %
Zinc	7.9 %	16.4 %
Mercury	0.0 %	< LOR
Physio-chemical		
pH	0.0 %	0.9 %
E Cond	0.4 %	3.1 %
TSS	ND	38.2 %
Total N	3.4 %	2.4 %

Monitoring event	July 2009	October 2009
Total P	5.1 %	2.7 %
Reactive P	120.0%	0.0 %
Ammonia-N	1.0 %	150.0 %
Nitrate - N	5.7 %	12.0 %
Nitrite - N	4.2 %	< LOR

5. Results and Discussion

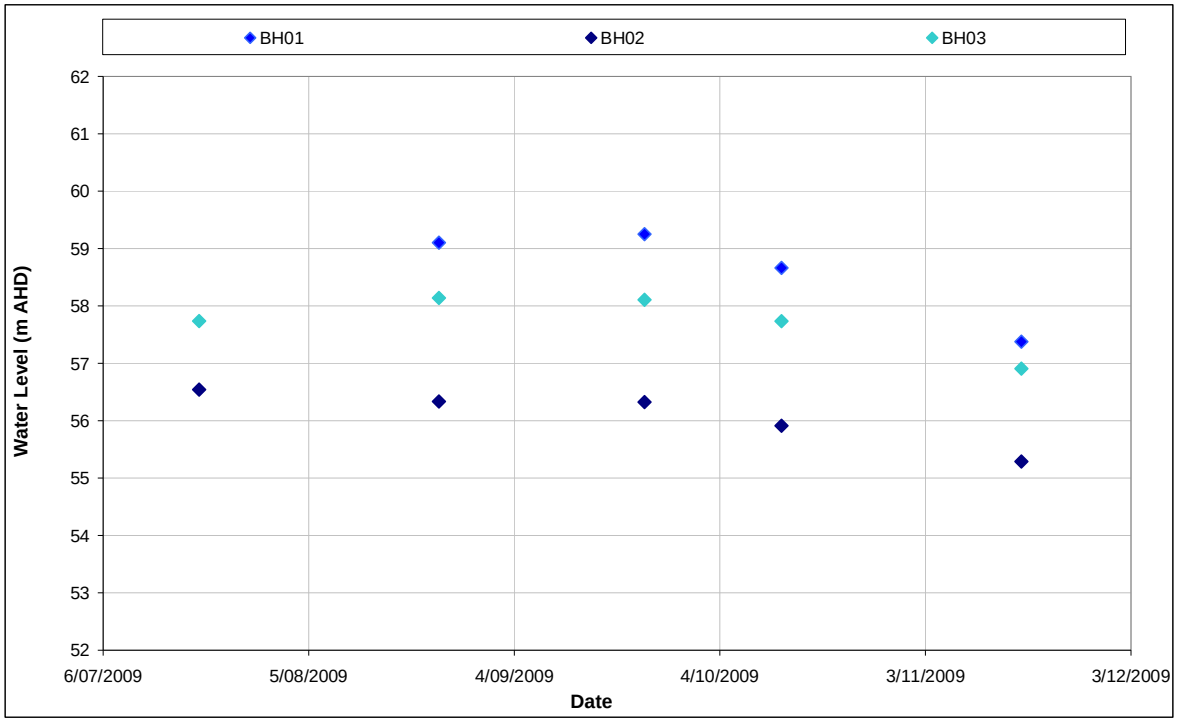
This section provides an interpretation of the groundwater level data and the water quality data against the relevant assessment criteria and available historical monitoring data for the Byford region. The complete set of results from each monitoring event is provided in tabulated form in Appendix B.

5.1 Groundwater Levels

Groundwater levels across the site for the period July 2009 to December 2009 followed a typical seasonal pattern with winter maxima and summer minima as shown in Figure 3. From August 2009 groundwater levels are highest within the southern part of the site at bore BH01. This bore was observed to be dry during the initial site visit, and groundwater was not intercepted during the drilling of the bore, to refusal (~6m), in June 2009. The central monitoring bore BH02 was observed to have the lowest water level for the monitoring period.

A search of the Department of Water's WIN database revealed historical groundwater level data (1996-1998) from a monitoring bore located immediately east of South Western Highway. The water level results from this historical monitoring bore (61414007) varied between 57.38 mAHD (May 1998) and 59.81 mAHD (September 1998), which are similar in range to the observed groundwater levels at the site.

Figure 3 Byford groundwater levels (July 2009 to December 2009)



5.2 Physiochemical Parameters

pH

Laboratory pH measurements ranged between 5.49 (BH03, October 2009) and 6.78 (BH02, October 2009). Monitoring bore BH03 had lower pH than the ANZECC guideline (6.5 – 8.0) for the two quarterly monitoring events.

Electrical Conductivity (EC)

Laboratory EC values ranged from 395µS/cm (BH02) to 2,490 µS/cm (BH01). ANZECC guidelines for conductivity in lowland streams range between 120 and 300 µS/cm. All bores recorded EC concentration above the ANZECC guideline.

Suspended Solids (SS)

Suspended solids values of groundwater were only monitored during the October monitoring event. The range in TSS values was from 3,900 mg/L in BH03 to 20,500 mg/L in BH01. Currently, there is no relevant ANZECC guideline for TSS.

5.2.1 Total Heavy Metals

Total heavy metal concentrations for this pre-development groundwater study were from unfiltered samples in accordance with the sampling parameters in the *Byford District Water Management Plan* (DoW 2008).

These concentrations represent total heavy metals that are a combination of dissolved chemical species as well as those that are bound to particles. Therefore total heavy metals are the highest concentrations that could possibly become bio-available and overestimate dissolved metal concentrations.

As there are no guideline values for total heavy metals for freshwater the majority of the total heavy metal concentrations exceeded the available ANZECC guideline values for dissolved heavy metals. The exceptions were arsenic and mercury, which were below the ANZECC guideline values for all samples, and below the LOR for the majority of samples. Cadmium concentrations were also lower than the guideline values in the October 2009 monitoring event, but slightly exceeded them in July 2009 at monitoring bores BH02 and BH03.

Several metals were found in high concentrations in the groundwater monitoring bores relative to the ANZECC guideline values. In particular copper concentrations were very high in BH02 in July 2009 and BH01 in October 2009, with values over 190-fold higher than the ANZECC guideline. Copper concentrations were also high in BH03 with values over 35-fold and 70-fold higher than the guideline values for July and October 2009, respectively. Other notably high metal concentrations is lead in monitoring bores BH02 (july 2009) and BH03 (October 2009) with values over 70-fold and 50-fold higher than the guideline values, respectively. Other total metal concentrations that exceeded the ANZECC guideline values include chromium, nickel and zinc.

It is again emphasised that total rather than dissolved concentrations were monitored and therefore the bio-available fraction is likely to be substantially lower. A recommendation for future monitoring would be to measure the dissolved rather than total heavy metal concentrations.

5.3 Nutrients

5.3.1 Nitrogen

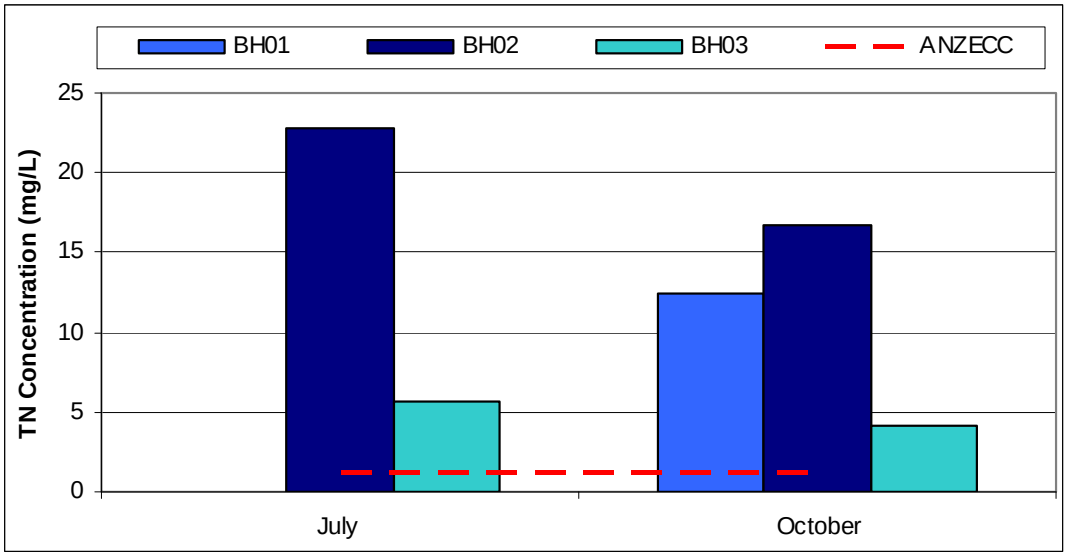
Total Nitrogen (TN) for all monitoring events ranged from 4.2 mg/L (BH03, October 2009) to 22.8 mg/L (BH02, July 2009) (Figure 4). Average TN concentrations for bores BH02 and BH03 were 19.75 and 4.9 mg/L, respectively, with BH01 recording a single value of 12.9 mg/L in October 2009[1].

TN was greater than the ANZECC guideline of 1.2 mg/L across all bores during both monitoring events. The highest TN concentrations were recorded from bore BH02, which is located within the central part of the study area within an ungrazed paddock.

TN was primarily composed of nitrate-N and total organic – N (total kjeldahl nitrogen [TKN] - N + ammonia-N) in all monitoring bores. Ammonia-N only comprised a small proportion (<10%) of the TKN concentration indicating that total organic nitrogen sources are dominant.

NO_x-N is predominantly comprised of nitrate-N. NO_x-N ranged between 0.62 mg/L (BH03, October 2009) and 13.2 mg/L (BH02, October 2009). Nitrate-N ranged between 0.62 mg/L (BH03, October 2009) and 13.2 mg/L (BH02, October 2009). Nitrate-N was detected at levels above the ANZECC NO_x-N guideline value in all groundwater samples, and was above the *Contaminated Sites Management Series: Assessment Levels for Soils, Sediment and Water* in samples from BH01 and BH02. Nitrite-N was detected at levels above the ANZECC NO_x-N guideline value on two occasions in BH02 (0.49 mg/L, July 2009) and BH01 (0.32 mg/L, October 2009).

Figure 4 Groundwater Total Nitrogen Concentration



[1] BH01 was dry during the July sampling event.

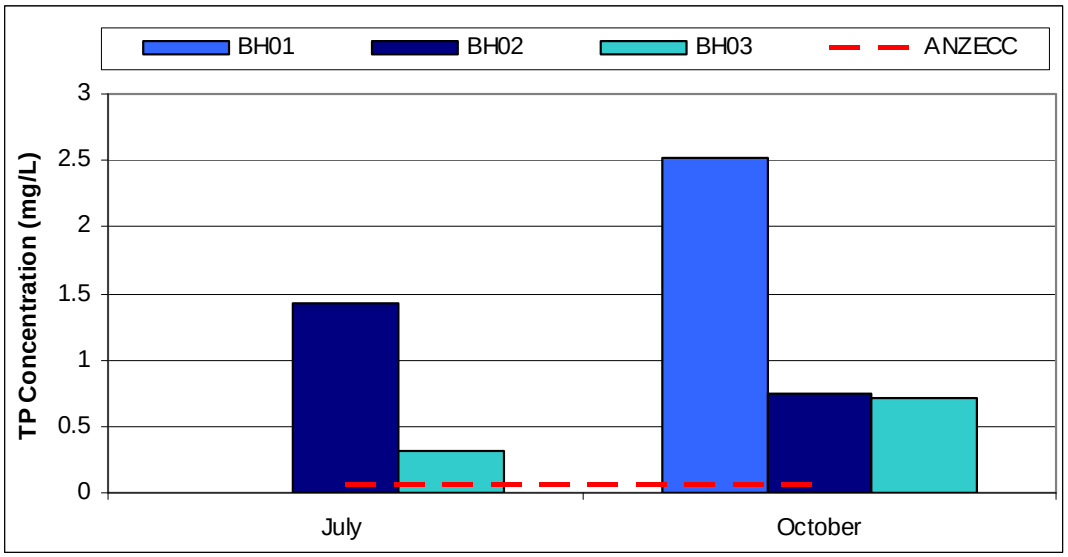
5.3.2 Phosphorus

TP concentrations of the monitoring events ranged from 0.32 mg/L (BH03 July 2009) to 2.52 mg/L (BH01, October 2009) (Figure 5). Average TP for bores BH02 and BH03 were 1.08 and 0.52 mg/L, respectively, with BH01 recording a single value of 2.52 mg/L in October 2009[2].

TP was above the ANZECC guideline value of 0.065 mg/L in all bores for both monitoring events. The highest TP concentration was recorded from monitoring bore BH01 which is located in the southern part of the study area, along the northern boundary of Lot 1.

Filterable reactive phosphorus (FRP) concentrations were below the LOR during the July 2009 monitoring event and ranged between 0.01 (BH03) and 0.08 mg/L (BH01) in October 2009. FRP concentration was not a major component of TP.

Figure 5 Groundwater Total Phosphorus Concentration



[2] BH01 was dry during the July sampling event.

6. Conclusions and Recommendations

An overview of the key results from the groundwater and surface water monitoring conducted for Lots 1, 3 and 128 South Western Highway Byford for the period July 2009 to October 2009 include:

- Groundwater levels across the site follow a typical seasonal pattern with summer minima and spring/winter maxima. Bore BH01 had the highest groundwater levels, while bore BH02 had the lowest groundwater levels during the monitoring period.
- pH for monitoring bore BH03 was below the ANZECC guideline range for both of the quarterly monitoring events.
- EC was higher than the ANZECC guideline range in all monitoring bores, particularly in bore BH01 during the October monitoring event. Similarly TSS was high in BH01 in October compared to the other bores.
- Several total heavy metals were found in high concentrations in the groundwater monitoring bores relative to the ANZECC guideline values. Metal concentrations measured for this pre-development groundwater study were from unfiltered samples, which would likely be substantially lower for dissolved metal concentrations.
- Groundwater nutrient concentrations were high for all monitoring bores during both quarterly monitoring events. TN concentrations were very high for monitoring bore BH02, located within the centre of the site, and comprised primarily nitrate-N and total organic-N. TP was also high for all monitoring bores, but FRP was a very small component of the observed TP concentrations.

This report discusses the results of six months of groundwater level monitoring and two quarterly groundwater quality monitoring events for the Byford site. Evaluation of the available data gives reasonable confidence in the identification of the pre-development groundwater quality and water levels across the site. In particular the groundwater levels at the site are of the same magnitude as historical water level results from nearby monitoring bores.

The only recommendation for any future monitoring would be to perform heavy metal analyses on dissolved samples rather than unfiltered samples. This would allow a direct comparison with the relevant ANZECC guidelines based on dissolved heavy metals.

7. Limits of Reporting

The data and advice provided herein relate only to the project and structures described herein and must be reviewed by a competent engineer/scientist before being used for any other purpose. GHD Pty Ltd accepts no responsibility for other use of the data.

The advice tendered in this report is based on information obtained from the monitoring locations and is not warranted in respect to the conditions that may be encountered across the Site at other than these locations. It is emphasised that the actual characteristics of the subsurface materials may vary significantly between adjacent test points and sample intervals and at locations other than where observations, explorations and investigations have been made. Subsurface conditions, including groundwater levels and contaminant concentrations can change in a limited time. This should be borne in mind when assessing the data.

This report is based partially on information issued and supplied to GHD by others. Where laboratory tests have been performed and data recorded, the responsibility for the accuracy of such data remains with the issuing authority, not with GHD.

8. References

ANZECC & ARMCANZ (2000) *Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Volume 1, The Guidelines*, Australian and New Zealand Environmental and Conservation Council and Agricultural and Resource Management Council of Australia and New Zealand.

Department of Environment and Conservation (2003) *Contaminated Sites Management Series, Assessment Levels for Soil, Sediment and Water; Version 3 Draft for Public Comment*.

(DoW) Department of Water (2008) *Byford District Water Management Plan*

Appendix A

Laboratory Results and Chain of Custody forms

CHAIN OF CUSTODY RECORD AND ANALYSIS REQUEST

GHD | CLIENTS|PEOPLE|PERFORMANCE

GHD House
239 Adelaide Terrace
Perth WA 6004

PO Box Y3106
Perth WA 6832

Telephone 08 6222 8222
Facsimile 08 6222 8555

4942

Project: BYFORD LWMS	Laboratory: ALS Laboratory
Client: URBAN SOLUTIONS	Address: 10 Hodd Way, Malaga
Job No.: 61/24146	Laboratory Contact:
Laboratory Quote No.	Turnaround Time
Job Manager (Invoice): Kelsey Hunt	Email Address (Results): Kelsey.Hunt@ghd.com.au

Please Note:
Please sign white copy on receipt and release of samples. Samples are delivered to Laboratory Address. On receipt of samples laboratory contact should sign white copy and fax to GHD contact at above address. On completion of analyses please return white copy with results. Yellow copy is retained by laboratory. Pink copy is retained by sampler.

	GHD Sample ID	Laboratory Sample ID	Date	Time	Sample Matrix (S-Soil/Sl-Sludge/W-Water/A-Air)	Container Type (B-Bottle/J-Jar/V-Vial/Bag G-Glass/P-Plastic)	Container Preservative (Unpreserved/HCl/H_2SO_4/HNO_3/Other)	Container No	Container Total Volume (mL)	Analyses: Dissolved metals	Analyses: *Inorganics	Analyses: * Metal Suite W-2	Analyses: Nutrient Suite NT-8	Analyses: FRP	Analyses: pH	Analyses: E Cond	Analyses: TDS	Remarks
1	BH02	BH02	20/7/09		W	B,P	Un/H_2SO_4					↓	↓	↓	↓	↓	↓	*As, Cd, Cr, Cu, Pb, Ni, Zn & Hg
2	BH03	BH03	↓		↓	↓	↓											
3	QA	QA	↓		↓	↓	↓											

Environmental Division
Perth
Work Order
EP0903981

Telephone : +61-8-9209 7655

Sampled by: K. Hunt	Date/Time 20/7/09	Relinquished by:	Date/Time
Received by: MW	Date/Time 21/7 11:56	Relinquished by:	Date/Time
Received by Lab:	Date/Time	Courier/Transport Company:	
Sample Conditions:	Remarks:		

CERTIFICATE OF ANALYSIS

Work Order	: **EP0903981**	Page	: 1 of 3
Client	: **GHD SERVICES PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: KELSEY HUNT	Contact	: Michael Sharp
Address	: GHD HOUSE PO BOX Y3106 PERTH WA, AUSTRALIA 6832	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: kelsey.hunt@ghd.com.au	E-mail	: michael.sharp@alsenviro.com
Telephone	: +61 08 6222 8222	Telephone	: +61-8-9209 7655
Facsimile	: +61 08 9429 6555	Facsimile	: +61-8-9209 7600
Project	: 61 24146	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: 4942	Date Samples Received	: 21-JUL-2009
Sampler	: K. Hunt	Issue Date	: 29-JUL-2009
Site	: BYFORD LWMS		
		No. of samples received	: 3
Quote number	: EN/005/09	No. of samples analysed	: 3

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

NATA Accredited Laboratory 825

This document is issued in accordance with NATA accreditation requirements.

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Perth Inorganics
Scott James	Assistant Laboratory Manager	Perth Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insuffient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **TDS by method EA-015 may bias high due to the presence of fine particulate matter, which may pass through the prescribed GF/C paper.Samples are very thick**

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: BH02	BH03	QA	----	----
				Client sampling date / time: 20-JUL-2009 15:00	20-JUL-2009 15:00	20-JUL-2009 15:00	----	----
				EP0903981-001	EP0903981-002	EP0903981-003	----	----
EA005: pH								
pH Value	----	0.01	pH Unit	**6.74**	**5.98**	**6.74**	----	----
EA010: Conductivity								
Electrical Conductivity @ 25°C	----	1	µS/cm	**681**	**710**	**684**	----	----
EA015: Total Dissolved Solids								
^ Total Dissolved Solids @180°C	GIS-210-010	5	mg/L	**19200**	**895**	**21900**	----	----
EG020T: Total Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	**0.002**	**0.002**	**0.002**	----	----
Cadmium	7440-43-9	0.0001	mg/L	**0.0004**	**0.0003**	**0.0004**	----	----
Chromium	7440-47-3	0.001	mg/L	**0.227**	**0.027**	**0.173**	----	----
Copper	7440-50-8	0.001	mg/L	**0.271**	**0.052**	**0.248**	----	----
Lead	7439-92-1	0.001	mg/L	**0.249**	**0.026**	**0.208**	----	----
Nickel	7440-02-0	0.001	mg/L	**0.099**	**0.040**	**0.089**	----	----
Zinc	7440-66-6	0.005	mg/L	**0.157**	**0.087**	**0.145**	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	**0.0002**	<0.0001	**0.0002**	----	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**0.99**	**0.08**	**0.98**	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	----	0.01	mg/L	**0.49**	<0.01	**0.47**	----	----
EK058G: Nitrate as N by Discrete Analyser								
^ Nitrate as N	14797-55-8	0.01	mg/L	**10.2**	**3.07**	**10.8**	----	----
EK059G: NOX as N by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	**10.6**	**3.07**	**11.2**	----	----
EK061: Total Kjeldahl Nitrogen (TKN)								
Total Kjeldahl Nitrogen as N	----	0.1	mg/L	**12.1**	**2.5**	**12.4**	----	----
EK062: Total Nitrogen as N								
^ Total Nitrogen as N	----	0.1	mg/L	**22.8**	**5.6**	**23.6**	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**1.42**	**0.32**	**1.35**	----	----
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	----	0.01	mg/L	<0.01	<0.01	**0.02**	----	----

HAIN OF CUSTODY RECORD
ND ANALYSIS REQUEST

GHD | CLIENTS|PEOPLE|PERFORMANCE

GHD House
239 Adelaide Terrace
Perth WA 6004

PO Box Y3106
Perth WA 6832

Telephone 08 6222 8222
Facsimile 08 6222 8555

5962

oject: Byford LWMS

ient: Urban Solutions

Job No.: 61/24176

boratory Quote No.:

Turnaround Time:

Manager (Invoice): Kelsey Hunt

Email Address (Results): kelsey.hunt@ghd.com.au

Laboratory: ALS

Address: 10 Hodd Way Malaga

Laboratory Contact:

GHD Sample ID	Laboratory Sample ID	Date	Time	Sample Matrix (S-Soil/SL-Sludge/W-Water/A-Air)	Container Type (B-Bottle/J-Jar/V-Vial/Bag G-Glass/P-Plastic)	Container Preservative (Unpreserved/HCl/H_2SO_4/ HNO_3/Other)	Container No	Container Total Volume (mL)	Analyses: Metal Suite N-Z	Analyses: Nutrient Suite NT-X	Analyses: FRP	Analyses: pH	Analyses: EC	Analyses: TSS	Remarks
BH01	1								↕	↕	↕	↕	↕	↕	
BH02	2								↕	↕	↕	↕	↕	↕	
BH03	3								↕	↕	↕	↕	↕	↕	
QA	4								↕	↕	↕	↕	↕	↕	

Please Note:
Please sign white copy on receipt and release of samples. Samples are delivered to Laboratory Address. On receipt of samples laboratory contact should sign white copy and fax to GHD contact at above address. On completion of analyses please return white copy with results. Yellow copy is retained by laborotory. Pink copy is retained by sampler.

Environmental Division
Perth
Work Order
EP0905864

Telephone : +61-8-9209 7655

mpled by:	Kelsey Hunt	Date/Time	13/10/09	Relinquished by:	Date/Time
ceived by:	JobR	Date/Time	14/10/09	Relinquished by:	Date/Time
ceived by Lab:	ALS	Date/Time	11:19	Courier/Transport Company:	
mple Conditions:		Remarks:			

CERTIFICATE OF ANALYSIS

Work Order	: **EP0905864**	Page	: 1 of 3
Client	: **GHD SERVICES PTY LTD**	Laboratory	: Environmental Division Perth
Contact	: KELSEY HUNT	Contact	: Michael Sharp
Address	: GHD HOUSE PO BOX Y3106 PERTH WA, AUSTRALIA 6832	Address	: 10 Hod Way Malaga WA Australia 6090
E-mail	: kelsey.hunt@ghd.com.au	E-mail	: michael.sharp@alsenviro.com
Telephone	: +61 08 6222 8222	Telephone	: +61-8-9209 7655
Facsimile	: +61 08 9429 6555	Facsimile	: +61-8-9209 7600
Project	: 61 24146	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: 5962	Date Samples Received	: 14-OCT-2009
Sampler	: Kelsey Hunt	Issue Date	: 22-OCT-2009
Site	: Byferd LWMS		
		No. of samples received	: 4
Quote number	: EN/005/09	No. of samples analysed	: 4

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

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Ankit Joshi	Inorganic Chemist	Perth Inorganics
Scott James	Assistant Laboratory Manager	Perth Inorganics

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Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When date(s) and/or time(s) are shown bracketed, these have been assumed by the laboratory for processing purposes. If the sampling time is displayed as 0:00 the information was not provided by client.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

Analytical Results

Sub-Matrix: WATER				Client sample ID	BH01	BH02	BH03	QA	----
				Client sampling date / time	13-OCT-2009 15:00	13-OCT-2009 15:00	13-OCT-2009 15:00	13-OCT-2009 15:00	----
Compound	CAS Number	LOR	Unit		EP0905864-001	EP0905864-002	EP0905864-003	EP0905864-004	----
EA005: pH									
pH Value	----	0.01	pH Unit		6.68	6.78	5.49	5.44	----
EA010: Conductivity									
Electrical Conductivity @ 25°C	----	1	µS/cm		2490	395	667	688	----
EA025: Suspended Solids									
^ Suspended Solids (SS)	----	5	mg/L		20500	4500	3900	5740	----
EG020T: Total Metals by ICP-MS									
Arsenic	7440-38-2	0.001	mg/L		0.002	0.001	0.002	0.002	----
Cadmium	7440-43-9	0.0001	mg/L		0.0002	<0.0001	0.0001	<0.0001	----
Chromium	7440-47-3	0.001	mg/L		0.120	0.059	0.052	0.069	----
Copper	7440-50-8	0.001	mg/L		0.326	0.020	0.101	0.122	----
Lead	7439-92-1	0.001	mg/L		0.180	0.033	0.032	0.042	----
Nickel	7440-02-0	0.001	mg/L		0.093	0.024	0.059	0.068	----
Zinc	7440-66-6	0.005	mg/L		0.175	0.027	0.129	0.152	----
EG035T: Total Recoverable Mercury by FIMS									
Mercury	7439-97-6	0.0001	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		0.36	0.04	0.14	0.02	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	----	0.01	mg/L		0.32	0.03	<0.01	<0.01	----
EK058G: Nitrate as N by Discrete Analyser									
^ Nitrate as N	14797-55-8	0.01	mg/L		5.53	13.2	0.62	0.55	----
EK059G: NOX as N by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		5.86	13.2	0.62	0.55	----
EK061: Total Kjeldahl Nitrogen (TKN)									
Total Kjeldahl Nitrogen as N	----	0.1	mg/L		6.6	3.5	3.5	3.6	----
EK062: Total Nitrogen as N									
^ Total Nitrogen as N	----	0.1	mg/L		12.5	16.7	4.2	4.1	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		2.52	0.74	0.72	0.74	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	----	0.01	mg/L		0.08	0.04	0.01	0.01	----

Appendix B

Tabulated Monitoring Results

Monitoring Event - 20 July 2009

Description	LOR[1]	Units	ANZECC 2000[2]	Groundwater Monitoring Bore Holes			
Reference				BH01	BH02	BH03	QA1
Laboratory Reference					EP0903981-001	EP0903981-002	EP0903981-003
Date				20/07/09	20/07/09	20/07/09	20/07/09
Field Measurements							
Easting	-	m	-	406246	406143	406304	
Northing	-	m	-	6432554	6432812	6433334	
Elevation (mAHD)	-	m	-	60.273	57.129	59.564	
WL (bTOC)	-	m	-		0.588	1.827	
Depth (bTOC)	-	m	-		4.532	5.528	
Bore Diameter	-	m	-		0.05	0.05	
WL (mAHD)	-	m	-		56.541	57.737	
Static Volume	-	L	-		7.70	7.26	
Purge Volume	-	L	-		24	22.0	
Temperature	-	deg C	-		17.91	19.60	
pH	-	units	6.5-8.0		6.57	5.91	
E Cond	-	µS/cm	**120 - 300**		632	647	
DO	-	ppm	-		2.55	2.80	
Eh (as ORP)	-	mV	-				
TDS	-	ppm	-				
Observation				Dry	Murky brown		
Metals*							
Arsenic	0.001	mg/L	0.013		0.002	0.002	0.002
Cadmium	0.0001	mg/L	0.0002		0.0004	0.0003	0.0004
Chromium	0.001	mg/L	0.01		0.227	0.027	0.173
Copper	0.001	mg/L	0.0014		0.271	0.052	0.248
Lead	0.001	mg/L	0.0034		0.249	0.026	0.208
Mercury	0.0001	mg/L	0.0006		0.0002	<0.0001	0.0002
Nickel	0.001	mg/L	0.011		0.099	0.04	0.089
Zinc	0.005	mg/L	0.008		0.157	0.087	0.145
Physio-chemical							
pH	0.01	units	6.5-8.0		6.74	5.98	6.74
E Cond	1	µS/cm	**120 - 300**		681	710	684
TSS	5	mg/L	-				
Total N	0.1	mg/L	1.2		22.8	5.6	23.6
Ammonia - N	0.01	mg/L	0.08		0.99	0.08	0.98
Nitrate - N	0.01	mg/L	3.1*		10.2	3.07	10.8
Nitrite - N	0.01	mg/L	-		0.49	<0.01	0.47
NOX - N	0.01	mg/L	0.15		10.6	3.07	11.2
TKN	0.1	mg/L	-		12.1	2.5	12.4
Total P	0.01	mg/L	0.065		1.42	0.32	1.35
Reactive P	0.01	mg/L	-		<0.01	<0.01	0.02

Notes:

1. Limit of Reporting

2. Assessment criteria from Tables 3.3.6-3.3.7 and Table 3.4.1 of the *National Water Quality Management Strategy : Australian and Ne*

Indicates those values exceeding ANZECC guidelines for South-West WA Lowland River physio-c

* Contaminated Sites Management Series: Assessment Levels for Soil, Sediment and Water (DEC, 2003)

^ Assessment criteria from Table 5.2.2 of the *National Water Quality Management Strategy : Australian and New Zealand Guidelines fo*

- No value

^^ Estimated value (ALS).

