The Glades, Byford
Revised Local Structure Plan

July 2025

Prepared for
Satterley Property Group

Taylor Burrell Barnett
Town Planning & Design

ENDORSEMENT PAGE

This structure plan is prepared under the provisions of the Shire of Serpentine-Jarrahdale Town Planning Scheme No. 2.

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

22 FEBRUARY 2011

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

Date of Expiry: **19 OCTOBER 2035**

TABLE OF AMENDMENTS

Amendment No.	Summary of the Amendment	Amendment Type	Date Approved by WAPC
Structure Plan Amendments approved by WAPC under Planning and Development (Local Planning Schemes) Regulations 2015			
8	Various - Icaria Precinct	Minor	22.11.17
9	Various - Woodland Grove Precinct	Minor	06.07.17
10	Various - Icaria Precinct	Minor	05.03.19
11	• Introduce R Code ranges, designate R20 along Cardup Brook • Changes to extent of service commercial precinct, mixed use and neighbourhood centre • Provide for 4 hectare district open space reserve south of Orton Road; • Modify the local open space network; • Rationalise intersections on Orton Road and modify the local road network	Major	12.08.25

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DOCUMENT HISTORY AND STATUS

Job No.	06/014			
Author	Kris Nolan			
Revision	**Date Issued**	**Reviewed by**	**Approved by**	**Date Approved**
0	06.07.09	Kris Nolan	Samantha Thompson	06.07.09
1	21.09.09	Kris Nolan	Samantha Thompson	
2	10.03.11	Jason Carr	Samantha Thompson	10.03.11
3	31.01.19	Katherine Shirley	Samantha Thompson	31.01.19
4	30.07.2025	Katherine Shirley	Samantha Thompson	30.07.2025

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Plan E
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APPENDICES

PART ONE – STATUTORY SECTION

1 STATUTORY PLANNING

1.1 THE STRUCTURE PLAN AREA

This Local Structure Plan (LSP) applies to the land contained within the areas 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 Local Planning Scheme No. 3 (as amended) (LPS3) 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

This 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

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 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 Town Site Drainage and Water Management Plan, The Glades Local Water Management Strategy and other relevant Shire of Serpentine-Jarrahdale strategies or policies;

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

iii) Establish key east-west multiple-use corridors in accordance with the requirements of the Byford Structure Plan 2005 (as amended);

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

v) Create a balanced distribution of and access to active, passive and conservation open space;

vi) Provide a diversity of housing typologies including medium and low residential development and mixed-use development, catering to a diverse population and ensuring the full range of housing alternatives;

vii) Create a highly connected road network with shared use pathways that relates strongly to the Byford Town Centre and adjacent recreation facilities; and

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

3 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. provision of rear lanes, public open space rationalisation, local road realignments 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.

Where required, Local Development Plans (LDPs) will be prepared and submitted consistent with the provisions of Clause 5.18.5 of Council's Scheme.

4 STRUCTURE PLAN MAP

The Structure Plan Map (refer **Figure 1**) outlines the planned pattern of development for the Structure Plan area.

All indicative subdivision layouts shown in this Structure Plan and associated appendices are for conceptual purposes only and are subject to further investigation and detailed design at subdivision stage.

5 ZONES AND RESIDENTIAL DENSITIES

The Structure Plan Map delineates and depicts the zones and residential density codes applicable to the Structure Plan according to the legend thereon.

The zones and residential density codes designated under this Structure Plan apply to the land within it as if they were incorporated in the Scheme.

All provisions, standards and requirements applicable to the zones and residential density codes in the Scheme shall apply, except where stipulated within **Section 5.0** of Part 1 of this report.

5.1 RESIDENTIAL ZONE

The provisions, standards and requirements of this Zone are in accordance with those applicable to the same zone in the Scheme.

For land zoned Residential on the Structure Plan Map, subdivision and development shall generally be in accordance with the adopted Structure Plan.

5.1.1 DENSITIES

The Structure Plan Map identifies broad residential density ranges that apply to specific areas within the Structure Plan area. A residential density code plan is to be submitted to the WAPC for its approval, at the time of applying to the WAPC for approval to subdivide. The residential density code plan is to be consistent with the residential density code ranges depicted on the Structure Plan Map.

5.1.2 LOCATIONAL CRITERIA

R20 to R40

R20, R25 and R30 code may be applied to all Residential zoned lots to ensure street setbacks are consistent for the length of the street (access streets only).

The R40 density code may be applied to Residential zoned lots:

a) abutting, or facing towards, public open space (excluding the Cardup Brook Foreshore Reserve);

b) within a 400 metre walking distance of a neighbourhood centre; and/or

c) fronting Orton Road and having rear laneway access.

5.1.3 RESIDENTIAL DENSITY CODE PLAN

The residential density code plan is to include a summary of:

a) the proposed dwelling yield;

b) the yield anticipated as a result of previously granted subdivision approvals within the entire structure plan area, but not yet acted on; and

c) the actual yield realised through the approval of subdivision and the issue of new certificates of title.

Further, the residential density code plan is to be accompanied by a consolidated density code plan showing the proposed and previously granted R-Code plans within the Cardup Brook Precinct.

5.1.4 LOTS CODED R20

R20 lots are to be oriented to provide the primary frontage toward Cardup Brook or otherwise suitably address all adjacent street frontages to maximise visual surveillance toward Cardup Brook.

5.1.5 LOTS ADJACENT TO ORTON ROAD

Lots adjacent to Orton Road are to be oriented to provide an appropriate streetscape to Orton Road including:

- laneway lots;
- controlled access place roads; and
- loop roads.

as appropriate to the context. The creation of large numbers of lots backing onto Orton Road should be avoided and side boundaries to Orton Road minimised.

5.2 VILLAGE CENTRE ZONE

The provisions, standards and requirements of this Zone are to be in accordance with those of an adopted Glades Village Centre Local Planning Policy.

The maximum amount of retail floorspace permissible within the Village Centre is 4,500 m^2 Net Lettable Area (NLA). The maximum amount of non-retail (commercial) floor space is 2,500 m^2 NLA.

5.3 NEIGHBOURHOOD NODE

The provisions, standards and requirements of this Zone are to be in accordance with those of the 'Neighbourhood Node', in the Local Planning Policy No. 19 – Byford Structure Plan Development Area Requirements, except where varied as follows:

- Neighbourhood Nodes shall not exceed 200 m2 retail floor space; and
- All Neighbourhood Nodes shall be the subject of a LDP to be approved by the Shire of Serpentine-Jarrahdale.

5.4 MIXED USE ZONE

The provisions standards and requirements of this Zone are to be in accordance with those applicable to the Commercial zone in the Scheme, except where varied by the following provisions:

a) All development within the Mixed Use Zone will be in accordance with the requirements of an approved LDP.

b) The residential density application to the Mixed Use zone is R80.

5.5 SERVICE COMMERCIAL ZONE

All development within the service commercial area shall be subject to and address the following matters:

a) Development siting and orientation to minimise adverse impacts to residential amenity.

b) Development scale and bulk to be sensitive to surrounding residential built form.

c) Development interface treatments to protect visual amenity to ensure an appropriate transition of development and land uses.

d) Appropriate landscaping and screening being applied at the development interface to provide a sensitive transition.

6 STRATEGIES AND PLANS

The following technical reports/strategies are to be prepared and submitted as part of a subdivision application or as a condition of subdivision approval as recommended by the local government (where applicable):

6.1 URBAN WATER MANAGEMENT PLAN

An Urban Water Management Plan is to be prepared as a condition of subdivision for any subdivision application and prepared in accordance with the adopted Local Water Management Strategy.

6.2 FORESHORE MANAGEMENT PLAN

A Foreshore Management Plan is to be prepared as a condition of subdivision or development that is south of Orton Road, north of the Cardup Brook and within the LSP area. The plan will identify opportunities to preserve existing vegetation, rehabilitation of the foreshore and planting of native species local to the area.

6.3 LAKE MANAGEMENT PLAN

A Lake Management Plan is to be prepared as a condition of subdivision or development approval for any land immediately abutting or including the proposed lake (as shown on **Figure 1**). The plan will detail the whole of life costings, maintenance responsibilities and monitoring requirements of the lake.

6.4 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 or Village Centre (as shown on **Figure 1**). The extent of the Landscape Management Plan will be at the discretion of the Director of Planning. The Landscape Management Plan (if necessary), shall consider matters of fire management.

6.5 BUSHFIRE MANAGEMENT PLAN

A Bushfire Management Plan is to be prepared to identify potentially affected areas and outline the necessary fire management requirements.

- A Bushfire Management Plan is to be provided at subdivision stage.
- Landscape concept plans which provide sufficient detail to assess bushfire impacts are to be submitted with any application containing or adjacent to public open space and/or foreshore areas.

6.6 NOISE MANAGEMENT PLAN

A noise management plan is to be prepared upon lodgement of a subdivision or development application involving land abutting Tonkin Highway (Water Corporation Corridor), Orton Road and Soldiers Road or within the trigger distance of roads, in accordance with State Planning Policy 5.4: Road and rail noise. The plan is to identify lots affected by traffic noise from Tonkin Highway which exceeds the noise targets set out in State Planning Policy 5.4: Road and rail noise and outline the relevant noise mitigations measures to be implemented.

6.7 LOCAL DEVELOPMENT PLANS

LDPs are to be prepared as a requirement of a condition of subdivision for proposed lots or lots that abut road reserves which accommodate existing significant vegetation worthy of retention, not affected by necessary subdivision works.

As a minimum requirement, LDPs shall be required for the following:

- Rear loaded or Laneway lots;
- Lots with dual frontages;
- Lots immediately abutting public open space or foreshore areas;
- Lots with frontage to or abutting Regional Roads, Other Regional Roads or Railway Reservations; and
- Lots with frontage to Abernethy and Orton Roads.

6.8 ADDITIONAL TECHNICAL REPORTS/STRATEGIES

The following technical reports/strategies are to be prepared and submitted as part of a subdivision application or as a condition of subdivision approval as recommended by the local government (where applicable):

The following technical reports/strategies are to be prepared and submitted as part of a subdivision application or as a condition of subdivision approval as recommended by the local government (where applicable):

- Geotechnical report
- Fauna management and relocation plan

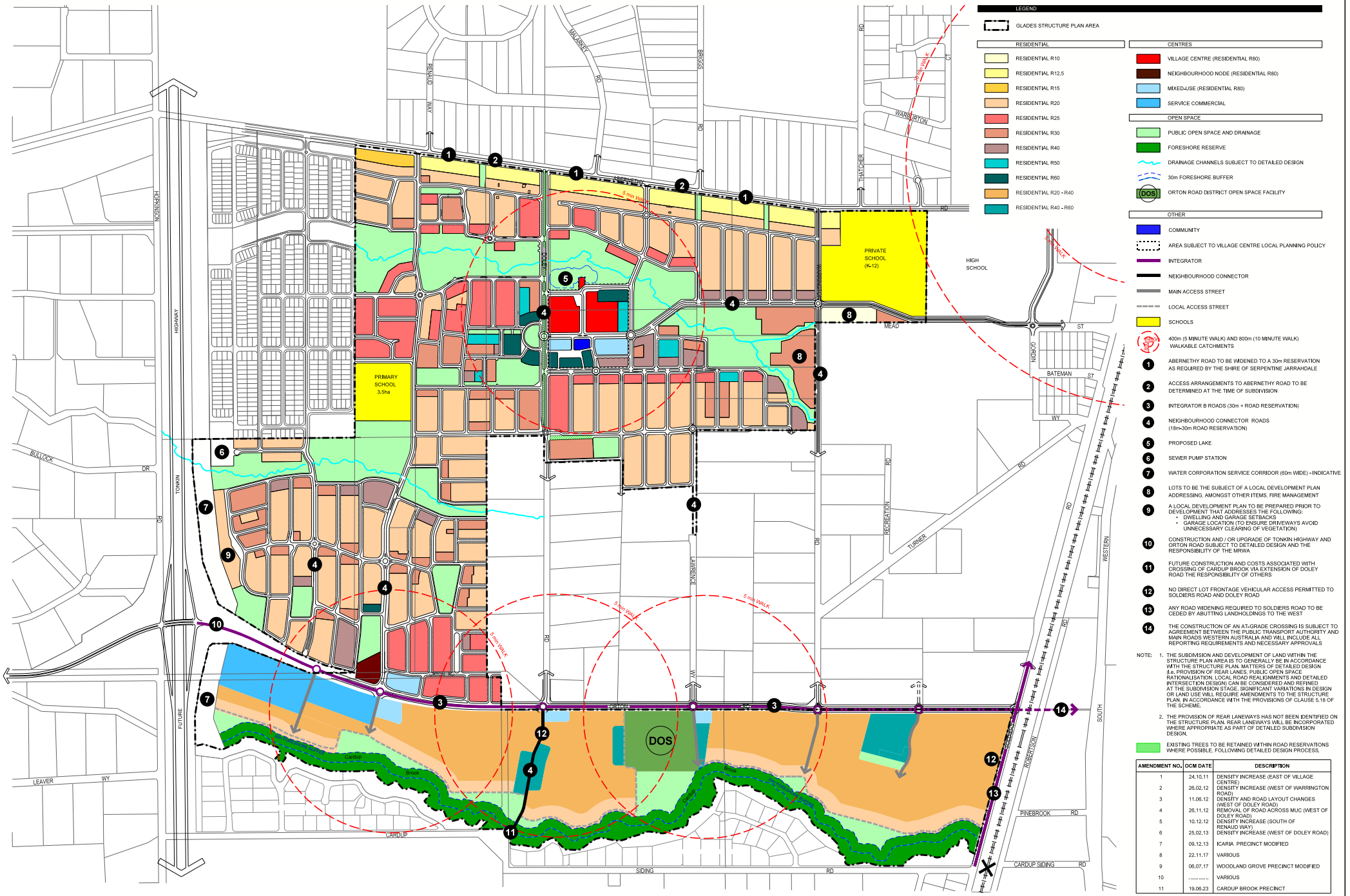
7 MISCELLANEOUS

7.1 BYFORD TROTTING COMPLEX

All landowners within 200m of the Byford Trotting Complex shall be notified by way of notification on title, of the possible impacts associated with the Trotting Complex.

7.2 ORTON ROAD ROUNDABOUT

With regard to the three-leg roundabout on Orton Road, which provides access south to the Service Commercial Area via Access Road 02, a 15% design of this intersection is to be provided with the relevant application for subdivision approval. The three-leg roundabout is to be constructed at landowner/applicant's cost. It should be noted that a 15% design/concept plan is required to determine necessary land requirements and demonstrate that the proposed subdivision would not compromise delivery of the roundabout.



The Glades - Local Structure Plan - Figure 1

A SATTERLEY PROPERTY GROUP PROJECT

Taylor Burrell Barnett Town Planning & Design
Taylor Burrell Barnett
Town Planning & Design

PART TWO – EXPLANATORY REPORT

1 INTRODUCTION

1.1 BACKGROUND

This Local Structure Plan has been prepared for Satterley Property Group on behalf of LWP Byford Syndicate over the land known as 'The Glades,' Byford (refer Part 1 and **Figure 1**). Hereafter referred to as "the Structure Plan," this report has been prepared to guide the development of The Glades at Byford. "The Glades" is the estate name of the planning precinct formerly known as Byford Main Precinct.

Satterley Property Group are also the developers of "The Brook" estate to the immediate south of the Structure Plan area, on the southern side of the Cardup Brook.

The Local Structure Plan was originally prepared and lodged in December 2005, however given the Shire's review of the Byford Structure Plan (2005 as amended) and the progression and finalisation of the Byford Townsite Drainage and Water Management Plan 2008 (superseding the previous Byford Urban Stormwater Management Strategy), the Structure Plan could not be progressed with any certainty. Given now the finalisation of the Byford Townsite Drainage and Water Management Plan (BTDWMP) and the review of the Byford Structure Plan, the Glades consultant team has been able to revise the Structure Plan in accordance with the requirements of both of these documents.

Accordingly it is important to note that this document represents a revision to the December 2005 version of the Local Structure Plan, to reflect the requirements of these documents, however the general intent and principles remain the same.

1.2 PURPOSE OF REPORT

Structure plans are forward-planning documents that resolve regional and/or localised issues concerning land use and infrastructure. Structure Plans are often prepared as a precursor to extensive development or redevelopment.

This Structure Plan has been prepared under Section 5.18.3 of Council's Scheme to facilitate the urbanisation of The Glades, being the sites transition from a rural to urban land use. Through the use of graphics and supporting technical data, the Structure Plan recommends the preferred:

- pattern of land use;
- network and hierarchy of roads;
- public open space network ; and
- servicing strategy for the precinct.

Once endorsed, the Structure Plan will become the reference document for all future subdivision and development within The Glades.

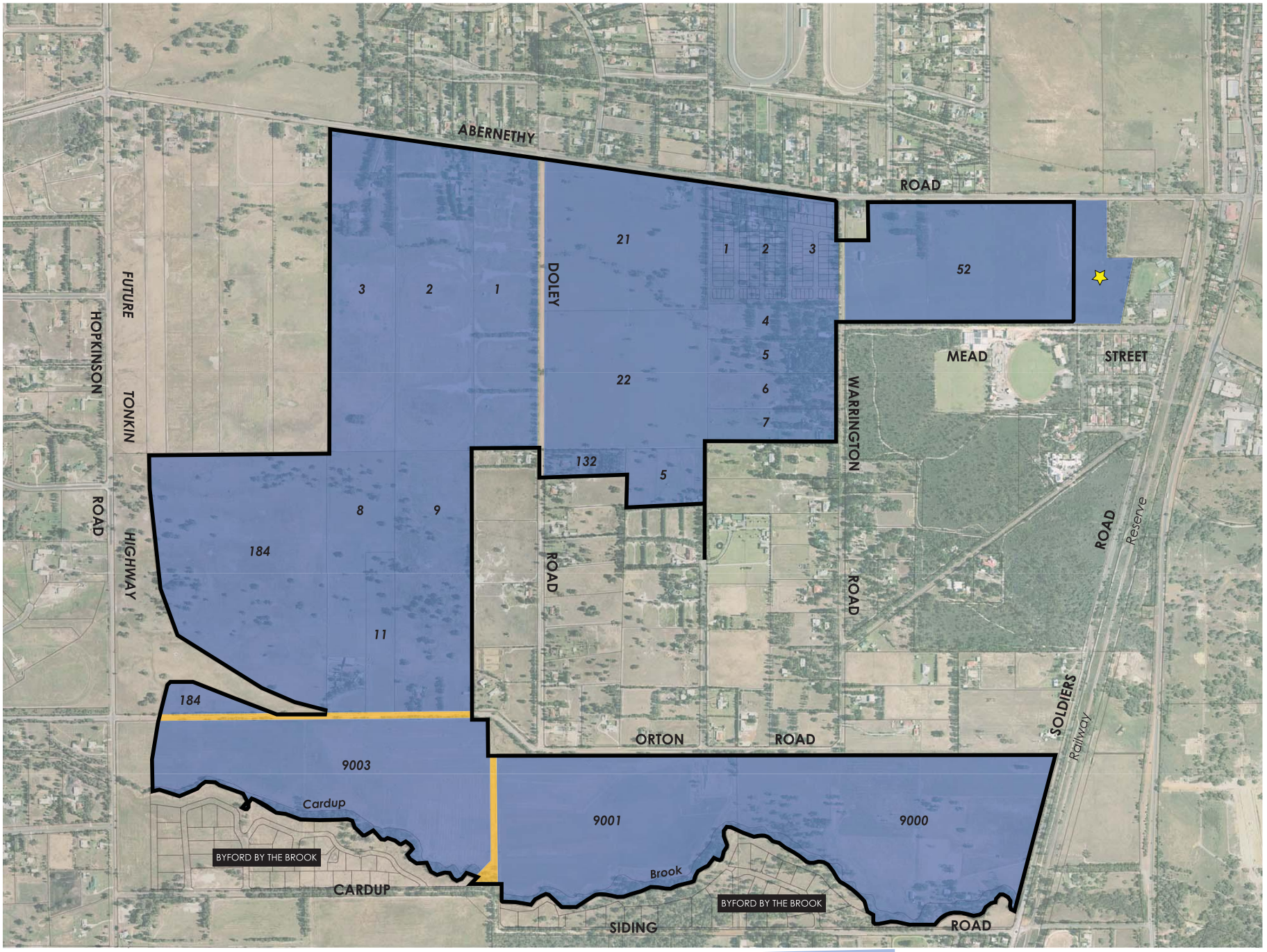
1.3 STRUCTURE PLAN AREA

The Structure Plan area (refer **Figure 2**) includes the following landholdings:

TABLE 1: LAND SCHEDULE

	Description	Vol/Folio	Area
Lot 9000	Orton Road	1414/690	36.8954 ha
Lot 9001	Orton Road	1007/489	28.9802 ha
Lot 9003	Orton Road	1038/46	32.1230 ha
Pt Lot 184	Orton Road	2135/962	35.1859 ha
Pt Lot 8	Orton Road	1578/358	11.4194 ha
Lot 9	Orton Road	1289/288	18.2285 ha
Lot 11	Orton Road	1566/487	4.0472 ha
Lot 1	Abernethy Road	2130/36	16.9664 ha
Lot 2	Abernethy Road	1694/347	21.1549 ha
Lot 3	Abernethy Road	1291/125	19.0050 ha
Lot 1	Abernethy Road	1416/14	4.0870 ha
Lot 2	Abernethy Road	1416/15	4.0726 ha
Lot 3	Abernethy Road	1416/16	4.9296 ha
Portion of Lot 52	Abernethy Road	2057/313	24.3741 ha
Lot 21	Doley Road	576/24A	20.1154 ha
Lot 22	Doley Road	576/22A	19.8802 ha
Lot 4	Warrington Road	2607/948	4.0495 ha
Lot 5	Warrington Road	1416/18	4.0410 ha
Lot 6	Warrington Road	1416/19	4.0381 ha
Lot 7	Warrington Road	1416/20	4.0528 ha
Lot 5	Lawrence Way	2094/682	4.4328 ha
Lot 132	Doley Road	1812/66	2.0653 ha
Road Reserve*			4.8598 ha
Total			329.4532 ha

** Does not include existing Doley and Warrington Road reserves (which will be utilised as part of future development)*



LEGEND

- LOCAL STRUCTURE PLAN BOUNDARY
- LAND OWNED BY LWP PROPERTY GROUP PTY LTD
- LAND EXCLUDED FROM STRUCTURE PLAN AREA - subject to the Byford Townsite Structure Plan
- ROAD RESERVE - to be closed / realigned

STRUCTURE PLAN AREA

The Glades - Local Structure Plan

0m 100 200m

s: scale bar
d: june 09
j: 06/014

figure 2

1.4 LOCATION

The Structure Plan area is generally bound by Abernethy Road to the north, Tonkin Highway to the west, Cardup Brook to the south and Doley/Warrington Roads to the east. The Structure Plan area is approximately 35 km from the Perth CBD to the north-west and 10 km from the Armadale Regional Centre to the north-east. Tonkin Highway and Thomas Road provide the key regional access points to the site.

Section 3 of this report considers the surrounding context of the Structure Plan area in greater detail.

1.5 STUDY TEAM

The Structure Plan has been prepared by Taylor Burrell Barnett in collaboration with the following team of specialist consultants:

- Coffey Environmental & Emerge Associates (Environmental & Bushfire);
- Ethnosciences (Aboriginal Heritage);
- JDA Consulting (Hydrology);
- Overman & Zuideveld (Architecture);
- Plan E (Landscape Architecture);
- Riley Consulting and Transcore (Traffic and Transport);
- Stantec (Civil Engineering);
- Taktics4 (Retail Needs); and
- MNG Survey (Surveyors).

1.6 REPORT FORMAT

This report comprises two distinct parts. **Part 1** provides the statutory basis for which the Structure Plan will be implemented and creates a statutory link between the Structure Plan and the Shire of Serpentine-Jarrahdale Local Planning Scheme No. 3 (LPS3). **Part 2** explains and describes the proposed Structure Plan and how it will be implemented.

Separation of the content in this manner allows the requirements of the Structure Plan to be read in isolation. This in turn aids in the implementation of the Plan.

Owing to the breadth of data that has been prepared in support of the Structure Plan, only summaries of the various technical reports are contained in this document. Full copies of the following reports are attached as appendices:

Appendix 1	Shire of Serpentine-Jarrahdale Local Planning Policy No. 19 – Byford Structure Plan Area Development Requirements
Appendix 2	Environmental Appraisal Report (Coffey Environmental)
Appendix 3	Black Cockatoo Assessment (Coffey Environmental)
Appendix 4	Aboriginal Heritage -Section 18 Advice for the Glades and Brook Developments
Appendix 5	The Glades Village Centre Retail and Commercial Analysis (Taktics 4)
Appendix 6	Traffic & Transportation Report (with various updates) (Riley Consulting and Transcore)
Appendix 7	Local Urban Stormwater Management Report (JDA Consulting)

1.7 PROJECT PHILOSOPHY

LWP Property Group (now Satterley Property Group), as Project Managers of The Glades development, set two critical objectives for the project team in preparing this Structure Plan. First was the fundamental imperative of setting, and subsequently realising, sustainability benchmarks. The second was the need to sensitively integrate this new development into an almost 100 year old, semi-rural town of proud and distinct character.

In order to facilitate achievement of these two objectives an overarching philosophy will apply to the development from inception through to delivery of the final stage. The project philosophy is to *'tread lightly'.*

This is a borrowed expression that can be applied to the individual, an organisation, corporation or government body. It may be interpreted in a number of ways but in the context of this Structure Plan *'treading lightly'* relates to finding a delicate balance between optimising environmental outcomes and continued progress/development. The public and private sectors alike must operate with awareness that subdivision and development is a legacy that future generations and the environment will either suffer or celebrate.

Satterley Property Group considers significant benefit will be enjoyed in the following key areas of the proposed Structure Plan.

1.7.1 TRADITIONAL NEIGHBOURHOOD DESIGN/SUSTAINABLE COMMUNITY

As part of the project brief, and in keeping with contemporary design practice in Western Australia, the Structure Plan is designed in accordance with the principle recommendations of Liveable Neighbourhoods (LN).

Liveable Neighbourhoods is the benchmark for community design in Western Australia and now enforced as a State Planning Policy. Whilst reference to the principles therein is the responsible path for any developer, it is particularly relevant in the Byford context where the existing townsite possesses characteristics also inherent to LN.

Integration between 'The Glades' project and the existing townsite will be aided where commonality of urban form exists.

The Glades at Byford design exhibits:

- A highly interconnected network of neighbourhoods with a traditional Village Centre at its core;
- A main street Village Centre that will offer a variety of uses including retail floorspace, commercial floorspace, medium density residential, mixed-use development, community facilities and civic spaces;
- Neighbourhood nodes that are interspersed throughout the Structure Plan area at important intersections;
- An interconnected street network that will link residential uses with the town and village centre, neighbourhood nodes, key civic spaces and a generous network of public open space and urban bush land; and
- A range of residential densities that are promoted across the Structure Plan area to;
  - optimise public equity (by maximising the available interface with community assets such as public open space, urban bushland, school sites, neighbourhood nodes and the neighbourhood centre);
  - provide a diversity of housing product for increased choice and to accommodate an evolving household/family structure; and

– promote higher densities in strategic locations thus facilitating a more efficient and sustainable use of land.

Combined, these elements promote variety and interest in the urban fabric, facilitate walkability, reduce car dependency, and ultimately encourage human interaction.

View south-east through the Village Centre

1.7.2 VIBRANT VILLAGE CENTRE

Central to the Glades project is the Village Centre. The Centre is anchored at the junction of two spine roads (Doley Road and Mead Street) that traverse the site.

The function of a Village Centre is to provide a convenience retail offer and a range of services that meet the daily needs of the surrounding populous.

In addition to this function, this Village Centre will act as a community focal point through the provision of landscaped public open space, massing of the built form, variety of interactive land uses (such retail, entertainment, and community facilities); highly pedestrianised public realm, and linkages with important civic infrastructure (such as the local High School, Byford Train Station, and the new Recreation Centre).

The Village Centre will bind the new community, yet, given its east west axis, will also forge visual and associative linkages with the existing Byford town centre.

View looking south towards the Village Centre across the lake

1.7.3 SUSTAINABLE ENVIRONMENT

All care has been taken in preparing this Structure Plan to reflect the principles of Liveable Neighbourhoods which facilitates sustainable urban outcomes and to identify a drainage strategy, earthworks regime and servicing plan that responds not only to the needs of the site, but meets sustainability targets.

1.7.4 SUSTAINABLE HOUSING

There are a number of architectural elements that can be incorporated in the design of new buildings that will help to reduce the energy load of the building and the resources spent during and after construction. Initiatives include:

- Orientating buildings for solar access;
- Adopting energy saving devices and systems;
- Using natural ventilation and daylight;
- Using light coloured materials to reflect heat externally and reflect daylight internally;
- Planning for a range of outdoor spaces to take advantage of daily and seasonal weather changes;
- Using low embodied energy, reused or recycled materials;
- Using materials and products with low toxic emissions;
- Utilizing building thermal mass and insulation to delay and reduce peak loads;
- Selecting products and systems that minimise water use; and
- Minimising waste during construction.

This list is by no means exhaustive but offers an insight into the simple design considerations that can significantly reduce ongoing energy expenditure. Taking care to design buildings for maximum efficiency helps to ease the burden on the environment.

It is often difficult for Governments to mandate stricter design requirements and so it can fall to the private sector to promote new benchmarks. To round out the suite of sustainability initiatives adopted for this project, it is vital that Satterley, in conjunction with the Shire of Serpentine Jarrahdale formulate design guidelines, which focus not only on integrating the development with the existing Byford townsite, but also promoting sustainable development solutions.

1.7.5 CELEBRATION OF NATURAL FEATURES

The Glades is located at the eastern extent of the Swan Coastal Plain near the foot of the Darling Range. The site is characterised by a series of creek/drainage systems and vast expanses of vacant pastureland. As it exists, The Glades is a picture of tranquillity only 40 minutes from the Perth city centre.

It is this low-density development and the dominance of the sites environmental attributes that define the existing character. The charge for the consultant team has been to weave the environmental assets through the development whilst achieving the appropriate level of urbanism demanded by a growing population.

The Structure Plan, and subsequent phases of subdivision, will therefore recognise and celebrate the available views back to the Darling Scarp, existing vegetation, the presence of the Cardup Brook and the drainage channels that feed into the Brook.

This desire to retain and consolidate upon the natural features is perhaps best articulated in Satterley's landscape brief, which states:

The landscape vision for The Glades project is to create a development with a strong sense of place and identity that is compatible with the surrounding environment. The incorporation of sustainable design principles is an over-riding objective, with tree retention in public open spaces and road reserves a key priority.

The creation of useful open spaces that fulfil a variety of functions is vital; such functions include:

- The establishment of significant multiple-use corridors along existing drainage lines;
- To re-create a diversity of indigenous plant communities and fauna habitats;
- To provide a showcase for a variety of environmental features and practices to assist in community education and foster a sense of community pride and ownership; and
- To provide a diversity of visual and recreational opportunities and experiences.

An overall approach in the open space design will be to minimise areas of irrigated grass and to re-establish extensive areas of bushland using endemic plant species.

2 PLANNING CONTEXT

2.1 EXISTING ZONING

2.1.1 METROPOLITAN REGION SCHEME

The Structure Plan area is predominantly zoned Urban under the Metropolitan Region Scheme (MRS). There is a portion of land in the north of the Structure Plan area abutting Abernethy Road and adjacent the Byford Trotting Complex that is zoned Urban Deferred (refer **Figure 3**)

To the west of the Structure Plan area is the Tonkin Highway and to the east is the South West Highway, which are both Primary Regional Road reservations under the MRS (refer **Figure 3**). To the east of the Structure Plan area there is also a substantial Parks and Recreation reservation (Bush Forever Site 321).

2.1.2 SHIRE OF SERPENTINE-JARRAHDALE LOCAL PLANNING SCHEME NO. 3

The site is predominantly zoned Urban Development under the Shire of Serpentine-Jarrahdale LPS3 (refer **Figure 4**). The 'Urban Development' zone is applied to land as a precursor to extensive development or redevelopment. LPS3 requires the preparation of a Local Structure Plan within the Urban Development zone, prior to subdivision and development

2.2 STRATEGIC PLANNING CONTEXT

2.2.1 BYFORD DISTRICT STRUCTURE PLAN

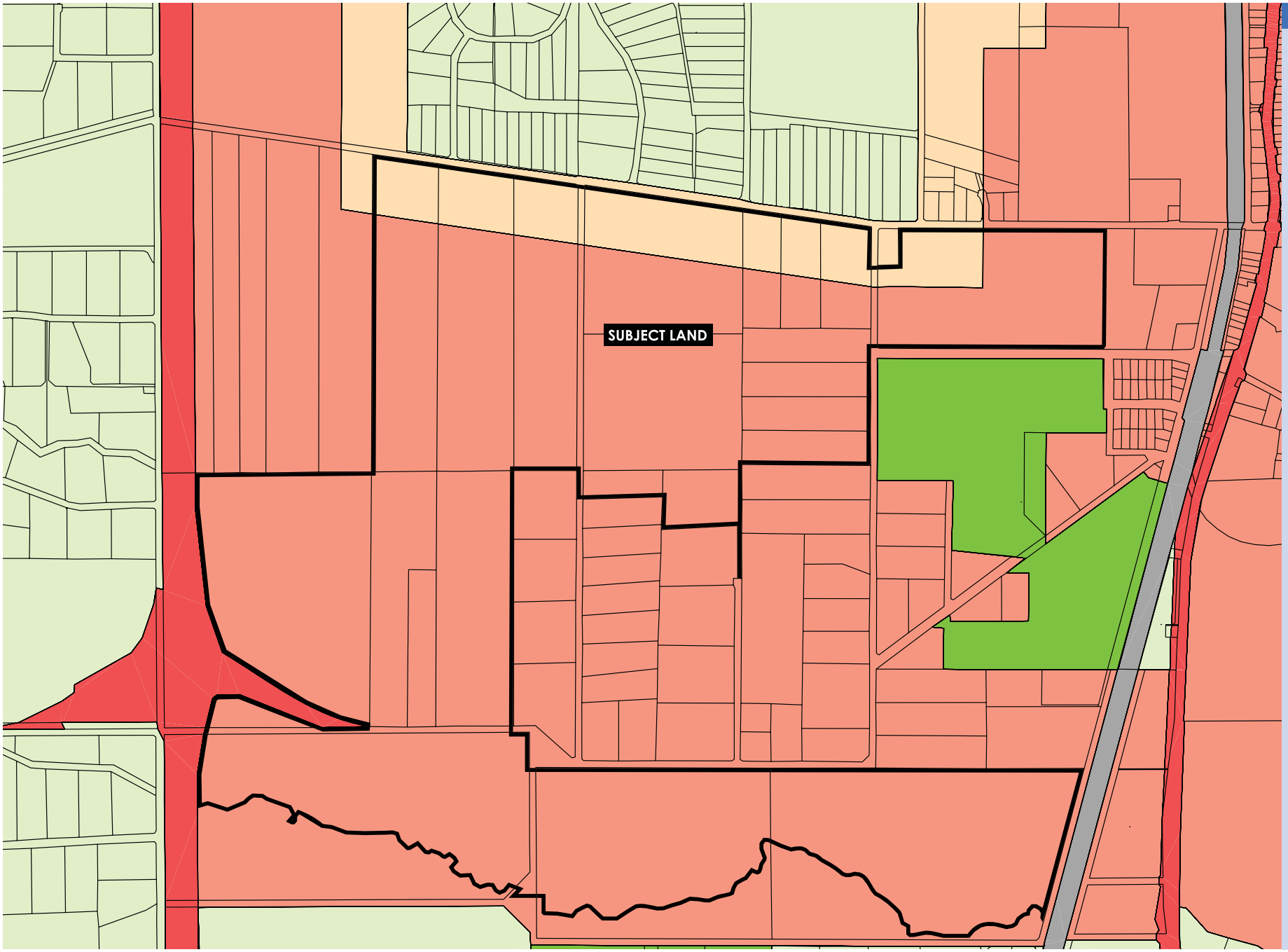
In accordance with the requirements of LPS3, the Shire commissioned Taylor Burrell Barnett and Kinhill Engineers to prepare a district structure for the land fringing the Byford townsite in late 1999. The Byford District Structure Plan or Byford Structure Plan as it is now known , was prepared over a number of years and finally approved in 22 August 2005. Council undertook a review of the Structure Plan in 2006, however this review and new design was never endorsed or adopted by Council. In 2007, Council decided to review the existing 2005 Byford Structure Plan and in February 2007, they formally adopted modifications to this plan. The Western Australian Planning Commission approved some of these modifications in April 2008.

The Shire undertook a further review of the Byford Structure Plan and this review was considered by Council in mid 2009.

Key elements of the WAPC approved Byford Structure Plan (2005 as amended) which informed the Glades Local Structure Plan included:

- A Village Centre, centrally located off Doley Road;
- Two major east-west Multiple Use Corridors;
- One High School and one Primary School site; and
- Some Mixed Business along Orton Road.

The Byford Structure plan (2005 as amended) also identified the land south of Orton Road as "Land subject to further study – planning to be finalised subject to resolution of alignment of Orton Road". This document addresses the alignment of Orton Road to enable development within this precinct to be facilitated through this structure plan. Further details are provided within **Table 2** below.



LEGEND

LOCAL STRUCTURE PLAN BOUNDARY

RESERVED LANDS

- PARKS AND RECREATION
- RAILWAYS
- PORT INSTALLATION
- STATE FORESTS
- WATER CATCHMENT
- CIVIC AND CULTURAL
- WATERWAYS

ROADS

- PRIMARY REGIONAL ROADS
- OTHER REGIONAL ROADS

PUBLIC PURPOSES - DENOTED AS FOLLOWS:

H	HOSPITAL
HS	HIGH SCHOOL
TS	TECHNICAL SCHOOL
CP	CAR PARK
U	UNIVERSITY
CG	COMMONWEALTH GOVERNMENT
SEC	STATE ENEGY COMMISSION
SU	SPECIAL USES
WSD	WATER AUTHORITY OF WA
P	PRISON

ZONES

- URBAN
- URBAN DEFERRED
- CENTRAL CITY AREA
- INDUSTRIAL
- SPECIAL INDUSTRIAL
- RURAL
- PRIVATE RECREATION
- RURAL - WATER PROTECTION

EXTRACT FROM METROPOLITAN REGION SCHEME

The Glades - Local Structure Plan

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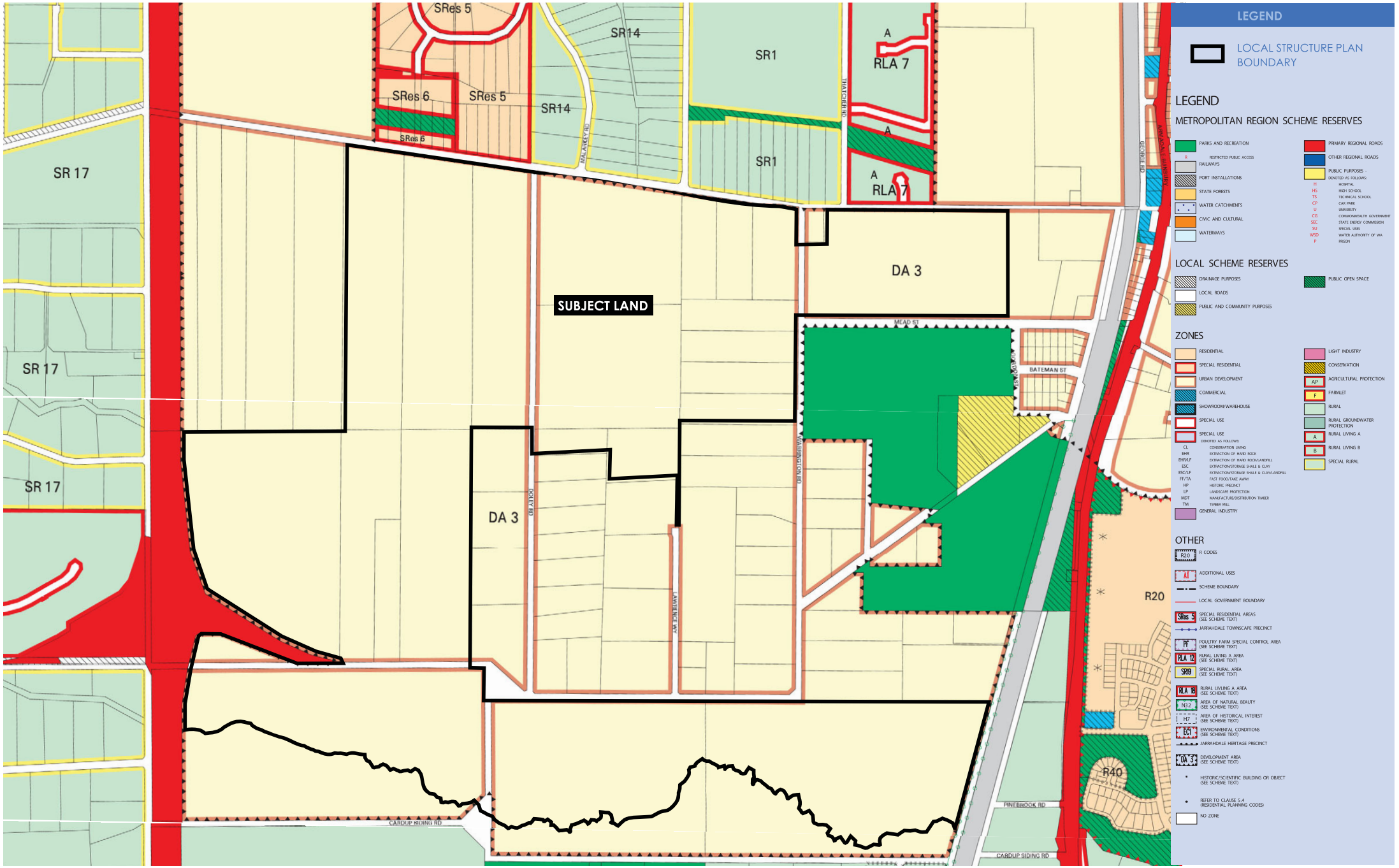
figure 3



EXTRACT FROM SERPENTINE-JARRAHDALE TPS No.2

The Glades - Local Structure Plan

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figure 4

Legend

- BYFORD DSP BOUNDARY
- DISTRICT CENTRE
- NEIGHBOURHOOD CENTRE
- MIXED USE
- COMMUNITY AND PUBLIC PURPOSE
- LIGHT INDUSTRIAL
- SERVICE COMMERCIAL
- BUSH FOREVER
- DISTRICT/ NEIGHBOURHOOD OPEN SPACE
- RESERVE
- MULTIPLE USE CORRIDOR
- SUBJECT TO FUTURE PRECINCT PLAN
- PLANNING CONTROL AREA 164
- MEDIUM - HIGH: R40-100
- LOW (SUBURBAN): R20-35
- LOW (TRANSITIONAL): R2-10
- SPECIAL RESIDENTIAL
- RR-1
- RR-2
- RURAL SMALL HOLDINGS
- RURAL
- SPECIAL USE
- PRIMARY DISTRIBUTOR
- SECONDARY DISTRIBUTOR
- DISTRICT DISTRIBUTOR
- PRIMARY CYCLE ROUTE
- SECONDARY CYCLE ROUTE
- RAILWAY RESERVE
- HIGH FREQUENCY TRANSIT CORRIDOR
- PASSENGER RAIL LINE
- RAIL STATION
- DIA BOUNDARY
- DIA DEVELOPMENT INVESTIGATION AREA
- EHS EXISTING HIGH SCHOOL
- EPS EXISTING PRIMARY SCHOOL
- HS HIGH SCHOOL
- PS PRIMARY SCHOOL
- D DISTRICT OPEN SPACE
- N NEIGHBOURHOOD OPEN SPACE
- * HIGH SCHOOL SITE LOCATION TO BE DETERMINED (REFER TO PART 1 SECTION 1.6.8)

Byford District Structure Plan

Hames Sharley

SOURCE: SHIRE OF SERPENTINE - JARRAHDALE, WAPC ENDORSED 2023.

BYFORD DISTRICT STRUCTURE PLAN
The Glades - Local Structure Plan

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figure 5

TABLE 2: BYFORD STRUCTURE PLAN LAND USE BREAKDOWN

Property	Designated Uses
Pt Lot 9001 Cardup Siding Road	Predominantly R20 with a conservation area along Cardup Brook, a neighbourhood node, a proposed local park, neighbourhood park & drainage basin.
Pt Lot 9000 Cardup Siding Road	Predominantly R20 with a conservation area along Cardup Brook, a portion of Mixed Business, a 4,000 sqm district recreation area, a proposed local park, neighbourhood park & drainage basin.
Pt Lot 9003 Cardup Siding	Predominantly R20 with a conservation area along Cardup Brook, two proposed local park, a portion of Mixed Business and drainage basin.
Pt Lot 184 Orton Road	Predominantly R20, with a multiple use corridor, a neighbourhood node, 3 drainage basins (or part thereof), portion of district recreation reserve, a portion of Mixed Business and a proposed neighbourhood park.
Pt Lot 8 Orton Road	Predominantly R20 with a multiple use corridor, portion of a drainage basin, portion of district recreation reserve, a porion of Mixed Business and a portion of a primary school site.
Lot 9 Orton Road	Predominantly R20 with a multiple use corridor, proposed local park within MUC, a proposed local park and portion of a primary school site.
Lot 11 Orton Road	R20 and a small portion of multiple use corridor.
Lot 1 Abernethy Road	Predominantly R20 with a multiple use corridor, a neighbourhood node, a fringing area of residential R30-60.
Lot 2 Abernethy Road	Predominantly R20 with a multiple use corridor and two local parks.
Lot 3 Abernethy Road	Predominantly R20 with a multiple use corridor, a portion of a drainage basin and portion of proposed district recreation reserve.
Lot 1 Abernethy Road (now Stage 1)	R20 with a neighbourhood node.
Lot 2 Abernethy Road (now Stage 1)	R20
Lot 3 Abernethy Road (now Stage 1)	R20
Lot 52 Abernethy Road	Predominantly R20 with a multiple use corridor, a neighbourhood node, drainage basin, proposed local park, high school site with a community purpose and area of residential R30-60.
Lot 21 Doley Road	Predominantly R20 with a multiple use corridor, 2 drainage basins, a portion of neighbourhood centre and fringing area of residential R30-60.
Lot 22 Doley Road	Predominantly R20 with a multiple use corridor, portion of proposed neighbourhood centre and fringing area of residential R30-60.
Lot 4 Warrington Road (formerly – now Stage 1)	Predominantly multiple use corridor with a small portion of R20.
Lot 5 Warrington Road	Predominantly multiple use corridor with a small portion of R20
Lot 6 Warrington Road	Predominantly R20 with multiple use corridor
Lot 7 Warrington Road	Predominantly R20 with multiple use corridor

Whilst the Byford Structure Plan resolves the district level planning issues, local structure planning is required before further subdivision and development may be contemplated within The Glades Estate.

Since the preparation of the 2005 and updated 2009 documents, the Shire has undergone a significant change due to exponential population growth, most of which has occurred in Byford. A number of new Local Structure Plans have been submitted and the State strategic and policy frameworks have changed. The reason for the revision to the Byford DSP in 2020 was to consider the significant population growth and the increased lot densities that have resulted from further planning. This revision also better reflects a number of State and local policy changes and to incorporate various strategic documents that have been produced by the Shire of Serpentine Jarrahdale since the Byford Structure Plan was first adopted in 2005. The DSP (refer **Figure 5)** was adopted by the Shire Council on 16 November 2020 and approved by the WAPC on 9 September 2023.

2.3 EXISTING STUDIES AND RELEVANT POLICY CONSIDERATIONS

2.3.1 BYFORD TOWNSITE DRAINAGE AND WATER MANAGEMENT PLAN

As previously mentioned, in 2005 the Byford Structure Plan was endorsed by the Shire of Serpentine-Jarrahdale. In support of the BSP was the Byford Urban Stormwater Management Strategy (2003) was prepared and later simplified as the Byford Urban Stormwater Management Plan Developer Guidelines in 2005.

In 2007, the Department of Water nominated to prepare the Byford Townsite Drainage and Water Management Plan (DWMP) to address the Byford Structure Plan. The DWMP was completed in 2008, and according to the document, now supersedes the Byford Urban Stormwater Management Strategy previously adopted by the Shire.

The DWMP provides a district scale assessment of the hydrology relevant to the implementation of the BSP. The LWMS included in this LSP addresses the water management criteria presented in the DWMP and provides a refinement of the hydrology to a local scale, appropriate for the implementation of The Glades LSP.

2.3.2 BETTER URBAN WATER MANAGEMENT (WAPC 2008)

The guideline document Better Urban Water Management (WAPC, 2008), focuses on the process of integration between land use and water planning by specifying the level of investigations and documentations required at various decision points in the planning process.

The LWMS included in this LSP complies with the BUWM process.

2.3.3 SHIRE OF SERPENTINE-JARRAHDALE LOCAL PLANNING POLICY 19 – BYFORD STRUCTURE PLAN AREA DEVELOPMENT REQUIREMENTS

The Shire of Serpentine-Jarrahdale's Local Planning Policy 19 (refer **Appendix 1**) provides guidance and requirements for land use and development within the Byford Structure Plan area. Importantly, this policy considers land use permissibility and development requirements for centres (including the Village Centre within the Structure Plan area) within the BSP area and specifically allows for Mixed Use development, which is currently not permissible based on the provisions of LPS3.

To provide further statutory rigour to the provisions of this policy, Part 1 of this Structure Plan re-iterates the provisions of this policy for many of the land uses identified on the Structure Plan.

2.3.4 DRAFT ACTIVITY CENTRES STRATEGY

It is understood the Shire is currently preparing a Draft Activity Centre Strategy across the entire municipality, however this is yet to be released to the public.

3 CONTEXTUAL ANALYSIS AND EXISTING LAND USE PATTERN

3.1 SITE CONTEXT

As outlined in **Figure 6**, the Structure Plan area is approximately 35 km from the Perth CBD to the north-west and 10 km from the Armadale Regional Centre to the north-east. Tonkin Highway (future extension) to the immediate west and Thomas Road (1.5 km to the north) provide the key regional access points to the site.

In a more local context, as outlined in **Figure 7**, the Structure Plan area is to the immediate east of the existing Byford Town Centre and this needs to be acknowledged and considered carefully as part of the planning of The Glades. To the east there are also existing recreation facilities and a private primary school and to the south is the existing Byford by the Brook development.

The Byford Trotting complex to the immediate north of the Structure Plan area will also require careful consideration from an interface perspective. The Structure Plan areas wrap around an area of fragmented semi rural landholdings (generally north of Orton Road and west of Warrington Road) which will also require careful consideration from an access and interface perspective.

3.2 EXISTING LAND USE PATTERN

For the purposes of describing the existing environment, the Structure Plan area has been broken up into 3 separate sub-precincts, as outlined in **Figure 8**.

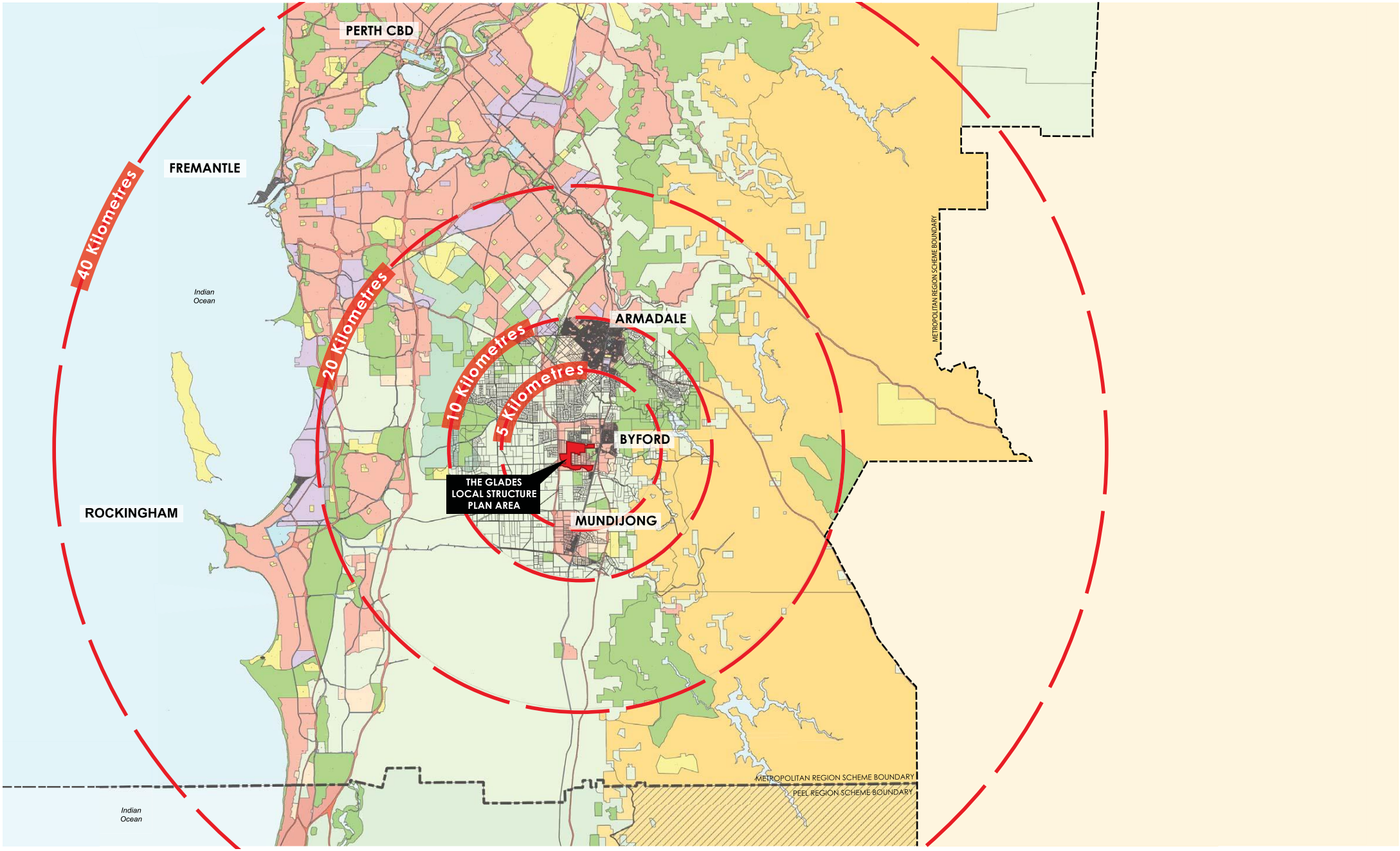
Sub-precincts 1 and 2 comprise the bulk of land bound by Abernethy Road, Soldiers Road, Orton Road and Hopkinson Road. The Tonkin Highway Reserve is located along the south-western and western boundaries of sub-precinct 2.

Of the small number of improvements located within sub-precincts 1 & 2, most are single residential dwellings (and associated outbuildings) located forward on their respective lots. This pattern of development renders much of the sub-precincts vacant and concentrates development towards the various road frontages. The balance of lots are utilised for pastureland.

A local structure plan has been prepared for land located immediately west of sub-precinct 1 (Byford West). The structure plan proposes residential development of densities between R20 and R30. It is also understood that subdivision approval has been granted (through a decision of the State Administrative Tribunal) over these landholdings, however there are some concerns in relation to the width of the approved Multiple Use Corridors and their ability to accommodate the drainage volumes anticipated by the Byford Townsite Drainage and Water Management Plan. Further negotiations with this landowner may be required at the detailed subdivision design stage to ensure an appropriate and realistic design outcome can be achieved.

Sub-precinct 3 comprises all land south of Orton Road and north of the Cardup Brook watercourse. The Tonkin Highway Reserve forms the western and north western boundaries of the sub-precinct.

The vast majority of sub-precinct 3 is pastureland with only one small cluster of buildings located towards Soldiers Road. It is understood that this cluster comprises a residential building and associated outbuildings.



REGIONAL CONTEXT PLAN

The Glades - Local Structure Plan

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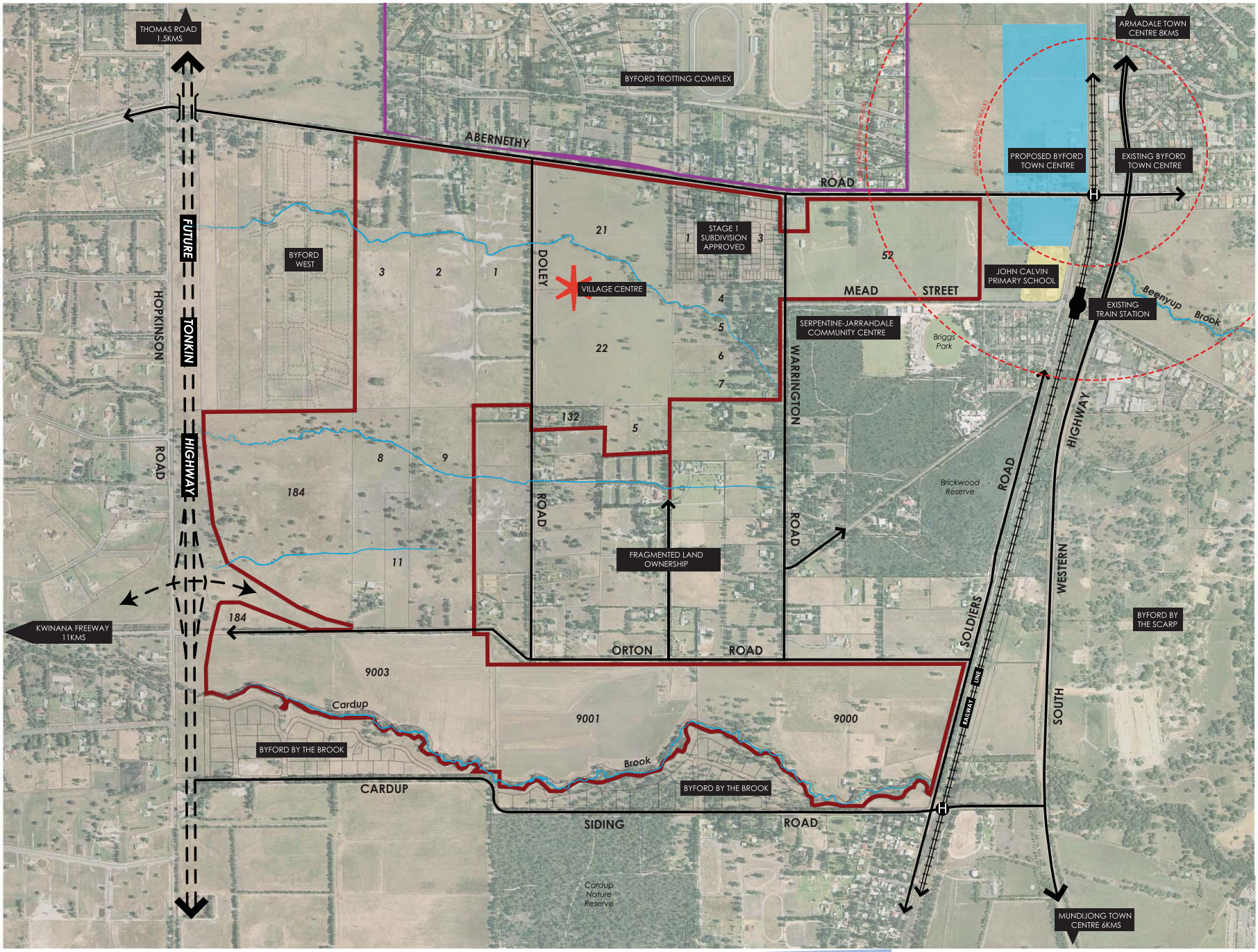
figure 6



LEGEND

- LOCAL STRUCTURE PLAN BOUNDARY
- BYFORD TOWN CENTRE (SUBJECT TO SEPERATE STRUCTURE PLAN)
- VILLAGE CENTRE LOCATION AS IDENTIFIED ON BYFORD STRUCTURE PLAN (2005)
- BYFORD TROTTING COMPLEX
- RAIL CROSSING
- BUSH FOREVER
- EXISTING WATERCOURSE

LOCAL CONTEXT ANALYSIS

The Glades - Local Structure Plan

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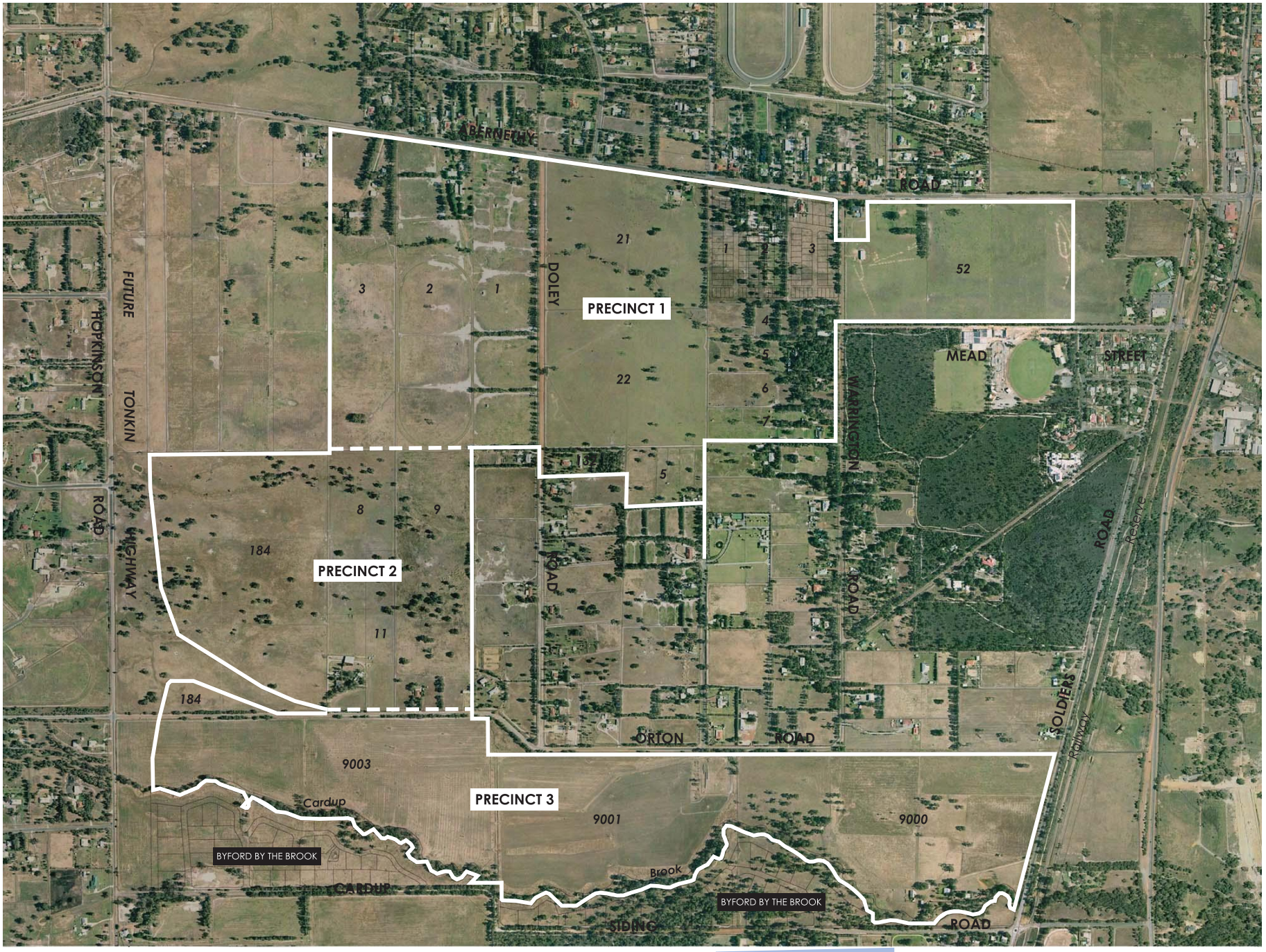
figure 7



LEGEND

LOCAL STRUCTURE PLAN BOUNDARY

AERIAL PHOTOGRAPH & SUB PRECINCTS

The Glades - Local Structure Plan

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figure 8

4 EXISTING ENVIRONMENT

4.1 INDIGENOUS HERITAGE SIGNIFICANCE

An Aboriginal Heritage assessment of The Glades was completed in 2006, which included a desktop study and archaeological field survey. The ethnographic field survey and community consultation was undertaken in January 2006.

A number of Aboriginal sites were listed on the Register of Aboriginal Sites within the Structure Plan area. These included:

- Cardup Brook (Site ID 16108), listed on the Interim Register of Aboriginal Sites as a mythological site and encompasses the entire brook and a buffer zone of 30 m on either side.
- Cardup (Site ID 3310), listed on the Interim Register of Aboriginal Sites as an artefact scatter is reportedly located approximately 50 m from the north bank of Cardup Brook and roughly 400 m southwest of the intersection of the Orton and Doley roads. The subsequent field survey could not locate the previously recorded Cardup site (Site ID 3310) and it is possible that either the spatial information recorded by DIA is incorrect or that the site has been destroyed by previous land use.

As a result of the archaeological field survey, three potential archaeological sites, stone artefact scatters (BAS-001, BAS-002 and BAS-005) and four isolated artefacts (BAS/ISO-003-BAS/ISO-006) were recorded within the Glades.

Following this assessment, conditional consent under Section 18 (3) of the Aboriginal Heritage Act 1972 has been granted over both the Glades and Brook developments. This advice has requested that in addition to the Cardup Brook, two sites (one within and one within close proximity to the Cardup Brook Foreshore) be retained and protected in open space. This advice however will be discussed in further detail in Sections 5 and 6.

4.2 ACCESS

To the north of the site, access is provided by Abernethy Road, a Neighbourhood Connector and due to the existing low traffic volumes all intersections operate with priority control. To the south of the site access can be taken from Orton Road, which is an Integrator B Road in accordance with Liveable Neighbourhoods road hierarchy. It is understood that Orton Road is unlikely to connect through to South-West Highway given the likely extension of the Tonkin Hwy to Mundijong Road.

Two north-south roads pass through the site, Doley Road and Warrington Road, which will operate as neighbourhood connectors. To the east lies the South West Highway, a Primary Regional Road under the control of Main Roads WA. It provides a regional link between Armadale, where it joins Albany Highway to Perth. In a southerly direction it extends to Walpole where it joins the South Coast Highway to Albany. The South Western Highway is a primary freight route and caters for large trucks throughout the year.

To the west of the site a primary regional road reservation is provided for the future extension of the Tonkin Highway. The Highway will be constructed to Freeway standard and will link South West Highway at Mundijong Road through to the Reid/Roe Highways at Midland.

4.3 LANDFORM

Generally site topography is relatively flat with terrain typically falling from east to west at a gradient of approximately 1 in 100, from RL 56 m AHD at Soldiers Road to RL 28 m AHD at Hopkinson Road.

The Western Australian Department of Agriculture and Food (DAFWA) mapping in the northern section of the Peel-Harvey catchment utilises existing land resource survey data such as soil type, landforms, and slope (WADA 1990). These characteristics and the distribution of these units within the site is shown in Figure 5 of **Appendix 2** (Environmental Appraisal Report, Coffey Environmental).

4.4 GEOTECHNICAL CONDITION

A preliminary geotechnical investigation has been completed for The Glades Structure Plan area. The general findings include:

- The subsurface profile for areas not adjacent to Cardup Brook consist of a 0.1 m thick topsoil layer overlying 0.4 – 1.3 m thick sand to clayey sand to sandy gravel overlying a clayey sand all of Guildford Formation.
- In accordance with AS2570-1996 the majority of the development is classified Class 'M'. The upgrade to a Class 'S' site will typically require 0.8 m of controlled fill over the insitu clay.
- The subsurface profile for areas adjacent to Cardup Brook consists of a 0.1 m thick topsoil layer overlying a 0.9 – 1.5 m thick clay to sandy clay layer overlying a 0.4– 1 m thick to gravely clayey sand to sandy clayey gravel overlying a clayey sand to clayey gravel all of Guildford Formation.
- The insitu soil is not suitable for soakage and as such lot connection pits will be required.
- Subsoil drains are required on both sides of the roads.
- Preliminary testing indicates that insitu material at the site does not have the potential for acid sulphate generation and is unlikely to require an acid sulphate soil management plan.

4.5 SURFACE HYDROLOGY

The Glades development is located at the eastern extent of the Swan Coastal Plain, near the foot of the Darling Range, and is characterized by a series of creek systems flowing east to west onto the Swan Coastal Plain from the Scarp. A series of five creeks run through the area with the major tributary, Cardup Brook, forming the southern boundary of the development area.

Historically these creeks were discontinuous over the Swan Coastal Plain, with the creeks flooding out into flat wetland areas further west of Byford. Flow within the creeks is a combination of surface rainfall runoff, including areas of the Darling Scarp where catchments extend further east of South Western Hwy, and groundwater discharge where the channel intercepts the watertable.

Several studies have been completed on the constraints and opportunities of these creeks (Evangelisti & Associates 1994, 95; JDA 1995), with the most recent being the Byford Townsite Drainage and Water Management Plan (DoW, 2008).

4.5.1 EXISTING DRAINAGE

With land-use changes over time open drainage has been constructed within the Byford area to reduce surface water logging and inundation and provide arable land for agricultural activities. Currently existing water courses flow through The Glades development area, west to Hopkinson Road, where they connect with the Oakland Drain. The Oakland drain flows to the Birrega Main Drain, which in turn flows south west discharging to Serpentine River and ultimately the Peel-Harvey Estuary.

Details of the catchment areas for each of the tributaries is summarised in the Byford Townsite DWMP (DoW, 2008).

With the exception of Cardup Brook, the creeks running through The Glades development area are unprotected from grazing activities and as such are generally suffering from eroded banks.

4.6 GROUNDWATER

Groundwater over the site is generally shallow (i.e. 0 to 5 m below natural surface) with 'perched' water tables forming locally where clay layers within the soil profile limit the rate at which rainfall recharge can infiltrate into the regional water table.

The watertable is the upper surface of the unconfined aquifer within the Superficial Formations. Groundwater abstraction for low rate users targets groundwater in sand lenses at the base of the Guildford Clay, with high rate water users drawing from the confined Cattamarra Coal Measures Aquifer below. A summary of the hydrogeology for Byford from Davidson (1995) is provided below. Department of Water have indicated there are currently water resources available for allocation within both aquifer systems.

4.6.1 REGIONAL HYDROGEOLOGY

4.6.1.1 SUPERFICIAL AQUIFER

The Superficial Aquifer in this region is referred to as the Byford Area, and covers approximately 166 km^2. The aquifer has a maximum thickness of 20 m and consists of clayey sediments of the Guildford Clay with an average transmissivity of about 100 m^2/day.

Due to the poor hydraulic conductivity of the clayey soils the area is characterised by extensive surface flow.

The Superficial Aquifer is directly underlain by the Cattamarra Coal Measures in the Study Area.

4.6.1.2 CATTAMARRA COAL MEASURES AQUIFER

The Cattamarra Coal Measures formation extends beneath all of the coastal plain between Gingin Brook and South Dandalup River, but it is presently at a relatively shallow depth only in the southern area where the Yarragadee Formation is absent (Davidson, 1995). The formation is made up of fluvial sandstones, siltstones and shales with minor coal seams. In the Perth region the sandstone are pale in colour, often clayey, mostly medium to course grained and in beds up to 50 m thick. The shales are dark grey, sometimes carbonaceous, often laminated and occur in beds up to 30 m thick. The upper section of the formation is often weathered to a yellow, reddish brown colour.