Monitoring Event - 13 October 2009

Description	LOR[1]	Units	ANZECC 2000[2]	Groundwater Monitoring Bore Holes			
Reference				BH01	BH02	BH03	QA1
Laboratory Reference				EP0905864-001	EP0905864-002	EP0905864-003	EP0905864-004
Date				13/10/09	13/10/09	13/10/09	13/10/09
Field Measurements							
Easting	-	m	-	406246	406143	406304	
Northing	-	m	-	6432554	6432812	6433334	
Elevation (mAHD)	-	m	-	60.273	57.129	59.564	
WL (bTOC)	-	m	-	1.61	1.217	1.829	
Depth (bTOC)	-	m	-	5.31	4.532	5.506	
Bore Diameter	-	m	-	0.05	0.05	0.05	
WL (mAHD)	-	m	-	58.663	55.912	57.735	
Static Volume	-	L	-	7.26	6.50	7.22	
Purge Volume	-	L	-	22	20	22	
Temperature	-	deg C	-	17.04	16.95	18.23	
pH	-	units	6.5-8.0	6.39	6.38	5.07	
E Cond	-	µS/cm	**120 - 300**	2,430	433	809	
DO	-	ppm	-	3.20	1.94	1.31	
Eh (as ORP)	-	mV	-	143.0	143.0	183.0	
TDS	-	ppm	-	1,600	3,000	5,000.0	
Observation				Light brown, silty	Rust brown, silty	Cloudy white	
Metals*							
Arsenic	0.001	mg/L	0.013	0.002	0.001	0.002	0.002
Cadmium	0.0001	mg/L	0.0002	0.0002	<0.0001	0.0001	<0.0001
Chromium	0.001	mg/L	0.01	0.12	0.059	0.052	0.069
Copper	0.001	mg/L	0.0014	0.326	0.02	0.101	0.122
Lead	0.001	mg/L	0.0034	0.18	0.033	0.032	0.042
Mercury	0.0001	mg/L	0.0006	<0.0001	<0.0001	<0.0001	<0.0001
Nickel	0.001	mg/L	0.011	0.093	0.024	0.059	0.068
Zinc	0.005	mg/L	0.008	0.175	0.027	0.129	0.152
Physio-chemical							
pH	0.01	units	6.5-8.0	6.68	6.78	5.49	5.44
E Cond	1	µS/cm	**120 - 300**	2490	395	667	688
SS	5	mg/L	-	20500	4500	3900	5740
Total N	0.1	mg/L	1.2	12.5	16.7	4.2	4.1
Ammonia - N	0.01	mg/L	0.08	0.36	0.04	0.14	0.02
Nitrate - N	0.01	mg/L	3.1*	5.53	13.2	0.62	0.55
Nitrite - N	0.01	mg/L	-	0.32	0.03	<0.01	<0.01
NOX - N	0.01	mg/L	0.15	5.86	13.2	0.62	0.55
TKN	0.1	mg/L	-	6.6	3.5	3.5	3.6
Total P	0.01	mg/L	0.065	2.52	0.74	0.72	0.74
Reactive P	0.01	mg/L	-	0.08	0.04	0.01	0.01

Notes:

1. Limit of Reporting

2. Assessment criteria from Tables 3.3.6-3.3.7 and Table 3.4.1 of the *National Water Quality Management Strategy : Australian and New*

Indicates those values exceeding ANZECC guidelines for South-West WA Lowland River physio-che

* Contaminated Sites Management Series: Assessment Levels for Soil, Sediment and Water (DEC, 2003)

^ Assessment criteria from Table 5.2.2 of the *National Water Quality Management Strategy : Australian and New Zealand Guidelines for F*

- No value

^^ Estimated value (ALS).

Appendix C

RPD summaries

RPD Calculation
Monitoring Event - 20 July 2009

Reference	BH02		
Sample Type	**Primary**	**Duplicate**	**RPD**
Date	20/07/09	20/07/09	
Metals			
Arsenic	0.002	0.002	0.0 %
Cadmium	0.0004	0.0004	0.0 %
Chromium (Total)	0.227	0.173	**27.0 %**
Copper	0.271	0.248	8.9 %
Lead	0.249	0.208	**17.9 %**
Nickel	0.099	0.089	**10.6 %**
Zinc	0.157	0.145	7.9 %
Mercury	0.0002	0.0002	0.0 %
Physio-chemical			
pH	6.74	6.74	0.0 %
E Cond	681	684	0.4 %
TSS	0	0	0.0 %
Total N	22.8	23.6	3.4 %
Total P	1.42	1.35	5.1 %
Reactive P	<0.01	0.02	**120.0 %**
Ammonia-N	0.99	0.98	1.0 %
Nitrate - N	10.2	10.8	5.7 %
Nitrite - N	0.49	0.47	4.2 %

Bolding indicates RPD above maximum expected range

RPD Calculation
Monitoring Event - 13 October 2009

Reference	BH03		
Sample Type	**Primary**	**Duplicate**	**RPD**
Date	13/10/09	13/10/09	
Metals			
Arsenic	0.002	0.002	0.0 %
Cadmium	0.0001	<0.0001	**133.3 %**
Chromium (Total)	0.052	0.069	**28.1 %**
Copper	0.101	0.122	**18.8 %**
Lead	0.032	0.042	**27.0 %**
Nickel	0.059	0.068	**14.2 %**
Zinc	0.129	0.152	**16.4 %**
Mercury	<0.0001	<0.0001	**< LOR**
Physio-chemical			
pH	5.49	5.44	0.9 %
E Cond	667	688	3.1 %
TSS	3900	5740	**38.2 %**
Total N	4.2	4.1	2.4 %
Total P	0.72	0.74	2.7 %
Reactive P	0.01	0.01	0.0 %
Ammonia-N	0.14	0.02	**150.0 %**
Nitrate - N	0.62	0.55	**12.0 %**
Nitrite - N	<0.01	<0.01	**< LOR**

Bolding indicates RPD above maximum expected range

GHD

GHD House, 239 Adelaide Tce. Perth, WA 6004
P.O. Box 3106, Perth WA 6832
T: 61 8 6222 8222 F: 61 8 6222 8555 E: permail@ghd.com.au

Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
Draft	K. Hunt	J. Romero		J. Romero		23-Mar-10
1	K. Hunt	K. Hunt		J. Romero		3-Nov-10

Appendix E

Geotechnical Investigation

Douglas Partners (2007)

Douglas Partners
Geotechnics • Environment • Groundwater

Integrated Practical Solutions

REPORT
ON
GEOTECHNICAL INVESTIGATION

PROPOSED INDUSTRIAL SUBDIVISION
LOT 3 SOUTH WESTERN HIGHWAY
BYFORD, WA

Prepared for
COLLI NOMINEES PTY LTD

PROJECT 46723
NOVEMBER 2007

Douglas Partners
Geotechnics • Environment • Groundwater

REPORT
ON
GEOTECHNICAL INVESTIGATION

PROPOSED INDUSTRIAL SUBDIVISION
LOT 3 SOUTH WESTERN HIGHWAY
BYFORD, WA

Prepared for
COLLI NOMINEES PTY LTD

PROJECT 46723
NOVEMBER 2007

Douglas Partners Pty Ltd
ABN 75 053 980 117

36 O`Malley Street
Osborne Park WA 6017
Australia

Phone: ***(08) 9204 3511***
Fax: *(08) 9204 3522*
e-mail: *perth@douglaspartners.com.au*

ACEA
The Association of Consulting Engineers Australia

TABLE OF CONTENTS

CC
Project No: 46723
29 November 2007

REPORT ON
GEOTECHNICAL INVESTIGATION
PROPOSED INDUSTRIAL SUBDIVISION
LOT 3 SOUTH WESTERN HIGHWAY, BYFORD, WA

1. INTRODUCTION

This report presents the results of a geotechnical investigation carried out for a proposed industrial subdivision at Lot 3 South Western Highway, Byford, WA. This investigation was commissioned by John Ranieri of PFR in a fax dated 12 October 2007 and was undertaken in general accordance with Douglas Partners' proposal dated 26 September 2007.

The purpose of the investigation was to assess the shallow sub surface conditions beneath the proposed development and thus:

- determine the suitability of the land to support the proposed development;
- determine the depth to rock, if encountered;
- assess filling material from a geotechnical perspective, if encountered;
- provide suitable classification of the site in accordance with the requirements of AS2870;
- provide recommendations regarding site preparation, compaction and earthworks, if required, so as to allow the development of the site;
- suggest appropriate foundation system(s) for the proposed structures, including assessment of allowable bearing pressures and likely settlements; and
- assess the permeability of the soils.

Details of the field work programme and geotechnical laboratory testing carried out are presented in this report, together with recommendations on the issues listed above.

2. SITE DESCRIPTION

The site is approximately 6 ha in area and is bounded by Pinebrook Road to the south, South Western Highway to the east and a railway line to the west. A drainage reserve lies to the north (Refer to Drawing 1, Appendix A).

At the time of the investigation the surface of the site was generally covered with grass. A dam covered an area of approximately 30 m x 12 m in the north-western corner of the site. Survey data provided by PFR indicates that surface levels across the site range from approximately 55.7 m AHD to 60.5 m AHD.

The Armadale 1:50 000 Environmental Geology sheet indicates that shallow sub surface conditions beneath the site comprise colluvial gravelly sandy clay. The Perth Groundwater Atlas (2004) indicates that the level of the regional surficial aquifer was approximately 26 m to 30 m below the existing surface level in May 2003.

3. FIELD WORK METHODS

Field work was carried out on 1 November 2007 and comprised the excavation of sixteen test pits with adjacent dynamic cone penetrometer (DCP) tests and two in-situ permeability tests.

A 5 tonne excavator equipped with a 400 mm wide bucket was used to excavate the test pits to a maximum depth of 2.2 m. Representative soil samples were recovered from selected test locations for subsequent laboratory analysis for the assessment of geotechnical parameters.

DCP testing was carried out adjacent to each test location to assess the *in situ* conditions of the shallow ground. This testing was carried out in accordance with AS1289.6.3.2.

The ground condition at each test location was logged in general accordance with AS1726 by a suitably experienced geotechnical engineer from Douglas Partners.

Permeability testing using the falling head and constant head methods were carried out at depths of 0.4 m and 0.7 m respectively adjacent to test locations TP2 and TP8.

Test sites were located using a hand held GPS and are shown on Drawing 1 in Appendix A. The surface level at each test location was interpolated from a contour plan provided by PFR.

4. FIELD WORK RESULTS

4.1 Ground Conditions

Detailed logs of ground conditions at the test locations and results of field testing are presented in Appendix B, together with notes defining descriptive terms and classification methods used.

Ground conditions encountered beneath the site generally comprised grey-brown slightly gravelly clayey sand overlying orange brown mottled grey brown clayey sandy material with a variable amount of gravel. A description of the general profile is outlined below:

TOPSOIL – sandy topsoil, up to 0.2 m thick;

CLAYEY SAND – medium dense to dense, grey brown slightly gravelly clayey sand was encountered to depths of between 0.45 m and 0.70 m at test locations TP1 to TP6. Sand with some clay to clayey sand with a variable amount of gravel was encountered at test locations TP7 to TP16;

GRAVELLY SANDY CLAY / GRAVELLY CLAYEY SAND – hard / medium dense to dense, orange brown mottled grey-brown gravelly sandy clay was encountered beneath the clayey sandy layer to depth of 1.2 m at test locations TP4 and TP11 and gravelly clayey sand was encountered to termination depth at test locations TP6, TP9, TP14 and TP15;

CLAYEY SAND / SANDY CLAY– medium dense to dense / very stiff to hard, orange-brown mottled grey-brown clayey sand with a variable amount of gravel was encountered at test locations TP1 to TP5, TP7, TP8, TP10 to TP13 and TP16 to termination depths.

4.2 Groundwater

Slight groundwater seepage was observed within the test pits between depths of 1.9 m and 2.0 m at test locations TP1, TP4 and TP9. This water was possibly perched on clayey material encountered at these depths. Free groundwater was not observed within the other test pits while they remained open to a depth of 2.2 m.

4.3 Results of Permeability Testing

Permeability testing were carried out using both the falling head and the constant head methods at depths of 0.4 m and 0.7 m respectively adjacent to test locations TP2 and TP8. Results of these *in situ* permeability tests are summarised in Table 1.

Table 1 – Result of In Situ Permeability Testing

Test Location	Depth (m)	Soil Description	Estimated Coefficient of Permeability (m/s)
TP2	0.4	CLAYEY SAND - grey brown slightly gravelly	1.8×10^{-5}
TP8	0.7	CLAYEY SAND – orange brown mottled grey brown slightly gravelly	2.5×10^{-6}

5. GEOTECHNICAL LABORATORY TESTING

A geotechnical laboratory testing programme was carried out on selected soil samples by a NATA registered laboratory and comprised the determination of:

- the particle size distribution on five samples; and
- Atterberg limits and linear shrinkage on three samples.

Results of the testing are summarised in Table 2 and test certificates are presented in Appendix C.

Table 2 – Summary of Geotechnical Laboratory Test Results

Test	Depth (m)	Soil Type	% fines	d_{10} (mm)	d_{60} (mm)	LL (%)	PL (%)	PI (%)	LS (%)
TP1	0.5	CLAYEY SAND - grey brown	20	0.015	0.500	SIC	NP	NP	0.0
TP2	1.4	CLAYEY SAND - orange brown mottled grey brown	39	<0.0135	0.330	-	-	-	-
TP8	1.1	CLAYEY SAND - orange brown mottled grey brown	39	<0.0135	0.420	48	21	27	10.0
TP9	1.9	GRAVELLY CLAYEY SAND - orange brown mottled grey brown	32	<0.0135	0.600	-	-	-	-
TP16	1.5	SANDY CLAY - orange brown mottled grey brown	69	<0.0135	0.034	45	16	29	8.5

Notes:
- The %Fines is the amount of particles smaller than 75 µm;
- A d_{10} of 0.17 mm means that 10 % of the sample particles finer than 0.17 mm;
- A d_{60} of 0.23 mm means that 10 % of the sample particles finer than 0.23 mm;
- '-' means not tested;
- LL: Liquid Limit;
- PL: Plastic Limit;
- PI: Plasticity Index;
- LS: Linear Shrinkage;
- SIC: Slipped in Cup; and
- NP: Non Plastic.

6. ENGINEERING EVALUATION AND RECOMMENDATIONS

6.1 Proposed Development

It is understood that the proposed development will comprise the construction of an industrial subdivision.

6.2 Site Classification

As noted in Section 4, ground conditions beneath the site generally comprised grey brown slightly gravelly clayey sand overlying orange brown mottled grey brown clayey sandy materials with variable amount of gravel

The results of the laboratory testing suggest that the clayey sand and sandy clay are moderately reactive to moisture changes, therefore the site should be classified as 'Class M' in accordance with AS2870, provided site preparation is carried out as detailed in Section 7.3. This

classification could possibly be revised to a Class S or Class A, provided that respectively 0.7 m or 1.8 m of non-reactive material exists or is placed over the reactive clayey layers. Recommendations regarding the placement of non-reactive filling are given in Section 6.3 below.

6.3 Site Preparation and Compaction

Prior to excavation of foundations and/or placement of fill, all deleterious material, including vegetation and topsoil should be stripped from within each building envelope and either removed from site or stockpiled for possible re-use in landscaping. Topsoil was encountered to depths up to 0.2 m across the site. Tree roots remaining from any clearing operations should be completely removed and the excavation backfilled with suitably compacted structural filling. A dam was noted in the north-western corner of the site. It is recommended that the dam be backfilled.

Following removal of unsuitable material and prior to any filling, it is recommended that each building envelope and cut areas be proof rolled using a medium to heavy (minimum 6 tonne) vibrating smooth drum roller for areas underlain by sand to achieve a dry density ratio of not less than 100% SMDD and the use of a sheep foot roller is recommended on clayey ground to achieve a dry density ratio of not less than 95% MMDD. It should be noted that the clayey materials are generally very stiff. It is therefore recommended that disturbance, thus loosening and softening of the clayey ground be minimised, if feasible. Care should be taken not to run heavy plant immediately adjacent to existing buildings and services.

Imported structural fill should comprise a clean, cohesionless, free draining sand, which is free of all organic and other deleterious material. The sand should contain no more than 5% (by weight) of fractions finer than 0.075 mm and no material greater than a nominal size of 150 mm. Sand should be placed close to its optimum moisture content, in layers not exceeding a loose lift thickness of 300 mm, each layer compacted to achieve a dry density ratio of not less than 100% SMDD.

The shallow sand encountered across the site could be reused as structural filling provided it is excavated and screened from any deleterious material prior to reuse. The sand, after treatment, should be placed close to its optimum moisture content, in layers not exceeding a loose lift thickness of 300 mm and compacted to achieve a dry density ratio of not less than 100% SMDD.

It should be noted that this sand contained some clay and should therefore not be classed as free draining material.

Compaction control of existing sand and imported sand could be carried out using a Perth Sand Penetrometer (PSP) in accordance with AS 1289.6.3.3. Owing to the unknown nature of the imported material, compaction control using a Perth sand penetrometer should be carried out only following determination of the relationship between soil dry density and number of PSP blows.

During construction, some loosening of the surface sand in foundation excavations is expected. Therefore the top 300 mm in the base of any foundation excavation should be re-compacted with a vibratory plate compactor prior to footing construction. Adequate compaction should be confirmed by carrying out PSP tests, as detailed above.

6.4 Foundation Design

Shallow foundation systems comprising slab, pad and strip footings founded in the medium dense to dense clayey sand should be able to support the proposed structures, providing site preparation is carried out as described in Section 6.3. Footings of buildings covered by AS2870 should be designed to satisfy the requirements of this standard for the appropriate site classification detailed in Section 6.2. It is emphasised that AS2870 applies to single houses, townhouses and the like classified as Class 1 and 10a under the Building Code of Australia.

Provided site preparation is carried out as detailed in Section 6.3, a maximum allowable bearing pressure of 150 kPa is suggested for foundation design of strip footings founded in medium dense to dense clayey sand. This should ensure that total and differential settlements will be less than 5 mm, the bulk of which should occur during construction.

It should be noted that the settlement estimate given above does not incorporate possible movements induced by the seasonal swelling and shrinkage of the reactive clays beneath the site. It is recommended that provisions be made for these movements by designing the structures in accordance with the requirements of AS2870.

6.5 Soil Permeability

As discussed in Section 4.1, the shallow ground conditions beneath the site generally comprise grey brown slightly gravelly clayey sand overlying orange brown mottled grey sandy clayey materials with variable amount of gravel. Results of the in situ permeability tests indicate permeability values of $1.8X10^{-5}$ m/s and $2.5X10^{-6}$ m/s for the clayey sand at depths of 0.4 m and 0.7 m respectively. It is therefore recommended that a soil permeability value of $1.0X10^{-7}$ m/s be adopted for the shallow soils across the site.

6.6 Drainage

It is recommended that a suitable drainage strategy be implemented in order to direct subsoil and surface water away from the proposed building envelopes.

If the proposed buildings are founded in the clayey material, suitable drainage could comprise:

- the installation of sub soil drains along the perimeter of the buildings in order to direct groundwater towards a suitable outflow; and
- ground surface grading away from the buildings.

If the site surface is raised using free draining material and the proposed buildings are founded in this filling, it is suggested that the surface of the clayey subgrade at the base of the sand filling be shaped prior to filling in order to direct groundwater into a suitable sub soil drainage network with a suitable outflow.

As noted above, moderately reactive clays occur beneath the site. Therefore, differential ground movements may occur beneath proposed structures following seasonal changes in soil moisture content.

It is therefore recommended that attention be paid to minimise moisture content changes within these clayey materials through the adoption of appropriate measures, such as ensuring that:

i) the site is well drained, both during construction and throughout the life of the structures. Surface water should not be allowed to accumulate in footing excavations during construction or near any footing systems of the proposed buildings. Surface water should be controlled and directed away from the proposed building;

ii) excessive drying and wetting of the exposed clayey materials be minimised. Excessive wetting of the base of the foundation excavations would also lead to softening of the clayey foundation materials. Drying could be avoided by minimising the amount of time during which the base of the excavation is exposed;

iii) plumbing systems be maintained and repaired to avoid leaks beneath and around structures;

iv) no large trees be planted or removed adjacent to structures; and

v) irregular or excessive watering around the structures be avoided.

For further advice on protecting structures overlying clayey soils, reference should be made to the CSIRO note, entitled 'Foundation Maintenance and Footing Performance: A Homeowner's Guide', which is attached in Appendix D of this report.

7. REFERENCES

1. Australian Standard AS 2870-1996, Residential Slabs and Footings.
2. Department of Environment (2004), Perth Groundwater Atlas, Second Edition
3. Australian Standard AS 1289-2000, Methods of Testing Soils for Engineering Purposes
4. Australian Standard AS 1726-1993, Geotechnical Site Investigations

DOUGLAS PARTNERS PTY LTD

Reviewed by:

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Caroline Chopier
Geotechnical Engineer

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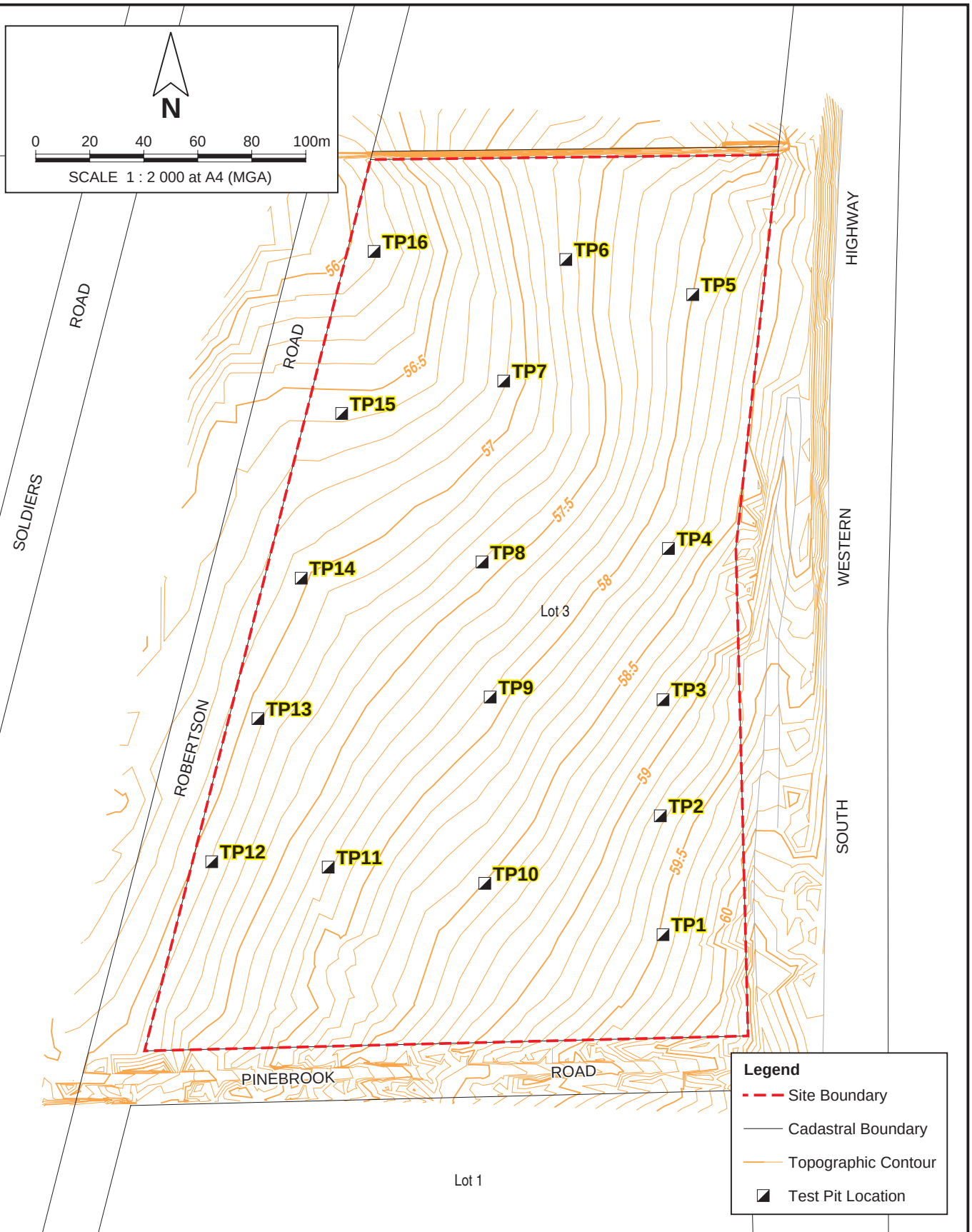
Principal

APPENDIX A

Site Plan and Test Locations



Douglas Partners
Geotechnics • Environment • Groundwater

Sydney, Newcastle, Brisbane, Melbourne, Perth, Wyong

Campbelltown, Townsville, Wollongong, Darwin, Cairns

Title:

TEST LOCATION PLAN

Client: COLLI NOMINEES PTY LTD - LOT 3 SOUTH WESTERN HIGHWAY, BYFORD, WA			Office: PERTH	
Drawn By: C. CHOPIER	Scale: 1 : 2 000	Project No: 46723	DRAWING 1	Revision: A
Approved By: --		Date: 22-11-07		

Thu 22 Nov 07

46723-d01.dgn

PINPOINT CARTOGRAPHICS (08) 9277 7763

APPENDIX B

Field Work Results

Notes Relating to this Report

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NOTES RELATING TO THIS REPORT

Introduction

These notes have been provided to amplify the geotechnical report in regard to classification methods, specialist field procedures and certain matters relating to the Discussion and Comments section. Not all, of course, are necessarily relevant to all reports.

Geotechnical reports are based on information gained from limited subsurface test boring and sampling, supplemented by knowledge of local geology and experience. For this reason, they must be regarded as interpretive rather than factual documents, limited to some extent by the scope of information on which they rely.

Description and Classification Methods

The methods of description and classification of soils and rocks used in this report are based on Australian Standard 1726, Geotechnical Site Investigations Code. In general, descriptions cover the following properties - strength or density, colour, structure, soil or rock type and inclusions.

Soil types are described according to the predominating particle size, qualified by the grading of other particles present (eg. sandy clay) on the following bases:

Soil Classification	Particle Size
Clay	less than 0.002 mm
Silt	0.002 to 0.06 mm
Sand	0.06 to 2.00 mm
Gravel	2.00 to 60.00 mm

Cohesive soils are classified on the basis of strength either by laboratory testing or engineering examination. The strength terms are defined as follows.

Classification	Undrained Shear Strength kPa
Very soft	less than 12
Soft	12—25
Firm	25—50
Stiff	50—100
Very stiff	100—200
Hard	Greater than 200

Non-cohesive soils are classified on the basis of relative density, generally from the results of standard penetration tests (SPT) or Dutch cone penetrometer tests (CPT) as below:

Relative Density	SPT "N" Value (blows/300 mm)	CPT Cone Value (q_c — MPa)
Very loose	less than 5	less than 2
Loose	5—10	2—5
Medium dense	10—30	5—15
Dense	30—50	15—25
Very dense	greater than 50	greater than 25

Rock types are classified by their geological names. Where relevant, further information regarding rock classification is given on the following sheet.

Sampling

Sampling is carried out during drilling to allow engineering examination (and laboratory testing where required) of the soil or rock.

Disturbed samples taken during drilling provide information on colour, type, inclusions and, depending upon the degree of disturbance, some information on strength and structure.

Undisturbed samples are taken by pushing a thin-walled sample tube into the soil and withdrawing with a sample of the soil in a relatively undisturbed state. Such samples yield information on structure and strength, and are necessary for laboratory determination of shear strength and compressibility. Undisturbed sampling is generally effective only in cohesive soils.

Details of the type and method of sampling are given in the report.

Drilling Methods.

The following is a brief summary of drilling methods currently adopted by the Company and some comments on their use and application.

Test Pits — these are excavated with a backhoe or a tracked excavator, allowing close examination of the in-situ soils if it is safe to descent into the pit. The depth of penetration is limited to about 3 m for a backhoe and up to 6 m for an excavator. A potential disadvantage is the disturbance caused by the excavation.

Large Diameter Auger (eg. Pengo) — the hole is advanced by a rotating plate or short spiral auger, generally 300 mm or larger in diameter. The cuttings are returned to the surface at intervals (generally of not more than 0.5 m) and are disturbed but usually unchanged in moisture content. Identification of soil strata is generally much more reliable than with continuous spiral flight augers, and is usually supplemented by occasional undisturbed tube sampling.

Continuous Sample Drilling — the hole is advanced by pushing a 100 mm diameter socket into the ground and withdrawing it at intervals to extrude the sample. This is the most reliable method of drilling in soils, since moisture content is unchanged and soil structure, strength, etc. is only marginally affected.

Continuous Spiral Flight Augers — the hole is advanced using 90—115 mm diameter continuous spiral flight augers which are withdrawn at intervals to allow sampling or in-situ testing. This is a relatively economical means of drilling in

clays and in sands above the water table. Samples are returned to the surface, or may be collected after withdrawal of the auger flights, but they are very disturbed and may be contaminated. Information from the drilling (as distinct from specific sampling by SPTs or undisturbed samples) is of relatively lower reliability, due to remoulding, contamination or softening of samples by ground water.

Non-core Rotary Drilling — the hole is advanced by a rotary bit, with water being pumped down the drill rods and returned up the annulus, carrying the drill cuttings. Only major changes in stratification can be determined from the cuttings, together with some information from 'feel' and rate of penetration.

Rotary Mud Drilling — similar to rotary drilling, but using drilling mud as a circulating fluid. The mud tends to mask the cuttings and reliable identification is again only possible from separate intact sampling (eg. from SPT).

Continuous Core Drilling — a continuous core sample is obtained using a diamond-tipped core barrel, usually 50 mm internal diameter. Provided full core recovery is achieved (which is not always possible in very weak rocks and granular soils), this technique provides a very reliable (but relatively expensive) method of investigation.

Standard Penetration Tests

Standard penetration tests (abbreviated as SPT) are used mainly in non-cohesive soils, but occasionally also in cohesive soils as a means of determining density or strength and also of obtaining a relatively undisturbed sample. The test procedure is described in Australian Standard 1289, "Methods of Testing Soils for Engineering Purposes" — Test 6.3.1.

The test is carried out in a borehole by driving a 50 mm diameter split sample tube under the impact of a 63 kg hammer with a free fall of 760 mm. It is normal for the tube to be driven in three successive 150 mm increments and the 'N' value is taken as the number of blows for the last 300 mm. In dense sands, very hard clays or weak rock, the full 450 mm penetration may not be practicable and the test is discontinued.

The test results are reported in the following form.

- In the case where full penetration is obtained with successive blow counts for each 150 mm of say 4, 6 and 7

  as 4, 6, 7
  N = 13

- In the case where the test is discontinued short of full penetration, say after 15 blows for the first 150 mm and 30 blows for the next 40 mm

  as 15, 30/40 mm.

The results of the tests can be related empirically to the engineering properties of the soil.

Occasionally, the test method is used to obtain samples in 50 mm diameter thin walled sample tubes in clays. In such circumstances, the test results are shown on the borelogs in brackets.

Cone Penetrometer Testing and Interpretation

Cone penetrometer testing (sometimes referred to as Dutch cone — abbreviated as CPT) described in this report has been carried out using an electrical friction cone penetrometer. The test is described in Australian Standard 1289, Test 6.4.1.

In the tests, a 35 mm diameter rod with a cone-tipped end is pushed continuously into the soil, the reaction being provided by a specially designed truck or rig which is fitted with an hydraulic ram system. Measurements are made of the end bearing resistance on the cone and the friction resistance on a separate 130 mm long sleeve, immediately behind the cone. Transducers in the tip of the assembly are connected by electrical wires passing through the centre of the push rods to an amplifier and recorder unit mounted on the control truck.

As penetration occurs (at a rate of approximately 20 mm per second) the information is plotted on a computer screen and at the end of the test is stored on the computer for later plotting of the results.

The information provided on the plotted results comprises: —

- Cone resistance — the actual end bearing force divided by the cross sectional area of the cone — expressed in MPa.
- Sleeve friction — the frictional force on the sleeve divided by the surface area — expressed in kPa.
- Friction ratio — the ratio of sleeve friction to cone resistance, expressed in percent.

There are two scales available for measurement of cone resistance. The lower scale (0—5 MPa) is used in very soft soils where increased sensitivity is required and is shown in the graphs as a dotted line. The main scale (0—50 MPa) is less sensitive and is shown as a full line.

The ratios of the sleeve friction to cone resistance will vary with the type of soil encountered, with higher relative friction in clays than in sands. Friction ratios of 1%—2% are commonly encountered in sands and very soft clays rising to 4%—10% in stiff clays.

In sands, the relationship between cone resistance and SPT value is commonly in the range:—

q_c (MPa) = (0.4 to 0.6) N (blows per 300 mm)

In clays, the relationship between undrained shear strength and cone resistance is commonly in the range:—

q_c = (12 to 18) c_u

Interpretation of CPT values can also be made to allow estimation of modulus or compressibility values to allow calculation of foundation settlements.

Inferred stratification as shown on the attached reports is assessed from the cone and friction traces and from experience and information from nearby boreholes, etc. This information is presented for general guidance, but must be regarded as being to some extent interpretive. The test method provides a continuous profile of engineering properties, and where precise information on soil classification is required, direct drilling and sampling may be preferable.

Hand Penetrometers

Hand penetrometer tests are carried out by driving a rod into the ground with a falling weight hammer and measuring the blows for successive 150 mm increments of penetration. Normally, there is a depth limitation of 1.2 m but this may be extended in certain conditions by the use of extension rods.

Two relatively similar tests are used.

- Perth sand penetrometer — a 16 mm diameter flat-ended rod is driven with a 9 kg hammer, dropping 600 mm (AS 1289, Test 6.3.3). This test was developed for testing the density of sands (originating in Perth) and is mainly used in granular soils and filling.
- Cone penetrometer (sometimes known as the Scala Penetrometer) — a 16 mm rod with a 20 mm diameter cone end is driven with a 9 kg hammer dropping 510 mm (AS 1289, Test 6.3.2). The test was developed initially for pavement subgrade investigations, and published correlations of the test results with California bearing ratio have been published by various Road Authorities.

Laboratory Testing

Laboratory testing is carried out in accordance with Australian Standard 1289 "Methods of Testing Soil for Engineering Purposes". Details of the test procedure used are given on the individual report forms.

Bore Logs

The bore logs presented herein are an engineering and/or geological interpretation of the subsurface conditions, and their reliability will depend to some extent on frequency of sampling and the method of drilling. Ideally, continuous undisturbed sampling or core drilling will provide the most reliable assessment, but this is not always practicable, or possible to justify on economic grounds. In any case, the boreholes represent only a very small sample of the total subsurface profile.

Interpretation of the information and its application to design and construction should therefore take into account the spacing of boreholes, the frequency of sampling and the possibility of other than 'straight line' variations between the boreholes.

Ground Water

Where ground water levels are measured in boreholes, there are several potential problems;

- In low permeability soils, ground water although present, may enter the hole slowly or perhaps not at all during the time it is left open.
- A localised perched water table may lead to an erroneous indication of the true water table.
- Water table levels will vary from time to time with seasons or recent weather changes. They may not be the same at the time of construction as are indicated in the report.
- The use of water or mud as a drilling fluid will mask any ground water inflow. Water has to be blown out of the hole and drilling mud must first be washed out of the hole if water observations are to be made.

More reliable measurements can be made by installing standpipes which are read at intervals over several days, or perhaps weeks for low permeability soils. Piezometers, sealed in a particular stratum, may be advisable in low permeability soils or where there may be interference from a perched water table.

Engineering Reports

Engineering reports are prepared by qualified personnel and are based on the information obtained and on current engineering standards of interpretation and analysis. Where the report has been prepared for a specific design proposal (eg. a three storey building), the information and interpretation may not be relevant if the design proposal is changed (eg. to a twenty storey building). If this happens, the Company will be pleased to review the report and the sufficiency of the investigation work.

Every care is taken with the report as it relates to interpretation of subsurface condition, discussion of geotechnical aspects and recommendations or suggestions for design and construction. However, the Company cannot always anticipate or assume responsibility for:

- unexpected variations in ground conditions — the potential for this will depend partly on bore spacing and sampling frequency
- changes in policy or interpretation of policy by statutory authorities
- the actions of contractors responding to commercial pressures.

If these occur, the Company will be pleased to assist with investigation or advice to resolve the matter.

Site Anomalies

In the event that conditions encountered on site during construction appear to vary from those which were expected from the information contained in the report, the Company requests that it immediately be notified. Most problems are much more readily resolved when conditions are exposed than at some later stage, well after the event.

Reproduction of Information for Contractual Purposes

Attention is drawn to the document "Guidelines for the Provision of Geotechnical Information in Tender Documents", published by the Institution of Engineers, Australia. Where information obtained from this investigation is provided for tendering purposes, it is recommended that all information, including the written report and discussion, be made available. In circumstances where the discussion or comments section

is not relevant to the contractual situation, it may be appropriate to prepare a specially edited document. The Company would be pleased to assist in this regard and/or to make additional report copies available for contract purposes at a nominal charge.

Site Inspection

The Company will always be pleased to provide engineering inspection services for geotechnical aspects of work to which this report is related. This could range from a site visit to confirm that conditions exposed are as expected, to full time engineering presence on site.

GHD

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	A Barrett-Lennard	N Deeks	On File	N Deeks	On File	10/1/11
1	A Barrett-Lennard	N Deeks	On File	N Deeks	On File	7/6/2011
2	N Deeks	N Deeks	On File	N Deeks	On File	4/7/2012

Appendix 3

Flora & Vegetation Assessment

Flora and Vegetation Assessment

Lots 1, 3 and 128 South Western Highway

Byford

May 2010

Flora and Vegetation Assessment

Lots 1, 3 and 128 South Western Highway

Byford

Landform Research
Land Systems - Quarries - Environment
ABN 29 841 445 694

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Contents

Tables

Figures

Vegetation Assessment, Lots 1, 3 and 128 South Western Highway, Byford

20 August 2011

1.0 INTRODUCTION

An assessment of the vegetation of Lots 1, 3 and 128 South Western Highway was conducted to provide comment on the type of vegetation present on site and its significance.

It is bounded to the south by Cardup Siding Road.

Brickwood Reserve, west of the rail reserve, is near the north western corner. This reserve is listed under Commonwealth EPBC legislation.

2.0 METHODOLOGY

2.1 Aims of the Survey

Landform Research conducted a vegetation assessment on 21 April 2010 to determine the quality of the vegetation and its significance.

The main aim was to determine which vegetation was the most significant with respect to preservation.

2.2 Methods of Survey

The vegetation assessment was conducted to the lowest level of assessment based on Environmental Protection Authority (2004) Guidance Statement, *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia*, No 51 June 2004.

The site was assessed by Lindsay Stephens of Landform Research who walked the site and all taxa observed were recorded. A total of 2.5 hours was spent on site.

However, bearing in mind the timing of the study, there will be a number of taxa that were not recorded, particularly those annual and smaller varieties which are only readily noticed when flowering.

The number and type of taxa present will however provide satisfactory information on the quality of the vegetation which in turn will provide information on the potential of finding additional taxa.

Searches of the Department of Environment and Conservation and WA Herbarium databases were made with respect to the species identified. The databases listed under the *Commonwealth Environment Protection and Biodiverstiy Conservation Act 1999* were also searched.

Exotic species were considered but are so widespread and common that the main and dominant species only were recorded, and in general areas rather than in each specific area.

The DEC Rare and Priority Flora and Ecological Communities databases were searched. The Commonwealth EPBC databases were also searched.

Determinations and inferences on the Vegetation Complexes and Floristic Community Types were made in a number of ways, relating to comparisons to published floristics and geomorphic and regolith matching.

- The Commonwealth EPBC databases were searched.
- Comparisons were made to published boundaries of Vegetation Complexes in Heddle et al, 1980.
- Comparisons of species were made to the descriptions of Floristic Community Types in Gibson et al 1994, pages 29 to 45.
- Comparisons of species were made to the sorted table in Gibson et al 1994, Table 12, which shows the species frequency within each Floristic Community Type. Weston 2004 states that Neil Gibson noted that such comparisons are possible.
- Comparisons were made to the descriptions of the Floristic Community Types and maps in Appendix 1 of Gibson et al 2004.
- Comparisons to local studies completed by Keighery and Trudgen for Department of Conservation and Land Management, (*Remnant Vegetation on the Alluvial Soils of the Eastern Side of the Swan Coastal Plain*).
- Comparison to Wilde S A and G H Low, 1978, 1 : 250 000 Perth Geological Series, Geological Survey of Western Australia.
- Comparisons were made to published boundaries of Landforms and Soils in Churchward and McArthur, 1980.
- Soil and regolith mapping and assessment of the geomorphology by Lindsay Stephens at the time of the site inspections. Soil and regolith mapping has been found to be very closely aligned to species composition through extensive field mapping by Landform Research, with small changes to the clay or sesqui-oxide content being related to the introduction and deletion of particular indicators.

The original and existing plant communities, vegetation condition and plant species were considered.

3.0 PHYSICAL ENVIRONMENT

3.1 Site Description

The study site lies on the eastern edge of the Swan Coastal Plain, just west of the Darling Fault.

Clays and sands shed from the Darling Scarp were washed onto the edge of the Swan Coastal Plain forming the sandy clays of the Guildford Formation that form the sediments of the eastern Swan Coastal Plain. Piled along the eastern edge of the Swan Coastal Plain are sands of the Yogannup Formation, which forms the Ridge Hill Shelf and represent a coastal edge of a marine transgression during the last million years.

During the Tertiary Period, and in more recent times, laterite developed across the landscape adding gravel to the soil profiles.

The soils of the study area are generally related to the Yogannup Formation.

The dominant soil types are gravely yellow clay sands, which occur across the majority of the site. They are yellow and more sandy and gravely in the surface horizons, but more clayey at depth. In earlier times these soils have been excavated as a local source of gravel.

A number of small creeks drain across the site from the Scarp, petering out in sands on the Swan Coastal Plain. The most significant of these is Cardup Brook that forms a small valley in the southern edge of the site.

Surface water collects to form seasonally wet soils in several low areas west of South Western Highway, due to road and surface water drainage.

The flows in the creeks only occur in winter and following response to storm events. Salinity levels in the creeks at the end of winter have been previously measured by Landform Research to contain 220 - 275 mg/L salt, which is fresh water.

Surface water collects in several low areas forming local temporary perching of surface water in winter.

Two southern holes, SW 81 and SE 287, have been drilled outside the southern tip of the area. SE 287 intersected 9 metres of silt over 12 metres of clayey sand to a depth of 21 metres and then cut through sand to a depth of 29 metres. SW 81, just on the eastern side of South Western Highway at Cardup Brook, intersected 1.5 metres of gravel over 2 metres of clay and then silt and clay to 22 metres with sand between 22 and 30 metres, (Jordan 1986).

Depth to groundwater was 4 metres in SE 287 and SW 81 in the south. It is not known whether these levels represent hydraulic heads, but based on the degree of incision by the creeks, the water is likely to have some hydraulic head.

3.2 Proposed Landuse

The site is being investigated for development and extension of Byford Precinct.

4.0 VEGETATION ASSESSMENT

4.1 Community Types

The study site lies on the Ridge Hill Shelf. The width of the shelf and the unique soils mean that the indigenous vegetation communities that occur on the shelf are not common.

In addition, most of the Shelf has been cleared and therefore any remaining remnant vegetation is highly significant. The vegetation complex is Guildford Complex. The Guildford Complex is poorly reserved on the Swan Coastal Plain with only 5% of the original area remaining (EPA 2003).

This vegetation is typified by that contained in the adjoining Brickwood Reserve that abuts the north western corner of the site. The Brickwood Reserve vegetation is listed as Bush Forever Site 321.

The site was included in the Byford Townsite Detailed Area Plan, and Plan D showing the vegetation of the area covered by that study is attached below.

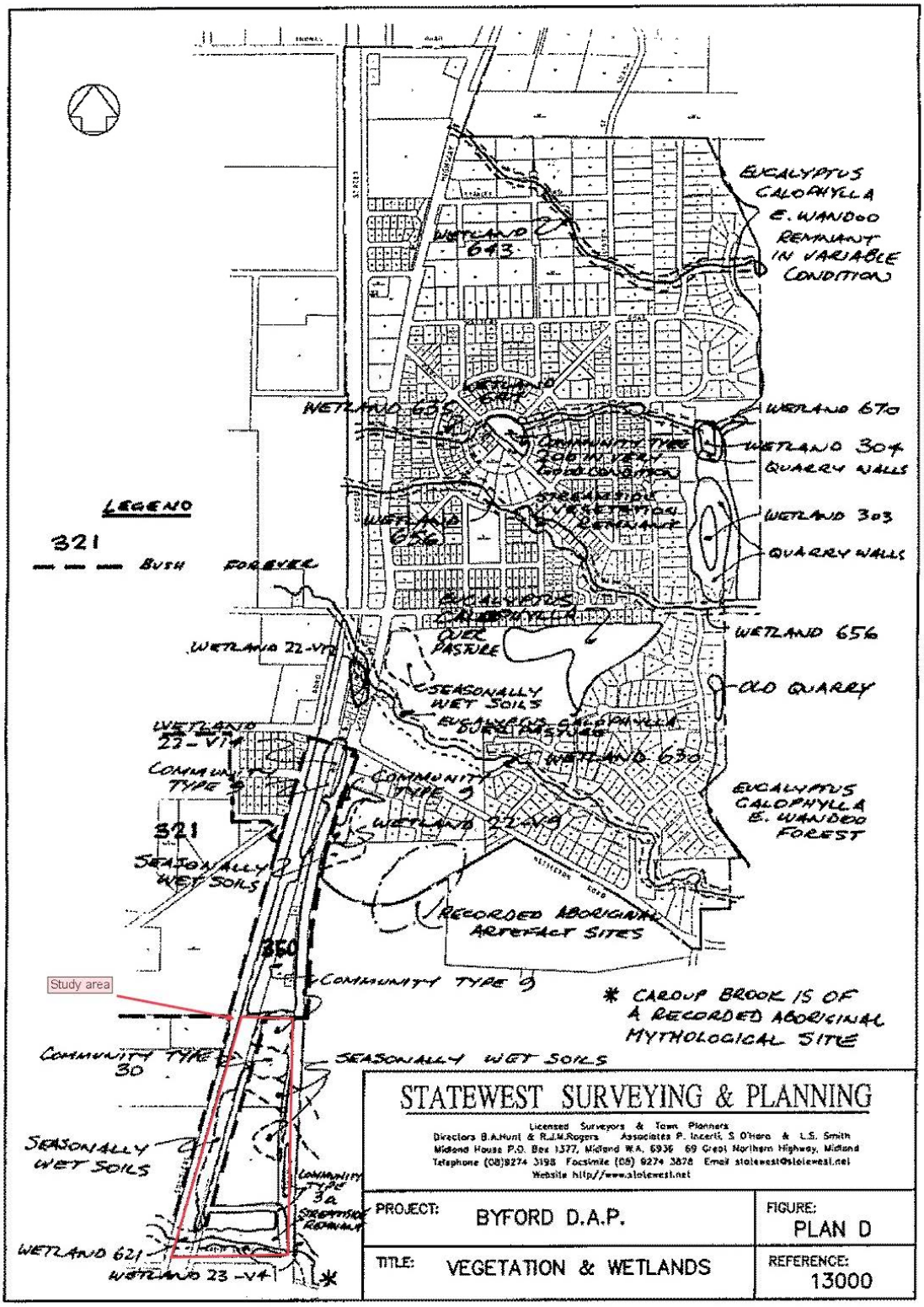


Figure 1

On Plan D from the Byford Townsite Detailed Area Plan, the site is shown as seasonally wet soils with an area of Community Type 9 and Community Type 3A in the north. The vegetation east of the site in the small traffic island is listed as Community Type 3A.

Cardup Brook is shown as Wetland 621 with the vegetation as 23-V4.

The vegetation in the north adjacent to Brickwood Reserve is described as below in the Byford Townsite Detailed Area Plan.

> "**Adjacent to Brickwood Reserve.**
>
> The vegetation adjacent to Brickwood Reserve is *Eucalyptus calophylla* woodland with some regrowth over an old gravel pit. Added in particular is *Melaleuca viminea*, which occurs in low areas and along the road reserve to the south. Wetland species increase to the west towards the rail reserve. The floristic community is 3a, *Eucalyptus calophylla - Kingia australis* woodlands on heavy soils. Community Type 3a is listed as Critically Endangered (WAPC 2000). Community Type 9 occurs on the wetter areas. Community Type 9 is the most northern representation of this vegetation and is therefore significant (WAPC 2000).
>
> Whist the taxa were not assessed, it was noted that they were similar to those of the Brickwood Reserve." *(Byford Townsite Detailed Area Plan)*

The remnant vegetation is shown on the attached Figures 2 and 3.

The best nomination for the remnant vegetation on site is altered to significantly degraded Floristic Community 3a*, Eucalyptus calophylla - Kingia australis* woodlands on heavy soils.

There is a small area of remnant vegetation within the extreme north eastern corner where part of Area 3 lies on the subject land with the remainder being within the road reserve of South Western Highway. Only a small area occurs on site at that location (Area 3). See Figure 2. The vegetation is likely to be a small area originally of Community Type 3a but is small with an area of about 15 x 20 metres which adjoins remnant vegetation on the adjoining land to the north.

A small area of roadside vegetation occurs outside the site in the north east (Areas 1 and 2). This is likely to be a remnant of original Community Type 3a.

There is a stand of parkland *Eucalyptus calophylla* in the central north (Area 4) which is regrowth Marri forming parkland pasture. The trees are generally not very old and with almost no understorey do not represent significant vegetation, but rather self seeded regrowth of a generally young age of perhaps 20 – 30 years. This vegetation does not justify a classification other than parkland pasture.

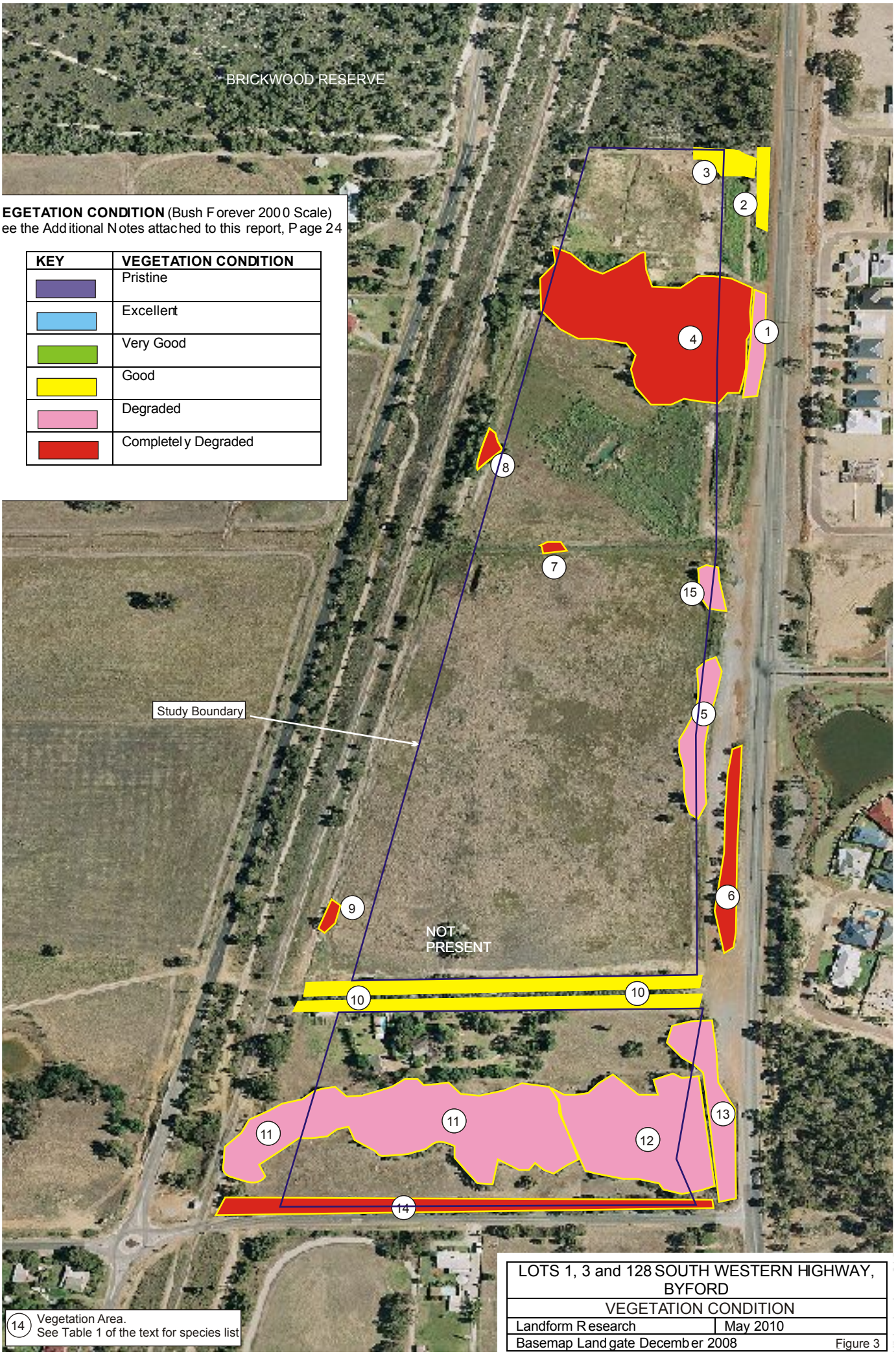
Vegetation occurs outside the study area along the railway reserve to the west, and along the road reserve of Pinebrook Road in the south.

The vegetation along Pinebrook Road consists of mixed vegetation with *Eucalyptus calophylla* tree layer and including *Kingia australis* in the tall shrub layer. This is Area 10 and the vegetation is classified as originally being Community Type 3a.

There is minor native vegetation along the road reserve east of the site.

The vegetation along Cardup Brook is described as below, in the Byford Townsite Detailed Area Plan.


BRICKWOOD RESERVE
Study Boundary
NOT PRESENT
1
2
3
4
5
6
7
8
9
10
10
11
11
12
13
14
15
14 Vegetation Area.
See Table 1 of the text for species list
LOTS 1, 3 and 128 SOUTH WESTERN HIGHWAY, BYFORD
REMNANT VEGETATION
Landform Research
May 2010
Basemap Landgate December 2008
Figure 2


BRICKWOOD RESERVE
EGETATION CONDITION (Bush Forever 2000 Scale)
ee the Additional Notes attached to this report, Page 24
KEY
VEGETATION CONDITION
Pristine
Excellent
Very Good
Good
Degraded
Completely Degraded
Study Boundary
NOT PRESENT
1
2
3
4
5
6
7
8
9
10
10
11
11
12
13
14
15
14 Vegetation Area. See Table 1 of the text for species list
LOTS 1, 3 and 128 SOUTH WESTERN HIGHWAY, BYFORD
VEGETATION CONDITION
Landform Research
May 2010
Basemap Landgate December 2008
Figure 3

"**Cardup Brook**

The vegetation adjoining Cardup Brook is Eucalyptus calophylla woodland with understorey similar to parts of Brickwood Reserve and John Crescent and the water courses, but including *Kingia australis, Dryandra lindleyana* and *Nuytsia floribunda* of Community Type 3a.

The vegetation condition along Cardup Brook varies from fair, with a significant ground cover of pasture species in some areas, to good. More degraded areas could benefit from spray and replanting programs to crowd out undesirable species and provide better filtration effects and improvements as a vegetation corridor." (*Byford Townsite Detailed Area Plan.)*

The assessment of the vegetation for the Byford Townsite Detailed Area Plan was general and broad scale. The on site vegetation was not all walked at the time, being on private land for which permission was not available. Edge assessment was used.

The current study of 21 April 2010 presents a much better analysis of the vegetation.

A brief description of the various remnants is listed below. The list of species from each remnant is shown in Table 2, and the vegetation condition and structure are also shown.

Table 1 Remnant Vegetation Summary.

Remnant	**Description**	**Vegetation Condition (Bush Forever Scale 2000)**		
		Overstorey > 4 metres	**Shrub layer 0.5 – 2 metres**	**Ground Cover <0.5 metres**
Area 1	Scattered *Eucalyptus calophylla* over isolated to occasional understorey species. Groundcover dominated by significant weed and exotic pasture species. Lies within the road reserve of South Western Highway.	Degraded	Absent	Pasture and exotics
Area 2	Occasional understorey species of *Hakea trifurcata, H. undulata* and *H. lissocarpha* with *Mesomelaena tetragona.* Groundcover dominated by significant weed and exotic pasture species. Lies within the road reserve of South Western Highway.	Absent	Degraded	Degraded
Area 3	Remnant of Floristic Community 3a *with Eucalyptus calophylla* over a range of understorey shrubs and groundcovers such as *Hakea trifurcata, H. undulata* and *H. lissocarpha, Kennedia prostrata, Daviesia incrassata, Lechenaultia biloba* with *Mesomelaena tetragona.* Much of the vegetation lies within the road reserve of South Western Highway.	Good	Good	Good - Degraded
Area 4	Monoculture of scattered *Eucalyptus calophylla* over pasture and exotic species. Complete absence of native understorey or groundcover. Too degraded to be classified as Floristic Community 3a.	Degraded	Absent	Pasture and exotics

Area 5	Scattered to occasional *Eucalyptus calophylla* over pasture and exotic species. Complete absence of native understorey or groundcover. Too degraded to be classified as Floristic Community 3a. Lies predominantly within the road reserve of South Western Highway.	Degraded	Absent	Pasture and exotics
Area 6	Planted *Eucalyptus calophylla* over planted non local native species such as *Callistemon* and *Grevillea* spp. Basically a native garden. Lies within the road reserve of South Western Highway.	Degraded	Exotic natives only	Absent
Area 7	Small clump of about 6 plants of *Astartea fascicularis* over pasture and exotic species.	Absent	Degraded	Pasture and exotics
Area 8	Occasional *Eucalyptus calophylla* over pasture and exotic species. Complete absence of native understorey or groundcover. Too degraded to be classified as Floristic Community 3a.	Degraded	Absent	Pasture and exotics
Area 9	Occasional *Eucalyptus calophylla* over pasture and exotic species. Complete absence of native understorey or groundcover. Too degraded to be classified as Floristic Community 3a.	Degraded	Absent	Pasture and exotics
Area 10	Remnant of Floristic Community 3a with *Eucalyptus calophylla* over a range of understorey shrubs and groundcovers such as *Hakea trifurcata, H. undulata* and *H. lissocarpha, Kennedia prostrata, Daviesia incrassata, Kingia australis, Hibbertia hypericoides, Lechenaultia biloba* with *Mesomelaena tetragona.* All the vegetation lies within the road reserve of Pinebrook Road.	Good	Good	Good - Degraded
Area 11	*Eucalyptus calophylla* and *E. rudis* over occasional *Darwinia citriodora*, and *Agonis linearifolia* with some exotic shrubs over pasture and exotic species. Lies within proposed Public Open Space.	Good	Degraded	Pasture and exotics
Area 12	*Eucalyptus rudis* and occasional *E. calophylla* associated with watercourse with *E. wandoo* on the bank and occasional *Dryandra armata and* some exotic shrubs over pasture and exotic species. Area of *Baumea vaginalis* in creek bed.	Good	Degraded	Pasture and exotics
Area 13	*Eucalyptus rudis* and occasional *E. calophylla* associated with watercourse with *E. wandoo* and occasional native understorey and significant exotic species. Much of Area 13 lies within the road reserve of South Western Highway.	Good	Degraded	Degraded
Area 14	Scattered *Eucalyptus calophylla* associated with *E. wandoo* over pasture in the road verge.	Degraded	Absent	Pasture and exotics
Area 15	Occasional *Eucalyptus calophylla* over isolated *Xanthorrhoea preissii* and *X. brunonis.*	Degraded	Degraded	Pasture and exotics

	About half the Area lies within the road reserve of South Western Highway.			

The vegetation along the rail reserve is in Good to Very Good condition and is a remnant of Floristic Communities 3a*, Eucalyptus calophylla - Kingia australis* woodlands on heavy soils and Community Type 9 *Dense shrublands on clay flats*.

Wetlands

The vegetation along Cardup Brook is listed as Bush Forever Site 271. The riparian vegetation is classified as Wetlands 62 and 23-V1 associated with Cardup Brook. Whilst these vegetated sites are classified as Conservation Category wetlands, they are coincident with the remnant vegetation.

4.2 Vegetation on Site

- **Species List**

Brickwood Reserve to the north west was assessed by Keighery and Keighery (undated). It was found to contain a total of 309 taxa of which ninety two taxa were considered to be of special significance and five were Priority taxa. Brickwood Reserve is listed on the register of National Estate and is subject to protection under the *Commonwealth Environment Protection and Biodiversity Act 1999*.

Cardup Remnant Vegetation ("Cardup Nature Reserve"), in a similar geomorphological position to the south west, was also assessed by Keighery and Keighery (undated). It contained 294 native taxa of which 58 were regarded as significant and included 4 Priority taxa. This is classified as Bush Forever Sites 271 and 352.