Drilling in the Structure Plan area has encountered the top of the formation at approximately 60 m below natural surface level. The Cattamarra Coal Measures represents the most feasible source of non-potable water supply in this area.

4.7 WETLANDS

Several wetlands occur on and adjacent to the study area. A large portion of the study area is mapped in the DEC's *Geomorphic Wetlands Swan Coastal Plain* dataset as palusplain (a seasonally waterlogged flat) (UFI 13500; 13912). Throughout the Swan Coastal Plain, areas of palusplain have historically been extensively cleared for rural pursuits (grazing and horse agistment) as is the case in the study area. The management category of the majority of these wetlands has been evaluated as Multiple Use (MU) wetlands. Wetlands that support native vegetation are identified as Conservation (CCW) or Resource Enhancement (RE) wetlands. Wetland Management categories and their objectives are shown in **Table 3** below**.**

TABLE 3: WETLAND MANAGEMENT CATEGORIES & OBJECTIVES

Management Category	General Description
Conservation Category Wetland (CCW)	Wetlands support a high level of ecological attributes and functions.
Resource Enhancement Wetland (REW)	Wetlands which may have been partially modified but still support substantial ecological attributes and functions.
Multiple Use Wetland (MU)	Wetlands with few important ecological attributes and functions remaining.

A large portion of the site is mapped in the DEC's *Geomorphic Wetlands Swan Coastal Plain* dataset as palusplain (a seasonally waterlogged flat). Throughout the Swan Coastal Plain, areas of palusplain have historically been extensively cleared for rural pursuits (grazing and horse agistment) as is the case in the site. The management category of the majority these wetlands has been evaluated as Multiple Use (MU) wetlands. Wetlands that support native vegetation are identified as Conservation (CCW) or Resource Enhancement (RE) wetlands.

Sections of Cardup Brook that support native riparian vegetation and parts of the Bush Forever Site 321 (within Cardup Brook) associated with wetlands have been identified in the *Geomorphic Wetlands Swan Coastal Plain* dataset as RE wetlands. These conservation areas will be protected within the Cardup Brook Foreshore Reserve.

A CCW was previously located on Lot 3 Abernethy Road (UFI 7829, 7866 and 7829). As part of the site investigations undertaken for this report, ATA Environmental conducted a site visit in September 2005 to 'ground truth' the appropriateness of the CCW management category of the wetland. It was concluded that due to the degraded nature of the wetland, along with other environmental characteristics of the site (discussed in further detail in Section 3 of **Appendix 2**), the DEC's CCW classification should be revised to a MU management category. The Wetlands Branch of the Department of Environment agreed to revaluate the wetland category of Conservation Category to Multiple Use in February 2006.

One CCW (UFI 15452) is located on land directly abutting the study area and is within the Bush Forever Site 321 to the east of the study area.

4.8 VEGETATION & FLORA

A flora and vegetation survey of the site was conducted by ATA Environmental on 7 September 2005. The survey was undertaken to determine if any of the significant species or Threatened Ecological Communities (TECs) identified by DEC occur, within the study area. This was based on sampling within quadrats of 10 m x 10 m dimension as well as a thorough a site walkover to record all plant species present at the time of the survey. This method complies with the Environmental Protection Authority's (EPA) guidelines for flora surveys as outlined in the EPA Guidance Statement No. 51 *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (EPA, 2004a).

The major vegetation types and associated flora were surveyed and delineated using a 1:4,000 colour aerial photograph (Figure 8 of **Appendix 2**). The vegetation was described and mapped according to the structure and species composition of the dominant stratum using the system adopted in *Bush Forever* (Government of Western Australia, 2000a).

The conservation status of all recorded flora was checked against the current lists published in the Governmental Gazette and available from the DEC's (October 2005) and Department of the Environment, Water, Heritage and the Arts (DEWHA). The results of these findings are considered in the following sections and **Appendix 2.**

4.8.1 VEGETATION COMPLEXES

The site contains vegetation characteristic of the Forrestfield Vegetation Complex (Heddle *et. al.,* 1980).

The Forrestfield Complex vegetation generally consists of Open Forest of *Corymbia calophylla, Eucalyptus wandoo* and *Eucalyptus marginata* to Open Forest of *Eucalyptus marginata – Corymbia calophylla – Allocasuarina fraseriana – Banksia* spp. A fringing Woodland of *Eucalyptus rudis* is often found in the gullies that dissect this landform (Heddle *et al*., 1980).

Approximately 9% of the Forrestfield Complex remains on the Swan Coastal Plain (Government of Western Australia, 2000b). The EPA's objective is to protect at least 30% of the original extent of the vegetation complexes in unconstrained areas and 10% in constrained areas (i.e. Urban zoned regions). While most of the vegetation complexes on the Swan Coastal Plain meet the 30% target, the Forrestfield Complex compares poorly with 9% of the original extent remaining on the Swan Coastal Plain. The Glades area is considered a constrained area due to its MRS "Urban" zoning and the 10% target therefore applies to the site.

The Glades however, has historically been used for pastoral and agricultural land uses and as such its original state has been highly modified. Although it contains characteristics of the Forrestfield Complex, it is not considered to be a good representation of this vegetation complex due to the extent of historical clearing. Figure 8 of **Appendix 2,** shows the vegetation types and condition found across the site and except for a couple of lots fronting Warrington Road and Bush Forever site 321 (Brickwood Reserve and adjacent bushland Byford), the best examples of the Forrestfield Complex are to be found within the adjacent road reserves.

4.8.2 VEGETATION TYPES

Vegetation types are vegetation units that can be described and mapped at a finer level than the vegetation complexes. Nineteen vegetation types associated with the site were identified and described during the flora and vegetation survey undertaken on 7 September 2005. These vegetation types are described in **Appendix 2** and in some instances a typical photograph and 10 m x 10 m quadrat data indicating species present, their percentage cover and height has also been included.

4.8.3 VEGETATION CONDITION

The condition of the vegetation was assessed according to the system devised by Keighery and described in *Bush Forever* (2000a). Keighery's condition rating scale ranges from Pristine (which the vegetation exhibits no visible signs of disturbance) to Completely Degraded (where the vegetation structure in no longer intact and without native plant species). Vegetation condition for the Byford Main Precinct is mapped in Figure 8 of **Appendix 2** and ranges from Excellent to Completely Degraded. The majority of the study area has been historically used for farming which has adversely affected areas of native vegetation through grazing, trampling, introducing and spreading weeds, and nutrient enrichment. Across the study area, intact areas of remnant vegetation are generally confined to sections of road reserves and Bush Forever sites.

4.8.4 THREATENED ECOLOGICAL COMMUNITIES

Based on Floristic data collected during this survey, a vegetation type in The Glades was inferred to have once been representative of one FCT (Gibson *et al.,* 1994):

- Floristic Community Type 3b – *Corymbia calophylla – Eucalyptus marginata* woodlands on sandy clay soils.

This Floristic Community Type is listed as a Threatened Ecological Community by English and Blythe (1997) and by DEC's list of TECs and is also listed as Vulnerable on the Endangered Community List under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

Due to the Degraded to Highly Degraded nature of the vegetation type CcEmLOW, it is Coffey Environments assessment that there are not any remaining vegetation types representative of TEC 3b in The Glades Local Structure Plan area.

The CcEmLOW vegetation type adjacent to the study area in the Warrington Road roadside reserve that abuts with the Bush Forever Site 321 is similar to TEC 3b and was considered to range in condition from Excellent to Very Good. This vegetation type may have once been present in the Glades LSP area adjacent to the Bush Forever Site 321 prior to vegetation clearing and grazing activities.

4.8.5 FLORA

A total of 100 plant species were recorded from the site during the September 2005 survey. The total includes three Gymnosperms, 30 Monocotyledons and 67 Dicotyledons. The flora assessment was undertaken on 7 September 2005, a time when the majority of ephemeral species such as lilies and orchids would have been recorded. As such the flora list is considered to represent at least 90% of the species likely to occur on the site. A full list of flora species recorded from the site is provided in **Appendix 2.**

Of the 100 plant species recorded, 60 (60%) were native and 40 (40%) were introduced or non-endemic planted species. Families with the highest representation of taxa were the Poaceae (Grass family – 11 taxa; 1 native, 10 introduced), the Myrtaceae (Eucalyptus family - 14 taxa; 12 native and 2 introduced), the Papilionaceae (Pea family – 10 taxa; 6 native and 4 introduced) and the Proteaceae (Banksia family – 11 taxa; 11 natives). This family composition is typical of the flora of the Swan Coastal Plain of Western Australia.

4.8.6 SIGNIFICANT FLORA

Prior to conducting site investigations, a search of DEC's Declared Rare and Priority Flora database (CALM, 2005b) was undertaken by Coffey Environmental. The database search found that eight Priority taxa and three Declared Rare Flora (DRF) species had been previously recorded within the vicinity of the site (refer **Table 4**).

TABLE 4: SPECIES LISTED ON CALM'S DATABASE RECORDED IN VICINITY OF THE GLADES

Species	Priority Code	Habitat	Flower Period
Aotus cordifolia	P3	Peaty soils and swamps	Aug-Jan
Baeckea sp. Perth Region (R.J Cranfield 444)	P3	Sandy white clay soils	
Drosera occidentalis subsp. Occidentalis	P4	Grey sandy clay	Oct-Jan
Johnsonia pubescens subsp, cygnorum	P2	White, grey, yellow black or lateritic sand, granite limestone. Flats, wet sites, coastal areas and road sides.	Aug-Nov
Schoenus pennisetis	P1	Grey or peaty sand, sandy clay. Swamps and winter flats.	Aug-Sep
Synaphea odocoileops	P1	Brown, orange loam and sandy clay granite. Swamps and winter wet areas.	Aug-Oct
Verticordia lindleyi subsp. Lindleyi	P4	Sand, sandy clay. Winter wet depressions.	May/Nov – Jan
Verticordia plumosa var. pleiobotrya	R	Clay, sandy loam. Seasonally inundated swamps and road verges.	Oct-Dec
Tetraria australiensis	R		Nov-Dec
Trichocline sp. Treeton (B. J Keighery & N. Gibson 564)	P2	Sand over limestone, sandy clay over ironstone. Seasonally wet flats	
Centrolepis caespitose	R	White sand, clay. Salt flats wet areas.	Oct-Dec

Source: CALM, 2005

Following actual site investigations, it was determined that no Declared Rare Flora, Priority Flora or Commonwealth Listed species were recorded on the site (refer **Appendix 2** for further details)

4.9 FAUNA

A desktop fauna assessment of the site was conducted based on the CALM Threatened and Priority Species database search conducted for the area, the Western Australian Museum *FaunaBase* (2005) and the Department of Environment and Conservation (DEC) database to identify Threatened and Priority species potentially occurring within the site. In February 2005, a site assessment of potential nesting hollows for Black Cockatoos (i.e. Carnaby's, Baudins's and Forest Red-tailed) was also conducted.

4.9.1 SIGNIFICANT FAUNA RECORDED OR PREDICTED

The fauna species listed in **Table 5** have protected status under either State or Commonwealth government legislation and were present in database searches. Four Schedule 1 species, two Schedule 4 species and two Priority species were identified as potentially being present within the Structure Plan area.

TABLE 5: THREATENED & PRIORITY FAUNA IN VICINITY OF BYFORD MAIN PRECINCT IDENTIFIED FROM CALM DATABASE SEARCH

Species	Status under Wildlife Conservation Act Schedule/Priority	Status under Commonwealth EPBC Act	Comment
Chuditch *Dasyurus geoffroii*	Schedule 1	Vulnerable	Species is *unlikely* to occur within area
Carnaby's Black-Cockatoo *Calyptorhynchus latirostris*	Schedule 1	Endangered	Species *likely* to occur within area
Baudin's Black-Cockatoo *Calyptorhynchus baudinii*	Schedule 1	Vulnerable	Species *likely* to occur within area
Forest Red-tailed Black-Cockatoo *Calyptorhynchus banksii naso*	Schedule 1		Species *likely* to occur within area
Peregrine Falcon *Falco peregrinus*	Schedule 4		Species *may* occur within area but *unlikely* to rely on project area
Quenda or Southern Brown Bandicoot *Isoodon obesulus fusciventer*	Priority 5		Species *may* occur within area
Rainbow Bee-eater *Merops ornatus*		Migratory	Species *likely* to occur within area but *unlikely* to rely on area for breeding

Each of these species and their potential relationship with the Structure Plan area are considered in further detailed as part of **Appendices 2** and **3** and **Section 4.9.2** below.

4.9.2 PREVIOUS ON-SITE BLACK COCKATOO INVESTIGATIONS

Coffey Environmental have conducted a Black Cockatoo assessment (refer **Appendix 3**) of numerous properties including Lots 494, 104 and 16 ('Byford by the Brook'); Lots 184, 8, 11, and 9 ('Byford by the Stables'); Lots 3, 2, 1, 21, 22, 5, 52, and 2 ('Byford by the Glade'); and Lots 523 and 521 ('Byford by the Scarp', refer **Appendix 3**). These areas include the Structure Plan area, as well as areas surrounding it. In addition to these properties, numerous bushland sites within a 10 km radius were also searched to provide a regional perspective of Black Cockatoo nesting and feeding opportunities (ATA Environmental, 2005).

The Glades has largely cleared undergrowth however there are remnant Marri and Jarrah pockets. All trees and remnant vegetation were assessed to identify areas that have potential as nesting hollows for breeding Black Cockatoos. A thorough search was made of the canopy of each of the trees within the site and the location of any significant trees recorded on 1 February 2005.

Twenty-two trees that contained hollows large enough for Black Cockatoo were identified in this assessment. Only nine of these trees are within the Glades. Although there are suitable sized hollows, some of these trees are in cleared paddocks and are therefore unlikely to be used as nesting sites.

There are many trees that would potentially provide feeding sites (i.e. Marri nuts), however none of the Marri trees examined showed any evidence of Black Cockatoo feeding. Black Cockatoos have a distinctive feeding method and their presence in an area can be determined by discarded Marri nuts or Banksia cones.

Although four Forest Red-tailed Black Cockatoos were observed flying over Lot 21 and 22 (1 Feb 2005), they were not observed to be utilising vegetation occurring on site.

Even though there are many trees that may provide feeding sites for Black Cockatoos, there was no evidence of Black Cockatoo's feeding in the area. A search of bushland within a 10 km radius of the site indicated that there were extensive areas of suitable feeding and nesting habitat that will not be impacted by the proposed development. Some of these alternative feeding and nesting habitats are also protected under Bush Forever.

5 OPPORTUNITIES AND CONSTRAINTS

As is outlined in this section, the subject site is characterised by a number of factors which are relevant in the formulation of the Local Structure Plan and which will influence design outcomes. The result of the opportunities and constraints analysis is described in further detail below.

5.1 OPPORTUNITIES

The key opportunities associated with the site are as follows (refer **Figure 9**).

5.1.1 EXISTING VEGETATION

As has been previously mentioned, whilst the site is predominantly cleared, there are a number of substantial stands of existing vegetation. Wherever possible (and where identified as worthy of retention), this vegetation will be retained in public open space, road reserves or transplanted to more appropriate locations.

5.1.2 EXISTING WATERCOURSES

The subject site contains a number of existing rural drainage lines, running east-west across the site. These existing drainage lines will provide the basis for the alignment of the Multiple Use Corridors (MUC) required by the Byford Structure Plan. The MUCs, whilst likely to provide a significant drainage function, will also provide a high level of amenity and both a passive and active recreation function. Furthermore, these green corridors will provide important environmental linkages through to the conservation areas to the east of the structure plan area.

5.1.3 CARDUP BROOK

The Cardup Brook provides the southern boundary to the site and is the most significant environmental asset within the structure plan area. As a high amenity, natural asset, view corridors should be created down to the foreshore to ensure maximum public enjoyment of this environment. As part of the Brook development to the south, the preparation of a foreshore management plan for the entire brook was required and accordingly, the northern foreshore of the brook will need to be developed in accordance with this plan.

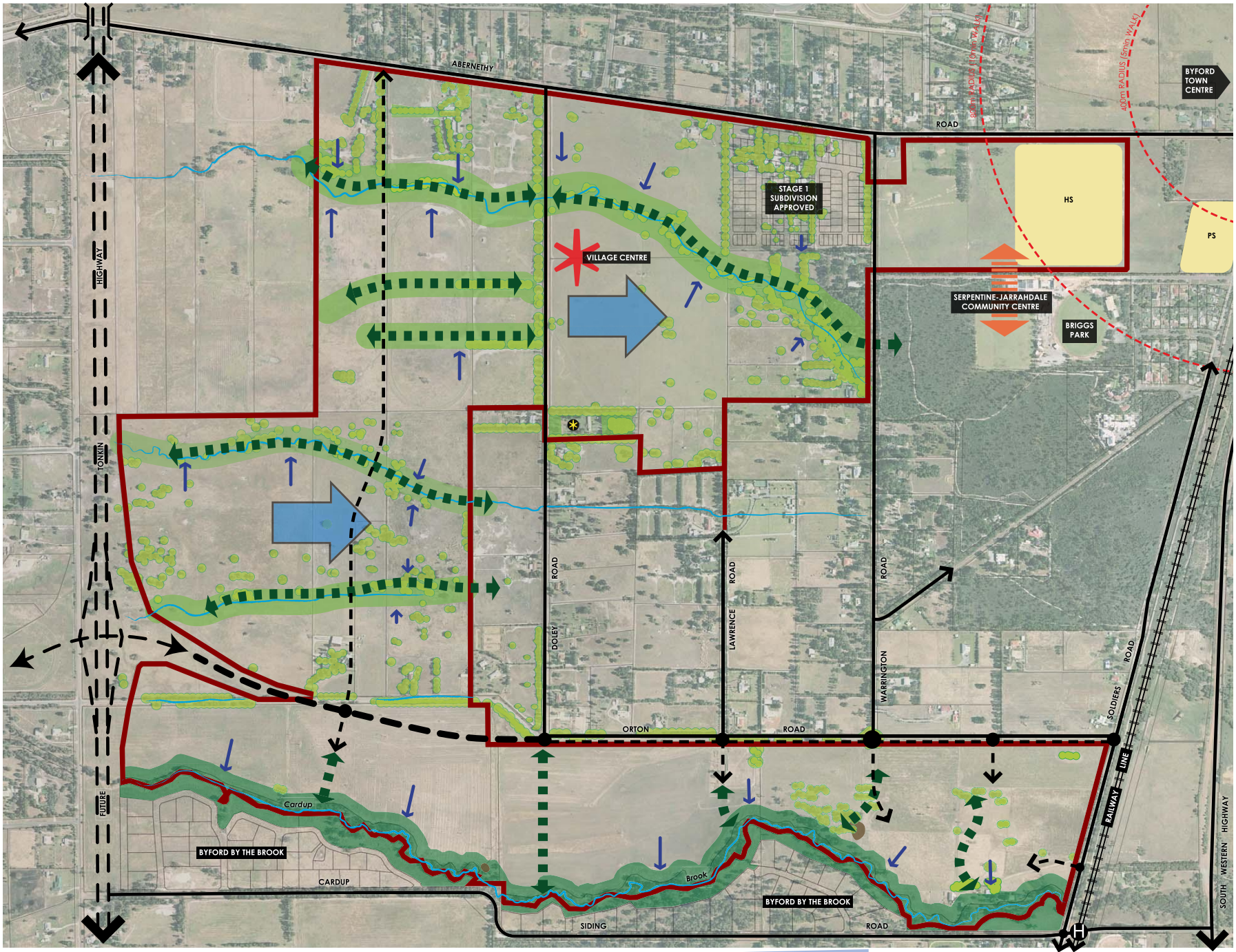
5.1.4 VILLAGE CENTRE

The location of the future Village or Neighbourhood Centre has been identified by the Byford Structure Plan as being to the immediate east of Doley Road and to the immediate south of the most northern MUC. Apart from potentially providing a key focal point for the project, the Village Centre will lend itself to the intensification of land uses in and around the Village Centre. Specifically there is the potential for the Village Centre to anchor increased residential densities (including aged persons) and mixed-use development.

5.1.5 COMMERCIAL OPPORTUNITIES – ORTON ROAD

The Byford Structure Plan 2005 (as amended) provides for a portion of commercial/mixed business land along Orton Road, within close proximity to the future Tonkin/Orton interchange. Whilst the ultimate function of Orton Road may be somewhat unclear, the ability to achieve commercial development needs to be considered.

Such development will also provide needed local employment.



LEGEND

- LOCAL STRUCTURE PLAN BOUNDARY
- EXISTING ROADS
- SCHOOL SITES
  - HS — HIGH SCHOOL LOCATION IN ACCORDANCE WITH BYFORD STRUCTURE PLAN (2005)
  - PS — JOHN CALVIN PRIMARY SCHOOL
- RAIL CROSSING

OPPORTUNITIES

- POTENTIAL VIEW CORRIDORS TO OPEN SPACE AND CONSERVATION AREAS
- POTENTIAL LINEAR POS LINKS WITH DRAINAGE FUNCTIONS
- POTENTIAL CO-LOCATION OF FACILITIES WITH RECREATION CENTRE
- OPPORTUNITY TO RETAIN TREES WITHIN POS / DRAINAGE AND ROAD RESERVE WHERE POSSIBLE
- EXISTING WATERCOURSE
- REGISTERED ABORIGINAL HERITAGE SITES LIKELY TO BE RETAINED
- POSSIBLE REALIGNMENT OF ORTON ROAD TO IMPROVE CONNECTIVITY AND LEGIBILITY THROUGHOUT THE STRUCTURE PLAN AREA
- POTENTIAL OPPORTUNITY FOR COMMERCIAL/MIXED-USE ALONG ORTON ROAD AS IDENTIFIED ON BYFORD STRUCTURE PLAN (2005)
- VIEWS TO DARLING SCARP

CONSIDERATIONS

- EXISTING DWELLING TO BE RETAINED
- VILLAGE CENTRE LOCATION AS IDENTIFIED ON BYFORD STRUCTURE PLAN (2005)
- ROAD CONNECTIONS THROUGH SITE TO INCREASE LEGIBILITY, MOVEMENT AND CONNECTIVITY

OPPORTUNITIES PLAN

The Glades - Local Structure Plan

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figure 9

5.1.6 ABORIGINAL HERITAGE

As previously mentioned, Section 18 advice regarding aboriginal heritage issues (refer **Appendix 4**) has been provided for the entire Local Structure Plan area and whilst not required, this advice requested that the following two Aboriginal Heritage sites be retained within open space:

- DIA 23914 (Byford Archaeological Survey 001); and
- DIA 23915 (Byford Archaeological Survey 002).

DIA 23914 is located within the Cardup Brook Foreshore reserve and will be protected accordingly. DIA 23915 is currently located in a cleared portion of the site and if protected, will need to be set aside within open space.

5.1.7 LAND USE AND RELATIONSHIP TO BYFORD TOWN CENTRE

The Byford Town Centre is located to the immediate north-east of the Structure Plan area. Whilst subject to a separate structure planning process, it is understood the Town Centre will essentially function as a District Centre, with the potential for a future train station and transit-oriented development. Not unlike the Village Centre, there is the ability within the north-east portion of the Glades Local Structure Plan for land use intensification or the introduction of uses with synergies such a large centre (i.e. education, medium residential densities, commercial etc).

5.1.8 SYNERGIES WITH EXISTING RECREATIONAL FACILITIES

To the immediate east of the Structure Plan area, there are the existing community and recreational areas. Given the such close proximity to the Structure Plan areas, there is great potential to create synergies between the land uses within the Structure Plan and these facilities.

5.1.9 VIEW CORRIDORS

The subject site currently has sweeping views to the east up to the Darling Scarp. Through the provision of the Multiple Use Corridors and a predominantly east-west road orientation, these views can be retained. Also, through appropriate design responses, view corridors to open space and conservation areas should be achieved.

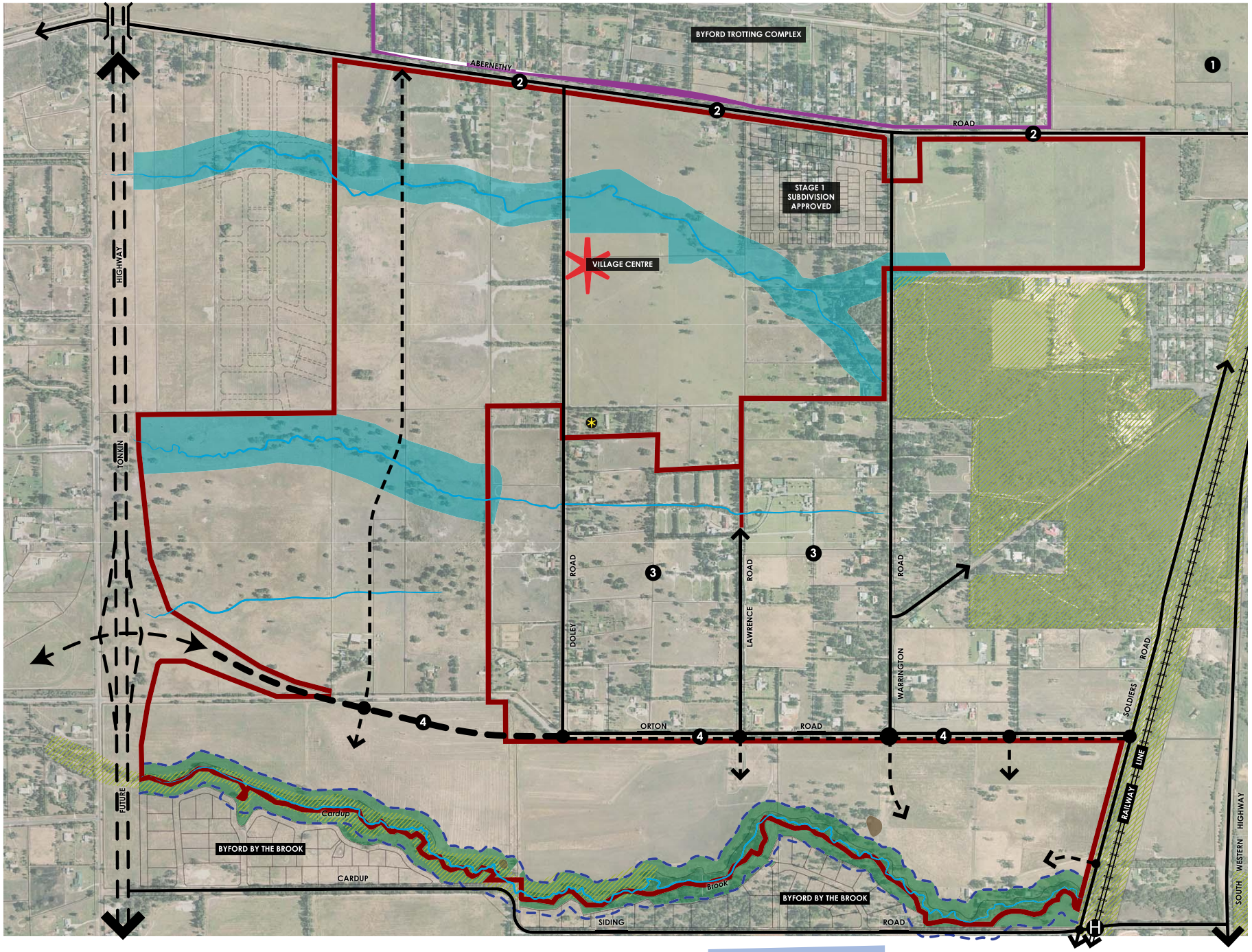
5.2 CONSTRAINTS

The key constraints associated with the site are as follows (refer **Figure 10**).

5.2.1 INTERFACE WITH MAJOR ACCESS STREETS

The subject site has frontage to three major roads in Tonkin Highway, Orton Road and Abernethy Road. Tonkin Highway is a high volume 'Regional Road' where issues such as access, intersection treatments, turning movement and noise all require detailed consideration. Abernethy and Orton Roads will function as Neighbourhood Connectors, however given the requirements of the Byford Townsite Drainage and Water Management Plan, both roads will have significant drainage functions that will have implications for access, intersection treatments and frontages to each of these roads.

Careful consideration will need to be given to the interface with each of these roads.



LEGEND

- LOCAL STRUCTURE PLAN BOUNDARY
- EXISTING ROADS
- RAIL CROSSING
- EXISTING WATERCOURSE

CONSTRAINTS

- VEHICLE MOVEMENT ACROSS RAILWAY LINE LIMITED BY NUMBER OF CROSSOVERS
- NO DEVELOPMENT WITHIN CARDUP BROOK FORESHORE
- BUFFER TO RESOURCE ENHANCEMENT WETLAND WITHIN CARDUP BROOK FORESHORE
- BUSH FOREVER SITES
- REGISTERED ABORIGINAL HERITAGE SITES LIKELY TO BE RETAINED
- POTENTIAL IMPACTS FROM BYFORD TROTTING COMPLEX
- EXISTING DWELLING TO BE RETAINED

CONSIDERATIONS

- ROAD CONNECTIONS THROUGH SITE TO INCREASE LEGIBILITY, MOVEMENT AND CONNECTIVITY
- MAJOR ROAD INTERFACE AND ACCESS, NOISE ATTENUATION REQUIRES CONSIDERATION
- 1 CLOSE PROXIMITY TO BYFORD TOWN CENTRE
- 2 ABERNETHY ROAD TO BE WIDENED IN ACCORDANCE WITH THE REQUIREMENTS OF THE BYFORD TOWNSITE DRAINAGE AND MANAGEMENT PLAN
- 3 FRAGMENTED LAND OWNERSHIP
- 4 POSSIBLE REALIGNMENT OF ORTON ROAD REQUIRED FOR LEGIBILITY
- VILLAGE CENTRE LOCATION AS DEFINED BY BYFORD STRUCTURE PLAN (2005)
- MULTIPLE USE CORRIDOR AS DEFINED BY THE BYFORD STRUCTURE PLAN (2005)

CONSTRAINTS PLAN

The Glades - Local Structure Plan

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figure 10

5.2.2 INTERFACE WITH BYFORD TROTTING COMPLEX

The Local Structure Plan area is located to the immediate south of the existing Byford Trotting Complex. Given the rural character of this area, as well as the potential noise/odour issues associated with such properties, the interface to Abernethy Road and the trotting complex will need to be carefully considered.

5.2.3 TOPOGRAPHY

The subject site is essentially flat and low-lying with very little variation in topography, somewhat limiting the ability to create new view corridors. Given the low lying nature of the site, substantial fill will also be required for groundwater separation purposes.

5.2.4 CARDUP BROOK

Cardup Brook is a mapped Resource Enhancement management category wetland and (partially) a Bush Forever site. Resource Enhancement wetlands typically (depending on condition) require retention and are to be protected by a land use buffer at least 30 metres-wide. There are also restrictions on locating drainage infrastructure within the 30 metre land use buffer and on the ability to direct stormwater flows into such wetlands.

5.2.5 ABORIGINAL HERITAGE

The Structure Plan design will need to give due consideration to the likely protection of the two previously mentioned Aboriginal Heritage Sites.

5.2.6 ADJACENT LANDHOLDINGS

To the east of the Structure Plan area is a large number of individual semi-rural landholdings. Whilst identified for future residential development, no detailed structure planning has occurred for this portion of land. Accordingly, careful consideration will need to be given to interface and movement network connectivity between the Structure Plan area and these landholdings.

Immediately adjacent to the north-west corner of the Local Structure Plan area is Byford West Estate. It is understood that subdivision approval has been granted over this portion of land and again consideration will need to be given to both interface and movement network connectivity with the Structure Plan area.

6 PROPOSED LOCAL STRUCTURE PLAN

The Glades Local Structure Plan (LSP), refer **Figure 11,** has been prepared utilising the diverse skills and experience of the project team and within the parameters established by the requirements of Council's Scheme with respect to LSP requirements and Liveable Neighbourhoods. The Local Structure Plan (formerly Byford Main Precinct) was originally prepared and lodged in December 2005, however given the progression and finalisation of the Byford Townsite Drainage and Water Management Plan 2008 (superseding the previous Byford Urban Stormwater Management Strategy), together with the Shire's review of the Byford Structure Plan (2005 as amended), the LSP could not be progressed with any certainty. Given the finalisation of the Byford Townsite Drainage and Water Management Plan (BTDWMP) and the review of the Byford Structure Plan, it is considered that the Glades LSP can now proceed in accordance with the outcomes of these two documents.

The proposed LSP being submitted now reflects the land use requirements of these elements and incorporates further design refinements that have been incorporated as a result of further detailed site investigations and knowledge.

6.1 COMMUNITY DESIGN

The Glades Structure Plan (refer **Figure 11**) has been formulated following detailed site investigations, consultation with key stakeholders and numerous design iterations. The Plan and design philosophy is based on the following founding principles:

- The Glades Estate will be under-pinned by traditional neighbourhood design principles, with a 'village style' centre at the heart of the Precinct;
- The Village Centre that is hinged off the intersection of the east-west (Mead Street deviation) and north-south (Doley Road) spine roads;
- A village core at the heart of the centre to encourage a strong sense of community;
- A modified grid road network radiates from the intersection of the spine roads;
- A mix of land uses in the Village Centre encourage social interaction, supported by a permeable road and pedestrian access system between neighbourhoods;
- A pedestrian friendly street environment with good accessibility to the neighbourhood centre, open space network and back into the Byford townsite will assist in reducing car dependency and encouraging social interaction;
- A pedestrian movement system, which provides linkages between key land uses such as the neighbourhood centre, educational facilities, open space network and conservation trail;
- Street networks and public open space designed to maximise passive surveillance;
- In a bid to optimise public equity, densities are applied strategically across the Structure Plan area in order to maximise access to open space, the neighbourhood centre and the Byford townsite; and
- A robust Village Precinct that will allow for change in land use activity over time.

The Glades - Structure Plan Area - Figure 11

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6.2 COMMUNITY BENEFIT

The Glades project will provide significant investment in the locality and community benefit for both existing and future residents, as outlined below:

- Enable development of a quality 'Main Street' and village centre precinct for the new urban area being created;
- Provide a broader choice of residential locations and lifestyle opportunities;
- Opportunities to expand the employment opportunities within the area by development of the Village Centre;
- Retention of existing vegetation and existing drainage lines where possible within road reserves and public open spaces; and
- A strong pedestrian connection through to the Brickwood Reserve through to link into the multiple use corridor extension.

6.3 DESIGN RESPONSE TO SITE

The desire to retain and consolidate upon the Structure Plan area's (the subject site) natural features is paramount to the LSP design. The key physical features of the site are the Cardup Brook in the south, the various drainage channels that traverse the site, sweeping views to the Darling Scarp and whilst the site is predominantly cleared, there are some significant stands of remnant vegetation worthy of retention.

The Cardup Brook will be a key design feature and focus for the southern portion of LSP, with a proposed strong orientation towards the brook itself and the co-location of open space areas with the associated foreshore region. The LSP also re-aligns the multiple use corridors as depicted on the Byford Structure Plan onto the current alignment of the existing drainage corridors that traverse the site, where these existing tributaries can still be utilised for drainage purposes.

The subject site is predominantly devoid of large stands of existing vegetation, however there are some areas where both endemic and exotic species can potentially be retained. Whilst the site will be earthworked substantially, it is intended that these existing trees will be retained wherever possible within public open space areas and road reserves. This is evident within the proposed LSP where in specific locations oversized or deflected verge treatments have been provided (in all cases for tree retention).

The sweeping views across to the Darling Scarp are obviously a key feature of the site. The strong east-west orientation of a number of key spine roads, as well as the multiple use corridors, will facilitate expansive view corridors up to the hills.

The retention and celebration of these natural site features will be essential in creating a sense of place and providing a suitably landscape setting.

6.4 LAND USE DISTRIBUTION AND RATIONALE

The following section describes the land uses proposed by the Local Structure Plan (refer **Figure 11** and listed below) and provides a rationale for their location within the structure plan area:

- Residential;
- Village Centre;
- Neighbourhood Nodes;
- Mixed Use;
- Community Facilities;
- Education Facilities; and
- Public Open Space.

6.4.1 RESIDENTIAL

Residential densities have been provided based on the principles outlined within Element 3 – Lot Layout of Liveable Neighbourhood. In particular, R2-R4, which specify the need for a variety of lots sizes and R12-14, which specify housing density near centres. **Figure 12** specifically highlights the residential densities proposed throughout the structure plan and are described in further detail later in this section of the report.

As is outlined in **Figure 11,** the Structure Plan provides for the following density ranges, which are all considered in further detail in the following sections:

- Low Residential Density Development;
- Medium Residential Density Development; and
- Potential Retirement Living Development.

In relation to the last residential development type mentioned above, the Structure Plan sets aside an R30 development site to the immediate west of the Village Centre, as a potential Retirement Living site.

Whilst the Retirement Living site is likely to be developed by another party, Satterley intend on preparing a Local Development Plan (LDP) to ensure strong public connections through the site and an active interface between the development and surrounding residential catchment. It is not the intention of Satterley for the proposed Retirement Living Precinct to be a "gated community."

Liveable Neighbourhoods Edition 4 (R12-14) require the achievement of 20-30 dwellings per site hectare within 400m of a neighbourhood or village centre. Accordingly the provision of higher residential densities within the Village Centre is not only desirable but a statutory requirement. As previously mentioned, two development sites (R60 and R50) have been identified overlooking the MUC (refer **Figure 12**). It is anticipated that these development sites will require guidelines and/or LDPs to facilitate development as either apartments or terraces as a minimum.

All Mixed Use sites on Main and Mead Streets (within the Village Centre) have a residential density coding of up to R80. Whilst all Mixed Use development may not achieve this density, it is considered adequate in seeking to encourage and achieve upper floor residential development. Other identified residential sites within the Village Centre (South of Mead Street) will have a residential density coding of either R30 or R40. It is anticipated that these sites will be developed as terrace style or small lot single house product.

Based on the densities proposed by the Local Structure Plan, approximately 31 dwellings per site hectare will be achieved within 400m of the Village Centre.

The Glades - Residential Densities Plan - Figure 12

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Table 6 provides an indicative dwelling yield breakdown for the Structure Plan area:

TABLE 6: DWELLING UNIT YIELDS

R-Code	Dwelling Yield
R10-15	87
R20	1162
R20-R40	769
R25	332
R30	321
R40	185
R40-R60	138
R50	63
R60	48
R80 (Mixed Use)	133
Total	**3238**

Note: The dwelling unit yields provided are based on **Figures 1** and **11**. These yields have been calculated at LSP stage and will be subject to detailed design refinement and are therefore subject to change. The dwelling yields have been determined based on a mix of RD Code averages and market input. The yields may vary at the landowners discretion as the development unfolds.

6.4.1.1 LOW RESIDENTIAL DENSITIES

Areas of Residential R10, R12.5 and R15 have been allocated in areas where the land may be influenced by external factors or where larger lots are considered a more appropriate transition between the surrounding land use. These areas include the southern side of Abernethy Road, (opposite the trotting complex and stable lots) and as an interface to the Tonkin Highway Reserve where noise impact may be experienced and in those areas adjacent Cardup Brook.

In addition to maximising amenity for residents, larger lots will soften the transition between the rural uses (located to the north and east) and the level of urbanism promoted within The Glades.

The R10-15 density permits a minimum lot size of 875 m^2 and an average lot area of 1,000 m^2 and R15 permits minimum 580 m^2 and an average of 666 m^2.

A base density coding of R20 has been applied across the Structure Plan area. The R20 coding allows for a minimum lot size of 440 m^2 and an average lot area of 500 m^2. Much of the Structure Plan area is designated R20.

6.4.1.2 MEDIUM RESIDENTIAL DENSITIES

Densities of R30 are strategically located around open space, multiple use corridors, the Cardup Brook, Neighbourhood Activity Nodes and the Village Centre.

As discussed earlier in this report, it is considered that maximising densities around community and areas of high amenity promotes a more equitable urban structure and offers high accessibility to open space for smaller lots. Increased densities also ensure that sufficient critical mass exists to support the provision of infrastructure, and the neighbourhood centre. The strategic allocation of densities also provides for increased accessibility and the promotion a lively community nucleus.

Specifically the two large R30 sites located off Warrington Road (within the most northern Multiple Use Corridor) will be developed as grouped housing as issues of surveillance and interface can be addressed as part of the Development Application process. The detailed design of all other single residential R30 lots is likely to be guided by LDPs.

The R30 density permits a minimum lot size of 270 m^2 and an average lot area of 300 m^2.

The R40 density coding permits a minimum lot size of 200 m^2 and an average lot area of 220 m^2. This is moderately dense in the context of Byford and will generally comprise grouped dwellings, (i.e. terrace or 4-pack configuration) with some single residential lots are also permissible.

The distribution of R40 sites within the Structure Plan area is generally in accordance with the same philosophy used for the allocation of R30 sites. However, the R40 sites are also concentrated around the Village Centre and Neighbourhood Nodes. Again detailed design of R40 designated areas will be guided by either LDPs or the Development Application process.

6.4.1.3 POSSIBLE RETIREMENT LIVING (R30)

As previously mentioned, the Structure Plan makes provision for a potential Retirement/Independent Living Village (or an 'Aged Persons Facility') at the intersection of Doley Road and the extension of Mead Street. This intersection is a key 'energy' location at the gateway to the Village Centre

It is anticipated that synergies can be nurtured between the Retirement Living units and surrounding Village Centre uses, such as potential future civic buildings, retail uses and medical facilities.

The site comprises approximately 6.54 hectares of developable area (including private open space). This gives potential for approximately 178 living units (without utilising the potential density bonus afforded by the Residential Design Codes). These yields however could potentially increase should a prospective developer wish to utilise the density bonus and it is considered that the layout proposed by the Structure Plan can and will accommodate such an increase in density.

Should the Retirement Living Site not come to fruition, the density coding and structure plan design is considered to be robust enough to accommodate standard residential development (at R30).

6.4.2 VILLAGE CENTRE

The Structure Plan provides for a Village Centre, generally located at the intersection of Mead Street and Doley Road, south of the most northern Multiple Use Corridor. This location is generally consistent with the Byford Structure Plan (2005 as amended). It is intended that the centre will be a mixed-use, main street based centre that could contain up to 4500 m^2 retail floor space.

Section 7 of this report however, will consider the Village Centre in detail.

6.4.3 NEIGHBOURHOOD NODES

Consistent with the Byford Structure Plan, the Local Structure Plan provides for a number of localised walkable catchment nodes, which allow the potential for 'corner stores' or other localised convenience uses (refer Local Planning Policy No. 19). The nodes are likely to be between 100-200 m^2 NLA. These have been strategically located, predominantly in the south of the Structure Plan area, to maximise residential catchment potential (refer **Figure 11**).

The primary objective of the Neighbourhood Node is to establish local focal centres to created localised communities. Whilst a small retail component may be permitted, other uses such as a medical centre, post office, residential, day care and or other community facilities will be encouraged in these locations.

6.4.4 MIXED USE

A significant proportion of Mixed Use development is set aside at the western end of Orton Road, within close proximity to Tonkin Highway. The Byford Structure Plan 2005 (as amended) identified much of this location as being appropriate for Mixed Business development, however given the lesser traffic volumes now anticipated on Orton Road (refer Section 8), it is considered that a 'Mixed Use' designation that permits residential as well as commercial/showroom development, is more appropriate. The land use permissibility for the Mixed Use zone is outlined in Part 1 of this Structure Plan.

As will be outlined within Section 7, the Village Centre is also intended to operate as a Mixed Use centre.

Areas of mixed-use development located along Orton Road at strategic sites (the intersections of Kokoda Boulevard and Lawrence Way with Orton Road) are intended to service the needs of the surrounding community. The mixed use designation allows for residential development (grouped and multiple dwellings, but not single dwellings) in accordance with the R80 residential density code and provides for commercial development servicing the daily and weekly needs of the surrounding community.

6.4.5 SERVICE COMMERCIAL

The Structure Plan includes a Service Commercial precinct on Orton Road in close proximity to Tonkin Highway. The Byford Structure Plan 2005 (as amended) identified much of this precinct as being suitable for Mixed Business development; however, given the lesser traffic volumes now anticipated on Orton Road (refer to Section 8), a Service Commercial designation that permits commercial/showroom development, is more appropriate.

The planned Service Commercial precinct is to integrate with the surrounding residential development sensitively for the protection of amenity. Provisions guiding development at the interface between Service Commercial and Residential are outlined in Part 1 of this Structure Plan.

6.4.6 COMMUNITY

Design creates social, economic and environmental opportunities.

It is widely acknowledged that the world we live in has changed at the local, regional, national and global level. These shifts are reflected in employment patterns, social attitudes, product development, market needs, built form, regulatory regimes and the state of the environment.

At the community level these changes have major repercussions, the most profound of which is that now more than ever before efforts need to be made to create communities. Mass production and consumption has led to a situation whereby the world has become more and more the same. Standard built form and planning practices over the last 20 years has led to a situation whereby the distinctiveness of many localities is lost in a sea of sub-urbanism.

What these trends and influences indicate is that traditional community structures are less likely to evolve naturally. What is often required, particularly in new localities, is a series of enablers to stimulate people to interact, build relationships, establish networks and create a local sense of community identity.

As part of the Glades project, a Community Development Plan (CDP) is being developed that will provide the framework in which these enablers are collated and documented. The intent and process of developing the CDP will serve to draw together key stakeholders and explore areas of mutual self-interest between the various partners.

6.4.6.1 COMMUNITY FACILITIES

Community facilities provide focal points for social interaction and assist in building a strong and cohesive local community. Within the structure plan a number of areas have been set aside for these facilities.

Whilst the final design and layout of this proposed infrastructure will need to be determined by discussions with the wider community and the Shire of Serpentine-Jarrahdale, the current framework provides a number of opportunities for existing and future populations. This includes:

EDUCATION

- A 9.5 ha private K-12 school site;
- A 4.0 ha primary school site;
- A 11.2 ha high school site;

OPEN SPACE

- 37 parcels of public open space with active, passive and conservation uses, plus variations in the foreshore reserves;

OTHER

- Shared paths throughout the subdivision; and
- Village Centre, comprising a range of retail, community, commercial and entertainment uses.

Initially it is proposed that a sales office will be established that could double as a community house. A more permanent integrated facility will be developed at the southern end of Main Street within the Village Centre to service local organisations.

A diverse set of leisure based facilities will also be provided within the development. The co-location of active sports ovals is proposed for the primary school site and ovals can also be provided as part of the High School site.

To encourage non-vehicle transport modes (i.e. walking, cycling), dual use pathways will also be developed throughout the subdivision. This will assist reduce the level of vehicle emissions and stimulate a healthy local population by encouraging walking/cycling activities.

6.4.7 EDUCATION FACILITIES

6.4.7.1 PRIMARY SCHOOL

The proposed Local Structure Plan provides for one 4.0 ha primary school government primary school (co-located with public open space) in the western portion of the Structure Plan area. Liveable Neighbourhoods requires the provision of one primary school site per 1500 residential dwellings. As is outlined **Section 6**, it is estimated that the Local Structure Plan area will generate approximately 3238 residential dwellings. In accordance with Liveable Neighbourhoods, this number of residential dwellings would typically necessitate the need for two primary school sites, however the Glades Local Structure Plan has only provided one site, consistent with the requirements of the Byford Structure Plan (refer **Figure 5**).

The Department of Entertainment and Training (DET) have recently advised that there is a shortfall of approximately 0.8 of a primary school within the Byford Structure Plan area west of the South-West Highway and that this additional school site should be located within the Glades Structure Plan area.

Numerous discussions have taken place with the DET to determine their catchment requirements and consider how these may be accommodated within the framework provided by the Byford DSP. There are a number of major constraints to including a second school site within the Glades LSP as outlined below:

- Whilst the cell defined as Tonkin Highway, Cardup Brook, Soldiers Road and Abernethy Road is a regular cell, Satterley's landholding is in fact irregular which makes consideration to the placement of a second school site within Satterley's landholding very difficult. In essence a large central portion of the cell exists in small lot holdings. Placement of a second school within Satterley's landholding north of Orton Road is impacted by this anomaly and would result in the second school site being too close (i.e within a 5 minute walk) to the currently planned school on the western boundary of their landholding.

- Orton Road is anticipated to carry in excess of 10,500 vpd. Any school site, planned to serve a catchment wider than the one contained south of Orton Road is likely to be constrained by the physical constraints of Orton Road

- The precinct south of Orton Road, by its elongated nature is constrained. It is approximately 2.6 kilometres in length and only 150m wide at its widest point. This shape could render parts of the catchment to be a considerable distance from any primary school located within it.

Specifically, this may result in students having to travel much greater than typical distances (potentially across major physical barriers such as Orton Road) to get to school. Such an approach is considered to be a particularly inefficient and inequitable approach to schools planning.

This rationale seeks to outline the difficulties in trying to identify a location for a second school site, that has to be constrained to Satterley's landholding. Whilst Satterley acknowledge their lot contribution does warrant the provision of two school sites, the physical constraints outlined above, would result in the compromised positioning of a second primary school site. As previously discussed, Satterley are not looking to negate their responsibilities with respect to the provision of primary school facilities, and in response have agreed to make the relevant contributions necessary to make up for any resulting shortfalls.

In addition it has been suggested that as opposed to providing one whole additional school that is unlikely to ever operate at full capacity, the 4 proposed school sites west of the South-West Highway be provided as larger (minimum 4.5 ha) school sites. This approach has been utilised elsewhere in other District Structure Plan areas such as Wungong, in Armadale Redevelopment Authority.

In addition, DET has previously discussed the opportunity for the oversized HS site that Satterley has generously provided to be utilised for some primary school facilities i.e. child care, kindergarten and pre-primary school. This would assist in reducing the requirements on any of the primary school sites.

Accordingly the Glades Structure Plan has provided one 4.0 ha primary school site, co-located with a large portion of public open space to accommodate the provision of a senior planning field. The provision of smaller primary school sites where they are co-located with open space is consistent with the requirements of Liveable Neighbourhoods (specifically Element 8, Requirement 11). The public open space in which the playing field is provided does form part of a Multiple Use Corridor but does not serve a drainage function.

6.4.7.2 HIGH SCHOOL SITE

One public high school site (11.22 ha) is proposed within the Structure Plan area on the southern side of Abernethy Road, southwest of the Byford Town Centre (which is consistent with the location identified on the Byford Structure Plan 2005). A larger than typically required high school site has been provided at the request of the Department of Education and Training. The high school site was chosen given its proximity to the Byford Town Centre and the potential synergies between the school site, Town Centre and possible future rail station. In accordance with Liveable Neighbourhoods requirements, this school site is also located on future public transport routes and has major road frontage to two major roads in Abernethy Road and Mead Street.

A subdivision application has been lodged to set aside this site and approval to this application is expected in the coming weeks.

6.4.7.3 PRIVATE K-12 SCHOOL CAMPUS

A private K-12 school site (9.59 ha) has been designated immediately to the west of the abovementioned High School site. It is likely that this school site will be operated by the Catholic Education Department. It is intended that in locating the Private K-12 school site in this location, the sharing of ovals and facilities (i.e. libraries) may be possible with the public High School site, immediately adjacent. This sharing of facilities supports the provision of the two school sites being immediately adjacent, with no dividing roads (which would typically be provided).

Co-locating the two school sites also essentially creates a small education precinct that again relates strongly to the Town Centre and would be well served by the possible railway station. The Private K-12 site enjoys the same public transport access and major road frontage as the public high school site.

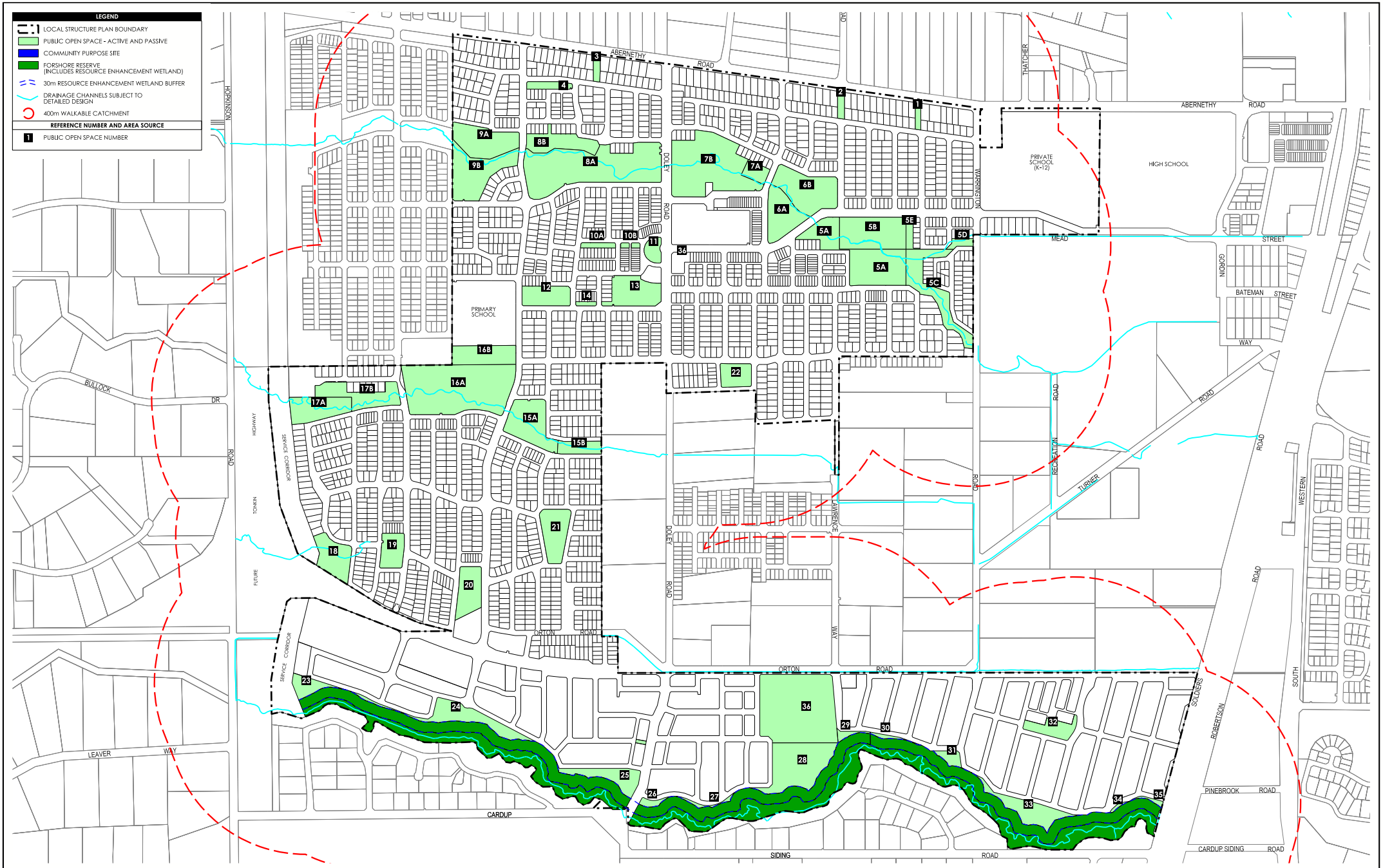
Again a subdivision application has been lodged to set aside this site and approval to this application is expected in the coming weeks.

6.4.8 PUBLIC OPEN SPACE

The Local Structure Plan proposes a generous network of open spaces that range in size and function (refer **Figure 13**). It is considered that the proposed distribution of open space will provide adequate levels of both passive and active open space. As previously mentioned, where possible, open space has been oriented to retain remnant stands of trees to add character and enhance these open space areas.

The public open space provision is summarised below:

- Two multiple use corridors traverse east-west across the site (refer POS areas 5-9 and 15-17 on **Figure 13**). These corridors provide an important drainage function but have been widened in areas to ensure they provide both an active and passive recreation function.



Public Open Space Provision Plan - Figure 13

THE GLADES - LOCAL STRUCTURE PLAN

A SATTERLEY PROPERTY GROUP PROJECT

TAYLOR BURRELL BARNETT

plan: 06/014/379A
date: 30/06/2025
projection: PCG 94
designed: KS
checked: KS
drawn: BR
scale: 1:5000@A1 | 1:10,000@A3
0 100 200m

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- Multi-purpose playing fields at POS area 16 (co-located oval with a primary school site)and area 36 (large open recreation area) provided predominantly for active open space purposes (refer **Figure 13)**.
- Linear open space corridor provides key green linkage between larger open space areas or key destinations.
- Small pocket parks predominantly provided for passive recreation purposes that wherever possible attempt to retain existing vegetation .

Table 7 below provides a detailed breakdown of the Public Open Space (POS) provision within the Structure Plan area. POS has been calculated in accordance with the requirements of Element 4 of Liveable Neighbourhoods. **Figure 14** identifies all POS areas and deductions considered when calculating the overall provision.

As is outlined below, the Structure Plan provides 16.27% POS overall; significantly exceeding the 10% minimum required by the Western Australian Planning Commission. This over-provision of open space is largely due to the need to provide the Multiple Use Corridors required by the Byford Structure Plan (2005) and specifically, the need for these corridors to have a significant drainage function (catering up to the 1 in 100 yr event) as required by the Byford Town Site Drainage and Water Management Plan.

TABLE 7: PUBLIC OPEN SPACE SCHEDULE

Gross Subdivision Area		**(ha)**	**318.6586**
Deductions			
D1	Private K-12 School Site	9.8908	
D2	Primary School Site	3.4975	
D3	Village Centre Core (Shopping Centre only)	2.4652	
D4	Sewer Pump Station	0.6841	
D5	Foreshore to Cardup Brook	18.0234	
D6	Water Corporation Services Corridor	5.6711	
D7	Neighbourhood Node	0.6180	
D8	Mixed Use Sites (north of Orton Road)	0.5722	
D9-D10	Service Commercial Sites	5.6313	
D11-D13	Mixed Use Sites (south of Orton Road)	0.9341	
	Drainage (up to 1:1 yr event including tributary)	5.5448	
	Surplus Restricted Open Space	2.9822	
	Total Area of Deductions		**56.5147**
Nett Subdivisible Area			262.1439
Public Open Space Required (10%)			26.2144
Public Open Space Requirements			
Unrestricted public open space – minimum 80%		20.9715	
Restricted public open space – maximum 20%		5.2429	
	Total		**26.2144**
Unrestricted Public Open Space being Provided			
1		0.1244	
2		0.1565	
3		0.1486	
4		0.2722	
5		5.2002	
6		2.4046	
7		3.2353	
8		3.6024	

Gross Subdivision Area		(ha)	318.6586
9		2.3355	
10		0.2245	
11		0.3043	
12		0.4981	
13		0.7177	
14		0.0712	
15		1.9451	
16		4.7716	
17		1.3659	
18		0.0140	
19		0.6546	
20		0.1402	
21		1.0630	
22		0.4415	
23		0.1844	
24		0.5355	
25		0.4698	
26		0.1319	
27		0.1038	
28		1.5741	
29		0.1207	
30		0.0872	
31		0.2421	
32		0.6033	
33		0.6511	
34		0.0409	
35		0.0740	
36		4.2920	
37	Community Purpose Site	0.2457	
	Less Tributaries 1:1 and 1:1>1:5	-1.6320	
SUB TOTAL			**37.4159**
RESTRICTED OPEN SPACE	Maximum 2% of 10% POS provided or 5.2429ha		
5	Surface Area between 1:1 yr event and 1:5 yr event	0.4690	
6	"	0.1095	
7	Surface Area between 1:1 yr event and 1:5 yr event + Lake	0.7590	
8	Surface Area between 1:1 yr event and 1:5 yr event	0.9840	
9	"	0.6240	
12	"	0.1430	
13	"	0.2840	
16	"	0	
17	"	0.6165	
18	"	0.6360	
20	"	0.4885	
22	"	0.0340	
23	"	0.0900	
24	"	0.4365	

Gross Subdivision Area		(ha)	318.6586
25	"	0.4000	
28	"	0.2145	
33	"	0.3370	
Trib	Surface Area between 1:1 yr event and 1:5 yr event	1.3056	
SUB TOTAL			**8.2251**
TOTAL (Restricted)	(Surplus Restricted Open Space – 2.9822ha)		**5.2429**
Total POS Provided (Restricted + Unrestricted)		**37.4159+5.2429= 42.6588 ha**	**16.27%**

Assumptions:

1. *Drainage inputs provided by JDA as follows:*
    a. *1m wide tributary through MUC 1:1 yr event.*
    b. *2m either side of tributary = up to 1:5 year event.*
    c. *All other basins as defined by JDA*

Note: The areas identified within this table are based on the level of design applied at the LSP stage. As detailed design progresses and design refinement occurs, these areas are subject to change and the calculations will therefore need to be adjusted as development progresses.

6.4.8.1 DESIGN AND TREATMENT OF LANDSCAPE AND OPEN SPACE

The vision for The Glades is to create a development with a strong sense of place and identity that is compatible and seamless with the surrounding environment. The incorporation of sustainable design principles is an over-arching objective, with tree retention in public open spaces and streets a key priority. The creation of useful open space that fulfils several functions is a key objective. These functions include the following:

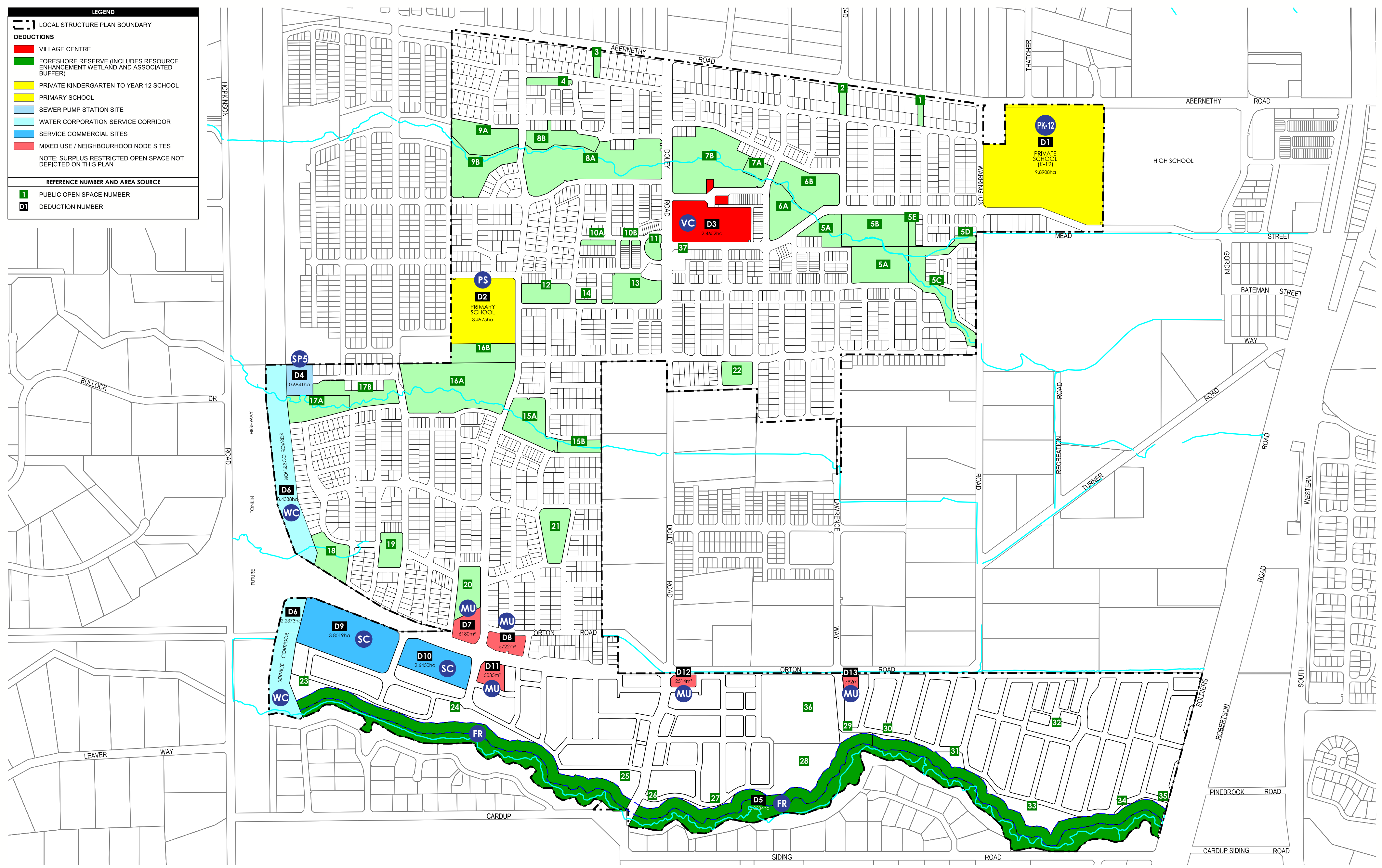
- establishes significant multiple-use corridors along existing drainage lines;
- recreates a diversity of indigenous plant communities and fauna habitats;
- provides a showcase for a variety of environmental features and practices to assist in community education and foster a sense of community pride and ownership; and
- provides a diversity of visual and recreational opportunities and experiences.

An overall approach in the open space design will be to minimise areas of irrigated grass and to re-establish extensive areas of bushland using endemic plant species. Grassed spaces will be incorporated into key nodes to enable passive and active recreational activity to occur.

6.4.8.2 SITE ANALYSIS

Prior to developing landscape ideas for the project it was important to gain an appreciation of the site and its context. Some of the key elements or features of the site include:

- The site is located within a rural/semi-rural setting:
- The site has an attractive easterly outlook to the hills, which provides both a sense of place and a sense of orientation;
- The site contains good stands of remnant vegetation in the eastern sector; and
- The site contains some good avenues of trees (planted natives and exotics), primarily along existing roads, driveways and fence lines.



Public Open Space Deductions Plan - Figure 14

THE GLADES - LOCAL STRUCTURE PLAN

A SATTERLEY PROPERTY GROUP PROJECT

plan: 06/014/380A
date: 30/06/2025
projection: PCG 94
designed: KS
checked: KS
drawn: BR
scale: 1:5000@A1 | 1:10,000@A3
0 100 200m

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6.4.8.3 LANDSCAPE THEME

The inspiration for landscape theming will derive from the existing site character and environs, the key elements being:

- rural/semi-rural/town character;
- native vegetation; and
- red/brown gravely clay soils.

Plant species endemic to the site will inspire both the planting palette for the development and may also provide the inspiration for artworks and other motifs.

The proposed landscape character will reflect the semi-rural/country town location, with the use of materials and colours complementary to the Byford area:

- Reds and browns in paving colours;
- Rammed earth walls;
- Stone paving in key feature areas; and
- Steel and timber.

These elements will be combined in a contemporary style to reflect a modern look.

6.4.8.4 KEY LANDSCAPE FEATURES

The key landscape elements of the Local Structure Plan are a series of significant east-west green spines and several north-south boulevards or primary streets that will provide a strong green-link effect.

EAST-WEST GREEN SPINES

There are several significant east-west green spines within the project; two major green spines that incorporate multiple use corridors located on existing stream lines, and two smaller green spines that have been located to capture significant stands or avenues of existing trees. A third major green spine is formed by Cardup Brook on the southern boundary of The Glades, and significant open spaces have been created adjacent to The Brook to capitalise on the visual and recreational amenity of this green spine.

NORTH-SOUTH ROADS

Wide road reserves incorporating existing avenues of trees will provide a distinctive rural character to the primary north-south roads, effectively providing north-south green spines that will intersect with the east-west green spine. These roads will incorporate shared use paths, providing an attractive and already shaded environment to encourage use by pedestrians and cyclists.

PARKLAND CORRIDOR TREE RETENTION

A park (POS area 31 on **Figure 13**) will be established in the eastern sector of the site where there are stands of remnant vegetation with potential to be retained. The park will aim to:

- Re-establish native bushland habitat along the brook; and
- Provide an extensive path network along the brook, with small recreation nodes/picnic areas developed to allow enjoyment and appreciation of the bush experience.

6.4.8.5 PUBLIC ART

Public art will be an important and integral component of the landscape design. Artworks will provide numerous benefits to the community, including:

- enrichment of the built environment;
- contribute to the local identity;
- development of community pride;
- interpret and express in a creative way the unique characteristics of this area (including natural, cultural and social characteristics);
- serve as landmarks and points of reference for orientation; and
- contribute to the safety of a place and reduce vandalism.

A public art strategy and program will be developed at the outset of the project to ensure the implementation of meaningful and relevant artworks throughout the development. Opportunities will be explored to involve local artists in specific projects. Public art opportunities involving local Aboriginal groups will also be explored to assist in the interpretation of indigenous heritage sites within the project.

6.4.9 ABORIGINAL HERITAGE

As previously mentioned, Section 18 advice for the Structure Plan area was obtained in 2007. As a consequence, no Aboriginal Heritage sites were required to be set aside and appropriately protected. This advice did however recommend that two sites be retained in open space. Accordingly, DIA 23915 has been set aside within POS area 34 (refer **Figure 13**) and DIA 23914 has been set aside within the foreshore of the Cardup Brook.

7 VILLAGE CENTRE

The Village Centre, in accordance with the Byford Structure Plan (2005 as amended) is provided at the intersection of Mead Street and Doley Road and to the immediate south of the most northern Multiple Use Corridor.

The design process for The Glades Village Centre has been an exhaustive one involving the entire project team, Shire of Serpentine - Jarrahdale Councillors and Council staff. As part of the evolution of the design, an Urban Design Framework was prepared to establish an agreed design framework for the future development of the Village Centre. The Urban Design Framework (UDF) was predominantly concerned with establishing an appropriate vision and urban structure. Whilst not fixing any elements, the UDF also considered built form scale, public realm and movement networks.

It is the intention that the outcomes of the UDF will be implemented through this Local Structure Plan and separate LDPs. The following provides a summary of the key outcomes of the Urban Design Framework process.

7.1 VILLAGE CENTRE DESIGN

As is outlined above, the purpose of an UDF is to establish the core principles and framework for a specific project. **Figure 15** (Urban Design Framework Plan) represents the key principles to guide more detailed planning and design for The Glades Village Centre itself. The following provides a description of the key design elements:

- A comparatively short, north-south Main Street, linking the Village Centre to the amenity of the Multiple use Corridor extending to the civic space or community focal point.
- A Main Street based retail and shopping core comprising a small neighbourhood supermarket and numerous speciality retail outlets.
- A public plaza at the northern end of Main Street, providing an important community meeting place and creating a strong public link between the Village Centre and the Multiple Use Corridor.
- A leisure/commercial precinct overlooking the Multiple Use Corridor (Road A). Tavern, cafés restaurants and some commercial/office development would be encouraged in these locations.
- Larger parking areas sleeved off public streets and provided with built form or landscaped edges to minimise impact on important streetscapes.
- Extension of Mead Street being the predominant east-west connector to the Village Centre and Main Street. As the predominant neighbourhood connector, Mead Street will divert traffic out of the core of the Village Centre, allowing for Main Street and The Promenade (Roads A and B) to be predominantly pedestrian friendly environments.
- Ability to potentially close Road A and utilise as a civic space for community fair market on a semi regular basis without disrupting the vehicular flow of traffic through the Village Centre.
- Provision of mixed use opportunities along Main Street but predominantly along Mead Street where commercial development can capitalise on anticipated higher traffic volumes.
- Medium residential densities along Roads A and C (terrace style development), taking advantage of the amenity afforded by the Multiple Use Corridor.

- A dispersion of further medium density development to the south of Mead Street where further terrace or small lot detached single housing will be encouraged.
- A civic site at the southern end of Main Street providing a key point of destination and an integral community function.
- A legible and well connected movement network that disperses traffic, provides numerous entry points into the Village Centre and relates strongly to the surrounding residential catchment.

These are considered to be the fundamental core design elements formulated through detailed site and case study analysis. The following sections of this report seeks to 'flesh-out' these principles to provide a further level of fine-grained detail in relation to elements of land use, public realm, retail floor space allocation, built form and traffic and transportation.