Table 2 Native species recorded during the site inspections

C Denotes common species.
M Occasional plants of a particular species
O Indicates uncommon plants
U Indicates a single plant or 1 – 3 plants

See Figure 1 for the location of each area

FAMILY	GENUS - SPECIES	1	2	3	4	5	6	7	8
Casuarinaceae	*Allocasuarina fraseriana*				**m**				
Cyperaceae	*Lepidosperma costale*			**m**					
	Mesomelaena tetragona		**m**	**m**					
Dasypogonaceae	*Kingia australis*								
Dilleniaceae	*Hibbertia commutata*								
	Hibbertia hypericoides								
Goodenaceae	*Lechenaultia biloba*		**o**	**o**					
	Conostylis aculeata		**u**						
Haemodoraceae	*Haemodorum paniculatum*								
	Haemodorum spicatum			**o**					
Cyperaceae	*Baumea vaginalis*								
	Juncus pallidus								
	Schoenus sp								
Laxmanniaceae	*Laxmannia squarrosa*								
Mimosaceae	*Acacia acuminata*								
	Acacia lasiocarpa			**m**					

	Acacia pulchella	**o**							
	Acacia saligna								
	Acacia stenoptera	**u**							
Myrtaceae	*Agonis linearifolia*								
	Astartea affinis							**o**	
	Baeckea camphorosmae								
	Darwinia citriodora								
	Eucalyptus calophylla	**c**		**c**	**c**	**c**	**c**		**o**
	Eucalyptus marginata								
	Eucalyptus rudis								
	Eucalyptus wandoo								
	Melaleuca viminea					**u**			
Papilionaceae	*Daviesia incrassata*			**m**					
	Gompholobium marginatum	**o**		**m**					
	Hovea trisperma			**o**					
	Kennedia prostrata	**o**							
	Viminea juncea					**u**			
Proteaceae	*Dryandra armata*								
	Dryandra bipinnatifida								
	Dryandra lindleyaa		**u**	**m**					
	Hakea auriculata								
	Hakea lissocarpha		**o**	**m**					
	Hakea prostrata					**o**			
	Hakea ruscifolia			**u**					
	Hakea trifurcata		**o**	**m**					
	Hakea undulata		**u**	**m**					
	Hakea varia					**o**			
	Synaphea odocoileops		**u**	**o**					
Restionaceae	*Desmocladus fasciculatus*			**m**					
	Hypolaena exsulca			**o**					
	Sp	**u**							
Xanthorrhoeaceae	*Xanthorrhoea brunonis*		**u**					**m**	
	Xanthorrhoea gracilis			**u**					
	Xanthorrhoea preissii		**u**					**m**	
TOTAL NATIVE SPECIES		**48**							

**See Figure 1 for the location of each area**

FAMILY	**GENUS - SPECIES**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Casuarinaceae	*Allocasuarina fraseriana*							
Cyperaceae	*Baumea vaginalis*				**m**			
	Lepidosperma costale		**c**			**m**		
	Mesomelaena tetragona		**c**					
	Schoenus sp		**o**					
Dasypogonaceae	*Kingia australis*		**u**					
Dilleniaceae	*Hibbertia commutata*							
	Hibbertia hypericoides		**c**					
Goodenaceae	*Lechenaultia biloba*							
	Conostylis aculeata							
Haemodoraceae	*Haemodorum paniculatum*		**u**					
	Haemodorum spicatum							
Juncaeae	*Juncus pallidus*			**o**				
Laxmanniaceae	*Laxmannia squarrosa*							
Mimosaceae	*Acacia acuminata*							
	Acacia lasiocarpa							

	Acacia pulchella			**o**	**o**			
	Acacia stenoptera							
Myrtaceae	*Agonis linearifolia*			**o**				
	Astartea affinis							
	Baeckea camphorosmae					**m**		
	Darwinia citriodora			**m**				
	Eucalyptus calophylla	**o**	**c**	**c**		**m**	**c**	**m**
	Eucalyptus marginata							
	Eucalyptus rudis			**c**	**c**			
	Eucalyptus wandoo		**u**	**m**	**c**			
	Kunzea glabrescens		**u**					
	Melaleuca viminea							
Papilionaceae	*Daviesia incrassata*							
	Gompholobium marginatum		**c**					
	Hovea trisperma							
	Kennedia prostrata		**m**					
	Viminea juncea							
Phormiaceae	*Stypandra lauca*							
Poaceae	*Neurachne alopecuroidea*							
	Austrostipa sp							
Proteaceae	*Dryandra armata*					**o**	**m**	
	Dryandra bipinnatifida		**o**					
	Dryandra lindleyaa		**m**					
	Hakea auriculata		**u**					
	Hakea lissocarpha					**o**		
	Hakea prostrata							
	Hakea ruscifolia							
	Hakea trifurcata		**c**					
	Hakea undulata							
	Hakea varia							
	Persoonia saccata		**u**					
	Synaphea odocoileops							
Restionaceae	*Desmocladus fasciculatus*							
	Hypolaena exsulca							
	Sp							
Xanthorrhoeaceae	*Xanthorrhoea brunonis*							**u**
	Xanthorrhoea gracilis		**c**					
	Xanthorrhoea preissii		**c**	**o**				**u**
TOTAL NATIVE SPECIES		**48**						

- **Plant Density**

The plant density of native taxa is significantly degraded and in most areas is replaced by exotic and pasture species.

- **Vegetation Structure**

Photographs of the vegetation are attached, which provide information on the vegetation structure.

The structure of the vegetation has been partially to completely altered, although this is not readily apparent from aerial photography or a casual site inspection. The land has previously been subject to weather influences and drought.

A summary of the vegetation structure is presented in Table 1 above.

5.0 SIGNIFICANT VEGETATION

5.1 Declared Rare, Priority or Significant Taxa

A search of the CALM and WA Herbarium databases in 2004, as part of the Byford Townsite Detailed Area Plan, revealed that a total of 9 Priority species and 3 Declared Rare species' listed below, occur in the general area. Most of these species are associated with wetlands and are most likely to occur in, or adjacent, to Brickwood Reserve outside of the study area.

Listed Declared Rare and Priority Species:

-	*Drosera occidentalis* subsp *occidentalis*	P4
-	*Lambertia multiflora* var *darlingensis*	P3
-	*Schoenus pennisetis*	P1
-	*Thelymitra stellata*	R
-	*Trichocline* sp Treeton (BJ Keighery & N Gibson 564)	P2
-	*Acacia oncinophylla*	P2
-	*Aotus cordifolia*	P3
-	*Centrolepis caespitosa*	R
-	*Dryandra kippistiana*	P3
-	*Johnsonia pubescens* subsp *cygnorum*	P2
-	*Synaphea odocoileops*	P1
-	*Verticordia plumosa* var *pleiobotrya*	R

Of the above taxa, *Lambertia multiflora* var *darlingensis, Dryandra kippistiana, Verticordia plumosa* var *pleiobotrya* and *Acacia oncinophylla* are easily recognised and were not observed on site. It is just possible that any of the other taxa may occur, but only in areas where ground cover of native vegetation still remains. That is Areas 2, 3, 10 and 13. It is most unlikely that any other area will contain one of these taxa or any other significant taxa.

It is likely that the *Synaphea* recorded in the north east in Areas 2 and 3 is *Synaphea odocoileops* a Priority 1 taxa.

All the areas listed as containing Significant or Priority species are recommended to be retained and enhanced.

5.2 Threatened or Priority Ecological Communities

The only vegetation that can still be classified as a Floristic Community Type is the extreme north eastern corner (Area 3), the road reserves of Pinebrook Road, and the rail reserve to the west. Much of these lie within existing road reserves.

Some road reserves contain minor significantly altered remnants that also represent a defined Floristic Community Type.

Even Areas 11 and 12 are so significantly altered that ascribing a Floristic Community Type is probably invalid.

The best nomination for the remnant vegetation is altered to significantly degraded Floristic Community 3a*, Eucalyptus calophylla - Kingia australis* woodlands on heavy soils. The best representation of this is the small area in the extreme north eastern corner most of which does not lie on the subject land but rather on road reserve. The only other remnant of this community is scattered remnants along the road verges, outside the study site, and the vegetation along Pinebrook Road.

Floristic Community Type 3a is listed as a Threatened Ecological Community under State and Commonwealth Legislation.

There is also an *Interim Recovery Plan for Corymbia calophylla – Kingia Australis Woodlands on Heavy Soil (Swan Coastal Plain Community Type 3a – Gibson et al 1994)* Commonwealth of Australia, 2003 – 2004.

This plan lists ten occurrences of Community Type 3a but does not appear to list this site, presumably because the vegetation remnants are too small, the vegetation is too degraded, the remnants are located in situations where recovery is difficult such as road reserves or a combination of factors.

A number of recovery actions are proposed in the recovery plan, but none appear to be readily achievable on this site without allocating areas of protection that are larger than the remnants, and then a concerted replanting program.

The only area of potential is the road reserve of Pinebrook Road. The potential to protect the road reserve has been reviewed within the planning process and a number of road alignments considered but none have proved satisfactory and likely to protect the vegetation as there would be clearing to access the land between Pinebrook Road and Cardup Brook.

All other vegetation is so altered and consisting of regrowth that, whilst it might have originally been part of the same community Type, it can no longer be considered so.

5.3 EPBC Legislation

Databases held under the *Commonwealth Environment Protection and Biodiverstiy Conservation Act 1999* were searched.

Floristic Community 3a is listed under Commonwealth legislation.

No unusual or unidentified species were recorded.

Brickwood Reserve is listed on the register of National Estate and is subject to protection under the *Commonwealth Environment Protection and Biodiversity Act 1999*.

6.0 VEGETATION CONDITION

The Vegetation Condition Score used in this study is that used in Bush Forever 2000.

A summary of the vegetation condition is shown in Table 1. The only area in better than Degraded condition is the extreme north eastern corner in Area 3 which is listed as being in Good Condition. All other areas are classed as Degraded or Completely Degraded, although Area 13 approaches Good.

Area 4 looks Good on an aerial photograph but is classified as Parkland Pasture which is Completely Degraded.

The majority of the site is pasture, with widespread pasture and other invasive species.

The open cleared areas are dominated by the invasive *Egrotis curvula* is widespread with *Digitaria sanguinalis, Lolium* spp, *Pennisetum clandestinum, Stenotaphrum secundatum, Erharta calicyna, Cyndodon dactylon, Avena* spp and *Briza maxima* among other pasture species. Other weed species include *Hypochaeris* spp, *Trifolium* spp, and *Echium plantagineum*.

7.0 REPRESENTATION OF THE FLORA - VEGETATION

7.1 Significant Flora

No Declared Rare, Priority Species or Significant flora was identified during the vegetation assessments.

Heddle et al 1980 show the site as being occupied originally by Guildford Complex.

The floristic community is 3a*, Eucalyptus calophylla - Kingia australis* woodlands on heavy soils. Community Type 3a is listed as Critically Endangered (WAPC 2000). The only remnants of this floristic Community are Areas 2 and 3 in the north eastern corner and Area 10, the reserve of Pinebrook Road, most of which lie on road reserves and not the subject land.

The vegetation along Cardup Brook is listed as Bush Forever Site 271. The riparian vegetation is classified as Wetlands 62 and 23-V1 associated with Cardup Brook. Whilst Degraded these vegetated sites are classified as Conservation Category wetlands, and are therefore listed as Significant.

Vegetation on site will be providing some habitats for birds and other small fauna, but with its sparseness on the low ridge the number of fauna species is likely to be significantly restricted.

7.2 Vegetation Representation

EPA Position Statement No 2, December 2000, *Environmental Protection of Native Vegetation in Western Australia*, specifically targets the retention of native vegetation in the Agricultural Areas in *4.1, Clearing in the agricultural areas for agricultural purposes*. In 4.3, *Clearing in other areas of Western Australia*, it is unclear what "other areas" refers to, but may refer to retention of a 30% threshold in non agricultural areas.

Section 4.3 *Clearing in other areas of Western Australia*, (EPA Position Statement No 2, December 2000) expects that clearing will not take vegetation types below the 30% of the pre-clearing vegetation as recommended by ANZECC, 1999, *National Framework for the Management and Monitoring of Australia's Native Vegetation*. The National Objectives and Targets for Biodiversity Conservation 2001 - 2005 (Commonwealth of Australia 2001) also recognise 30% as the trigger value.

The cutoff for consideration of vegetation complexes when dealing with preservation in the Perth metropolitan Area is 10% as noted in Bush Forever and EPA Guidance Statement No 10.

The Guildford vegetation complex is listed as having 5% of the pre-European area still occurring, with 0.2% in secure tenure in 2003 (EPA Position Statement 2), well below the nominated 10% retention, hence the nomination of the Guildford Complex and Floristic Community Types as threatened.

7.3 Protection of Significant Vegetation

The site is zoned Industrial. Industrial zoned land does not require the allocation of Public Open Space.

However the alignment of Cardup Brook is listed as Bush Forever and represents a more significant community asset than the small discontinuous vegetation remnants of the regrowth Marri trees in the north.

Therefore in order to protect the community assets for biodiversity the landholders have elected to place Cardup Brook and its banks within Public Open Space. The vegetation within that suggested Public Open Space is degraded and could benefit from additional planting.

The landholders suggest that replanting and protection of the creekline has more chance of survival and forms better linkages.

They have tried a number of combinations and designs to try and save the vegetation along Pinebrook Road but in the end they deemed that the protection effort should be directed to protecting the larger remnant of Cardup Brook.

8.0 CLEARING ASSESSMENT

Clearing is controlled under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004*. These regulations provide for a number of principles against which clearing is assessed. (See attached notes for explanations).

	CLEARING PRINCIPLE *(Schedule 5 Environmental Protection Amendment Act, 1986*
1a	*High Level of diversity*
1b	*Significant fauna habitat*
1c	*Necessary to existence of Rare flora*
1d	*Threatened Ecological Community*
1e	*Significant area of vegetation in an area that has been extensively cleared*
1f	*Wetland or watercourse*
1g	*Land degradation*
1h	*Impact on adjacent or nearby conservation areas*
1i	*Deterioration of underground water*
1j	*Increase flooding*

The *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* provide for planning and other policy issues to be taken into account when determining clearing applications.

Section 51O of the *Environmental Protection Act 1986* allows the CEO to take planning matters into account when making clearing decisions, such as a State Planning Policy. There is an agreement between DEC and DMP permitting DMP to issue Clearing Permits.

Table 3 Assessment against the Clearing Principles

	CLEARING PRINCIPLE *(Schedule 5 Environmental Protection Amendment Act, 1986).*	**COMMENT**
1a	High Level of diversity	• Only Areas 2 and 3 (north east corner) and 10 (Pinebrook Road) have sufficiently high levels of diversity to justify retention. Of these Area 2 and most of Area 3 lie outside the subject land. • Some of scattered vegetation on the road verges such as Area 2 and 5 have minor value but may be better replaced by strategic revegetated corridors and linkages. • The railway reserve outside the site has very high diversity and should be retained. • Some areas have low diversity and could be replaced by strategic corridors and linkages which are planted to a high species richness. Areas of low value are Areas 4, 6, 7 and 9.
1b	Significant fauna habitat	• All remnant vegetation has some habitat for fauna. Again Areas 2, 3 and 10 offer the most value. • Also of high value and potential for enhancement is the linkage along Cardup Brook, Areas 11 to 13. This is earmarked for greater conservation effort as it is capable of providing for Public Open Space and linkages from east to west. • If possible trees and vegetation could be protected within the road reserves and are recommended for retention and enhancement.
1c	Necessary to existence of Rare flora	• No Declared Rare flora was found.
1d	Threatened Ecological Community	• Threatened Ecological Community, Floristic Community 3a occurs on site in Areas 1 and 10 which are recommended for retention if possible. • Community Type 3a is listed as a Threatened Ecological Community on both State and Commonwealth databases. This is listed as having very little of its original extant remaining. • The vegetation complex, Guildford is listed as having 5% of the pre-European area still occurring, with 0.2% in secure tenure in 2003 (EPA Position Statement 2), well below the nominated 10% retention, hence the nomination of the Guildford Complex and Floristic Community Types as threatened.
1e	Significant area of vegetation in an area that has been extensively cleared	• The remaining vegetation of Floristic Community 3a has very high conservation value because the vegetation community has largely been cleared. • The Guildford Complex is listed as having 5% of the pre-European area still occurring, with 0.2% in secure tenure in 2003 (EPA Position Statement 2) well below the nominated 10%. • Floristic Community 3a has an uncommon mixture of taxa. The same vegetation is present in the adjoining Brickwood reserve and Cardup Remnant Vegetation. The railway reserve also has Community 3a and 9. • Other vegetation remnants could be cleared provided they were replaced by species rich linkages of local species. • The best vegetation for retention is the Cardup Brook where the vegetation can be enhanced and will provide a linkage. It is proposed to be located within Public Open Space.
1f	Wetland or watercourse	• The vegetation along Cardup Brook is listed as Bush Forever Site 271. The riparian vegetation is classified as Wetlands 62 and 23-V1 associated with Cardup Brook. Whilst Degraded these vegetated sites are classified as Conservation Category wetlands, and are therefore listed as Significant. • It is recommended to be retained and enhanced. See above.
1g	Land degradation	• The development of the site can be managed in a manner that does not lead to degradation of adjoining areas by the use of normal construction techniques and best practice environmental management.

		• The majority of the site is already cleared and under pasture which contains much weed and highly invasive species. • The small watercourse that is directed into the site from the stormwater basin east of South Western Highway will require design as a constructed wetland or stormwater management system.
1h	Impact on adjacent or nearby conservation areas	• The adjoining Brickwood Reserve has potential to be better linked to features such as Cardup Brook.
1i	Deterioration of underground water	• Any impact on groundwater will depend on the land use and the design of stormwater management. • The earthy clay soils of the Yogannup Formation are relatively good to good at dealing with pollution risk.
1j	Increase flooding	• This will be considered in stormwater design and management and as the site is already predominantly cleared there will be little additional risk from clearing of some minor vegetation.

9.0 DISCUSSION

No Declared Rare or Significant flora was identified. It is likely that the *Synaphea* recorded in the north east in Areas 2 and 3 is *Synaphea odocoileops* a Priority 1 taxa.

Some of the taxa listed on DEC databases as possibly occurring are either large and easily recognised, but were not observed, such as *Lambertia multiflora* var *darlingensis, Dryandra kippistiana, Verticordia plumosa* var *pleiobotrya, Acacia oncinophylla* or will only occur where a ground cover of native vegetation still remains. That is Areas 2, 3, 10 and 13.

All the areas listed as containing Significant or Priority species are recommended to be retained and enhanced.

The original vegetation complex is Guildford Formation of which only 5% remains.

The vegetation on site was originally Floristic community 3a*, Eucalyptus calophylla - Kingia australis* woodlands on heavy soils which is listed as Threatened on State and Commonwealth databases. However the majority of Community 3a is located within road reserve and not on site. It may be possible during the development of roads that some parts of the vegetation can be retained. A Recovery Plan is in place for Community Type 3a and is attached. This site is not listed as being part of the recovery plan and probably is too small to be sustainable.

Therefore any areas of Good vegetation will have high conservation value. The only areas on site in Good vegetation condition are the small portion of Area 3 in the north eastern corner that still remains as on the site and the road reserve of Pinebrook Road. To this should be added Area 2, also in the north eastern corner, because of the presence of *Synaphea odocoileops* but Area 2 lies within the road reserve of South Western Highway and is not therefore able to be managed by this subdivision.

The vegetation along Cardup Brook (Areas 11, 12 and 13) is listed as Bush Forever Site 271. The riparian vegetation associated with Cardup Brook is classified as Wetlands 62 and 23-V1. Whilst Degraded these vegetated sites are classified as Conservation Category wetlands, and are therefore listed as Significant. It is recommended they be retained and enhanced and included as Public Open Space.

All other areas of remnant vegetation are either too small and/or too degraded to have high significance for retention. They could be removed. An offset of vegetation planting that has a higher species richness could be used to replace or compensate for any loss of vegetation. This could be a linkage or corridor or might include infill planting and revegetation of the vegetation along Cardup Brook.

The adjoining Brickwood Reserve west of the rail reserve is near the north western corner. This reserve is listed under Commonmwealth EPBC legislation.

Weed and dieback management is recommended to be incorporated into the guidelines for development of the site.

Cleared land, view north towards Area 4

Cleared land in the south

Area 4 showing complete absence of native understorey

Area 4 showing complete absence of native understorey

Road verge. View north towards areas 3 and 4

Area 2

Area 3 in the north eastern corner

Area 10. Road reserve of Pinebrook Road

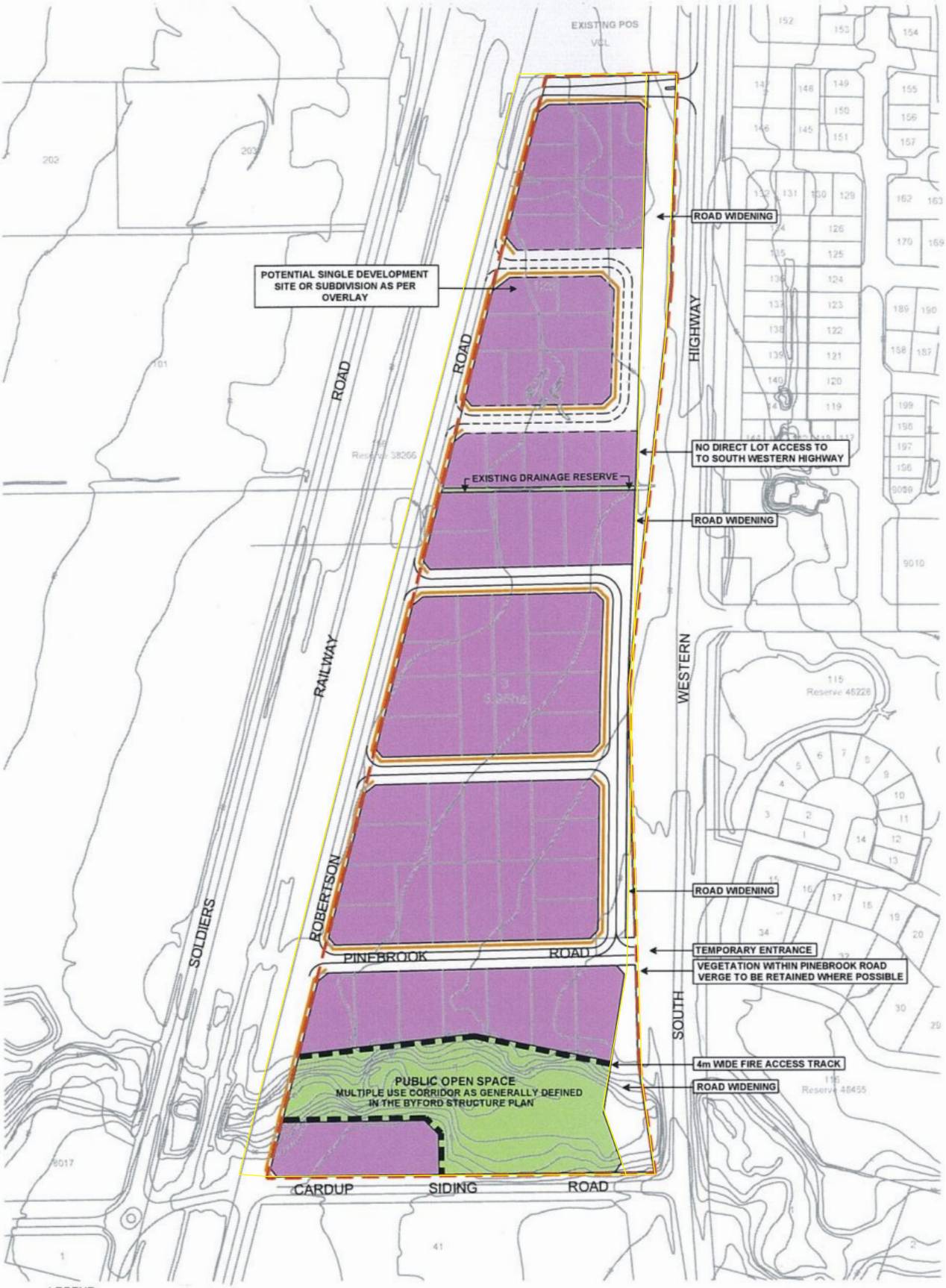
Area 5, view north

Area 5, view south

Area 12 in the south east on Cardup Brook

Area 11, Cardup Brook

Figure 5


EXISTING POS
VCL
ROAD WIDENING
POTENTIAL SINGLE DEVELOPMENT SITE OR SUBDIVISION AS PER OVERLAY
ROAD
HIGHWAY
NO DIRECT LOT ACCESS TO TO SOUTH WESTERN HIGHWAY
EXISTING DRAINAGE RESERVE
ROAD WIDENING
RAILWAY
WESTERN
SOUTH
ROBERTSON
SOLDIERS
PINEBROOK
ROAD
ROAD WIDENING
TEMPORARY ENTRANCE
VEGETATION WITHIN PINEBROOK ROAD VERGE TO BE RETAINED WHERE POSSIBLE
4m WIDE FIRE ACCESS TRACK
PUBLIC OPEN SPACE
MULTIPLE USE CORRIDOR AS GENERALLY DEFINED IN THE BYFORD STRUCTURE PLAN
ROAD WIDENING
CARDUP
SIDING
ROAD
LEGEND:
LOCAL SCHEME RESERVES
Local Roads
Public Open Space and Drainage
ZONES
Mixed Use
OTHER
Local Structure Plan Boundary
Footpath / Dual Use Path Network
NOTE
All proposed roads 20m wide
Distances and areas subject to survey
Road carriageways diagrammatic only
Minimum lot size 1000m²
LOCAL STRUCTURE PLAN
LOTS 1, 3 & 128 SOUTH WESTERN HIGHWAY
BYFORD
SCALE 1:4000 @ A4
GRAY & LEWIS
LAND USE PLANNERS
FIGURE 1
Suite 5, 2 Hardy Street
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T (08) 9474 1722
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perth@graylewis.com.au

Figure 6

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RARE AND SIGNIFICANT FLORA AND VEGETATION NOTES

1.0 RARE AND SIGNIFICANT FLORA AND VEGETATION

Flora can be significant on the basis of features of the taxa, its distribution and rarity. Flora as a vegetation community or complex can also be significant based on similar principles. The most commonly used determinants of significance are listed below.

A number of flora are regarded as significant even though they may not be listed as Declared Rare or Priority species. "Significant flora" and "Significant vegetation" are defined in Environmental Protection Authority (2004) Guidance Statement, Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia, No 51, June 2004.

Species, subspecies, varieties, hybrids and ecotypes may be significant for a range of reasons, other than as Declared Rare Flora or Priority flora, and may include the following:

- *a keystone role in a particular habitat for threatened species, or supporting large populations representing a significant proportion of the local regional population of a species;*
- *relic status;*
- *anomalous features that indicate a potential new discovery;*
- *being representative of the range of a species (particularly, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range);*
- *the presence of restricted subspecies, varieties, or naturally occurring hybrids;*
- *local endemism/a restricted distribution;*
- *being poorly reserved.*

1.1 DECLARED RARE FLORA

Species specially protected under the Wildlife Conservation Act 1950*, as identified in the current listing. Normally listed within a Wildlife Conservation (Rare Flora) Notice; Schedule 1 Extant taxa.*

R: Declared Rare Flora – Extant Taxa

Taxa which have been adequately searched for and are deemed to be in the wild either rare , in danger of extinction, or otherwise in need of special protection and have been gazetted as such.

X: Declared Rare Flora – Presumed Extinct Taxa

Taxa which have not been collected, or otherwise verified, over the past 50 years despite thorough searching, or of which all known wild populations have been destroyed more recently, and have been gazetted as such.

1.2 PRIORITY FLORA

Lists of plant taxa, maintained by the Department of Conservation and Land Management that are either under consideration as threatened flora but are in need of further survey to adequately determine their status, or are adequately known but require monitoring to ensure their security does not decline.

1: Priority One – Poorly known taxa

Taxa which are known from one or a few (generally <5) populations which are under threat, either due to small population size, or being on lands under immediate threat, eg road verges, urban areas, farmland, active mineral leases, etc, or the plants are under threat, eg from disease, grazing by feral animals, etc. May include taxa with threatened populations on protected lands. Such taxa are under consideration for declarations as "rare flora", but are in urgent need of further survey.

2: Priority two – Poorly known taxa

Taxa which are known from one or a few (generally <5) populations, at which some at least are not believed to be under immediate threat (ie currently not endangered). Such taxa are under consideration for declarations as "rare flora", but are in urgent need of further survey.

3: Priority Three – Poorly known taxa

Taxa which are known from several populations, and the taxa are not believed to be under immediate threat (ie not currently endangered), either due to the number of known populations (generally >5), or known populations being large, and either widespread or protected. Such taxa are under consideration for declarations as "rare flora", but are in urgent need of further survey.

4: Priority Four – Poorly known taxa

Taxa which are considered to have been adequately surveyed and which, whilst being rare (in Australia), are not currently threatened by any identifiable factors. These taxa require monitoring every 5 – 10 years.

Significant Vegetation

Vegetation may be significant for a range of reasons, other than a statutory listing as Threatened Ecological Communities or because the extent is below a threshold level, and may include the following reasons:

- *scarcity;*
- *unusual species;*
- *novel combination of species;*
- *a role as a refuge;*
- *a role as a key habitat for threatened species or large populations representing a significant proportion of the local to regional total population of a species;*
- *being representative of the range of a unit (particularly, a good local and/or regional example of a unit in "prime" habitat, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range);*
- *a restricted distribution.*

1.3 THREATENED ECOLOGICAL COMMUNITY

Ecological communities that have been assessed through a procedure (coordinated by CALM) and assigned to one of the following categories related to the status of the threat to the community. (EPA Guidance Statement No 51 2004).

Presumed Totally Destroyed

Critically Endangered

<10% of the pre-European extent remains in an intact condition in the bioregion.

Endangered

10 – 30% of pre-European extent remains

Vulnerable

Declining and/or has declined in distribution and/or condition, and whose ultimate security is not yet assured (it could move into a category of higher threat in the near future if threatening processes continue)

1.4 PRIORITY ECOLOGICAL COMMUNITY

Ecological communities that have been assessed through the procedures for Threatened Ecological Communities, but do not meet the criteria although still potentially at risk are assigned to one of the following categories related to the status of the threat to the community. (Definitions and Criteria for Priority Ecological Communities, DEC and CALM Policy Statement No 9).

Priority One

Poorly known ecological communities that are very restricted and not actively managed for conservation.

Priority Two

Poorly known ecological communities that are restricted and mostly actively managed for conservation

Priority Three

Poorly known ecological communities that are of more widespread occurrence, which may not be well reserved or subject to disturbance pressures or significant communities that are not under threat.