7.2 LAND USE DISTRIBUTION

Figure 15 (UDF) illustrates the proposed land use distribution within the Village Centre core. In keeping with current urban design principles and the requirements of Liveable Neighbourhoods Edition 4, the Village Centre will be predominantly mixed-use based, with the provision of other essential retail, commercial and civic uses. Importantly, the proposed design also affords a number of medium density residential opportunities within the Village Centre core, in addition to the Mixed-Use development provided for throughout.

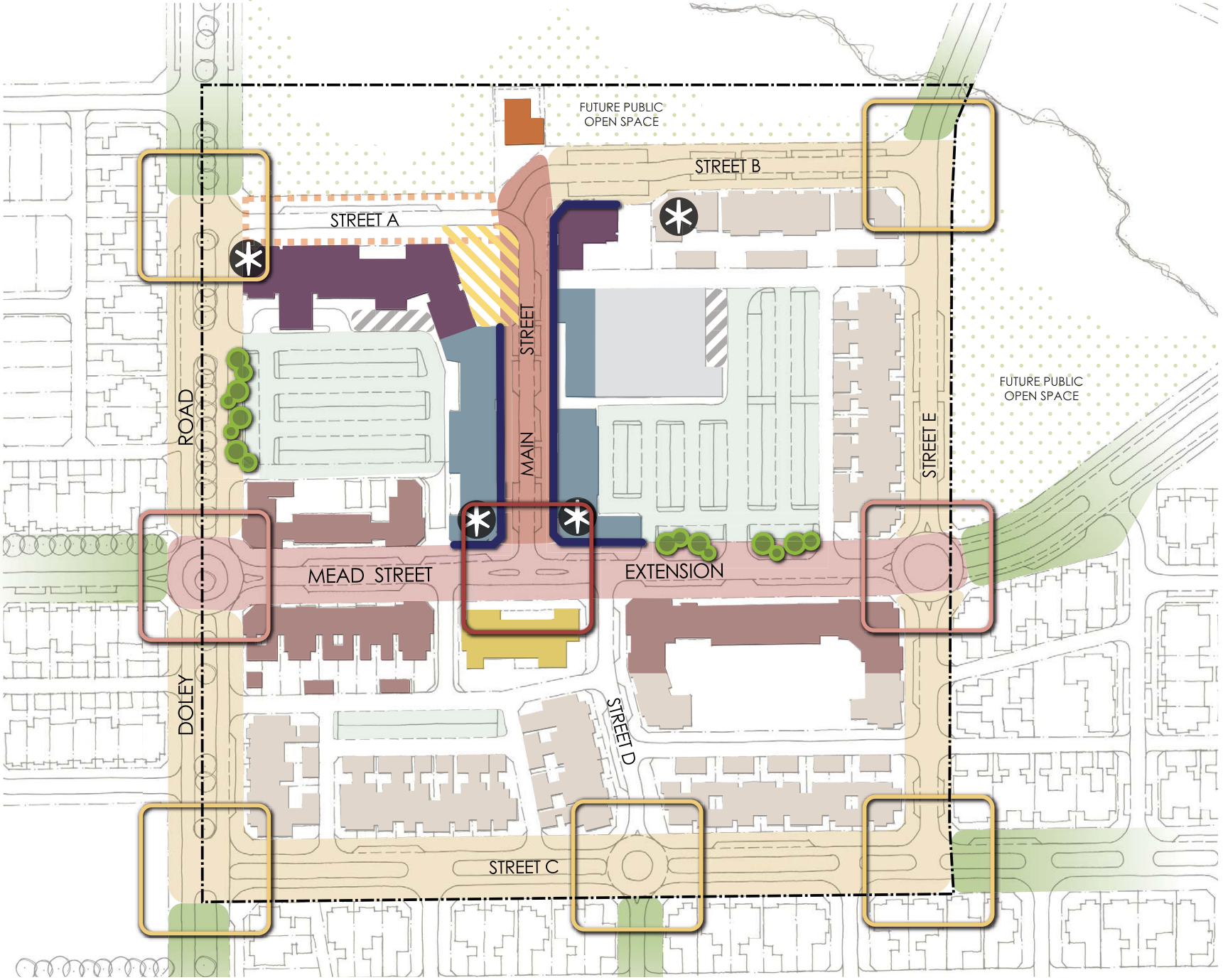
7.2.1 RETAIL

Retail development will largely be located along the Main Street and Streets A and B (fronting the Multiple Use Corridor). Retail development will bring vibrancy and activity to the centre and thus will play a particularly important role in the success of The Glades Village Centre.

A Centre Strategy has been undertaken to consider the appropriate amount and mix of retail, non-retail, commercial and civic uses within the Village Centre (refer **Appendix 5 -** The Glades Village Centre Retail and Commercial Analysis, Taktics 4). Specifically, the report suggests that The Glades Village Centre, in the context of its location in the future Byford residential catchment and the Byford Town Centre, could accommodate up to 4500 m^2 retail floor space. The suggested breakdown of these retail land use allocations is discussed below and outlined in **Table 8** overleaf.

The largest single component of the provision of retail floor space within the Village Centre is the supermarket. It is possible this centre could accommodate a larger full – line supermarket (i.e. Coles or Woolworths). However, in striving to achieve a more compact and localised Village Centre, the preference is to provide for a smaller supermarket format (i.e. IGA) of approximately 1,500 m^2. IGA formats generally have greater flexibility in their required design elements (and trading hours) and accordingly are better suited to Main Street development (as is intended in this location). As depicted in **Figure 15**, unlike many Main Street supermarkets that are intentionally sleeved behind the building mass to Main Street, it is proposed that the supermarket will have direct frontage and interact with the Street.

The UDF also provides for up to 1500 m^2 speciality retail outlets. This floorspace will be distributed between the eastern and western sides of Main Street. Based on a format of approximately 100 m^2 for each store, it is anticipated that up to 15 speciality stores could be accommodated along Main Street.



LEGEND

Land Use

- Medium-High Density Residential
  Facilitating a diversity of higher density residential dwelling choices.
- Mixed Use Potential
  Key area for growth of commercial land use, including a mix of residential.
- Leisure and Commercial
  Tavern/cafes and restaurants, and some offices, overlooking public spaces.
- Civic Building
  Hall/activity and meeting rooms/Post Office
- Landmark Parkside Building
  Cafe/Restaurant/Shelter
- Focal area for supermarket and specialty retail shops, including potential for upper-floor residential.
- Supermarket Site
- Key Service Area
  Screened, well-maintained

Public Domain

- Village Plaza
  Highly landscaped formal public space with planting, seating etc.
- Main Street
  Pedestrian-friendly environment with numerous safe crossings, continuous shade and shelter and no vehicle crossings.
- Mead Street Extension
  Slow-speed (40kph), well landscaped environment with numerous pedestrian crossings.
- Street A
  Opportunity to close street for weekly/occasional events. No parking on southern side to provide a wide north-facing al-fresco area.
- Key Frame Streets
  High quality built form and public realm treatments.
- Primary Gateway
  Feature landscaping and built form design.
- Secondary Gateway
  Attention to high quality built form and landscaping design.
- Central Junction
  Pedestrian-oriented area defined by landmark building architecture.
- Main Street buildings set at, or close to, the edge, with limited gaps between buildings.
- High quality landscaping along street edge of exposed parking area.
- Key approaches to be specially landscaped
- Well-landscaped parking areas, at rear of Main Street buildings.
- Landmark Sites
  Incorporating third storey architectural element
- Future Public Open Space
- Subject Site

URBAN DESIGN FRAMEWORK PLAN

The Glades - Local Structure Plan

0 15 30m

s: scale bar
d: june 09
j: 06/014

figure 15

The Taktics 4 Centre Strategy designates up to 1000 m^2 of floor space for the purposes café/restaurants. It is anticipated that these uses will be located predominantly along Roads A and B to take advantage of the views across to the Multiple Use Corridor, fronting the Public Plaza and potentially along Main Street. A site has also been specifically designated at the northern end of Main Street, within the Multiple Use Corridor; again to take advantage of the high visual amenity with views across the MUC and to provide a point of destination at the northern end of the Village Centre. The provision cafés/restaurants provide integral day and night time activity needed for a centre of this scale.

The Village Centre design provides for a Tavern site along Road A. Whilst a tavern is for the most part a non-retail land use, it will have a retail component (i.e. bottle shop). Accordingly, 500 m^2 retail floor space has been provided for retail associated with the Tavern.

7.2.2 COMMERCIAL

It is intended that commercial development will occur along Main and Mead Streets in either stand alone commercial development sites or on the ground floor within designated mixed use development (refer **Figure 15**). Specifically, it is intended that much of this commercial development will be located along Mead Street, where development can capitalise on the higher volumes of traffic (4000-5000 vehicle per day).

Table 8 below outlines the proposed allocation of Commercial (non-retail) floor space within The Glades Village Centre. Specifically the Centre Strategy designates 1000 m^2 non-retail floor space to typical commercial (office) type development. Whilst there is not anticipated to be a considerably large demand for office type development (demand for office development is likely to be stronger within the Byford Town Centre), it is considered that a small amount of floor space to provide for essential services such as banks, post office, medical facilities is required to provide essential services for a centre of this size.

The tavern is the other major commercial type development within the Village Centre. Whilst there is a retail component to the Tavern, it is predominantly a non-retail land use. The tavern has been located along Road A (The Promenade) to take advantage of the outlook and relationship to the Multiple Use Corridor. It is anticipated that built form requirements for the tavern will ensure that the building appropriately addresses and interacts with the street.

The location of the tavern has also been strategically selected to minimise any potential adverse impact on the amenity of the surrounding residential development.

TABLE 8: PROPOSED RETAIL AND COMMERCIAL FLOORSPACE ALLOCATION, THE GLADES VILLAGE CENTRE

Supermarket	1,500 m^2
Speciality Retail (up to 15 outlets)	1500 m^2
Café/restaurants (4-5)	1000 m^2
Tavern (1) (25% utilised for retail purposes)	500 m^2
Total Retail	**4,500 m^2**
Tavern (1) (non retail allocation)	1500 m^2
Office/Non retail commercial space	1000 m^2
Total Non-Retail (Commercial)	**2,500 m^2**

7.2.3 MIXED USE

Mixed use development is predominantly provided for along Main and Mead Streets within the Village Centre (refer **Figure 15**). The intent for Main Street mixed-use development will be to provide for retail/commercial opportunities along the ground floor and potential residential or commercial/office development within upper storeys. Mixed use development along Main Street will provide for a variety of uses needed to achieve an active, vibrant and sustainable village centre.

Much of Mead Street has also been designated for mixed use development. Given the comparatively high traffic volumes (3500 vehicles per day), it is considered that the mixed use in this location would be appropriate for commercial/office type ground floor development, again with the opportunity for residential or office/commercial development on the upper floors.

Mixed use development located on the periphery of The Glades Village Centre provides an appropriate transition between commercial and residential development. Mixed use lots will also be flexible and allow for residential development to occur with a transition to retail or commercial development when viable.

7.2.4 RESIDENTIAL

Providing a residential catchment is critical to the viability of any centre and resultant achievement of an active and vibrant mixed use Village Centre. Apart from the mixed use development opportunities provided for along Main and Mead Streets, the Village Centre design also provides for medium density residential development in two locations, overlooking the Multiple Use corridor (refer **Figure 15**). The north facing site has been designated Residential R60 and is intended to provide for apartment or terrace style housing. The east facing development site, also overlooking the MUC, is designated Residential R50 and is intended to facilitate terrace/town house type development.

Upper storey residential development is to be encouraged within the designated mixed use sites along Main Street and the Mead Street extension.

Residential development to the south of Mead Street is well connected through efficient road and pedestrian routes. The densities provided for these surrounding locations is predominantly Residential R40. It is intended that many of the residential lots will be flexible in that they allow for re-subdivision and either one or two dwellings could be constructed. This will offer alterative lifestyles for residents through the opportunity of choosing to own a large lot, or the option of subdividing the lot and retaining a smaller area. Those residents that may prefer to own a larger lot, particularly if they have young children and want to provide a play area, may at some time in the future subdivide and sell off a portion of the land or construct another dwelling for their family or extended family to reside in.

All residential development within the Village Centre will be the subject of separate LDPs and requirements of Design Guidelines. This will ensure that this re-subdivision and further infill development is managed through the planning process and north on an ad hoc basis.

7.2.5 CIVIC USES

The Shire of Serpentine-Jarrahdale has indicated the need for a civic site within the Village Centre. Whilst not specific in its requirements, it is anticipated that such a site may be utilised for either a Community Hall or Library facility.

Accordingly, a 1700 m^2 site has been identified at the southern end of Main Street. This site is considered a key focal point of the Centre and will serve an important community function within the Centre and for the surrounding residential catchment.

7.3 PREFERRED LAND USES

Whilst land use permissibility is governed by the Shire of Serpentine-Jarrahdale LPS3, it is intended that preference be given to some land uses over others in the context of achieving the desired vision for the Village Centre. Accordingly, Part 1 of this Structure Plan stipulates that land use discretion for the Village Centre shall be in accordance with the zoning table outlined in the Shire of Serpentine-Jarrahdale Local Planning Policy 19. Reinforcing these provisions within Part 1 will provide further statutory weight to these requirements.

7.4 LANDMARK SITES

Four landmark sites have been identified within The Glades Village Centre to enable the built form to announce the centre in critical locations (refer **Figure 15**). Specifically, a landmark site has been provided on the corner of Doley Road and the Road A (The Promenade) to announce the entrance into the centre for vehicles travelling south on Doley Road. Built form on this site also has the opportunity to take advantage of extensive views to the north over the Multiple Use Corridor.

Two landmark sites are identified on the intersections of the Main Street and Mead Street intersection to announce the beginning of Main Street. It would be preferable for some symmetry to be provided in the development of any landmark elements on these sites.

A landmark site has also been identified on the western portion of the Residential R60 site (overlooking the MUC). It is considered that this provides a prime opportunity for residential development to be built to a greater height within the Village Centre and take advantage of northerly and easterly views over the public open space.

All landmark sites are to be a minimum of two storeys with a third storey architectural element.

A Village Centre Masterplan (refer **Figure 16**) has been prepared to demonstrate how it is anticipated the elements of urban design and landscape are will be brought together to deliver the Village Centre.

LEGEND

1. A 'CENTRAL PARK' ACTING AS AN EXTENSION TO THE VILLAGE CENTRE, CONTAINING KEY ELEMENTS SUCH AS: THE CREEK, DRAINAGE WATER BODY, WEIR, BOARDWALKS, CHILDREN'S PLAYGROUNDS, ACTIVE PLAY AREAS, SHADE STRUCTURES, FOOTPATH NETWORK, LANDSCAPED DRAINAGE DETENTION AREAS.
2. A NATURAL, LANDSCAPE BASED 'MULTIPLE USE CORRIDOR' FLANKING THE CENTRAL PARK, CONTAINING ELEMENTS SUCH AS: THE CREEK, DRAINAGE DETENTION AREAS AND ACTIVE PLAY AREAS.
3. FEATURE LAKE FOR PURPOSE OF IRRIGATION AND DRAINAGE CATCHMENT.
4. CAFE SITUATED ON THE WEIR AS A TERMINATION OF MAIN STREET, ADDING TO VILLAGE CENTRE ACTIVATION AND VIBRANCY.
5. PARKSIDE PROMENADE CREATED AS A PEDESTRIAN-FRIENDLY STREET EDGED BY TAVERN AND CAFES, AND WITH POTENTIAL FOR ROADWAY TO BE CLOSED FOR COMMUNITY EVENTS AND MARKETS.
6. A SMALL, BEAUTIFUL 'VILLAGE SQUARE' EDGED BY CAFES AND SHOPS BEING THE FOCUS FOR OUTDOOR SOCIALISING AND DINING IN THE VILLAGE CENTRE.
7. STREET-FRONT SUPERMARKET PROVIDING A KEY ACTIVATION POINT AND COMMUNITY FOCUS ON MAIN STREET.
8. WELL-LANDSCAPED CAR PARKING AND SERVICE AREAS LOCATED BEHIND SHOPS TO ENABLE PEDESTRIAN-ORIENTED STREETS.
9. PEOPLE-FRIENDLY MAIN STREET EDGED BY RETAIL OUTLETS, OFFICES, CAFES AND SHOP-TOP HOUSING.
10. DOLEY ROAD DESIGNED AS AN ATTRACTIVE BOULEVARD ACCOMMODATING EXISTING TREES IN THE MEDIAN ISLAND.
11. MIXED-USE BUILDINGS AT A KEY VILLAGE CENTRE 'GATEWAY', WITH THE ABILITY FOR COMMERCIAL TO BE INCORPORATED INTO RESIDENTIAL.
12. MEAD STREET, THROUGH THE VILLAGE CENTRE, CREATED AS A PEOPLE-FRIENDLY ENVIRONMENT WITH HIGH QUALITY LANDSCAPING AND SAFE CROSSING POINTS.
13. PERIPHERY OF VILLAGE CENTRE CONTAINING COTTAGES AND TOWNHOUSES FOR INCREASED HOUSING DIVERSITY AND AFFORDABILITY OPPORTUNITIES.
14. LANDMARK CIVIC BUILDING ANCHORS SOUTHERN END OF MAIN STREET AND PROVIDES A STRONG VISUAL COUNTERPOINT WITH THE PARKSIDE CAFÉ.
15. KEY HIGH-DENSITY RESIDENTIAL SITE WITH ADAPTABLE MIXED-USE FLOOR SPACE ALONG MEAD STREET.
16. MEAD STREET EXTENDED ALONG SOUTHERN SIDE OF THE VILLAGE CENTRE TO MOVE THROUGH-TRAFFIC AWAY FROM THE HIGH-AMENITY PARKSIDE PROMENADE, AND PROVIDE GOOD EXPOSURE TO THE SOUTHERN END OF MAIN STREET.

VILLAGE CENTRE MASTERPLAN

The Glades - Local Structure Plan

0m 25 50m

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figure 16

7.5 PUBLIC REALM

7.5.1 MULTIPLE USE CORRIDOR

The relationship and interface between the Multiple Use Corridor (MUC) is a critical element of the Village Centre design. The MUC (incorporating the constructed lake) will provide a strong east-west link through the Village Centre (refer **Figure 17**). This corridor performs two key functions in that it provides a diverse range of recreational and educational opportunities and experiences for residents and the public alike, offering a variety of recreation spaces and a high level of accessibility in the form of dual use paths, boardwalks and walking trails. Secondly, the MUC forms an important component of the urban water management of the development, with the corridor aligning closely with the natural environment of existing drainage line, and the retention of existing trees a key consideration in the drainage design.

A central lawn area with a pavilion and play facilities to the north of the lake will provide an area for more community based events/active recreation, with a pedestrian/cycle bridge an important connector to the Village Centre. Smaller areas of lawn parkland with pathways and groves of native trees to the north of the lake will provide space for informal semi-active and passive recreation in close proximity to residents and dual use path and cycle way facilities.

The proposed lake will enhance the Village Centre by providing greater recreation and visual amenity, as well as providing an irrigation reservoir and contributing to drainage function and responsible stormwater management. The lake and promenade will enhance commercial development opportunities adjacent the lake in the Village Centre, such as cafés/restaurants overlooking the lake, and will encourage social interaction.

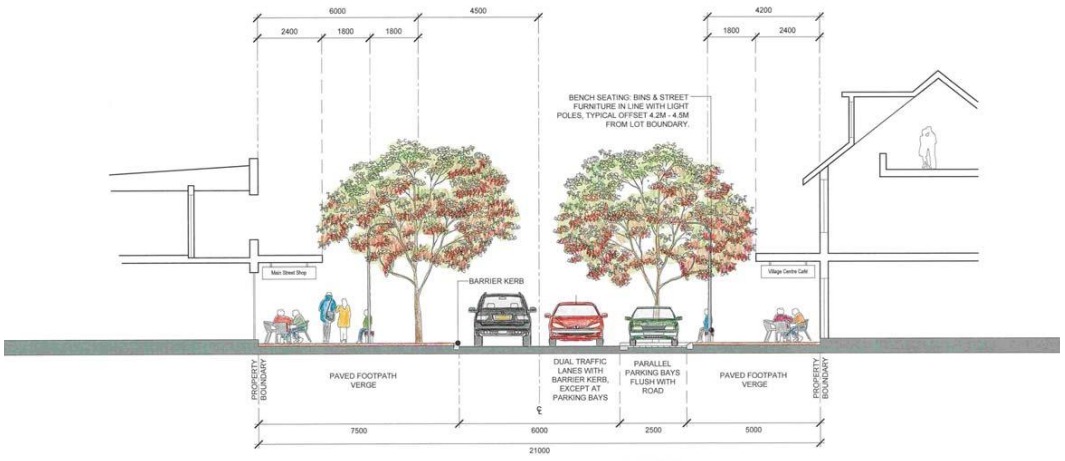
Endemic and native 'water-wise' species will be utilised to reduce the irrigation and maintenance requirements of the public open space landscape (refer **Figure 18**). Where possible, existing trees have been retained on site and development levels maintained as close as possible to existing ground levels.

7.5.2 STREETSCAPE

The design for the streetscape and public realm within the Village Centre will establish a high quality, intimate, and well detailed public environment that reflects the rural character of the site. The public realm within the Village Centre includes the roads, streets, paved verges and setbacks, lanes and the lake promenade edge, offering a diversity of spaces with a high level of amenity to cater for a variety of needs and uses.

An interesting and vibrant public realm will be established through the creative use of a simple palette of hard and soft landscape materials and colours, with a special sense of arrival created at major entry points into the Village Centre, and along the main roads connecting the Village Centre with the surrounding residential fabric.

The streetscape design will be dominated by hard landscape elements to create a series of flexible civic, urban and pedestrian spaces able to accommodate high levels of pedestrian use and promote walkability through the Village Centre. Staggered setbacks, fine detailing, covered lanes, public art and a robust street furniture palette combine to create an interesting streetscape character and provide a diversity of visual and recreational opportunities and experiences.



A SECTION A : MAIN STREET
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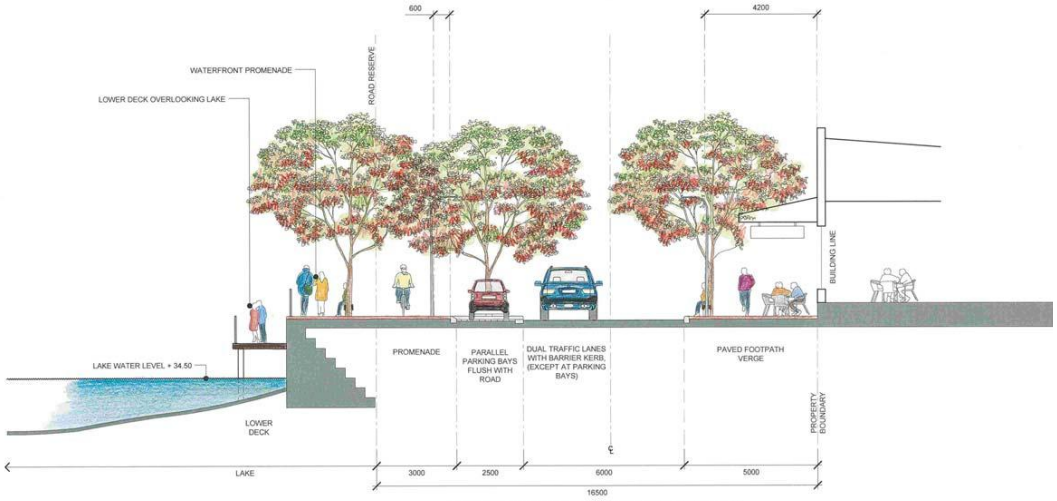

B SECTION B : PROMENADE
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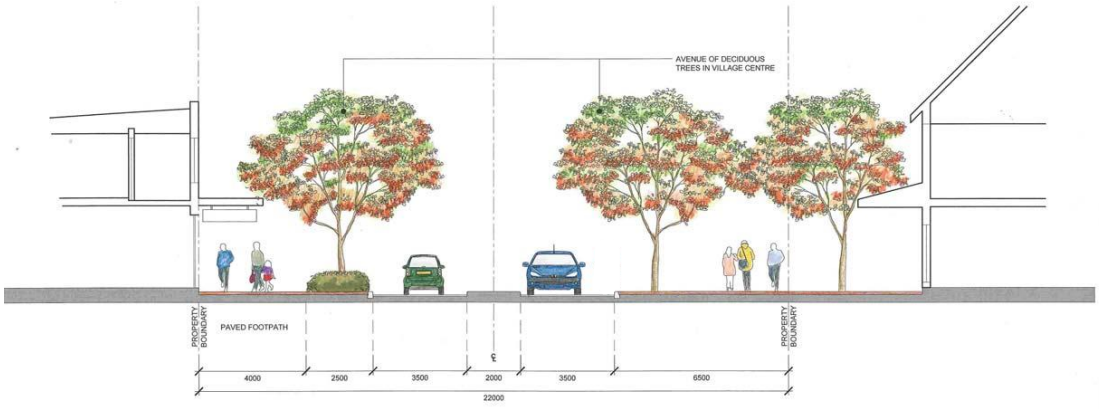

C SECTION C : MEAD STREET EXTENSION
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VILLAGE CENTRE STREET CROSS SECTIONS A,B & C

The Glades - Local Structure Plan

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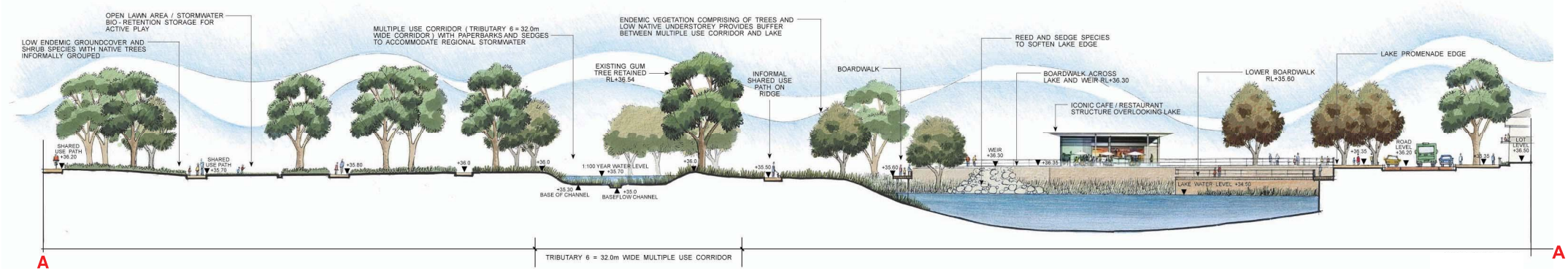
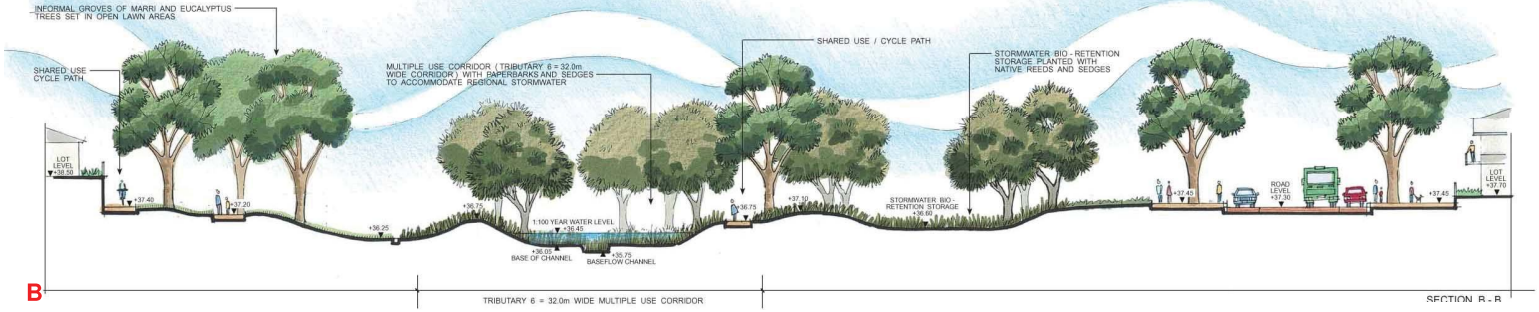
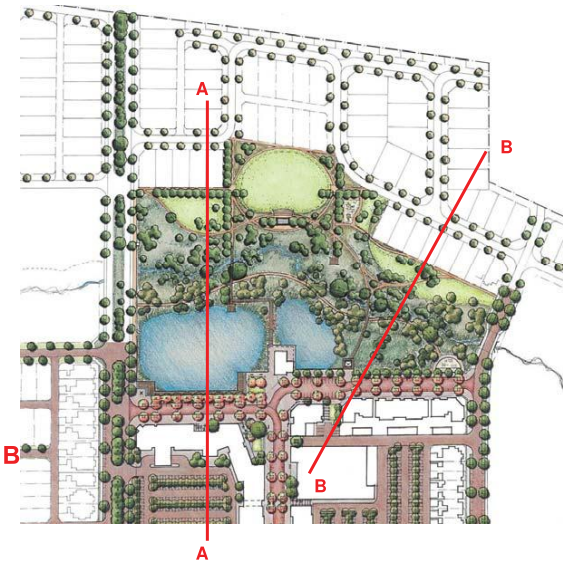
figure 17







KEY POINTS :

→ Lake waterbody creates an important visual focus and visual amenity to the Village Centre, providing a distinctive point of destination:

→ The Lake creates social amenity (being a natural attractor for residents and visitors);

→ The Lake contributes to the recreational amenity value of the Multiple Use Corridor (MUC) providing an attractive focal element within the major recreation node of the MUC adjacent the Village Centre ;

→ Lake and permanent water-body accommodates key drainage and irrigation requirements for The Glades;

→ The Lake has hard edges adjacent the urban edge of the Village Centre, and soft edges with a wetland character within the MUC; and

→ The MUC recreation node incorporates a variety of passive, semi-active and active spaces catering for a variety of users.

7.5.3 VILLAGE PLAZA

A public plaza, located at the heart of the Village Centre, will provide a strong recreational and visual focus. It is strategically located on the main east-west road overlooking the Multiple Use Corridor, adjacent possible future tavern/dining facilities, and across the road from the iconic café/restaurant, sales office and community buildings, so that its visual prominence is reinforced (refer **Figure 16**).

The design philosophy for the public plaza will focus on developing a multi-functional, vibrant and active social hub to the heart of the Village Centre, which relates strongly to the Public Open Space across the road and the promenade/boardwalk edge.

As the primary plaza space within the Village Centre, it will have a high level of treatment, including a lawn area for community events, shaded seating, informal performance space, public art and a mature feature tree (transplanted from site).

7.5.4 MAIN STREET

The Main Street of the Village Centre is to be memorable and use mature vegetation as the entry sequence (refer **Figure 17**). A continuous avenue of feature Coral Trees (transplanted from site) in paved tree wells is proposed to either side of the carriageway and will provide summer shade, winter sun and seasonal colour and will create a distinctive character to the Village Centre precinct whilst framing the central axis with views towards the public plaza, lake, and central public open space.

Additional evergreen tree planting is proposed where building setbacks occur, creating intimate spaces and shaded areas for alfresco dining, lunchtime socialising and rest, while providing some diversity and interest to the streetscape, often found in rural towns and villages. Roadside parking with paved tree wells between every second car bay, creates an abundance of crossing points with which to slow traffic and promote amenity within the Village Centre.

The paving treatment to the road and car bays of Main Street and Promenade Road are to be of a higher quality than the surrounding streets to enhance and define the character of the Village Centre precinct, slow traffic and create a pedestrian friendly street. A simple treatment of large concrete pavers in earthy tones and bench seating under Coral Trees defines the character of Main Street.

7.5.5 MEAD STREET

As the Mead Street extension is the primary route to the Village Centre from the east and west, it is be developed as a tree-lined boulevard, signifying its importance in the road hierarchy and also promoting its use as one of the primary pedestrian and cycle routes through to the Village Centre and development. Dual-use and cycle paths play an important part in linking the Village Centre with the broader community and public open space.

High quality landscaping to Mead Street comprising native understorey planting with avenues of endemic trees to provide shade will create a strong local character for Mead Street. The use of tall trees with low native groundcovers will permit glimpsed views down Mead Street to the Darling Ranges, enhancing the sense of place.

The landscape and paving treatment to the section of Mead Street directly flanking the Village Centre precinct is to be a continuation of the Village Centre treatment with feature paving to the verges and potentially Coral Tree transplants to highlight the sense of arrival into the Village Centre. The tree wells to Mead Street are to be planted to soften the verge, and provide 'green link' connections to the public open space areas that flank Mead Street in other areas of the development.

The Village Centre road treatment is to continue out into Mead Street in the area directly in front of the civic building to highlight the civic plaza forecourt and reinforce the sense of arrival into Main Street.

7.5.6 DOLEY ROAD

The wide road reserve of Doley Road incorporates an existing avenue of mature eucalyptus trees to provide a distinctive rural character to the north-south road leading into the heart of the Village Centre precinct. The existing trees have been retained within a central median and are to be enhanced by the planting of additional large eucalyptus trees on each side of the road. The verge is to be paved for foot and cycle traffic, with pockets of dense native planting alongside the road to enhance the existing native tree avenue and create a continuous canopy to the main entry roads leading into the Village Centre.

Roadside parking will be provided with car bays in groups of three (3) where possible with planted tree wells between the car bays, and sections of verge planted with native species to soften the streetscape and integrate with the adjacent public open space and 'green' corridors.

Additional planting between the footpath and lot boundary has been introduced to soften the appearance of the lot frontages and enhance the 'bush' character of Doley Road.

It should be noted that a partial road closure of the existing portion of Doley Road, will be required to facilitate the retention of the existing eucalypts within the central median (refer Section 8).

7.5.7 PROMENADE ROAD/ROAD A

The Promenade Road runs along the southern edge of the Central Public Open Space and Multiple Use Corridor, and features avenues of mature Coral Trees (transplanted from site) to create instant amenity and impact. The iconic and colourful Coral trees, which were traditionally planted in many rural properties, are to be set into paved tree wells to both sides of the road, and on the northern edge of the promenade the trees are set in paved tree wells between car parking bays. This avenue is supported by a more densely planted secondary avenue of Coral trees to create a shaded pedestrian promenade overlooking the lake defining the edge of the public open space.

The wide paved verge/promenade space has a predominantly hard treatment in keeping with the urban nature of this edge and will be flanked by Coral Trees providing a setting for community events, and a foreshore space promoting views out over the lake. The avenues of trees will provide shade and formality set within the paving to provide an easily traversable lake edge.

Feature public artwork strategically located at the corner of Promenade Road and Doley Road creates a focal point directing views to the lake and hills, and functions as the commencement point for the 'journey' through the Village Centre. Furniture, such as bench seating, lighting and cycle racks line the pedestrian promenade and broad seating steps leading down to lower boardwalk, creating opportunities for rest and respite overlooking the lake.

7.6 MOVEMENT NETWORK

As has been outlined previously, the proposed Village Centre is to be a Main Street based centre. The relatively short Main Street (approximately 125 m) reflects the compact scale of the proposed centre and the desire to create a relatively intimate setting, with a contemporary, yet rural feel. Main Street itself will accommodate relatively low levels of traffic (400-600 vpd), as it is not a neighbourhood connector or through connection road between neighbourhood connectors. This small amount of traffic will promote the pedestrian friendly environment being sought.

Doley Road will function as a key neighbourhood connector through the Local Structure Plan area and provide the key north-south connection to the Village Centre site. Doley Road will be provided as a 30 m median divided road, with the central median accommodating a significant row of eucalypts. Doley Road will accommodate up to 6000 vpd at the southern and north ends of the Local Structure Plan area but approximately 3500 vpd adjacent the Village Centre. Like Doley Road, Mead Street will function as a key neighbourhood connector and provided the key east-west connection through to the Village Centre and be provided as a 22.0 m median divided road. Mead Street will accommodate approximately 2500-3000 vpd.

The Promenade Road between the Village Centre and the Multiple Use Corridor will provide a key function in establishing the Village Centre, whilst creating a clear delineation between the public and private realms.

7.7 IMPLEMENTATION

Land Use within the Village Centre will be guided by the requirements of Part 1 of this Structure Plan and the LPS3.

LDPs will be provided for all lots within the Village Centre to vary the built form requirements of the Residential Design Codes and achieve more site responsive design outcomes including optimum solar orientation, good interface with the street and appropriate framing of street corners. The LDPs will add an additional level of detail to the building height and setback plan requirements and will be provided prior to subdivision. It is intended that these Detail Area Plans will be considered and approved by both the Shire of Serpentine-Jarrahdale and Satterley Property Group.

8 MOVEMENT NETWORK

8.1 ACCESS

Access to the subject land will primarily be taken to Abernethy Road to the north of the site and Orton Road to the south of the site. Most intersections would be expected to operate with priority control, but neighbourhood connectors may need a roundabout. Both Orton and Abernethy Roads will require a substantial median to accommodate substantial drainage requirements, which may result in careful consideration.

The following provides a summary of all traffic and transport matters to be considered. The numerous traffic reports undertaken to date are included in **Appendix 6** (Traffic & Transportation Reporting, Riley Consulting and Transcore).

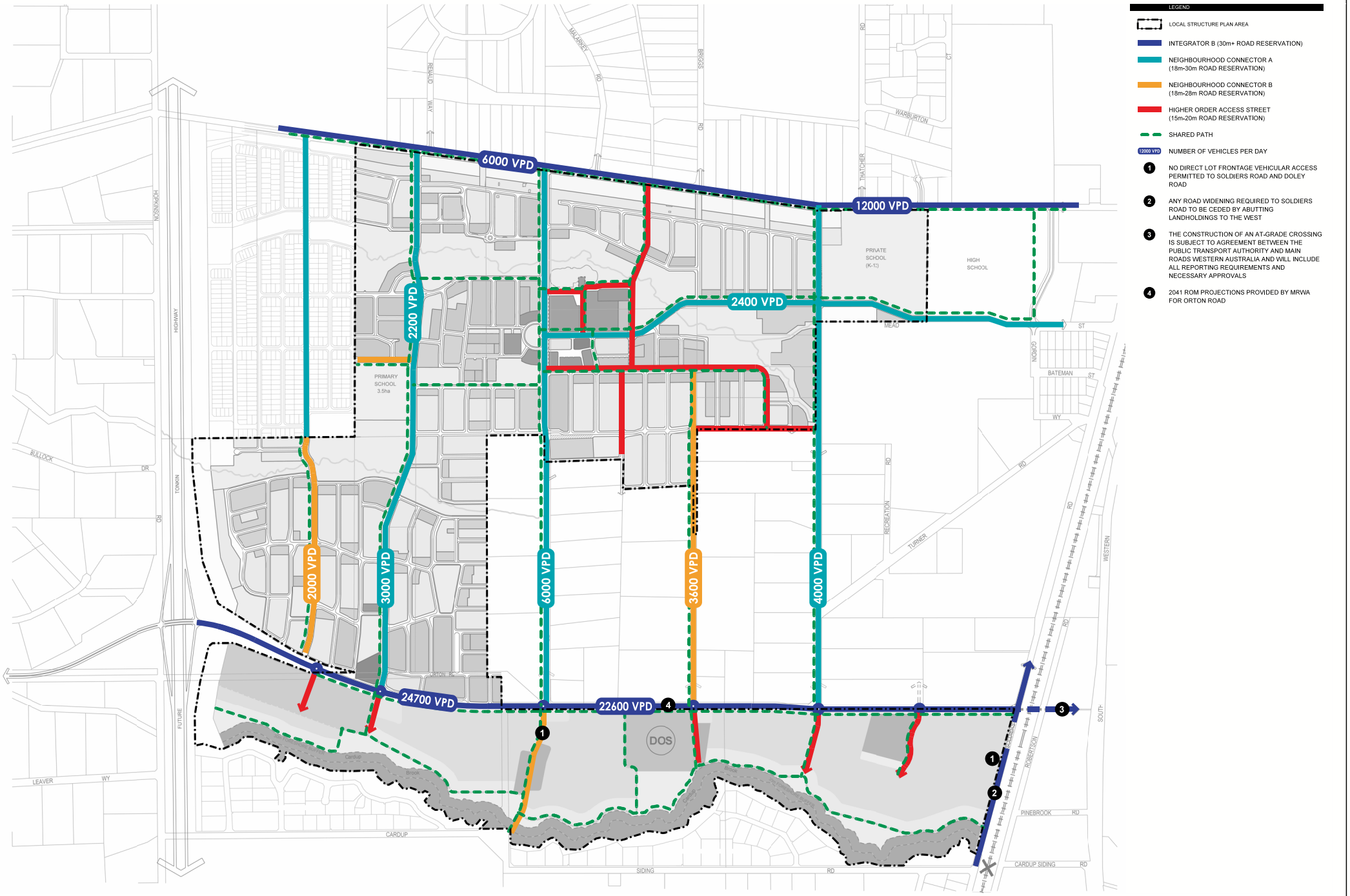
Figure 19 summarises the hierarchy of roads, depicts anticipated traffic volumes and proposed path locations.

8.2 STRATEGIC TRANSPORT ISSUES

Of significance to the subject site is the extension of Tonkin Highway. Initially the extension of the Tonkin Highway was planned to terminate at Orton Road. This extension would provide a by-pass so that regional freight traffic could be removed from traversing through the Byford Town Centre. This would require that Orton Road be upgraded to a rural Highway standard road. Whilst a Primary Regional Road reservation is included in the MRS for the Tonkin Highway and Orton Road intersection, no land is indicated in the MRS to provide for the Orton Road link to South West Highway.

Analysis, however of the current traffic volumes and regional growth indicates that South West Highway will require upgrading to a four-lane divided carriageway within the next 12 months. This growth rate also does not include for any traffic generated by current and proposed developments. It is likely therefore that the need to upgrade South-West Highway will be imminent and it is strongly suggested that as a more appropriate alternative, the Tonkin Highway should be extended to Mundijong Road providing local access to Orton Road and thereby reducing the traffic load on South-West Highway. This point has been raised on numerous occasions with Main Roads WA and Department for Planning and Infrastructure staff by both the Shire of Serpentine-Jarrahdale and Satterley Property Group. Accordingly, the proposed Local Structure Plan provides for the Tonkin Hwy/Orton intersection. As provisionally shown on the Byford DSP, **Figure 1, 11** and **19** indicatively shows a possible future connection of Orton Road through to the South West Highway. The Local Structure Plan does however provide a connection through to the existing Soldiers Road reservation, where vehicles do have the ability to make there way through to the South-West Highway if required.

Whilst not a traffic related issue, it should be noted that it is understood that there is the recorded presence of a Threatened Ecological Community within close proximity of the Orton/Railway Reserve intersection that also impacts on the ability to provide a connection o South-West Highway. The TEC (Floristic Community Type 3a) is listed as a TEC at the State and Commonwealth level and is protected under the Commonwealth *Environment Protection and Biodiversity Conservation (EPBC) Act*. Accordingly, again this Local Structure Plan (whilst not extending beyond Soldiers Road) does not anticipate or consider Orton Road connecting with the South-West Highway.



The Glades - Movement and Path Network Plan - Figure 19

A SATTERLEY PROPERTY GROUP PROJECT

DRAFT

TAYLOR BURRELL BARNETT

Taylor Burrell Barnett Town Planning & Design

8.3 PUBLIC TRANSPORT

The subject land is currently serviced by one bus route running between Mundijong and Armadale train station. The service is infrequent and is timed to provide a connection to trains departing Armadale train station. Current journey times between Byford and Perth CBD are approximately 50 minutes.

Further negotiations with the PTA will be required in relation to future internal bus routes through The Glades project, however it is anticipated that at least one route will service the Village Centre, High School and Private K-12 school sites, whilst connecting through to the Byford Town Centre. It is also anticipated that another route connecting with Orton Road will service the southern portion of the Structure Plan, running east-west through the estate (but not along Orton Road).

The Australind passenger rail service passes through Byford and the station is within walking distance to the subject land. At present only two services per day are provided between Perth and Bunbury (and return) and bookings are required. At present the existing public transport provision would not be attractive to local residents. There is however, a significant opportunity to increase local public transport to provide a reliable and accessible connection to Perth CBD.

8.4 HIGHER ORDER ROADS

8.4.1 ABERNETHY ROAD

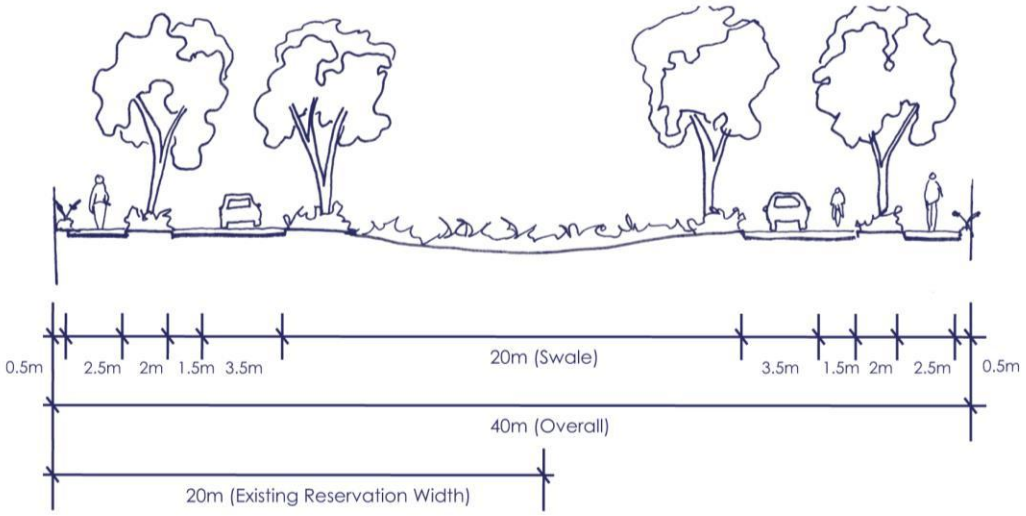
In accordance with the requirement of Liveable Neighbourhoods, Abernethy Road will function as a Neighbourhood Connector and accommodate between approximately 4000 and 8000 (8000 vpd only adjacent to the proposed High School site) vehicles per day. Abernethy Road will provide the northern entry into the estate and a key east-west distributor function. It is important to note that Abernethy Road will not connect through to the Tonkin Highway but is likely to retain its connection to Hopkinson Road which provides access through to Thomas Road.

Typically a neighbourhood connector accommodating these volumes of traffic would be provided as a median divided road reserve in the vicinity of 22-25 m. However, as required by the Byford Town Site Drainage and Water Management Plan, Abernethy Road will be required to provide an important drainage function and potentially up to an additional 20 m of road reserve to accommodate a major swale in either the central median or verge. The cross sections below identify a number of different design options (in three different locations) for accommodating these drainage requirements. We understand that the Shire of Serpentine-Jarrahdale is currently considering the ultimate design requirements for Abernethy Road. Once this has been determined, the detailed design of Abernethy Road will need to be finalised.

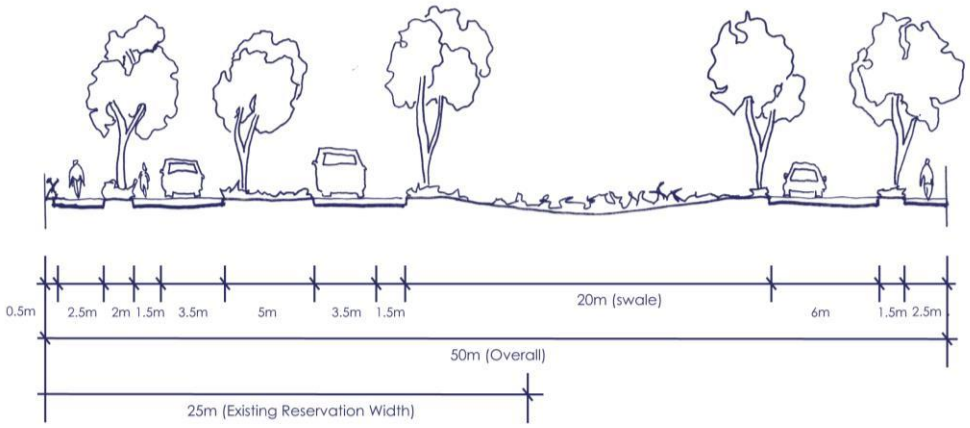
It is maintained that the proposed Local Structure Plan has the flexibility to accommodate the impacts of this widening.

OPTIONS FOR THE TREATMENT OF ABERNETHY ROAD

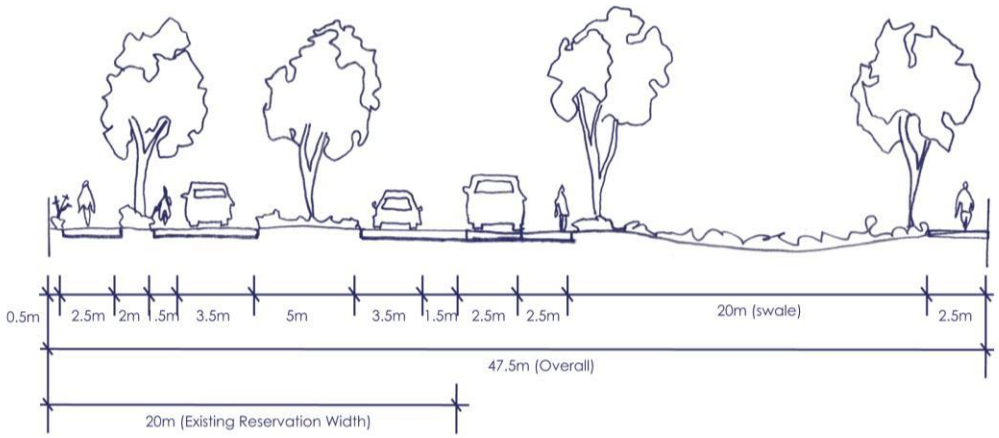
Option 1



Option 2



Option 3



8.4.2 DOLEY ROAD

Doley Road will also function as a neighbourhood connector and provide the key north-south distributor function, providing the key connection to the Village Centre and connecting Abernethy and Orton Roads. Doley Road is anticipated to accommodate approximately 3,000-5,500 vpd, with the peak volumes being adjacent the Village Centre.

In accordance with Liveable Neighbourhoods, Doley Road would typically be provided as a 20-24 m reservation; however it is proposed that the existing Eucalypts within the existing road reserve be retained within a central median. As such a reservation of 30 m (refer **Figure 20**), incorporating a shared path, the oversized median and parking embayments on one side of the street, will be provided. In order to ensure the retention of these trees within a central median, the Doley Road reservation will need to be repositioned further west. As such, a portion of the existing Doley Road reserve will require closure for inclusion within future subdivision and development.

8.4.3 ORTON ROAD

As discussed in **Section 8.2**, the Byford DSP (WAPC endorsed May 2023) advocates that Orton Road connects through to the South-West Highway. Noting this as an indicative connection only, it is intended that Orton Road will function as a lower Order Integrator B (with volumes approximately 14,000 vpd in the west of the site and decreasing down to 3500 vpd near Solider Road) until this road performs a broader district level function. The Local Structure Plan proposes to utilise the existing road reserve wherever possible and the final upgrade will require coordination with the adjacent landowners to the north (approximately 5m widening either side of the existing reservation).

It is anticipated that Orton Road will require an 8-10m drainage swale and this is proposed to be located within a central median (see **Figure 21**). Accordingly total road reservation of approximately 30.0 m will be required for Orton Road.

8.4.4 OTHER NEIGHBOURHOOD CONNECTORS

The Local Structure Plan identifies a number of other neighbourhood connectors (including Warrington Road and Mead Street) throughout the Structure Plan area. These roads will accommodate between 3000-5500 vpd and will be provided with a variety of treatments (median divided, direct frontage/no direct frontage etc) depending on surrounding land use and design.

8.5 LOCAL STREETS

Traffic volumes on local streets will be low and fall into the requirements set out in Liveable Neighbourhoods. The internal road hierarchy will be provided with access streets to service residential development; higher order access streets are provided with a wider reservation where traffic flows are greater than 1,000 vpd and Neighbourhood Connectors provide access to the existing external road network.

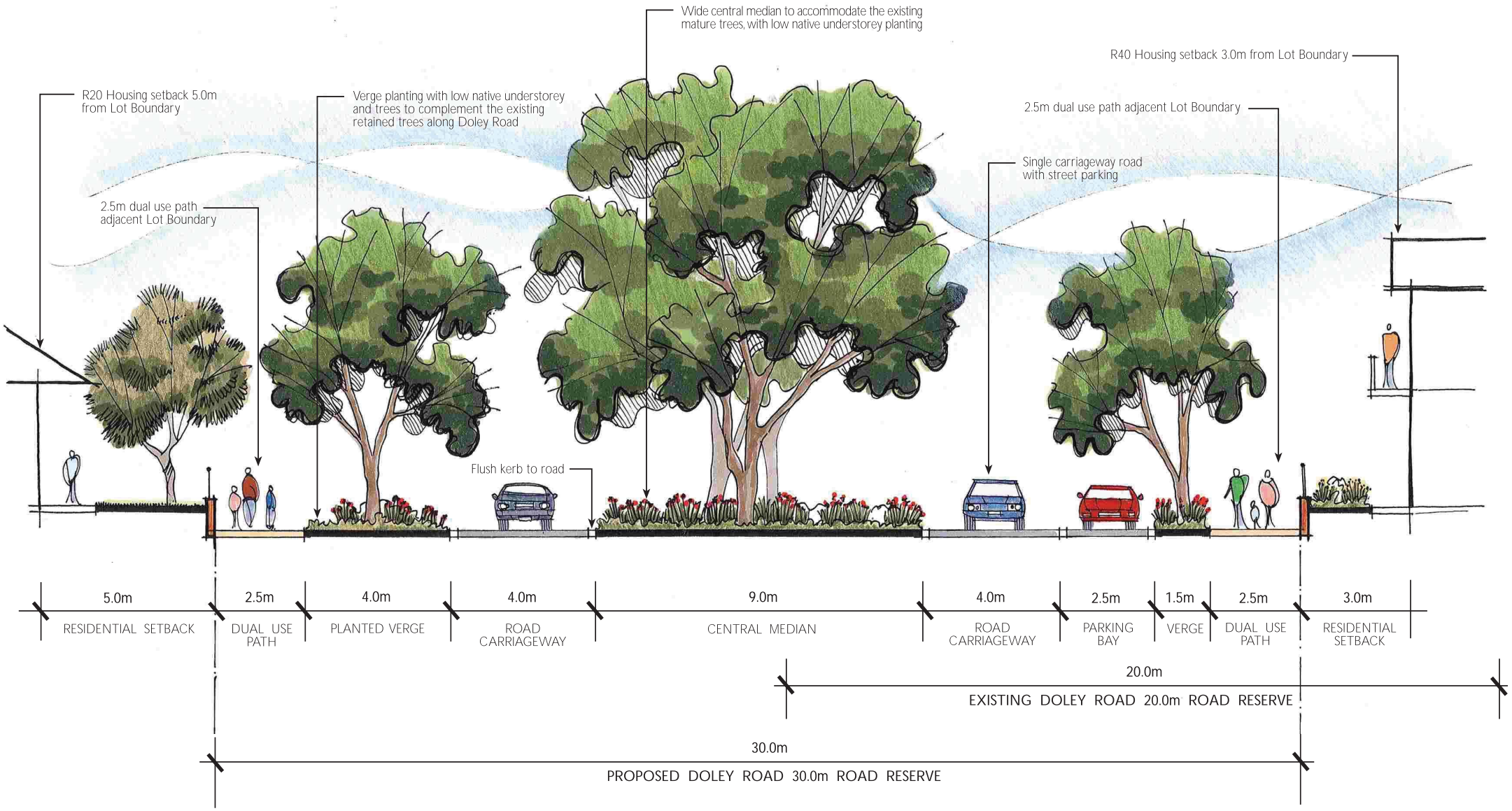
From a sustainability and design perspective, it is suggested that the minimum (15 m) road reservation be provided within the Local Structure Plan area so that internal residential streets are not attractive for high speed traffic movements. This will increase car travel time throughout the subject land whilst providing a safer environment for local residents and their children.

Localised widening of streets will be required to provide parking adjacent to shops, open space and schools and will be addressed at the time of subdivision. In some locations the Structure Plan has allowed for some localised widening for likely tree retention.

8.6 PEDESTRIAN MOVEMENT

A hierarchy of paths will be established throughout The Glades in accordance with the Path Network Plan (PNP) attached as **Figure 19.** The network will include:

- Shared Paths constructed to 2.1 m wide (minimum); The paths will be used by pedestrians and less experienced cyclists;
- Footpaths constructed to 1.5 m wide (this enables two pedestrians to pass with comfort and enables ease of use for people with prams); and
- Informal Paths located within areas of public open space. (These lower order paths will be identified in a Landscape Master Plan to be forwarded to the Shire for approval during the implementation phases).
- Paths will be provided in the verge of the more important streets in the local network.
- In the heart of the Village Centre, 'main street' design standards will apply and on-road cycle lanes will not be provided. In these low speed environments, cyclists will share the street with other users.
  - A series of footpaths are also proposed to supplement the Path Network. The footpaths enable users to connect with the shared paths from local streets. Given low traffic volumes, it is not considered necessary for all minor streets to offer footpaths. This is supported by Liveable Neighbourhoods.
- Streets in the Village Centre adjacent to higher density residential development or linking important activity sites will be provided with 1.5 m footpaths on both sides (or a shared path on one side and a footpath on the other side).
- In accordance with Liveable Neighbourhoods, residential streets with very low traffic volumes and low traffic speeds are provided with a footpath on one side only.



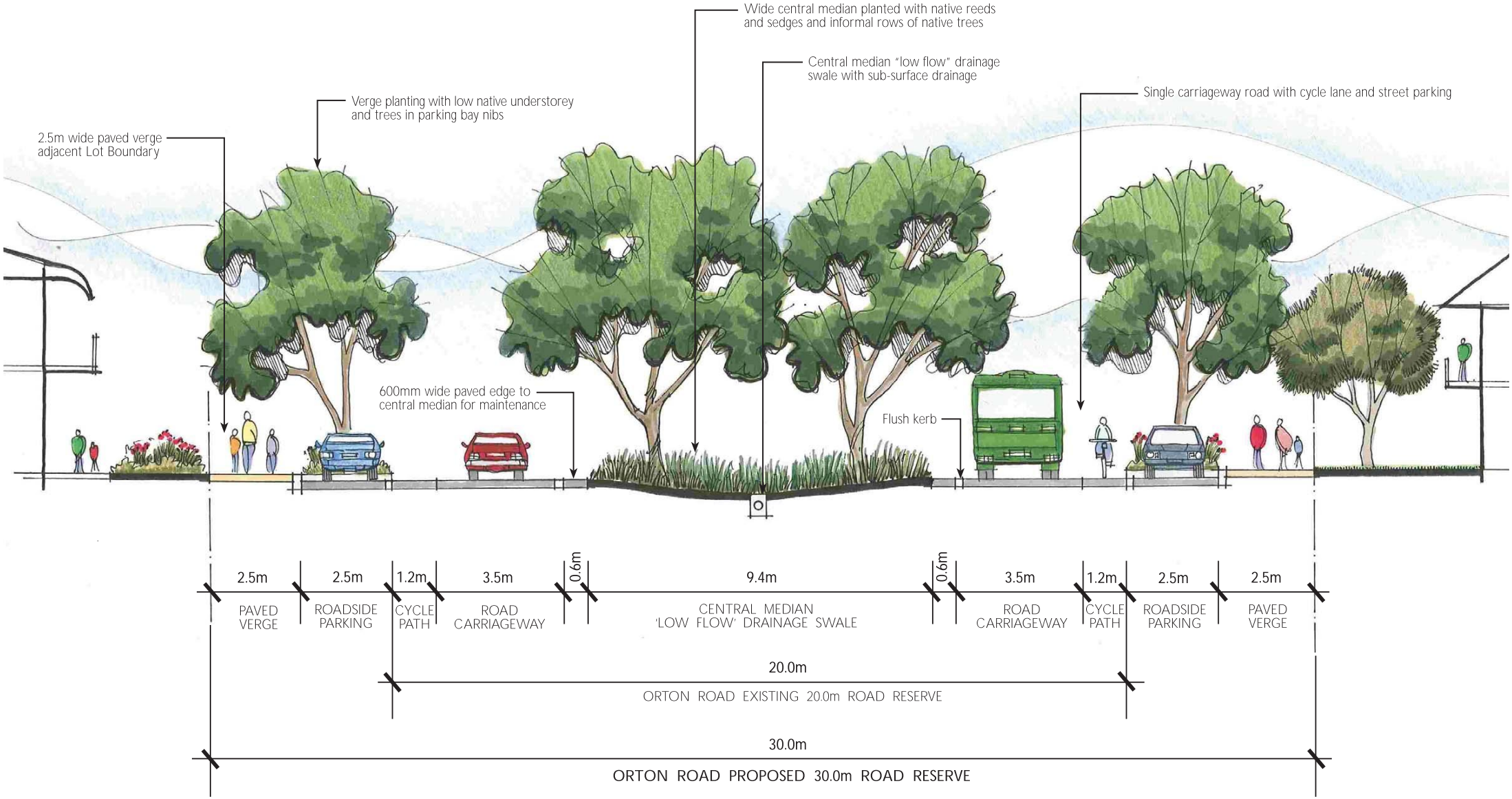
DOLEY ROAD PROPOSED STREET CROSS SECTION

The Glades - Local Structure Plan

0m 1 2m

s: scale bar
d: june 09
j: 06/014

figure 20



ORTON ROAD PROPOSED STREET CROSS SECTION

The Glades - Local Structure Plan

0 1 2m

s: 1:100
d: April 09
j: 06/014

figure 21

9 URBAN WATER MANAGEMENT

9.1 LOCAL WATER MANAGEMENT STRATEGY (LWMS)

A detailed LWMS (refer **Appendix 7** – Local Urban Stormwater Management Report, JDA Consulting) has been prepared and lodged with the Shire for The Glades development area. Provided below is a summary of the key elements taken from the LWMS.

9.1.1 WATER SUSTAINABILITY

To achieve water efficiency targets, households are to be built consistent with current BCA water efficiency standards and the State Government's 5 Star Plus scheme. To further improve the water efficiency of residential lots Satterley will enter into a sustainability contract with each lot owner.

As part of the contract, Satterley will provide the following waterwise initiatives:

- A waterwise front landscaping package to each home (eco-landscape), designed by a certified waterwise landscaper; and
- Provision of a 2,000 litre rainwater tank for each home plumbed to the toilet and laundry, with an overflow to the stormwater drainage system.

The water supply for the public open spaces is proposed to be from local groundwater resources. The superficial aquifer will provide a limited resource, but there are still significant groundwater allocation volumes available from the confined aquifer.

9.1.2 VILLAGE CENTRE LAKE

A constructed lake is proposed as part of the Village Centre precinct. The lake is intended as a community asset providing:

- Aesthetic functions which make the Village Centre an active hub for commercial and social activities;
- A focus for recreational activity, supported by the network of paths and boardwalks that provide access to the lake for residents;
- Structural benefits which include increased flexibility in the design of the POS irrigation system by providing storage;
- Additional stormwater detention storage in major flood events; and
- Water source for fire fighting.

9.1.3 PHYSICAL LAKE DESIGN CHARACTERISTICS

PROPOSED CONSTRUCTION

The proposed lake will be approximately 6000 m^2 in area. To account for the fall over the site of approximately 1:100 (v:h), the lake will be split into 2 levels, with the top level covering a slightly smaller in area than the bottom level.

The upper level will be located on the east side and overflow into the lower level on the west side adjacent to Doley Rd via a broad weir structure. The weir can be landscape for a more natural appearance and to improve access to the lake for residence a boardwalk could be constructed along the weir.

The lake will be a total depth of 2-3 m on both sides with the upper level approximately 1 m higher than the lower level.

LAKE WATER LEVELS

The lake will have a proposed top water level of 34.5 m AHD. This level is largely controlled by Doley Rd adjacent, which needs to be maintained at its existing level of approximately 35.3 m AHD to retain the roadside avenue of existing trees.

The watertable in the location of the proposed Village Centre Lake is greater than 2 m below natural surface at the seasonal maximum recorded level, but fluctuates in excess of 5 m. The lake will be designed so that the lake water level remains relatively constant (±0.30 m). In order to achieve this it will be necessary to line the lake, hydraulically separating the lake from the highly fluctuating watertable. The liner can be a natural clay based product or a PVC liner, so long as the base of the lake is sufficiently sealed to ensure minimal water losses from the lake via leakage.

BORE WATER TOP-UP

To maintain water levels in the lake it is proposed to top-up the lake using an artesian bore located on the west side of Doley Road. The bore was constructed in January 2008 and is currently licensed for abstraction of 50,000 kL/annum.

FLOOD RISK

In order to manage the water quality of the lake, the lake should be 'offline' of the minor drainage system (rainfall events up to the 5 yr ARI), as these rainfall events vary significantly in water quality and include catchment 'first flush' events. Regular stormwater flows should not enter the lake.

For events in excess of the 5 yr ARI, the drainage system may overflow into the lake and utilise the lake for additional flood detention storage. The lake is proposed to be designed with an additional 0.8 m of freeboard above the constant water level, with 0.5 m utilised for flood detention storage in the 100 yr ARI. This provides for 0.3 m freeboard to infrastructure outside of the lake in the 100 yr ARI flood event. For the lower lake this means a constant water level of approximately 34.5 m AHD, a 100 yr ARI peak water level of 35.0 m AHD, providing 0.30 m of freeboard to Doley Rd at 35.3 m AHD.

9.1.4 LAKE MANAGEMENT

To address lake management issues a Lake Management Plan should be prepared. The Lake Management Plan should address the flowing as a minimum:

- Control of nuisance algae;
- Control of nuisance insects and disease vectors;
- Control of feral fish and exotic plant invasions;
- Management of gross pollutants;
- Odour management;
- Management schedule; and
- Maintenance schedule.

This Lake Management Plan should be required as a condition of subdivision for the Village Centre precinct.

9.1.5 STORMWATER MANAGEMENT

The stormwater drainage system will be designed using a major/minor approach. The major drainage system is defined as the arrangement of roads, drainage reserves, detention or infiltration areas and open space planned to provide safe passage of stormwater runoff from extreme events which exceeds the capacity of the minor system. The locations of key features of the drainage system are shown in **Figure 14.**

The minor drainage system is defined as the series of pipes, kerbs, gutters etc designed to carry runoff generated by low frequency ARI storms, typically less then 5 year ARI. The minor drainage incorporates a treatment train of best management practice (BMP) water quality structural controls such as GPT's and bio-retention systems that provide water quality treatment from the proposed development.

9.1.5.1 MAJOR DRAINAGE SYSTEM

The major drainage system is designed to manage rainfall events greater than the 5 yr ARI, up the 100 yr ARI. The design strategy is consistent with the objectives provided in the District DWMP. Key points of the major drainage system strategy are as follows:

- Roads graded to direct flow to the lowest point in the catchment;
- Detention storage to be provided in the lowest point of the catchment to control outflows from the catchment;
- Flush kerbing or kerb breaks at the low point, graded to drain flows off the street into the detention storage; and
- Discharge from the detention storages consistent with pre-development outflows for the 5 yr and 100 yr ARIs.

Due to the low permeability of the soils over the site it is not possible to infiltrate large volumes of water. Therefore the major drainage system makes use of detention storages to control major runoff events to outflows consistent with pre-development flow rates.

The key design criteria for the major detention storages are as follows;

- Where storage is located near a tributary the detention storage will be designed with capacity to hold at least the 5 yr ARI;
- Where controls points along the main tributary exist (e.g. a road crossing) the detention storage can be designed to overflow into the tributary with the additional storage for the 100 yr ARI provide at the control point;
- Where no control point exists the 100 yr ARI storage volume must be provided outside of the tributary; and
- All storages are designed to dry out between storms with base levels at least 0.3 m above the design groundwater level. The minimum building floor levels will comply with DoW requirements for a 0.5 m clearance above the estimated 100 yr ARI flood level in the storages.

9.1.5.2 MINOR DRAINAGE SYSTEM

The minor drainage system is designed to manage rainfall events up to the 5 yr ARI. To meet the design criteria for the minor drainage system the following strategies are proposed:

- Residential lots will be connected to the road pipe drainage system with a connection capacity of 5 yr ARI;
- The road drainage system is via roadside pipe network with capacity for a 5 yr ARI;
- Bio-retention swales and bio-retention storages should be provided with a minimum treatment capacity of the 1 yr ARI 1 hour event; and
- For all outlets to minor stormwater detention storages, stormwater will be treated by Gross Pollutant Traps prior to discharge.

Specific details of 1 in 1 year treatment measures will be documented in the relevant UWMP.

9.1.6 GROUNDWATER MANAGEMENT

Over some low lying parts of the study area the seasonal fluctuation in the watertable results in the watertable being close to the natural surface level for a few months of the year. This generally occurs in August/September consistent with the seasonal rainfall pattern of Perth. It is appropriate to limit construction in these areas, but where construction is required a watertable design level needs to be specified in order to provide adequate separation of building footings from the winter maximum water level. As documented in the Byford Townsite DWMP, a separation of 1.2 m from the winter maximum level is considered appropriate, achieved by importing fill to the site.

The winter maximum varies from year to year consistent with the variation in the amount and intensity of rainfall and evapotranspiration; therefore the watertable design level needs to allow for this natural variation. The seasonal fluctuation in the watertable is particularly important in the proximity of the significant vegetation and wetlands over the site that have adapted to the variation.

To determine the watertable design levels over the study area, local groundwater investigations were conducted by JDA.

9.1.6.1 SEASONAL VARIATION IN THE WATER TABLE

The Superficial Aquifer in the Byford area is characterised by a high clay content in the sediments which ensures only a low percentage of rainfall migrates through the soil profile to recharge the water table. Davidson and Yu (2008) estimate the average recharge in this area to be 10% or equivalent of 87 mm per year. Depending on the specific yield of the local soils, fluctuations in the watertable may vary 2-5 m seasonally.

9.1.6.2 CHANGES IN GROUNDWATER LEVELS

The majority of the Glades development area is currently pasture. The change in land-use from pasture to urban is likely to result in only a small change in groundwater levels (<0.25 m rise). Pasture allows a large percentage of rainfall recharge to reach the water table, as grass allows little interception of rainfall, and has a lower transpiration loss compared to woodland. Urbanisation similarly has a high percentage of rainfall recharge, due to increases in impervious surfaces, onsite infiltration, importation of scheme water for garden irrigation, etc. In addition the provision of sub-soil drainage will prevent a water table rise into the placed fill, with sub-soil drainage laid at the elevation of the watertable design level or CGL.

It follows that the groundwater levels over The Glades development area are not expected to rise as a result of urbanisation.

9.1.6.3 MANAGING GROUNDWATER LEVELS TO PROTECT INFRASTRUCTURE

To protect infrastructure from high seasonal groundwater levels the average maximum annual watertable level has been calculated by measurement of the watertable. The estimated maximum groundwater levels are generally consistent with the CGL contours presented in the Byford Townsite DWMP with some local scale refinements. With reference to these contours (refer **Appendix 7**) the criteria for the installation of subsoil pipes will be as follows:

- Where a perched watertable exists or the predicated maximum groundwater level is at or within 1.2 m of natural surface, clean fill and/or the provision of subsoil drainage will be provided. In such instances subsoil pipes will be placed at or above the CGL level.
- Development should ensure finished lot levels are a minimum of 0.8 m above the level of any groundwater mounding between subsoil pipes.
- Subsoil pipe systems must be designed with free draining outlets.

Based on these criteria and the presence of clay soils over the site that will cause a perched watertable to form, subsoil pipes will be required for all building sites as part of this development.