Priority Four

Communities that are adequately known, but rare and not threatened, or are near the status of Threatened. They are divided into Rare, Near Threatened or communities removed from the Threatened List.

Priority Five

Communities that are not threatened, but are dependant on conservation for their survival.

1.5 COMMONWEALTH LEGISLATION

Some vegetation communities or plant taxa that are very rare or of National importance are listed under the Commonwealth Environment Protection and Biodiverstiy Conservation Act 1999.

Databases held under the Commonwealth Environment Protection and Biodiverstiy Conservation Act 1999 can be searched.

1.6 REPRESENTATION OF VEGETATION COMMUNITIES

The significance of the flora depends on a number of issues.

- *Rare, Priority or Significant species may be present.*
- *A Threatened Ecological Community may be present.*
- *The development may take the area of the particularly vegetation community or complex below desirable levels or guidelines.*
- *There may be an aspect of the flora that may be listed under the Commonwealth Environment Protection and Biodiverstiy Conservation Act 1999.*

EPA Position Statement No 2, December 2000, Environmental Protection of Native Vegetation in Western Australia, specifically targets the retention of native vegetation in the Agricultural Areas in 4.1, Clearing in the agricultural areas for agricultural purposes. In 4.3, Clearing in other areas of Western Australia, it is unclear what "other areas" refers to, but may refer to retention of a 30% threshold in non agricultural areas.

Section 4.3 Clearing in other areas of Western Australia, (EPA Position Statement No 2, December 2000) expects that clearing will not take vegetation types below the 30% of the pre-clearing vegetation as recommended by ANZECC, 1999, National Framework for the Management and Monitoring of Australia's

Native Vegetation. The National Objectives and Targets for Biodiversity Conservation 2001 - 2005 (Commonwealth of Australia 2001) also recognise 30% as the trigger value.

For the Perth Metropolitan Area and the Greater Bunbury Area the minimum retention figure is 10%.

VEGETATION CONDITION NOTES

The vegetation condition mapping used is that used by the Department of Environment and Conservation and is taken from Bush Forever 2000.

Vegetation Condition Scale reproduced from page 48 (Bush Forever 2000).

Condition Score	***Vegetation Condition***	***Vegetation Descriptors***
1	***Pristine***	*Pristine or nearly so, no obvious signs of disturbance*
		0% weed cover
2	***Excellent***	*Vegetation structure intact, disturbance affecting individual species, and weeds are non aggressive species.*
		1 – 5% weed cover
3	***Very Good***	*Vegetation structure altered, obvious signs of disturbance.* *For example disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.*
		5 – 25% weed cover
4	***Good***	*Vegetation structure significantly altered by very obvious signs of multiple disturbance. Retains basic structure or ability to regenerate it.* *For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.*
		25 – 50% weed cover
5	***Degraded***	*Basic structure of the vegetation severely impacted on by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management.* *For example disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.*
		50 – 75% weed cover
6	***Completely Degraded***	*The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as "parkland cleared" with the flora comprising weed or crop species with isolated native trees or shrubs.*
		75 – 100% weed cover

This condition scale uses a scale that can distort the public perception of middle vegetation condition when compared to previous vegetation studies. In previous studies the word "Good" would have been a lower classification such as "Poor" as shown in Bush Forever 2000, page 48. The scale Good also does not seem to match the vegetation description provided on page 48. The Bush Forever 2000 Condition Score is possibly better related to the potential for regeneration of remnant vegetation rather than being a descriptor of its current condition. See Attachment 2.

The weed data has been added from the DEC Guideline for collecting the Graceful Sun-Moth.

Another approach is to use the number of remaining species as an indicator of vegetation condition. This provides for a less subjective assessment of the vegetation condition.

Kaesehagen, 1995, Bushland Condition Mapping, IN Invasive Weeds and Regenerating Ecosystems in Western Australia, Proceedings of Conference held at Murdoch University, July 1994, Institute for Science and Technology Policy, Murdoch University, 1995, A copy of the Kaesehagen 1995 vegetation condition table is shown below.

Descriptor	***Percentage of species remaining***	***Comments***
Very Good - Excellent	***80 – 100%***	• *Vegetation structure intact or nearly so.* • *Cover / abundance of weeds less than 5%.* • *No or minimal signs of disturbance.*
Fair - Good	***50 – 80%***	• *Vegetation structure modified.* • *Cover / abundance of weed 5 – 20%, any number of individuals.* • *Minor signs of disturbance*
Poor	***20 – 50%***	• *Vegetation structure completely modified.* • *Cover / abundance of weeds 20 – 60% any number of individuals.* • *Disturbance incidence high*
Very Poor	***0 – 20%***	• *Vegetation structure disappeared.* • *Cover / abundance of weeds 60 – 100% cover, any number of individuals.* • *Disturbance incidence very high.*

CLEARING PRINCIPLES

Clearing is controlled under the Environmental Protection (Clearing of Native Vegetation) Regulations 2004. These regulations provide for a number of principles against which clearing is assessed.

	CLEARING PRINCIPLE *(Schedule 5 Environmental Protection Amendment Act, 1986*
1a	*High Level of diversity*
1b	*Significant fauna habitat*
1c	*Necessary to existence of Rare flora*
1d	*Threatened Ecological Community*
1e	*Significant area of vegetation in an area that has been extensively cleared*
1f	*Wetland or watercourse*
1g	*Land degradation*
1h	*Impact on adjacent or nearby conservation areas*
1i	*Deterioration of underground water*
1j	*Increase flooding*

The *Environmental Protection (Clearing of Native Vegetation) Regulations 2004* also provide for planning and other policies and issues to be taken into account when determining clearing applications.

Section 51O of the *Environmental Protection Act 1986* allows the CEO to take planning matters into account when making clearing decisions, such as a State Planning Policy. There is an agreement between DEC and DMP permitting DMP to issue Clearing Permits.

As well as considering Biodiversity and other conservation issues the Clearing Principles that have to be satisfied are apparently designed for rural regions and do not adequately address the issues of resource needs. Therefore some additional principles need to be added when considering the need for essential Raw Materials. In an attempt to provide a better balance to the clearing principles those principles have been expanded as listed in the tables below.

	ADDITIONAL CLEARING PRINCIPLES – EXTRACTIVE INDUSTRIES
Environmental Protection Act 1984 Section 51O Planning Matters	
1	*Planning Matters*
Environmental Protection Act 1984 Section 51O Relevant Matters	
2a	*Need for the resource*
2b	*Classification of the resource and existing approvals*
2c	*Availability of alternative resources and the impact of their use*
2d	*Proposed final land use*
2e	*Offsite Environmental impacts if the resource is not used*
2f	*Sound environmental management and rehabilitation*

Appendix 4

Traffic Impact Assessment

Porter
Consulting Engineers

LOTS 1, 3 & 128 SOUTH WESTERN HIGHWAY, BYFORD

TRAFFIC IMPACT ASSESSMENT

Porter

Report Prepared For:

URBAN SOLUTIONS

Report Prepared By:

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Job No:	09-06-080
Date:	12/3/2014
Our Ref:	R21.10
Rev:	C
Checked:	

CONTENTS

1.0 INTRODUCTION

Porter Consulting Engineers has been engaged by Urban Solutions to prepare a traffic assessment report for a proposal to subdivide Lots 1, 3 and 128 South Western Highway, Byford. The Shire of Serpentine Jarrahdale Byford Structure Plan for subdivision of these lots indicates that development for this land is to be as mixed business. A Local Structure Plan for development of these lots is to be read in conjunction with this traffic assessment.

The Shire of Serpentine Byford Structure Plan is a District Structure to be used as the basis for more detailed planning in conjunction with the Byford Structure Plan report. The Byford Structure Plan indicates that these lots and the abutting land to the west are subject to further study. A purpose of this further study has been to identify the future of the proposed Orton Road extension to South Western Highway. Recent advice indicates that this road extension will no longer proceed.

The Shire of Serpentine Jarrahdale in conjunction with Main Roads WA have requested assessment of South Western Highway traffic for the year 2031 and to include the adjacent intersections potentially effected by other future land development in the surrounding area. Accordingly, the following roads intersecting with South Western Highway are included in this traffic assessment; Wilaring Street, Clondyke Drive and Cardup Siding Road.

2.0 SCOPE OF REPORT

The scope of this report is primarily to address the following matters:

- Proposed development traffic generation and site access.
- Assess traffic impacts on the surrounding environment.
- Assess impact on the road network traffic safety and efficiency.
- Define the type of intersection with South Western Highway needed in the medium and long terms.

3.0 DEVELOPMENT PROPOSAL

The proposed Structure Plan for development of Lots 1, 3 and 128 consists of the creation of access roads servicing subdivided lot sizes ranging from approximately 900m^2 to 5,000m^2.

Land use will be mixed business in accordance with the Shire of Serpentine Jarrahdale Byford Structure Plan dated 23 June 2009.

Vehicle access to the site will be via:

- A new a road will be created at the northern end of the site connecting with the presently unmade Robertson Road and South Western Highway.
- An Emergency Access from Pinebrook Road onto South Western Highway

4.0 EXISTING SITE AND ACCESS

4.1 Site Location

The subject site is located on land generally north-west of the intersection of South Western Highway and Cardup Siding Road, Byford in the local authority of the Shire of Serpentine Jarrahdale. The Site is approximately bounded by South Western Highway, Cardup Siding Road and the Public Transport Authority of Western Australia rail line.

The Site currently contains a single residential dwelling on Lot 1 to the south of Pinebrook Road. The two other lots are mostly cleared undeveloped rural land.

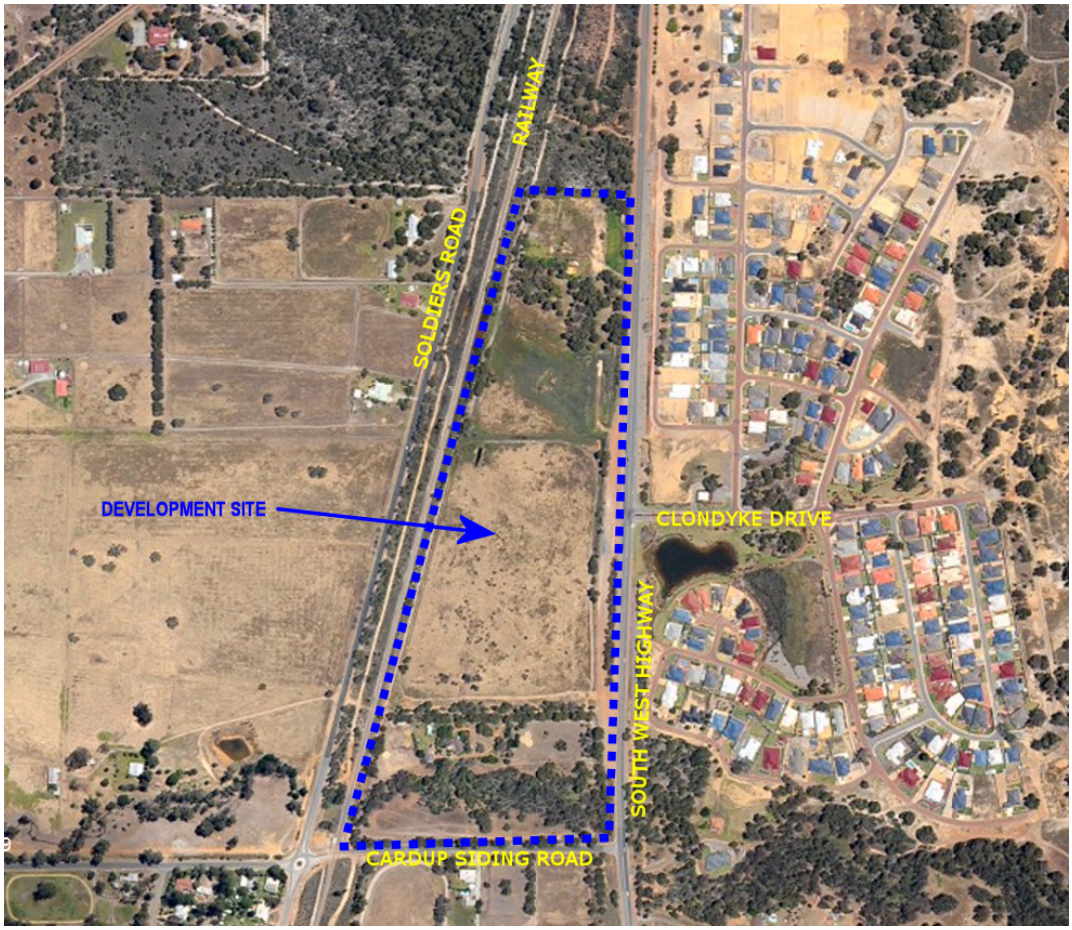


Figure 1. Site Location

Details of roads surrounding the development site are listed in the following table.

Table 1
Surrounding Roads

Road	Classification	Geometry
South Western Highway	Primary Distributor	Undivided two-way carriageway
Nettleton Road	Regional Distributor	Undivided two-way carriageway
Wilaring Street	Access Road	Undivided two-way carriageway
Kiln Road	Access Road	Undivided two-way carriageway
Cardup Siding Road	Access Road	Undivided two-way carriageway
Pinebrook Road	Access Road	Undivided two-way carriageway
Robertson Road	Access Road	Unconstructed

4.2 South Western Highway

The section of South Western Highway fronting the development is an undivided two-way single carriageway rural highway that is classified a Primary Distributor under the Main Roads WA Functional Road Hierarchy. South Western Highway is also a Freight Route carrying heavy haulage vehicles.

The Main Roads WA web site shows recorded traffic count data for this road abutting the subject site. The most recently presented traffic count for this section of South Western Highway near the development site was in November 2008 where a combined two-way traffic volume of 16,150 veh/day AWT was recorded.

South Western Highway is intended to perform the function of carrying large volumes of traffic and freight between districts. To achieve that function traffic flow must receive as little constraint and interruption as possible. No special provision is generally made for small numbers of vehicles entering and exiting. However, where large volumes must do so, then dependant on the volume, appropriate treatment at the connecting road is provided.

4.3 Cardup Siding Road

Cardup Siding Road is an undivided single carriageway unkerbed rural standard road with a single lane in each direction. It is classified a Local Access Road under the MRWA Functional Road Hierarchy.

The Shire of Serpentine Jarrahdale most recent recorded traffic count for the section of Cardup Siding Road west of South Western Highway was undertaken in August 2013 where a combined two-way traffic volume of 1,630 veh/day AWT was recorded.
Main Roads WA interactive web site provides summary crash data indicating that 3 crashes were recorded at the intersection of Cardup Siding Road with South Western Highway in the 5 years from 2008 to 2012. No predominant crash type is indicated.

4.4 Pinebrook Road

Pinebrook Road is an undivided narrow single carriageway two-way unsealed rural road. It is classified a Local Access Road under the MRWA Functional Road Hierarchy. It provides access to the single residential dwelling on Lot 1.

Main Roads WA interactive web site provides summary crash data. There is no listing for the intersection of Pinebrook road with South Western Highway in the 5 years from 2008 to 2012.

4.5 Robertson Road

The Robertson Road reserve abutting the development does not yet contain a constructed road. This future road when constructed will likely be classified a Local Access Road under the Functional Road Hierarchy.

4.6 Wilaring Street

Advice received from Main Roads WA indicates that in the future Wilaring Street is proposed to extend to connect with South Western Highway. On that basis this report assumes that by 2031 that connection will be made and the expanded residential development on the eastern side of South Western Highway will be utilising this connection.

On that basis Wilaring Street and Clondyke Drive will share residential trip movements to/from South Western Highway and with the majority of trips movements generated in the residential area being to/from the north, there is potential for Wilaring Street to have a higher preference than Clondyke Drive for traffic movements in and out of this residential area. Benalla Crescent provides a north-south link between Wilaring Street and Clondyke Drive allowing residents to use this as an internal thoroughfare between.

4.7 Clondyke Drive

The majority of future expansion of this residential area is to the north Clondyke Drive and mainly clustered around Wilaring Street. Accordingly, it can reasonably be anticipated that when Wilaring Street connects with South Western Highway and the residential development is fully constructed Clondyke Drive traffic movements will either remain at the present level or decrease slightly.

The Shire of Serpentine Jarrahdale most recent recorded traffic count for Clondyke Drive east of South Western Highway was undertaken in August 2013 where a highest combined two-way traffic volume of 1,160 veh/day ADT was recorded.
Main Roads WA interactive web site provides summary crash data indicating that 8 crashes were recorded at the intersection of Clondyke Drive with South Western Highway in the 5 years from 2008 to 2012. All 8 crashes are thru-right. 1 crash required hospitalisation, 2 required medical treatment, 4 were major property damage and 1 was minor property

damage. The crashes occurred predominantly in dry conditions during daylight between 3pm to 6pm.

4.8 Kiln Road

Kiln Road presently receives little traffic as current traffic generation consists mainly of trips generated by the brickworks. Residential development is proposed in the future to replace the brickworks. Kiln Road traffic generation will then increase significantly. Assuming that by 2031 this proposed future residential development will have occurred and be fully complete then Kiln Road traffic movements will require upgrading of the intersection with South Western Highway. A signalised intersection has been recommended to accommodate the substantial increase in traffic movements.

Main Roads WA interactive web site provides summary crash data indicating that 1 crash was recorded at the intersection of Kiln Road with South Western Highway in the 5 years from 2008 to 2012. From a single isolated crash no predominant crash indicators can be identified.

4.9 Nettleton Road

The Main Roads WA Regional Operations Model for 2031 indicates that Nettleton Road traffic will increase to 21,000 veh/day and South Western Highway will increase north of Nettleton Road to 32,100 veh/day. At this intensity of traffic movements signalisation of the intersection of Nettleton Road with South Western Highway will be required.

Main Roads WA interactive web site provides summary crash data indicating that 4 crashes were recorded at the intersection of Nettleton Road with South Western Highway in the 5 years from 2008 to 2012. Two were right-thru and 2 thru-right. All 4 crashes resulting in major property damage only.

5.0 PROPOSED ROAD NETWORK

This section of the report details the investigations required to estimate the traffic generated by the development.

5.1 Site Operation

The proposed Structure Plan for development of the total land area requires construction of an internal road network servicing the created subdivided lots. External access to the internal road network requires connection with South Western Highway.
The Shire of Serpentine Jarrahdale has advised that the proposed future Orton Road extension will now not proceed. As the road will not be constructed and the future road reserve alignment is not acceptable to MRWA, access to South Western Highway via a future Orton Road is not available to this site.

Discussions with Main Roads Western Australia on alternative options for access to the site has resulted in the advice that only a single main access point from the land development site will be permitted onto South Western Highway. Further, MRWA advises that access must be located at the most northern end of the development. That is, at the northern end of Lot 128. In this position it is at an approximate mid-distance between the existing Clondyke Drive intersection and a proposed future Wilaring Street intersection. MRWA has advised that the resulting separation distance of approximately 400 metres between each intersection will be acceptable.

A single point of access to a commercial subdivision is not considered appropriate for reasons of safety for evacuation should the main access become blocked or in any way otherwise unusable in a hazardous situation, such as fire. Accordingly, MRWA has suggested that a secondary access for "Emergency Only" use from Pinebrook Road onto South Western Highway is acceptable.

5.2 Trip Generation

There are a number of resource documents used to determine the traffic generated by particular development land use types. The two most relevant in Australia are:

- Land Use Traffic Generating Guidelines, Director General of Transport, South Australia, 1986
- Guide to Traffic Generating Developments, Roads and Traffic Authority, NSW, 2002

- Trip Generation, Institute of Transportation Engineers, 7th Edition, 2003

These are the industry recognised documents used by Traffic Engineers and Planners Australia wide.

The current and proposed site consists of a three Lots with a total combined land area of approximately 10.4 hectare comprising the uses and trip generation described in the following table. Trip generation described in the table is the potential maximum occurring under full utilisation for each use.

Table 2. Traffic Generation – Current Approved Use

Land Use	Area	Trip Rate		No. of Trips	
		Peak Hour	Daily	Peak Hour	Daily
Single Residential Dwelling		.8	9	.8	9
			Total	1	9

Table 3. Traffic Generation – Development Proposed Use

Land Use	Area	Trip Rate		No. of Trips	
		Peak Hour	Daily	Peak Hour	Daily
Commercial	10.4ha x 0.4	2/100m^2 GFA	10/100m^2 GFA	832	4,160
			Total	832	4,160

GFA = Gross Floor Area

For commercial land uses the buildings are assumed to be single storey and the floor area ratio of each lot is estimated to average 0.4 of the total available lots land area. The Shire of Serpentine-Jarrahdale Town Planning Scheme No.2 limits site coverage to a maximum of 0.5 with 10% landscaping. It is assumed that the Shire's car parking and bin storage requirements are not excessive and that large service vehicle access requirements will only be needed to service the larger lots.

The above evaluation has been conservative so that a robust analysis is presented in comparing the current and proposed land use. That is, traffic movements generated by this site are fairly presented and should not exceed anticipated peaks described by the trip generation guideline documents.

6.0 ASSESSMENT OF TRAFFIC IMPACTS

This site is within an area zoned for mixed business and residential. Surrounding and adjacent land uses are a mix of conservation land and residential development.

There is not anticipated to be any significant change in amenity as the proposed use is consistent with adjacent areas in accordance with the Byford Structure Plan.

The following assumptions are made for the 2031 year assessment:

- Wilaring Street will be connected to South Western Highway
- Clondyke Drive residential area will have doubled and traffic will redistribute to include Wilaring Street as another main access to/from South Western Highway
- With Clondyke Drive being at the southern area of the residential development and the majority of trip movements to/from north the trip distribution will be shared approximately 50/50 between Wilaring Street and Clondyke Drive.
- The redevelopment of the brickworks land into residential development abutting Kiln Road will be at full development and the South Western Highway/Kiln Road intersection will require/have traffic signal control.
- Nettleton Road/South Western Highway intersection will require/have traffic signal control.

6.1 Operation of Intersections

6.1.1 Pinebrook Road

Pinebrook Road has previously provided for all traffic entry and exit access to Lot 1 in its use by a single residential dwelling on the subject land. The two other lots being undeveloped.

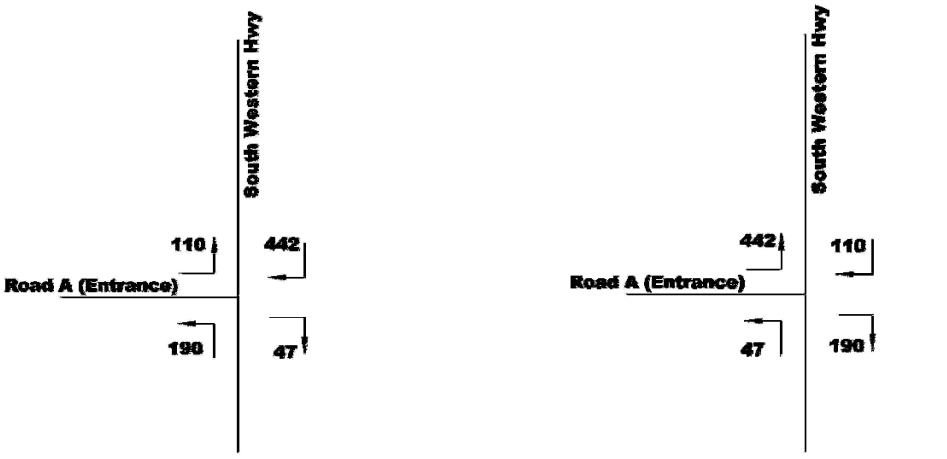
For this development proposal, except during emergencies the Pinebrook Road access to South Western Highway will be closed. At all other times traffic entry and exit to the site will be via the proposed northern Main Access onto South Western Highway. This intersection is proposed to be to the Main Roads WA Rural Type C intersection standard.

6.1.2 Road A (Main Access)

Currently the main developed areas in vicinity of this site are to the north and west. However, new residential land development is occurring to the east of South Western Highway and further is proposed. As a result of future residential land development the direction of trip movements to and from the development Site may undergo a gradual reduction from a large majority of northward movements toward a more even distribution. However, based on current attraction by population density and for the purpose of this evaluation a distribution of 70% north and 30% south along South Western Highway is assumed.

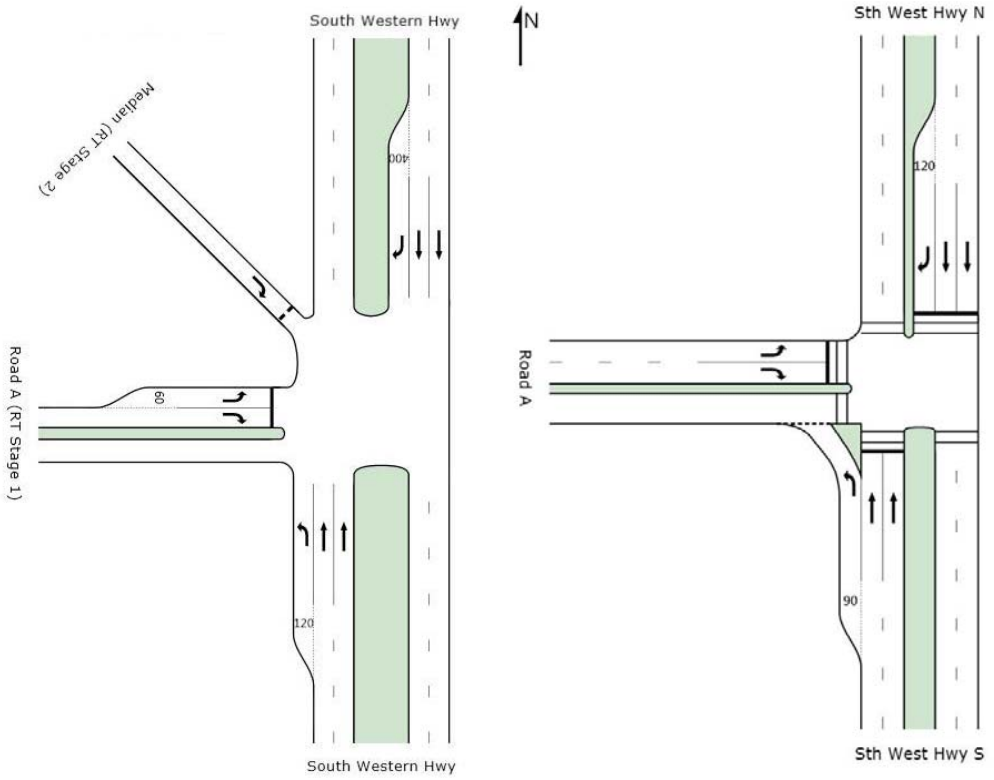
In determining the estimated peak hour entry and exit traffic flows the following assumptions have been made.

- 95% of trips generated by the development in the peak hours will be from an external origin or destination and 5% will be internal.
- 80% of trips generated in the AM peak hour will be entering from South Western Highway and 20% will be exiting. This will reverse in the PM Peak.
- Distribution of entering and exiting traffic is split 70% north and 30% south.



AM Peak Hour Trip Movements PM Peak Hour Trip Movements

Figure 2. Estimated Peak Hour Entry and Exit Traffic Flows



a) Stop Sign Control

b) Traffic Signal Control

MOVEMENT SUMMARY

Site: AM Peak Stop Sign Control - 2031

South Western Hwy / Road A

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: Road A (RT Stage 1)											
1	L	110	10.0	0.408	27.7	LOS D	1.6	12.4	0.85	1.07	35.3
3	R	47	10.0	0.549	73.0	LOS F	1.8	13.7	0.96	1.08	19.3
Approach		157	10.0	0.549	41.3	LOS E	1.8	13.7	0.88	1.07	28.9
East: South Western Hwy											
4	L	190	10.0	0.110	8.6	LOS A	0.0	0.0	0.00	0.67	49.0
5	T	983	10.0	0.268	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		1173	10.0	0.268	1.4	NA	0.0	0.0	0.00	0.11	57.9
West: South Western Hwy											
11	T	895	10.0	0.244	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
12	R	442	10.0	1.385	381.6	LOS F	85.3	648.7	1.00	5.53	5.3
Approach		1337	10.0	1.385	126.2	NA	85.3	648.7	0.33	1.83	13.5
South West: Median (RT Stage 2)											
32	R	47	10.0	0.114	8.9	LOS A	0.4	2.5	0.70	0.78	20.6
Approach		47	10.0	0.114	8.9	LOS A	0.4	2.5	0.70	0.78	20.6
All Vehicles		2714	10.0	1.385	65.3	NA	85.3	648.7	0.23	1.02	21.3

MOVEMENT SUMMARY

Site: PM Peak Stop Sign Control - 2031

South Western Hwy / Road A

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: Road A (RT Stage 1)											
1	L	442	10.0	2.509	1401.2	LOS F	175.1	1331.1	1.00	6.75	1.5
3	R	190	10.0	1.870	854.2	LOS F	61.6	468.2	1.00	3.83	2.1
Approach		632	10.0	2.509	1236.7	LOS F	175.1	1331.1	1.00	5.87	1.6
East: South Western Hwy											
4	L	47	10.0	0.027	8.6	LOS A	0.0	0.0	0.00	0.67	49.0
5	T	1304	10.0	0.356	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		1351	10.0	0.356	0.3	NA	0.0	0.0	0.00	0.02	59.5
West: South Western Hwy											
11	T	719	10.0	0.196	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
12	R	110	10.0	0.456	29.0	LOS D	1.9	14.2	0.90	1.05	33.6
Approach		829	10.0	0.456	3.8	NA	1.9	14.2	0.12	0.14	54.3
South West: Median (RT Stage 2)											
32	R	190	10.0	0.352	8.2	LOS A	1.6	10.4	0.68	0.89	21.4
Approach		190	10.0	0.352	8.2	LOS A	1.6	10.4	0.68	0.89	21.4
All Vehicles		3002	10.0	2.509	262.1	NA	175.1	1331.1	0.29	1.34	6.9

SIDRA modelling analysis of this intersection at full locality development indicates that it will be unable to operate satisfactorily during the AM and PM Peak periods under Stop/Give Way Sign Control in 2031 using traffic model flows for South Western Highway provided by Main Roads WA. The SIDRA analysis indicates likely queuing can anticipated to extend up to 650m for the right turn on South Western Highway during the AM Peak. During the PM Peak on Road A the exiting traffic queues can be anticipated to extend up to 468m for the right turn and 1,331m for the left turn.

It is anticipated that at 50% of full development of the area under the Structure Plan the capacity of the intersection to accommodate traffic movements (under Stop/Give Way sign control) will commence being exceeded. That is, at 50% of development of the area under the present Structure Plan other traffic access arrangements will be required.