9.1.7 WETLAND MANAGEMENT

9.1.7.1 MAINTAINING THE HYDROLOGICAL REGIME

The natural condition of the site results in limited recharge due to the clay sediments, with a high proportion for rainfall runoff. The hydrology of the wetlands located in the Study Area are therefore characterised by rainfall recharge directly onto the surface of the wetland, surface runoff into the wetland and only a small proportion of groundwater through-flow.

The hydrological regime of the wetlands will be maintained post-development by the following measures:

- The wetland areas will be preserved. The surface area for rainfall recharge directly onto the wetland will therefore remain unchanged:
- The watertable design level has been determined to allow the watertable to fluctuate up to the average annual maximum level in low lying areas where the seasonal maximum level is close to the existing natural surface level: and

- The estimated water balance of the site indicates the recharge to the Superficial Aquifer is relatively unchanged.

There are no water level criteria for significant wetlands in the region presented in the Byford Townsite DWMP.

9.1.7.2 PROTECTION OF WETLANDS FROM THE IMPACT OF URBAN RUNOFF

Consistent with the pre-development hydrological characteristics of the wetlands within the site (Cardup Brook) there will be no direct runoff from the stormwater drainage system into wetlands. For the five watercourses located within the Study Area, all runoff up to the 1 yr ARI 1 hour duration event will be treated prior to discharge into the waterways. Peak flows will be maintained to pre-development rates for 1 yr, 5 yr and 100 yr ARI with scour protection included as part of the restoration works of the waterways within the study area.

9.1.8 WATER QUALITY MANAGEMENT

The effective implementation of structural and non-structural controls as part of the urban development treatment train will improve stormwater quality runoff from this site as a result of the land use change.

9.1.8.1 NON STRUCTURAL SOURCE DETAILS

Non structural source controls to reduce nutrient export from the site need to focus on reducing the need for nutrient inputs into the landscape. The following strategies are proposed:

- Local native plants make up a minimum 50% of the landscape and streetscape treatments;
- Street sweeping and GPT education, co-ordinated with the Shire of Serpentine-Jarrahdale;
- Promotion of local native plants and drought tolerant gardens to lot purchasers via a landscape package; and
- Promotion of Fertilise Wise practices to new residents coordinated with the Shire of Serpentine-Jarrahdale.

9.1.8.2 STRUCTURAL SOURCE CONTROLS

Structural source controls are proposed to compliment the non-structural source controls and provide a complete treatment train for stormwater movement through the development. The following structural controls are considered appropriate for the development area:

- The use of bio-retention swales preferentially over pipe systems where design constraints permit. The swale should have capacity to treat the 1 yr ARI 1 hr flow and convey the 5 yr ARI critical flow:

- The use of bio-retention systems to treat road runoff. A minimum treatment capacity of approximately 2% of connected impervious area should be provided: and

- A GPT will be installed upstream of any outlets to detention/bio-retention storages sized to treat the 3 month ARI but with capacity to bypass the 5 yr ARI.

9.1.8.3 ASSESSMENT OF PROPOSED STRUCTURAL BEST MANAGEMENT PRACTICES TO DESIGN CRITERIA

Table 9 details a summary from DoW's Stormwater Management Manual for Western Australia (2007) of expected pollutant removal efficiencies for bio-retention and detention/retention systems in relation to the water quality design criteria specified in Better Water Management (DPI, 2008). Expected nutrient input reductions via non structural measures are outlined in **Appendix 7**.

While DoW (2007) does not provide expected pollutant removal efficiencies for all Best Management Practices (BMPs) application of a treatment train approach using a combination of non structural and structural measures will achieve the design objectives for water quality.

Specific details on the location, scale of application, and responsibilities for individual BMPs are to be assessed for individual development areas within the Precinct during development of Urban Water Management Plan.

TABLE 9: BMP WATER QUALITY PERFORMANCE IN RELATION TO DESIGN CRITERIA

Parameter	Non Structural Controls Nutrient Input Reduction	Structural Controls Nutrient Output Reduction 1	
		Bio-retention System	Detention/ Retention Measures
Total Suspended Solids	-	80%	65-99%
Total Phosphorus	70%	60%	40-80%
Total Nitrogen	60%	50%	50-70%
Gross Pollutants	-	-	>90%

1. Typical Performance Efficiencies via DoW (2007)

10 ENGINEERING INFRASTRUCTURE

Engineering infrastructure will be designed to be compatible with the overall planning intent of the Local Structure Plan.

Engineering input to the Local Structure Plan has been made to ensure that the provision of this infrastructure meets the sustainability goals of the project. Significant engineering aspects of the project are detailed below.

10.1 EARTHWORKS

The final earthworks levels for the site are a complex combination of geotechnical, hydrological, planning, environmental, engineering design and marketing factors.

The natural gradient of the development site falling at approximately 1 in 100 from East to West provides the proposed structure plan with the flexibility to orientate the majority of home sites to suit passive solar orientation.

The Structure Plan has paid particular attention to maintaining existing drainage routes and locating significant existing vegetation within Public Open Space. This will maximise the opportunity to preserve significant vegetation and existing ground form.

From a geotechnical perspective, the final lot classification in accordance with AS2570-1996 will depend on the clearance of sand fill over insitu clay materials. Presently market forces dictate that the preparation of S Class sites is highly preferable to M Class sites. The long duration of this project will however provide the opportunity for the building market to mature and accept M Class sites thus potentially significantly reducing imported fill requirements.

Market forces also presently dictate the provision of flat building sites with retaining walls to accommodate level differences. Satterley acknowledges the Shire of Serpentine-Jarrahdale's desire for retaining wall material to blend in with the surrounding natural environs and will reflect this in visible retaining structures.

In summary final earthworks levels and thus imported fill requirements will be a combination of the following factors:

- Providing adequate clearance to average annual maximum groundwater levels;
- Providing adequate clearance to 1 in 100 year ARI storm event flood levels:
- Roadway geometrical design incorporating flood routing constraints:
- Providing sufficient site levels for the operation of gravity sewer and stormwater lot connections:
- Provision of flat or gently sloping home sites:
- Lot classification achieved at Subdivision stage of works; and
- Maximising tree retention.

10.2 STORMWATER DRAINAGE

In accordance with the Byford Townsite Drainage & Water Management Plan (BTDWMP), the stormwater drainage design must ensure that the post development flows are maintained to the predevelopment levels specified. In summary it is proposed that a piped drainage network discharging to a combination of wet and dry offline and online detention basins would be utilised to achieve this. A project specific Local Water Management Strategy (LWMS) has been prepared by JDA Consultant Hydrologists for this project, which provides full details in this regard.

Due to the groundwater fluctuations, the developer may wish to have some lined basins in high amenity areas to achieve social and economic goals, together with providing irrigation reservoir, fire fighting storage and main storm event detention functions.

Separate first flush basins to minimise nutrient and sediment loads positioned offline to major storm events are proposed for the project.

The proposed structure plan has been designed to generally accommodate the stormwater detention requirements of the LWMS in accordance with the BTDWMP. POS locations have been selected to logically and sympathetically cater for proposed catchments.

In accordance with current Water Sensitive Urban Design principles, the BTDWMP and the LWMS, the following features will be incorporated into stormwater drainage works:

- Rubber ring jointed pipes with separate subsoil drainage pipes;
- First flush nutrient and sediment removal basins;
- Gross pollutant traps;
- Flush kerbs;
- Bioretention swales will be used as appropriate; and
- Vegetated swales.

Subsoil drains may be required on both sides of road pavements to ensure pavement integrity, subject to the specific geotechnical characteristics of each Stage of the site.

Lot connection points will be provided for each lot to allow for the collection of stormwater from each property. Soakwells will not be specified for the local disposal of stormwater due to the underlying clay ground conditions. The use of soakwells in this environment would have a detrimental impact on the AS2570-1996 lot classifications and would require substantially increased building setbacks.

10.3 ROAD WORKS

Roadways within the proposed Local Structure Plan will be constructed in accordance with the configurations established as part of the traffic engineering requirements of this proposal and the Shire's standard requirements.

A number of existing roads will be upgraded as part of development, including Abernethy Road, Orton Road, Hopkinson Road, Doley Road, Warrington Road and Mead Street. The funding for construction of the some of the major roads will be achieved by a developer contribution arrangement currently being prepared by the Shire.

An array of different pavement treatments would be envisaged to achieve the traffic calming and theme requirements of the various precincts of the project.

Road pavement configuration would be designed in accordance with specific geotechnical advice to accommodate the site's clay subgrade conditions. This will involve the provision of subsoil drains (or equivalent) on both sides of road pavements.

10.4 WASTEWATER

Disposal of wastewater will be achieved via a network of gravity reticulation sewers discharging into branch and collection sewers gravitating to a permanent wastewater pumping station located adjacent to the future Tonkin Highway reserve near the western boundary of the site.

The Local Structure Plan has been designed to provide very direct east west roadway links. This provides for efficient key sewer routes to be constructed at as shallow depth as possible.

The Water Corporation's current sewer planning indicates that a Type 180 wastewater pumping station would ultimately be required for the development. Due to the large flows required for this to operate, together with the design and construction timeframe required, a Type 180 wastewater pumping station is not feasible in the short term. Accordingly an interim Type 40 wastewater pumping station is currently being designed and will be shortly constructed to provide a sewer outfall for this project.

An outfall for the ultimate wastewater pumping station will achieved by construction of a sewer pressure main approximately 8 kilometres long to the Westfield Wastewater Treatment Plant. The interim wastewater solution requires a lesser extent of pressure main installation, discharging to the existing Byford Wastewater Pumping Station Number 1 located to the North of the site along Hopkinson Road. The timing for the ultimate sewer solution will depend on the development rates of both this and other subdivision projects in Byford.

The structure plan currently provides for a 50 m x 50 m site for the sewer pump station together with a minimum 50 m radius odour buffer to proposed residential development from the pump station wet well in accordance with current Water Corporation sewer planning.

10.5 WATER SUPPLY

Provision of a potable water supply to the project will be achieved by the extension of water distribution mains to the project site, with individual lots serviced by a network of water reticulation mains.

The Water Corporation is currently reviewing their overall water supply planning for the Byford Area based on the current Byford Structure Plan and expected development rates.

It is anticipated that ultimately a distribution main connection to the DN500 distribution main currently being constructed along George Street from near Larsen Road to Abernethy Road, together with smaller distribution mains along Abernethy Road and Doley Road will feed the site. The distribution main construction would be the subject of a prefunding agreement with the Water Corporation.

In the interim a DN200 water reticulation main is currently being constructed along Briggs Road to provide a suitable water supply to early stages of the project.

The grid like nature of the road network provides for an efficient project water main design layout.

10.6 UNDERGROUND POWER

Existing overhead high voltage infrastructure located in Abernethy Road and Orton Road will be utilised to provide a high voltage power supply to the development.

An underground network will be progressively constructed through the proposed subdivision with switchgear and transformers located about the site to feed the low voltage internal underground power cables connecting to each lot.

Existing overhead powerlines along existing roads within the proposed subdivision would be progressively undergrounded in accordance with current practise to satisfy subdivision approval conditions.

10.7 TELECOMMUNICATIONS

Telecommunications for the development area would be provided by connection to Telstra's Byford Exchange.

The size of the proposed subdivision and it's subsequent long development period will probably result in many changes in the way that telecommunication is delivered. The continual technological advances in this area over time will provide increased opportunity for home-based commerce activities and reduction in commuter based employment.

The developer is intent on pursuing best practice in this area, which currently involves the provision of Telstra 'Smart Community' infrastructure.

Infrastructure installation will be designed and constructed in a way to ensure for maximum flexibility for future technology advances.

Telecommunications conduits will be installed by Telstra, in a common trench with underground power, provided by the developer.

10.8 GAS

The site is currently serviced by an existing DN100 high-pressure gas main located in Soldiers Road and a DN150 medium pressure gas main located in Abernethy Road.

It is anticipated that Alinta Gas will service this development by the internal reticulation of natural gas about the subdivision, utilising a common trench with water reticulation being provided by the developer, connecting to the existing gas mains adjacent to the site.

A pressure-regulating valve is likely to be required on the existing high-pressure gas main to supply gas to the development at a pressure suitable for domestic use for later stages of the project.

11 IMPLEMENTATION

In order for the Structure Plan to fulfil its function as a formal component of the planning framework a number of actions are required to be undertaken, or finalised. The following items are the key actions required to complete the framework:

- Adoption of Local Structure Plan;
- Amendments to Local Planning Framework; and
- Commitments and Responsibilities.

11.1 ADOPTION OF THE LOCAL STRUCTURE PLAN

A fundamental objective of contemporary structure plans is to establish a planning framework that will enable an area to develop in the most orderly and integrated manner, meeting sound planning principles, and promoting high quality sustainable development solutions. In terms of The Local Glades Structure Plan, the statutory vehicle used to implement this objective is the Shire of Serpentine-Jarrahdale LPS3.

This Structure Plan should be formally adopted under Clause 5.18.3 of the LPS3.

Once adopted, this Structure Plan will provide the basis for guiding subdivision and development within The Glades estate.

11.2 AMENDMENT TO LOCAL PLANNING FRAMEWORK

11.2.1 COST SHARING ARRANGEMENTS

It is understood that the Shire of Serpentine-Jarrahdale is currently preparing an amendment to LPS3 to establish a cost-sharing framework for the Byford Structure Plan area. Furthermore, it is understood that certain items within this arrangement will be funded by development throughout the Structure Plan area and other will be shared between specific precincts.

Of key importance to the Glades project is the construction of Abernethy and Orton Roads. As has been previously identified, Abernethy Road will serve essentially a district drainage function and accordingly, the cost of upgrading the road should be shared by development within the entire Byford Structure Plan area. Orton Road, whilst not at the same magnitude, will also provide a key district drainage function (as well as a traffic function) and as such it is proposed that the cost of its construction (and land required for acquisition) should be shared between the Glades project and the landowners to the immediate north of the existing Orton Road reservation.

11.2.2 METROPOLITAN REGION SCHEME

Modifications will be required to the Metropolitan Region Scheme (MRS) to:

- Reflect the final location of the proposed High School site on Abernethy Road; and
- An area of Urban Deferred land immediately south of Abernethy Road.

Upon final resolution of the Local Structure Plan and detailed design, Council is requested to seek the WA Planning Commission's support to the modification to the MRS.

11.2.3 MODIFICATIONS TO THE BYFORD STRUCTURE PLAN

The Byford Structure Plan currently identifies the land south of Orton Road as "being subject to further study – Planning to be finalised subject to resolution of alignment of Orton Road". This Structure Plan identifies the proposed location and design treatment for Orton Road with much of it on its current reservation alignment. It is requested that Council concurrently endorses a variation to the Byford Structure Plan that seeks to remove the restriction "B" relating to the land being subject to further study, regarding resolution of the alignment of Orton Road.

11.3 ONGOING INITIATIVES

To ensure the successful implementation of the project, it is necessary that the commitment to undertake the works and ongoing responsibilities be clearly defined at the outset of the project.

The commitments and responsibilities that will be carried out by the stakeholders are defined below:

Item	Action	Responsibilities
Statutory Framework		
Adoption of Structure Plan	Shire of Serpentine-Jarrahdale to review, assess and adopt structure plan in consultation with Shire of Serpentine Jarrahdale.	Consultant team, Satterley and Shire of Serpentine-Jarrahdale
Modify Scheme to facilitate Structure Plan proposals	Prepare and implement all necessary modifications to the Scheme to facilitate the Structure Plan proposals and initiate appropriate scheme amendments with the support of the Shire of Serpentine-Jarrahdale.	Consultant team, Satterley and Shire of Serpentine-Jarrahdale
Management Plans		
Local Water Management Strategy	Prepare and implement Local Water Management Strategy and Urban Water Management Plans	Consultant team, Satterley, Shire of Serpentine-Jarrahdale, DoW, Water Corp
Wetland Management Plan	Prepare and implement Wetland Management Plan	Consultant team, Satterley and Shire of Serpentine-Jarrahdale, DOE
Environmental Management Plans	Prepare as required, necessary management plans to ensure the proper protection of significant areas of vegetation and to address other environmental issues as they arise.	Consultant team, Satterley and Shire of Serpentine-Jarrahdale, DEC
Lake Management Plan	Prepare and implement a Lake Management Plan (required as a condition of subdivision) to ensure the appropriate ongoing management of the proposed water body.	Satterley, Consultant Team, DoW and Shire of Serpentine-Jarrahdale
Provision of Services		
Internal Service Infrastructure	Satterley to design and implement to the satisfaction of the Shire of Serpentine-Jarrahdale.	Consultant team, Satterley and Shire of Serpentine-Jarrahdale

Item	Action	Responsibilities
External Services Infrastructure	The subdivider to upgrade external services as agreed with the Shire of Serpentine Jarrahdale and other service authorities to facilitate the Structure Plan proposals	Consultant team, Satterley and Shire of Serpentine-Jarrahdale
Public Open Space		
Maintenance	Landscaping to be established by the subdivider and maintained for a period of two years following clearance of diagrams by Council or as agreed by Satterley.	Satterley
	Council to accept handover of landscaping and public open space after this maintenance period, and continue maintenance of POS, including drainage to a standard previously determined by Satterley.	Shire of Serpentine-Jarrahdale
Other		
	Consultation with existing adjoining residents during development.	Satterley
	Investigate opportunities to create community facilities.	Satterley, Shire of Serpentine-Jarrahdale

The Glades, Byford
Local Structure Plan

APPENDICES

Taylor Burrell Barnett
Town Planning & Design

APPENDIX 1
SHIRE OF SERPENTINE-JARRAHDALE LOCAL PLANNING POLICY NO. 19 – BYFORD STRUCTURE PLAN AREA DEVELOPMENT REQUIREMENTS

serpentine jarrahdale shire

LOCAL PLANNING POLICY LPP19
BYFORD STRUCTURE PLAN AREA DEVELOPMENT REQUIREMENTS

Adopted 27 March 2006

1.0 APPLICATION

This policy applies to all land within the area covered by the adopted Byford Structure Plan, the Byford Detailed Area Plan and the Byford by the Scarp estate.

This policy will be rescinded upon gazettal of Scheme Amendment 148 to Town Planning Scheme No. 2, which will insert the zoning table contained in this policy into the town planning scheme.

2.0 OBJECTIVES

The objectives of this policy are:

1. To clearly define the permissibility of various land uses within the zones contained in the Byford Structure Plan and the Byford Detailed Area Plan; and
2. To identify the circumstances in which planning approval is required to be obtained for development within the policy area; and
3. To identify the relationship between this policy and:
   Town Planning Scheme No. 2;
   the Residential Design Codes of Western Australia; and
   other policies lawfully adopted by the Council.
4. To set guidelines for the net lettable retail floor area of land within the structure plan area and the Byford by the Scarp residential estate designated Neighbourhood Centre and Neighbourhood Node.

3.0 DEVELOPMENT CONTROL

3.1 Development Requiring Council Approval

Development for the purposes of this policy shall have the same meaning as given to it by the Town Planning and Development Act 1928 (as amended).

Within the policy area the following types of development require the written planning consent of the Council:

- All developments of a commercial or industrial nature.
- Home Occupations and Home Businesses but not Home Offices (refer to Appendix 1 of Town Planning Scheme No. 2 for definitions of these uses).
- Development of a Single House on all lots less than 350m2 in accordance with clause 2.3.3 of the Residential Design Codes.
- Aged and Dependent Persons Dwellings
- Grouped and Multiple Dwellings.
- Ancillary Accommodation (Granny Flats)
- Change of use (ie change of use of a building from “Shop” to “Office”)
- any variation to the requirements of a local structure plan or detailed area plan that applies to the policy area.

3.2 Interpretations relating to Land Uses

Interpretations relating to land uses listed in the Zoning Table contained in this policy are as per Appendix 1 of Town Planning Scheme No. 2 and those additional interpretations listed below:

"betting agency" means an office or totalisator agency established under the Totalisator Agency Board Betting Act 1960;

“Bed and Breakfast Establishment” means a private dwelling intended for short stay/overnight accommodation in which one or two guest bedrooms are utilised to provide incidental holiday accommodation for not more than four persons or one family located under the main roof of the dwelling house.

“cinema/theatre” means premises where the public may view a motion picture or theatrical production;

"exhibition centre" means premises used for the display, or display and sale, of materials of an artistic, cultural or historical nature, and includes a museum or art gallery;

"home store" means any shop with a net lettable area not exceeding 100 square metres attached to a dwelling and which is operated by a person resident in the dwelling;

“Land Sales Office” means a temporary office established within a subdivisional area for the purpose of selling vacant lots on site.

"lunch bar" means premises or part of premises used for the sale of takeaway food (in a form ready to be consumed without further preparation) within industrial or commercial areas;

"motor vehicle wash" means premises where the primary use is the washing of motor vehicles;

"restricted premises" means premises used for the sale by retail or wholesale, or the offer for hire, loan or exchange, or the exhibition, display or delivery of -

(a) publications that are classified as restricted under the Censorship Act 1996;

(b) materials, compounds, preparations or articles which are used or intended to be used primarily in or in connection with any form of sexual behaviour or activity;

"showroom" means premises used to display, sell by wholesale or retail, or hire, automotive parts and accessories, camping equipment, electrical light fittings, equestrian supplies, floor coverings, furnishings, furniture, household appliances, party supplies, swimming pools or goods of a bulky nature;

"warehouse" means premises used to store or display goods and may include sale by wholesale;

"convenience store" means premises -

(a) used for the retail sale of convenience goods commonly sold in supermarkets, delicatessens or newsagents, or the retail sale of petrol and those convenience goods;

(b) operated during hours which include, but may extend beyond, normal trading hours;

(c) which provide associated parking; and

(d) the floor area of which does not exceed 300 square metres net lettable area;

"fast food outlet" means premises used for the preparation, sale and serving of food to customers in a form ready to be eaten without further preparation, primarily off the premises, but does not include a lunch bar;

3.3 Relationship of this Policy to the Residential Design Codes

Unless otherwise provided for in Clause 5.4 of Town Planning Scheme No. 2 or any policy lawfully adopted by the Council, the development of land within the policy area for any of the residential purposes dealt with by the Residential Design Codes of Western Australia shall conform to the provisions of those Codes.

The Residential Design Code density applicable to land within the policy area shall be determined by reference to the Residential Design Code density numbers superimposed on the particular areas shown on the Byford Structure Plan or any subsequently adopted local structure plan or detailed area plan.

3.4 Car Parking Requirements

Car parking requirements for all land uses/developments within the policy area shall be as provided for within clause 7.7 of Town Planning Scheme No. 2.

3.5 Development Requirements

The development requirements (ie landscaping, plot ratio, setbacks etc.) for specific zones within the Byford Structure Plan area are as follows:

Zone	Document containing requirements
Residential - Land within Byford Detailed Area Plan area - remainder of Byford Structure Plan Area	 - Residential Design Codes of WA - Byford Detailed Area Plan - TPS 2 – Clauses 5.3 to 5.5 - Residential Design Codes of WA - Any local structure plan or detailed area plan adopted by the Council that includes the development site. - TPS 2 – Clauses 5.3 to 5.5
Rural-Residential - Land within Byford Detailed Area Plan area - remainder of Byford Structure Plan Area	 - Residential Design Codes of WA – R2-5 - Byford Detailed Area Plan - TPS 2 – clause 5.8 - Residential Design Codes of WA - Any local structure plan or detailed area plan adopted by the Council that includes the development site. - TPS 2 – Clause 5.8
Neighbourhood Node - Residential - Non-Residential	- Residential Design Codes of WA - Any local structure plan or detailed area plan adopted by the Council that includes the development site. See table below
Neighbourhood Centre	As determined by the Council
Town Centre	Byford Detailed Area Plan
Highway Commercial	Byford Detailed Area Plan
Mixed Business	Byford Detailed Area Plan

Non-residential developments in Neighbour Node Zone

Zone	Minimum building setbacks from boundaries (metres)			Max. Site Coverage	Minimum % of site to be landscaped
	Street(s)	Side	Rear		
Neighbourhood Node	As per relevant R-Code			As per relevant R-Code	25% of site

3.6 Maximum retail floor area - Neighbourhood Centre zone & Neighbourhood Nodes

There are three categories of Neighbourhood Centre as follows:

Small Neighbourhood Centre – shopping floorspace of between 600m2 to 1000m2 comprising a large deli/convenience store and a few small shops or other services as set out in the Land Use/Zoning table below.

Medium Neighbourhood Centre – shopping floorspace of between 1500m2 to 2500m2 and comprising a supermarket of between 1500m2 to 2000m2 together with a limited range of support shops and local services (ie hairdresser, chemist, newsagency) as set out in the Land Use/Zoning table below.

Large Neighbourhood Centre - shopping floorspace of between 3500m2 to 4500m2 and comprising a supermarket of between 2000m2 to 3000m2 together with a limited range of support shops and local services (ie hairdresser, chemist, newsagency, small offices) as set out in the Land Use/Zoning table below.

The three neighbourhood shopping areas within the Byford urban area are designated as follows:

Byford by the Scarp shopping area: Small Neighbourhood Centre
Malarkey Road shopping area: Medium Neighbourhood Centre
Doley Road centre: Large Neighbourhood Centre

Neighbourhood Nodes
The maximum net lettable retail floor area of each Neighbourhood Node precinct (ie a single intersection containing 1 lot designated as a neighbourhood Node on each corner of the intersection) be restricted to a maximum of 300m2 (ie corner store or delicatessen) plus other uses such as small offices, child care centres and consulting rooms as set out in the Land Use/Zoning table below.

3.7 Zoning/Land Use Table
The permissibility or otherwise of a land use within the policy area is as set out on the Zoning/Land Use Table contained in this policy.

The symbols used in the cross reference in the Zoning/Land Use Table have the following meanings:

'P' means that the use is permitted provided it complies with the relevant standards and requirements laid down in the Scheme and all conditions (if any) imposed by the Council in granting planning consent;
'AA' means that the Council may, at its discretion, permit the use;
'SA' means that the Council may, at its discretion, permit the use after notice of the application has been given in accordance with Clause 6.3; and
'IP' means a use that is not permitted unless such use is incidental to the predominant use as decided and approved by the Council.

Where no symbol appears in the cross reference of a use class against a zone in the Zoning/Landuse Table a use of that class is not permitted in that zone.

TABLE 1A - BYFORD STRUCTURE PLAN AREA ZONING/LAND USE TABLE

USE CLASSES	Residential	Rural-Residential	Neighbourhood Node	Neighbourhood centre	Town Centre	Highway Commercial	Mixed Business
Amusement Parlour				AA	AA		
Automotive & Marine Sales						SA	SA
Automotive Repairs							AA
Automotive Vehicle Wash						AA	P
Caravan or Trailer Hire						AA	P
Betting Agency				P	P	IP	IP
Bed & Breakfast Establishment	AA	AA					
Car Park			IP	IP	P	IP	IP
Child Minding Centre	SA	SA	AA	P	P		
Civic Buildings	SA	SA	P	P	P	P	P
Cinema/Theatre				SA	P		
Club Premises				SA	AA	AA	
Consulting Rooms			AA	P	P		
Convenience Store			SA	AA	P	AA	AA
Corner Store/Home Store			AA				
Craft Workshop							P
Display Home	AA	AA				IP	IP

The symbols used in the cross reference in the Zoning Table have the following meanings:

'P' means that the use is permitted provided it complies with the relevant standards and requirements laid down in the Scheme and all conditions (if any) imposed by the Council in granting planning consent;

TABLE 1A - BYFORD STRUCTURE PLAN AREA ZONING/LAND USE TABLE

USE CLASSES	Residential	Rural-Residential	Neighbourhood Node	Neighbourhood centre	Town Centre	Highway Commercial	Mixed Business
Dry Cleaning Premises				AA	AA	AA	
Educational Establishment	SA	SA	AA	AA	P		
Exhibition Centre				P	P	P	P
Fast Food/Takeaway				AA	P	AA	
Funeral Parlour				AA	P	AA	P
Garden Centre					AA	AA	P
Health Studio				AA	P	AA	P
Home Office	IP	IP	IP				
Home Business	IP	IP	IP				
Home Occupation	IP	IP	IP				
Hospital					AA		
Hotel					P	AA	
Industry: - Light - Service - Rural						AA	P P P
Land Sales Office	AA	AA					
Lunchbar				P	P	P	P
Market				AA	AA	AA	AA
Medical Centre				AA	P	P	AA
Motel					P	AA	
Nightclub					AA		
Office			AA	P	P	P	IP

TABLE 1A - BYFORD STRUCTURE PLAN AREA ZONING/LAND USE TABLE

USE CLASSES	Residential	Rural-Residential	Neighbourhood Node	Neighbourhood centre	Town Centre	Highway Commercial	Mixed Business
Private Recreation					AA	AA	AA
Public Amusement				AA	AA	AA	
Public Recreation				AA	P		
Public Utility	AA	AA	AA	P	P	P	P
Public Worship - Place of	SA			SA	P	AA	AA
Radio & TV Installation				AA	AA	AA	AA
Reception Centre				SA	AA	AA	
Residential (see notes 1 and 2): - Single House - Grouped Dwelling - Multiple Dwelling - Aged & Dependent Persons Dwelling - Caretaker's Dwelling - Ancillary Accommodation - Residential Building	 P P P (See Note 2.) P IP SA	 P P P	 IP IP IP	 SA (See note 3) SA (See note 3) SA IP AA	 SA (See note 3) SA (See note 3) SA IP AA	 IP	 IP
Restaurant			SA	P	P	AA	
Restricted Premises							
Service Station					SA	SA	AA
Shop				P	P		IP
Shopping Centre				P	P		
Showroom				AA	P	P	P
Tavern				SA	AA	AA	
Trade Display						AA	AA
Transport Depot						SA	AA
Vehicle Hire					AA	AA	P
Veterinary Establishment			SA	SA	AA	AA	AA

USE CLASSES	Residential	Rural-Residential	Neighbourhood Node	Neighbourhood centre	Town Centre	Highway Commercial	Mixed Business
Warehouse					IP	AA	P

Notes:

1. See Residential Planning Codes for definitions of Residential dwelling types;
2. Multiple Dwellings only permitted in R40 and higher density codes.
3. Grouped and Multiple Dwellings are only permitted in Neighbourhood Centre and Town Centre zones as part of combined Commercial/Residential developments such as shop-top housing or work/live developments.

APPENDIX 2
ENVIRONMENTAL APPRAISAL REPORT
(COFFEY ENVIRONMENTAL)

coffey environments
SPECIALISTS IN LIVING AND WORKING PLACES

ENVIRONMENTAL APPRAISAL
THE GLADES AT BYFORD

Prepared for:

LWP Property Group Pty Ltd
34 Main Street
ELLENBROOK WA 6060

Report Date: 8 June 2009
Project Ref: EP2009-052 V3
ENVIPERT00121AA

Written/Submitted by:	Reviewed/Approved by:
Belinda Heath	Paul Van Der Moezel
Senior Environmental Scientist	Principal

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coffey environments
SPECIALISTS IN LIVING AND WORKING PLACES

8 June 2009

LWP Property Group Pty Ltd
34 Main Street
ELLENBROOK WA 6060

Attention: Phil Cuttone

Dear Phil

RE: Environmental Appraisal The Glades at Byford

Coffey Environments have revised the Environmental Appraisal – Byford Main Precinct Report V2.

The revised Environmental Appraisal The Glades at Byford V3 has been provided to Kris Nolan at Taylor Burrell Barnett for inclusion in The Glades at Byford Local Structure Plan Report.

For and on behalf of Coffey Environments Pty Ltd

Belinda Heath
Senior Environmental Scientist

Attachment A: Environmental Appraisal - The Glades at Byford

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RECORD OF DISTRIBUTION

No. of copies	Report File Name	Report Status	Date	Prepared for:	Initials
1	LWP-2005-004-ENAS_002_bv_V2	V2	8 Nov 2005	LWP Property Group Pty Ltd	BvdW
1	ENVIPERT00121AA_Glades_008_BH_V3	V3	8 June 09	LWP	BH

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1 INTRODUCTION

1.1 Background

The LWP Property Group Pty Ltd (LWP) are the landowners of “The Glades” formerly known as the Byford Main Precinct located to the south west of the existing Byford town site (Figure 1).

LWP is proposing to develop their landholdings and is preparing a Local Structure Plan (LSP) for the area. The LSP area includes Part Lots 16, 104 and 494 Cardup Siding Road; Part Lots 184 and 8 Orton Road; Lots 9 and 11 Orton Road; Lots 1, 2, 3, 52 Abernethy Road; Lots 21, 22 and 132 Doley Road; Lot 4, 5, 6, and 7 Warrington Road; and Lot 5 Lawrence Way (Figure 2).

The LSP covers only the northern portion of the Cardup Brook landholdings. The southern portion was subject to a separate development “Byford by the Brook” Detailed Area Plan (DAP) which is in its final stage of development.

This Environmental Appraisal Report was prepared on behalf of LWP to assist the preparation of The Glades LSP for future urban development of the area.

The environmental appraisal includes a description of the existing environmental attributes of the study area, identifies potential opportunities and constraints to the LSP area and documents the recommended management strategies that should be implemented in association with the future development of the study area.

Specifically, the scope of works included describing or investigating the following issues:

- Climate and topography;
- Geology, geomorphology and soils;
- Land capability;
- Hydrogeology and hydrology – including wetlands;
- Remnant vegetation (vegetation complexes and associations);
- Bush Forever sites;
- Potential for the presence of significant flora and fauna including the location and population size;
- Spring flora survey;
- Historical use of the study area and surrounding land use; and
- Impact of surrounding land uses.

The investigation has incorporated a detailed desktop review of flora, fauna, and geophysical mapping, followed by site inspections to assess vegetation and a spring flora survey and targeted fauna survey (Black Cockatoo). Site inspections were conducted by ATA Environmental personnel (now Coffey Environments) in April 2004, February, July, and September 2005.

The results of the detailed desktop review and the subsequent on-site investigations have provided the relevant information to determine the opportunities and constraints of implementing the proposed LSP.

The opportunities and constraints have been outlined in this Environmental Appraisal, with each having a recommended management strategy to be incorporated into the development of the area.

1.2 Location

The project area is located approximately 33 km south east of Perth and situated in the Shire of Serpentine-Jarrahdale (Figure 1). The area covers approximately 1500ha of land generally bounded by Abernethy Road to the north, Soldiers Road/South West Highway to the east, Hopkinson Road to the west and Cardup Brook to the south (Figure 2).

1.3 Land Use

The Glades is subject to the Shire of Serpentine - Jarrahdale Town Planning Scheme (TPS) No.2 & associated local planning policies. The site is zoned 'Urban' under the Metropolitan Region Scheme and 'Urban Development' in accordance with TPS No. 2.

The area has previously been extensively parkland cleared to facilitate activities such as dairy farming, horse agistment and cattle grazing and includes numerous private residences and sheds.

Surrounding land use includes agricultural land and some large residential lots. The Cardup Brook and associated foreshore area has some remnant riparian vegetation, of which the western portion forms the Bush Forever Site 351 (Figure 2).

An extensive pocket of remnant vegetation is located to the east of the study area and forms the Bush Forever site 321 (Figure 2).

An existing MRS road reserve for the proposed Tonkin Highway Extension is located along the western boundary of the LSP area to enable a sweeping connection to Orton Road.

1.4 Byford Local Structure Plan

Taylor Burrell Barnett (TBB) has prepared on behalf of LWP a draft LSP layout and Report which incorporates a range of landuses and environmental improvements for the proposed development of the study area. The Glades at Byford design exhibits:

- A highly interconnected network of neighbourhoods with a traditional neighbourhood centre at its core.
- The main street neighbourhood centre will offer a variety of uses including retail floorspace, commercial floorspace, medium density residential, community facilities and civic spaces.
- Neighbourhood nodes are interspersed throughout the Structure Plan area at important intersections.
- An interconnected street network will link residential uses with the neighbourhood centre, neighbourhood nodes, key civic spaces and a generous network of public open space and urban bush land.
- A range of residential densities are promoted across the Structure Plan area to:
  - optimise public equity (by maximising the available interface with community assets such as public open space, urban bushland, school sites, neighbourhood nodes and the neighbourhood centre);

- provide a diversity of housing product for increased choice and to accommodate an evolving household/family structure; and
- promote higher densities in strategic locations thus facilitating a more efficient and sustainable use of land.

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2 STUDY AREA DESCRIPTION

2.1 Climate

The study area experiences a Mediterranean climate characterised by hot dry summers and mild wet winters. The temperature ranges from a average maximum of 33℃ in the hottest months of January and February to an average of 17℃ in the colder months of July and August. Temperature extremes are greater on the Darling Plateau than the Scarp with temperatures higher during the day and lower at night. Frost also occurs in the winter months from May to September.

Rainfall averages 877mm per year with up to 80% of the annual rain falling between May and October (Ecological Engineering, 2005). Windy conditions are experienced from late winter through spring and summer. The prevailing winds in July and August are west, north-west and north, while summer winds deviate from the south-west through to the south and east in the typical anti-cyclonic cycle (King *et al.,* 1990).

2.2 Topography

The study area appears flat, however there is a gradual slope from 45m AHD in the east down to the 30m AHD in the west (Figure3).

2.3 Geology, Geomorphology and Soils

2.3.1 Geology

Published geological mapping (Jordan, 1986) indicates that the geological units within the study area comprises three main units, as described in Table 1. The distribution of these units within the study area is shown in Figure 4.

TABLE 1

GEOLOGICAL UNITS FOUND WITHIN THE GLADES

Reference	Description
Cs	Sandy Clay – white-grey to brown, fine to coarse-grained, subangular to rounded sand, clay of moderate plasticity gravel and silt layers near scarp.
Csg	Gravely sandy clay – variable, with lenses of silt and gravel, quartz sand, subangular with eolian rounded component; heavy minerals common; gravel rounded, of colluvial origin.
S10	Sand – as S8 (Sand – white to pale grey at surface, yellow at depth, fine to medium-grained, moderately sorted, subangular to subrounded, minor heavy minerals, of eolian origin) over sandy clay to clayey sand of the Guildford formation, of eolian origin.

Source: Jordan, 1986

2.3.2 Geomorphology and Soils

The Western Australian Department of Agriculture and Food (DAFWA) has produced a mapping system that displays land resources in the northern section of the Peel-Harvey catchment (WADA, 1990). The system utilises existing land resource survey data such as soil type, landforms, and slope. These characteristics for each lot are described in Table 2. The distribution of these units within the study area is shown in Figure 5.

TABLE 2

LAND RESOURCE MAPPING UNITS FOUND WITHIN THE GLADES

Reference	Description
Pinjarra Plain	Broad low relief plain west of the foothills, comprising predominantly Pleistocene fluvial sediments and some Holocene alluvium associated with major current drainage systems. Major soils are naturally poorly drained and many swamps occur.
P1a	Flat to very undulating plain with deep acidic mottled yellow duplex (or "effective duplex") soils comprising shallow pale sand to sandy loam over clay; imperfect to poorly drained and generally not susceptible to salinity.
P1b	Flat to very undulating plain with deep acidic mottled yellow duplex (or "effective duplex") soils comprising moderately deep pale sand to sandy loam over clay; imperfectly drained and moderately susceptible to salinity in limited areas.
P1e	Flat to very undulating plain with deep acidic mottled yellow duplex (or "effective duplex") soils comprising shallow pale sand to sandy loam over very gravely clay; moderately well drained.
P3	Flat to very gently undulating plain with deep, imperfect to poorly drained acidic gradational yellow or grey-brown earths and mottled yellow duplex soils, with loam to clay loam surfaces.
Ridge Hill Shelf (Foothills)	Lateritized, low relief, foothills of the Darling Scarp comprising fossil shoreline bench, sediments, Holocene colluvium, and narrow bands of alluvial deposits. Slopes are very gently to very gently inclined and soils are moderately well to well drained.
F4	Incised stream channels with deep acidic yellow duplex soils and sandy alluvial gradational brown earths.
F5	Poorly drained stream channels on lowest slopes and with soils similar to F4.

Source: King and Wells, 1989

2.3.3 Acid Sulphate Soils

Acid sulphate soils (ASS) are wetland soils and unconsolidated sediments that contain iron sulfides which, when exposed to atmospheric oxygen in the presence of water, form sulphuric acid. ASS form in protected low energy environments such as barrier estuaries and coastal lakes and commonly occurs in low-lying coastal lands such as Holocene marine muds and sands. When disturbers, these soils are

prone to produce sulphuric acid and mobilise iron, aluminium, manganese and other heavy metals. The release of these reaction products can be detrimental to biota, human health and built infrastructure.

Figure 4 (South Metropolitan Region Scheme ASS) of the WAPC Planning Bulletin 64 identifies the study area as having a moderate to low risk of actual acid sulphate soil (AASS) and potential acid sulphate soil (PASS) occurring generally at depths of more than 3m (WAPC, 2003). The relevant section of the WAPC mapping as it relates to the site is shown in Figure 6.

2.4 Land Capability

Land capability refers to the ability of a site to support a particular landuse without causing damage. An assessment of land capability may also indicate constraints to proposed landuses and therefore, environmental planning or engineering measures may be required to minimise adverse environmental impacts. Hence, land capability assessment can be used to assist in the development of an environmentally sensitive landuse plan for proposed subdivision or residential developments.

The DAFWA has developed a system for the assessment of land capability for rural residential development, hobby farming and agricultural land uses. The system utilises existing land resource survey data such as soil type, landforms, and slope and matches these qualities with the physical requirements of a particular land use.

Table 3 summarises the land capabilities of soil types present in study area for the purposes of house and road construction and effluent disposal based on the DAFWA assessments (King and Wells, 1989; van Gool, 1990). Land unit P1e covers approximately 70% of The Glades LSP area.

The Glades has a Fair to High capability for road and house construction however there are some limitations relating to flood risk, waterlogging and inundation risk (P1a, P1b, P1e, and P3) and water pollution risk from overland flow in the Cardup Brook area and east of Warrington Road in the F4 and F5 land units.

TABLE 3

LAND USE CAPABILITY RATING FOR THE GLADES

Land Resource Unit (refer to Table 2)	House and Road Construction	Effluent Disposal
P1a	III i	IV
P1b	III i	III
P1e	II	III
P3	III i	III p
F2b	II	III
F4	IV f	V o
F5	III i, f	III f

Capability Class General Description

I Very High capability for the proposed activity or use. Very few physical limitations present which are easily overcome. Risk of land degradation is negligible.

II High Capability. Some physical limitations affecting risk of land degradation. Limitations easily overcome with careful planning

III Fair Capability. Moderate physical limitations significantly affecting risk of land degradation. Careful planning and conservation measures required.

IV Low capability. High degree of physical limitations not easily overcome by standard development techniques and or resulting in a high risk of land degradation. Extensive conservation requirements.

V Very Low Capability. Severity of physical limitations is such that its use is usually prohibited in terms of either development costs or the risk of land degradation.

Land Capability Sub Class (land-use limitations)

f flood risk

i waterlogging/inundation risk

o water pollution risk, by overland flow

p microbial purification ability

2.5 Hydrogeology and Hydrology

2.5.1 Hydrogeology (Groundwater)

Much of the developable land in the LSP area has a very shallow groundwater, is subject to seasonal waterlogging and periodic inundation during infrequent flood events (Ecological Engineering, 2005; JDA, 2009).

The *Perth Groundwater Atlas* (Department of Environment, 2004) indicates that groundwater is typically shallow across the study area ranging between 0 and 6m in depth and is often 'perched' ie the groundwater ponds on a lens of relatively impermeable clayey sand that prevents it infiltrating into the deeper aquifers (Ecological Engineering, 2005). The groundwater flow direction beneath the study area is generally from east to west. The *Atlas* displays the watertable contours across The Glades LSP area as ranging from 26m AHD to 30m AHD (Figure 3).

Work undertaken during the development of the Byford Urban Stormwater Management Strategy (BUSMS) found that there are approximately 100 private ground water bores within the study area, the majority of which target groundwater in sand lenses at the base of the Guildford Clay at 17.5 to 25m in depth (Ecological Engineering, 2005). Limited groundwater quality monitoring of these bores undertaken in the BUSMS investigations indicated that groundwater within the study area contained low levels of phosphorus and moderate concentrations of nitrogen (both 'Total N' and nitrate and nitrite). The levels measured were considered to be low when compared to typical sites on the Swan Coastal Plain that have historically been used for pasture or horticulture as is the case in the study area (Ecological Engineering, 2005).

The *Perth Groundwater Atlas* indicates that the whole of the study area is a groundwater development risk area (Department of Environment, 2004).

2.5.2 Hydrology (Surface Water)

Watercourses

The Glades LSP area is located within the Peel-Harvey catchment and contains four surface drainage features.

Cardup Brook, a perennial stream, flows along the southern boundary of the study area (Figure 2).

Three other watercourses (intermittent streams) flow through the study area: the most southerly watercourse through Lot 184 Orton Road; the middle watercourse flows from Doley Road through the northern portion of Lots 8, 9 and 184 Orton Road; and the most northerly has its headwaters in the Bush Forever Site 321 that straddles Turner Road and flows in a northwesterly direction through to Hopkinson Road.

Wetlands

Several wetlands occur on and adjacent to the study area. A large portion of the study area is mapped in the DEC's *Geomorphic Wetlands Swan Coastal Plain* dataset as palusplain (a seasonally waterlogged flat) (UFI 13500; 13912). Throughout the Swan Coastal Plain, areas of palusplain have historically been extensively cleared for rural pursuits (grazing and horse agistment) as is the case in the study area. The management category of the majority of these wetlands has been evaluated as Multiple Use (MU) wetlands. Wetlands that support native vegetation are identified as Conservation (CCW) or Resource Enhancement (RE) wetlands. Wetland Management categories and their objectives are shown in Table 4.

TABLE 4

WETLAND MANAGEMENT CATEGORIES AND OBJECTIVES

Management Category	General Description	Management Objectives
Conservation Category Wetland (CCW)	Wetlands support a high level of ecological attributes and functions.	Highest priority wetlands. Objective is preservation of wetland attributes and functions through various mechanisms including: • Reservation in national parks, crown reserves and State owned land; • Protection under Environmental Protection Policies; and • Wetland covenanting by landowners. These are the most valuable wetlands and the Commission will oppose any activity that may lead to further loss or degradation. No development.
Resource Enhancement Wetland (REW)	Wetlands which may have been partially modified but still support substantial ecological attributes and functions	Priority wetlands. Ultimate objective is for management, restoration and protections towards improving their conservation value. These wetlands have the potential to be restored to conservation category.

		This can be achieved by restoring wetland structure, function and biodiversity. Protection is recommended through a number of mechanisms.
Multiple Use Wetland (MUW)	Wetlands with few important ecological attributes and functions remaining.	Use, development and management should be considered in the context of ecologically sustainable development and best management practice catchment planning through landcare. Should be considered in strategic planning (eg drainage, town/land use planning).

Several wetlands occur on and adjacent to the study area. The DEC dataset mapping of wetlands, as supplied by the DEC for the study area is shown in Figure 7 (DEC, 2009).

A CCW was previously located on Lot 3 Abernethy Road (UFI 7829, 7866 and 7829). As part of the site investigations undertaken for this report, ATA Environmental conducted a site visit September 2005 to 'groundtruth' the appropriateness of the CCW management category of the wetland. It was concluded that due to the degraded nature of the wetland, along with other environmental characteristics of the site (discussed in further detail in Section 3), the DEC's CCW classification should be revised to a MU management category. The Wetlands Branch of the Department of Environment agreed to revaluate the wetland category of Conservation Category to Multiple Use in February 2006 (Appendix D).

CCWs (UFI 8005; 7844; 13911; 13901) were previously located along parts of the Cardup Brook that support native riparian vegetation. As part of the site investigations undertaken for the Byford by the Brook DAP, ATA Environmental conducted a site visit in 2004 to ground truth the appropriateness of the CCW management category. It was concluded that the degraded nature of the wetland and other environmental characteristics that the DEC classification should be revised to REW. The Wetlands Branch of the Department of Environment agreed to revaluate the wetland category of CCW to REW in July 2004 (Appendix D).

One CCW (UFI 15452) is located on land directly abutting the study area and is within the Bush Forever Site 321 to the east of the study area.

2.6 Vegetation and Flora

2.6.1 Methodology

A flora and vegetation survey was conducted on site by ATA Environmental (now Coffey Environments) on 7 September 2005. The survey was undertaken to determine if any of the significant species or Threatened Ecological Communities (TECs) identified by CALM (now DEC) actually occur, or are likely to occur, on the study area. The survey was based on sampling within quadrats of 10m x 10m dimensions as well as a thorough site walkover to record all plant species present at the time of the survey. This method complies with the Environmental Protection Authority's (EPA) guidelines for flora surveys as outlined in the EPA Guidance Statement No. 51 *Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia* (EPA, 2004a).

The major vegetation types and associated flora were surveyed and delineated using a 1:4,000 colour aerial photograph (Figure 8). The vegetation was described and mapped according to the structure and species composition of the dominant stratum using the system adopted in *Bush Forever* (Government of Western Australia, 2000a).

All plant specimens not identified during the flora survey were collected, dried and fumigated in accordance with the requirements of the West Australian Herbarium (2005) and then sorted for identification.

Plant specimens were identified by using local and regional flora keys and by comparison with the named specimens held at the West Australian Herbarium. Plant taxonomists who are considered to be an authority on a particular group were consulted, where necessary.

The conservation status of all recorded flora was checked against the current lists published in the Governmental Gazette and available from the DEC's (October 2005) and Department of the Environment, Water, Heritage and the Arts (DEWHA).

Prior to conducting the site investigation a search of DEC's Declared Rare and Priority Flora database was undertaken by ATA Environmental. The database search found that eight Priority taxa and three Declared Rare Flora (DRF) species had been previously recorded from the vicinity of the study area (Table 5).

TABLE 5

SPECIES LISTED ON DEC's DATABASE RECORDED IN THE VICINITY OF THE GLADES

Species	Priority Code	Habitat	Flower Period
Aotus cordifolia	P3	Peaty soils and swamps	Aug-Jan
Baeckea sp. Perth Region (R.J Cranfield 444)	P3	Sandy white clay soils	
Drosera occidentalis subsp. *occidentalis*	P4	Grey sandy clay	Oct-Jan
Johnsonia pubescens subsp: *cygnorum*	P2	White, grey, yellow black or lateritic sand, granite limestone. Flats, wet sites, coastal areas and road sides.	Aug-Nov
Schoenus pennisetis	P1	Grey or peaty sand, sandy clay. Swamps and winter flats.	Aug-Sep
Synaphea odocoileops	P1	Brown, orange loam and sandy clay granite. Swamps and winter wet areas	Aug-Oct
Verticordia lindleyi subsp. *lindleyi*	P4	Sand, sandy clay. Winter wet depressions	May/Nov – Jan
Verticordia plumosa var. *pleiobotrya*	R	Clay, sandy loam. Seasonally inundated swamps and road verges.	Oct-Dec

Centrolepis caespitosa	P4	White sand, clay. Salt flats wet areas	Oct-Dec
Tetraria australiensis	R		Nov-Dec
Trichocline sp. Treeton (B. J Keighery & N. Gibson 564)	P2	Sand over limestone, sandy clay over ironstone. Seasonally wet flats	

2.6.2 Vegetation Complexes

The small amount of native vegetation that remains in the study area consists of vegetation characteristic of the Forrestfield Complex (Heddle *et al.,* 1980).

The Forrestfield Complex vegetation ranges from Open Forest of *Corymbia calophylla, Eucalyptus wandoo* and *Eucalyptus marginata* to Open Forest of *Eucalyptus marginata – Corymbia calophylla – Allocasuarina fraseriana – Banskia* spp. A Fringing Woodland of *Eucalyptus rudis* is often found in the gullies that dissect this landform (Heddle *et al.,* 1980).

Approximately 9% of the Forrestfield Complex remains on the Swan Coastal Plain (Government of Western Australia, 2000b). The EPA's objective is to protect at least 30% of the original extent of the vegetation complexes in unconstrained areas and 10% in constrained areas (i.e. Urban zoned regions). While most of the vegetation complexes on the Swan Coastal Plain meet the 30% target, the Forrestfield Complex compares poorly with 9% of the original extent remaining in the Swan Coastal Plain. The Glades area is considered a constrained area due to its MRS "Urban" zoning. The 10% target therefore applies to the study area. The Forrestfield Vegetation Complex is below the minimum protection target.

However The Glades has historically been used for pastoral and agricultural land uses and as such its original state has been highly modified. Although it contains characteristics of the Forrestfield Complex it is not considered to be a good representative of this vegetation complex due to the extent of clearing. Figure 8 shows the vegetation types and condition found across the study area. The best examples of the Forrestfield Complex in the area are to be found within the adjacent Bush Forever Site 321 and 352 and some nearby road reserves.

2.6.3 Vegetation Types

Vegetation types are vegetation units that can be described and mapped at a finer level than the vegetation complexes.

Nineteen vegetation types associated were identified in the study area and described during the flora and vegetation survey undertaken by ATA Environmental in 7 September 2005. These vegetation types are briefly described below and in some instances a typical photograph and 10m x 10m quadrat data indicating species present, their percentage cover and height are shown in Appendix B.

Woodlands

C?mLOW

Low Open woodland of *Corymbia ?maculata* (Spotted Gum) over introduced species on clayey soils

There was evidence of heavy disturbance and according to the *Bush Forever* (2000a), the condition was considered to be Completely Degraded (Figure 8).

CcW

Woodland of *Corymbia calophylla* with occasional **Melia azedarach* (Cape Lilac) and *Callistemon phoeniceus* (Bottlebrush) over introduced grasses. There was moderate evidence of disturbance and the condition was considered to be Good (Figure 8).

ErLOW

Low Open Woodland of *Eucalyptus rudis* (Flooded Gum) over a Very Open Sedgeland dominated by *Juncus subsecundus* and introduced grasses. There was moderate evidence of disturbance and the condition was considered to be range from Good to Degraded (Figure 8).

CcEmLOW

Low Open Woodland of *Corymbia calophylla* with occasional *Eucalyptus marginata* (Jarrah) over a Tall Open Shrubland dominated by *Kingia australis* over a Closed Low Heath dominated by *Mesomelaena tetragona* and *Xanthorrhoea preissii* on clayey loamy soils. There was low evidence of disturbance and the condition was considered to range from Excellent to Very Good (Figure 8).

EsLOW

Low Open Woodland of introduced *Eucalyptus species.* with scattered *Xanthorrhoea preissii* over introduced grasses. There was moderate evidence of disturbance and the condition was considered to be range from Good to Degraded (Figure 8).

BmBaLOW

Low Open Woodland dominated by *Banksia menziesii* and *Banksia attenuata* with occasional **Pinus radiata* and *Macrozamia riedlei* over introduced grasses on clayey loamy soils. There was evidence of disturbance associated with this vegetation type and the condition was considered to range from Very Good to Good (Figure 8).

ErGLOW

Low Open Woodland of *Eucalyptus rudis* over introduced grasses on clayey loamy soils. There was evidence of heavy disturbance and the condition was considered to be Completely Degraded (Figure 8).

ErTI

Low Open Woodland to Open Woodland of *Eucalyptus rudis* over an open understorey comprising of *Taxandria linearifolia* and stands of *Juncus subsecundus.* A number of invasive weeds were noted along the creek line including **Gomphocarpus fruticosus* (Cotton Bush),* *Zantedeschia aethiopica* (Arum lily), **Cynodon dactylon* (Couch grass) and **Olea europea* (Olive trees). There was evidence of disturbance associated with this vegetation type and the condition was considered to be Degraded (Figure 8).

EmLW

Low Woodland of *Eucalyptus marginata* with scattered *Corymbia calophylla* over an Open Shrubland dominated by *Xanthorrhoea preissii, Acacia pulchella* and *Jacksonia sternbergiana* over introduced grasses on clayey loamy soils. There was moderate disturbance associated with this vegetation type and the condition was considered to be Good (Figure 8).

CcXpLOW

Low Open Woodland of *Corymbia calophylla* with scattered *Xanthorrhoea preissii* over introduced grasses. There was evidence of heavy disturbance and the condition was considered to be Completely Degraded (Figure 8).

CcEm

Woodland to Open Woodland of *Eucalyptus marginata* and *Corymbia calophylla* over occasional *Kingia australis, Xanthorrhoea preissii* and introduced grasses and herbs including **Cynodon dactylon, *Lupinus consetinii, *Hypochaeris glabra* and **Avena fatua.* There was evidence of disturbance associated with this vegetation type and the condition was considered to be Degraded (Figure 8).

CcAsLOW

Low Open Woodland of *Corymbia calophylla* over a Tall Open Shrubland dominated by *Acacia saligna, Viminaria juncea* and *Hakea trifurcata* over a Low Open Shrubland dominated by *Dielsia stenostachya* and **Watsonia meriana* var*. bulbillifera* over introduced grasses on clayey loamy soils. There was moderate evidence of disturbance and the condition was considered to be range from Good to Degraded (Figure 8).

CcVjLOW

Low Open Woodland of *Corymbia calophylla* with occasional *Viminaria juncea* over a Low Open Shrubland dominated by *Xanthorrhoea preissii, Hakea trifurcate*, *Pericalymma ellipticum, Hakea sulcata* and *Mesomelaena tetragona* on clayey loamy soils. There was evidence of disturbance associated with this vegetation type and the condition was considered to be Good (Figure 8).

Forests

EmCcLOW

Low Open Forest of *Eucalyptus marginata* and *Corymbia calophylla* over an Open Shrubland dominated by *Jacksonia sternbergiana* and *Acacia pulchella* with scattered *Xanthorrhoea preissii* and *Banksia grandis* on sandy clay loams. There was low evidence of disturbance associated with this vegetation type and the condition was considered to be Very Good (Figure 8).

Shrublands

XpOS

Open Shrubland dominated by *Xanthorrhoea preissii* with occasional introduced *Eucalyptus species*, *Macrozamia riedlei* and *Jacksonia furcellata* over introduced grasses. There was moderate evidence of disturbance and the condition was considered to be range from Good to Degraded (Figure 8).

CpOS

Open Shrubland of *Callistemon phoeniceus* with scattered *Calothamnus quadrifidus* over introduced grasses on loamy clayey soils. There was evidence of heavy disturbance and the condition was considered to be Completely Degraded (Figure 8).

AsXpLOW

Low Open Shrubland dominated by *Acacia saligna, Xanthorrhoea preissii* and *Mesomelaena tetragona* with occasional *Jacksonia sternbergiana* over introduced grasses. There was moderate disturbance associated with this vegetation type and the condition was considered to be Good (Figure 8).

Grasslands

G

Grasslands with scattered native and introduced grasses. There was heavy evidence of disturbance associated with this community type and the condition was considered to be Completely Degraded (Figure 8).

Gs

Grasslands with scattered native and introduced species. There was heavy evidence of disturbance associated with this community type and the condition was considered to be Completely Degraded (Figure 8).

2.6.4 Floristic Community Types

Based on Floristic data collected during this survey the vegetation types on The Glades are inferred to be representative of one FCT (Gibson *et al.,* 1994):

- Floristic Community Type 3b – *Corymbia calophylla – Eucalyptus marginata* woodlands on sandy clay soils.

This Floristic Community Types is listed as a Threatened Ecological Community by English and Blythe (1997) and by DEC's list of TECs and is also listed as Vulnerable on the Endangered Community List under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*.

The Glades LSP area does not have any vegetation types representative of TEC 3b.

The CcEmLOW vegetation type is adjacent to the study area in the Warrington Road roadside reserve that abuts with the Bush Forever Site 321. This vegetation type is similar to TEC 3b and was considered to range in condition from Excellent to Very Good. This vegetation type may have once been present in the Glades LSP area adjacent to the Bush Forever Site 321 prior to vegetation clearing and grazing activities.

2.6.5 Vegetation Condition

The condition of the vegetation was assessed according to the system devised by Keighery and described in *Bush Forever* (2000a). Keighery's condition rating scale ranges from Pristine (which the vegetation exhibits no visible signs of disturbance) to Completely Degraded (where the vegetation structure in no longer intact and without native plant species). Vegetation condition for The Glades is mapped in Figure 8 and ranges from Degraded to Completely Degraded. The majority of the study area has been historically used for farming which has adversely affected areas of native vegetation through grazing, trampling, introducing and spreading weeds, and nutrient enrichment.

Across the study area, intact areas of remnant vegetation are generally confined to sections of road reserves and Bush Forever sites.

The roadside reserve adjacent to the western edge of the Bush Forever Site 321 on Warrington Road has vegetation condition ratings of Very Good to Good. This road side reserve is outside of the study area, however should Warrington Road be widened this reserve should be managed appropriately.

A description of the vegetation condition ratings for those conditions identified in the study area are outlined in Table 6.

TABLE 6

VEGETATION CONDITION RATING SCALE (After Keighery)

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

2.6.6 Flora

A total of 100 plant species were recorded from the study area by ATA Environmental (now Coffey Environments) from the September 2005 survey. The total includes three Gymnosperms, 30 Monocotyledons and 67 Dicotyledons. The flora assessment was undertaken on 7 September 2005, a time when the majority of ephemeral species such as lilies and orchids would have been recorded. As such the flora list is considered to represent at least 90% of the species likely to occur in the study area. A full list of flora species recorded from the study area is provided in Appendix A.

Of the 100 plant species recorded, 60 (60%) were native and 40 (40%) were introduced or non-endemic planted species. Families with the highest representation of taxa were the Poaceae (Grass family – 11 taxa; 1 native, 10 introduced), the Myrtaceae (Eucalyptus family - 14 taxa; 12 native and 2 introduced),

the Papilionaceae (Pea family – 10 taxa; 6 native and 4 introduced) and the Proteaceae (Banksia family – 11 taxa; 11 natives).

2.6.7 Significant Flora

No Declared Rare Flora, Priority Flora or Commonwealth Listed species were recorded from the study area. The timing of the survey in September allowed for the identification of most ephemeral species including orchids and lilies. Additionally, much of the significant flora known to occur in the vicinity of the site is easily identifiable throughout the year.

2.6.8 Introduced Species

Forty introduced weed species were recorded within the study area (Appendix A).

The main weed species that occur in riparian areas include Cotton Bush (*Gomphocarpus fruiticosus*), Arum Lily (*Zantedeschia aethiopica*), Watsonia (*Watsonia* sp.), Bridal Creeper (*Asparagus asparagoides*), isolated Fig Trees (*Ficus carica*) and some Blackberry (*Rubus fruticosus*).

Cotton Bush stands were also found extending into dry areas away from the Cardup Brook.

The dry pasture areas are dominated by Ryegrass (*Lolium perenne*), Capeweed (*Arctotheca calendula*), Couch Grass (*Cynodon dactylon*), Lupin (*Lupinus* sp.), Flat weed (H*ypochaeris glabra*), Veldtgrass (*Ehrharta calycina*), *Hordeum leporinum* and Oats (*Avena fatua*).

Declared Plants are defined as “Pest plants targeted for legislative control…which have, or could have, serious economic, environmental or social impact” (Department of Agriculture Western Australia, 2004). It follows that only certain species of plants are classed as Declared Plants and are only Declared Plants in certain areas. For example, Blackberry exists as a Declared Plant in some southwest regions of Western Australia but not anywhere else in the State. Landowners with Declared Plants on their landholdings are obliged to control them at their own expense.

Cotton Bush, Arum Lily and Blackberry are Declared Plants under the *Biosecurity and Agriculture Management Act 2007* (BAM Act).

2.7 Bush Forever Sites

The *Directory of Bush Forever Sites* (Government of Western Australia, 2000b) indicates that three Bush Forever Sites are located in close proximity to the study area (Figure 7). These are:

- Bush Forever Site 351 (Cardup Brook Bushland, Cardup/Peel Estate) is located on the southern boundary and contains the riparian bushland adjacent to Cardup Brook. The associated Brook is designated a regional creekline with Open Woodland vegetation that is part of a regionally significant contiguous bushland/wetland linkage (Government of Western Australia, 2000b);

- Bush Forever Site 321 (Brickwood Reserve and Adjacent Bushland, Byford) is located directly south of Lot 52 Abernethy Road. It is bounded by Mead Street, Warrington Road and Soldiers Road (Government of Western Australia, 2000b).

- Bush Forever Site 352 (Cardup Nature Reserve) is located to the south of Cardup Siding Road therefore south of the study area. The site incorporates Reserve 2457 for the conservation of flora and fauna (CALM managed land) (Government of Western Australia, 2000b); and

2.8 Fauna

2.8.1 Methodology

A desktop survey was conducted using the CALM Threatened and Priority Species database, the Western Australian Museum *FaunaBase* (2005) and the DEC and DEWHA database to identify Threatened and Priority species potentially occurring within the study area.

2.8.2 Significant Flora Recorded or Predicted to Occur

The fauna species listed in Table 7 have conservation status under either State or Commonwealth government legislation and were present in database searches. Four Schedule 1 species, two Schedule 4 species and two Priority species were identified as potentially being present in the study area.

TABLE 7

THREATENED AND PRIORITY FAUNA IN THE VICINITY OF THE THE GLADES

Species	Status under Wildlife Conservation Act Schedule/Priority	Status under Commonwealth EPBC Act	Comment
Chuditch *Dasyurus geoffroii*	Schedule 1	Vulnerable	Species is unlikely to occur within area
Carnaby's Black-Cockatoo *Calyptorhynchus latirostris*	Schedule 1	Endangered	Species likely to occur within area
Baudin's Black-Cockatoo *Calyptorhynchus baudin*ii	Schedule 1	Vulnerable	Species likely to occur within area
Forest Red-tailed Black-Cockatoo *Calyptorhynchus banksii naso*	Schedule 1		Species likely to occur within area
Carpet Python *Morelia spilota imbricata*	Schedule 4		Species unlikely to occur within area
Peregrine Falcon *Falco peregrinus*	Schedule 4		Species may occur within area but unlikely to rely on project area
Southern Brush-tailed Phascogale *Phascogale tapoatafa tapoatafa*	Priority 3		Species unlikely to occur within area
Quenda or Southern Brown Bandicoot *Isoodon obesulus fusciventer*	Priority 5		Species may occur within area
Rainbow Bee-eater *Merops ornatus*		Migratory	Species likely to occur within area but unlikely to rely on project area

2.8.3 Species Potentially Occurring within the Site Identified as Being of National Environmental Significance under the EPBC Act 1999

Carnaby's and Baudin's Black Cockatoos (*Calyptorhynchus latirostris* and *C. baudinii*), are both listed under the *EPBC Act* 1999 as having national environmental significance and are likely to be present in

The Glades area. The Rainbow Bee-eater (*Merops ornatus*) listed as a migratory bird species under the EPBC Act is likely to be in the region although unlikely to be affected by any proposed development. The Chuditch is unlikely to be found on site due to lack of suitable habitat.

The Rainbow Bee-eater is found across the better-watered parts of Western Australia including islands. It prefers lightly wooded, preferably sandy, country near water. It is a resident, breeding visitor, postnuptial nomad, passage migrant and winter visitor, wintering from the Gascoyne north to Indonesia and is scarce to very common across its range. The Rainbow Bee-eater was recorded in the DEWHA database search and it is likely to be observed in the region, however, it is unlikely to rely on the site for breeding or feeding purposes.

2.8.4 Significant Fauna Species Potentially Occurring within the Site Listed under the WA Wildlife Conservation Act 1950

In Western Australia all native fauna species are protected under the *Wildlife Conservation Act 1950-1979*. Fauna species that are considered rare, threatened with extinction or have a high conservation value are specially protected under the Act. In addition, some species of fauna are covered under the 1991 ANZECC Convention, while certain birds are listed under the Japan and Australian Migratory Bird Agreement (JAMBA) and the China and Australian Migratory Bird Agreement (CAMBA). Classification of rare and endangered fauna under the *Wildlife Conservation (Specially Protected Fauna) Notice* 2003 recognises four schedules of taxa. In addition to the above classification, DEC also classifies fauna under five different Priority codes (Appendix C).

Threatened and priority species listed under the *WA Wildlife Conservation Act* 1950 as potentially occurring within the area are shown in Table 7. Included are four Schedule 1 species, two Schedule 4 species, one Priority 3 species and one Priority 5 species.

Schedule 1 – Fauna which are Rare or Likely to Become Extinct

Baudin's Black-Cockatoo (*Calyptorhynchus baudinii*) – This species is most common in the far southwest of WA where it breeds. It is known to breed from the southern forests north to Collie and east to near Kojonup. Baudin's Cockatoo is typically found in vagrant flocks and utilises the taller, more open Jarrah and Marri woodlands, where it feeds mainly on Marri seeds and various Proteaceous species. Baudin's Black-Cockatoo is likely to be present within the study area.

Carnaby's Black-Cockatoo (*Calyptorhynchus latirostris*) - This species inhabits the southwest of WA. Its preferred habitat is the woodland (salmon gum, or wandoo) and shrubland dominated by *Hakea*, *Dryandra* and *Banksias* species, where it preferentially feeds on plants of the Proteaceae family. In winter, flocks can be found in heaths. Breeding occurs in winter/spring in the eastern forests and Wheatbelt where they nest in hollows in large Eucalypts, primarily Salmon Gum and Wandoo. Some of these species on which it feeds are present at the site and therefore Carnaby's Black-Cockatoo is likely to occur within the study area.

Forest Red-tailed Black-Cockatoo (*Calyptorhynchus banksii naso*) – Its patchy distribution includes the humid and sub-humid areas from Gingin and Mt Helena throughout the eucalypt forests to the south coast. It is attracted to seeds of Marri, Jarrah, Blackbutt and Karri. This species has been recorded from the nearby Cardup Nature Reserve and suitable habitat for this species is present within the study area. Four individuals were observed flying over the study area during the February 2005 survey (ATA Environmental, 2005).

Chuditch or Western Quoll (*Dasyurus geoffroii*) – The Chuditch is formally known from over 70% of Australia, however, the Chuditch now has a patchy distribution throughout the Jarrah forest and mixed

Karri/Marri/Jarrah forest of southwest Western Australia. Although present on a DEC Threatened Fauna search, the Chuditch is unlikely to be present due to unsuitable habitat within the study area.

Schedule 4 – Fauna that are in Need of Special Protection

Peregrine Falcon (*Falco peregrinus*) – This species is uncommon, although widespread throughout much of Australia, excluding the extremely dry areas and has a wide and patchy distribution. It shows habitat preference for areas near cliffs along coastlines, rivers and ranges and within woodlands along watercourses and around lakes. It may occasionally be seen in the vicinity of the study area but is unlikely to rely on the study area for survival.

Carpet Python (*Morelia spilota imbricata*) – The Carpet Python inhabits forest, heath or wetland areas and shelters in hollow logs or in branches of large trees. Carpet Pythons are often found in colonies, particularly during the breeding season in spring. This species is widespread within the southwest of Western Australia, but is not in high density across its distribution. Carpet Pythons have not been recorded within the vicinity of the study area and were not listed in the DEC's Threatened Fauna search. Due to the cleared vegetation across the precinct it is unlikely to be present.

Priority 3 – Taxa with Several, Poorly Known Populations, some on Conservation Lands

Southern Brush-tailed Phascogale (*Phascogale tapoatafa tapoatafa*) – The present range of this species is believed to have been reduced to 50% of its former range. It is now known from Perth and south to Albany, west of Albany Highway. It occurs in highest densities in the Perup/Kingston area, Collie River valley and near Margaret River and Busselton and also occurs at lower densities in the northern Jarrah forest. This arboreal marsupial occurs in forest and woodland where suitable tree hollows are available. Populations tend to fluctuate dramatically in response to invertebrate prey abundance. It was not recorded within the vicinity of the study area and was not listed in the CALM Threatened Fauna search. Due to the cleared vegetation across the precinct it is unlikely to be present.