The requirement by Main Roads Western Australia to limit access for this development to a single intersection onto South Western Highway is therefore not feasible in this instance if the intersection is operating under Stop/Give Way Sign Control. This intersection during peak hours is not able to operate at a satisfactory Level of Service under Sign Control to provide reasonable and safe access to the development Site and South Western Highway.

An alternative option is therefore required that will enable a single road connection with South Western Highway to function in a satisfactory manner to accommodate traffic entering and exiting the development Site.

Traffic signalisation of the intersection is a potential solution. Analysis of this intersection using SIDRA modelling under traffic control signals is presented in the following.

MOVEMENT SUMMARY

Site: AM Peak Traffic Signals - 2031

Development Access Road at South Western Highway
With Traffic Control Signals (AM Peak)
Signals - Fixed Time Cycle Time = 50 seconds (Practical Cycle Time)

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: Sth West Hwy S											
1	L	190	10.0	0.143	10.9	LOS B	0.6	4.9	0.28	0.70	55.4
2	T	983	10.0	0.781	19.7	LOS B	12.4	94.5	0.96	0.92	45.0
Approach		1173	10.0	0.781	18.3	LOS B	12.4	94.5	0.85	0.88	46.2
North: Sth West Hwy N											
8	T	895	10.0	0.712	17.3	LOS B	10.4	78.8	0.93	0.84	47.2
9	R	442	10.0	0.742	28.8	LOS C	10.7	81.2	0.94	0.90	38.0
Approach		1337	10.0	0.742	21.1	LOS C	10.7	81.2	0.93	0.86	44.1
West: Road A											
10	L	110	10.0	0.150	17.9	LOS B	1.7	12.8	0.65	0.75	38.8
12	R	47	10.0	0.064	17.4	LOS B	0.7	5.2	0.62	0.71	39.2
Approach		157	10.0	0.150	17.8	LOS B	1.7	12.8	0.64	0.74	39.0
All Vehicles		2667	10.0	0.781	19.7	LOS B	12.4	94.5	0.88	0.86	44.6

MOVEMENT SUMMARY

Site: PM Peak Traffic Signals - 2031

Development Access Road at South Western Highway
With Traffic Control Signals (PM Peak)
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		Prop. Queued	Effective Stop Rate	Average Speed
							Vehicles	Distance			
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Sth West Hwy S											
1	L	47	10.0	0.034	10.6	LOS B	0.1	1.1	0.21	0.68	56.0
2	T	1304	10.0	0.783	18.3	LOS B	18.1	137.9	0.91	0.87	46.4
Approach		1351	10.0	0.783	18.0	LOS B	18.1	137.9	0.89	0.87	46.6
North: Sth West Hwy N											
8	T	719	10.0	0.432	12.3	LOS B	7.3	55.4	0.73	0.63	53.2
9	R	110	10.0	0.140	20.8	LOS C	1.9	14.5	0.62	0.76	44.4
Approach		829	10.0	0.432	13.4	LOS B	7.3	55.4	0.71	0.64	52.0
West: Road A											
10	L	442	10.0	0.721	28.3	LOS C	12.1	92.3	0.93	0.89	33.3
12	R	190	10.0	0.310	23.6	LOS C	4.1	31.5	0.77	0.78	35.6
Approach		632	10.0	0.721	26.9	LOS C	12.1	92.3	0.88	0.85	34.0
All Vehicles		2812	10.0	0.783	18.7	LOS B	18.1	137.9	0.83	0.80	44.3

Operation of this intersection under traffic control signals with the following geometry has been modelled:

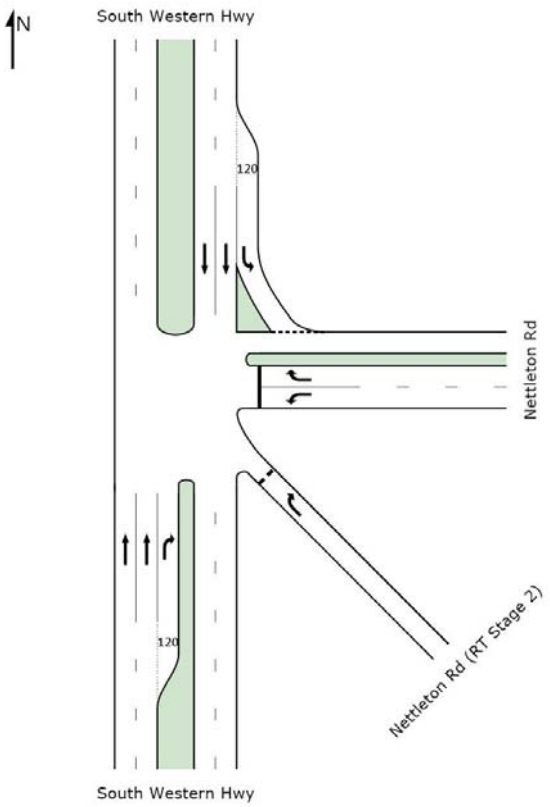
- 2 lanes on all approaches merged to one lane on departures
- right turn pocket southbound
- left turn slip lane northbound

The SIDRA modelling indicates that an intersection of this configuration will operate generally under an average Level of Service B. However, the South Western Hwy right turn pocket which will operate at a LoS C during the AM Peak with queuing extending up to approximately 81 metres. As the highway is a single lane in each direction this will require the right turn pocket to be of 81 metres for storage plus a deceleration length for the design speed of approach.

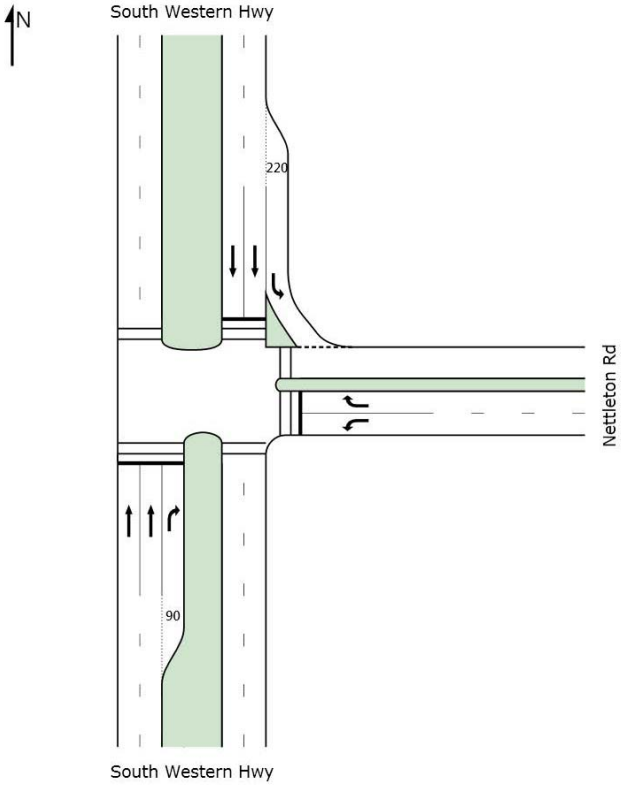
6.1.3 Nettleton Road

The operation of the Nettleton Road/South Western Highway intersection has been modelled under the following scenarios:

- T-Junction under Give Way control with wide median for two-stage right turns as per MRWA concept geometry for South Western Highway upgrade for 2031 traffic.
- T-junction under traffic signals control for 2031 traffic.



a) Stop/Give Way Sign Control



b) Traffic Signal Control

MOVEMENT SUMMARY

Site: Peak Hour 2031 - Stop Control

South Western Hwy / Nettleton Rd - Stop Control
Stop (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 Hwy											
2	T	844	10.0	0.230	0.0	LOS A	0.0	0.0	0.00	0.00	80.0
3	R	341	10.0	0.831	34.4	LOS D	7.4	56.3	0.93	1.38	34.4
Approach		1185	10.0	0.831	9.9	NA	7.4	56.3	0.27	0.40	60.0
South East: Nettleton Rd (RT Stage 2)											
23	R	371	5.0	0.753	16.3	LOS C	5.7	35.9	0.87	1.68	22.1
Approach		371	5.0	0.753	16.3	LOS C	5.7	35.9	0.87	1.68	22.1
East: Nettleton Rd											
4	L	333	5.0	2.077	1017.0	LOS F	115.4	842.7	1.00	6.28	2.3
6	R	371	5.0	6.183	4747.6	LOS F	210.7	1538.4	1.00	4.54	0.4
Approach		704	5.0	6.183	2983.0	LOS F	210.7	1538.4	1.00	5.36	0.7
North: South Western Hwy											
7	L	1057	10.0	1.145	154.6	LOS F	109.6	833.3	1.00	4.06	11.6
8	T	931	10.0	0.254	0.0	LOS A	0.0	0.0	0.00	0.00	80.0
Approach		1988	10.0	1.145	82.2	NA	109.6	833.3	0.53	2.16	20.6
All Vehicles		4248	8.7	6.183	537.0	NA	210.7	1538.4	0.57	2.16	3.8

MOVEMENT SUMMARY

Site: Peak Hour 2031 - Traffic Signal Control

South Western Highway/Nettleton Rd - TCS
Signals - Fixed Time Cycle Time = 100 seconds (User-Given Cycle Time)

Movement Performance - Vehicles

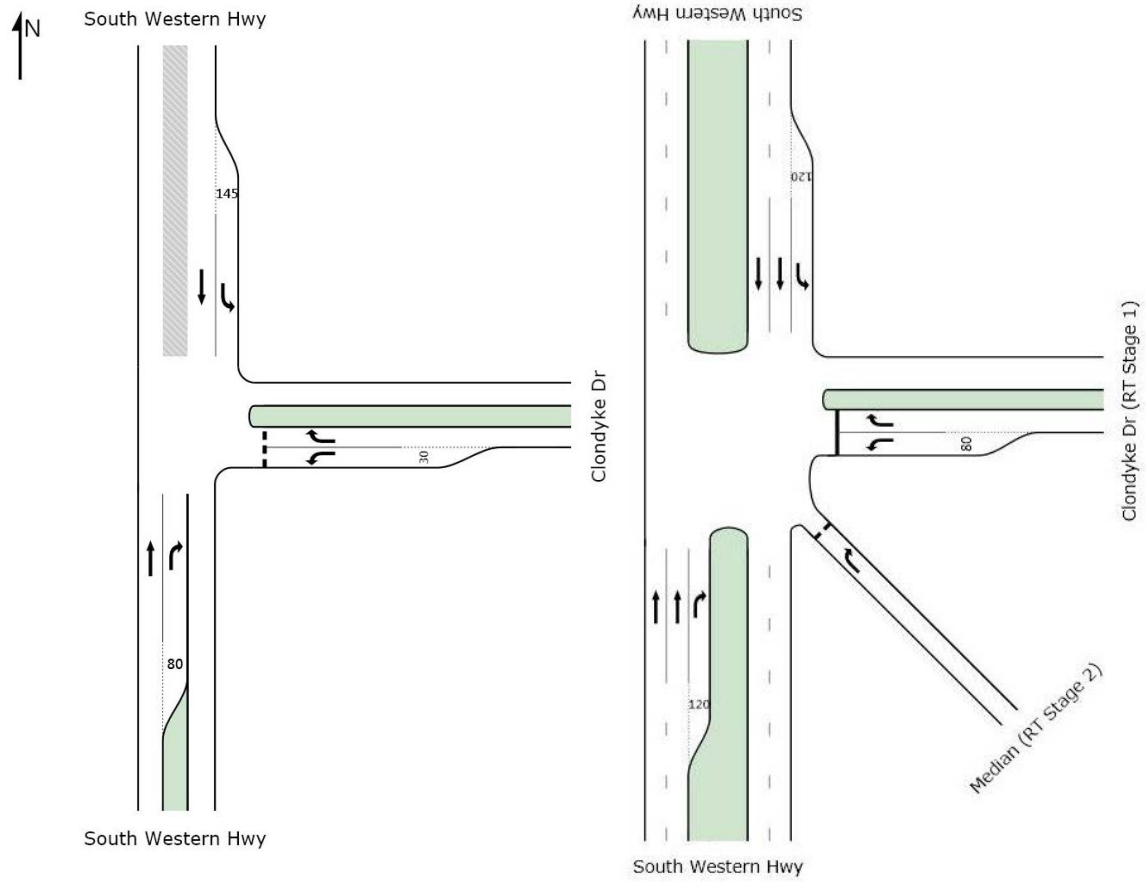
Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue		Prop. Queued	Effective Stop Rate	Average Speed
							Vehicles	Distance			
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: South Western Hwy											
2	T	844	10.0	0.691	31.5	LOS C	18.0	136.8	0.93	0.81	37.2
3	R	341	10.0	0.695	32.7	LOS C	10.1	77.0	0.95	0.88	35.5
Approach		1185	10.0	0.695	31.8	LOS C	18.0	136.8	0.93	0.83	36.7
East: Nettleton Rd											
4	L	333	5.0	0.681	43.7	LOS D	14.8	107.9	0.95	0.85	27.5
6	R	371	5.0	0.758	46.5	LOS D	17.5	128.0	0.98	0.89	26.7
Approach		704	5.0	0.758	45.1	LOS D	17.5	128.0	0.97	0.87	27.1
North: South Western Hwy											
7	L	1057	10.0	0.877	27.5	LOS C	36.6	278.2	0.80	0.95	38.9
8	T	931	10.0	0.762	34.2	LOS C	21.2	161.0	0.96	0.87	35.7
Approach		1988	10.0	0.877	30.6	LOS C	36.6	278.2	0.87	0.91	37.2
All Vehicles		3877	9.1	0.877	33.6	LOS C	36.6	278.2	0.91	0.88	34.6

Results from the SIDRA modelling indicate that traffic signal control is required for this intersection at 2031 traffic flows.

6.1.4 Clondyke Drive

The operation of the Clondyke Drive/South Western Highway intersection has been modelled under the following scenarios:

- Existing T-Junction intersection under Give Way control
- Future T-junction under Give Way control at 2031 traffic flows.



a) Stop/Give Way Control - Existing

b) Stop/Give Way Control - 2031

MOVEMENT SUMMARY

Site: AM Peak Give Way - Existing

South Western Hwy / Clondyke Drive, Byford - Stop/Give Way Staged Crossing

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 Hwy											
2	T	353	8.0	0.190	0.0	LOS A	0.0	0.0	0.00	0.00	80.0
3	R	13	38.0	0.018	13.4	LOS B	0.1	0.6	0.37	0.68	54.4
Approach		366	9.1	0.190	0.5	NA	0.1	0.6	0.01	0.02	78.9
East: Clondyke Dr											
4	L	14	7.0	0.012	8.7	LOS A	0.0	0.3	0.32	0.59	44.9
6	R	178	4.0	0.174	10.4	LOS B	0.8	5.7	0.56	0.77	44.0
Approach		192	4.2	0.174	10.3	LOS B	0.8	5.7	0.55	0.76	44.0
North: South Western Hwy											
7	L	43	12.0	0.025	10.6	LOS B	0.0	0.0	0.00	0.71	57.1
8	T	196	13.0	0.109	0.0	LOS A	0.0	0.0	0.00	0.00	80.0
Approach		239	12.8	0.109	1.9	NA	0.0	0.0	0.00	0.13	75.3
All Vehicles		797	9.0	0.190	3.3	NA	0.8	5.7	0.14	0.23	65.5

MOVEMENT SUMMARY

Site: PM Peak Give Way - Existing

South Western Hwy / Clondyke Drive, Byford - Stop/Give Way Staged Crossing

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 Hwy											
2	T	250	7.0	0.134	0.0	LOS A	0.0	0.0	0.00	0.00	80.0
3	R	10	0.0	0.012	12.2	LOS B	0.0	0.3	0.45	0.70	54.0
Approach		260	6.7	0.134	0.5	NA	0.0	0.3	0.02	0.03	78.8
East: Clondyke Dr											
4	L	13	23.0	0.015	10.5	LOS B	0.1	0.5	0.47	0.64	44.4
6	R	52	8.0	0.057	10.8	LOS B	0.2	1.8	0.56	0.74	43.8
Approach		65	11.0	0.057	10.8	LOS B	0.2	1.8	0.54	0.72	43.9
North: South Western Hwy											
7	L	147	3.0	0.081	10.2	LOS B	0.0	0.0	0.00	0.71	57.1
8	T	327	10.0	0.179	0.0	LOS A	0.0	0.0	0.00	0.00	80.0
Approach		474	7.8	0.179	3.2	NA	0.0	0.0	0.00	0.22	72.1
All Vehicles		799	7.7	0.179	2.9	NA	0.2	1.8	0.05	0.20	70.4

MOVEMENT SUMMARY

Site: AM Peak Give Way - 2031

South Western Highway / Clondyke Drive, Byford – Stop/Give Way Staged Crossing

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: Clondyke Dr (RT Stage 1)											
1	L	14	7.0	0.072	28.3	LOS D	0.2	1.6	0.84	1.00	34.9
3	R	178	4.0	1.221	272.5	LOS F	26.3	190.5	1.00	2.72	6.2
Approach		192	4.2	1.221	254.7	LOS F	26.3	190.5	0.99	2.60	6.7
East: South Western Hwy											
4	L	43	12.0	0.025	8.6	LOS A	0.0	0.0	0.00	0.67	49.0
5	T	1260	13.0	0.350	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		1303	13.0	0.350	0.3	NA	0.0	0.0	0.00	0.02	59.6
West: South Western Hwy											
11	T	1190	8.0	0.321	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
12	R	13	38.0	0.110	39.3	LOS E	0.3	3.1	0.90	0.96	29.4
Approach		1203	8.3	0.321	0.4	NA	0.3	3.1	0.01	0.01	59.3
South West: Median (RT Stage 2)											
32	R	178	4.0	0.609	20.7	LOS C	2.8	17.6	0.90	1.28	12.8
Approach		178	4.0	0.609	20.7	LOS C	2.8	17.6	0.90	1.28	12.8
All Vehicles		2876	9.9	1.221	18.6	NA	26.3	190.5	0.13	0.27	39.1

MOVEMENT SUMMARY

Site: PM Peak Give Way - 2031

South Western Highway / Clondyke Drive, Byford – Stop/Give Way Staged Crossing

Movement Performance - Vehicles

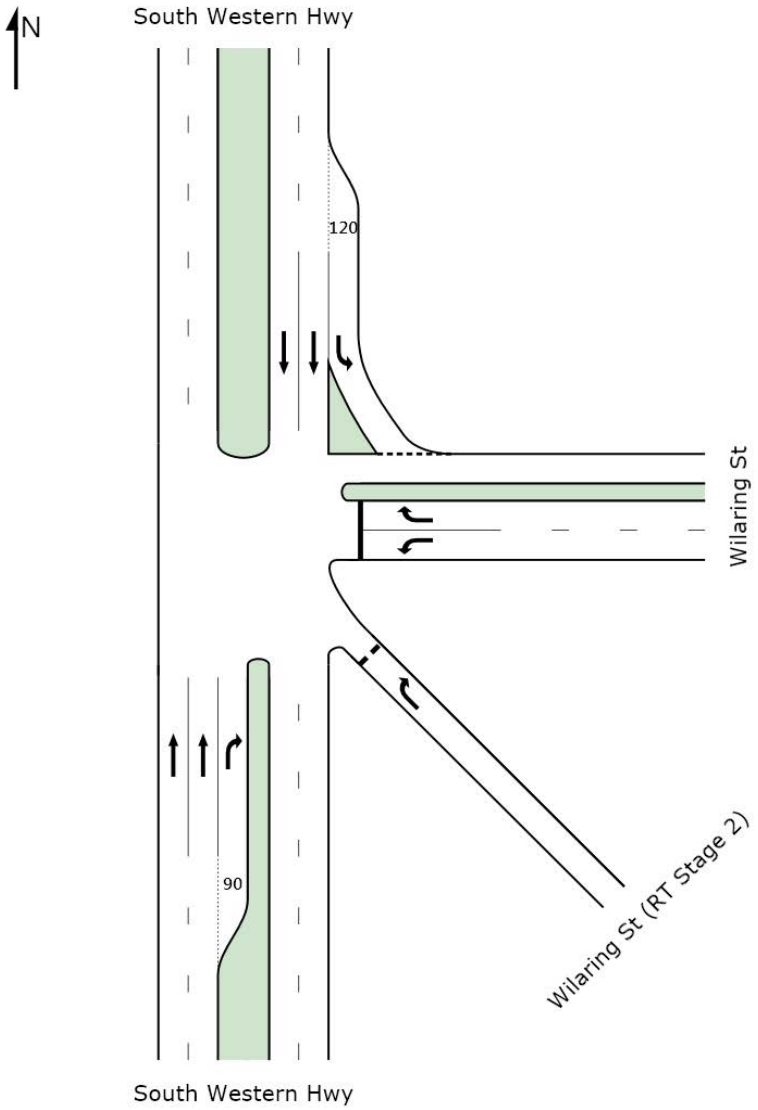
Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue		Prop. Queued	Effective Stop Rate	Average Speed
							Vehicles	Distance			
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Clondyke Dr (RT Stage 1)											
1	L	13	7.0	0.073	30.0	LOS D	0.2	1.6	0.86	1.00	34.0
3	R	52	4.0	0.391	45.8	LOS E	1.3	9.3	0.92	1.05	26.8
Approach		65	4.6	0.391	42.7	LOS E	1.3	9.3	0.91	1.04	28.1
East: South Western Hwy											
4	L	147	12.0	0.086	8.6	LOS A	0.0	0.0	0.00	0.67	49.0
5	T	1260	13.0	0.350	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		1407	12.9	0.350	0.9	NA	0.0	0.0	0.00	0.07	58.6
West: South Western Hwy											
11	T	1190	8.0	0.321	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
12	R	10	38.0	0.106	46.8	LOS E	0.3	2.9	0.92	0.97	26.7
Approach		1200	8.3	0.321	0.4	NA	0.3	2.9	0.01	0.01	59.4
South West: Median (RT Stage 2)											
32	R	178	4.0	0.609	20.7	LOS C	2.8	17.6	0.90	1.28	12.8
Approach		178	4.0	0.609	20.7	LOS C	2.8	17.6	0.90	1.28	12.8
All Vehicles		2850	10.2	0.609	2.9	NA	2.8	17.6	0.08	0.14	55.3

Results from the SIDRA modelling indicate that Stop/Give Way control will produce up to 190m of queuing during the AM peak for this intersection at 2031 traffic flows and average delay of over 4 minutes.

6.1.5 Wilaring Street

The operation of the Wilaring Street/South Western Highway intersection has been modelled under the following scenarios:

- T-Junction under Stop/Give Way control with wide median for two-stage right turns as per MRWA concept geometry for South Western Highway for 2031 traffic.



MOVEMENT SUMMARY

Site: AM Peak Hour 2031 – Stop/Give Way Control

South Western Hwy / Wilaring St - Stop Control

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 Hwy											
2	T	1068	10.0	0.292	0.0	LOS A	0.0	0.0	0.00	0.00	80.0
3	R	25	10.0	0.102	24.6	LOS C	0.3	2.5	0.84	0.95	41.1
Approach		1093	10.0	0.292	0.6	NA	0.3	2.5	0.02	0.02	78.6
South East: Wilaring St (RT Stage 2)											
23	R	120	5.0	0.348	13.4	LOS B	1.3	8.4	0.81	0.99	24.5
Approach		120	5.0	0.348	13.4	LOS B	1.3	8.4	0.81	0.99	24.5
East: Wilaring St											
4	L	15	5.0	0.064	25.0	LOS C	0.2	1.5	0.81	1.00	35.7
6	R	120	5.0	0.729	50.5	LOS F	3.3	24.3	0.95	1.23	22.4
Approach		135	5.0	0.729	47.6	LOS E	3.3	24.3	0.94	1.21	23.7
North: South Western Hwy											
7	L	50	10.0	0.037	10.1	LOS B	0.1	1.1	0.09	0.62	56.9
8	T	1214	10.0	0.332	0.0	LOS A	0.0	0.0	0.00	0.00	80.0
Approach		1264	10.0	0.332	0.4	NA	0.1	1.1	0.00	0.02	78.9
All Vehicles		2612	9.5	0.729	3.5	NA	3.3	24.3	0.10	0.13	70.0

MOVEMENT SUMMARY

Site: PM Peak Hour 2031 – Stop/Give Way Control

South Western Hwy / Wilaring St - Stop Control

Movement Performance - Vehicles

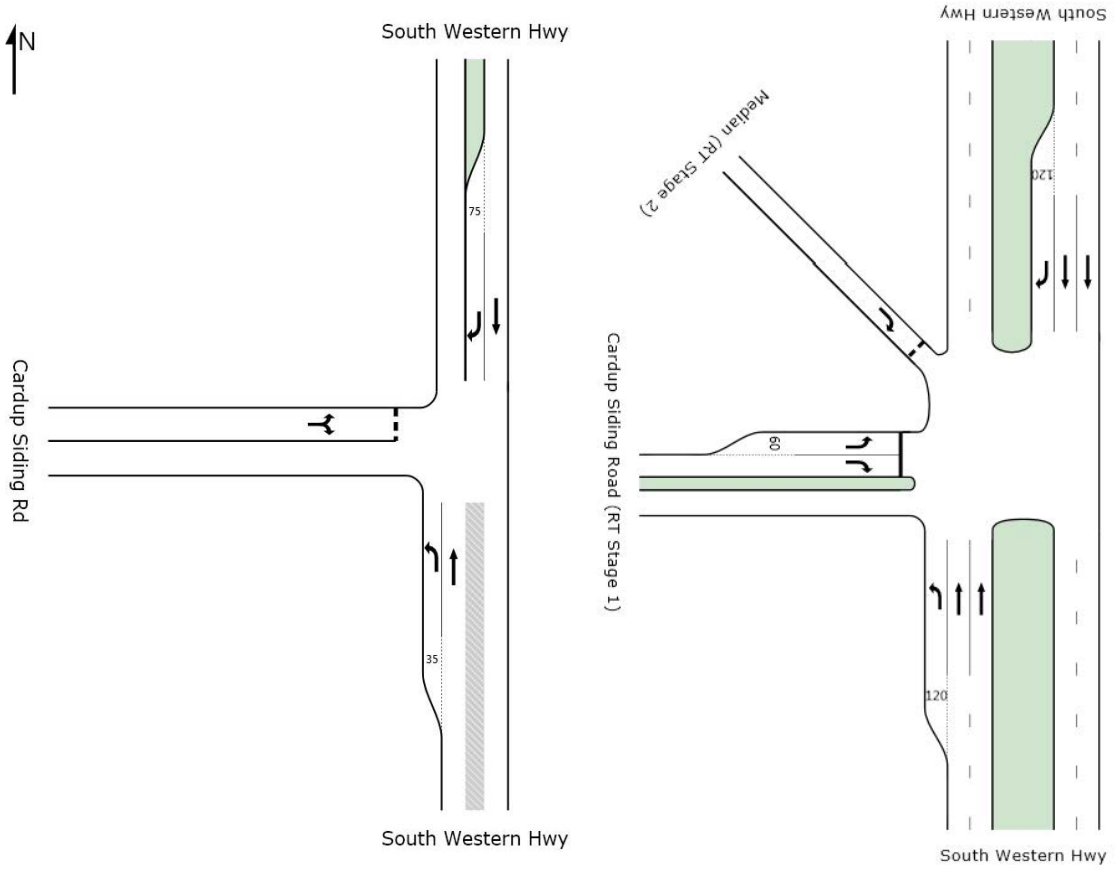
Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue		Prop. Queued	Effective Stop Rate	Average Speed
							Vehicles	Distance			
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: South Western Hwy											
2	T	1746	10.0	0.477	0.0	LOS A	0.0	0.0	0.00	0.00	80.0
3	R	25	10.0	0.102	24.6	LOS C	0.3	2.5	0.84	0.95	41.1
Approach		1771	10.0	0.477	0.3	NA	0.3	2.5	0.01	0.01	79.1
South East: Wilaring St (RT Stage 2)											
23	R	50	5.0	0.610	70.0	LOS F	2.0	12.4	0.98	1.16	7.9
Approach		50	5.0	0.610	70.0	LOS F	2.0	12.4	0.98	1.16	7.9
East: Wilaring St											
4	L	15	5.0	0.070	26.4	LOS D	0.2	1.6	0.83	1.00	35.1
6	R	50	5.0	0.333	37.2	LOS E	1.1	7.9	0.90	1.05	26.7
Approach		65	5.0	0.333	34.7	LOS D	1.1	7.9	0.88	1.04	28.6
North: South Western Hwy											
7	L	150	10.0	0.112	10.1	LOS B	0.5	3.7	0.10	0.62	56.8
8	T	1214	10.0	0.332	0.0	LOS A	0.0	0.0	0.00	0.00	80.0
Approach		1364	10.0	0.332	1.1	NA	0.5	3.7	0.01	0.07	77.0
All Vehicles		3250	9.8	0.610	2.4	NA	2.0	12.4	0.04	0.07	73.4

Results from the SIDRA modelling indicate that Stop/Give Way signed control is adequate for this intersection at 2031 traffic flows.