Priority 5 – Taxa in Need of Monitoring (Conservation Dependent)

Quenda or Southern Brown Bandicoot (*Isoodon obesulus fusciventer*) – This species is widely distributed near the southwest coast from Guilderton north of Perth to east of Esperance, with a patchy distribution through the Jarrah and Karri forest and on the Swan Coastal Plain, and inland as far as Hyden. There is concern that the species may be declining as a result of continuing habitat loss and predation pressures due to introduced fauna. The Quenda is found in dense scrubby, often swampy, vegetation with dense cover up to 1m high and often feeds in adjacent forest and woodland that is burnt on a regular basis and in areas of pasture and cropland lying close to dense cover. This species has been recorded from the nearby Cardup Nature Reserve.

2.8.5 Black Cockatoo Targeted Survey

In February 2005, ATA Environmental conducted a Black Cockatoo assessment of numerous properties including Lots 494, 104 and 16 ('Byford by the Brook'); Lots 1, 2, 3, 5, 8, 9, 11, 21, 22, 52, 184, (The Glades'); and Lots 523 and 521 ('Byford by the Scarp'). These areas include The Glades as well as areas surrounding it. In addition to these properties, numerous bushland sites within a 10km radius were also searched to provide a regional perspective of Black Cockatoo nesting and feeding opportunities (ATA Environmental, 2005).

The Glades has largely cleared undergrowth however there are remnant Marri and Jarrah pockets. All trees and remnant vegetation were assessed to identify areas that have potential as nesting hollows for breeding Black Cockatoos. A thorough search was made of the canopy of each of the trees within the study area and the location of any significant trees recorded on 1 February 2005.

Twenty-two trees that contained hollows large enough for Black Cockatoo were identified in this assessment. Only nine of these trees are within The Glades LSP area. Although there are suitable sized hollows, some of these trees are in cleared paddocks and are therefore unlikely to be used as nesting sites.

There are many trees that would potentially provide feeding sites (i.e. Marri nuts), however none of the Marri trees examined showed any evidence of Black Cockatoo feeding. Black Cockatoos have a distinctive feeding method and their presence in an area can be determined by discarded Marri nuts or Banksia cones.

Although four Forest Red-tailed Black Cockatoos were observed flying over Lot 21 and 22 (1 Feb 2005), they were not observed to be utilising vegetation occurring on site.

Even though there are many trees that may provide feeding sites for Black Cockatoos, there was no evidence of Black Cockatoo's feeding in the area. A search of bushland within a 10km radius of the site indicated that there were extensive areas of suitable feeding and nesting habitat that will not be impacted by the proposed development. Some of these alternative feeding and nesting habitats are also protected under Bush Forever.

2.9 Historical and Surrounding Land Use

Historical aerial photographs for the site between 1953 and 2004 were reviewed to identify activities at the site that may indicate potential soil and/or water contamination. Any contamination present could result in constraints on future development.

The aerial photographs suggest the whole study area was used for agricultural farming, which was still evident in the site visit in 2005. The 1978 photograph displays a horse race track on Lot 2, Abernethy Road.

Historical land use and grazing throughout most of the landholdings have resulted in the clearing of the native understorey vegetation to an extent that introduced weeds and grasses proliferate across the study area.

2.10 Indigenous Heritage

An Aboriginal Heritage assessment of the The Glades was undertaken in 2006.

Two Aboriginal sites are listed on the Register of Aboriginal Sites in the Glades at Byford:

- Cardup Brook (Site ID 16108), listed on the Interim Register of Aboriginal Sites as a mythological site and encompasses the entire brook and a buffer zone of 30m on either side.
- Cardup (Site ID 3310), listed on the Interim Register of Aboriginal Sites as an artefact scatter is reportedly located approximately 50m from the north bank of Cardup Brook and roughly 400m southwest of the intersection of the Orton and Doley roads.

As a result of the 2006 assessment three new archaeological sites, stone artefact scatters (BAS-001, BAS-002 and BAS-005) and four isolated artefacts (BAS/ISO-003-BAS/ISO-006) were recorded in the vicinity of The Glades at Byford. These sites comprise small clusters of flaked stone artefacts (34, 6 and 22 respectively) and are of low-moderate archaeological significance. All are located on Bassendean Sands or on Bassendean Sands overlying the Guildford Formation. There is also potential for further artefacts to be present in sub-surface sands in the immediate vicinity of the sites.

The field survey could not locate the previously recorded Cardup site (Site ID 3310) and it is possible that either the spatial information recorded by DIA is incorrect or that the site has been destroyed by previous land use.

Apart from Cardup Brook (site 16108) no ethnographic surveys were identified during the 2006 consultation with indigenous families.

A section 18 Notice has been granted by the Department of Indigenous Affairs that allow development of The Glades at Byford.

3 OPPORTUNITIES AND CONSTRAINTS

This section identifies the potential opportunities and constraints to the proposed development in relation to the environmental attributes of the site described in Section 2. Appropriate management measures for the potential opportunities and constraints identified in this study are discussed in Section 4.

3.1 Drainage and Stormwater Runoff

The areas that comprise of Ridge Hill Shelf units F5 and F4 generally have moderately well, to well-drained soils. The areas that would cause the most concern in terms of flooding would be the areas that have naturally poorly drained soils (i.e. Pinjarra Plain Units P1a, P1b, P1e and P3). The WADA Land capability assessment maps the southern portion of the site identified the area on the northern boundary of Cardup Brook as being subject to seasonal waterlogging and inundation. The soils contained within the P3 land unit (Figure 5) are recognised for their shallow ground water table and lack of permeability (WADA, 1990). In conjunction with being in close proximity to the watercourses (such as the areas in and around Cardup Brook), these soils are subject to periods of seasonal inundation and waterlogging.

Appropriate management measures (refer to 4.1 Drainage and Stormwater Runoff) will be required to control runoff from roads, car parking areas, roofs of buildings and lawn/landscape areas. Nutrient rich runoff from first flush rainfall events (and other potential sources of contamination eg hydrocarbons) should not be allowed to directly enter either Cardup Brook or the three intermittent watercourses flowing across the study area. Low nutrient stormwater from larger rainfall events should be allowed to overflow into these water courses.

3.2 Soils and Erosion

Nutrient retention ability refers to the ability of the soil profile to retain nutrients and in rural residential developments, is mostly relevant to the disposal of septic tank effluent.

The nutrient retention ability of soils can be demonstrated by the Phosphorus Retention Index (PRI) which measures how strongly P is adsorbed onto soil particles. Based on the subsoil samples collected from around Cardup Brook during a previous study (ATA Environmental, 2004), the Ridge Hill Shelf (F2b and F4) and Pinjarra Plain (P3) land units are characterised by moderate to very strong P retention indices (WADA, 1990).

Wind erosion risk relates to the susceptibility of bare soil to be transported by wind. Severe wind erosion is generally limited to land which has been cleared, overstocked and grazed. Wind erosion can cause the loss of topsoil, leaving behind bleached/nutrient poor soils at the surface. comparison, The better-structured soil types (eg P3) across the study area have a very low risk of wind erosion.

3.3 Surface Water Flows

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

A very low risk of water erosion exists throughout most of The Glades due to the flat topography and the lack of significant watercourses. An increased risk of water erosion is present for land in the vicinity of the seasonally flowing Cardup Brook.

3.4 Surface Water Bodies

Potential risks and pressures to the surface water bodies include:

- impact on water quality through lack of control of suspended solids during construction activities;
- impact on water flows downstream through inappropriate damming and groundwater extraction; and
- removal of riparian vegetation and associated fauna habitat.

Watercourses may be adversely affected over time because of conflicting land uses. Protection of such watercourses from any future degradation can be achieved in a number of ways including the creation of buffer zones or setbacks.

A setback is a defined area along a waterway within which clearing and certain activities are considered inappropriate. Setbacks are designed to safeguard and maintain the ecological processes and functions thereby protecting the waterway from potential negative impacts associated with land use. The DEC recommends that adequate vegetated separation buffers be maintained between developed land areas and natural waterways to minimise the risk of degradation of water quality. These separation distances should be determined in accordance with the Department's *Foreshore Policy No. 1*, with consideration to the waterway values, vulnerability and local biophysical criteria (Department of Environment 2005).

Opportunities

- Promotion of passive recreational activities (walking and cycling) with limited river access to preserve the ecological significance of the Brook.

Constraints

- During and following construction, pressures may include weed infestation, domestic animals and misuse by residents.

3.5 Wetlands

The REW located in along the Cardup Brook has some remnant vegetation and should be limited to passive recreation in keeping with the strategies and management detailed in the Foreshore Management Plan prepared by ATA Environmental (now Coffey Environments)for the southern side of the Cardup Brook (ATA, 2008).

Management of public access within REW will still need to consider a balance between the maintenance of the ecological value of the wetlands and the importance for passive recreational activities. The buffer setback for the northern side of the Foreshore Reserve should be reflective of the 30m buffer set from the riparian vegetation to the Lots for the southern side of the Brook.

The CCW in the Bush Forever Site 321 located to the east of The Glades LSP area has Good to Very Good vegetation along its western boundary. An appropriate buffer will provide a level of protection from potential negative impacts of nearby land uses.

Opportunities

- Promotion of passive recreational activities (walking and cycling) with limited river access to preserve the ecological significance of the Brook.
- Delineation of appropriate buffer setbacks from wetland within the study area and CCW in the adjacent Bush Forever Site 321 located to the east of The Glades LSP area.

3.6 Remnant Vegetation

As the majority of the study area has been cleared and used for grazing over an extended period the majority of the site is cleared of remnant native vegetation. Exceptions to this include the fringing and riparian vegetation of the Cardup Brook. The remnant vegetation across the rest of the lots was restricted to several large trees (Figure 8).

The vegetation survey in September 2005 noted that the roadside vegetation that abuts with the Bushforever Site 321 area on Warrington Road has similar vegetation type to TEC 3b and was in Good to Very Good Condition. In addition the Bush Forever 321 site is listed as a CCW on the *Geomorphic Wetlands of the Swan Coastal Plain* dataset. This roadside reserve is outside of the study area however impacts from increased road usage, urbanisation and development drainage must be limited where possible. Should there be a requirement to increase the width of Warrington Road in this area appropriate measures to protect the vegetation should be put in place.

Opportunities

- Protection of remnant vegetation along the Cardup Brook.
- Opportunities to establish and work in partnership with a local Friends/catchment group should be examined to help maintain remnant native vegetation across the site.
- Retention of large trees where possible to provide visual enhancement and vertical elevation to the otherwise flat site.

Constraints

- Pressure on remnant vegetation by residents and development drainage may lead to degradation of remnant vegetation.
- The change of land use to urban may lead to an increase in exotic weed species that may threaten the ecological integrity of remnant native vegetation and wetlands.

3.7 Significant Flora

None of the species listed as significant by DEC that have been previously recorded from the vicinity of the study area were identified from the site during the September 2005 investigation.

There are no constraints relating to significant flora.

3.8 Significant Fauna

Four conservation species species, Black Cockatoo (*Calyptorhynchus latirostris, C. baundinii, C. banksii naso*), and Rainbow Bee-eater (*Merops ornatus*) were identified as likely to be found on site. These species, excluding *C. banksii naso,* are also listed under the Commonwealth *EPBC Act* 1999.

In areas contained within The Glades, only nine individual trees were identified by the ATA Environmental (2005) survey as having potential nesting hollows for the three species of Black Cockatoo. Although there are suitable sized hollows present, some of these trees are in cleared paddocks and are therefore unlikely to be used as nesting sites. Even though there are many trees that may provide feeding sites for Black Cockatoos, there was no evidence of Black Cockatoo's feeding in the area. A search of bushland within a 10km radius of the site indicated that there were extensive areas of suitable feeding and nesting habitat that will not be impacted by the proposed development.

The clearing of vegetation for the proposed development is unlikely to have a significant impact on the three species of Black-Cockatoo.

The Quenda and Peregrine Falcon may potentially occur in the area. Given that most of the native understorey vegetation has been cleared, it is improbable that these species rely on the study area for feeding or breeding purposes. Although no targeted investigations were conducted to determine the population numbers of Quenda or Peregrine Falcons, it is unlikely that they will be significantly affected by the proposed development as areas of bushland that provide alternative and less degraded habitat are located nearby. These areas include Cardup Nature Reserve, Unnamed No. 23012 and 46818 Nature Reserves, Serpentine National Park and Bush Forever Sites 271 and 351 (Cardup Brook Bushland), 321 (Brickwood Reserve and Adjacent Bushland, Byford), and 354 (Norman Road Bushland, Whitby/Cardup).

Given that grazing throughout most of the study area has resulted in the clearing of the native understorey vegetation and that there are extensive areas of higher quality remnant vegetation reserved within close proximity, it is Coffey Environment's view that the proposed development will not significantly impact upon Commonwealth listed conservation significant species and that a Commonwealth referral under the *EPBC Act* 1999 is not required.

There are no constraints relating to fauna.

4 ENVIRONMENTAL MANAGEMENT PRACTICES FOR FUTURE DEVELOPMENT

It is recommended that the following management practices be implemented to ensure the potential for environmental damage is mitigated:

4.1 Drainage and Stormwater Runoff

All management measures should be in keeping with those presented in the BUSMS and adopted by the Shire of Serpentine Jarrahdale. To ensure nutrient rich runoff (and other potential sources of contamination) does not directly enter the watercourses the following management measures are proposed:

- In the vicinity of watercourses construct purpose built 'detention' basins that have the ability to trap sediments and nutrients. These basins should not be allowed to discharge directly to watercourses;
- Lawn areas (that require fertiliser, pesticide and/or herbicide application) should be minimised in areas of POS adjacent to watercourses;
- A 'nutrient stripping buffer' should be placed between the watercourses and the lawn areas. This may include, for example, a cut off swale planted with species capable of high nutrient uptake. Additional investigative work may be required to assess other nutrient stripping buffer methods that fit into the landscape plan and aesthetics of the site as recommended in the BUSMS; and
- During the subdivision of the study area, provide the local community/new landowners with informative literature describing preventative methods they can implement themselves (i.e. reducing nutrient run-off) to reduce adverse impacts on the environment.

4.2 Soils and Erosion

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

Ground disturbing activities should be kept to a minimum and carried out 'as required' (in stages) immediately prior to lots being released for sale as part of a 'staged' development of the site;

Landscaping/stabilising/dust suppression of areas where ground disturbance has occurred should be scheduled to occur immediately after clearing/and or infrastructure construction has been completed; and

Clearing activities have the potential to add clay 'fines' into the waterway creating turbid water downstream (mainly relevant to areas in and around Cardup Brook) and the installation of temporary drop-out basins to capture and aid in the settling of clay fines should be considered.

4.3 Surface Water Flows

With regard to maintaining surface water flows it is recommended that:

- Advice be sought from the regulatory authorities, including the Shire of Serpentine-Jarrahdale and DoW, in relation to the on-going maintenance of these flows; and
- Any requirements recommended by the regulatory authorities should be adhered to.

4.4 Surface Water Bodies/Wetlands

To minimise potential for degradation of surface water bodies or wetland, it is recommended that:

- All liquid effluent be disposed of to deep sewer;
- Implementing the drainage and stormwater runoff control measures outlined in Section 4.1;
- Adopting the recommendations in Section 4.2 to minimise the impact of soil erosion, particularly during construction;
- Direct impact on riparian vegetation and associated habitat be avoided wherever possible;
- A minimum building setback of 30m from the Cardup Brook is required to maintain the biophysical attributes of the watercourse. Creating vegetated buffer zones will provide additional habitats for wildlife using the watercourses. The setbacks are to be measured from the edge of the riparian vegetation;
- Preparation of a Foreshore Management Plan including revegetation plans for the northern side of Cardup Brook that complements the existing Foreshore Management Plan for the southern side of the Cardup Brook; and
- Native vegetation should be retained where possible within all drainage lines on the study area to prevent erosion and flooding during the wetter seasons and to prevent potential impacts on downstream areas.

4.5 Remnant Vegetation

The following recommendations have been made with respect to remnant vegetation:

- Remnant vegetation should be retained on larger lots where possible and where it is safe to do so, or within POS/road reserves;
- Vegetation should be retained near drainage channels to prevent erosion and flooding;
- Locate proposed residential development more than 30m from the edge of the riparian vegetation adjacent to Cardup Brook; and
- Preparation of a Revegetation Plan to improve any proposed POS areas, road reserves or watercourse buffers is recommended. All areas should be revegetated using local native species. The plan should set out the environmental functions that rehabilitation of these areas needs to perform including maintenance of water quality (e.g. by nutrient stripping) and improving fauna habitat.

4.6 Significant Flora

No management practises are required for significant flora, as there were none found during the Spring 2005 flora survey.

4.7 Significant Fauna

The following recommendations have been made with respect to Significant Fauna:

- Retention of the nine significant trees from within the study area identified by the ATA Environmental 2005 survey as having potential for nesting Black Cockatoos; and

- Where possible, the retention of mature native Eucalypt species is desirable to provide habitat for the three species of Black-Cockatoos.

5 CONCLUSION

The potential constraints and opportunities to the proposed development, in relation to the environmental attributes of the site outlined in Section 2, are summarised below. Appropriate management measures have been identified (Section 3) and recommendations made as to likely management practices to ameliorate the environmental constraints to the proposed development (Section 4).

Environmental Constraints

Environmental constraints to the proposed development plan have been identified as:

- The management of nutrient (and chemical) runoff from roads, buildings and lawn/landscaped areas;
- Soil erosion and the potential to impact on surface water quality from any ground disturbing activities (i.e. construction);. and
- The change of land use to urban may lead to an increase in exotic weed species that may threaten the ecological integrity of remnant native vegetation and wetlands.

Environmental Opportunities

Environmental opportunities associated with the proposed development plan include:

- the re-instatement of riparian vegetation (and provision of improved fauna habitat) of Cardup Brook;
- maintaining appropriate 'buffer' setbacks from watercourses to protect water-related ecological, recreational and cultural values

If managed correctly it is considered that the implementation of the proposed LSP will not:

- impact on existing surface water flows;
- impact on the groundwater quality;
- impact on significant wetlands;
- disturb any acid sulphate soils or create significant soil erosion;
- impact on any DEC listed vegetation or fauna species; or
- result in the removal of any riparian vegetation.

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

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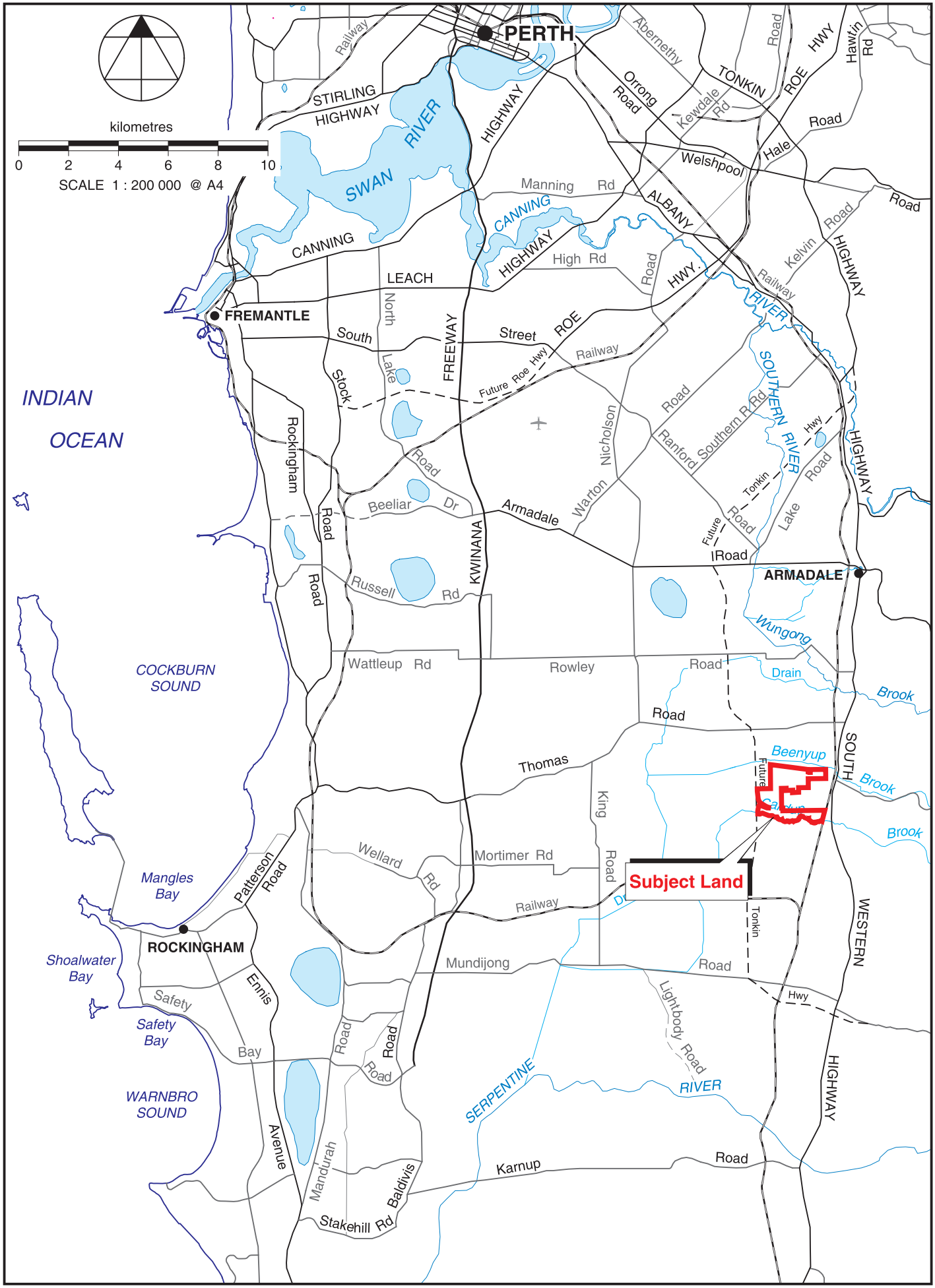

PRINTED: Mon 08 Jun 09
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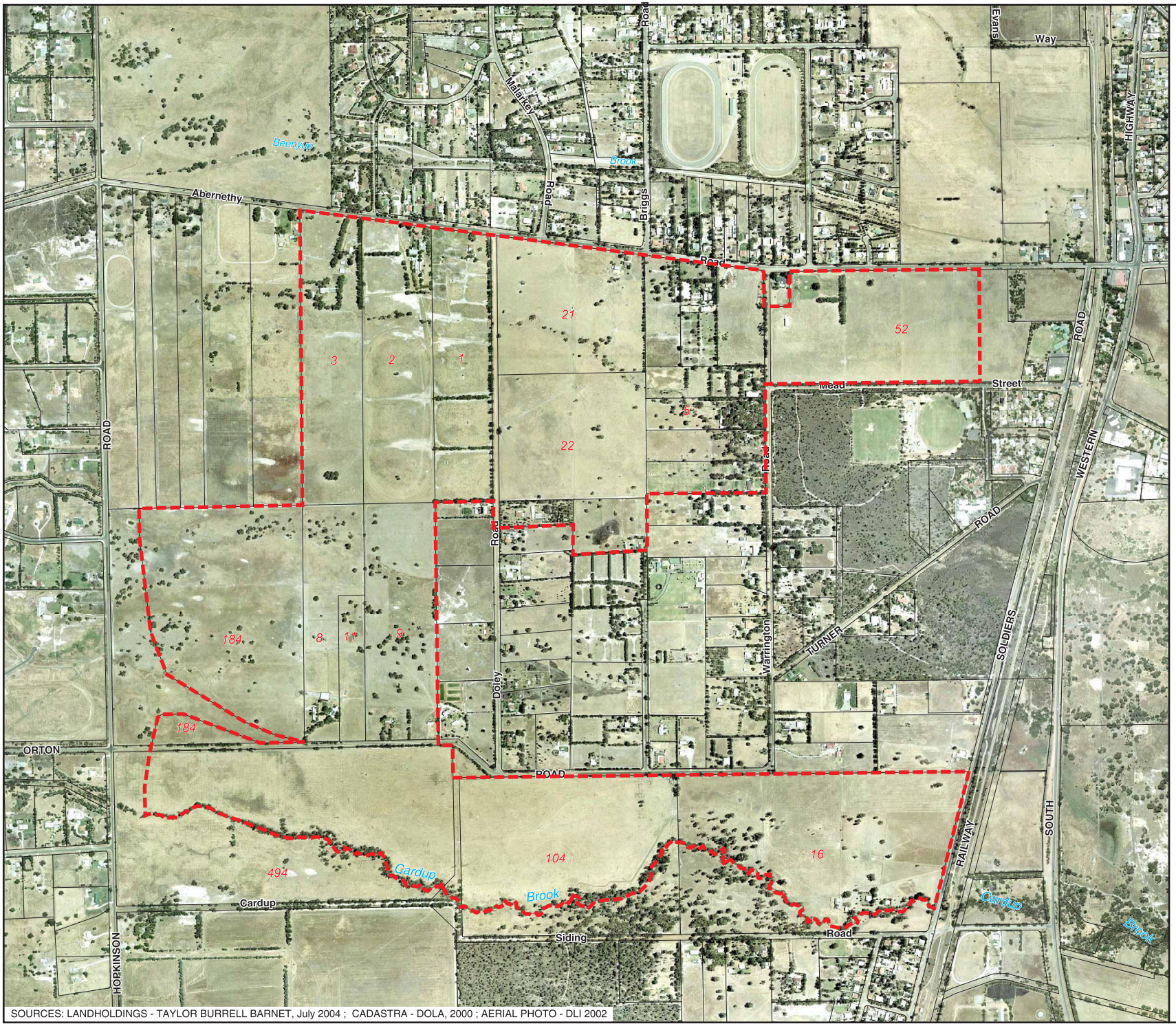
ENVIRONMENTAL APPRAISAL
THE GLADES, BYFORD

REGIONAL LOCATION

FIGURE 1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Evans
Way
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ROAD
Mead
Street
WESTERN
ROAD
TURNER
ROAD
SOLDIERS
SOUTH
RAILWAY
Road
Warrington
Road
Dolley
Road
ROAD
ORTON
HOPKINSON
ROAD
Cardup
Brook
Cardup
Siding
Road
Cardup
Brook
21
52
3
2
1
5
22
184
8
11
9
184
494
104
16
metres
0 100 200 300 400 500
SCALE 1 : 12 000 @ A3
LEGEND
Local Structure Plan Area
Cadastral Boundary
494 Lot No. within Landholdings
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ENVIRONMENTAL APPRAISAL
THE GLADES, BYFORD
THE GLADES AT BYFORD
LOCAL STRUCTURE PLAN AREA
FIGURE 2
SOURCES: LANDHOLDINGS - TAYLOR BURRELL BARNET, July 2004 ; CADASTRA - DOLA, 2000 ; AERIAL PHOTO - DLI 2002
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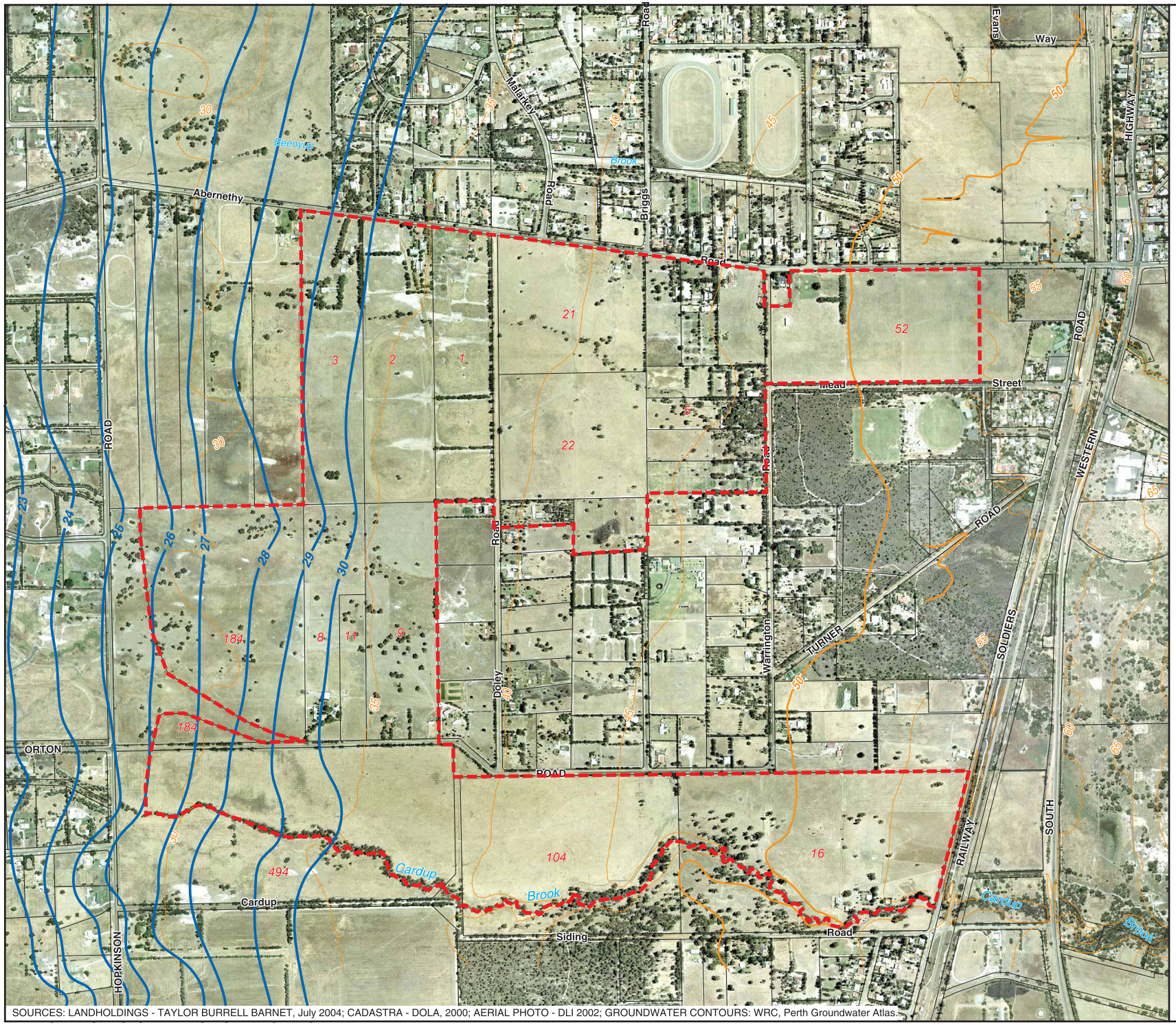

metres

0 100 200 300 400 500

SCALE 1 : 12 000 @ A3

LEGEND

- Local Structure Plan Area
- Cadastral Boundary
- 494 Lot No. within Landholdings
- 35 Topographic Contour (m AHD, 5m interval)
- Groundwater Contour (m AHD)

SOURCES: LANDHOLDINGS - TAYLOR BURRELL BARNET, July 2004; CADASTRA - DOLA, 2000; AERIAL PHOTO - DLI 2002; GROUNDWATER CONTOURS: WRC, Perth Groundwater Atlas.

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ENVIRONMENTAL APPRAISAL
THE GLADES, BYFORD

TOPOGRAPHY & GROUNDWATER CONTOURS

FIGURE 3

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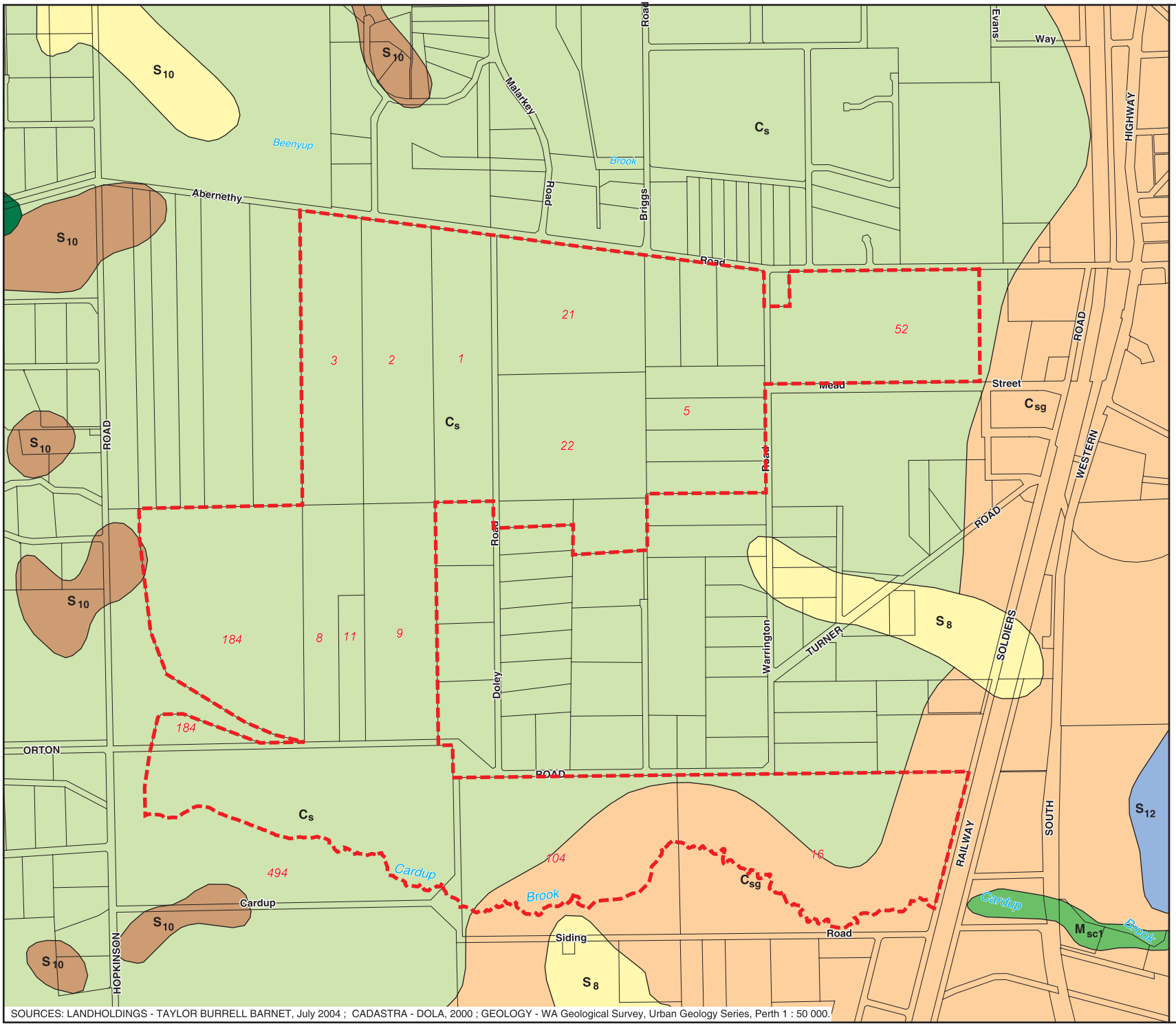

metres

0 100 200 300 400 500

SCALE 1 : 12 000 @ A3

LEGEND

- Local Structure Plan Area
- Cadastral Boundary
- 494 Lot No. within Landholdings
- —35— Topographic Contour (m AHD, 5m interval)

Geology Legend

M_{sc1}	CLAYEY SANDY SILT - Pale brown, angular to rounded sand, low cohesion, of alluvial origin.
C_{sg}	GRAVELLY SANDY CLAY - Variable, with lenses of silt and gravel, quartz sand, subangular with aeolian rounded component; heavy minerals common; gravel rounded, of colluvial origin.
S_8	SAND - White to pale grey at surface, yellow at depth, fine to medium-grained, moderately sorted, subangular to subrounded, minor heavy minerals, of eolian origin.
S_{10}	SAND - as S8 over sandy clay to clayey sand of the Guildford Formation, of eolian origin.
C_s	SANDY CLAY - white-grey to brown, fine to coarse-grained, subangular to rounded sand, clay of moderate plasticity gravel and silt layers near scarp.
S_{12}	SAND - structureless, yellow, fine-grained, subangular and medium to coarse-grained subrounded to rounded quartz, feldspar and heavy minerals common, minor silt and clay, of colluvial origin.

SOURCES: LANDHOLDINGS - TAYLOR BURRELL BARNET, July 2004 ; CADASTRA - DOLA, 2000 ; GEOLOGY - WA Geological Survey, Urban Geology Series, Perth 1 : 50 000.

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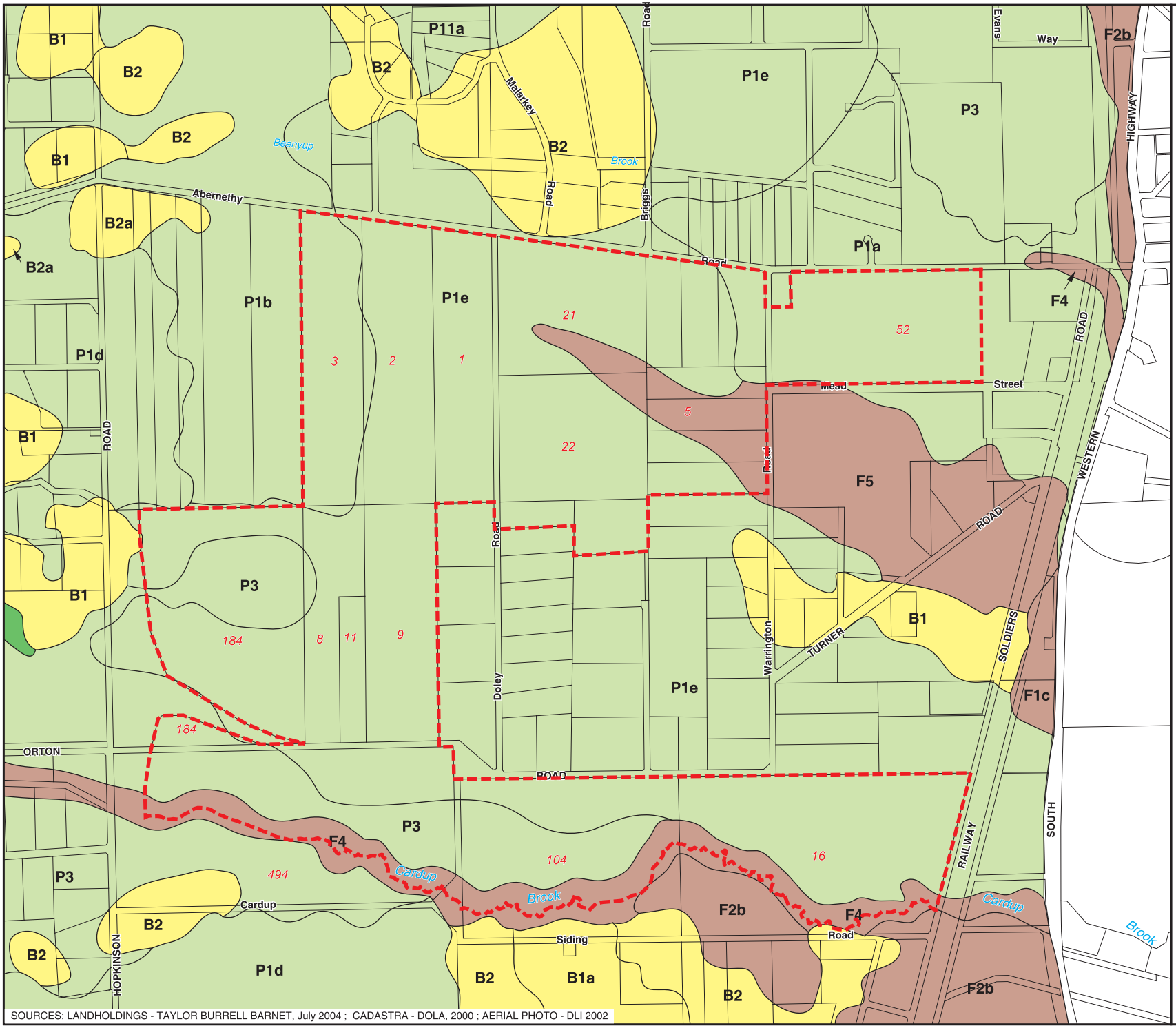
SPECIALISTS IN LIVING AND WORKING PLACES

ENVIRONMENTAL APPRAISAL
THE GLADES, BYFORD

GEOLOGICAL UNITS

FIGURE 4

PRINTED: Mon 08 Jun 09 CHECKED: BH 08-06-09 DRAWN: GLM/CR 12-05-09 DATUM: MGA zn50 ENV/PERT/00121AA/Management The Glades at Byford/EP2009-052F04.dgn



SOURCES: LANDHOLDINGS - TAYLOR BURRELL BARNET, July 2004 ; CADASTRA - DOLA, 2000 ; AERIAL PHOTO - DLI 2002

PRINTED: Mon 08 Jun 09
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DRAWN: GLM/CR 08-06-09
DATUM: MGA zn50
ENV/PERT/00121AA/Management The Glades at Byford/EP2009-052F05.dgn

metres
0 100 200 300 400 500
SCALE 1 : 12 000 @ A3

LEGEND

- Local Structure Plan Area
- Cadastral Boundary
- 494 Lot No. within Landholdings
- 35 Topographic Contour (m AHD, 5m interval)

Land Resource Mapping Units Legend

Pinjarra plain	Broad low relief west of the foothills, comprising predominantly Pleistocene fluvial sediments and some Holocene alluvium associated with major current drainage systems. Major soils are naturally poorly drained and many swamps occur.
P1a	Flat to very undulating plain with deep acidic mottled yellow duplex (or "effective duplex") soils comprising shallow pale sand to sandy loam over clay; imperfect to poorly drained and generally not susceptible to salinity.
P1b	Flat to very undulating plain with deep acidic mottled yellow duplex (or "effective duplex") soils comprising moderately deep pale sand to sandy loam over clay; imperfectly drained and moderately susceptible to salinity in limited areas.
P1e	Flat to very undulating plain with deep acidic mottled yellow duplex (or "effective duplex") soils comprising shallow pale sand to sandy loam over very gravely clay; moderately well drained.
P3	Flat to very gently undulating plain with deep, imperfect to poorly drained acidic gradational yellow or grey-brown earths and mottled yellow duplex soils, with loam to clay loam surfaces.
Ridge Hill Shelf (Foothills)	Lateritized, low relief, foothills of the Darling Scarp comprising fossil shoreline bench sediments, Holocene colluvium, and narrow bands of alluvial deposits. Slopes are very gently to gently inclined and soils are moderately well to well drained.
F2b	Very gently to gently inclined lower slopes to (1 to 5%) with moderately deep to deep, gravely acidic yellow duplex soils and rare laterite.
F4	Incised steam channels with deep acidic yellow duplex soils and sandy alluvial gradational brown earths.
F5	Poorly drained stream channels on lowest slopes and with soils similar to F4.

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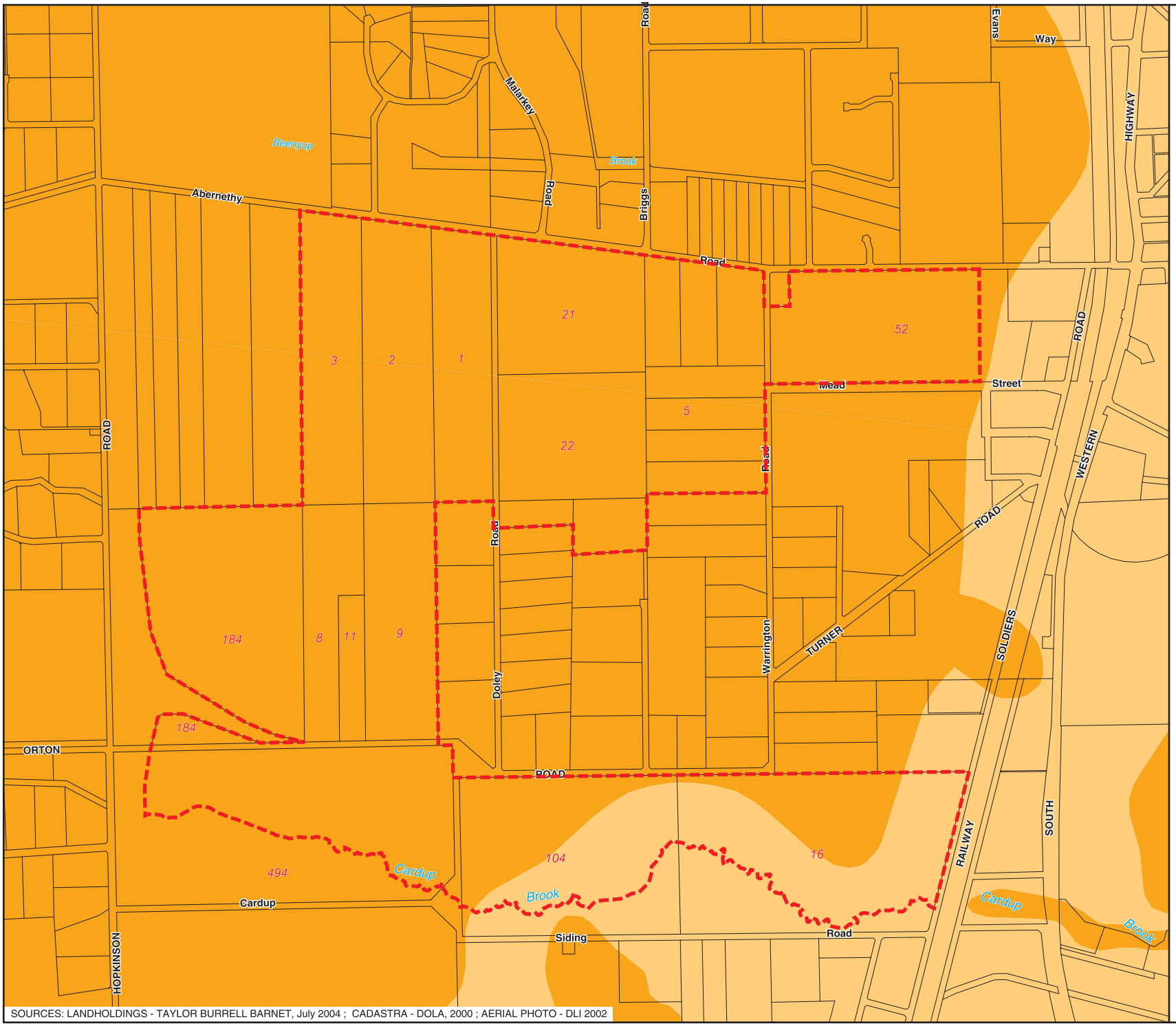
ENVIRONMENTAL APPRAISAL
THE GLADES, BYFORD

LAND RESOURCE MAPPING UNITS

FIGURE 5


Abernethy
Road
Malarkey
Road
Briggs
Road
Evans
Way
HIGHWAY
Beenyup
Brook
ROAD
Mead
Street
ROAD
WESTERN
Road
ROAD
TURNER
Warrington
Doley
Road
SOLDIERS
ROAD
ORTON
ROAD
RAILWAY
SOUTH
Cardup
Brook
Cardup
Brook
Siding
Road
HOPKINSON
21
52
3
2
1
5
22
184
8
11
9
184
494
104
16
metres
0 100 200 300 400 500
SCALE 1 : 12 000 @ A3
LEGEND
Local Structure Plan Area
Cadastral Boundary
494 Lot No. within Landholdings
ACID SULFATE SOILS RISK CATEGORY
High risk of actual acid sulfate soil (AASS) & potential acid sulfate soil (PASS) <3m from surface (N/A)
Moderate to low risk of AASS and PASS occuring generally at depths of >3m
Low to no risk of AASS and PASS occuring generally at depths of >3m
Source: DPI, 25-2-04; Datum: MGA
Mapped Scale 1:200 000,
Accurate up to 1:25 000
Indicative at
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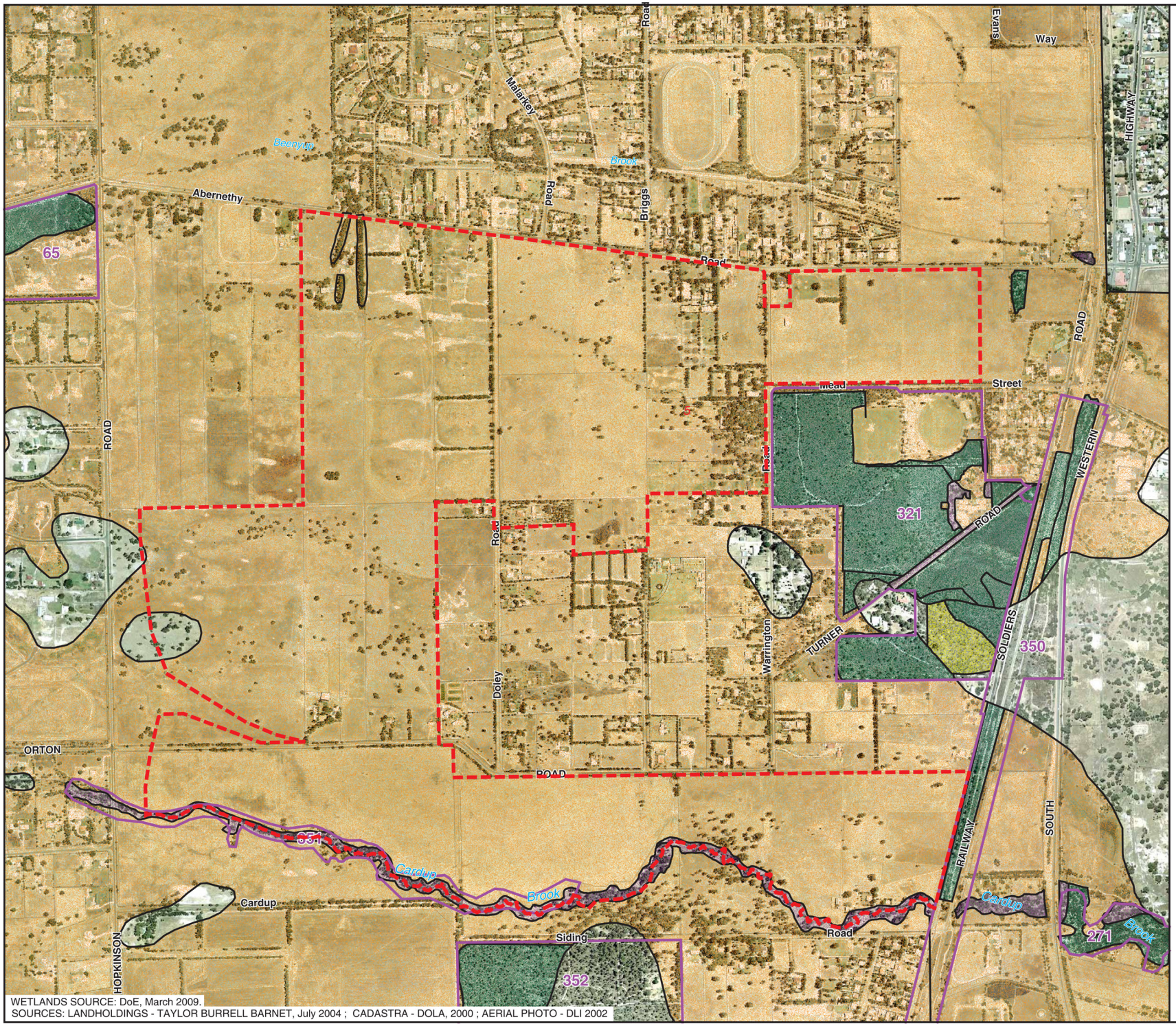
ENVIRONMENTAL APPRAISAL
THE GLADES, BYFORD
ACID SULFATE SOILS
FIGURE 6
SOURCES: LANDHOLDINGS - TAYLOR BURRELL BARNET, July 2004 ; CADASTRA - DOLA, 2000 ; AERIAL PHOTO - DLI 2002
PRINTED: Mon 08 Jun 09
CHECKED: BH 08-06-09
DRAWN: GLM/CR 12-05-09
DATUM: MGA zn50
ENV/PERT/00121AA/Management The Glades at Byford/EP2009-052F06.dgn



metres

0 100 200 300 400 500

SCALE 1 : 12 000 @ A3

LEGEND

- Local Structure Plan Area
- Cadastral Boundary
- Bush Forever Site Boundary

Wetlands Legend

- Conservation Category Wetland
- Resource Enhancement Category Wetland
- Multiple Use Wetland
- Not Applicable

WETLANDS SOURCE: DoE, March 2009.
SOURCES: LANDHOLDINGS - TAYLOR BURRELL BARNET, July 2004 ; CADASTRA - DOLA, 2000 ; AERIAL PHOTO - DLI 2002

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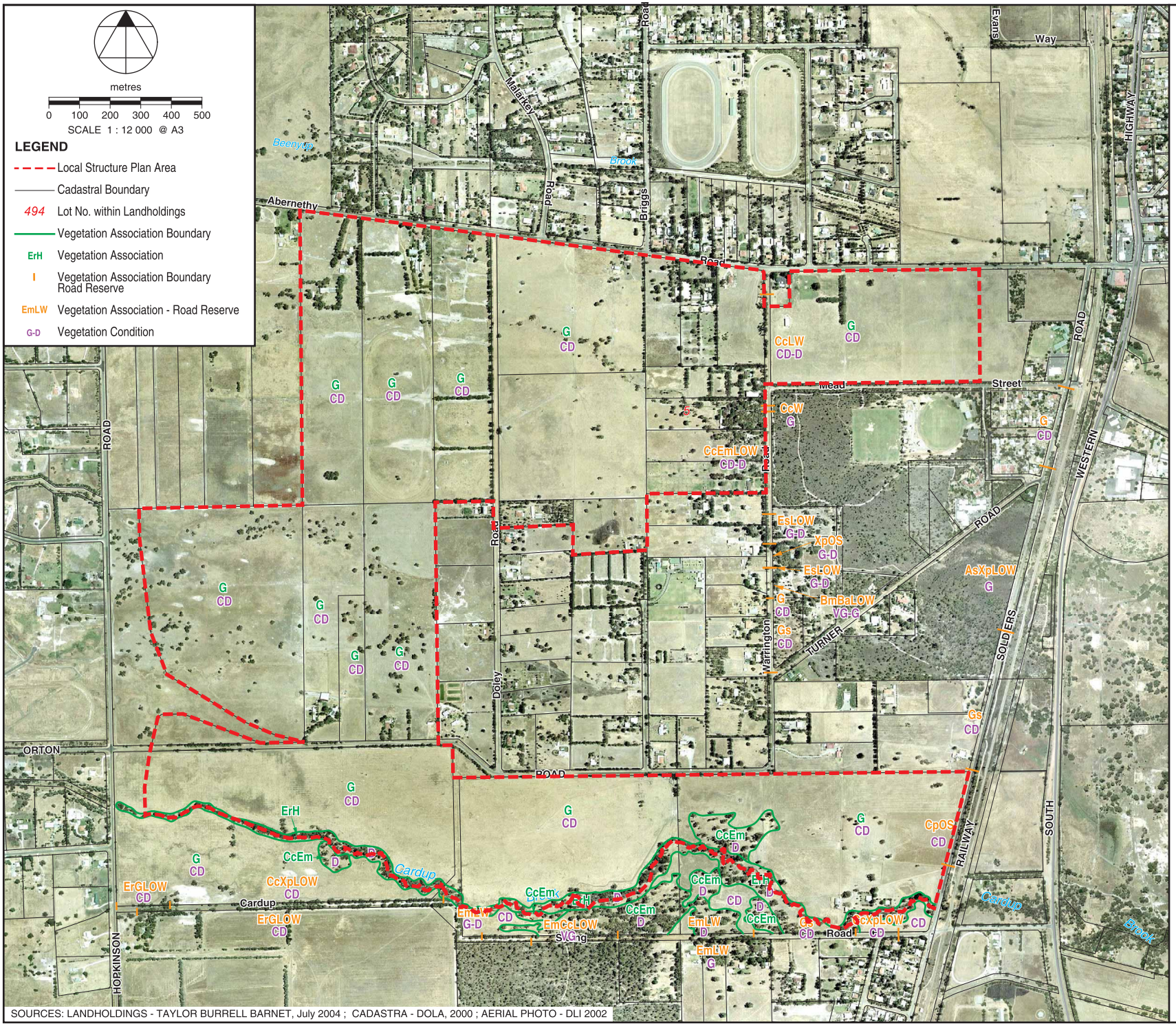
ENVIRONMENTAL APPRAISAL
THE GLADES, BYFORD

WETLAND MANAGEMENT CATEGORIES & BUSH FOREVER SITES

FIGURE 7

PRINTED: Mon 08 Jun 09 CHECKED: BH 08-06-09 DRAWN: GLM/CR 02-06-09 DATUM: MGA zn50 ENV\PERT\00121AA\Management The Glades at Byford\EP2009-052F07.dgn



PRINTED: Tue 09 Jun 09
CHECKED: BH 09-06-09
DRAWN: GLM/CR 09-06-09
DATUM: MGA zn50
ENV\PERT\00121AA\Management The Glades at Byford\EP2009-052F08.dgn

VEGETATION ASSOCIATIONS LEGEND

Woodlands

CcLOW	Low Open woodland of *Corymbia ?maculata* over introduced species on clayey soils.
CcW	Woodland of *Corymbia calophylla* with occasional **Melia azedarach* and *Callistemon phoeniceus* over introduced grasses.
ErLOW	Low Open Woodland of *Eucalyptus rudis* over a Very Open Sedgeland dominated by *Juncus subsecundus* over introduced grasses.
CcEmLOW	Low Open Woodland of *Corymbia calophylla* with occasional *Eucalyptus marginata* over a Tall Open Shrubland dominated by *Kingia australis* over a Closed Low Heath dominated by *Mesomelaena tetragona* and *Xanthorrhoea preissii* on clayey loamy soils. *FCT
EsLOW	Low Open Woodland of introduced *Eucalyptus* spp. with scattered *Xanthorrhoea preissii* over introduced grasses.
BmBaLOW	Low Open Woodland dominated by *Banksia menziesii* and *Banksia attenuata* with occasional **Pinus radiata* and *Macrozamia riedlei* over introduced grasses on clayey loamy soils.
ErGLOW	Low Open Woodland of *Eucalyptus rudis* over introduced grasses on clayey loamy soils.
EmLW	Low Woodland of *Eucalyptus marginata* with scattered *Corymbia calophylla* over an Open Shrubland dominated by *Xanthorrhoea preissii, Acacia pulchella* and *Jacksonia sternbergiana* over introduced grasses on clayey loamy soils.
CcXpLOW	Low Open Woodland of *Corymbia calophylla* with scattered *Xanthorrhoea preissii* over introduced grasses.
CcAsLOW	Low Open Woodland of *Corymbia calophylla* over a Tall Open Shrubland dominated by *Acacia saligna, Viminaria juncea* and *Hakea trifurcata* over a Low Open Shrubland dominated by *Dielsia stenostachya* and **Watsonia meriana var. bulbillifera* over introduced grasses on clayey loamy soils.
ErH	Low Open Woodland to Open Woodland of *Eucalyptus rudis* over an open understorey comprising of *Taxandria linearifolia* and stands of *Juncus subsecundus*. A number of invasive weeds were noted along the creek line including **Gomphocarpus fruticosus* (Cotton Bush), **Zantedeschia aethiopica* (Arum lily), **Cynodon dactylon* (Couch grass) and **Olea Europe* (Olive trees).
CcEm	Woodland to Open Woodland of *Eucalyptus marginata* and *Corymbia calophylla* over occasional *Kingia australis, Xanthorrhoea preissii* and introduced grasses and herbs including **Cynod dactylon, *Lupinus consentinii, *Hypochaeris glabra* and **Averia latu.*
CcVjLOW	Low Open Woodland of *Corymbia calophylla* with occasional *Viminaria juncea* over a Low Open Shrubland dominated by *Xanthorrhoea preissii, Hakea trifurcata Pericalymma ellipticum, Hakea sulcata* and Mesomelaena tetragona on clayey loamy soils.

Forests

EmCcLOW	Low Open Forest of *Eucalyptus marginata* and *Corymbia calophylla* over an Open Shrubland dominated by *Jacksonia sternbergiana* and *Acacia pulchella* with scattered Xanthorrhoea preissii and Banksia grandis on sandy clay loams.

Shrublands

XpOS	Open Shrubland dominated by *Xanthorrhoea preissii* with occasional introduced *Eucalyptus* spp., *Macrozamia riedlei* and *Jacksonia furcellata* over introduced grasses.
CpOS	Open Shrubland of *Callistemon ?phoeniceus* with scattered *Calothamnus quadrifidus* over introduced grasses on loamy clayey soils.
AsXpLOW	Low Open Shrubland dominated by *Acacia saligna, Xanthorrhoea preissii* and *Mesomelaena tetragona* with occasional *Jacksonia sternbergiana* over introduced grasses.

Grasslands

G	Grasslands with scattered native and introduced grasses and trees.
Gs	Grasslands with scattered native and introduced species.

*FCT - Inferred Floristic Community Type (FCT) 3b - *Corymbia calophylla-Eucalyptus marginata* woodlands on sandy clay soils.

VEGETATION CONDITION LEGEND

SOURCE: BUSH FOREVER Govt. of W.A., 2000

E	**Excellent** - Vegetation structure intact, disturbance affecting individual species and weeds are non aggressive species.
VG	**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.
G	Good - Vegetation structure significantly altered by very obvious signs of multiple disturbance. Retains basic vegetation structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
D	**Degraded** - Basic vegetation structure severely impacted by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example, disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
CD	**Completely Degraded** - The structure of the vegetation is no longer intact and the areas is completely or almost completely without native species. These areas are often described as 'parkland cleared' with the flora composing weed or crop species with isolated native trees or shrubs.

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ENVIRONMENTAL APPRAISAL
THE GLADES, BYFORD

VEGETATION TYPES & CONDITIONS

FIGURE 8

Appendix A
The Glades Flora List

APPENDIX A

THE GLADES FLORA LIST

Family	Confirmed ID
GYMNOSPERMAE	
Zamiaceae	*Macrozamia riedleii*
Pinaceae	**Pinus radiata*
Cupressaceae	**Cuppressus sempevirens*
MONOCOTYLEDONAE	
Anthericacea	*Chamaescilla corymbosa*
Araceae	**Zantedeschia aethiopioca*
Asparagaceae	**Asparagus asparagoides*
Colchicaceae	*Burchardia umbellata*
Cyperaceae	*Cyathochaeta avenacea*
	Lepidosperma pubisquameum
Dasypogonaceae	*Kingia australis*
Haemodoraceae	*Anigozanthos humilis*
	Conostylis ?seminuda
	Conostylis aculeata
	Conostylis setigera subsp. *setigera*
	Haemodorum laxum
Iridaceae	*Freesia x alba*
	**Romulea rosea*
	**Watsonia meriana* var. *bulbillifera*
Juncaceae	*Juncus subsecundus*
Poaceae	**Aira caryophyllea*
	Amphipogon caricinus
	**Arundo donax*
	**Avena fatua*
	**Briza minor*
	**Cynodon dactylon*
	**Ehrharta calycina*
	**Ehrharta longiflora*
	**Eragrostis curvula*
	**Hordeum* sp.
	**Lolium rigidum*
Restionaceae	*Dielsia stenostachya*
	Hypolaena exsulca
Xanthorrhoeaceae	*Xanthorrhoea preissii*
DICOTYLEDONAE	
Asclepiadaceae	**Gomphocarpus fruticosus*
Asteraceae	**Arctotheca calendula*
	**Cotula turbinata*
	**Hypochaeris glabra*
	**Sonchus oleraceus*
	**Ursinia anthemoides*

Family	Confirmed ID
Brassicaceae	**Raphanus raphanistrum*
Dilleniaceae	*Hibbertia huegelii*
	Hibbertia hypericoides
Drosercaceae	*Drosera menziesii* subsp. *menziesii*
Euphorbiaceae	**Ricinus communis*
Geraniaceae	**Erodium botrys*
	**Pelargonium capitatum*
Goodeniaceae	*Dampiera linearis*
	Lechenaultia floribunda
	Scaevola sp.
Lamiaceae	**Stachys arvensis*
Lauraceae	*Cassytha racemosa*
Loranthaceae	*Nuytsia floribunda*
Meliaceae	**Melia azedarach*
Mimosaceae	**Acacia iteaphylla*
	Acacia ?lasiocarpa var. lasiocarpa
	Acacia pulchella
	Acacia saligna
Moraceae	**Ficus* sp.
Myrtaceae	*Callistemon phoeniceus*
	Calothamnus quadrifidus
	Corymbia ?maculata
	Corymbia calophylla
	Eucalyptus camaldulensis
	Eucalyptus marginata
	Eucalyptus rudis
	Eucalyptus wandoo
	**Eucalyptus* spp.
	Hypocalymma robustum
	**Melaleuca armillaris*
	Melaleuca raphiophylla
	Pericalymma ellipticum
	Taxandria linearifolia
Oxalidaceae	**Oxalis pes-caprae*
Papilionaceae	*Daviesia physodes*
	**Erythrina x sykesii*
	Gompholobium tomentosum
	Jacksonia furcellata
	Jacksonia sternbergiana
	Kennedia prostrata
	**Lotus angustissimus*
	**Lupinus cosentinii*
	**Trifolium campestre*
	Viminaria juncea
Polygonaceae	**Acetosella vulgaris*
	**Rumex crispus*
Proteaceae	*Banksia attenuata*

Family	Confirmed ID
	Banksia menziessii
	Dryandra lindleyana
	Grevillea pilulifera
	Hakea lissocarpha
	Hakea prostrata
	Hakea ruscifolia
	Hakea sulcata
	Hakea trifurcata
	Stirlingia latifolia
	Synaphea ?petiolaris
Ranunculaceae	*Clematis linearifolia*
Rutaceae	*Philothca spicata*
Solanaceae	**Solanum nigrum*
Tropaeolaceae	**Tropaeolum majus*
TOTAL **Natives** **Introduced**	**100** **60** **40**

*Denotes introduced and non-endemic species (weeds)

Appendix B
Flora Quadrat Data

QUADRAT Q1
406364E 6434606N
(G)
Grasslands with scattered native and introduced grasses
Condition: Completely Degraded

QUADRAT Q1 (10x10m)

SPECIES	% COVER	HEIGHT (M)
**Cuppressus sempevirens*	3	7
Melaleuca rhaphiophylla	1	4
**Zantedeschia aethiopica*	<1	0.8
**Sonchus oleraceus*	1	0.2
**Arctotheca calendula*	2	0.2
**Cynodon dactylon*	3	0.2
**Ehrharta longiflora*	90	0.1

*Denotes introduced and non-endemic species (weeds)

QUADRAT 2
405466E 6434524N
(G)
Grasslands with scattered native and introduced grasses
Condition: Completely Degraded

QUADRAT Q2 (10x10m)

SPECIES	% COVER	HEIGHT (M)
**Eucalyptus* spp.	3	12
**Romulea rosea*	<1	0.2
**Avena fatua*	2	0.2
**Arctotheca calendula*	5	0.2
**Cynodon dactyloniflora*	80	0.2
**Aira caryophyllea*	<1	0.1
**Rumex crispus*	3	0.1
**Oxalis pes-caprae*	10	0.1

*Denotes introduced and non-endemic species (weeds)

QUADRAT Q3
404836E 6434605N
(G)
Grasslands with scattered native and introduced grasses
Condition: Completely Degraded

QUADRAT Q3 (10X10M)

SPECIES	% COVER	HEIGHT (M)
**Eragrostis curvula*	2	0.7
**Arctotheca calendula*	60	0.6
**Lupinus cosentinii*	<1	0.3
**Cynodon dactylon*	90	0.3
**Stachys arvensis*	<1	0.1

*Denotes introduced and non-endemic species (weeds)

QUADRAT Q4
404000E 6434462N
(C?mLOW)

Low Open woodland of *Corymbia ?maculata* over introduced species on clayey soils

Condition: Completely Degraded

QUADRAT Q4 (10x10m)

SPECIES	% COVER	HEIGHT (M)
Corymbia ?maculata	4	9.5
**Cynodon dactylon*	60	0.3
**Romulea rosea*	2	0.1
**Tropaeolum majus*	<1	0.4
**Solanum nigrum*	<1	0.3
Hordeum sp.	2	0.3

*Denotes introduced and non-endemic species (weeds)

QUADRAT Q5
405393E 6434459N
(CcLW)

Low Woodland of *Corymbia calophylla* with occasional *Xanthorrhoea preissii* over introduced grasses.

Condition: Completely Degraded to Degraded

QUADRAT Q5 (10x10m)

SPECIES	% COVER	HEIGHT (M)
Corymbia calophylla	12	8
Xanthorrhoea preissii	2	1.5
**Eragrostis curvula*	80	0.7
**Ehrharta longiflora*	2	0.6
**Erodium botrys*	<1	0.1
**Romulea rosea*	<1	0.1

*Denotes introduced and non-endemic species (weeds)

QUADRAT Q6
405392E 6434095N
(CcW)

Woodland of *Corymbia calophylla* with occasional **Melia azedarach* and *Callistemon phoeniceus* over introduced grasses.

Condition: Good

QUADRAT Q6 (10x10m)

SPECIES	% COVER	HEIGHT (M)
Corymbia calophylla	15	12
**Solanum nigrum*	<1	0.4
**Eragrostis curvula*	2	0.4
**Ehrharta longiflora*	75	0.4
**Romulea rosea*	5	0.3
**Trifolium campestre*	2	0.1

*Denotes introduced and non-endemic species (weeds)

QUADRAT Q7
405824E 6432440N
(ErLOW)

Low Open Woodland of *Eucalyptus rudis* over a Very Open Sedgeland dominated by *Juncus subsecundus* over introduced grasses

Condition: Good to Degraded

QUADRAT 7 (10x10m)

SPECIES	% COVER	HEIGHT (M)
Eucalyptus rudis	4	9
**Zantedeschia aethiopica*	<1	0.6
Juncus subsecundus	3	0.6
**Ehrharta longiflora*	50	0.4
**Oxalis pes-caprae*	30	0.1

*Denotes introduced and non-endemic species (weeds)

QUADRAT Q8
405418E 6434076
(CcEmLOW)

Low Open Woodland of *Corymbia calophylla* with occasional *Eucalyptus marginata* over a Tall Open Shrubland dominated by *Kingia australis* over a Closed Low Heath dominated by *Mesomelaena tetragona* and *Xanthorrhoea preissii* on clayey loamy soils.

Condition: Excellent to Very Good

QUADRAT 8 (10x10m)

SPECIES	% COVER	HEIGHT (M)
Corymbia calophylla	6	7
Eucalyptus marginata	3	6.5
Kingia australis	2	4.5
Hakea ruscifolia	<1	2
Jacksonia furcellata	1	1.2
Daviesia physodes	1	1
Xanthorrhoea preissii	6	1
Philotheca spicata	<1	0.8
Cyathochaeta avenacea	<1	0.8
Hakea prostrata	3	0.7
Lechenaultia floribunda	1	0.6
Grevillea pilulifera	<1	0.6
Lepidosperma pubisquameum	<1	0.6
Acacia pulchella	<1	0.6
Synaphea ?petiolaris	<1	0.6
Gompholobium tomentosum	<1	0.6

Mesomelaena tetragona	70	0.6
Acacia ?lasiocarpa var. *lasiocarpa*	<1	0.5
Stirlingia latifolia	<1	0.4
Amphipogon caricinus	<1	0.4
Haemodorum laxum	<1	0.4
Acacia stenoptera	<1	0.4
Conostylis aculeata	<1	0.4
**Cynodon dactylon*	2	0.4
Conostylis setigera subsp. *setigera*	2	0.3
Chamaescilla corymbosa	<1	0.2
Dryandra lindleyana	<1	0.2
Cassytha racemosa	<1	Creeper
Drosera menziesii subsp. *menziesii*	<1	Creeper

*Denotes introduced and non-endemic species (weeds)

QUADRAT Q9
405420E 6433741N
(EsLOW)

Low Open Woodland of introduced *Eucalyptus* spp. with scattered *Xanthorrhoea preissii* over introduced grasses.