6.1.6 Cardup Siding Road

The operation of the Cardup Siding Road/South Western Highway intersection has been modelled using under the following scenarios:

- Existing T-junction intersection.
- T-Junction under Give Way control with wide median for two-stage right turns as per MRWA concept geometry for South Western Highway upgrade for 2031 traffic.



a) Stop/Give Way Control - Existing

b) Stop/Give Way Control - 2031

MOVEMENT SUMMARY

Site: AM Peak Existing

South Western Hwy / Cardup Siding Rd T-junction
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 Hwy											
1	L	11	18.0	0.007	10.9	LOS B	0.0	0.0	0.00	0.71	57.1
2	T	260	17.0	0.148	0.0	LOS A	0.0	0.0	0.00	0.00	80.0
Approach		271	17.0	0.148	0.4	NA	0.0	0.0	0.00	0.03	78.9
North: South Western Hwy											
8	T	166	18.0	0.095	0.0	LOS A	0.0	0.0	0.00	0.00	80.0
9	R	42	10.0	0.086	15.0	LOS C	0.3	2.5	0.51	0.79	51.0
Approach		208	16.4	0.095	3.0	NA	0.3	2.5	0.10	0.16	72.6
West: Cardup Siding Rd											
10	L	105	7.0	0.088	10.6	LOS B	0.4	3.0	0.40	0.67	49.4
12	R	10	10.0	0.088	10.8	LOS B	0.4	3.0	0.40	0.73	49.5
Approach		115	7.3	0.088	10.6	LOS B	0.4	3.0	0.40	0.67	49.4
All Vehicles		594	14.9	0.148	3.3	NA	0.4	3.0	0.11	0.20	68.9

MOVEMENT SUMMARY

Site: PM Peak Existing

South Western Hwy / Cardup Siding Rd T-junction
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 Hwy											
1	L	16	0.0	0.009	10.1	LOS B	0.0	0.0	0.00	0.71	57.1
2	T	237	13.0	0.132	0.0	LOS A	0.0	0.0	0.00	0.00	80.0
Approach		253	12.2	0.132	0.6	NA	0.0	0.0	0.00	0.04	78.3
North: South Western Hwy											
8	T	256	11.0	0.141	0.0	LOS A	0.0	0.0	0.00	0.00	80.0
9	R	69	9.0	0.126	14.1	LOS B	0.5	3.7	0.48	0.77	52.1
Approach		325	10.6	0.141	3.0	NA	0.5	3.7	0.10	0.16	72.6
West: Cardup Siding Rd											
10	L	50	6.0	0.054	10.8	LOS B	0.2	1.8	0.39	0.64	49.4
12	R	15	20.0	0.054	11.5	LOS B	0.2	1.8	0.39	0.74	49.5
Approach		65	9.2	0.054	10.9	LOS B	0.2	1.8	0.39	0.67	49.5
All Vehicles		643	11.1	0.141	2.9	NA	0.5	3.7	0.09	0.17	71.3

MOVEMENT SUMMARY

Site: Peak Hour 2031

South Western Hwy/Cardup Siding Rd
Stop (Two-Way)

Movement Performance - Vehicles

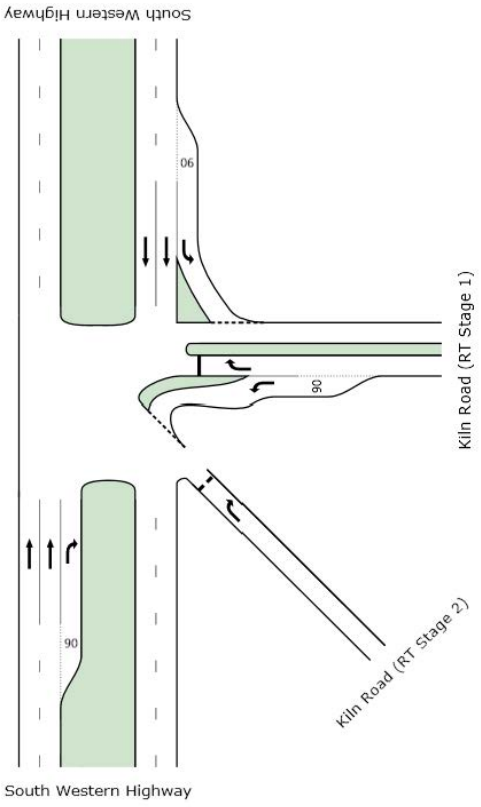
Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue		Prop. Queued	Effective Stop Rate	Average Speed
							Vehicles	Distance			
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: Cardup Siding Road (RT Stage 1)											
1	L	274	10.0	0.839	40.0	LOS E	6.8	51.8	0.94	1.48	29.5
3	R	60	10.0	0.488	52.3	LOS F	1.7	12.8	0.93	1.07	24.6
Approach		334	10.0	0.839	42.2	LOS E	6.8	51.8	0.94	1.41	28.6
East: South Western Hwy											
4	L	91	10.0	0.053	8.6	LOS A	0.0	0.0	0.00	0.67	49.0
5	T	912	10.0	0.249	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		1003	10.0	0.249	0.8	NA	0.0	0.0	0.00	0.06	58.8
West: South Western Hwy											
11	T	880	10.0	0.240	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
12	R	385	10.0	0.939	48.9	LOS E	13.3	100.8	0.97	1.94	25.8
Approach		1265	10.0	0.939	14.9	NA	13.3	100.8	0.30	0.59	42.7
South West: Median (RT Stage 2)											
32	R	60	10.0	0.142	8.8	LOS A	0.5	3.1	0.70	0.78	20.7
Approach		60	10.0	0.142	8.8	LOS A	0.5	3.1	0.70	0.78	20.7
All Vehicles		2662	10.0	0.939	12.9	NA	13.3	100.8	0.27	0.50	44.5

Results from the SIDRA modelling indicate that under Give Way control and with the wide median permitting two-stage right turns as per the MRWA concept geometry for the 2031 upgrading, this intersection will operate satisfactorily under Give Way control.

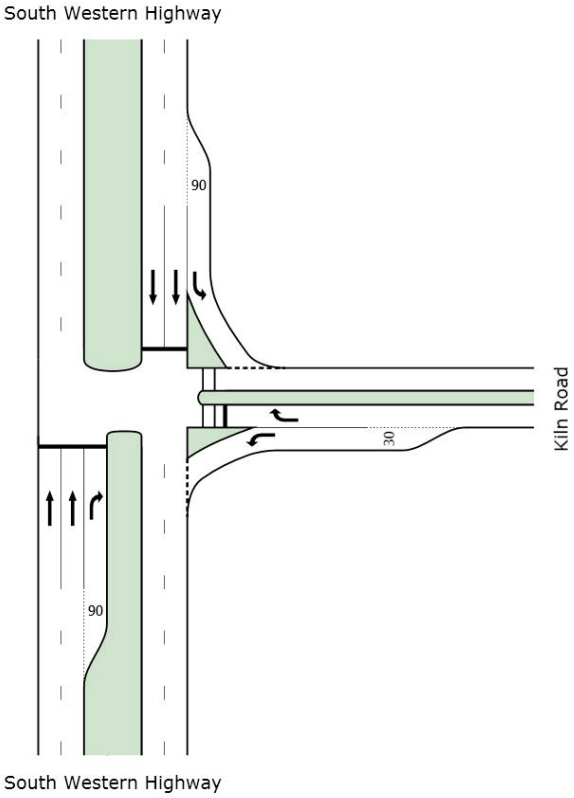
6.1.7 Kiln Road

The operation of the Kiln Road/South Western Highway intersection has been modelled using under the following scenarios:

- T-Junction under Give Way control with wide median for two-stage right turns as per MRWA concept geometry for South Western Highway upgrade for 2031 traffic.
- T-junction under traffic signals control for 2031 traffic.



a) Stop/Give Way Control - 2031



b) Traffic Signal Control - 2031

MOVEMENT SUMMARY

Site: Stop 3-way AM Peak Hr at Full Development

Staged crossing at three-way intersection with 4-lane major road (Stop control)

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: Kiln Road (RT Stage 1)											
1	L	72	2.0	0.186	15.9	LOS C	0.6	4.5	0.72	0.89	41.9
3	R	284	2.0	4.737	3447.5	LOS F	152.3	1084.4	1.00	3.92	0.5
Approach		356	2.0	4.737	2757.1	LOS F	152.3	1084.4	0.94	3.31	0.7
East: South Western Highway											
4	L	95	2.0	0.074	7.7	LOS A	0.3	2.0	0.09	0.57	49.3
5	T	918	5.0	0.243	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		1013	4.7	0.243	0.7	NA	0.3	2.0	0.01	0.05	58.8
West: South Western Highway											
11	T	1028	5.0	0.272	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
12	R	24	2.0	0.049	13.8	LOS B	0.2	1.2	0.66	0.85	43.6
Approach		1053	4.9	0.272	0.3	NA	0.2	1.2	0.02	0.02	59.5
South West: Kiln Road (RT Stage 2)											
32	R	284	0.0	3.098	1945.0	LOS F	129.3	775.9	1.00	9.29	0.2
Approach		284	0.0	3.098	1945.0	LOS F	129.3	775.9	1.00	9.29	0.2
All Vehicles		2705	3.9	4.737	567.3	NA	152.3	1084.4	0.24	1.44	3.3

MOVEMENT SUMMARY

Site: Stop 3-way PM Peak Hr at Full Development

Staged crossing at three-way intersection with 4-lane major road (Stop control)

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: Kiln Road (RT Stage 1)											
1	L	36	2.0	0.108	17.3	LOS C	0.4	2.5	0.75	0.90	40.9
3	R	142	2.0	2.368	1322.6	LOS F	57.6	409.8	1.00	3.20	1.4
Approach		178	2.0	2.368	1060.0	LOS F	57.6	409.8	0.95	2.73	1.8
East: South Western Highway											
4	L	239	2.0	0.187	7.9	LOS A	0.8	5.6	0.16	0.57	48.9
5	T	954	5.0	0.252	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
Approach		1193	4.4	0.252	1.6	NA	0.8	5.6	0.03	0.11	57.4
West: South Western Highway											
11	T	995	5.0	0.263	0.0	LOS A	0.0	0.0	0.00	0.00	60.0
12	R	58	2.0	0.122	14.6	LOS B	0.4	3.1	0.70	0.89	43.0
Approach		1053	4.8	0.263	0.8	NA	0.4	3.1	0.04	0.05	58.7
South West: Kiln Road (RT Stage 2)											
32	R	142	0.0	2.166	1135.8	LOS F	54.1	324.8	1.00	5.91	0.4
Approach		142	0.0	2.166	1135.8	LOS F	54.1	324.8	1.00	5.91	0.4
All Vehicles		2565	4.2	2.368	137.5	NA	57.6	409.8	0.15	0.59	12.0

MOVEMENT SUMMARY

Site: 3-way Signals AM Peak at Full Development

Three-way intersection (Signals)
Signals - Fixed Time Cycle Time = 50 seconds (Practical Cycle Time)

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											
2	T	1028	5.0	0.486	7.3	LOS A	7.7	56.2	0.65	0.57	60.1
3	R	24	5.0	0.225	37.3	LOS D	0.6	4.6	0.98	0.70	32.8
Approach		1053	5.0	0.486	8.0	LOS A	7.7	56.2	0.66	0.57	59.1
East: Kiln Road											
4	L	72	0.0	0.104	11.4	LOS B	0.7	4.6	0.49	0.67	43.1
6	R	284	0.0	0.765	31.8	LOS C	7.5	52.5	1.00	0.96	31.7
Approach		356	0.0	0.765	27.7	LOS C	7.5	52.5	0.90	0.90	33.5
North: South Western Highway											
7	L	95	0.0	0.067	10.5	LOS B	0.3	2.1	0.26	0.69	55.6
8	T	918	0.0	0.841	24.7	LOS C	12.9	90.3	1.00	1.00	41.1
Approach		1013	0.0	0.841	23.4	LOS C	12.9	90.3	0.93	0.97	42.0
All Vehicles		2421	2.2	0.841	17.3	LOS B	12.9	90.3	0.81	0.79	46.1

MOVEMENT SUMMARY

Site: 3-way Signals PM Peak at Full Development

Three-way intersection (Signals)
Signals - Fixed Time Cycle Time = 50 seconds (Practical Cycle Time)

Movement Performance - Vehicles

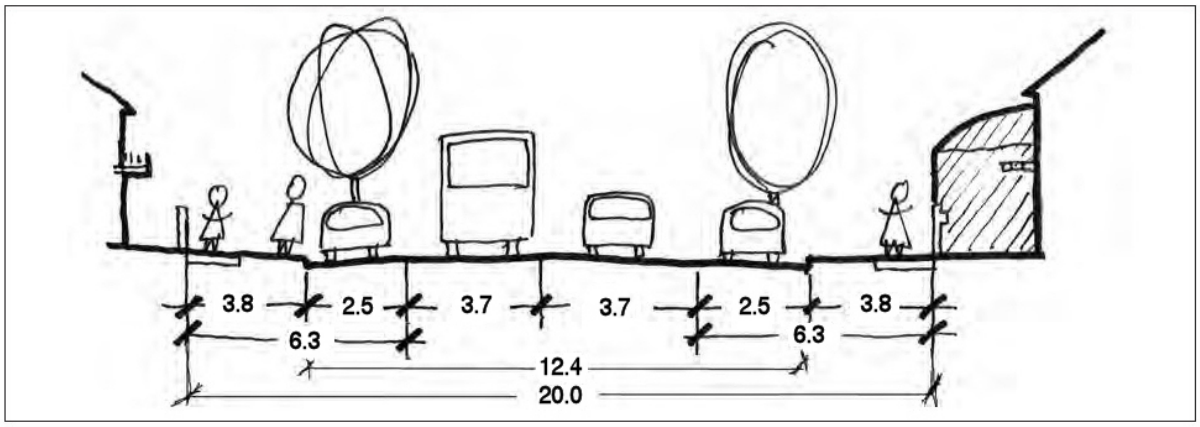
Mov ID	Turn	Demand Flow	HV	Deg. Satn	Average Delay	Level of Service	95% Back of Queue		Prop. Queued	Effective Stop Rate	Average Speed
							Vehicles	Distance			
		veh/h	%	v/c	sec		veh	m		per veh	km/h
South: South Western Highway											
2	T	995	5.0	0.411	4.8	LOS A	6.0	43.7	0.52	0.46	64.3
3	R	58	5.0	0.538	38.5	LOS D	1.6	11.5	1.00	0.76	32.2
Approach		1053	5.0	0.538	6.6	LOS A	6.0	43.7	0.55	0.48	61.4
East: Kiln Road											
4	L	36	0.0	0.056	10.9	LOS B	0.3	2.1	0.47	0.66	43.5
6	R	142	0.0	0.638	32.9	LOS C	3.7	25.8	1.00	0.85	31.2
Approach		178	0.0	0.638	28.5	LOS C	3.7	25.8	0.89	0.81	33.1
North: South Western Highway											
7	L	239	0.0	0.168	10.6	LOS B	0.8	5.8	0.29	0.71	55.4
8	T	954	0.0	0.679	15.6	LOS B	10.4	73.0	0.90	0.80	48.8
Approach		1193	0.0	0.679	14.6	LOS B	10.4	73.0	0.78	0.78	49.9
All Vehicles		2423	2.2	0.679	12.2	LOS B	10.4	73.0	0.69	0.65	52.2

Results from the SIDRA modelling indicate that traffic signals control is required for this intersection at 2031 traffic flows.

6.2 Internal Traffic Circulation

The proposed local structure plan road network is intended to accommodate all internal traffic movements between lots and connection with the existing major road network.

Internal roads cross section enabling on-street parking and pedestrian paths fronting each commercial development are proposed to be similar to the following.



Road Reservation Widths	20 metres
Speed Limit	50km/h Default Urban Limit
Intersection controls	Give Way

6.3 Pedestrians and Cyclists

South Western Highway currently has no special facilities for pedestrians and cyclists. There is a narrow sealed shoulder in both directions that may accommodate cyclists.

The proposed development will include provision on the internal road network for pedestrians and cyclists through an off-street shared path on one side of each street.

The current lack of provision of pedestrian and cycling facilities on South Western Highway including road crossing facilities should be addressed in the future by Main Roads WA and the Shire of Serpentine-Jarrahdale to provide connectivity with the proposed development's internal network.

6.4 Public Transport

The Public Transport Authority web site indicates the nearest Transperth Bus Service Routes are Nos. 251, 252 and 253 which travel north-south along South Western Highway until reaching Abernethy Road where they diverge to travel along Soldiers Road. The nearest stop on these routes is located on Soldiers Road south of Bateman Street where a bus Terminus is located on the eastern side of the road. The Terminus is located opposite the unconstructed Kershaw Street. An informal vehicle's track is located at this point crossing the rail line joining with Soldiers Road. Pedestrians are able to use this track to walk to and from the bus terminus. However, the walking distance between Kershaw Street and Pinebrook Road is approximately 1.5kms. This is not considered within a normally acceptable walking distance for the provision of public transport to the subject site.

Figure 4. Public Transport Routes

6.5 Service Vehicles

The proposed land subdivision is intended for commercial and retail development which will all require access by various Service vehicles. It is anticipated that in addition to the Shire's Waste Refuse trucks there will be other types of service trucks of up to semi-trailer dimensions.

The minimum two-way single carriageway road pavement is proposed to be 2 x 3.7 metre width traffic lanes and with the geometry of intersections able to accommodate swept paths of trucks up to and including semi-trailers.

6.6 Impact on Neighbouring Areas

Local Government does not permit the amenity of abutting residential dwellings to be adversely affected by commercial development.

There will be no residential dwellings directly abutting the development site accordingly there is not expected to be any detrimental residential amenity effects.

7.0 SUMMARY

Estimated traffic generation and arrangements for operation of the proposed development have been assessed. It is considered that the proposed development will operate in a satisfactory manner so as not to have undue impact on the abutting road environment.

The traffic generation by the proposed development is anticipated to be in accordance with the permitted land use as described by current practice trip generation rate guidelines.

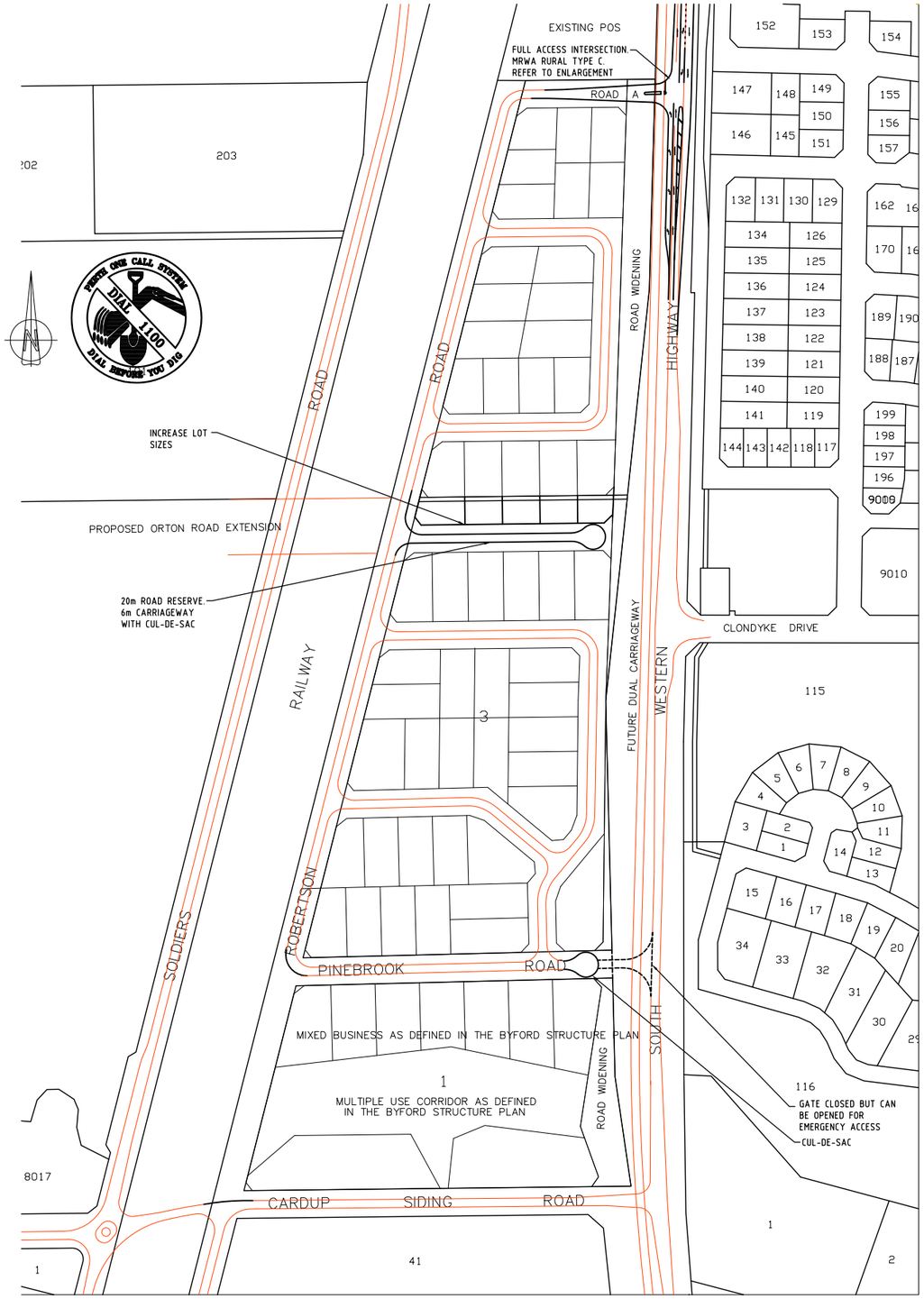
The 2.3km section of South Western Highway from Nettleton Road to Kiln Road reviewed in this report will have up to seven intersections with separations ranging from approximately 250m to 500m. Each intersection has been reviewed and modelled separately as it is not within the intent and scope of this report to perform road network integrated modelling.

- The Main Roads WA condition in limiting access onto South Western Highway for the subdivision to one main intersection and an emergency access only will require that this access (Road A) main intersection is upgraded to traffic signals control at approximately 50% of full traffic generation from development within the subdivision.
- The intersection of Clondyke Drive with South Western Highway has begun experiencing a significant number of through-right type crashes. To improve safety and reduce the operational delays and queuing at this intersection by 2031 the installation of traffic signals may be warranted in the future.
- At the 2031 traffic flows predicted by the Main Roads WA Regional Operations Model the following intersections with South Western Highway will be required to operate under traffic signals control for capacity reasons:
    - Nettleton Road / South Western Highway
    - Road A / South Western Highway
    - Kiln Road / South Western Highway

Recommended intersection controls are as follows:

Intersection	Control
South Western Highway / Nettleton Road	Traffic signals
South Western Highway / Wilaring Street	Stop/Give Way
South Western Highway / Road A	Traffic signals
South Western Highway / Clondyke Drive	Traffic signals
South Western Highway / Cardup Siding Road	Stop/Give Way
South Western Highway / Kiln Road	Traffic signals

1.0 Proposed Development Structure Plan



50 40 30 20 10 0 50 100 m

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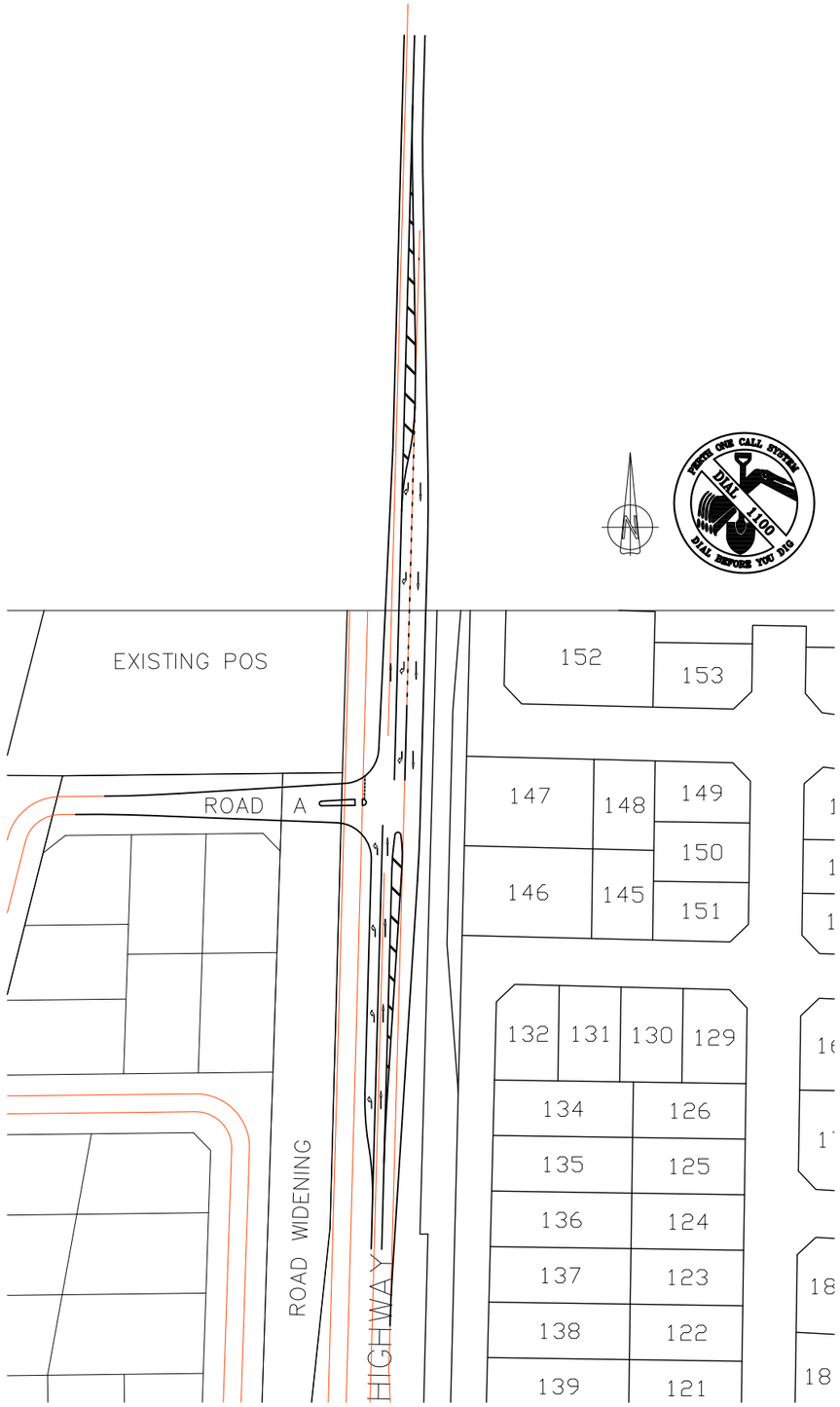


RURAL INTERSECTION TYPE "C" ENLARGEMENT

SCALE 1:1000

10 5 0 10 20 30 40 50 60 70 m

SCALE 1:1000

PROJECT:

LOTS 1, 3 & 128 SOUTH WEST HWY BYFORD

No.	DATE	REVISION	BY
A	10-9-2009	PRELIMINARY PLOT FOR APPROVAL	MJV

NOTES

Porter Consulting Engineers
TSCAD Pty Ltd ACN 070 097 164 as trustee for the Consulting Engineering Unit Trust trading as Porter Consulting Engineers ABN 78 836 396 385
Level 2 Kishorn Court
58 Kishorn Road
Mt Pleasant 6153 WA
PO Box 1036
Canning Bridge 6153 WA
Tel (08) 9315 9955
Fax (08) 9315 9959
Email office@porterenq.com.au
www.porterenq.com.au

CLIENT: **URBAN SOLUTIONS**

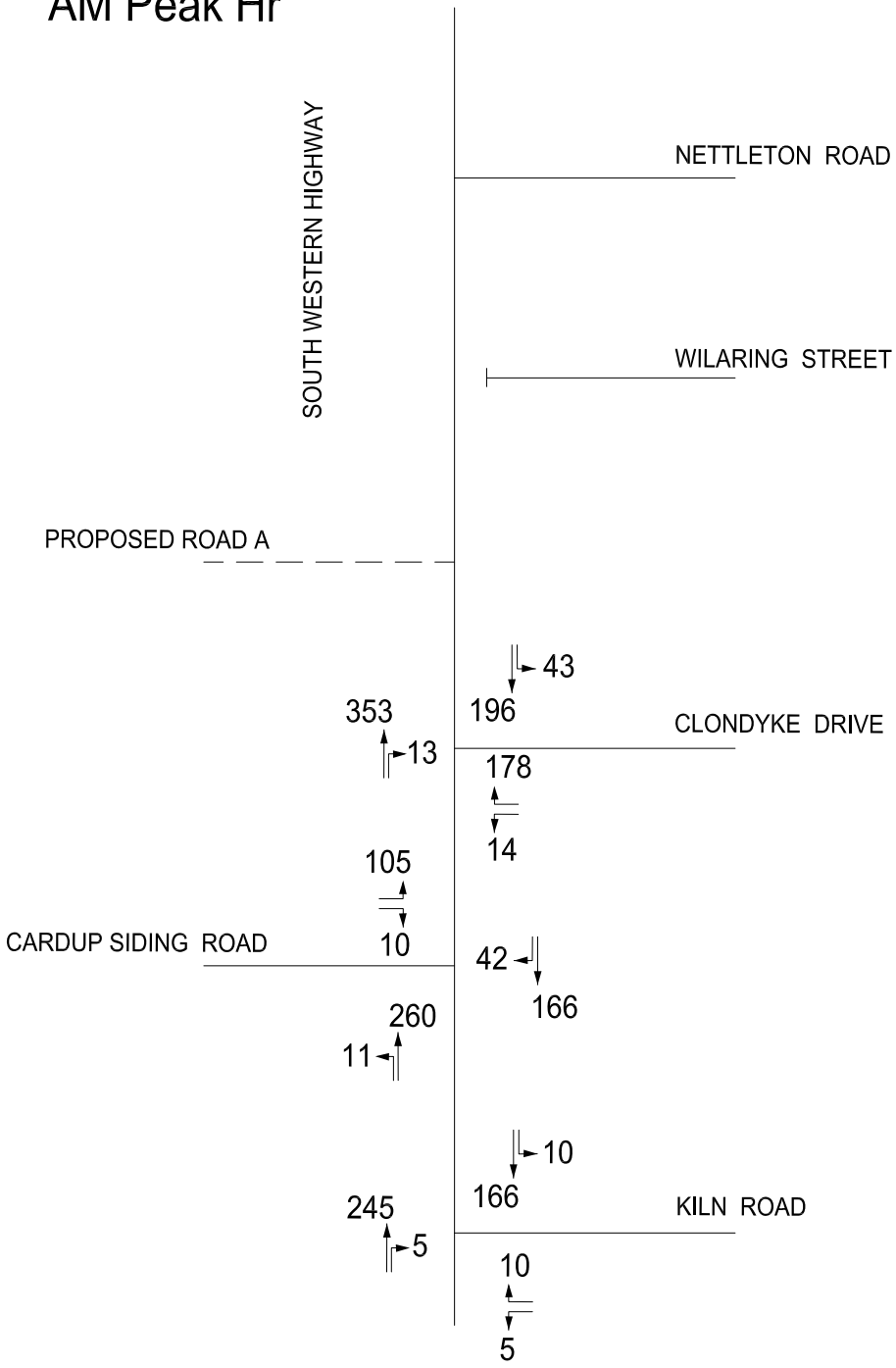
DRAWING: **OPTION 2**

STATUS: **FOR APPROVAL**

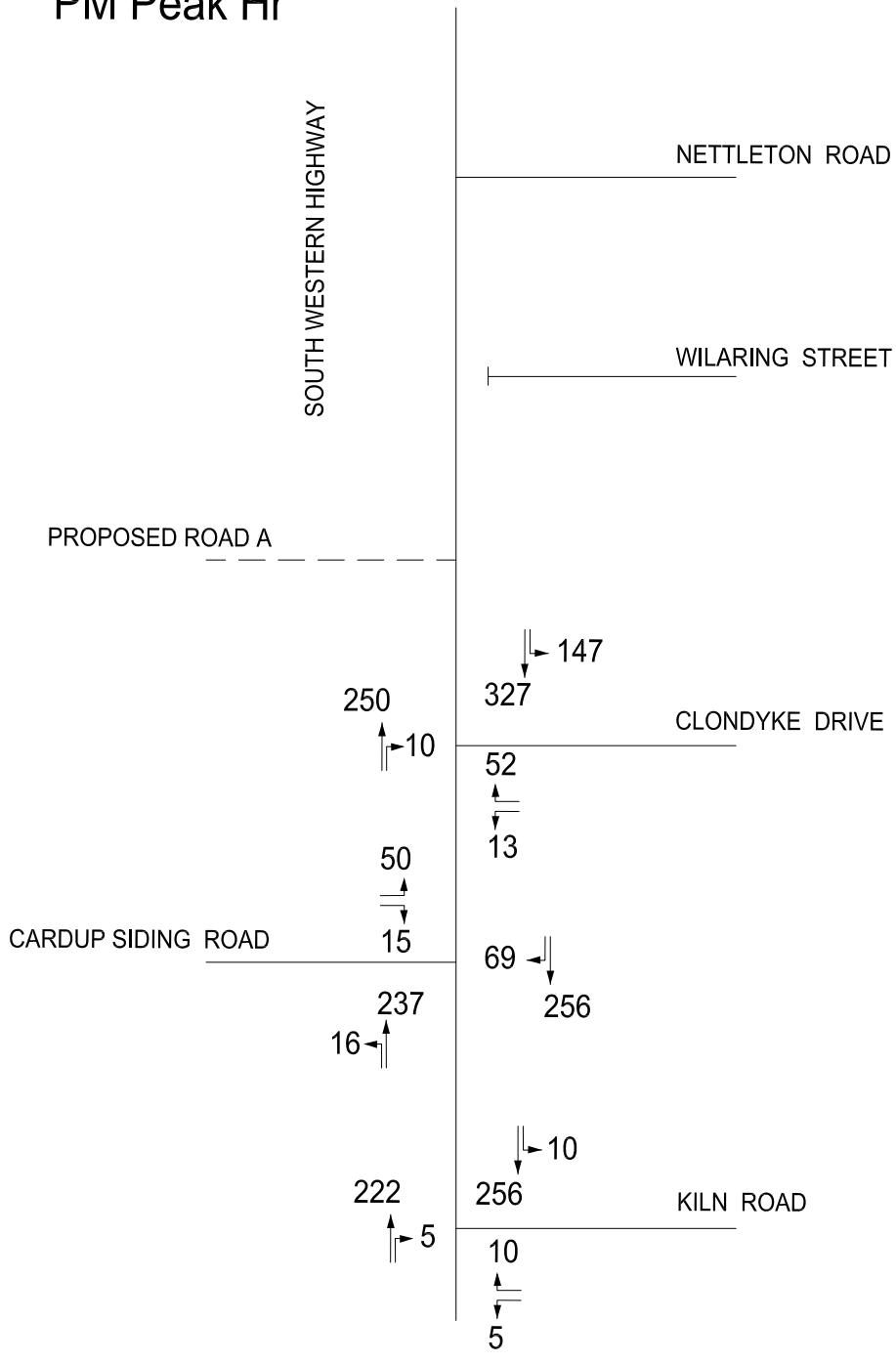
SCALE	AS SHOWN
DATE	SEPT 2009
DESIGN	MJV
DRAWN	ELW
CHECK	
DRAWING No.	09-6-80/2
REV No.	A
ORIGINAL DRAWING SIZE	A1
FILE NAME	c\dpce\09-6-80\option2.dwg
APP'D	

2.0 Current and Anticipated 2031 Traffic Flows

Existing 2013
AM Peak Hr



Existing 2013
PM Peak Hr



Byford - Mundijong Redevelopment (ARA-option 1)

2031 Link Volume using network and land use as specified by client - Reassigned using Cube Voyager Platform

Regional Operations Model (ROM) Network
Unadjusted Average Weekday 24-Hour Traffic Volumes (Factor X 100)
Network and Land Use Data is modified as per client's specification
Traffic forecasts should be primarily used for relative comparison, not as absolute values.
Terms & Conditions :
MRWA Traffic Modelling Data as supplied to approved clients is confidential and is not to be made available to unauthorised persons or organisations. This data should not be used for any purpose other than the stated purpose for which it was requested from MRWA. The MRWA ROM is for estimating regional traffic volumes on regional and major local roads, and it should not be used for estimating local traffic on local roads. The MRWA ROM includes local roads but this is to provide connectivity in the model. MRWA Traffic Modelling Data should be interpreted by an experienced/qualified person. This data should not be used in making decisions relating to commercial or residential developments.