Condition: Good to Degraded

QUADRAT 9 (10x10m)

SPECIES	% COVER	HEIGHT (M)
**Eucalyptus* spp.	3	4
Xanthorrhoea preissii	3	1.5
**Eragrostis curvula*	2	0.4
**Ehrharta longiflora*	5	0.4
**Arctotheca calendula*	3	0.2
**Lotus angustissimus*	6	0.1

*Denotes introduced and non-endemic species (weeds)

QUADRAT Q10
405412E 6433643N
(XpOS)

Open Shrubland dominated by *Xanthorrhoea preissii* with occasional introduced *Eucalyptus* spp., *Macrozamia riedlei* and *Jacksonia furcellata* over introduced grasses.

Condition: Good to Degraded

QUADRAT 10 (10x10m)

SPECIES	% COVER	HEIGHT (M)
**Hypochaeris glabra*	<1	Prostrate
Xanthorrhoea preissii	2	2
**Eragrostis curvula*	50	0.8
**Ehrharta longiflora*	10	0.3

*Denotes introduced and non-endemic species (weeds)

QUADRAT Q11
405412E 6433566N
(BmBaLOW)

Low Open Woodland dominated by *Banksia menziesii* and *Banksia attenuata* with occasional **Pinus radiata* and *Macrozamia riedlei* over introduced grasses on clayey loamy soils

Condition: Very Good to Good

QUADRAT 11 (10x10m)

SPECIES	% COVER	HEIGHT (M)
Banksia menziesii	4	5
Banksia attenuata	3	4.5
**Pinus radiata*	2	3
**Eragrostis curvula*	3	0.8
Mesomelaena tetragona	<	0.6
Macrozamia riedlei	<1	0.6
**Erharta longiflora*	5	0.4
**Ursinia anthemoides*	<1	0.3

*Denotes introduced and non-endemic species (weeds)

QUADRAT Q12
405411E 6433466N
(Gs)
Grasslands with scattered native and introduced species
Condition: Completely Degraded

QUADRAT 12 (10x10m)

SPECIES	% COVER	HEIGHT (M)
**Eragrostis curvula*	90	0.8
**Ehrharta calycina*	2	0.7
**Hypochaeris glabra*	3	0.1
**Ursinia anthemoides*	5	0.1

*Denotes introduced and non-endemic species (weeds)

QUADRAT Q13
403341E 6432455N
(ErGLOW)

Low Open Woodland of *Eucalyptus rudis* over introduced grasses on clayey loamy soils

Condition: Completely Degraded

QUADRAT 13 (10x10m)

SPECIES	% COVER	HEIGHT (M)
Eucalyptus rudis	3	8
**Ehrharta longiflora*	90	0.4

*Denotes introduced and non-endemic species (weeds)

QUADRAT Q14
404629E 6432357N
(EmLW)

Low Woodland of *Eucalyptus marginata* with scattered *Corymbia calophylla* over an Open Shrubland dominated by *Xanthorrhoea preissii, Acacia pulchella* and *Jacksonia sternbergiana* over introduced grasses on clayey loamy soils.

Condition: Good

QUADRAT 14 (10x10m)

SPECIES	% COVER	HEIGHT (M)
Eucalyptus marginata	11	9
Jacksonia sternbergiana	3	2.2
Xanthorrhoea preissii	6	1.4
Lepidosperma pubisquameum	<1	0.7
Acacia pulchella	<1	0.6
Burchardia umbellate	<1	0.6
Mesomelaena tetragona	2	0.6
Hibbertia hypericoides	2	0.6
**Ehrharta longiflora*	60	0.6
**Briza minor*	<1	0.3
**Zantedeschia aethiopica*	<1	0.2
**hypochaeris glabra*	<1	0.1

*Denotes introduced and non-endemic species (weeds)

QUADRAT Q15
405829E 6432364N
(CcXpLOW)

Low Open Woodland of *Corymbia calophylla* with scattered *Xanthorrhoea preissii* over introduced grasses

Condition: Completely Degraded

QUADRAT 15 (10x10m)

SPECIES	% COVER	HEIGHT (M)
Corymbia calophylla	3	8
Xanthorrhoea preissii	2	0.8
**Romulea rosea*	60	0.3
**Oxalis pes-caprae*	20	0.2

*Denotes introduced and non-endemic species (weeds)

QUADRAT Q16
404912E 6432354N
(EmCcLOW)

Low Open Forest of *Eucalyptus marginata* and *Corymbia calophylla* over an Open Shrubland dominated by *Jacksonia sternbergiana* and *Acacia pulchella* with scattered Xanthorrhoea preissii and Banksia grandis on sandy clay soils.

Condition: Very Good

QUADRAT 16 (10x10m)

SPECIES	% COVER	HEIGHT (M)
Eucalyptus marginata	20	8
Corymbia calophylla	15	7.5
Jacksonia sternbergiana	7	2
Acacia pulchella	5	1.6
Xanthorrhoea preissii	4	1.5
Haemodorum laxum	<1	0.8
Lepidosperma pubisquameum	<1	0.7
**Eragrostis curvula*	3	0.6
**Ehrharta calycinus*	5	0.6
**Watsonia meriana* var. *bulbillifera*	<1	0.4
Conostylis ?seminuda	<1	0.4
Hibbertia hypericoides	2	0.4
Mesomelaena tetragona	3	0.4
Kennedia prostrata	<1	Creeper

QUADRAT Q17
405988E 6432594N
(CpOS)

Open Shrubland of *Callistemon ?phoeniceus* with scattered *Calothamnus quadrifidus* over introduced grasses on loamy clayey soils

Condition: Completely Degraded

QUADRAT 17 (10x10m)

SPECIES	% COVER	HEIGHT (M)
Callistemon phoeniceus	3	2
Calothamnus quadrifidus	2	1.8
**Eragrostis curvula*	5	0.7
**Ehrharta longiflora*	70	0.3
**Ehrharta calycina*	15	0.2

*Denotes introduced and non-endemic species (weeds)

QUADRAT Q18
406173E 6433360N
(AsXpLOW)

Low Open Shrubland dominated by *Acacia saligna, Xanthorrhoea preissii* and *Mesomelaena tetragona* with occasional *Jacksonia sternbergiana* over introduced grasses

Condition: Good

QUADRAT 18 (10x10m)

SPECIES	% COVER	HEIGHT (M)
Jacksonia sternbergiana	1	2.1
Acacia saligna	10	2.1
Xanthorrhoea preissii	3	1
**Eragrostis curvula*	3	0.7
Mesomelaena tetragona	5	0.6
Synaphea ?petiolaris	2	0.4
**Romulea rosa*	<1	0.1

*Denotes introduced and non-endemic species (weeds)

QUADRAT Q19
406261E 6433683N
(CcAsLOW)

Low Open Woodland of *Corymbia calophylla* over a Tall Open Shrubland dominated by *Acacia saligna, Viminaria juncea* and *Hakea trifurcata* over a Low Open Shrubland dominated by *Dielsia stenostachya* and **Watsonia meriana* var*. bulbillifera* over introduced grasses on clayey loamy soils.

Condition: Good to Degraded

QUADRAT 19 (10x10m)

6.1.1.1.1.1.1.1 SPECIES	**% COVER**	**HEIGHT (M)**
Corymbia calophylla	3	6.5
Viminaria juncea	2	4
Acacia saligna	2	3
Hakea trifurcata	1	2.1
Dielsia stenostachya	30	0.7
Mesomelaena tetragona	2	0.6
**Watsonia meriana var. bulbillifera*	25	0.6
**Cynodon dactylon*	10	0.1

*Denotes introduced and non-endemic species (weeds)

QUADRAT Q20
406155E 6433223N
(CcVjLOW)

Low Open Woodland of *Corymbia calophylla* with occasional *Viminaria juncea* over a Low Open Shrubland dominated by *Xanthorrhoea preissii, Hakea trifurcata Pericalymma ellipticum, Hakea sulcata* and Mesomelaena tetragona on clayey loamy soils.

Condition: Good

QUADRAT 20 (10x10m)

SPECIES	% COVER	HEIGHT (M)
Corymbia calophylla	3	5
Kingia australis	<1	3
Viminaria juncea	4	1.5
Xanthorrhoea preissii	3	1.2
Hakea trifurcata	2	0.8
Mesomelaena tetragona	5	0.8
Hakea sulcata	2	0.4
Pericalymma ellipticum	5	0.3

*Denotes introduced and non-endemic species (weeds)

Appendix C
DEC Threatened Fauna Search Results

DEPARTMENT OF ENVIRONMENT AND CONSERVATION

THREATENED FAUNA INFORMATION

Conditions In Respect Of Supply Of Information

- All requests for data to be made in writing to the Executive Director, Department of Conservation and Land Management, Attention: Senior Zoologist, Wildlife Branch.
- The data supplied may not be supplied to other organisations, nor be used for any purpose other than for the project for which they have been provided without the prior consent of the Executive Director, Department of Conservation and Land Management.
- Specific locality information for Threatened Fauna is regarded as confidential, and should be treated as such by receiving organisations. Specific locality information for Threatened Fauna may not be used in reports without the written permission of the Executive Director, Department of Conservation and Land Management. Reports may only show generalised locations or, where necessary, show specific locations without identifying species. The Senior Zoologist is to be contacted for guidance on the presentation of Threatened Fauna information.
- Receiving organisations should note that while every effort has been made to prevent errors and omissions in the data, they may be present. The Department of Conservation and land Management accepts no responsibility for this.
- Receiving organisations must also recognise that the database is subject to continual updating and amendment, and such considerations should be taken into account by the user.
- It should be noted that the supplied data do not necessarily represent a comprehensive listing of the Threatened Fauna of the area in question. Its comprehensiveness is dependent of the amount of survey carried out within a specified area. The receiving organisation should employ a biologist/zoologist, if required, to undertake a survey of the area under consideration.
- Acknowledgment of the Department of Conservation and Land Management as the source of data is to be made in any published material. Copies of all such publications are to be forwarded to the Department of Conservation and Land Management, Attention; Senior Zoologist, Wildlife Branch.

32.22 °S 115.97 °E / 32.24 °S 116.01 °E Cardup Main Precinct Area

*	*Date*	*Certainty*	*Seen*	*Location Name*	*Method*

Schedule 1 - Fauna that is rare or is likely to become extinct

Dasyurus geoffroii **Chuditch** *0 records*

This carnivorous marsupial occupies large home ranges, is highly mobile and appears able to utilise bush remnants and corridors. This species is likely to occur as occasional vagrants in the area in question.

Calyptorhynchus banksii naso **Forest Red-tailed Black-Cockatoo** *0 records*

This subspecies of the Red-tailed Black Cockatoo is restricted to the forests of the south-west. It requires tree hollows to nest and breed and is totally dependent on jarrah-marri forest. This species has been recorded from nearby Cardup Nature Reserve.

Calyptorhynchus baudinii **Baudin's Black-Cockatoo** *0 records*

This species is a seasonal visitor to the northern forests and adjacent eastern edge of the coastal plain, feeding on the seeds of eucalypts and various proteaceous species. It breeds in spring/summer in the southern forests, nesting in tree hollows (primarily in Marri). It may occur in the area in question.

Calyptorhynchus latirostris **Carnaby's Black-Cockatoo** *0 records*

This species moves around seasonally in flocks to feeding areas in proteaceous scrubs and heaths and eucalypt woodlands as well as pine plantations. Breeding occurs in winter/spring, mainly in the eastern forests and wheatbelt where they can find mature hollow-bearing trees to nest in. It is likely to occur in the area in question.

Priority Five: Taxa in need of monitoring (conservation dependent)

Isoodon obesulus fusciventer **Quenda** *0 records*

This species prefers areas with dense understorey vegetation, particularly around swamps and along watercourses, that provides ample protection from predators. This species has been recorded from nearby Cardup Nature Reserve.

---

* Information relating to any records provided for listed species:-
Date: date of recorded observation
Certainty (of correct species identification): 1=Very certain; 2=Moderately certain; and 3=Not sure.
Seen: Number of individuals observed.
Location Name: Name of reserve or nearest locality where observation was made
Method: Method or type of observation

Appendix D
DoE Letters – Wetland Re-evaluation Response (29 July 2004, 17 February 2006)

Department of Environment

Your ref:	ENASWET001cm
Our ref:	15849V16
Enquiries:	Jennifer Higbid
Direct tel:	6364 6619

Ms Christine McCagh
ATA Environmental
Dilhorn House
2 Bulwer Street
PERTH WA 6000

ENTERED
21 FEB 2006

Dear Ms McCagh,

RE: REQUEST TO ALTER THE *GEOMORPHIC WETLANDS SWAN COASTAL PLAIN* DATASET FOR LOT 3 ABERNETHY RD, BYFORD (UFI No's. 7865, 7866 and 7829).

I refer to your correspondence of 13 February 2006 requesting modification of the *Geomorphic Wetlands Swan Coastal Plain* dataset for the above location. The Department of Environment (DoE) has reviewed the information and provides the following assessment of the wetland modification request.

Environmental Protection Authority Bulletin (EPA) 686 Questionnaire (EPA 1993) is acknowledged as a method of determining wetland management categories but is also recognised as being focused on wetlands with open water bodies (EPA 2004). In assessing wetland evaluation, the DoE considers the results of EPA Bulletin 686 Questionnaire within the context of all available information, but not as the sole determinant of a wetland management category.

Wetland areas 7865, 7866 and 7829 have been significantly altered through past land use activities and few ecological attributes and functions are remaining. The wetland management category will therefore be modified to Multiple Use.

The *Geomorphic Wetlands Swan Coastal Plain* dataset will be updated to reflect the change in wetland management category. Please contact Jennifer Higbid on 6364 6619 if you require further information regarding this matter.

Yours sincerely,

Natalie Thorning
Wetlands Program Coordinator

17 February 2006

Westralia Square
Level 8 141 St Georges Terrace
Perth Western Australia 6000
PO Box K822 Perth Western Australia 6842
Telephone (08) 9222 7000 Facsimile (08) 9322 1598
E-mail info@environment.wa.gov.au
www.environment.wa.gov.au

WESTERN AUSTRALIAN environment AWARDS

The Atrium
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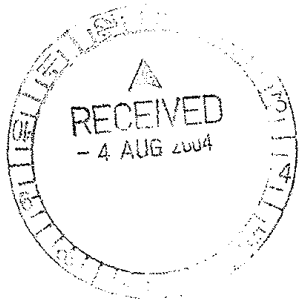
PO Box K822 Perth Western Australia 6842
Telephone (08) 6364 6500 Facsimile (08) 6364 6520
E-mail info@environment.wa.gov.au
www.environment.wa.gov.au

Department of Environment

Your ref: LWP-2003-001_013_sm
Our ref: 13668-05
Enquiries: Justine Lawn
Direct tel: 9278 0451



Sarah Maxwell
Senior Environmental Scientist
ATA Environmental
Dilhorn House
2 Bulwer Street
PERTH WA 6000

Dear Sarah,

RE: WETLAND RE-EVALUATION AND BOUNDARY REDEFINTION REQUEST, CARDUP BROOK, BYFORD

Thank you for your correspondence of 3 May 2004 requesting the re-evaluation of wetlands within Lot 104 Cardup Siding Rd, Lot 494 Hopkinson Rd and Lot 16 Soldiers Rd, Byford. The documentation has been reviewed by the Wetlands Program and the Waterways and NRM Program and the assessment is as follows:

1. Wetland MIN No. 906 2033 I SE– Cardup Brook channel
   The Department of Environment approves the re-evaluation of this wetland from Conservation to Resource Enhancement management category.

2. Wetland MIN No. 139-V26 2033 I SE
   The Department of Environment approves the re-evaluation of this wetland from Conservation to Resource Enhancement management category.

3. Wetland MIN 139-V20 2033 I SE
   The Department of Environment approves the re-evaluation of this wetland from Conservation to Conservation and Multiple Use management category.

4. Wetland MIN 139-V22 2033 I SE
   Insufficient information has been provided to demonstrate that this area is not/no longer wetland.

5. Wetland MIN 139-V27 2033 I SE
   Insufficient information has been provided to demonstrate that this area is not/no longer wetland.

Accordingly, the Geomorphic Wetlands Swan Coastal Plain dataset will be updated to reflect the changes to Wetland MIN No. 906, 139-V26 and 139-V20 of map sheet 2033 I SE.

Westralia Square
Level 8 141 St Georges Terrace
Perth Western Australia 6000
PO Box K822 Perth Western Australia 6842
Telephone (08) 9222 7000 Facsimile (08) 9322 1598
E-mail info@environment.wa.gov.au
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Hyatt Centre
Level 2 3 Plain Street
East Perth Western Australia 6004
PO Box 6740 Hay Street East Perth Western Australia 6892
Telephone (08) 9278 0300 Facsimile (08) 9278 0301
National Relay Service (Australian Communication Exchange) 132 544
E-mail info@environment.wa.gov.au
www.environment.wa.gov.au

Further information is required to determine the adequacy of the proposed 30m development setback. The proponent is directed to the Department's Foreshore Policy 1 – Identifying the Foreshore Areas (available from the Department's website) which outlines the use of biophysical criteria in determining appropriate setbacks for development. ATA are advised that the following information will be required, together with a review of the biophysical criteria, to evaluate the proposed development setback:

- proposed land use/zoning of lots in the proposed development;
- proposed methods for delineation of buffers; and
- location of infrastructure within the foreshore area (including dual use paths and recreation areas).

The information provided to date indicates that roads and lots will be located within the foreshore area. This should be clarified in future correspondence.

The process of determining the adequacy of the foreshore area will be handled by the Department's Kwinana Peel regional office based in Mandurah with advice where required to be provided by the Restoration and Management Section. Therefore, future correspondence in this regard should be directed to:

Adrian Parker, Senior NRM Officer
Department of Environment
Suite 8, Sholl House
21 Sholl Street
Mandurah, WA 6210.

The Wetlands Program would like to take this opportunity to note some shortcomings of the re-evaluation request, which have caused delays in the assessment process. In particular, the absence of wetland identification numbers within the written request has meant that the Wetlands Program has had to identify the wetland being discussed in each paragraph by a process of elimination. This task was made more difficult by the fact that the original mapping has been misinterpreted such that upland and wetland had been mistaken for the other.

Yours sincerely

Sharon Stratico
COORDINATOR, WETLANDS PROGRAM

29 July 2004

cc Adrian Parker

APPENDIX 3
BLACK COCKATOO ASSESSMENT (COFFEY ENVIRONMENTAL)

coffey environments
SPECIALISTS IN LIVING AND WORKING PLACES

BLACK COCKATOO ASSESSMENT
THE GLADES AT BYFORD

Prepared for:

LWP Property Group Pty Ltd
34 Main Street
ELLENBROOK WA 6060

Report Date: 29 May 2009
Project Ref: EP2009-078, V1

Written/Submitted by:

Scott Thompson
Senior Environmental Scientist
(Zoology)

Written/Submitted by:

Belinda Heath
Senior Environmental Scientist

Reviewed/Approved by:

Paul van der Moezel
Principal

Coffey Environments Pty Ltd ABN 45 090 522 759
Suite 2, 53 Burswood Road Burswood WA 6100 Australia
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ENVIPERT00121AA_Glades_006_bh_V1.docx

coffey environments
SPECIALISTS IN LIVING AND WORKING PLACES

29 May 2009

LWP Property Group Pty Ltd
34 Main Street
ELLENBROOK WA 6060

Attention: Phil Cuttone

Dear Phil

RE: Black Cockatoo Assessment - The Glades at Byford

Coffey Environments have prepared a Black Cockatoo Assessment Report for The Glades Local Structure Plan area. This report has been based on the findings of the survey undertaken in February 2005 by Dr Scott Thompson.

A copy of this report has been sent to Kris Nolan at Taylor Burrell Barnett for inclusion in The Glades Local Structure Plan Report.

For and on behalf of Coffey Environments Pty Ltd

Belinda Heath
Senior Environmental Scientist

Coffey Environments Pty Ltd ABN 45 090 522 759
Suite 2, 53 Burswood Road Burswood WA 6100 Australia
PO Box 4223 Victoria Park 6979 Australia
T (+61) (8) 9355 7100 F (+61) (8) 9355 7111 coffey.com

RECORD OF DISTRIBUTION

No. of copies	Report File Name	Report Status	Date	Prepared for:	Initials
1	LWP-2003-001-faas_001_st_V1.doc	final	07 February ,2005	LWP Property Group	ST
1	ENVIPERT00121AA 006 BH V1.doc	final	4 June 2009	LWP Property Group	BH
1	ENVIPERT00121AA 006 BH V1.doc	final	4 June 2009	Taylor Burrell Barnett	BH

CONTENTS

LIST OF ATTACHMENTS

Figures

1 INTRODUCTION

1.1 Purpose and Scope

LWP are proposing to develop part of their landholdings “The Glades” at Byford. The Glades LSP area includes Part Lots 16, 104 and 494 Cardup Siding Road; Lots 8, 9, 11 and 184 Orton Road; Lots 1, 2, 3 and 52 Abernethy Road; Lots 21, 22, and 132 Doley Road; Lots 4, 5, 6, and 7 Warrington Road; and Lot 5 Lawrence Road. Taylor Burrell and Barnett (TBB) are preparing on behalf of LWP a draft Local Structure Plan (LSP) layout and Report for The Glades.

ATA Environmental (now Coffey Environments) was commissioned in February 2005 by LWP Property Group Pty Ltd (LWP) to conduct a Black Cockatoo assessment on landholdings in Byford (ATA, 2005). These properties include Lots 494, 104 and 16 (Byford by the Brook); Lots 184, 8, 11 and 9 (Byford by the Stables); 3, 2, 1, 21, 22, 5, 52, and 2 (Byford by the Glade) and Lots 523 and 521 (Byford by the Scarp).

This report has been prepared on behalf of LWP for The Glades LSP area which is a subset of the larger area surveyed by ATA in February 2005. Lots 4, 6 and 7 Warrington Road, Lot 5 Lawrence Way and Lot 132 Doley Road are additional to the 2005 survey area and have not been assessed. Due to the degraded condition of these Lots it is expected that they would provide limited nesting and feeding habitat for Black Cockatoos.

1.2 Location

The project area is located approximately 33km south east of Perth and situated in the Shire of Serpentine – Jarrahdale (Figure 1). The area covers approximately 1500ha of land bounded by Abernethy Road to the north, Soldiers Road/South West Highway to the east, Hopkinson Road to the west and Cardup Brook to the south (Figure 2).

1.3 Site Description

The area has been extensively parkland cleared to facilitate activities such as dairy farming, horse adjustment, cattle grazing and includes numerous private residences and sheds. Historical land use and grazing throughout most of the landholdings have resulted in the clearing of the native understorey vegetation to an extent that introduced weeds and grasses proliferate. Scattered Marri (*Corymbia calophylla*), Jarrah (*Eucalyptus marginata*) and Christmas trees (*Nuytsia floribunda*) occur throughout the sites.

Areas to the east of the LWP landholdings in the Darling Scarp contain Jarrah, Marri and Banksia Woodlands that are relatively undisturbed. Bush Forever sites 351 (Cardup Brook Bushland), 352 (Cardup Nature Reserve and adjacent bushland), 321 (Brickwood Reserve and adjacent bushland) and 271 (Cardup Brook bushland) are in the local area and provide alternative remnant bushland for fauna.

1.4 Black Cockatoos

There are three species of Black Cockatoo that may possibly inhabit the Byford area. These are Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*), Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*) and Baudin's Black Cockatoo (*Calyptorhynchus baudinii*).

Carnaby's Black Cockatoo (*Calyptorhynchus latirostris*) - Listed as Schedule 1 (Fauna that are rare or likely to become extinct) under the *WA Wildlife Conservation Act 1950*; Endangered under the *EPBC Act 1999*.

Carnaby's Black-Cockatoo inhabits the southwest of WA. Its preferred habitat is the woodland where it preferentially feeds on plants of the Proteaceae family. In winter flocks can be found in heaths.

Baudin's Black Cockatoo (*Calyptorhynchus baudinii*) - Listed as Schedule 1 (Fauna that are rare or likely to become extinct) under the *WA Wildlife Conservation Act 1950*; Vulnerable under the *Environment Protection Biodiversity Conservation Act 1999 (EPBC Act)*.

Baudin's Cockatoo is most common in the far southwest of Western Australia where it breeds. It is known to breed from the southern forests north to Collie and east to near Kojonup. Baudin's Cockatoo is typically found in vagrant flocks and utilises the taller, more open Jarrah and Marri woodlands, where it feeds mainly on Marri seeds and various Proteaceous species. It breeds in Spring/Summer in the southern forests, nesting in tree hollows (primarily Marri).

Forest Red-tailed Black Cockatoo (*Calyptorhynchus banksii naso*) - Listed as Schedule 1 (Fauna that are rare or likely to become extinct) under the *WA Wildlife Conservation Act 1950*.

The Forest Red-tailed Cockatoo is restricted to the south-west of WA. It is most commonly seen in Eucalypts where it is attracted to seeding Marri, Jarrah, Blackbutt, Karri and Snottygobble. Forest Red-tailed Black Cockatoo's were formally common but are now rare to uncommon and patchily distributed usually in pairs or small flocks, seldom in large flocks (up to 200). The main cause of population decline has been habitat loss and modification.

If there is likely to be a significant impact on the species or species habitat as a result of development, a Commonwealth referral may be required for either Carnaby's or Baudin's Black Cockatoo's.

1.5 Potential Fauna Habitat within the Site

The Glades LSP area have largely cleared undergrowth, however there are remnants of Marri and Jarrah, and small pockets of Slender Banksia (*Banksia attenuata*). The large remnant trees may offer hollows or food resources that are suitable for Black Cockatoos.

2 METHODOLOGY

A survey was undertaken to assess the presence and habitat usage by Black Cockatoos on the site. The survey was undertaken by Dr Scott Thompson, a qualified zoologist with ATA Environmental (now Coffey Environmental) with assistance from Sean Stankowski.

All trees and remnant vegetation were assessed to identify areas that have potential as nesting hollows for breeding Black Cockatoos. A thorough search was made of the canopy of each of the trees within the study area and the location of any significant trees recorded. The search was undertaken on Tuesday 1 February 2005. The conditions were fine and warm with an afternoon westerly breeze.

In addition to the LWP landholdings, numerous bushland sites within a 10km radius were also searched to provide a regional perspective of Black Cockatoo nesting and feeding opportunities.

3.0 RESULTS

Nine trees were identified that contained hollows large enough for Black Cockatoo nest sites in The Glades LSP area. These are detailed below:

- 3 trees on Part Lot 494 (Cardup Siding Road);
- 2 trees on Part Lot 104 (Cardup Siding Road);
- 3 trees on Lot 21 (Abernethy Road); and
- 1 tree on Lot 184 (Orton Road).

The location of each tree containing a hollow large enough for a Black Cockatoo is shown in Figure 3a, 3b, 3c and 3d.

Across the landholdings there are many trees that would potentially provide feeding sites (i.e. Marri nuts), however none of the Marri trees examined showed any evidence of Black Cockatoo feeding at the time of the survey. Black Cockatoos have a distinctive feeding method and their presence in an area can be determined by discarded Marri nuts or Banksia cones.

Although four Forest Red-tailed Black Cockatoos were observed flying over Lot 21 and 22 they were not observed to be utilising vegetation occurring in The Glades LSP area.

Three of the trees identified as possessing nesting potential had bees inhabiting the hollows.

3.1 Biodiversity Value

The EPA *Position Statement No 3 Terrestrial Biological Surveys as an Element of Biodiversity Protection* (2002) indicates an ecological assessment of a site must consider its biodiversity value at the genetic, species and ecosystem levels and its ecological functional value at the ecosystem level.

3.1.1 Biodiversity Value at the Genetic, Species and Ecosystem Levels

It is our view that project area would provide limited nesting and feeding habitat compared with the surrounding region. This site is more degraded than the many hundred of hectares of similarly vegetated areas to the east. Brief investigations of other habitats within a 10km radius of the LWP landholdings showed that there are many other higher quality feeding and nesting opportunities. Some of these alternative feeding and nesting habitats are also protected under Bush Forever. Therefore, the clearing of vegetation from this project area will not have a significant impact on the biodiversity value at the genetic, species and ecosystem levels for Black Cockatoos in this region.

3.1.2 Ecological Functional Value at the Ecosystem Level

There were no special features or specific habitat on the LWP landholdings that would indicate it has ecological functional significance that is different to many other areas to the east.

4.0 SUMMARY

Only nine individual trees were identified as having potential for nesting Black Cockatoos on The Glades LSP area. None showed signs of having been used for nesting (ie. No chew marks).

Even though there are some trees that may provide feeding sites for Black Cockatoos, there was no evidence of Black Cockatoos feeding in the area. A search of bushland within a 10km radius of the LWP landholdings showed that there were extensive areas of suitable feeding and nesting habitat that will not be impacted by the proposed development. Some of these alternative feeding and nesting habitats are also protected under Bush Forever.

Where possible, the retention of native Eucalypt species in road reserves is desirable as they may provide habitat for other species of birds or Brushtail Possums.

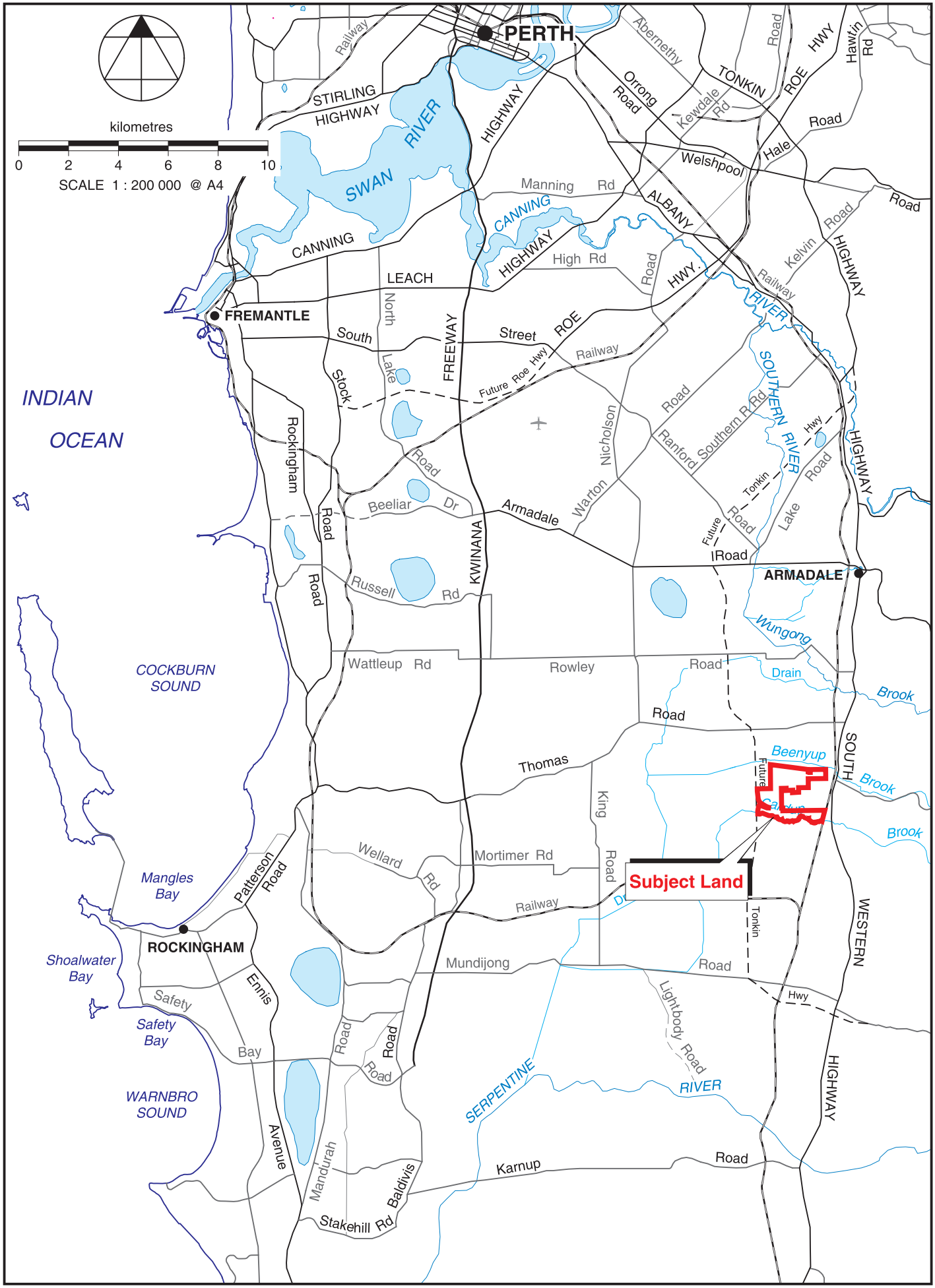
It is our assessment that development of The Glades LSP area will not significantly impact upon Black Cockatoos in the Byford area and that a Commonwealth referral under the *EPBC Act 1999* is not necessary.

REFERENCES

Environmental Protection Authority (2002) Terrestrial *Biological Surveys as an Element of Biodiversity Protection: Position Statement No. 3.* Environment Protection Authority, Perth.

Figures

Black Cockatoo Assessment
The Glades at Byford



PRINTED: Mon 08 Jun 09 CHECKED: BH 08-06-09 DRAWN: GLM/CR 29-05-09 DATUM: MGA zn50 ENVI/PERT/00121AA/Management The Glades at Byford/EP2009-078F01.dgn

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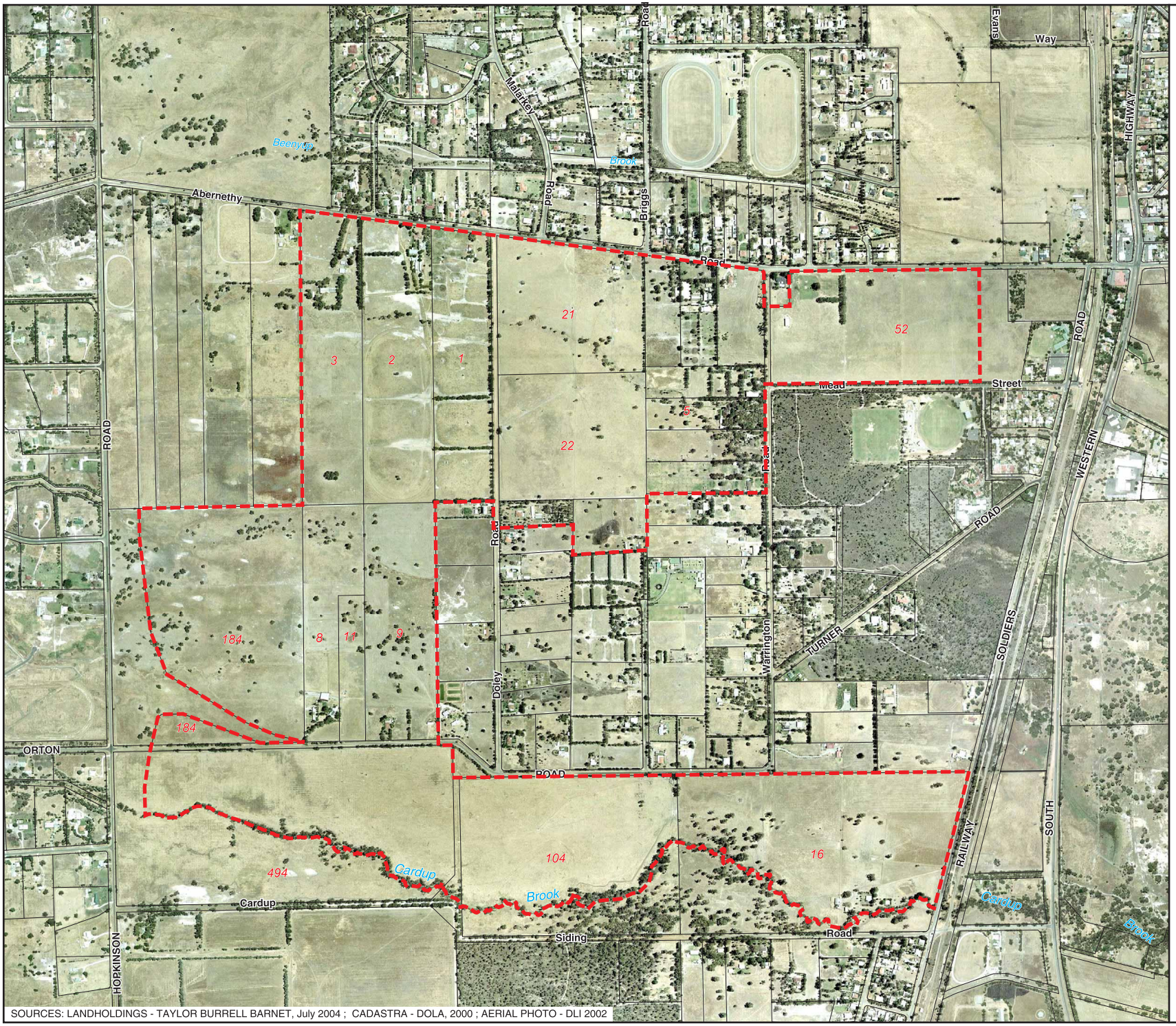
BLACK COCKATOO ASSESSMENT
THE GLADES, BYFORD

REGIONAL LOCATION

FIGURE 1



metres

0 100 200 300 400 500

SCALE 1 : 12 000 @ A3

LEGEND

- Local Structure Plan Area
- Cadastral Boundary
- 494 Lot No. within Landholdings

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BLACK COCKATOO ASSESSMENT
THE GLADES, BYFORD

THE GLADES AT BYFORD
LOCAL STRUCTURE PLAN AREA

FIGURE 2

PRINTED: Mon 08 Jun 09
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metres

0 50 100 150 200 250

SCALE 1 : 5 000 @ A3

LEGEND

- Local Structure Plan Area
- Cadastral Boundary
- 494 Lot No. within Landholdings
- Significant Tree Within Local Structure Plan Area
- Significant Tree Outside Local Structure Plan Area

SOURCES: LANDHOLDINGS - TAYLOR BURRELL BARNET, July 2004 ; CADASTRA - DOLA, 2000 ; AERIAL PHOTO - DLI 2002

coffey environments
SPECIALISTS IN LIVING AND WORKING PLACES

BLACK COCKATOO ASSESSMENT
THE GLADES, BYFORD

THE GLADES AT BYFORD
SIGNIFICANT HABITAT TREES

FIGURE 3a

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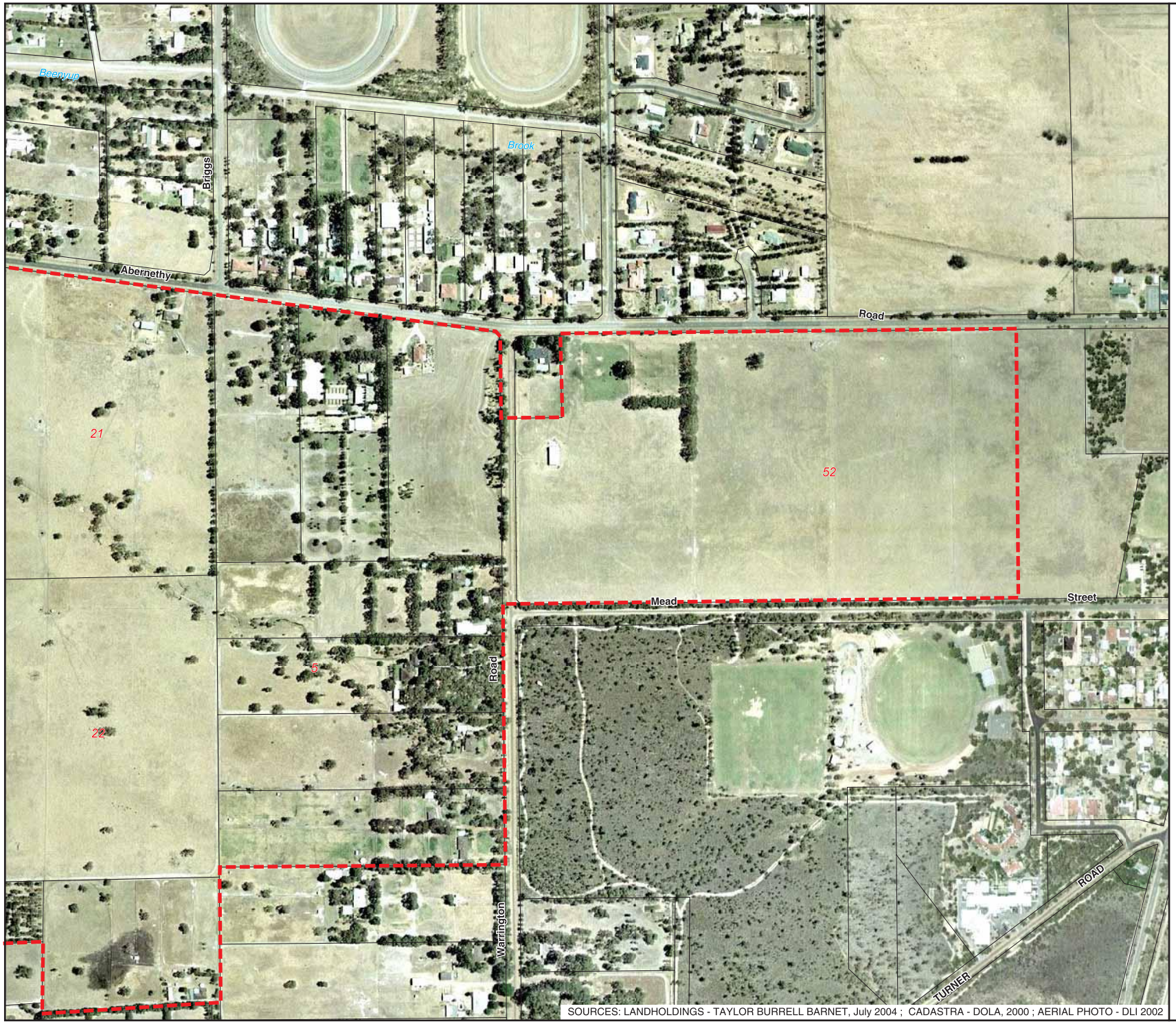

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DATUM: MGA zn50
ENV\PERT\00121AA\Management The Glades at Byford\EP2009-052F03b.dgn

metres
0 50 100 150 200 250
SCALE 1 : 5 000 @ A3

LEGEND

- Local Structure Plan Area
- Cadastral Boundary
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- Significant Tree Within Local Structure Plan Area
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SOURCES: LANDHOLDINGS - TAYLOR BURRELL BARNET, July 2004 ; CADASTRA - DOLA, 2000 ; AERIAL PHOTO - DLI 2002

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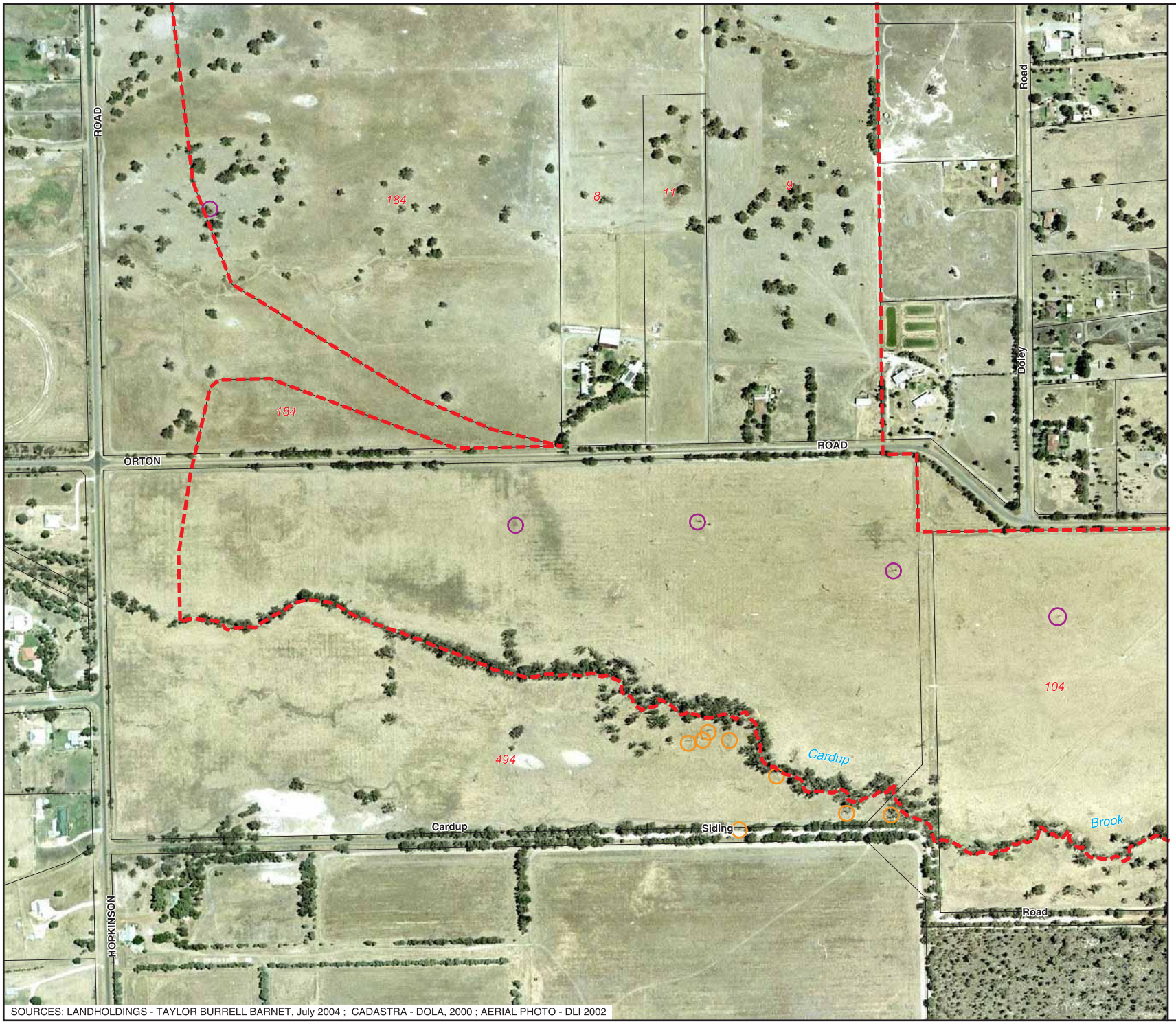
THE GLADES, BYFORD

THE GLADES AT BYFORD
SIGNIFICANT HABITAT TREES

FIGURE 3b



metres

0 50 100 150 200 250

SCALE 1 : 5 000 @ A3

LEGEND

- Local Structure Plan Area
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SOURCES: LANDHOLDINGS - TAYLOR BURRELL BARNET, July 2004 ; CADASTRA - DOLA, 2000 ; AERIAL PHOTO - DLI 2002

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SIGNIFICANT HABITAT TREES

FIGURE 3c

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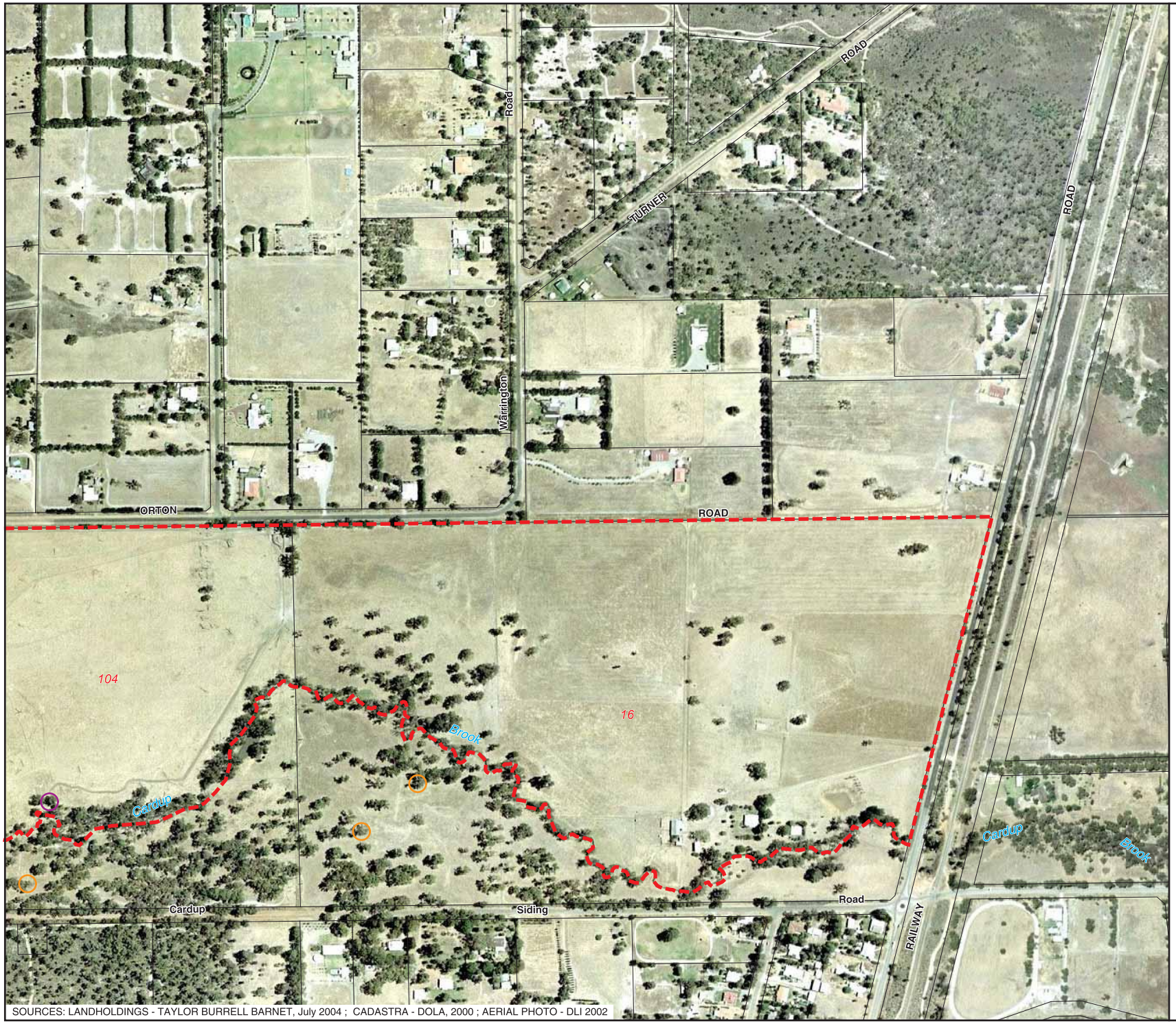

metres

0 50 100 150 200 250

SCALE 1 : 5 000 @ A3

LEGEND

- Local Structure Plan Area
- Cadastral Boundary
- 494 Lot No. within Landholdings
- Significant Tree Within Local Structure Plan Area
- Significant Tree Outside Local Structure Plan Area

SOURCES: LANDHOLDINGS - TAYLOR BURRELL BARNET, July 2004 ; CADASTRA - DOLA, 2000 ; AERIAL PHOTO - DLI 2002

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SPECIALISTS IN LIVING AND WORKING PLACES

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THE GLADES AT BYFORD
SIGNIFICANT HABITAT TREES

FIGURE 3d

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APPENDIX 4
ABORIGINAL HERITAGE -SECTION 18 ADVICE FOR THE GLADES AND BROOK DEVELOPMENTS

MINISTER FOR HOUSING AND WORKS; HERITAGE; INDIGENOUS AFFAIRS; LAND INFORMATION

Our Ref: 11-8919

12 APR 2007

Mr Phil Cuttone
General Manager South Projects
LWP Byford Syndicate Pty Ltd
34 Main Street
ELLENBROOK WA 6069

Dear Mr Cuttone

Residential subdivision and associated infrastructure - Conditional Consent Under Section 18(3) of the *Aboriginal Heritage Act 1972*

Introduction

I refer to the Notice dated 16 January 2007 ("the Notice") submitted by LWP Byford Syndicate Pty Ltd ("the Landowner") to the Aboriginal Cultural Material Committee ("the ACMC") pursuant to section 18(2) of the *Aboriginal Heritage Act 1972* ("the AHA").

The Notice advised that you require to use the land described in Schedule 1 of the Notice as Byford by the Brook (Pt Lot 16, Pt Lot 104 & Pt Lot 494 Cardup Siding Road) and Byford Main Precinct (Lots 1, 2, 3, 8, 9 on plan P8207, Lots 1,2, 3, 4, 5, 6, 7 on diagram D49045, Lot 2 on diagram D 65664, Lots 21, 22 on diagram D38573, Lot 52 on diagram D89805, Lot 11 on diagram D50537, Lot184 on Serpentine AA, Lot 5 on diagram D53167, Lot 132 on diagram D74222, Lot 131 Doley Road and Lot 2 George St) ("the Land"), for the purpose described in Schedule 2 of the Notice as residential subdivision and associated infrastructure and the installation of a walk trail along Cardup Brook ("the Purpose").

Consent

In accordance with my powers under section 18(3) of the AHA and following consideration of recommendations from the ACMC, I hereby grant consent to the use of the Land for the Purpose, subject to the conditions below.

I am advised that, based on current knowledge, the Purpose will impact upon

13th Floor, Dumas House, 2 Havelock Street, West Perth, Western Australia 6005
Telephone: (08) 9213 6600 Facsimile: (08) 9213 6601 Email: michelle-roberts@dpc.wa.gov.au

two (2) Aboriginal sites within the meaning of section 5 of the *Aboriginal Heritage Act 1972* (AHA) ("Sites") on the Land. The Sites are DIA 396 (South-east Corridor 07/Cardup Siding) and DIA 23917 (Byford Archaeological Survey 004). The purpose may also impact upon areas that the Aboriginal people have described as being associated with Aboriginal mythology and cultural activity on the Land. The locations are DIA 3310 (Cardup), DIA 16108 (Cardup Brook), DIA 23914 (Byford Archaeological Survey 001), DIA 23915 (Byford Archaeological Survey 002), DIA 23916 (Byford Archaeological Survey 003), DIA 23918 (Byford Archaeological Survey 005) and DIA 23919 (Byford Archaeological Survey 006).

Conditions of Consent

That the Landowner:

1. Avoid impact upon DIA 396 (South-east Corridor 07/Cardup Siding) and DIA 23917 (Byford Archaeological Survey 004).

2. Immediately cease all Works if skeletal remains ("Remains") are found and report the matter to the Western Australia Police and the Registrar of Aboriginal Sites ("the Registrar"). Where it is determined that the Remains are Aboriginal in origin and not a police matter, they must remain *in situ* and undisturbed until the Registrar makes a decision about how to proceed in respect of the Remains. The Landowner must at its expense manage the Remains in accordance with the Registrar's decision and report the whereabouts of the Remains to the Department of Indigenous Affairs ("DIA") and Anthropology Department of the Western Australian Museum.

3. Provide to the Registrar annually, or at the completion of the Purpose if the Purpose is completed within one year, a written report advising the Registrar whether and to what extent the Purpose has impacted on all or any Sites or objects within the meaning of section 6 of the AHA ("Objects") that may be located on the Land, including a detailed description of:
   a. whether such Sites or Objects have been partially or entirely impacted by the Purpose;
   b. the level, type and effect of any such impact (including, where possible, the provision of photographs taken during and after the impact);
   c. where Sites or Objects have been salvaged, when and how such salvage took place, who was present at the salvage and, subject to issues of cultural confidentiality, to where the material was re-located.

   Nothing in this condition should be construed as preventing the proponent from advising the Registrar in writing of all or any of the matters outlined

above at any time prior to the completion of the development. The Registrar and the ACMC welcome the provision of comprehensive and ongoing information about Sites and Objects in Western Australia.

Failure to comply with these conditions may constitute an offence under section 55 of the AHA. DIA carries out routine checks on compliance with conditions of ministerial consents.

Requests and Advice

The following information is provided for the information and guidance of the Landowner and does not form part of the conditions of the consent.

Although the ACMC has assessed the following two locations as not sites within the meaning of the AHA, the Landowner is requested to preserve locations DIA 23914 (Byford Archaeological Survey 001) and DIA 23915 (Byford Archaeological Survey 002) within the area designated Public Open Space.

Further, the ACMC requests that the Landowner give due consideration to requests made by Aboriginal people during consultation about the Purpose regarding the protection of Aboriginal heritage and the recognition of Aboriginal culture and history.

The Landowner should also ensure that all persons employed or engaged in respect of the Purpose and the Works are made aware of their obligations under the AHA, including by inserting into all and any relevant contracts, project plans, scopes of works, tenders and other similar documents a requirement that such persons be provided with a copy of a document prepared by DIA and entitled "Advice to Developers" and/or an electronic copy of a document prepared by DIA and the Department of Housing and Works and entitled "Aboriginal Heritage Procedures Manual", both of which can be found at:

- http://www.dia.wa.gov.au/Heritage/IntroForDevelopers.aspx; and
- http://www.dia.wa.gov.au/Heritage/HeritageManual/default.aspx

Other Matters

This consent can be relied upon by only the applicant Landowner. Any subsequent 'owner' of the land within the meaning of the AHA must make its own application under the AHA.

Right of Review of Decision

Where the Landowner is aggrieved by a decision of the Minister made under section 18(3) of the AHA, the Landowner may apply to the State Administrative Tribunal ("SAT") for a review of the decision. The SAT's website is: www.sat.justice.wa.gov.au

Copies of legislation

Extracts from the AHA and the *Aboriginal Heritage Regulations 1974* are attached for your information.

Copies of the *AHA*, the *Aboriginal Heritage Regulations 1974* and the *State Administrative Tribunal Act 2004* may be viewed and downloaded from the website of the State Law Publisher at www.slp.wa.gov.au.

Yours sincerely

Michelle Roberts

HON MICHELLE ROBERTS MLA
MINISTER FOR INDIGENOUS AFFAIRS

Att.
Extracts from the AHA and the *Aboriginal Heritage Regulations 1974*

10 APR 2007

APPENDIX 5
THE GLADES VILLAGE CENTRE RETAIL AND COMMERCIAL ANALYSIS
(TAKTICS 4)

TAKTICS4
GLADES VILLAGE CENTRE
BYFORD

Centre Strategy

LWP beyond the plan

October 2008

Contact

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Version Control

Document Name	Date	Description	Prepared
Glades Village Centre Strategy - T4-8024-01	12th Oct 08	Draft for Review	GD

Distribution Control

Document Name	Date	Distribution	Format	Delivery
Glades Village Centre Strategy - T4-8024-01	12th Oct 08	MB - LWP	PDF	email

Disclaimer

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1 INTRODUCTION

Key decisions that reflect the desired positioning and vision for planned commercial activity should be predicated on a thorough understanding of the market drivers that will influence the likely performance of its tenants. Analysis of consumer markets and economic drivers will ensure that development and initiatives involving commercial activity planned for Glades Village in Byford will be able to operate in a sustainable manner.

1.1 Objectives & Outputs

The purpose of this strategy is to:

- Determine the existing and future needs for retail and other commercial space within the Village Centre
- Identify the type and mix of retail and commercial product most appropriate to serve the needs of the immediate catchment
- Determine an appropriate retail floor space cap for the centre
- Analysis of the Byford Community needs in relation to retail and commercial activity.
- Prepare an overall analysis report with recommendations to be utilised as supporting documentation to an amendment to the local structure plan

1.2 Methods

The findings in this report are based on investigations and analysis of the:

1. Review of existing documentation
2. Size and economic value of relevant consumer markets
3. Expected contribution (market share) from each market
4. Correlation of these outputs to commercial sales performance and sustainable floorspace
5. Economic drivers underpinning consumer access and movement between activities

2 CONSUMER MARKETS

This section explores the extent, nature and value of consumer markets likely to influence the performance, nature and sustainability of the planned commercial activity. Consumer markets that are capable of contributing to the performance of retail activity include:

- Residents
- Visitors & Tourists
- Businesses & Employees

2.1 Resident Catchment Definition

Resident based sales generally produce the major contribution to the performance of retail and service related commercial activity. The following drivers play a major role in determining the extent of a resident catchment.

- Centre & Major Tenant Distribution

  The distribution of centres and in particular major tenants such as Supermarkets and Discount Department Stores will therefore play a key role in consumer's retail shopping behaviour and subsequent contribution to the delineation of trade areas by determining how far residents need to travel to access goods and services.

- Natural, infrastructure and perceived barriers

  Elements that ease or impede travel will influence the relative access of a particular location to a range of locations, and subsequently improve the attraction of one activity over another – especially to residents in more distant catchments.

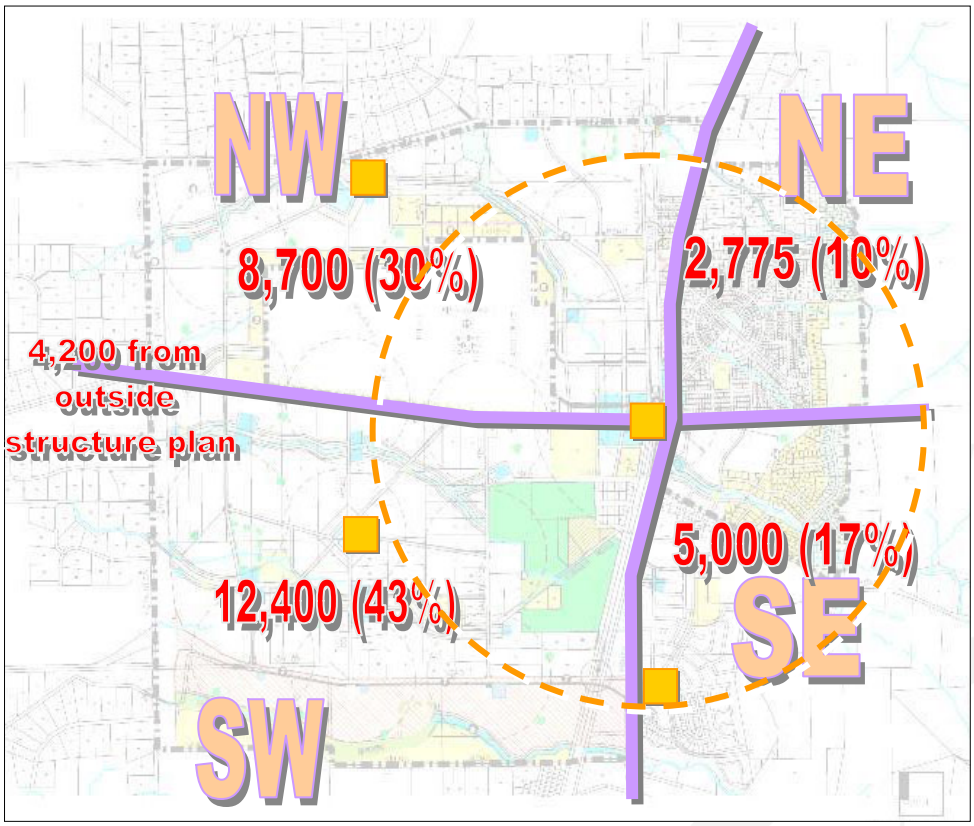
Catchments

- It is reasonable to expect that the majority of shopping activity in Byford will be generated from within the Byford community.
- Very little overnight visitation is expected to the region, with its relative proximity to Perth and other tourist accommodation locations within the metropolitan region.
- Some day trip visitation may be expected in the region, although this is expected to represent a small proportion of the available market for Byford commercial activity.
- The majority of employment in Byford may also be expected to be sourced from local residents – and their subsequent spending behaviour will already be allocated to resident spending.
- Non resident spending is estimated to represent 5% of the total available sales to Byford retailers, suggesting that 95% of sales will be captured from Byford residents.

Markets

- Over 11,000 dwellings are forecast to be developed in Byford creating an ultimate community comprising 30,000 residents
- Current structure planning indicates that the vast majority of these residents will live within 3km of the existing town centre located on the South West Highway.
- The Byford community effectively produces four community quadrants that may be used to assess catchment and commercial planning.

- The south west highway is the only significant barrier to travel from one side of the Byford Township to the other.
- Only 27% of the intended Byford population will ultimately live east of the South West Highway.
- The Glades Village is located central to the south west quadrant. This quadrant is estimated to accommodate 43% of the total Byford population.



- The Glades Village is well located to service the majority of Byford residents.
- While the Glades Village may expect to capture the majority of its sales from residents within the SW quadrant, it is not unreasonable to expect significant sales to be captured from other residents in Byford.
- The semi rural nature of the community indicates that distances of 3-4km from one side of town to the other to access desired commercial goods and services will not be unreasonable to the majority of the community, especially given the distance to the next available option in Mundijong or Armadale.
- The majority of large scale supermarket operators (Coles and Woolworths) require a catchment of at least 1.5km radius of continuous catchment to achieve sustainable sales.
- It is not uncommon for both Coles and Woolworths to operate within the same 1.5km catchment. It is reasonable to assume that there is normally sufficient retail dollars in a typical 1.5 km radius resident catchment to sustain two supermarkets.
- The SW quadrant in Byford effectively forms a 1.5 km radius catchment. However it also has a significant overlap with the catchment for the town centre. This will limit the market share available to the Glades Village and is likely to restrict the sustainable size of the centre to a single supermarket based centre.

3 CENTRE SUSTAINABILITY

The sustainability of retail activity is determined by correlating spending patterns and market share with the level of sales required to attract and retain the major tenants necessary to support other tenants.

Sustainable Floor space

- Byford consumers are estimated to spend in excess of $305M p.a. with nearly 60% ($175M p.a.) of spending captured by convenience based retailers.
- The SW quadrant alone will generate in excess of $130M p.a. with over $75M p.a. to be captured by convenience based retailers.
- Another $15M p.a. ($8M p.a. on food and grocery) may be generated from the passing trade, visitors and employee and business trade.

DDS

- The Byford resident catchment is contained within an area of approximately 4km square
- A DDS in an urban environment typically requires a primary resident catchment of at least 4km
- An operator may usually expect to share this catchment with other DDS operators with additional sales generated from outside the immediate catchment offsetting any loss of sales to competing operators
- The Byford resident catchment is expected to generate $27 M p.a. in spending that can reasonably be expected to be captured by a DDS operator.
- A single DDS operator varies in size from 7,000sqm – 8,000sqm
- A DDS operator may expect to produce sales of $3,500/sqm p.a.
- A DDS capturing 100% of the DDS spending available in the market could therefore sustain 7,700sqm of retail floorspace
- There will be sufficient dollars generated in the Byford catchment to sustain a single DDS in Byford.
- However with limited residential development planned beyond the immediate 3-4km Byford catchment
- The development of the DDS will not be sustainable until close to full development of the residential catchment
- The Byford Town Centre planned adjacent to the existing Byford Centre is the logical location for any DDS operator to be ultimately introduced to the Byford catchment
- There is therefore no opportunity for a DDS operator to be developed at Glades Village Centre in the immediate or the foreseeable long term of the centre development.
- We recommend that the centre not be developed to a DDS based role and function

Supermarket

- Supermarkets can expect to capture $87M p.a. in sales from resident spending from the completed residential catchments
- Full line supermarkets are generally developed to around 3,500sqm of floorspace
- Supermarkets may typically produce sales of $8,500/sqm p.a. in retail sales generating sales of $25M p.a.
- Spending generated from a completed residential catchment is therefore likely to support up to three full line supermarkets
- There are only two full line supermarkets available in Western Australia – Coles and Woolworths
- Both of these operators will be keen to establish a presence in Byford when the catchment is sustainable
- Smaller operators such as IGA are more flexible in their floorspace models
- But typical larger store sizes are currently in the order of 1,500sqm
- With both full line supermarkets operating in Byford, an alternative model may be to substitute two smaller IGA's for the third full line operator.
- These options create a range of spatial scenarios for consideration

Spatial Distribution of Supermarkets

- It is generally accepted that the town centre will remain in or close proximity to its current location.
- It may be expected that the two full line supermarket operators will both be attracted to the Byford Town Centre
- This leaves a number of options for Glades village
- Option 1 - the remaining full line supermarket operator (effectively a second Coles or Woolworths store) to be located at Glades Village
- Option 2 - two smaller IGA stores to be distributed outside the town centre – with one at Glades Village and the other to be determined.
- One location for a second IGA store is the existing location in the current Byford Centre on the South West Highway.
- While there may be some serious doubt to the continued viability of a small IGA operator in close proximity to two full line supermarkets (across the railway line)
- It may mean that the existing operator be transferred or relocated as part of the redevelopment of the Byford Town Centre
- In any effect, the decision on the size and nature of the supermarket at Glades Village will have the potential to influence the distribution of another smaller IGA operator and centre in Byford.
- The decision will also be influenced by the findings from the Shire of Serpentine Jarrahdale's Commercial Centres Strategy
- The Strategy is currently being produced for the Shire by a consultant team and there is no draft available for consideration by stakeholders at the time of reporting

Specialty Shops

- A smaller IGA operation may require up to half that size which would provide opportunities for two full line supermarket chains to be established in Byford and two smaller IGA stores (up to 1,500sqm each)
- These supermarkets would be responsible for generating sufficient sales and pedestrian traffic to support an additional 100 convenience based shops. About 30 shops per full line supermarket or 25 per four supermarkets.
- This number is consistent with the sustainable development of neighbourhood based centres anchored by a supermarket chain.

The total retail activity under the development of a small IGA store includes

Supermarket	1,500sqm
Specialty Retail shops (15)	1,500sqm
Café/restaurants (4-5)	1,000sqm
Tavern (1) (25% used for retail purposes)	500sqm
Total Retail	***4,500sqm***
Tavern (1) (non retail allocation)	1,500sqm
Office/Non retail commercial space	1,000sqm
Community/Civic	1,000sqm
Total Commercial	***8,000sqm***

The types of retail uses typically attracted to neighbourhood based centres include:

Retail Activity

- Supermarket
- Butcher/ Fish monger
- Fruit & Veg
- Liquor
- Bakery
- Takeaway/café & restaurants
- Deli
- Newsagent
- Photo shop
- Pharmacy
- Fashion

- Florists
- Jewellers
- Nursery/ Garden supplies
- Petrol Stations
- Hair dresser
- Video Hire

Office (or non retail) activity

- Real estate
- Banks
- Travel agents
- Post office
- Medical facilities
- Gymnasium

Community/Civic activity

- Community Hall
- Library
- Recreation facility

These uses are considered to be a guide only and are not recommended to be formalised as the nature and function of individual tenants may vary from time to time – especially as the market and business mix develops

We do not support the inclusion of particular retail types to be included as part of formal policy measures in relation to the centres development and approval

It is unusual for modelling to support the high market shares or retention of total available dollars in a particular catchment.
However the isolated nature of the catchment produced by the satellite development of Byford provides retail and commercial operators with an opportunity to effectively trade to a captive market.

Distribution of activity

The distribution of activity throughout the centre will depend on the ultimate design and layout of the respective uses however an indication of the distribution of activity may include:

Lakeside Drive (West)	Tavern Cafe	2,000 sqm 250 sqm
Main Street (West)	Retail/Commercial	1,500 sqm (1,000 sqm retail) (500 sqm commercial)
Main Street (East)	Supermarket Retail/Commercial	1,500 sqm 1,000 sqm (500 sqm retail) (500 sqm commercial)
East West Drive	Commercial Civic/Community (including medical)	500 sqm 1,000 sqm

Staging and Timing

There are a number of benefits associated with promoting a smaller supermarket based centre at Glades Village

1. The development is seen to remove the perception that a larger supermarket operator will influence the performance and integrity surrounding development of the Byford Town Centre
2. The smaller operator will require a smaller catchment base to trade successfully and may subsequently be developed ahead of the larger supermarkets in the Town Centre.