IMPORTANT NOTE:
This plan depicts the results of regional traffic modelling undertaken by Main Roads WA, in conjunction with the Serpentine Jarrahdale Shire. All land use and road network inputs within the modelled study area were provided to Main Roads by the Shire of Serpentine / Jarrahdale. The land use outside the study area represents trend case land use forecasts as provided by the Department of Planning.

The modelling was undertaken having regard to the best information available at that point in time and will need to be regularly reviewed and updated. The modelling assumed a complete build-out (post 2031) scenario for the localities of Byford and Mundijong-Whitby. This regional modelling is intended to be used as a basis for more detailed transport assessments for planning proposals including but not limited to, district structure plans, local structure plans, subdivision and development applications.
While every effort has been made to ensure the accuracy of the information herein provided, neither Main Roads nor the Serpentine Jarrahdale Shire cannot accept any responsibility for any action taken or costs incurred based on this information.

Main Roads Western Australia
Transport Modelling Section
Enquiries Clare Yu 9323 4967
MRWA Reference Job #29131

Mon 05 Aug 2013 Catalogue Folder: T:\VOYAGER\JOBS_V2012\29131\29131_MRDLOAD\29131_MRDLOAD.cat
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T:\VOYAGER\JOBS_V2012\29131\Reports\LVP_Byford_ARA1_2031.VPR

- 1 Lane Each Direction
- 2 Lanes Each Direction
- 3 Lanes Each Direction
- 4 Lanes Each Direction
- Zone Connector
- Zone Number

TITLE:	Turning Movement Volume Estimates
DATE:	5/08/2013
INTERSECTION:	South Western Hwy/Zone 911/South Western Hwy
YEAR:	2031
SOURCE:	Main Roads WA Traffic Model
JOB NUMBER:	29131
SCENARIO:	2031 Byford ARA Option 1
REPORT FILE:	T:\WOYAGER\JOBS_V2012\29131\29131_MRDLOAD\Base\Byford_ARA1\TURNS.csv
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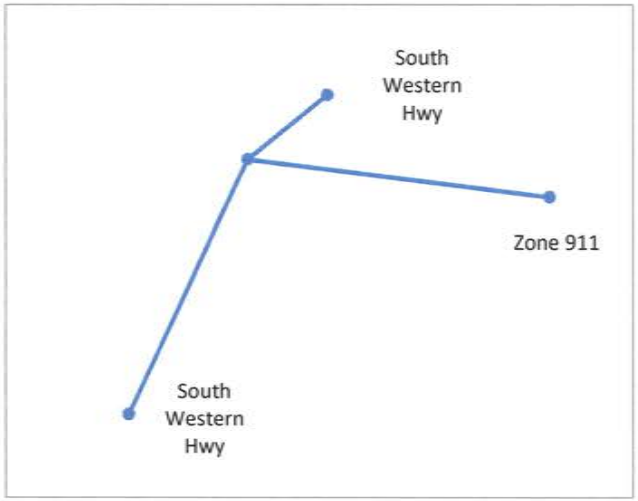
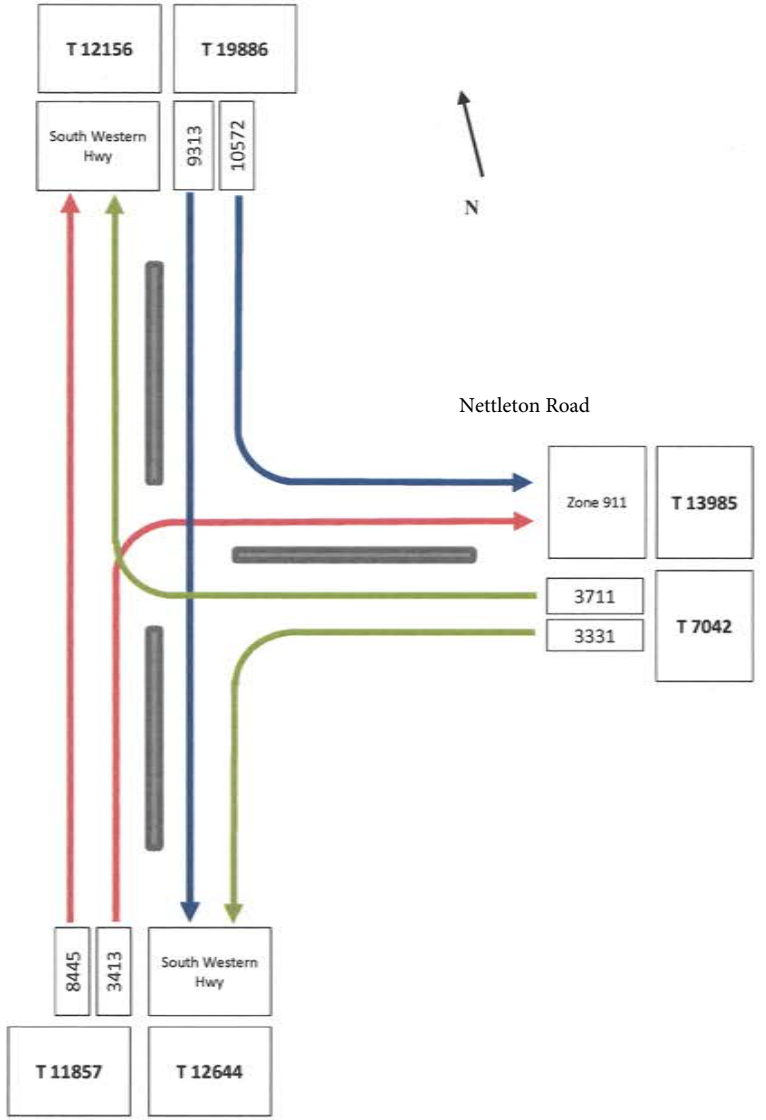
AUTHOR:	Thomas Ng
STATUS:	Unadjusted All Vehicle Volumes





TITLE:	Turning Movement Volume Estimates
DATE:	5/08/2013
INTERSECTION:	South Western Hwy/Cardup Siding Rd/South Western Hwy
YEAR:	2031
SOURCE:	Main Roads WA Traffic Model
JOB NUMBER:	29131
SCENARIO:	2031 Byford ARA Option 1
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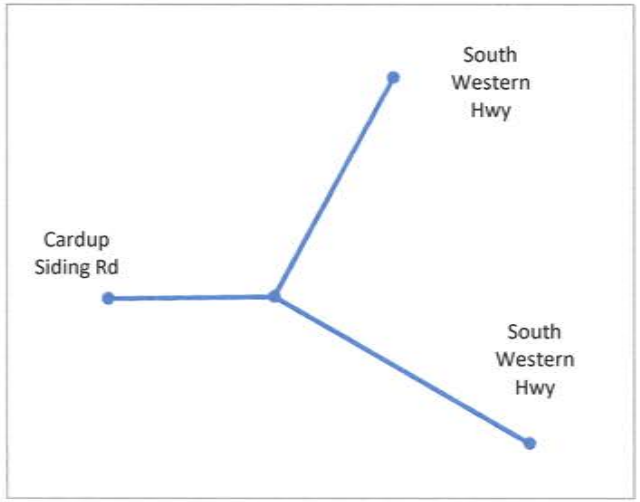
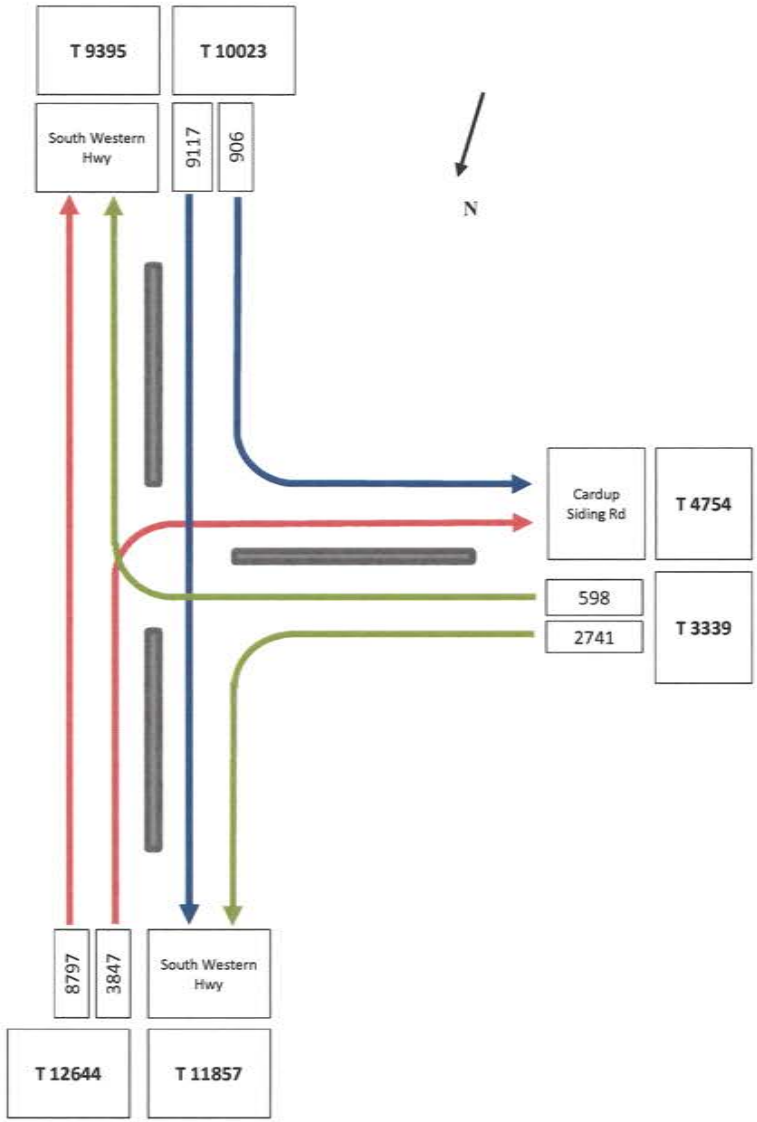
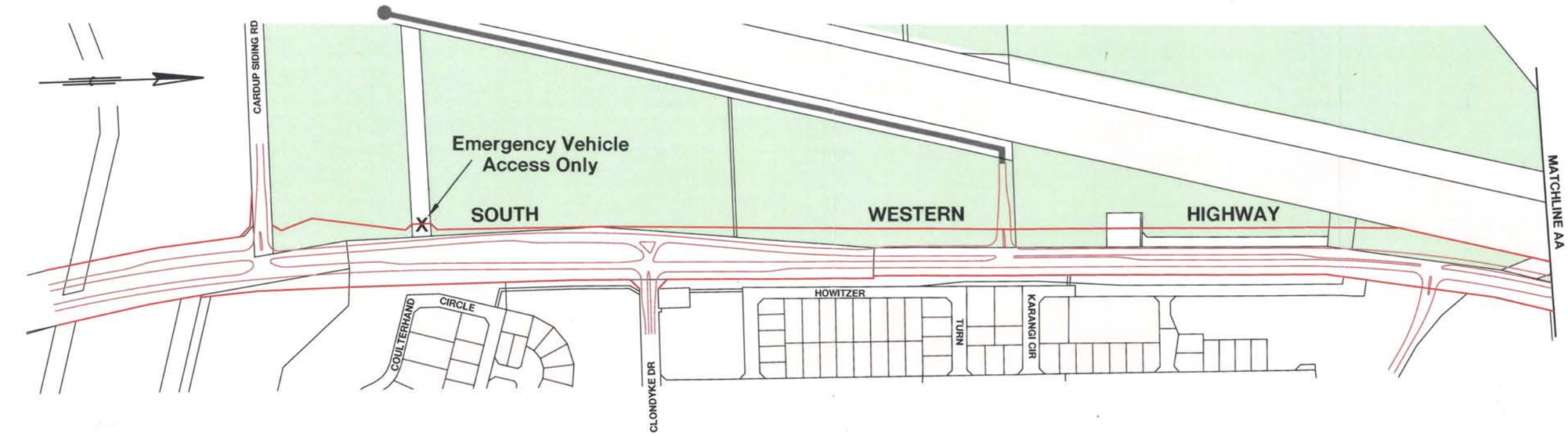
AUTHOR:	Thomas Ng
STATUS:	Unadjusted All Vehicle Volumes

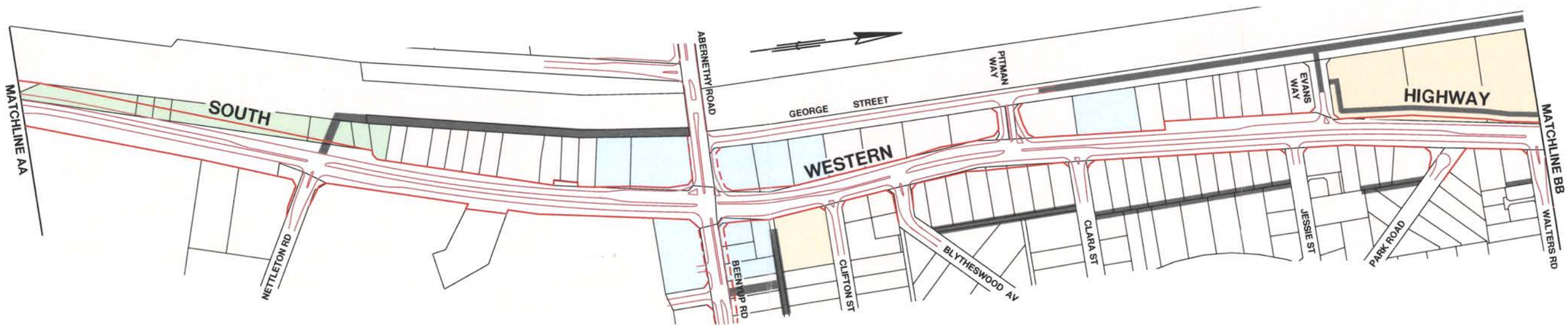




3.0 MRWA South Western Highway Access Strategy

Received 26/7
from MRWA at meeting





SOUTH WESTERN HIGHWAY ACCESS STRATEGY

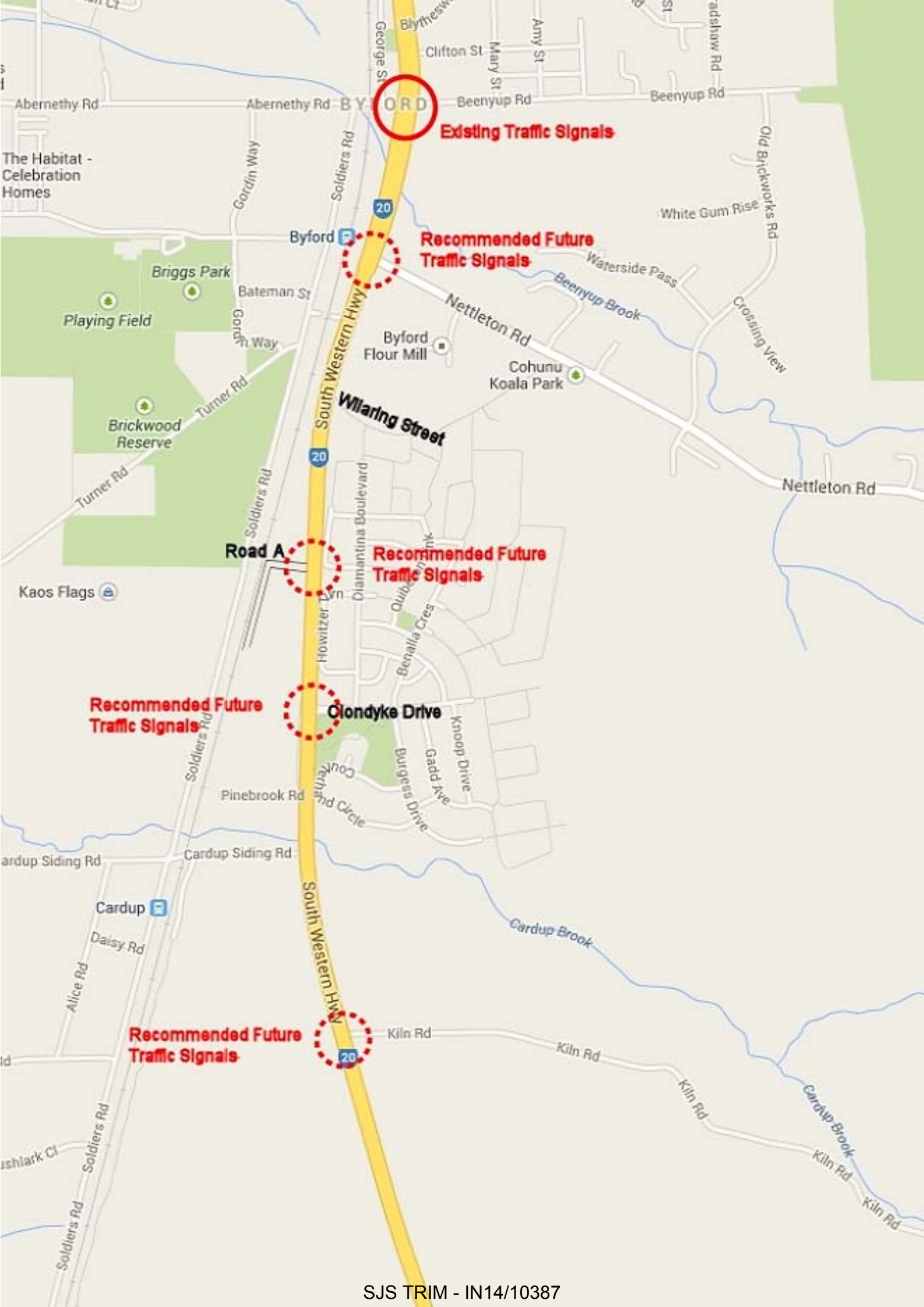
LEGEND

- URBAN DEVELOPMENT
- COMMERCIAL
- PUBLIC AND COMMUNITY PURPOSES
- PUBLIC OPEN SPACE
- RIGHT OF CARRIAGEWAY
- PROPOSED ROAD RESERVATION

DATE : DECEMBER 2010
NOTE : THIS IS NOT A ZONING MAP

CAD REF. No 201132-0079

SCALE 1:5000


Existing Traffic Signals
Recommended Future Traffic Signals
Recommended Future Traffic Signals
Recommended Future Traffic Signals
Recommended Future Traffic Signals
Wilaring Street
Road A
Clondyke Drive
BYFORD
Byford
Cardup
Abernethy Rd
Beenyup Rd
Clifton St
George St
Amy St
Mary St
Gordin Way
Soldiers Rd
South Western Hwy
Nettleton Rd
Waterside Pass
Beenyup Brook
Crossing View
Old Brickworks Rd
White Gum Rise
Bateman St
Briggs Park
Playing Field
Brickwood Reserve
Turner Rd
Byford Flour Mill
Cohunu Koala Park
Diamantina Boulevard
Howitzer Turn
Benalla Cres
Knoop Drive
Gadd Ave
Burgess Drive
Pinebrook Rd
Cardup Siding Rd
Daisy Rd
Alice Rd
Cardup Brook
Kiln Rd
Kaos Flags
The Habitat - Celebration Homes
20

Appendix 5

Fire Management Assessment

FirePlan WA

Bill Harris
10 Bracken Rd
Thornlie WA 6108

Phone 08 9493 1692
Fax 08 9493 1692
Mobile 0418 941540
Email:
firepla@bigpond.net.au
ABN 44 116 937 762

16th May 2011

Urban Solutions
2/443 Albany Highway
VICTORIA PARK WA 6100
Attention: John Ranieri

Dear John

RE: LOCAL STRUCTURE PLAN LOTS 1, 3 AND 128 SOUTH WESTERN HIGHWAY BYFORD

I carried out a site inspection of the property on Sunday 15th May 2011 and make the following comments regarding the fire protection requirements for the proposed development.

1.0 Bush Fire Hazard Assessment

The site is generally cleared except for an area along the section of the Cardup Brook in the southern portion and a small section in the northern third of the site.

These two areas would be rated as “extreme” with the remainder of the site rated as “low”. The adjoining areas to the north are rated as “extreme”, to the east is urban residential, to the south is cleared rural land and to the west is currently rural land which is proposed to be developed in urban residential.

2.0 Proposed Access

The proposed access for the development allows for 2 access/egress points, one onto South Western Highway, Robertson Road along the western boundary provides the second access onto Cardup Siding Road. This complies with Planning for Bush Fire Protection.

3.0 Water Supplies

The site will have reticulated water to all lots, fire hydrants will be installed by the developer, which complies with Planning for Bush Fire Protection.

4.0 Cardup Brook Public Open Space (POS)

- A 4 metre wide dual purpose footpath/fire access is to be constructed on the southern side of the POS and a 4 metre wide fire access on the north wide of the POS.
- All habitable buildings will be required to be setback a minimum of 21 metres from the boundary of the POS and habitable dwellings have a construction standard of AS 3959-2009 BAL – 29.
- The 21 metre setback will be required to meet the Building Protection Zone standard detailed in A4.3 page 42 *Planning for Bush Fire Protection*.
- The whole of the lots adjoining the POS will have to comply with the Building Protection Standard.

5.0 Northern Bush Area

Depending on the use of this area and whether it is to be one lot or subdivided further will affect the amount of vegetation retained.

If the area is subdivided into smaller lots and habitable buildings are constructed on the site the whole of the lots would have to comply with the Building Protection Zone Standards. This would require the removal of some trees and vegetation.

6.0 Development on the Northern Boundary of the Site

A 20 metre road reserve will separate the proposed development from the existing POS (Reserve 38266) to the north.

A 31 metre setback/Building Protection Zone is required from the boundary of the POS to the walls of and habitable buildings and construction of dwellings would have to be to AS 3959-2009 BAL-9. The whole of the lots would have to be treated as a Building Protection Zone.

7.0 Revegetation of the Area

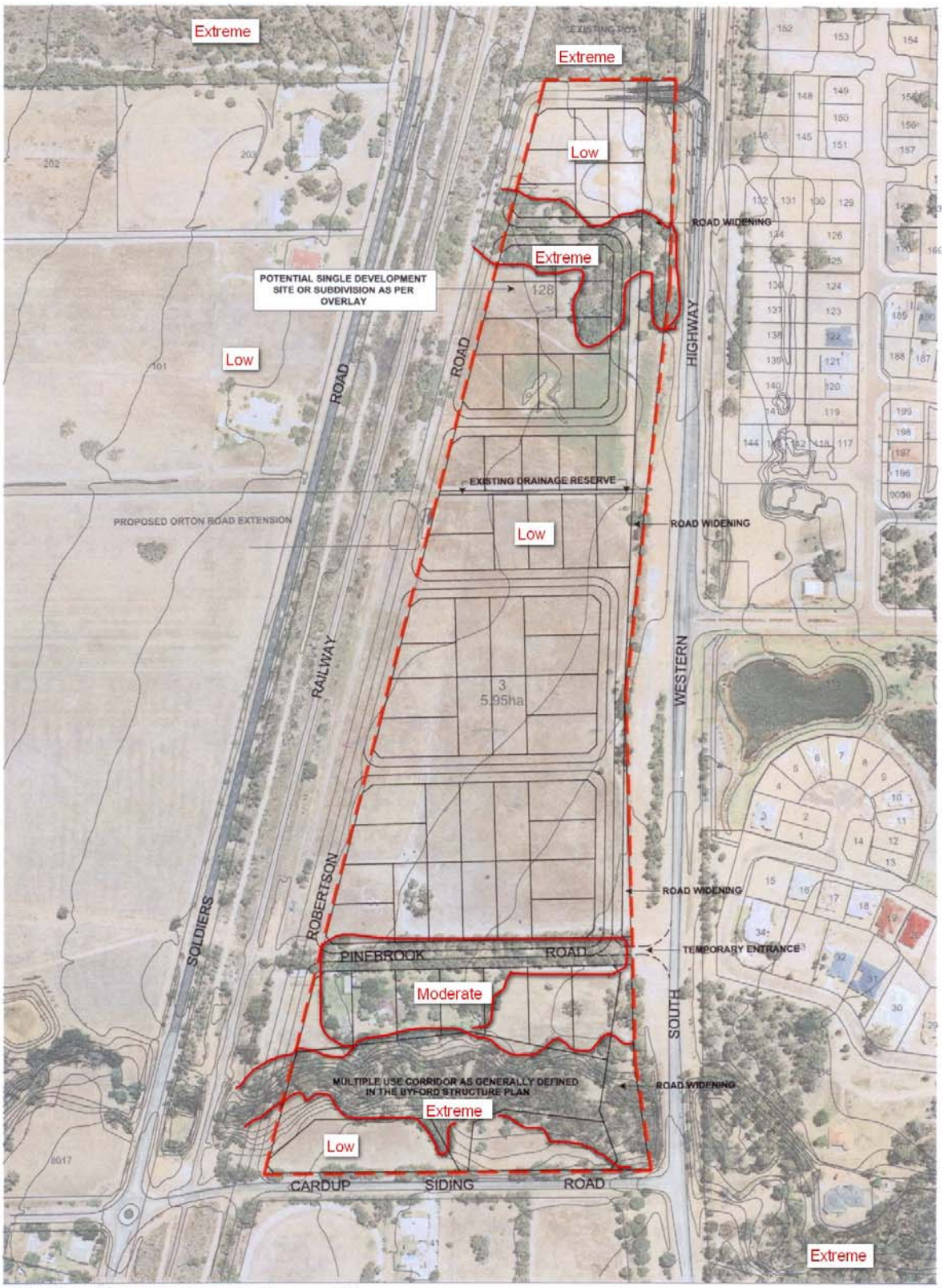
Any planting of trees and shrubs throughout the site must comply with the Building Protection Zone Standards detailed in Planning for Bush Fire Protection so as not to increase the bushfire risk in the site and adjoining areas.

8.0 Detailed Fire Management Plan

A detailed Fire Management Plan complying with *Planning for Bush Fire Protection* will be prepared as a condition of subdivision.

Yours faithfully

B.W. Harris. AFSM. ACM.
Managing Director FirePlan WA.



PROPOSED LOCAL STRUCTURE PLAN
LOTS 1, 3 & 128 SOUTH WESTERN HIGHWAY
BYFORD

JOB REF: 100634

12th JANUARY 2010

NOTE
All proposed roads 20m wide
Distances and areas subject to survey
Road carriageways diagrammatic only
Minimum lot size 1000m²

LEGEND:
Subject Land

SCALE 1:2500

GRAY & LEWIS
LAND USE PLANNERS

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South Perth, WA 6151
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perth@graylewis.com.au