The latter allows for the development to be developed earlier and for consumers in Byford to establish travel patterns and trading habits, which will assist with the centres longevity and performance as the Town Centre develops.

Glades Village may be developed in a number of stages – although the sustainability and function of the centre will only be realised once the supermarket is developed and trading profitably.

It will be difficult to attract tenants to the centre prior to the development of the supermarket operator.

The supermarket is capable of being sustainable based upon the development of at least 25% of the South West quadrant catchment – combined with existing population this equates to a population of about 10,000 across the entire Byford catchment.

This population reflects a third of the overall population planned for Byford but importantly it will not pull significant trade from existing population closer to the SW highway because the offer will be similar to that offered by the existing town centre.

Some retail and office activity may be developed earlier to accommodate a range of purposes such as sales offices and cafes/restaurant to establish or reinforce a theme for the centre.

But tavern, medical facilities and other office space in particular should not be considered prior to the development of the supermarket.

APPENDIX 6
TRAFFIC & TRANSPORTATION REPORT
(WITH VARIOUS UPDATES)
(RILEY CONSULTING AND TRANSCORE)

GLADES LOCAL STRUCTURE PLAN
SHIRE OF SERPANTINE - JARRAHDALE

TRAFFIC IMPACT STATEMENT

transport planning • traffic engineering • project management

The Glades – Revised Local Structure Plan

Shire of Serpentine – Jarrahdale

Transport Impact Statement

Prepared for:
LWP Byford Syndicate

June 2009

Prepared by:
TRANSCORE PTY LTD
61 York Street, Subiaco WA 6008
PO Box 42, Subiaco WA 6904
Telephone (08) 9382 4199
Facsimile (08) 9382 4177

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APPENDIX B – Glades Local Structure Plan (Draft)
APPENDIX C – Tonkin Highway Extension Project – Concept Plan (MRWA)
APPENDIX D – South-Western Highway Upgrade – Preliminary Plan (MRWA)

1 INTRODUCTION

The LWP Byford Syndicate has requested Transcore to undertake a Transport Impact Statement (TIS) for the Glades Revised Local Structure Plan.

Shire of Serpentine-Jarrahdale originally adopted Byford Structure Plan in August 2005. Revision No.1 of the Structure Plan was adopted in February 2007. As a result of the modification to the Byford Structure Plan and other local issues, the Glades Local Structure Plan has also been modified. Accordingly, the purpose of this Traffic Impact Statement is to update the Traffic and Transportation report prepared for the Revised Local Structure Plan in November 2005.

A copy of the Byford Structure Plan is provided in Appendix A of this report and Appendix B contains a copy of the Revised Local Structure Plan.

2 EXISTING SITUATION AND REGIONAL TRANSPORT PLANNING

2.1 Existing Transport Network

The Glades Revised Local Structure Plan (hereafter referred to as LSP) area is located approximately 33 km southeast of the Perth CBD. The LSP site is approximately 342 hectares in area, of which approximately 216 hectares is developable area.

The area is broadly bounded by Abernethy Road to the north; Tonkin Highway corridor and Hopkinson Road to the west; Cardup Siding Road and Cardup Brook Reserve to the south; and the rural lands, Perth-Armadale Rail and Soldier Road to the east.

The subject area is largely undeveloped and entails a number of existing rural lots and dwellings, other agricultural and rural land uses, and an established internal local road system, which will be maintained and upgraded to Liveable Neighbourhoods urban standards as part of the development process. Further development of existing road network to fit the requirements of the proposed LSP is also part of this Revised LSP proposal. **Figure 1** outlines the existing boundary and internal road system within the LSP.

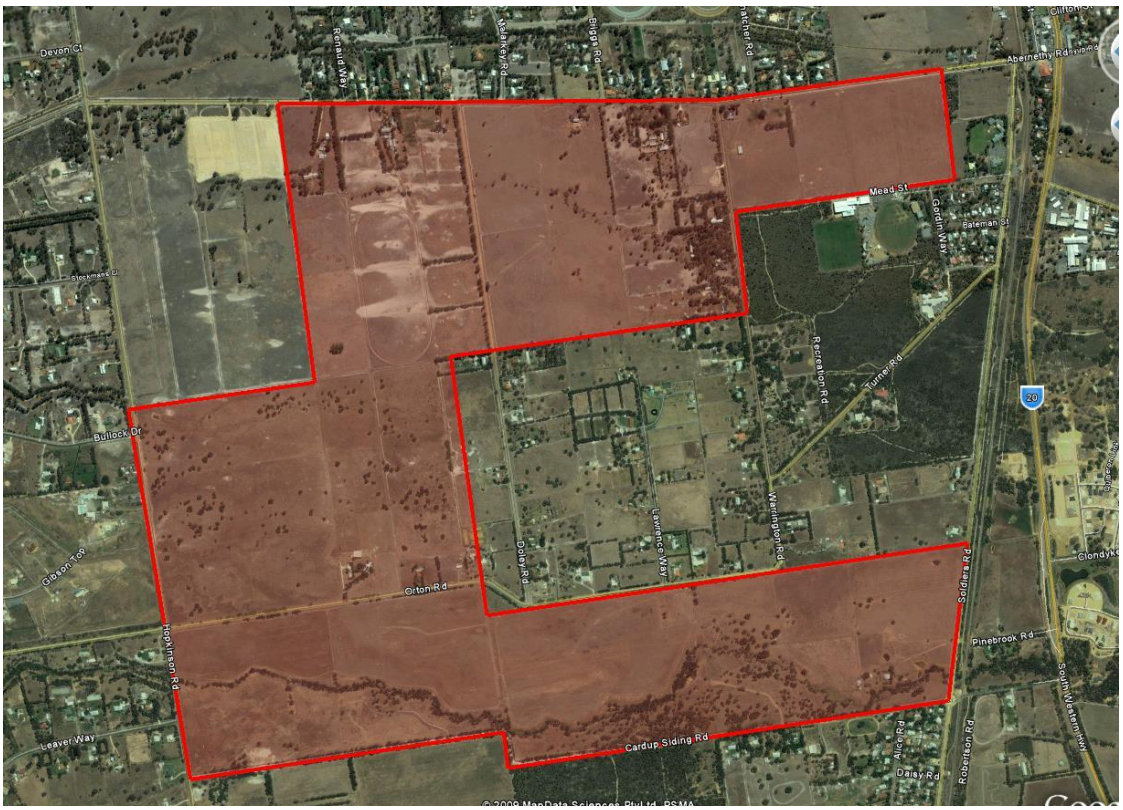


Figure 1. LSP Area

Abernethy Road has a *District Distributor B* classification between Soldiers Road and South Western Highway but is classified as a *Local Distributor* west of Soldiers Road in the Main Roads WA *Metropolitan Functional Road Hierarchy* (1999). West of Soldiers Road it is a single carriageway rural road with a 7.4m sealed width, unsealed shoulders and table drains. Abernethy Road has a speed limit of 70km/h west of Soldiers Road and 60km/h between Soldiers Road and South Western Highway. The Shire of Serpentine-Jarrahdale has advised that the average daily traffic volumes on Abernethy Road in 2007 were 3,400 vehicles per day (vpd) between South Western Highway and Hopkinson Road.

Soldiers Road is classified as a *District Distributor A*. Between Abernethy Road and Turner Road it is constructed with a 7.4m sealed carriageway and 0.6m sealed shoulder on the eastern side. This section has a 60km/h speed limit but a 40km/h school zone also applies adjacent to the existing John Calvin School (200m south of Abernethy Road). Soldiers Road is kerbed on the western side only. Between Turner Road and Cardup Siding Road it is rural in nature with similar carriageway width and unsealed shoulders. This section of Soldiers Road entails a speed limit of 80km/h, reduced to 60km/h at the approach to the Cardup Siding Road intersection. Cardup Siding Road and Soldiers Road form a 4-way roundabout intersection. The shire advises it carried 1,600 vpd in 2007.

South-Western Highway is a Primary Regional Road under care and control of Main Roads WA and is classified as a *Primary Distributor Road* in the Main Roads WA *Metropolitan Functional Road Hierarchy* (1999) document. It is constructed to a wide, single carriageway, two-lane standard along most of its length, dualling to four-lane divided carriageway through towns. It generally entails a speed limit of 90km/h, which is reduced to 60km/h at the approach to built up areas. According to Main Roads WA traffic count data from November 2008, this road carried approximately 16,000vpd during typical weekday (south of Abernethy Road). The Abernethy Road/South-Western Highway intersection has recently been upgraded and traffic signals have been installed.

Hopkinson Road is classified as a *District Distributor B* road. It is rural in nature and between Abernethy Road and Cardup Siding Road, constructed as 7.0m sealed carriageway with 0.5-1m shoulders on either sides. The shire advises it carried 1,600 vpd in 2007. Hopkinson Road forms a STOP-controlled, 4-way intersection with Abernethy Road.

Cardup Siding Road is classified as a *Access* road. It is rural in nature and constructed as 6.0m sealed carriageway with 0.5-1m shoulders on both sides. Hopkinson Road forms a simple PRIORITY-controlled, T-intersection with Hopkinson Road. It entails a railway crossing with warning lights with Perth-Armadale railway line. According to the shire's advice, this road carried 230 vpd in 2007.

2.2 Regional Transport Network Planning

Tonkin Highway abuts the western edge of the LSP area with a future grade-separated interchange proposed at the intersection with Orton Road. According to the information sourced from Main Roads WA web site (latest information update from June 2008), construction of Stage 2 of Tonkin Highway extension which involves a 14km, 4-lane standard, section between Thomas Road and South Western Highway (via Mundijong Road) is largely dependant on future traffic growth in the south-east corridor and the rate of urban development in the Mundijong area.

Although presently no funds are allocated toward this project, Main Roads WA and DPI are progressing with the planning work for the extension of Tonkin Highway. The current plans involve the extension from Thomas Road to Orton Road, however Main Roads WA and DPI preference is the extension all the way to Mundijong. Also, currently Abernethy Road terminates east of Tonkin Highway, however Main Roads have prepared plans for Abernethy Road to bridge over Tonkin Highway, in case this need arises in the future.

The Main Roads WA concept plan for Tonkin Highway Extension is attached in **Appendix C.**

South Western Highway runs to the east of the LSP area. Main Roads WA proposals for the Highway include upgrading to dual carriageway standard. The preliminary plan and profile drawings illustrate the proposed upgrades to the South-Western Highway section north of Abernethy Road intersection. The upgrades incorporate carriageway dualling with addition of dedicated right-turn pockets and left-turning lanes at designated intersections.

Main Roads WA preliminary plan for South-Western Highway upgrade is attached in **Appendix D.**

2.3 Public Transport

Existing public transport in Byford is relatively low frequency. Three existing bus routes service Byford from Armadale and travel on Soldiers Road, east of the SP area, as shown in Figure 2. Together these existing bus services provide one bus per hour each way on Soldiers Road on weekdays and less on weekends. There are also existing school bus services in this area with school bus stops located on Abernethy Road west of Soldiers Road and west of Warrington Road.

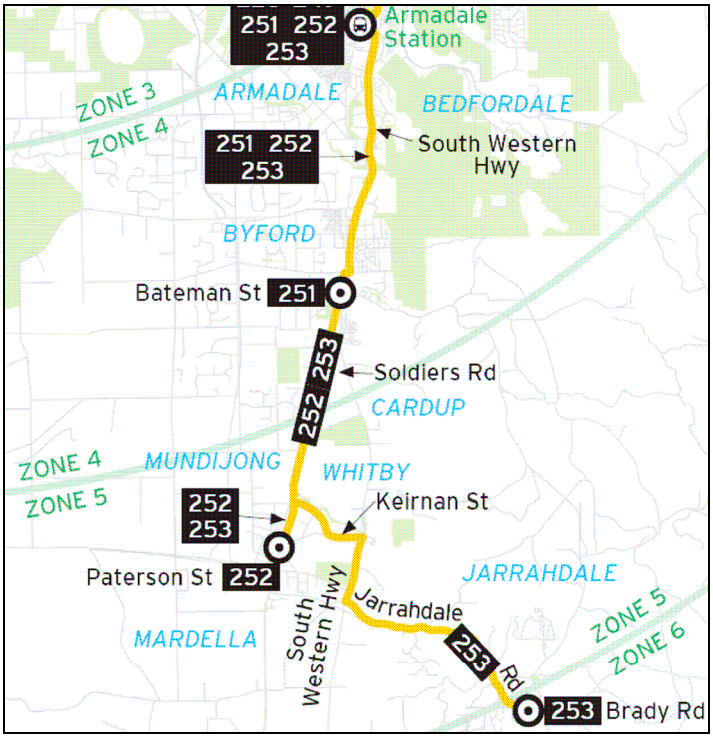


Figure 2. Existing Transperth Bus Routes

The LSP area is conveniently located immediately west of the Perth-Armadale Rail line, however, presently there are no train stations in this vicinity. The nearest train station on this route is Armadale Train Station, which is located approximately 8km to the north.

2.4 Cyclist and Pedestrian

The Perth Bike Map series published by the Department for Planning and Infrastructure just shows Abernethy Road as a good road-riding environment and South Western Highway as a poor road-riding environment refer **Figure 3**).

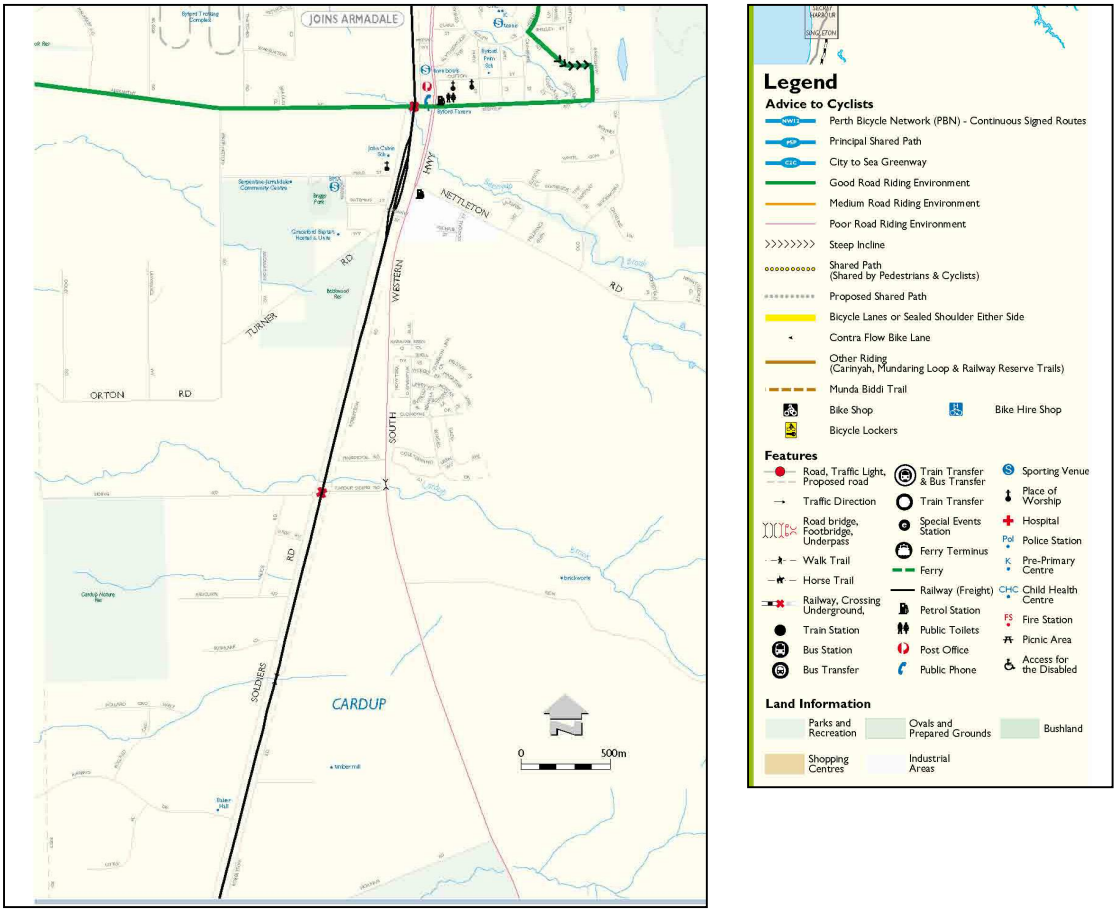


Figure 3. Perth Bike Map Extract

However, there are limited existing footpaths or shared paths on some of the roads surrounding and within the LSP area, largely in direct vicinity of the developed areas.

3 PROPOSED LOCAL STRUCTURE PLAN LAND USES

According to the information provided by Taylor Burrell Barnett Town Planning & Design, the LSP area encompasses approximately 329 hectares. The land uses proposed for the LSP area are detailed as follows:

- Approximately 3,320 lots (combination of R10, R12.5, R15, R20, R25, R30, R40 and R60 densities and a 6.54ha R30 retirement village site) – 164.88 hectares;
- 1 private primary school (Kindergarten - Year 12) – 10.03 hectares;
- 1 public primary schools – 4.48 hectares;
- 1 High School – 12.13 hectares;
- Village Centre 4,500m2 NLA;
- Neighbourhood retail facilities (Neighbourhood Nodes) – 100m2-200m2 per node;
- Mixed uses – 15.42 hectares;
- POS – 53.4 hectares.

Appendix B shows the proposed LSP.

4 TRAFFIC VOLUME ESTIMATION

The internationally recognised EMME/3 software package has been used to undertake modelling for the Byford Structure Plan and to estimate the future traffic on the internal and external roads relevant to the LSP.

EMME/3 represents a road network as a series of links (roads) and nodes (intersections). The traffic generating land uses are represented as a number of zones connected to the network.

For this application, a 24-hour average weekday model was developed for the future scenario assuming full development of Byford Structure Plan and LSP areas. The average weekday was selected as it represents the typical activity for the LSP area.

4.1 Modelled Road Network and Access points

The modelled road network includes key roads for the Byford Structure Plan and all the major and minor roads proposed within the LSP area.

The road network coding was based on an estimate of the road hierarchy as established through the previous Traffic and Transportation report. Different road categories have been allocated different traffic capacities through the use of a volume-delay function. These functions change the travel time based on the amount of traffic using each section of the road.

The Modelling area roads were coded as single carriageway roads except for South Western Highway and Tonkin Highway, which were coded as dual 4-lane carriageway.

Two railway crossings have been modelled for the connection to the South Western Highway, the main railway crossing at Abernethy Road and the secondary railway crossing in this vicinity at Cardup Siding Road.

According to latest plans available for the extension of the Tonkin Highway, there is no connection on Abernethy Road to Tonkin Highway and the intersection of Orton Road and Tonkin Highway would be in the form of a grade-separated interchange.

4.2 Model Structure

The traffic model uses the traditional four-stage model processes which includes the following stages:

- Trip generation;
- Mode split;

- Trip distribution; and
- Trip assignment.

4.3 Trip generation

Trip generation calculations for this report are based on a trip rate of 8 vehicles per day for the residential lots. According to the latest Byford Structure Plan, the area would contain about 10,000 lots, therefore it is estimated that about 80,000 vpd would be generated from the Area. These trips have been classified to three different categories as work trips, education trips and other trips and distributed to the major attractions proposed in the Byford Structure Plan area.

4.4 Mode Split

The trip generation within this model considered only vehicle trips and therefore the mode split process was not required.

4.5 Trip Distribution

The trip distribution to the external zones (developments) used in the model is based on the assumptions summarised in **Table 1**.

Table 1: Trip distribution to external zones

Purpose of trip	**% of Trips**	**North Nicholson**	**North Tonkin Hwy**	**North SW Hwy**	**East**	**South SW Hwy**	**South Tonkin Hwy**	**West**
Home Based Work	27%	20%	35%	20%	0%	2%	3%	20%
Home Based Education	*							
Home Based Other	33%	5%	20%	30%	5%	10%	15%	15%
Home Based Evening	20%	5%	30%	35%	0%	0%	10%	30%
Non-Home Based	12%	20%	35%	15%	0%	3%	7%	20%

*Population based - All school trips will be local

4.6 Traffic Assignment

The EMME/3 transport modelling software was used to assign the traffic to the road network. EMME/3 uses the equilibrium auto assignment principal to assign the traffic to the road network.

The behavioural assumption of the equilibrium traffic assignment is that each user chooses the route that he or she perceives to be the best.

4.7 Modelled Outputs

Figure 4 illustrates the forecast daily traffic volumes on the Byford Structure Plan and LSP road network. It must be noted that the modelled output doesn't include the background traffic (through traffic) and it only represents the traffic generated from the Byford Structure Plan incorporating the LSP area.

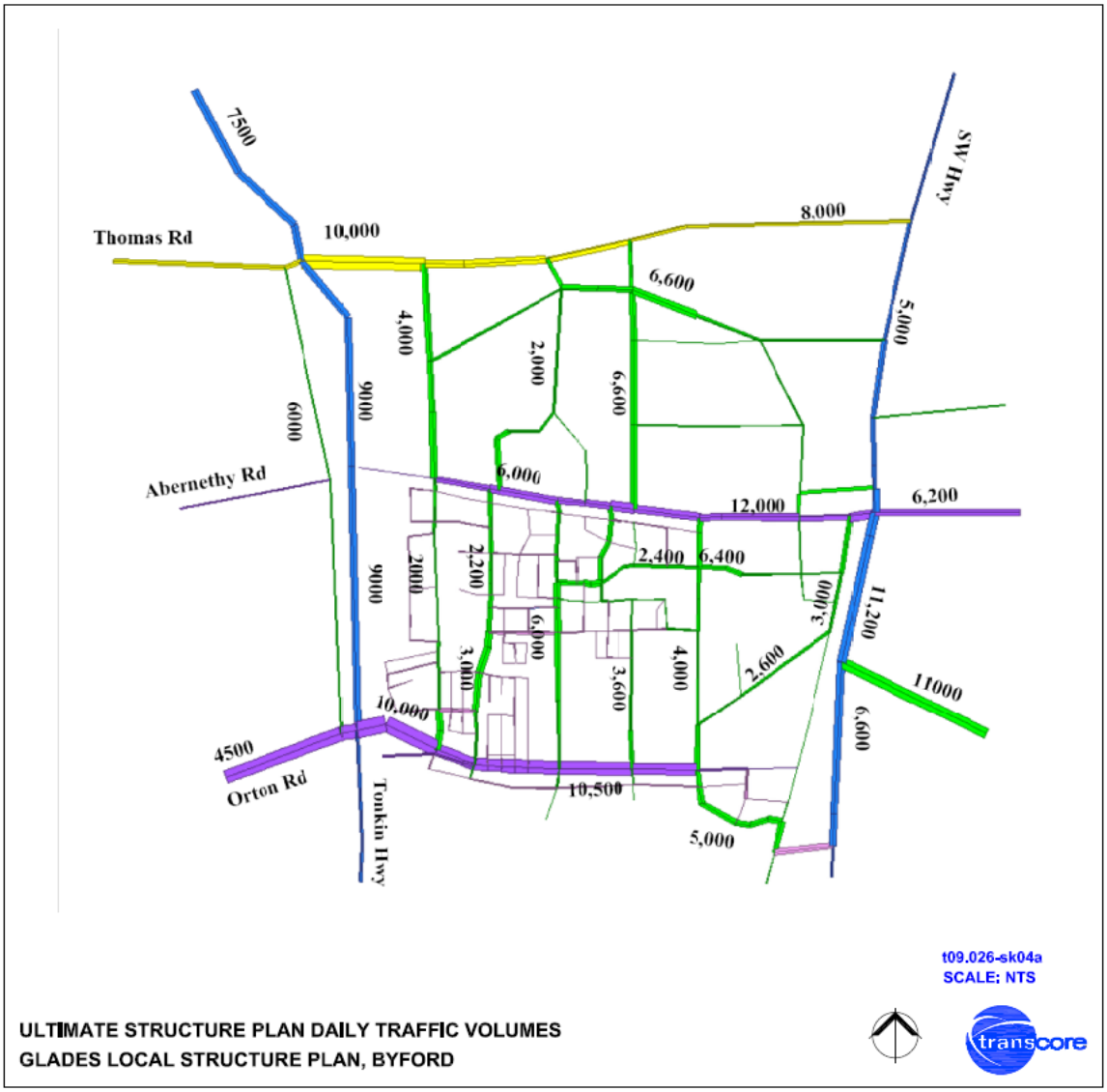


Figure 4: Forecast Daily Traffic Volumes

5 INTERNAL MOVEMENT NETWORK

5.1 Road Hierarchy, Reserve Widths and Road Cross Sections

Based on the forecast flows on the LSP roads, **Figure 5** shows the proposed internal road hierarchy. The hierarchy is based on guidelines set out in Liveable Neighbourhoods.

Using the recommended road hierarchy and with reference to the Liveable Neighbourhoods document, recommendations are made with respect to the typical road reservations and cross sections.

Abernethy Road is classified as Integrator B. Due to the drainage requirements in this area, the reservation for Abernethy Road is to include a swale in the middle within the total reservation. **Figures 6 to 9** show various reservation options for Abernethy Road. There are two 40m reserve options provided. Option 2 includes a one-way service road to provide direct lot frontages for the proposed large lots to the south of Abernethy Road. Options 3 and 4 show reduced reservations of 30m and 34m respectively with Option 4 including the one-way service road. The final reservations for Abernethy Road is to be determined through discussions and negotiations with the Shire at subdivision design stage.

Orton Road is classified as Integrator B between Tonkin Highway and Warrington Road. **Figures 10 and 11** show typical reservations of 29.4m and 32.4m with and without on-street parking respectively. Orton Road is classified as Neighbourhood Connector B east of Warrington Road.

The four main north-south roads in the LSP area are classified as Neighbourhood Connector A. Liveable Neighbourhoods document suggests a typical reservation of 24.4m for this class of roads including a boulevard treatment with central median, on road cycle lanes and on street parking as shown in **Figure 12**.

The remaining north-south road within the LSP area is classified as Neighbourhood Connector B with a typical reservation of 19.4m (parking on both sides) or 17.7 (parking on one side next to the public primary school) as shown in **Figures 13** and **14**. The other roads are classified as Access Street C and D with typical reservation of 15.4 -16m and 14.2m respectively as shown in **Figures 15** and **16**. All laneways will have a width of 6m.

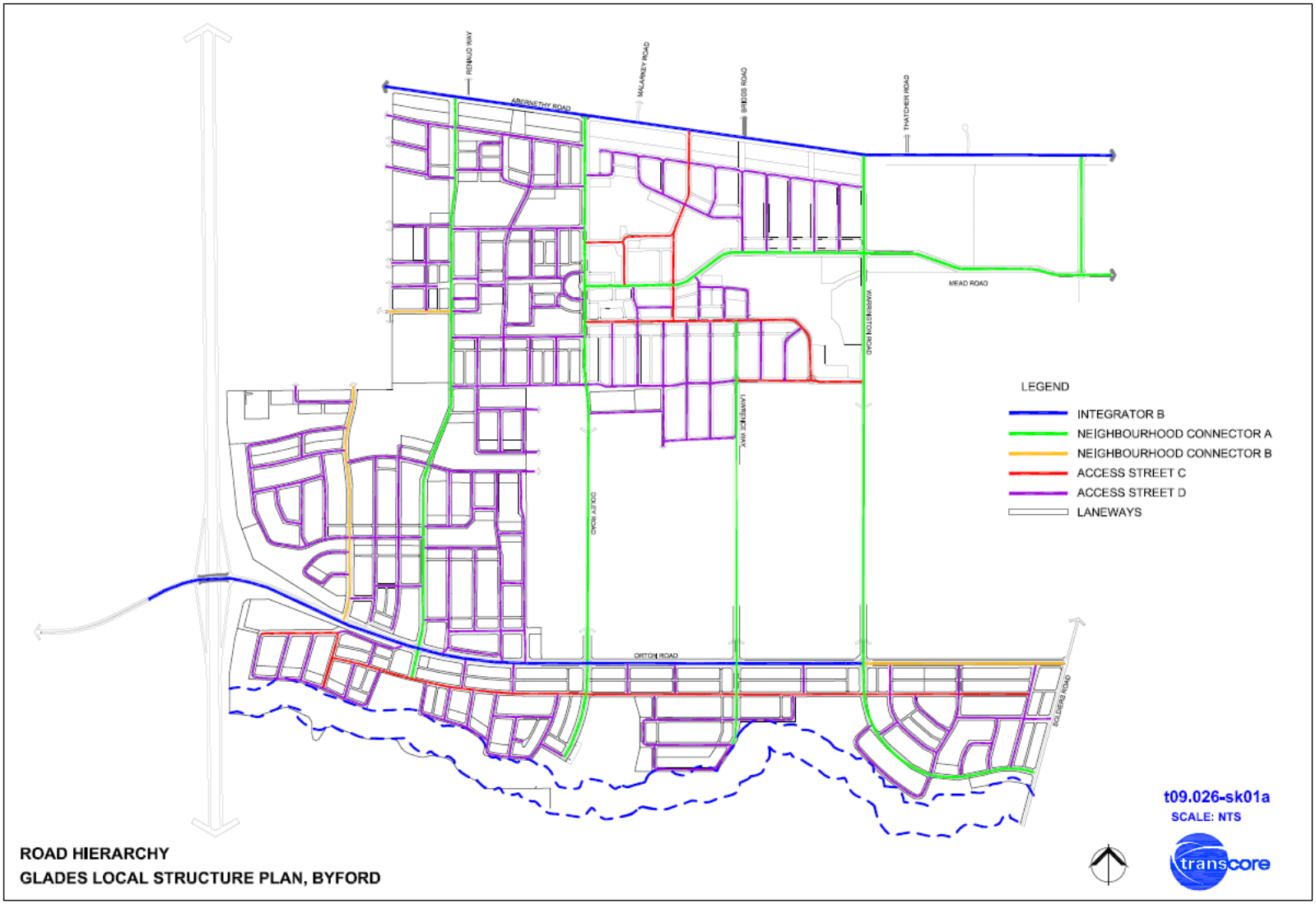


Figure 5: LSP Road Hierarchy

Figures 6 to **16** illustrate the typical road cross sections for the LSP area.

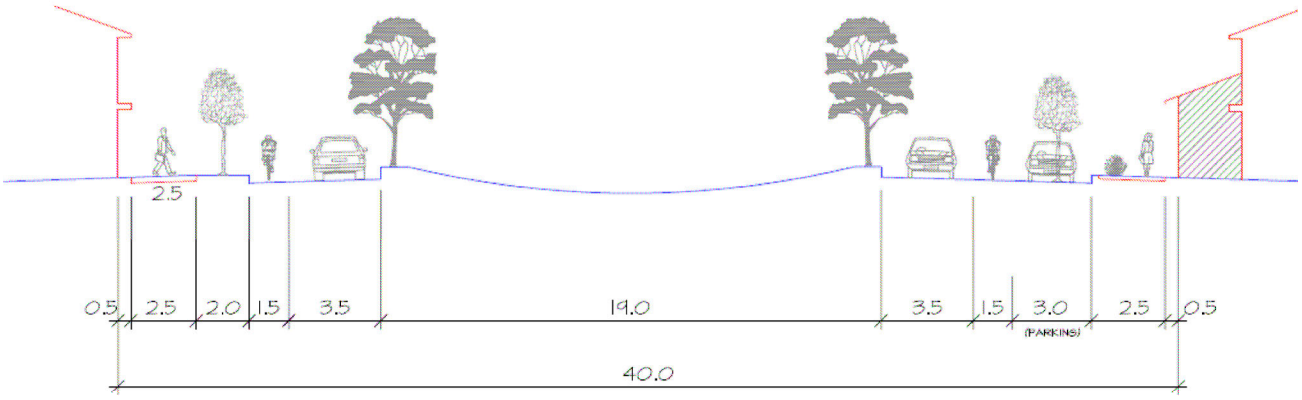


Figure 6: Integrator B, Option1 – Typical Cross-section with Drainage Swale in the Middle

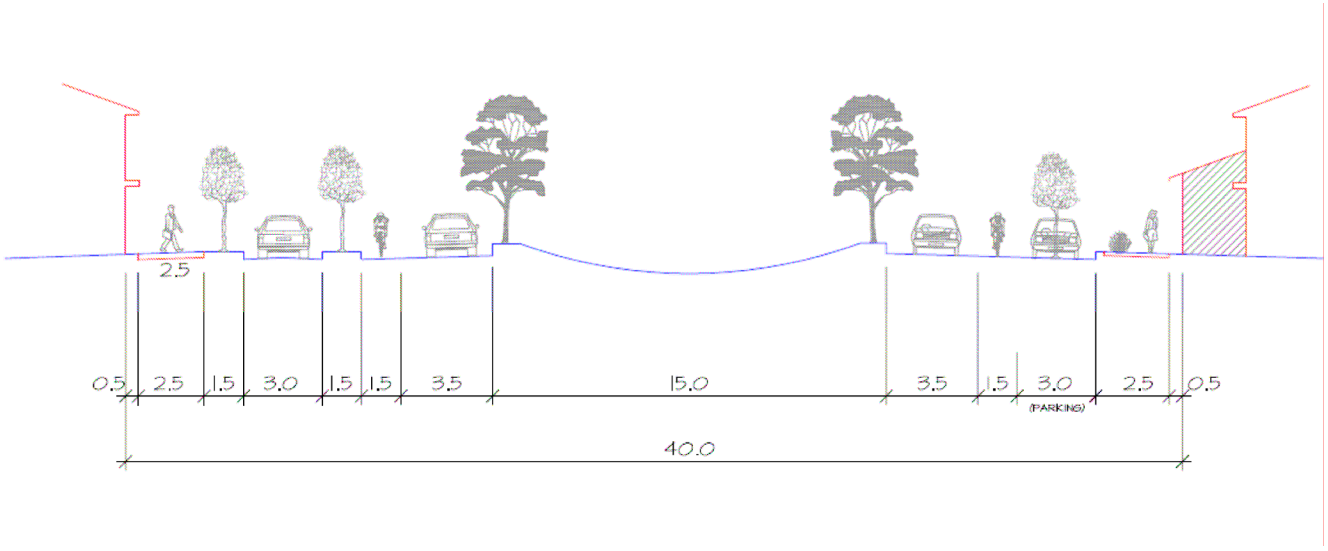


Figure 7: Integrator B, Option 2 – Typical Cross-section with Drainage Swale in the Middle and Service Road

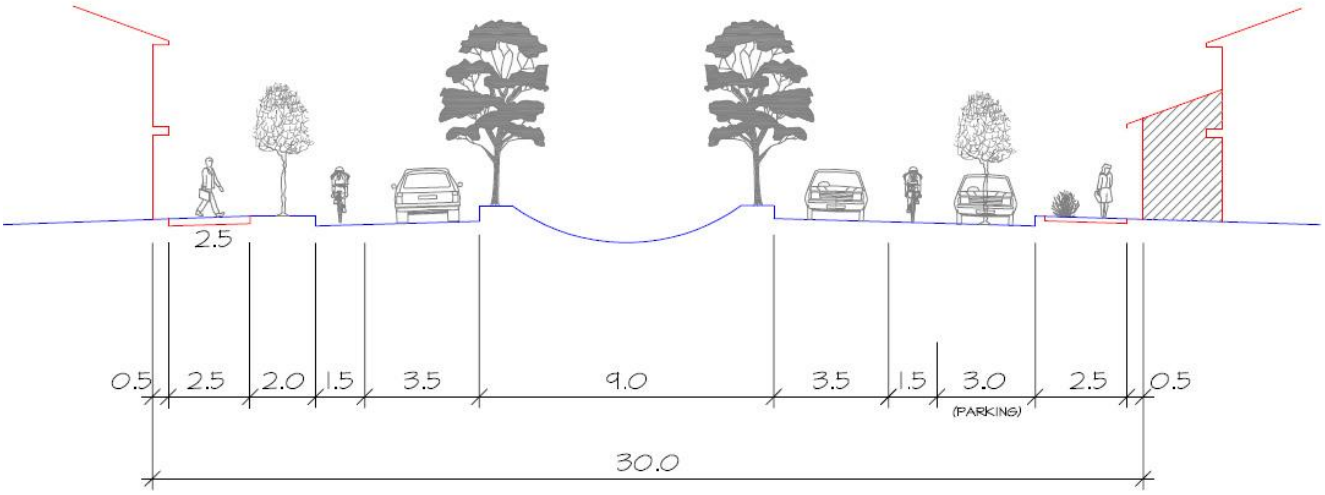


Figure 8: Integrator B, Option 3 – Typical Cross-section with Drainage Swale in the Middle - 30m Reserves

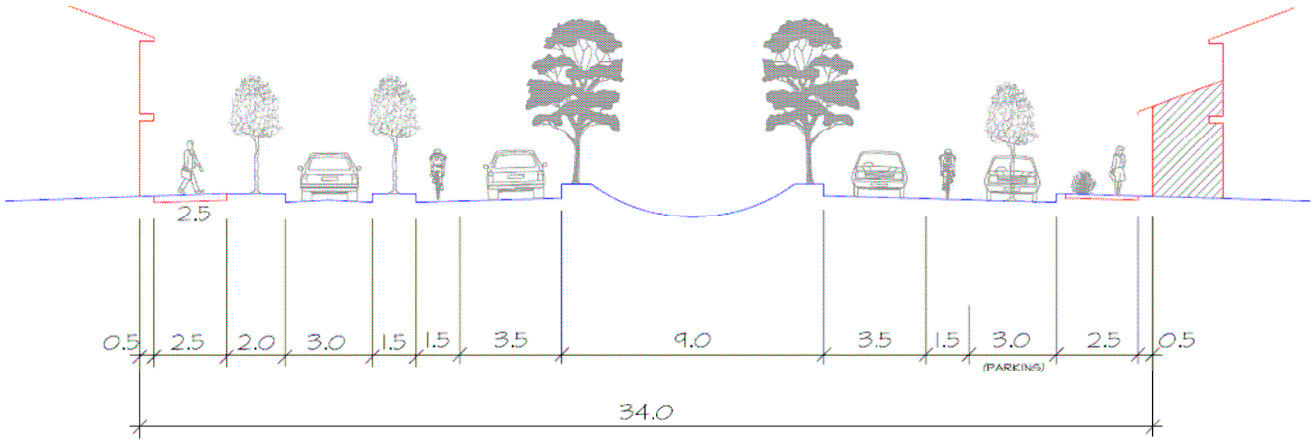


Figure 9: Integrator B, Option 4 – Typical Cross-section with Drainage Swale in the Middle and Service Road – 34m Reserves

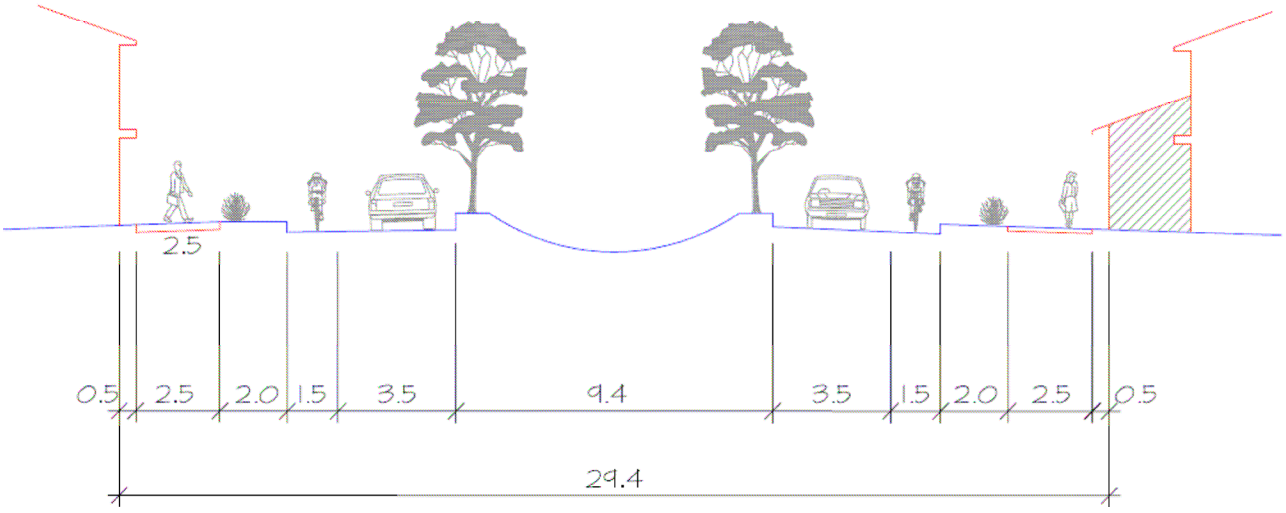


Figure 10: Integrator B, Option 5 – Typical Cross-section with Drainage Swale in the Middle – 29.4m Reserves without on-street Parking

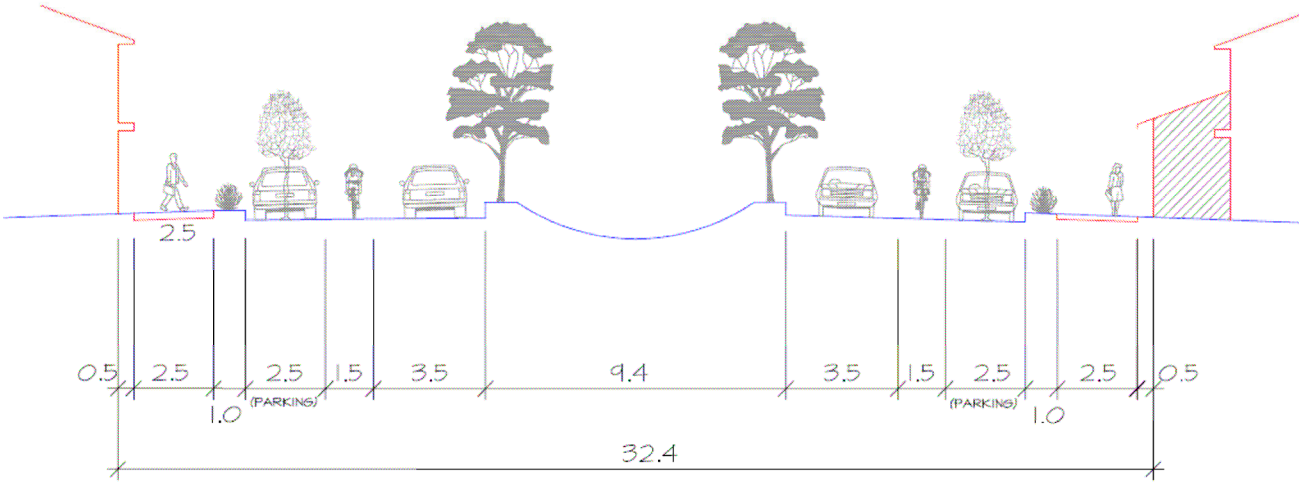


Figure 11: Integrator B, Option 6 – Typical Cross-section with Drainage Swale in the Middle – 32.4m Reserves with on-street Parking

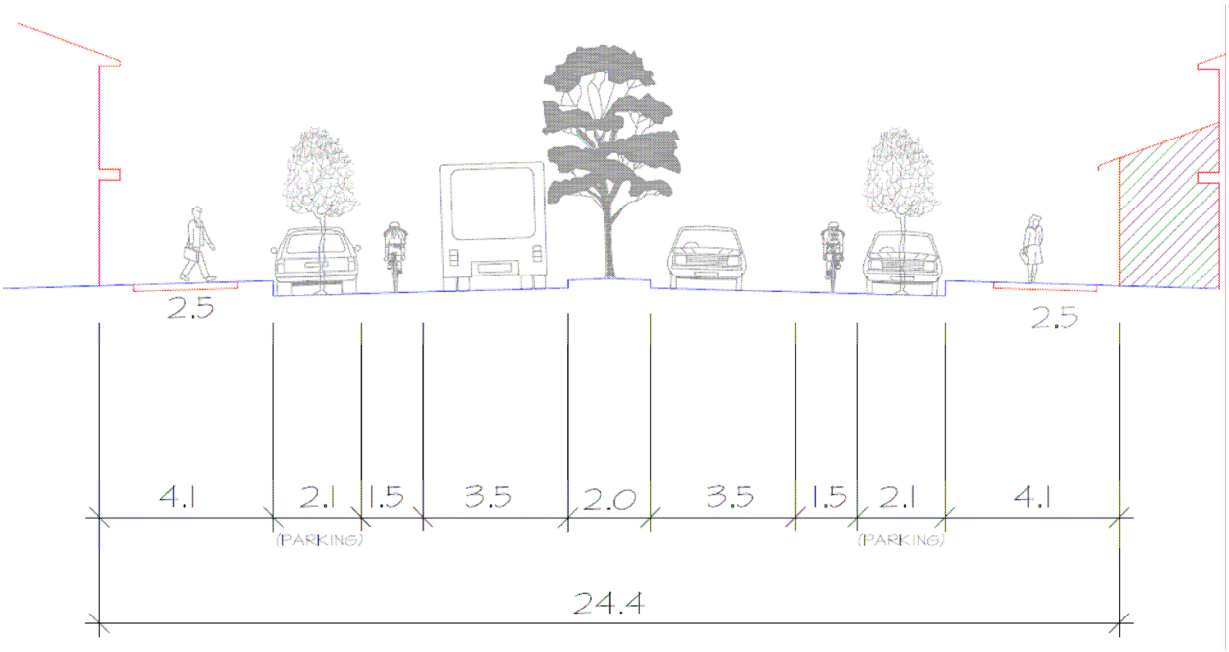


Figure 12: Neighbourhood Connector A – Typical Cross-section with Parking on Both Sides

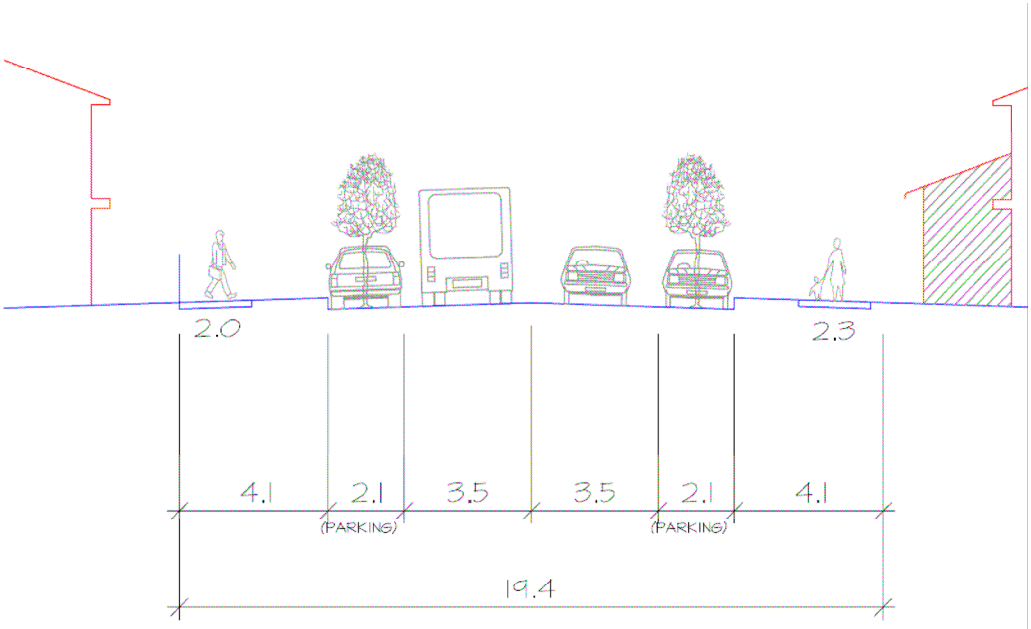


Figure 13: Neighbourhood Connector B – Typical Cross-section with Parking on Both Sides

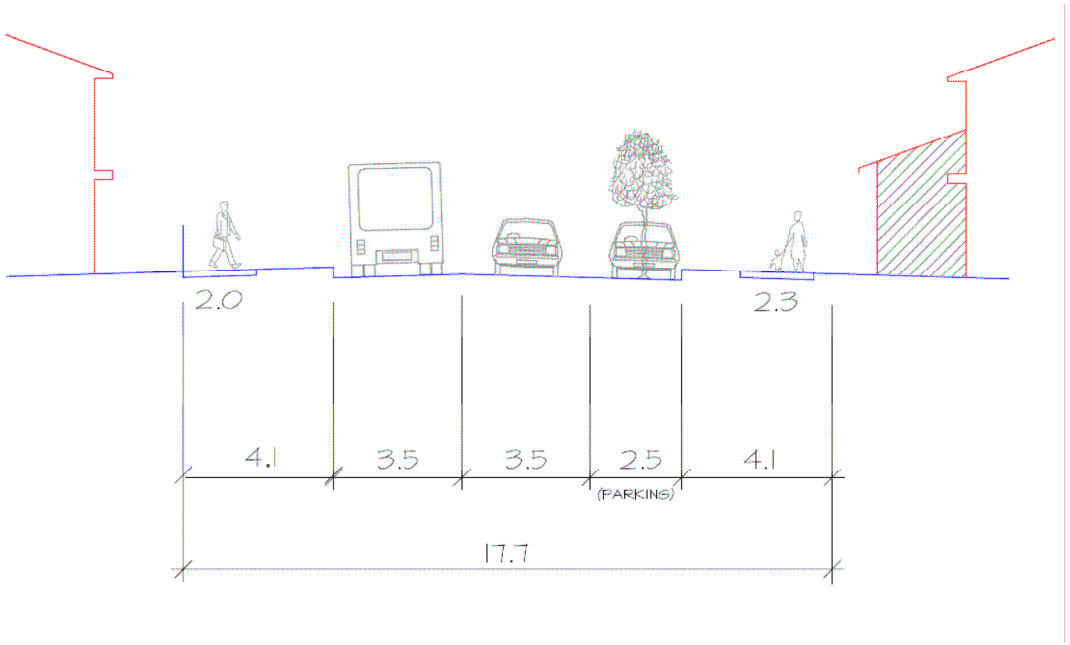


Figure 14: Neighbourhood Connector B – Typical Cross-section with On-Street Parking on One Side

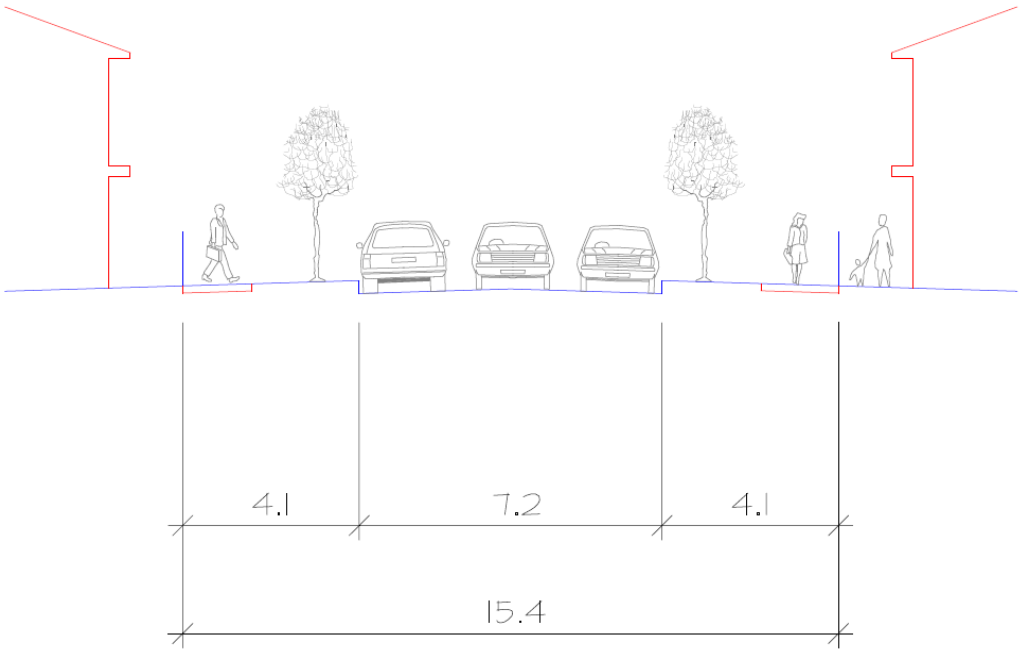


Figure 15: Typical Cross Section for a 15.4 m Access Street C

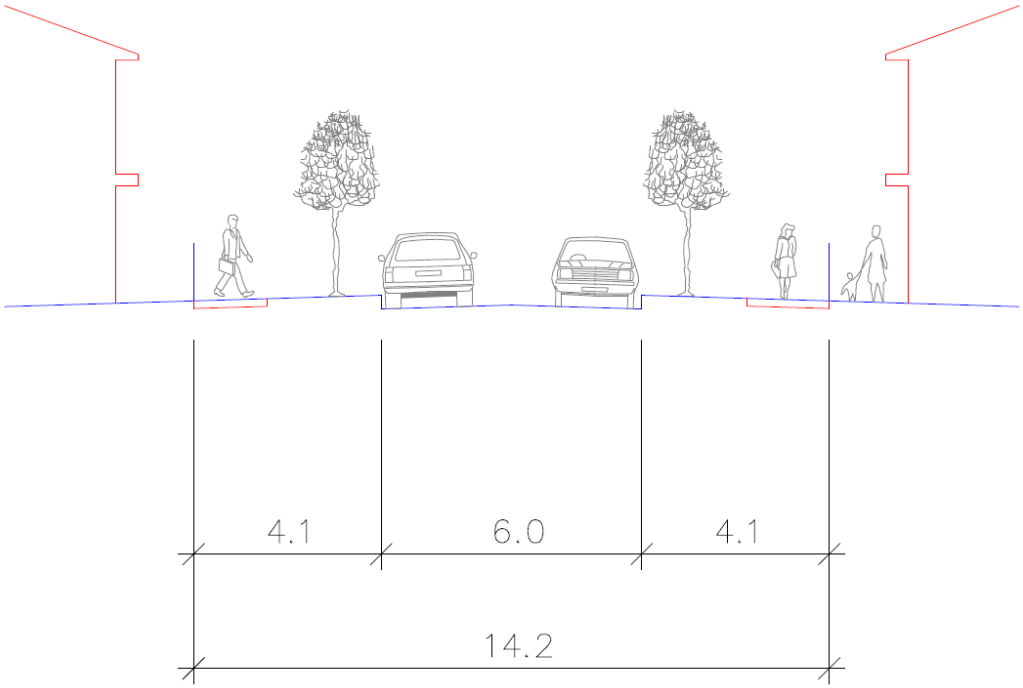


Figure 16: Typical Cross Section for a 14.2 m Access Street D

6 INTERSECTION TREATMENTS

The proposed intersection controls for the key LSP intersections are shown in **Figure 13**. In establishing the proposed intersection controls, consideration was given to the road network layout and classifications, estimated traffic volumes, effective traffic management and road safety.

For the four-way priority controlled intersections, appropriate treatments such as coloured bitumen and/or raised plateaus are recommended for the minor legs of these intersections. Details of such treatment are to be finalised during the subdivision design stage.

Figure 17 illustrates the proposed intersection treatments for the LSP area.

Figure 17: Intersection Treatments for the LSP Area

7 PEDESTRIANS, CYCLISTS

The overall pedestrian and cyclist network within the LSP area aims to connect centres of attraction within and immediately beyond the LSP area and provide good links with external generators. Specifically this includes the primary school, High school, shopping and neighbourhood centres and other centres of pedestrian/ cyclist activity.

On Integrator Roads, Shared Paths (Dual Use Paths) should be provided on both sides of the road. ON Neighbourhood Connectors, Shared Paths should be provided at least on one side of the road and on both sides in the vicinity of schools and retail/commercial land uses.

Footpaths should be provided on at least one side of all streets, with the possible exception of short cul-de-sac and laneways.

Figure 18 shows the recommended path system for the LSP area.

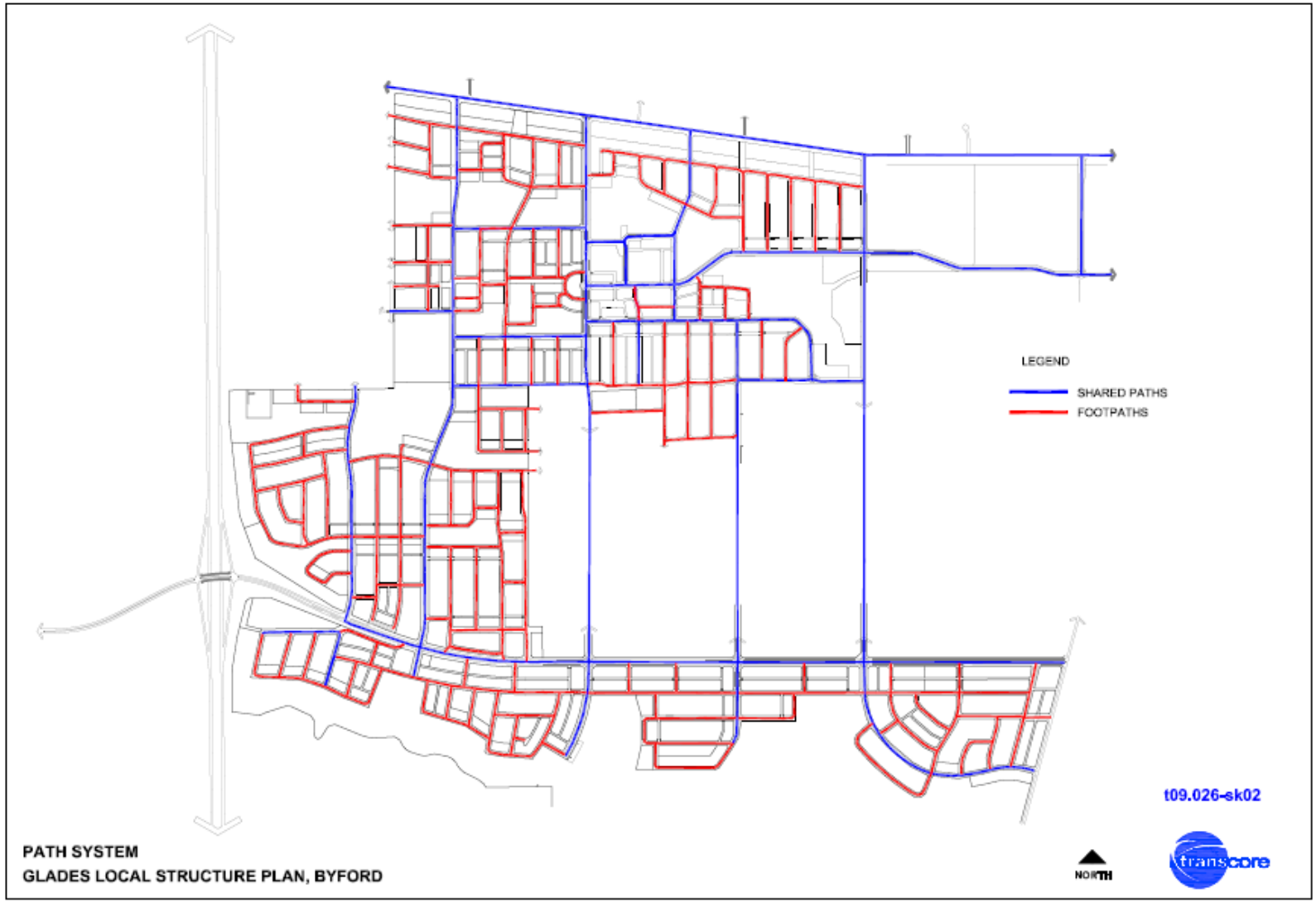


Figure 18: Path Network for the LSP area

8 PUBLIC TRANSPORT

Based on liaison undertaken with Public Transport Authority and Transperth, there are immediate plans to upgrade route 251, which services the area, but this upgrade is yet to get funding from government.

Further in the future, Transperth are planning two or three routes to service Byford west of the existing town centre. Subject to the final development pattern and availability of funds, it is most likely that the new routes would operate in the town centre and then connect to route 251 into Armadale or continue on to Armadale. Transperth prefers this latter option.

The potential bus routes servicing the Byford Structure Plan and the LSP area are shown in **Figure 19**. The Route 1 is likely to be introduced first and Route 2 would follow after further developments.

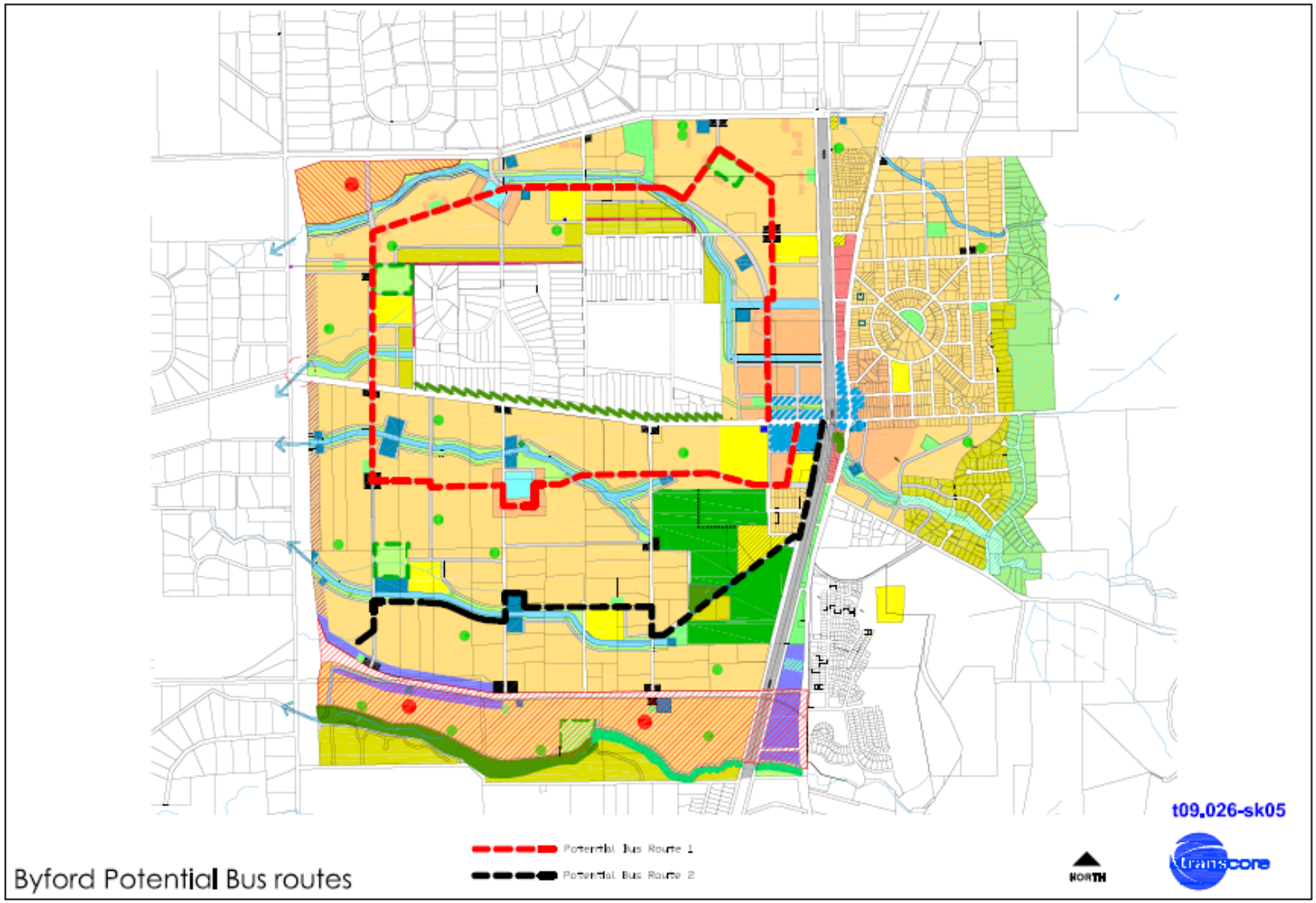


Figure19: Recommended Bus Routes for the LSP Area

APPENDIX A – Byford District Structure Plan

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 NEW TOWN CENTRE DISTRICT DISTRIBUTOR INTEGRATOR 'B' ROAD AND LARSEN ROAD TO BE REVIEWED AS PART OF FURTHER DETAILED STRUCTURE PLANNING
4. CARDUP BROOK FORESHORE RESERVE: NOMINAL WIDTH 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 REQUIRE THE FINAL WIDTH OF ABERNETHY ROAD TO BE 40 METRES UNLESS OTHERWISE DETERMINED AT THE LOCAL STRUCTURE PLAN STAGE.
7. POSSIBLE ALTERNATE LOCATION FOR FUTURE RAILWAY STATION BASED ON RECOMMENDATIONS OF THE TOWNSCAPE STUDY.
8. APPROX. LOCATION OF SEWER PUMP STATION AND 150m BUFFER.
9. THE BYFORD STRUCTURE PLAN PROVIDES 8.6% PUBLIC OPEN SPACE. THE BALANCE 1.4% PUBLIC OPEN SPACE WILL BE REQUIRED TO BE IDENTIFIED IN FURTHER DETAILED STRUCTURE PLANNING AND TO BE GIVEN UP AT THE TIME OF SUBDIVISION.
10. PROSPECTIVE PURCHASERS OF ALL NEW RESIDENTIAL LOTS CREATED WITHIN 200 METRES OF ANY LOT CONTAINED WITHIN THE BYFORD TROTTING COMPLEX WILL BE REQUIRED TO BE NOTIFIED THAT THEY ARE WITHIN PROXIMITY OF THE TROTTING COMPLEX AND ASSOCIATED LAND USES.
11. ANY DETAILED STRUCTURE PLANS FOR THE LAND ABUTTING THE SOUTH SIDE OF ABERNETHY ROAD SHOULD INCLUDE MEASURES TO PROVIDE FOR AN ADDITIONAL BUFFER BETWEEN ABERNETHY ROAD AND THE RURAL LAND ON THE NORTH SIDE OF ABERNETHY ROAD. SUCH MEASURES COULD INCLUDE, BUT ARE NOT LIMITED TO, THE ORIENTATION OF LOTS, LOCATION OF LOCAL PUBLIC OPEN SPACE AND ATTENTION TO THE LOCAL ROAD SYSTEM.
12. THE FUTURE CONSTRUCTION OF ABERNETHY ROAD SHOULD INCLUDE MEASURES TO PROVIDE AN AMENITY BUFFER TO THE RESIDENTIAL LAND ON THE SOUTH SIDE OF ABERNETHY ROAD. SUCH MEASURES COULD INCLUDE SOME LANDSCAPING, APPROPRIATE FENCING OR BUNDING. ABERNETHY ROAD / TONKIN HIGHWAY MAY INTERACT BY MEANS OF A GRADE SEPARATION.
13. NOTWITHSTANDING LAND HAVING A CLASSIFICATION OF RESIDENTIAL (R20) WHERE SUCH LAND ABUTS LAND ZONED RURAL RESIDENTIAL, AN APPROPRIATE LOWER RESIDENTIAL DENSITY CONSISTENT WITH THIS 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. CONSIDERATION TO BE GIVEN TO THE HISTORICAL SIGNIFICANCE OF THE BUILDING IN 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 DESIGN GUIDELINES, PRIOR TO ANY SUBDIVISION OR DEVELOPMENT. THE STRUCTURE PLAN SHOULD INCORPORATE INTO HIGH-DENSITY RESIDENTIAL DENSITIES WITHIN THE 800 METRE WALKABLE CATCHMENT AND ITS RELATIONSHIP WITH TRANSIT ORIENTED URBAN DESIGN. THE LOCATION, NATURE, ROLE, RELATIONSHIP AND DISTRIBUTION OF DIFFERENT ACTIVITIES WITHIN THE TOWN CENTRE INCLUDING 800 METRE WALKABLE CATCHMENT AREA. ANY CHANGE TO RESIDENTIAL DENSITIES OR USES WITHIN THE 800 METRE WALKABLE CATCHMENT OF THE TOWN CENTRE WILL BE SUBJECT TO A SEPARATE MODIFICATION TO THE R30 AND COMMUNITY CONSULTATION.
18. THE EXISTING WATERWAY WILL BE SUBJECT TO WATER SENSITIVE URBAN DESIGN PRINCIPLES AT THE DETAILED ENGINEERING DESIGN STAGE. THE SPECIFIC WIDTH OF THE WATERWAY 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 BASINS AND ASSOCIATED WATERWAYS WILL BE DETERMINED AT THE DETAILED AREA PLAN AND LOCAL STRUCTURE PLAN STAGE. THE FINAL LOCATION OF THE PRIMARY SCHOOL MAY BE SUBJECT TO CHANGE AND ITS LOCATION IS TO BE DETERMINED IN CONSULATION WITH THE DET DURING DETAILED STRUCTURE PLANNING.
21. RESIDENTIAL DENSITY LIMITED TO R30 IN ACCORDANCE WITH THE BYFORD TOWNSITE DETAILED AREA PLAN.
22. THERE IS A POTENTIAL FOR A RAIL CROSSING LINKING MEAD STREET AND SOUTH WESTERN HIGHWAY. HOWEVER, THIS IS A LONG TERM OPTION AND SUBJECT TO 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 STUCTURE PLANNING INCLUDING PREPARATION AND FINALISATION OF A DRAINAGE AND NUTRIENT MANAGEMENT PLAN).
28. THE FINAL ALIGNMENT OF THE TOWN CENTRE DISTRIBUTOR ROAD THROUGH LOT 1 ABERNETHY ROAD WILL BE DETERMINED DURING DETAILED STRUCTURE PLANNING.
29. FINAL LOCATION OF THE PRIMARY SCHOOL NORTH OF ORTON ROAD AND WEST OF DOLEY ROAD IS TO BE DETERMINED IN CONSULTATION WITH THE DEPARTMENT OF EDUCATION AND TRAINING DURING DETAILED STRUCTURE PLANNING FOR THE AREA.

GENERAL NOTES:

THE PREPARATION AND IMPLEMENTATION OF A BICYCLE AND PEDESTRIAN PLAN FOR EACH LOCAL STRUCTURE PLAN IN ACCORDANCE WITH THE 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 DISTRICT ROADS, PUBLIC OPEN SPACE, RESERVES, MULTIPLE USE CORRIDORS AND ARTERIAL ROADS TO ENSURE THE BUILT FORM REFLECTS THE RURAL CHARACTER OF THE AREA.

LEGEND

- STRUCTURE PLAN AREA
- DOLEY/WARRINGTON ROAD PRECINCT BOUNDARY
- RURAL RESIDENTIAL
- RESIDENTIAL (R20)
- RESIDENTIAL (R30-60)
- LAND SUBJECT TO FURTHER STUDY. (SEE NOTES 25 & 26 WHERE APPLICABLE)
- TOWN CENTRE (DEVELOPMENT 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 INTERFERENCE WITH THE ADJACENT HIGHWAY PRIMARY REGIONAL ROAD RESERVATION
- B — LAND SUBJECT TO FURTHER STUDY - PLANNING TO BE FINALISED SUBJECT TO RESOLUTION OF ALIGNMENT OF ORTON ROAD

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		10/9/2008
PLAN NUMBER	SCALE	PROJECTION
02/128/001H-struct	1:10,000 @A0 NTS @ A3	MGA 94
DESIGNED BY	CHECKED BY	DRAWN BY
KN	ST	YH

200m 0 200 400 600m

ALL AREAS AND DIMENSIONS DISPLAYED ARE SUBJECT TO DETAIL SURVEY.

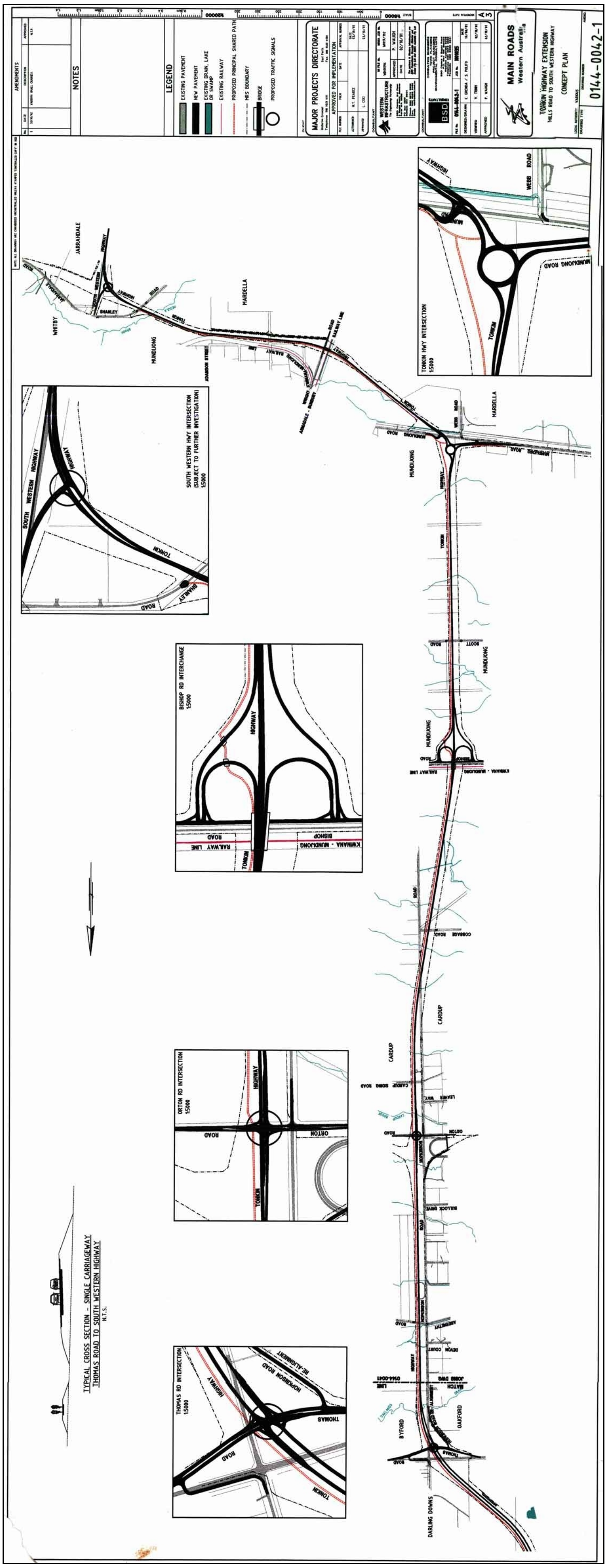
TAYLOR BURRELL BARNETT
Town Planning and Design
187 Roberts Road Subiaco
Western Australia 6008
Telephone: (08) 9382 2911
Facsimile: (08) 9382 4586
admin@tbbplanning.com.au

APPENDIX B – Glades Local Structure Plan

Byford Main Precinct - Revised Local Structure Plan (Draft)

LWP PROPERTY GROUP PTY LTD

APPENDIX C – TONKIN HIGHWAY EXTENSION PROJECT CONCEPT PLAN (MAIN ROADS WA)



MAIN ROADS
Western Australia
TONKIN HIGHWAY EXTENSION
TONKIN HWY INTERSECTION
SOUTH WESTERN HWY INTERSECTION
BISHOP RD INTERCHANGE
ORTON RD INTERSECTION
THOMAS RD INTERSECTION
TYPICAL CROSS SECTION - SINGLE CARRIAGEWAY
THOMAS ROAD TO SOUTH WESTERN HIGHWAY
0144-0042-1

APPENDIX D – South-Western Highway Upgrade Preliminary Plan (Main Roads WA)


TYPICAL CROSS SECTION STA 6900 TO VICINITY STA 6960
TYPICAL CROSS SECTION VICINITY STA 6960 TO VICINITY STA 7980
BYFORD
BYFORD BAPTIST (HUNTER)
NURSERY
BYFORD HALL
BYFORD SHOPPING CENTRE
TAVERN
BYFORD & DISTRICTS COUNTRY CLUB
PROPOSED COMMERCIAL CENTRE
PROPOSED OPEN DRAIN
BUS EMBAYMENT AND LEFT TURN LANE
DETAILS SHOWN ON THIS PLAN ARE PRELIMINARY ONLY. STAGE CONSTRUCTION AND ULTIMATE DEVELOPMENT MAY DIFFER FROM DETAILS SHOWN.
APPROXIMATE POSITION OF BUILDINGS
NOTES:
1. FOR LAND PROTECTION PLAN SEE DRG. Nos 8221-83 & 8321-29
2. DATE OF PHOTOGRAMMETRY 22/2/80
3. PROJECT FILE No 2112
4. VERTICAL CURVE DATA SHOWN FOR RIGHT MEDIAN EDGE ONLY.
5. EXISTING BITUMEN
6. SCALE FACTOR = 0.9997063
STANLEY ROAD
WALTERS ROAD
PARK ROAD
JESSIE STREET
CLARA STREET
BLYTHESWOOD ROAD
CLIFTON STREET
BEENYUP ROAD & ABERNETHY ROAD
LARSEN ROAD
VPI STA 7419 ELE 54.29 LVC 160 K -122
-0.88%
0.32%
HORIZONTAL ALIGNMENT
SUGGESTED LEVELS ON LEFT MEDIAN EDGE
SUGGESTED LEVELS ON RIGHT MEDIAN EDGE
EXISTING SURFACE
DISTANCE
TRANS 66
CURVE LEFT RAD = 3080
TRANS 66 CURVE LEFT RADIUS 880 TRANS 66
ARMADALE-BUNBURY ROAD M2
CARRIAGEWAY PATTERN AND PROFILE
THOMAS ROAD TO BEENYUP ROAD
6.74 - 8.53 S.L.K.
MAIN ROADS DEPARTMENT W.A.
URBAN PLANNING SECTION
04 03
8321-53-3

APPENDIX 7
LOCAL URBAN STORMWATER MANAGEMENT REPORT
(JDA CONSULTING)

LWP Property Group Ltd

The Glades at Byford
Local Water Management Strategy (LWMS)

June 2009

DISCLAIMER

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1. INTRODUCTION

1.1 Background

This local water management strategy (LWMS) has been prepared by JDA Consultant Hydrologists on behalf of LWP Property Group Pty Ltd in support of the Local Structure Plan addressing the landholding shown in Figure 1 and herein referred to as the Study Area.

The LWMS provides the framework for the application of total water cycle management to the proposed urban structure consistent with Better Urban Water Management (WAPC, 2008) and Department of Water (DoW) principles of Water Sensitive Urban Design (WSUD) described in the Stormwater Management Manual (DoW, 2007).

1.2 Key Design Principles and Objectives

The LWMS employs the following key documents to define its content, key principles and objectives:

- Peel Harvey WSUD Local Planning Policy (Peel Development Commission, 2006)
- Stormwater Management Manual for Western Australia (DoW, 2007)
- Better Urban Water Management (WAPC, 2008)
- Byford Townsite Drainage and Water Management Plan (DoW, 2008)

A summary of the key design principles and objectives from these documents is provided in Table 1 and summarised below in chronological order.

1.2.1 Peel Harvey WSUD Local Planning Policy (2006)

The *Peel Harvey WSUD Local Planning Policy* (Peel Development Commission 2006) was developed through the Federal Governments Coastal Catchments Initiative and endorsed by the Environmental Protection Authority (EPA). It aims to assist local government to help integrate catchment management objectives with land and resource planning in urban landscapes.

The policy identifies broad policy objectives against which strategic and statutory proposals can be assessed. WSUD principles, in order of priority, are outlined below:

- Provide protection to life and property from flooding that would occur in a 100 year Average Recurrence Interval (ARI) flood event
- Manage rainfall events to minimise runoff as high in the catchment as possible. Use multiple low cost ‘in-system’ management measures to reduce runoff volumes and peak flows (for example, maximise infiltration from leaky pipes and stormwater pits installed above pollutant retentive material)

- Retain and restore existing elements of the natural drainage system, including waterway, wetland and groundwater features and processes, and integrate these elements into the urban landscape, possibly through a multiple use corridor.

- Minimise pollutant inputs through implementation of appropriate non-structural source controls (such as town planning controls, strategic planning controls, pollution prevention procedures, education and participation programs and regulatory controls) and structural controls (that manage the quantity and quality of stormwater runoff and prevent or treat stormwater pollution)

- Maximise water use efficiency, reduce potable water demand, and maximise the re-use of water harvested from impermeable surfaces

Water quantity management principles and objectives are provided based on post-development discharges being maintained relative to predevelopment levels. Criteria are provided for both ecological protection (1 in 1 year events), and flood protection (1 in 100 year events). Water quality management principles and objectives are based on maintaining or improving water quality relative to existing conditions.

Specific water quality guidelines are provided in the document including limitations on developments where average input rates of nutrients exceed 15 kg/phosphorus/ha per annum or 150 kg/nitrogen/ha per annum.

In addition, stormwater management is stated as having to provide (as compared to a development that does not actively manage stormwater quality):

- At least 80% reduction of total suspended solids

- At least 60% reduction of total phosphorus

- At least 45% reduction of total nitrogen

- At least 70% reduction of gross pollutants

The policy is consistent with the *Decision Process for Stormwater Management in WA* (DoE and Swan River Trust 2005) which is appended to the policy and is consistent with the objectives of the Environmental Protection Policy (Peel Inlet – Harvey Estuary) 1992.

This policy is stated as holding no legal standing and envisages each local government in the Peel Harvey catchment will customise the model policy to suite its own specific requirements.

At the time of preparing this LWMS, it is understood no customisation of this policy has been undertaken by the Shire of Serpentine -Jarrahdale.

1.2.2 Stormwater Management Manual for Western Australia (2007)

The Water and Rivers Commission (now Department of Water, DoW) released *A Manual for Managing Urban Stormwater Quality in Western Australia* in 1998 to define and practically describe Best Management Practices (BMP's) to reduce pollutant and nutrient inputs to stormwater drainage systems. The Manual also aimed to provide guidelines for the incorporation of water sensitive design principles into

urban planning and design, which would enable the achievement of improved water quality from urban development.

The document was released to provide a guideline for best planning and management practices and was intended for use by Water and Rivers Commission, but also by other State and Local Government Authorities and sectors of the urban development industry.

DoW has recently completed a major review of the manual in consultation with a working team comprising industry and government representatives. The revised manual was officially launched in August 2007.

DoW's current position on Urban Stormwater Management in Western Australia is outlined in Chapter 2: Understanding the Context of the Stormwater Management Manual for Western Australia (DoW 2007), which details the management objectives, principles and a stormwater delivery approach for WA. Principle objectives for managing urban water in WA are stated as:

- Water Quality: To maintain or improve the surface and groundwater quality within development areas relative to pre-development conditions
- Water Quantity: To maintain the total water cycle balance within development areas relative to the pre-development conditions
- Water Conservation: To maximise the reuse of stormwater
- Ecosystem Health: To retain natural drainage systems and protect ecosystem health
- Economic Viability: To implement stormwater systems that are economically viable in the long term
- Public Health: To minimise the public risk, including risk of injury or loss of life to the community
- Protection of Property: To protect the built environment from flooding and waterlogging
- Social Values: To ensure that social aesthetic and cultural values are recognised and maintained when managing stormwater
- Development: To ensure the delivery of best practice stormwater management through planning and development of high quality developed areas in accordance with sustainability and precautionary principles

To provide a decision framework for planning and design of stormwater management systems and assist in meeting the objectives specified above, the Department of Environment (now Department of Environment and Conservation / DoW) and Swan River Trust released the Decision Process for Stormwater Management in WA in 2005. An update of the decision process is in progress, but a review of the draft indicates no significant changes are proposed.

1.2.3 Better Urban Water Management (2008)

The guideline document Better Urban Water Management (WAPC, 2008), focuses on the process of integration between land use and water planning by specifying the level of investigations and documentations required at various decision points in the planning process.

This LWMS complies with the BUWM process.

1.2.4 Byford Townsite Drainage and Water Management Plan (2008)

In 2005 the Byford District Structure Plan was endorsed by the Shire of Serpentine-Jarrahdale. In support of the DSP was the Byford Urban Stormwater Management Strategy (Parsons Brinkerhoff, 2003) which was later simplified to the Byford Urban Stormwater Management Plan Developer Guidelines in 2005 (Parsons Brinkerhoff, 2005).

In 2007 the Department of Water nominated to prepare the Byford Townsite Drainage and Water Management Plan (DWMP) to address the DSP. The DWMP was completed in 2008, and according to the document, now supersedes the Byford Urban Stormwater Management Strategy previously adopted by the Shire.

The DWMP provides a district scale assessment of the hydrological relevant to the implementation of the Byford DSP. The DWMP includes:

- Regional groundwater contour mapping based on regional groundwater modelling by Cymod.
- Hydrological modelling (flows, flood levels) of the main tributaries through the DSP area for both the pre-development and post-development condition.
- Post-development 5yr and 100 yr ARI peak runoff compensation volumes for sub-catchments discharging to the Oakland Main Drain and the hydraulic backwater conditions. Modelling allows discharge at pre-development peak discharge rates and assumes 1yr ARI is infiltrated.
- Alternative definitions of groundwater terms (CGL, MGL, phreatic line) and groundwater management requirements to determine the CGL and phreatic line. Fill requirements for finished lot levels are 1.2m above the MGL or phreatic line where sub surface drainage is installed at or above regional CGL contours. No guidance is provided in the document on how such CGL or MGL calculations should be carried out.
- Sub surface drainage design criteria.
- Groundwater and surface water quality management objectives.

This LWMS addresses the water management criteria presented in the DWMP and provides a refinement of the hydrology to a local scale, appropriate for the implementation of The Glades LSP.

TABLE 1: SUMMARY OF LWMS DESIGN PRINCIPLES AND OBJECTIVES

Key Guiding Principles		
• Facilitate implementation of sustainable best practice in urban water management • Encourage environmentally responsible development • Provide integration with planning processes and clarity for agencies involved with implementation • Facilitate adaptive management responses to the monitored outcomes of development • To minimise public risk, including risk of injury or loss of life • To maintain the total water cycle		
Category	DWMP Criteria	LWMS Objective
Water Balance	• To minimise changes to the water balance to prevent negative impacts on water courses and wetlands	• To minimise changes to the water balance to prevent negative impacts on water courses and wetlands
Water Conservation and Sustainability	• The State Water Plan target for water use of 100 kL/person/yr with no more than 60 kL/person/yr of scheme water.	• The State Water Plan target for water use of 100 kL/person/yr with no more than 60 kL/person/yr of scheme water.
Village Centre Lake	• Constructed Lakes are not recommended by the Department of Water.	• To demonstrate that a well designed and maintained constructed lake, providing aesthetic, recreational and health benefits to the Glades community, is feasible at the Village Centre site.
Watercourse restorations and alignments	• Restoration or waterways with channel realignments and profile modifications is permitted provide the cross-sectional area of the channel is maintained.	• Restoration or waterways with channel realignments and profile modifications is permitted provide the flow capacity of the channel is maintained.
Stormwater Management	• All 1 yr 1 hr ARI event runoff be infiltrated at sources where possible • Post-development critical 1 yr ARI peak flow and volume and the 100 yr ARI peak flow shall be consistent with pre-development peak flow at the discharge point of each sub-catchment and discharge points of all subdivisions into waterways	• All 1 yr 1 hr ARI event runoff treated prior to discharge. • Post-development critical 1 yr ARI peak flow and volume and the 100 yr ARI peak flow shall be consistent with pre-development peak flow at the discharge point of each sub-catchment and discharge points of all subdivisions into waterways
Groundwater Management	• Protection of infrastructure and assets from flooding and inundation by high seasonal groundwater levels, perching and/or soil moisture. • Managing and minimising changes in groundwater levels and groundwater quality following development.	• Protection of infrastructure and assets from flooding and inundation by high seasonal groundwater levels, perching and/or soil moisture. • Managing and minimising changes in groundwater levels and groundwater quality following development.
Water Quality	• To develop site specific targets for the area. In the interim when compared to a development that does not actively manage water quality a 60% reduction in Total Phosphorus and 45% reduction in Total Nitrogen should be achieved.	• To develop site specific targets for the area. In the interim when compared to a development that does not actively manage water quality a 60% reduction in Total Phosphorus and 45% reduction in Total Nitrogen should be achieved. • To minimise and manage Total Phosphorus and Total Nitrogen inputs consistent with the targets of the Peel Harvey WSUD Local Planning Policy (2006).
Wetlands	• To maintain the pre-development hydrological regime of the wetlands • Protect wetlands from the impacts of urban runoff	• To maintain the pre-development hydrological regime of the wetlands • Protect wetlands from the impacts of urban runoff

1.3 Statutory Framework

1.3.1 Regional Planning

The Glades at Byford is zoned urban under the Metropolitan Regional Scheme (WAPC, 2007).

1.3.2 District Planning

The Glades at Byford development lies within the Byford District Structure Plan area. The Byford District Structure Plan was prepared by the Shire of Serpentine Jarrahdale in 2005. Following a revision in 2006 the plan was adopted in February 2007.

A regional Byford Urban Stormwater Management Strategy (BUSMS) initiated by the Shire was prepared for the Byford Structure Plan area by Parsons Brinkerhoff and Ecological Engineering (2003) along with the subsequent BUSMS Guidelines for Developers (2005). The BUSMS Guidelines for Developers (2005) includes guidance on water reuse options, sizing stormwater treatment measures, water-quality related monitoring and vegetation treatments for stormwater structures.

The Department of Water released the Drainage and Water Management Plan (DWMP) for the Byford area in September 2008 which includes revised hydraulic modelling of major water courses.

1.3.3 Local Structure Plan

This LWMS is presented in support of the Local Structure Plan.

The LWMS addresses the LWP Property Group landholding and provides a refinement of the flood modelling, surface water management strategy and groundwater management strategy to a local scale. This LWMS is consistent with the DWMP and water sensitive urban design practices as described in the Stormwater Management Manual of WA (DoW, 2007).

2. PROPOSED DEVELOPMENT

The subject land is 328 ha and is situated within the south eastern corridor of the Perth Metropolitan Region and is located approximately 25km south of the Perth CBD.

The site is bounded by Hopkinson Rd to the west, Abernethy Road to the north, Soldiers Rd to the east and Cardup Brook to the south (Figure 1). The subject land starts approximately 500 m west of the existing Byford Town site.

The proposed land use is for residential development consistent with the Byford Structure Plan. The structure plan for The Glades is shown in Figure 7.

Major existing hydrological features within the study area include Cardup Brook and 3 minor unnamed watercourses which pass through the site.

Key elements of the Structure Plan related to urban water management include:

- The use of Multiple Use Corridors (MUC) to retain and enhance the natural water courses passing through the study area.
- Use of bio-retention treatment systems for detention and treatment of stormwater.
- All drainage infrastructure located outside of CCW's and associated buffers.
- The extensive use of local native species in open spaces, streetscapes and wetland buffers to reduce nutrient input and conserve water resources.
- The creation of a feature lake in the Village Centre precinct providing amenity to this community area.

3. PREDEVELOPMENT ENVIRONMENT

3.1 Location and Existing Land Use

The subject site was historically utilised for rural purposes, predominately horse agistment and therefore has been previously cleared.

Existing land use of the site is shown in Figure 2. The Study Area is approximately 95% cleared pasture with some pockets of trees in around existing rural dwellings.

3.2 Topography

The existing topography of the Study Area is shown in Figure 3. The site features several small sand dunes but in generally slopes gently to the west with the most elevated land along the eastern boundary at 56 m AHD and the lowest portion of the site along the western boundary at 27 m AHD.

3.3 Climate

The Perth region is characterised by a Mediterranean climate comprising hot dry summers and cool wet winters. The closest rainfall station to the study area is Cardup, Bureau of Meteorology Station No 009137, which has an annual mean of 871.5 mm recorded from 1970 to 2005.

The average annual pan evaporation is approximately 1898 mm (Luke et al, 1988).

3.4 Aboriginal Heritage

An Aboriginal Heritage assessment of The Glades was undertaken in 2006.

Two Aboriginal sites are listed on the Register of Aboriginal Sites in the Glades at Byford:

Cardup Brook (Site ID 16108), listed on the Interim Register of Aboriginal Sites as a mythological site and encompasses the entire brook and a buffer zone of 30m on either side.

Cardup (Site ID 3310), listed on the Interim Register of Aboriginal Sites as an artefact scatter is reportedly located approximately 50m from the north bank of Cardup Brook and roughly 400m southwest of the intersection of the Orton and Doley roads.

As a result of the 2006 assessment three new archaeological sites, stone artefact scatters (BAS-001, BAS-002 and BAS-005) and four isolated artefacts (BAS/ISO-003-BAS/ISO-006) were recorded in the vicinity of The Glades at Byford. These sites comprise small clusters of flaked stone artefacts (34, 6 and 22 respectively) and are of low-moderate archaeological significance. All are located on Bassendean Sands or on Bassendean Sands overlying the Guildford Formation. There is also potential for further artefacts to be present in sub-surface sands in the immediate vicinity of the sites.

The field survey could not locate the previously recorded Cardup site (Site ID 3310) and it is possible that either the spatial information recorded by DIA is incorrect or that the site has been destroyed by previous land use.

Apart from Cardup Brook (site 16108) no ethnographic surveys were identified during the 2006 consultation with indigenous families.

A section 18 Notice has been granted by the Department of Indigenous Affairs that allow development of The Glades at Byford.

3.5 Geology and Soils

The soils are classified by Jordan (1986) as Colluvium with sandy clays dominant (Figure 5). The soils are variable with lenses of silt, rounded gravels and quartz sands.

A preliminary geotechnical investigation has been completed for the site by Coffey Geotechnical in September 2005. The investigation included 30 test pits where sampling and pocket penetrometer readings were recorded. Dynamic Cone Penetrometer test were also conducted at 30 locations varying in depth from 1.05 m to 2.10 m below existing ground surface. The location of the test pits are shown on Figure 3.

The results of the preliminary geotechnical assessment generally agree with the mapping by Jordan (1986)

3.6 Acid Sulphate Soils

Regional Acid Sulphate Soil (ASS) risk mapping from Planning Bulletin no 64 (WAPC, 2003), is shown in Figure 5. The risk mapping is associated with geology as the ASS mapping was derived on the basis of geological origin and depth to groundwater. Mapping identifies the sandy clay areas in the Study Area as Class 2; moderate to high risk of ASS or PASS occurring >3 m of natural soil surface, but no risk < 3 m from soil surface, the maximum depth that most development activates would disturb. A portion of land in the south east corner of the site is classified as Class 3; No risk of ASS of PASS.

Most of the development activity will not disturb soils greater than 3 m below natural surface and as such no further ASS investigations have been undertaken to date. Construction of the main sewer line from the pump station located in the eastern side of the Study Area requires excavation in excess of 3 m below natural surface. An ASS assessment was completed for the sewer line. The results of the testing, assessed against the *Water Corporation Acid Sulphate Soil and Dewatering Management Strategy* found the level of ASS risk to be low (Level 1 Management Ranking). This is consistent with the regional ASS mapping.

3.7 Surface Water Hydrology

3.7.1 Existing Surface Drainage

The Byford area drains east to west, with catchments of the major tributaries extending back into the Darling Scarp. Naturally these tributaries would have dissipated to the west where the flow moves out onto the sandy soils of the Swan Coastal Plain and infiltrates, but historically the construction of a series of open drains west of Hopkinson Rd now connects these tributaries to the Serpentine River which ultimately flows to the Peel-Harvey Estuary. West of Hopkinson Rd the watercourses flow into the Water Corporation main drainage network, referred to as Oakland Drain.

Beenyup Brook

Beenyup Brook is a major tributary located just north of Abernethy Rd, with a catchment of approximately 1350 ha extending east of South Western Hwy into the Darling Scarp. Beenyup Brook does not flow through the Study area, but the development of the Byford District Structure plan influences the flow route of Beenyup Brook in major flood events which has implication for The Glades development. This is discussed further in Section 4.4.

Cardup Brook

Cardup Brook marks the southern boundary of the study area, just south or Orton Rd. The Brook flows east to west with a catchment extending into the Darling Scarp. The catchment east of South Western Hwy is approximately 1286 ha.

Minor Tributaries

A series of minor tributaries are present over the study area. These tributaries are local drainage commencing at the foot of the hills and flowing west. The tributaries are generally quite degraded as they pass through open paddocks where livestock can access the creek line.

The minor tributaries passing through the Study area have no official title and are referred to as Tributary 6, 7 and 10 in the DWMP. For consistency these names have been adopted in this report.

3.7.2 Peak Flow Estimates

Pre-development peak flow estimates for each of the tributaries are presented in the Byford Townsite DWMP (DoW, 2008). The flows for the relevant tributaries at the upstream and downstream boundaries of the study area are summarised in Figure 9.

3.7.3 Surface Water Quality

Surface water sampling from four surface water monitoring sites commenced in August 2006 and is ongoing (Figure 6). Samples were analysed for physical parameters and nutrients.

A summary of the surface water quality results are shown in Table 2 in relation to ANZECC (2000) guideline values, as well as Australian Runoff Quality mean stormwater concentrations (IEA, 2006) and the Phosphorus targets presented in the Peel-Harvey WQIP (EPA, 2008).

All of the sites flow seasonally, generally from May to December each year depending on rainfall.

TABLE 2: PRE-DEVELOPMENT AVERAGE SURFACE WATER QUALITY VALUES

Parameter and unit of measurement	ANZECC Guide-line Values	Mean ARQ Urban Stormwater Concentration	Peel-Harvey Estuary WQIP Target for the Upper Serpentine	Monitoring Sites					
				S1	S2	S3	S4	S5	S6
Electrical conductivity (mS/cm)	0.12 – 0.30	-	-	0.52	0.43	0.53	0.51	0.44	0.54
pH	6.5 – 8.0	6.80	-	7.09	6.92	7.15	6.75	6.75	6.92
Total Nitrogen (mg/L)	1.20	2.70	-	1.02	1.02	1.26	0.53	0.55	0.69
Nitrate/Nitrite NOx as N (mg/L)	0.15	-	-	0.46	0.24	0.84	0.23	0.24	0.41
Total Kjeldahl Nitrogen (mg/L)	-	-	-	0.60	0.83	0.43	0.29	0.31	0.32
Total Phosphorus (mg/L)	0.06	0.29	0.1	0.07	0.09	0.02	0.05	0.03	0.03
Filterable Reactive Phosphorus (mg/L)	0.040	-	-	0.050	0.026	0.003	0.012	0.003	0.002

Note: Average values derived from at least 6 samples at each site.

3.8 Groundwater Hydrology

The geological formations have been grouped into two distinct aquifers, each being assigned the name of the major geological unit contributing to it. In descending order of depth from natural surface they are:

- Superficial Aquifer (unconfined)
- Cattamarra Coal Measures (confined)

3.8.1 Superficial Aquifer

The Superficial Aquifer in this region is referred to as the Byford Area, and extends approximately 166 km^2. The aquifer has a maximum thickness of 20 m and consists of clayey sediments of the Guildford Clay with an average transmissivity of about 100 m^2/day.

Due to the poor hydraulic conductivity of the clayey soils the area is characterised by extensive surface flow. The Superficial Aquifer is directly underlain by the Cattamarra Coal Measures in the Study Area.

3.8.2 Cattamarra Coal Measures Aquifer

The Cattamarra Coal Measures formation extends beneath all of the coastal plain between Gingin Brook and South Dandalup River, but it is present at a relatively shallow depth only in the southern area where the Yarragadee Formation is absent (Davidson, 1995). The formation is made up of fluvial sandstones, siltstones and shales with minor coal seams. In the Perth region the sandstone are pale in colour, often clayey, mostly medium to course grained and in beds up to 50 m thick. The shales are dark grey, sometimes carbonaceous, often laminated and occur in beds up to 30 m thick. The upper section of the formation is often weathered to a yellow, reddish brown colour.

Drilling in The Glades development area has encountered the top of the formation at approximately 60 m below natural surface level. The Cattamarra Coal Measures represents the most feasible source of non-potable water supply in this area.

3.8.3 Seasonal Variation in the Watertable

The Superficial Formation in the Byford area is characterised by a high clay content in the sediments which ensures only a low percentage of rainfall migrates through the soil profile to recharge the watertable. Davidson and Yu (2008) estimate the average recharge in this area to be 10% or equivalent of 87 mm per year.

The low rate of infiltration and the presence of hardpan layers in the soil profile mean that a 'perched watertable' can form locally. In average and above average rainfall years the rate of recharge will be sufficient that any perched layers will be seasonal, with the regional watertable rising up over the course of winter to incorporate the perched layers into a continuous saturated column. In below average rainfall years the rainfall recharge may not be sufficient to cause the regional watertable to rise significantly and the 'perched watertable' will remain above the regional watertable. Given the location of the study area to the Darling Scarp, a significant proportion of recharge to the regional watertable will be via groundwater throughflow in the Superficial Formations, rather than vertical recharge over the Study area.

Depending on the specific yield of the local soils, fluctuations in the regional watertable may vary 2 to 5m seasonally.

3.8.4 Estimated Regional Watertable Design Levels

Over parts of the study area the seasonal fluctuation in the regional watertable results in the watertable being close to the natural surface level for a few months of the year. This generally occurs in August/September consistent with the seasonal rainfall pattern of Perth. Where construction occurs in these areas a watertable design level needs to be specified in order to provide adequate separation of building levels from the average winter maximum watertable level. As documented in the Byford Townsite DWMP a separation of 1.2 m from the average winter maximum level is considered appropriate, achieved by importing sand fill to the site.

The winter maximum watertable varies from year to year consistent with the variation in the amount and intensity of rainfall and evapotranspiration; therefore the watertable design level needs to allow for this natural variation.

To determine the regional watertable design levels over the study area local groundwater investigations were conducted by JDA. In summary, 12 groundwater monitoring bores were installed across the study area (Figure 6), with water levels first measured in all of the bores on 13 September 2005, then measured monthly from August 2006. To date the highest level in all of the bores was recorded on 13 September 2005.

Details of the bores are provided in Table 3. The lithological logs for the bores are provided in Appendix A and a time series plot of water levels recorded in the bores is included as Appendix B.

TABLE 3: DETAILS OF GROUNDWATER MONITORING BORES

Bore ID	GDA Coordinates		Ground Level (m AHD)	Top of Casing (m AHD	Screened Interval (m BNS)	Estimated watertable design level (m AHD)
	Easting	Northing				
BDM1	404525	6434630	34.88	35.45	3.5-7.5	33.47
BDM2	404621	6433858	37.34	38.07	5.0-7.0	35.56
BDM3	404835	6432861	42.37	42.98	4.0-6.0	40.46
BDM5	403901	6432978	31.98	32.63	3.5-5.5	31.84
BDM6	403447	6432498	29.12	29.63	3.0-5.0	28.46
BDM7	404075	6433783	32.73	33.39	3.0-5.0	32.58
BDM8	403891	6434720	30.62	31.30	3.0-5.0	30.57
BDM9	405222	6434091	42.06	42.72	3.5-5.5	42.13
BDM10	405398	6433455	47.00	47.00	4.0-6.0	45.18
BDM11	405012	6433364	41.88	41.88	4.0-6.0	41.69
BDM12	406253	6433849	56.07	56.06	5.5-7.5	55.99
BDM13	405383	6432380	50.88	51.57	7.0-9.0	42.76

To correlate the water levels recorded in the JDA bores on 13 September 2005 to long-term groundwater measurements, water levels were also recorded in 4 Department of Water (DoW) monitoring bores on the 13 September 2005. Four monitoring bores were located within 1 km of The Glades development area. These bores are T170, T220, SES20 and SES21. Bores T170 and T220 have long-term records spanning from 1975 to present. Bores SES20 and SES21 were originally installed by Rockwater in 1995, with DoW taking custody of the bores following completion of the Rockwater study. These bores have only been measured on 5 occasions since 1997. Water levels recorded in the DoW bores on 13 September are presented in Table 4.

TABLE 4: DETAILS OF DOW MONITORING BORES

Bore ID	Record Period	Top of Casing (m AHD)	Water Level 13/9/05 (m AHD)	Calculated average of peaks (m AHD)	Difference (m)
T170	1975- 2008	26.94	24.96	26.08	+1.12
T220	1975- 2008	21.44	19.57	19.57	0.00
SES20	1995- 1998	39.03	37.57	-	-
SES21	1995-	60.74	59.65	-	-
				Average	**+0.56**

The average of the annual groundwater peaks over the period 1975 – 2005 was calculated to determine the watertable design level. The calculation was undertaken as a two stage process:

- An initial estimate of the AAMGL (1975 – 2005) made by applying an adjustment of +0.56 m to 13 September 2005 readings for all monitoring bores and contouring this data over The Glades development area. This adjustment was based on an average of the 2 DoW bores measured on the same day.

- Adjusting the initial AAMGL (1975 – 2005) contours to include the local groundwater drawdown effect due to Cardup Brook and the creeks. The drawdown in the creeks was based on an estimated baseflow depth of 0.5 m within the creeks.

3.8.5 Groundwater Quality

Groundwater quality monitoring of the Superficial Aquifer was done by JDA monthly for all 12 bores from August 2006 and is ongoing. Samples were analysed for physical parameters and nutrients. A time series plot for each of the parameters measured is provided in Appendix B, with a summary of average values presented in Table 5.

Key results from the monitoring are as follows:

- The average Total Nitrogen (TN) concentration varied between bores indicating local affects from different land uses.
- The average dissolved Phosphorus (FRP) concentrations are below detection limit which indicates a large proportion of Phosphorus is held in sediments and organics.

TABLE 5: PRE-DEVELOPMENT AVERAGE GROUNDWATER QUALITY

	Parameter and Unit of Measure						
Site	EC (mS/cm)	pH	Total Nitrogen (mg/L)	NOx (as N) (mg/L)	Total Kjeldahl Nitrogen (mg/L)	Total Phosphorus (mg/L)	Filterable Reactive Phosphorus (mg/L)
BDM1	0.11	5.34	3.80	2.44	1.34	0.40	<0.005
BDM2	0.30	6.42	6.40	5.14	1.29	0.13	<0.005
BDM3	0.21	6.25	8.22	5.90	2.25	0.04	<0.005
BDM5	0.37	5.13	4.26	4.47	0.55	0.53	<0.005
BDM6	1.60	6.49	2.18	1.66	0.67	0.05	<0.005
BDM7	0.28	5.99	0.93	0.69	0.27	0.04	<0.005
BDM8	0.29	5.65	3.84	3.96	0.76	0.05	<0.005
BDM9	0.63	6.39	2.04	1.30	0.39	0.05	<0.005
BDM10	0.21	5.74	0.51	0.19	0.37	0.40	<0.005
BDM11	0.59	5.81	0.97	0.74	0.45	0.47	<0.005
BDM12	1.28	5.05	1.20	0.75	0.43	0.12	<0.005
BDM13	0.15	5.51	1.93	1.50	0.56	0.07	<0.005

3.9 Wetlands

Several wetlands occur on and adjacent to the study area. A large portion of the study area is mapped in the DEC's *Geomorphic Wetlands Swan Coastal Plain* dataset as palusplain (a seasonally waterlogged flat) (UFI 13500; 13912). Throughout the Swan Coastal Plain, areas of palusplain have historically been extensively cleared for rural pursuits (grazing and horse agistment) as is the case in the study area. The management category of the majority of these wetlands has been evaluated as Multiple Use (MU) wetlands. Wetlands that support native vegetation are identified as Conservation (CCW) or Resource Enhancement (RE) wetlands (Coffey Environments, 2009).

A CCW was previously located on Lot 3 Abernethy Road (UFI 7829, 7866 and 7829). As part of the site investigations undertaken by ATA Environmental, a site visit was conducted in September 2005 to 'groundtruth' the appropriateness of the CCW management category of the wetland. It was concluded that due to the degraded nature of the wetland, along with other environmental characteristics of the site (discussed in further detail in Section 3), the DEC's CCW classification should be revised to a MU management category. The Wetlands Branch of the Department of Environment agreed to revaluate the wetland category of Conservation Category to Multiple Use in February 2006.

CCWs (UFI 8005; 7844; 13911; 13901) were previously located along parts of the Cardup Brook that support native riparian vegetation. Following site investigations by ATA Environmental in 2004 it was concluded that the degraded nature of the wetland and other environmental characteristics that the DEC classification should be revised to REW. The Wetlands Branch of the Department of Environment agreed to revaluate the wetland category of CCW to REW in July 2004.

One CCW (UFI 15452) is located on land directly abutting the study area and is within the Bush Forever Site 321 to the east of the study area.

3.10 Water Resources

3.10.1 Groundwater availability

The Study Area is located within the Serpentine groundwater area and the Perth – Cattamarra Coal Measure North groundwater sub-area. Department of Water has advised that there was 1,000,000 kL/yr available for allocation as of 19 June 2007.

Opportunities for utilising this aquifer as a non-potable supply are discussed in Section 4.2.1.

4. LOCAL WATER MANAGEMENT STRATEGY

4.1 Water Balance

Design Criteria (from DWMP):

To minimise changes to the water balance to prevent negative impacts on watercourses and wetlands

No guidance is provided in the Byford Townsite DWMP on changes to the water balance as a result of the land use changes proposed in the Byford DSP. In the absence of a district water balance model a simplistic water balance has been developed to enable assessment of the Study Area as a result of implementing The Glades LSP.

As rainfall is the primary input to the local environment, scheme water has not been considered in the water balance which aims to assess the impacts of urban development on wetlands and watercourses. As the most reliable estimates of rainfall, evaporation, transpiration and recharge are at regional scales, for the purposes of this water balance assessment, annual average values have been assumed for the site as a whole, without further detailed breakdowns.

As discussed in section 3.7.3 the site is characterised by limited recharge due to the clay sediments with a high proportion for rainfall runoff.

TABLE 6: ESTIMATED RAINFALL WATER BALANCE

	Area (ha)	mm	Abstractions	Discharge	ML/yr
Pre-Development					
Input Rainfall	328	872			2860
Water Use					
Native Bush	-	570[1]			
Rural	319	600[2]			- 1914
Watercourses + Buffers	9	800[2]		572	- 644
Balance (Recharge)					**+ 302**
Post-Development					
Input Rainfall	328	872			2860
Water Use					
Urban (Residential)	190	260[1]			- 494
Urban (Commercial)	51	175[1]			- 90
Parks	59	600[2]			- 354
Watercourses + Buffers	27	800[2]		1520	- 1734
Village Centre Lake	0.6	1700			-10
Rainwater Tanks Initiative	190	30			- 57
Balance (Recharge)					**+ 235**

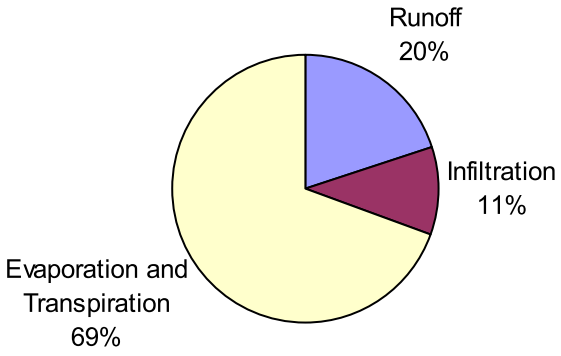
Notes: 1. Based on recharge estimates provided in Davidson and Yu (2006)

2. Based on evaporation and transpiration estimates provided in Silberstein *et al* (2007)

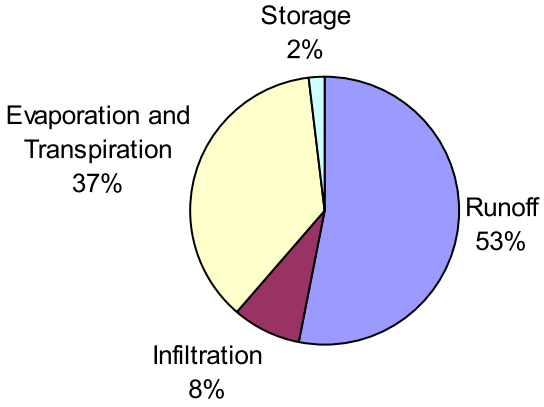
Table 6 shows that recharge to the watertable is likely to be in the order of 10% under the existing predominately rural land use. This is governed largely by the limited infiltration rate of the local soils, with only a slight reduction post-development. Following residential development evaporation and transpiration is reduced due to the reduction in vegetative cover and more ready infiltration into the imported sandy fill. The surplus recharge into the fill is collected and discharged by the subsoil pipes laid at the base of the fill. This is shown in the water balance as additional discharge from the watercourses, the discharge points for the subsoil system.

The overall outcome is likely to be an increased baseflow in the watercourses passing through the development, a similar rate of recharge to the watertable and a small proportion retained as storage within rainwater tanks as a result of the rainwater tank initiative (see section 4.2.2). The impacts of this change are discussed in Section 4.5 and 4.6.

Pre-development rainfall distribution



Post-development rainfall distribution



4.2 Water Sustainability Initiatives

Design Criteria (from DWMP):

The State Water Plan (Government of Western Australia, 2007) target for water use of 100kL/person/yr with no more than 60kL/person/yr of scheme water.

4.2.1 Water Supply

Public Open Spaces

Considering the fit for purpose strategy, the water supply for the public open spaces is proposed to be from local groundwater resources. There are still significant groundwater allocation volumes available from the confined aquifer.

Currently, one licence of 50 000 kL/yr is held for the Glades development, GWL 164628(1) which is valid to March 2010. On renewal of this licence a Staged Development Licence will be applied for consistent with the Department of Water's guidance on Staged Development licences to secure an allocation suitable to supply the complete development proposal.

Residential Lots

Water supply to households is to be scheme water via extension of the existing system. This is supported by Water Corporation.

4.2.2 Water Efficiency measures

Public Open Spaces

The estimated irrigated POS area for the development is 30 ha which will require an approximate 200 000 kL/yr. This water should be sourced from the confined groundwater reserves consistent with a fit for purpose strategy.

Landscaped Public Open Space areas are to be at least 50% native plants, with water wise irrigation system design.

Residential Lots

To achieve water efficiency targets, households are to be built consistent with current BCA water efficiency standards and the State Governments 5 Star Plus scheme. To further improve the water efficiency of residential lots LWP commit to a sustainability contract with each lot owner. A copy of the contract is included in Appendix D as an example. As part of the contract LWP will provide the following waterwise initiatives;

- A waterwise front landscaping package to each home, designed by a certified waterwise landscaper.
- Provision of a 2 kL rainwater tank for each home plumbed to the toilet and laundry, with an overflow to the stormwater drainage system (Appendix D). Please note that the contract shown in Appendix D is a blank contract. On the contract provided to purchasers the option for the rain tank is already ticked by LWP. This format is used to help educate lot purchasers about water conservation options.

4.3 Village Centre Lake

Design Criteria (proposed by LWP);

To demonstrate that a well designed and maintained constructed lake, providing aesthetic, recreational and health benefits to the Glades community, is feasible at the Village Centre site.

4.3.1 Lake Benefits to the Village Centre

A constructed lake is proposed as part of the Village Centre precinct. The lake is intended as a community asset providing:

- Aesthetic functions which make the village centre an active hub for commercial and social activities.
- A focus for recreational activity, supported by the network of paths and boardwalks that provide access to the lake for residents.
- Structural benefits which include increased flexibility in the design of the POS irrigation system by providing storage and;
- Additional stormwater detention storage in major flood events.

The Village Centre Masterplan including the lake concept is shown in Figure 8.

4.3.2 Physical Lake Design Characteristics

Proposed Construction

The proposed lake will be approximately 6000 m^2 in area, with an approximate total volume of 8000 m^3. To account for the fall over the site of approximately 1: 100 (v:h) the lake will be split into 2 levels, with the top level smaller in area than the bottom level.

The upper level will be located on the east side and overflow into the lower level on the west side adjacent to Doley Rd via a broad weir structure. The weir can be landscape for a more natural appearance and to improve access to the lake for residence a boardwalk could be constructed along the weir.

The lake will be a total depth of 2-3m on both sides with the upper level approximately 1 m higher than the lower level.

The lake will be designed to circulate water between the two levels. For water quality management purposes, the residence time for the water in either tier of the lake should ideally be less than 30 days. Based on the indicative volume of the lake, an average circulation rate of approximately 12 m^3/hour (3.5 L/s) is required to achieve the required residence time.

Lake Water Levels

The lake will have a proposed constant water level of 34.5 m AHD in the bottom lake, with a top water level in the 100 yr ARI of approximately 35.0 m AHD. This level is largely controlled by Doley Rd adjacent, which needs to be maintained at its existing level of approximately 35.3 m AHD to retain the

roadside avenue of existing trees. The upper lake will be set higher than the lower lake, but the top water level should not exceed 36.20 m AHD in the 100 yr ARI to remain hydraulically disconnected from the bio-retention storage located immediately to the east.

The watertable in the location of the proposed Village Centre Lake is 1 to 1.5 m below natural surface at the average seasonal maximum recorded level, but fluctuates in excess of 5 m. The lake will be designed so that the lake water level remains relatively constant (±0.30 m). In order to achieve this it will be necessary to line the lake, hydraulically separating the lake from the highly fluctuating watertable. The lake liner can be a natural clay based product or a PVC liner, so long as the base of the lake is sufficiently sealed to ensure minimal water loss from the lake via leakage.

Bore Water Top-Up

To maintain water levels in the lake it is proposed to top-up the lake using an artesian bore located on the west side of Doley Rd. The location of the bore can be seen in Figure 7. The bore was constructed in January 2008 and is currently licensed for abstraction of 50 000kL/annum.

The submersible pump fitted to the bore is a variable speed pump with a maximum pump rate of 25 L/s, but a sustainable pump rate of 20 L/s. Preliminary testing of the water shows the water to have moderate levels of Total Iron (0.16 mg/L), low levels of Total Nitrogen (<0.005 mg/L), moderate levels of Total Phosphorus (0.02 mg/L), with low levels of dissolved Phosphorus (<0.005 mg/L).

Table 7: Bore Water Quality Analysis

Parameter and unit of measurement	ANZECC Guideline Trigger Values	Bore Water
Electrical conductivity (mS/cm)	0.12 – 0.30	1.40
pH	6.5 – 8.0	5.75
Total Nitrogen (mg/L)	1.2	<0.05
Ammonia N (mg/L)	0.8	<0.005
Nitrate/Nitrite NOx as N (mg/L)	0.15	<0.10
Total Phosphorus (mg/L)	0.065	0.02
Filterable Reactive Phosphorus (mg/L)	0.04	<0.005

This water is considered to be of appropriate quality for the lake, which will be further improved by the addition of rainfall recharge falling on the lake over the winter period.

To enhance circulation between the 2 lake levels, pumping from the bore should be delivered to the upper lake, with abstraction for irrigation taken from the lower lake.

Evaporation Management

The existing bore's sustainable pump rate is 20L/s or 72 m^3/hr. Assuming an irrigation depth of 10 mm for parkland areas, this equates to 100 m^3/ha, so the bore has capacity to fill the lake for irrigation at a rate of approximately 0.72 ha per hour.

The lake surface area is proposed as 6000 m^2. Table 6 shows the estimated evaporation loss from the lake as 10 ML (10 000 kL) per annum. This represents 5% of the total groundwater abstraction estimated for the development of 200 000 KL/annum.

This evaporation loss is based on a Class A Pan evaporation for Byford of 1898 mm/yr and a waterbody evaporation coefficient of 0.9 (Luke et al, 1988).

Flood Risk

In order to manage the water quality of the lake, the lake should be 'offline' of the minor drainage system (rainfall events up to the 5 yr ARI), as these rainfall events vary significantly in water quality and include catchment 'first flush' events. Separate bio-retention storage is proposed immediately east of the lake within the MUC to receive flows up to the 5 yr ARI. It is proposed that the outflow from the bio-retention storage be monitored as part of the relevant UWMP, and if it can be demonstrated that the water quality from the bio-retention storage is of suitable quality, outflow from the bio-retention storage could be (partially) diverted into the lake to increase the rainfall harvest of the lake.

For events in excess of the 5 yr ARI, the runoff will be conveyed overland via the road network and flow directly into the lake to utilise the lake for additional flood detention storage. The lake is proposed to be designed with an additional 0.8 m of freeboard above the constant water level, with 0.5 m utilised for flood detention storage in the 100 yr ARI. This provides for 0.3 m freeboard to infrastructure outside of the lake in the 100 yr ARI flood event. For the lower lake this means a constant water level of approximately 34.5 m AHD, a 100 yr ARI peak water level of 35.0 m AHD, providing 0.30 m of freeboard to Doley Rd at 35.3 m AHD.

Soil Acidity

The calculated average winter maximum watertable level in the proposed location for the lake is approximately 34.5 m AHD. The proposed minimum constant water level in the lake of 34.5 m AHD is consistent with the watertable in this location, and therefore should not disturb any potentially acidic soils in this location.

The lake liner will separate the lake water from any potential acidity in the surrounding natural soils. Preliminary ASS testing in the area indicates low risk of ASS for soils less than 3 m below natural surface.

Fire Fighting Water Supply

The lake may be used as a water supply for fire fighting purposes in the vicinity of The Glades development. Any abstractions from the lake for fire fighting purposes should be limited to a total volume of 1500 m^3 in a 24 hour period to ensure that water levels in the lake are not excessively impacted.

4.3.3 Lake Management

To document the design details of the lake, maintenance and management requirements a Lake Management Plan should be stipulated as a condition of subdivision for the Village Centre Precinct.

The Lake management plan should address the following issues as a minimum;

- Control of nuisance algae
- Control of nuisance insects and disease vectors
- Control of feral fish and exotic plant invasions
- Management of gross pollutants
- Management schedule
- Maintenance schedule

4.4 Stormwater Management

4.4.1 District Stormwater Management

Beenyup Brook (Abernethy Rd)

Beenyup Brook is located just north of Abernethy Rd and flows east to west with the catchment commencing in the Darling Scarp. The district flood analysis presented in the DWMP indicates that the peak flow in Beenyup Brook at the Abernethy Rd crossing is 32 m^3/s, but constraints exist in the flow path north of Abernethy Rd which result in a significant amount of flooding in the location of the new town centre. To alleviate the potential flooding problem, the DWMP provides guidance on a swale to be built in the Abernethy Rd reserve to convey flow away from Beenyup Brook in rainfall events greater than the 50 yr ARI. The flow from Beenyup Brook diverted down Abernethy Rd is estimated in the DWMP to be 11.5 m^3/s (DWMP ref: Table 6-2) in the 100 yr ARI.

The DWMP flood route also shows some of the flow along Abernethy Rd being diverted down Warrington Rd and Doley Rd to Tributary 6. The diverted flow is estimated to be 1.3 m^3/s (DWMP ref: Table 6-2 and Figure A-8).

The Glades development will not be adopting these diversions, but will instead provide for the full flow (11.5 m^3/s) to continue down Abernethy Rd in the drainage design of Abernethy Rd. This negates the need to provide a drainage swale in Warrington Rd and Doley Rd, allowing a significant number of trees to be preserved.

The Shire has recently provided advice to JDA that the following design provisions need to be made for Abernethy Rd fronting the Glades development for consistency with the Town Centre design currently being prepared for the Shire (Appendix C). The 3 requirements are as follows

- The Abernethy Rd reserve will have a final width of 40 m along the full frontage of the Glades development

- Outflow to Abernethy Rd from The Glades estate will be consistent with the Byford Townsite DWMP.

- Any point of outflow from the estate should be designed such that they can be connected to a median swale at a time when the road upgrade design is finalised.

Under the pre-development scenario, the land fronting Abernethy Rd drains unattenuated into the Abernethy Rd drainage system. Given the low density (R10) of the lots proposed in the Glades LSP along Abernethy Rd (Figure 7), this land will continue to discharge unattenuated into Abernethy Rd. This approach is consistent with the direction provided for sub-catchments 5C and 5D in the Byford Townsite DWMP (DoW, 2008).

Cardup Brook

A foreshore reserve will be provided along the Cardup Brook to accommodate the Bush Forever and Conservation Category Wetland mapping shown over the brook. The reserve will be located between the wetland boundary and the northern edge of the proposed Byford by the Brook subdivision. The width of the reserve will range from 10 m to 60 m, averaging 32 m.

The intention is to retain the character of the Brook, with some rehabilitation by slashing grass and supplementary plantings of additional indigenous trees.

Flood conveyance in Cardup Brook will not be altered by development in the study area (the northern side).

Minor Tributaries

The minor tributaries passing through the Study area are labelled Tributary 6, 7 and 10 in the Byford Townsite DWMP. For consistency these names have been adopted in this report. The minor tributaries are generally very degraded. Consistent with the DWMP these watercourses can be modified to restore a living stream. In modifying the watercourse the DWMP stipulates that the cross sectional area of the tributary must be maintained, such that the upstream and downstream flood levels and flows at the boundary of the study are remain consistent with the levels and flows provided in the DWMP.

Tributaries 6 and 7 have catchments commence at the foot of the Darling Scarp, with flows entering the study area at the Warrington Rd crossing (Figure 9). The district inflows from east of Warrington Rd must be considered in the restoration of the tributaries through the study area and the location of flood detention storages.

The catchment of Tributary 10 commences within the study area (Figure 9). Therefore only a downstream flood level and flow criteria applies.

4.4.2 Watercourse Restoration and Alignments

Design Criteria (from DWMP):

Restoration of waterways with channel realignments and profile modifications is permitted provided the flow capacity of the channel is maintained.

4.4.2.1 Watercourse Restoration

The watercourses passing through The Glades development have been highly degraded by stock access to the channel. The structure plan for The Glades provides a series of multiple use corridors (MUC's) that take in the tributaries and preserve the general alignment of the watercourses.

Within the MUC's the watercourses will be restored with areas of passive landscaping and rehabilitation to provide a mix of natural, aesthetic and recreational landscapes. Where rehabilitation is undertaken to improve the environmental value of the watercourse this will generally include weed removal and a basic level of re-vegetation with local native plant species.

4.4.2.2 Watercourse Realignments

The development will retain the natural watercourse alignments wherever possible, but relatively minor realignments of the tributary will be required in some locations to allow additional facilities to be included within the MUC.

Key criteria for any channel realignments are as follows;

- The realigned channel must maintain the flow capacity of the original channel. Flow capacity is considered a more appropriate design criterion to cross-sectional area, as specified in the DWMP, as adjustments to the channel grade can vary the flow velocity, which in turn alters the cross sectional area required to accommodate the design flow.
- Any reconstructed banks will have a 1:6 batter.
- The realigned channel must include a baseflow channel and broader 'floodway' consistent with the 'floodway' widths provided in Figures 10 to 15. An example cross section showing the tributary "floodway" taken from the DWMP is provided in Figure 17.

4.4.3 Floodway Corridors

The Byford Townsite DWMP provides indicative 'floodway' corridor widths for each of the tributaries to ensure provision is made within the local structure planning for conveyance for district flood flows.

As part of this LWMS the 'floodway' corridor widths have been refined based on the additional information and design undertaken as part of this LWMS. The revised 'floodway' corridor widths are shown in Figures 10, 12 and 14 and include provision for the district flood flows. This included utilising hydrographs from the district Infoworks model at the upstream boundaries of the study area provided by GHD. Further details of the local scale refinement and design are discussed in section 4.4.4.

4.4.4 Local Stormwater Management

Design Criteria (from DWMP);

All 1yr 1hr ARI event runoff treated prior to discharge;

Post-development critical one year ARI peak flow and volume and the 100 year ARI peak flow shall be consistent with pre-development peak flow at the discharge points of each sub-catchment and discharge points of all subdivisions into waterways.

The Local Stormwater Management system has been designed in consonant with the following constraints:

- The multiple district flood pathways through the structure plan area.
- Wetlands
- Low soil infiltration rates

The stormwater drainage system will be designed using a major/minor approach. The major drainage system is defined as the arrangement of roads, drainage reserves, detention or infiltration areas and open space planned to provide safe passage of stormwater runoff from extreme events which exceeds the capacity of the minor system. The locations of key features of the drainage system are shown in Figures 10 to 14.

The minor drainage system is defined as the series of pipes, kerbs, gutters etc designed to carry runoff generated by low frequency ARI storms, typically less then 5 year ARI. The minor drainage incorporates a treatment train of best management practice (BMP) water quality structural controls such as GPT's and bio-retention systems that provide water quality treatment from the proposed development.

4.4.4.1 Major Drainage System

The major drainage system is designed to manage rainfall events greater than the 5yr ARI, up the 100yr ARI. The design strategy is consistent with the objectives provided in the District DWMP. Key points of the major drainage system strategy are as follows:

- Roads graded to direct flow to the lowest point in the catchment.
- Detention storage to be provided in the lowest point of the catchment to control outflows from the catchment.
- Flush kerbing or kerb breaks at the low point, graded to drain flows off the street into the detention storage.
- Discharge from the detention storages consistent with pre-development outflows for the 5yr and 100 yr ARI's.

Due to the low permeability of the soils over the site it is not possible to infiltrate large volumes of water. Therefore the major drainage system makes use of detention storages to control major runoff events to outflows consistent with pre-development flow rates.

To enhance the use of the tributaries located within MUC's as 'living streams', discussions were held with the Department of Water about the option to store part of the 100 yr ARI flood water within the MUC. This

concept is not consistent with the general guidance provided within the Byford Townsite DWMP, which specifies that all 100yr ARI detention must be achieved outside (offline) of the watercourse 'floodway'.

From the discussion with DoW it was agreed that some storage could occur within the 'floodway' provided the flowing requirements were achieved;

1. Flood detention storage for the subdivision should be provided offline to the floodway corridor for all events up to the 5 yr ARI.

2. The 'floodway' corridor for each Tributary as defined in the DWMP can be utilised for detention storage for events greater than the 5yr ARI provided it is demonstrated that this will not adversely affect the conveyance of the district flood flow.

3. Flood detention in the floodway for events greater than the 5 yr ARI is permissible provided the peak flow and HGL at Hopkinson Rd for each tributary is consistent with the values presented in the DWMP.

A copy of the correspondence with the Department of Water is included as Appendix C.

Based on these outcomes the key design criteria for the major detention storages are as follows;

- Where storage is located near a tributary the detention storage will be designed with capacity to hold at least the 5 yr ARI.

- Where controls points along the main tributary exist (e.g. a road crossing) the detention storage can be designed to overflow into the tributary with the additional storage for the 100 yr ARI provide at the control point.

- Where no control point exists the 100 yr ARI storage volume must be provided outside of the tributary.

- All storages are designed to dry out between storms.

- The minimum building floor levels will comply with DoW requirements for a 0.5 m clearance above the estimated 100yr ARI flood level in the storages.

POS Detention Storages

The detention storages to control outflow from the development in major storm events are located in the lowest point of the catchment. This is typically within POS areas. To achieve the required storage volumes, it is intended that the POS is shaped to provide low points with sufficient capacity as opposed to any formal drainage structure. Landscape treatments are appropriate to accommodate the frequency of drainage inundation. The key design elements of the detention storages are as follows;

- Due to the natural fall of the site it may be necessary to tier the storage areas to achieve the required volumes. The tiers should be arranged such that the low area in the storage is smaller and opens out to a broader higher level storage. This allows the more frequent inflow to be stored in a smaller area, with the larger less frequent rainfall events stored over the broader area.

- The POS detention storage is independent of the minor event storage. There should be no overflow to or from the adjacent minor event storage. See section 4.4.2.2 for further discussion of this point.

- The DWMP specifies that detention basins should be dry with a minimum clearance of 0.3 m above the design watertable level. We acknowledge that this criteria generally offers improved serviceability and reduces maintenance within the storage, however there may be catchments were the optimal design is compromised by this requirement and therefore the separation to the watertable design level should be considered on a case by case basis with consideration for the proposed landscape treatment.

Catchment Mapping

The internal study area catchment boundaries were based on structure plan design, topography and site inspections. The devised sub-catchments and areas are presented in Figure 9, consistent with the proposed structure plan. It should be noted that the refinement of the sub-catchments mapping has resulted in some variations in catchments from those shown in the DWMP. Where appropriate, this refinement has taken into consideration the upstream and downstream catchments and these external catchments were validated by site inspection and culvert surveys.

A total of 53 sub-catchments were considered, with 42 sub-catchments identified within the Glades LSP area.

Sub-Catchment Peak Outflow Criteria

With the refined sub-catchment boundaries differing from the sub-catchments shown in the DWMP it was not possible to utilise the peak flows for each sub-catchment presented in Table 6.2 of the DWMP. Following discussions with DoW it was agreed that sub-catchment discharge rates could be developed for the refined catchment mapping provided the following 2 criteria was satisfied;

1. The overall post-development peak flow and flood level at Hopkinson Rd for each Tributary remained consistent with the values shown in the DWMP.

2. Provision is made through the Glades LSP for upstream catchments and district flows as specified in the DWMP.

Further discussions were also held with GHD regarding the DWMP modelling to clarify the link on the eastern side of Hopkinson Rd, allowing flow from Tributary 6 down to Tributary 7. It was confirmed that the major flow at Tributary 6 in the 100 yr ARI is over Hopkinson Rd and as the flow backs up behind Hopkinson Rd a portion of the flow is able to breach south to the Tributary 7 culvert crossing under Hopkinson Rd. To maintain the pre-development flow balance the outflow rates for Tributary 6 and 7 were considered as a combined flow. A summary of this strategy is as follows;

Tributary	100yr ARI Peak Outflow (m^3/s)	
	Byford Townsite DWMP	The Glades LWMS
Tributary 6	6.7	11.8
Tributary 7	5.1	
Cardup Brook	33.2	33.9
Tributary 10	1.4	1.4

On this basis, the 5 yr and 100 yr pro-rata peak flood detention criteria for the revised sub-catchments is presented in Table 8.

TABLE 8: SUB-CATCHMENT DRAINAGE PLANNING CRITERIA - ULTIMATE DEVELOPMENT

Sub-catchment	Area (ha)	5yr ARI		100 yr ARI	
		Peak Flow (m^3/s)	Detention Volume (m^3)	Peak Flow (m^3/s)	Detention Volume (m^3)
Tributary 6					
US Inflow provided from DWMP		1.28	-	2.29	-
6A	10.48	0.16	-	0.28	-
6B	11.21	0.25	2898	0.30	4324
6C	9.58	0.19	2689	0.26	3804
6D	3.98	0.17	444	0.19	764
6E	1.37	0.03	227	0.07	206
6F	6.30	0.13	1025	0.17	1831
6G	9.42	0.13	1340	0.18	1910
6H	5.14	0.06	730	0.09	1040
6I	1.68	0.04	202	0.05	384
6J	9.38	0.19	2064	0.25	2521
6K	1.30	0.03	175	0.04	306
6L	5.52	0.10	982	0.15	1502
6M	10.17	0.11	1957	0.27	2830
6N	3.74	0.08	512	0.10	1002
6O	5.57	0.12	917	0.15	1594
6P	9.35	0.18	1751	0.25	2773
6Q	8.60	0.17	1506	0.23	2395
6R	8.91	0.20	1313	0.24	2452
6S	2.96	0.06	403	0.08	789
6T	2.42	0.05	309	0.07	646
6U	7.92	0.18	1063	0.21	2132
6V	7.29	0.15	1200	0.20	2011
6W (DS)	27.53	0.42	-	0.74	-
6MUC1	4.15	0.07	-	0.11	-
6MUC2	0.96	0.02	-	0.03	-
6MUC3	2.83	0.05	-	0.08	-
6MUC4	0.97	0.02	-	0.03	-
6MUC5	1.20	0.02	-	0.03	-
Sum of peak flows (6)		**4.65**		**7.14**	
Tributary 7					
7A	31.26	0.55	-	0.84	-
7B	52.86	0.93	-	1.43	-
7C	7.48	0.13	-	0.20	-
7D	5.54	0.12	494	0.15	1339
7E	10.53	0.22	1362	0.28	2242
7F	5.89	0.12	560	0.16	1447
7G	5.57	0.12	366	0.15	1200
7H	2.11	0.04	160	0.06	524
7I	9.27	0.21	1505	0.25	2567
7J	34.82	0.61	-	0.94	-
7MUC1	1.54	0.02	-	0.04	-
7MUC2	1.78	0.03	-	0.05	-
7MUC3	2.99	0.04	-	0.06	-
Sum of peak flows (7)		**3.14**		**4.61**	
Sum of peak flows (6 & 7)		**7.78**		**11.75**	
Cardup Brook					
Orton Rd Inflow		1.30	-	2.00	-
8A	5.81	0.14	-	0.21	-
8B	19.56	0.47	-	0.72	-
8C	8.59	0.20	-	0.31	-
8D	7.08	0.17	-	0.26	-
8E	5.55	0.13	-	0.20	-
Cardup Brook Inflow		5.80		23.53	
9A	25.30	0.78	2780	0.83	5530
9B	21.15	0.66	1973	0.75	4400
9C	16.68	0.46	2054	0.61	3900
9D&E	12.31	0.32	1835	0.45	2980
Sum of peak flows (CB)		**10.43**		**29.88**	
Tributary 10					
10A + 10B + 10C	34.29	0.93	3473	1.40	5760
10D	6.82	-	-	-	-

Sizing Detention Storages

To size the detention storages the XP-SWMM model was used. Storage areas were designed to contain runoff from the 100 year ARI storm event, with discharge for the 100 year ARI event designed not to exceed the ultimate development flow criteria as specified in Table 8.

Storage locations were determined based on existing topographic contours, depth to groundwater mapping, and local structure plan constraints. Side slopes of 1 in 6 (v:h) have been adopted for all storages.

The design storms modelled in XP-SWMM were calculated according to the methodology in Australian Rainfall & Runoff (AR&R) (Institution of Engineers, Australia 2000). The rainfall temporal pattern was assumed to be spatially uniform across the catchment. Storm durations modelled ranged from 10 minutes to 72 hours.

The catchment runoff parameters applied for the various land uses were consistent with the parameters provided in the DWMP, as follows;

Land Use	**Surface Roughness (Mannings n)**		**Initial Loss (mm)**		**Infiltration Loss (mm/hr)**	
	Perv.	Imperv.	Perv.	Imperv.	Perv.	Imperv.
Rural Pasture	0.050	0.015	10	1.5	4	0
Existing Urban	0.025	0.015	10	1.5	4	0
Constructed Urban	0.025	0.015	10	15	4	0

Land Use Category	**Pervious Area (%)**	**Impervious Area (%)**
Roads	30	70
Mixed business	25	75
Neighbourhood centre	45	55
Residential (R20-R60)	50	50
Schools	50	50

There is insufficient information provided in the DWMP to reconcile the peak outflows and sub-catchment detention storages for the 5 yr ARI based on the runoff parameters described. As such the for the revised sub-catchments the detention storage volumes for the 5 yr ARI were calculated based on achieving

similar detention volumes to those provided in the DWMP using the DWMP runoff parameters. In most cases this results in higher peak outflow in the 5 yr ARI than shown in the DWMP.

The results for the detention storage are presented in Figures 10, 12 and 14. Long-sections of each tributary post-development are provided in Figures 11, 13 and 15.

A long section of Cardup Brook is not provided in the figures. Due to the complexity of modelling the large 100 yr ARI flow in Cardup Brook we have not tried to reproduce the DWMP modelling. Instead, the basins proposed by JDA (shown in Figure 14) were added to the district Infoworks model by GHD and checked for compliance with the DWMP flood management strategy. Compliance was confirmed and this advice is included in Appendix C.

Note that storage shapes and volumes shown in the figures are indicative and appropriate at a local planning scale only. The final configuration (side slopes etc) and exact location of storage areas will be dependent on final earthworks, drainage, and road design levels for the development, and catchment areas shown in this report may change as a result. The details will be refined at the sub-division stage and reported in the relevant Urban Water Management Plan (UWMP).

100yr Flood Emergency Access Routes

The Byford Townsite DWMP identifies Abernethy Rd, Kardan Boulevard, Thomas Rd and South West Hwy as major arterial roads that should remain passable in the 100 yr ARI.

Within The Glades structure plan area, if the design is achievable without affecting the existing trees, Doley Rd should also be designed to remain passable in the 100 yr ARI, providing a link to Abernethy Rd through the sub-division.

4.4.4.2 Minor Drainage System

The minor drainage system is designed to manage rainfall events up to the 5yr ARI and includes GPT's, swales, bio-retention structures, lot connection pits and the pipe drainage system. The minor drainage system is designed to also provide the structural controls for water quality treatment.

The minor drainage system for The Glades has been designed with the intention of separating the flow paths of major and minor rainfall events. Separating the flow paths of the major and minor rainfall events provides many benefits to the water quality structures incorporated into the minor drainage system which include;

- Limits potential erosion and scour of bio-retention structures by large flows.
- Reduced potential re-mobilisation of pollutants captured during minor flows.
- Reduced maintenance requirements as a result of the above 2 points.

Due to the local soils, infiltration of stormwater at the lot scale via soakwells is problematic. Geotechnical advice to LWP Property Group is that implementing such a strategy would result in a significant additional cost to new home builders by way of increased footing specifications for the building. As such a conscious decision has been made to provide a lot connection point to the street drainage network and treat the 1 yr ARI 1 hour duration event (16.9 mm rainfall) at the neighbourhood catchment scale. For this

solution to be effective, the minor drainage system for The Glades incorporates the following design elements;

- Residential lots will be connected to the road pipe drainage system with a connection capacity of 5 yr ARI.
- The road drainage system is via roadside pipe network with capacity for a 5yr ARI.
- Bio-retention swales and bio-retention storages provided require a minimum treatment capacity of the 1yr ARI 1 hour event.
- For all outlets to minor stormwater detention storages, stormwater will be treated by Gross Pollutant Traps prior to discharge.
- A diversion structure will be located immediately downstream of the GPT to separate the major runoff events from the minor runoff events and protect the minor event detention storage (typically a bio-retention storage structure) from excess flooding and scour.

The key design principles for the diversion structure and bio-retention systems are discussed in more detail below.

Drainage Diversion Structure

The key design principle to the separation of the major and minor drainage system is the use of the diversion structure located upstream of the stormwater storage structures. A typical design for the diversion structure is shown in Figure 17

The function of the diversion structure is as follows;

- The bio-retention storage downstream of the diversion structure is sized to treat a 1yr ARI 1hr duration event (16.9 mm/hr). For rainfall events up to this intensity the pipe outlets from the diversion structure provide sufficient capacity for the flows to continue downstream to the bio-retention storage.
- For rainfall events in excess of 16.9 mm/hr the outlet pipes will be full. The diversion structure has been designed with minimal cover over the outlet obvert so that once the outlet pipes are full any hydraulic head that builds up behind the pipes is released via an open grate in the top of the manhole (bubble up). This excess water is then diverted away from the diversion structure via an overland flow path to the major detention storage.
- To ensure that the diversion structure operates correctly the top water level in the bio-retention storage is designed as the same level as the overflow level in the diversion structure. With the design levels matching, once the bio-retention storage is full it creates a backwater in the pipes that matches the diversion structure overflow level which further ensures that any additional inflow to the diversion structure will bubble out rather than flow down the pipes.

Bio-retention Swales

Bio-retention swales will typically be located within the central median of roads, but can be located on either side of the road reserve where the design dictates this as a preferred location. A typical section of a bio-retention swale is shown in Figure 17. The key design elements to the function of the swale are as follows;

- The central median is an inverted crown with flush kerbing so that rainfall runoff can flow directly from the paved road surface into the swale by sheet flow. Sheet flow minimises potential scour of the swale banks that would be caused by concentrating this flow in a pipe.

- The swale in underlain by a minimum of 0.5 m thick permeable soil material to encourage water to soak into the swale rather than continue to flow along the swale. Water soaking into the permeable soil is improved by a combination of chemical and biological process. Water soaking into the permeable soil is available to vegetation for evapotranspiration, which reduces the outflow from the system.

- If the wetting front of the infiltrated water reaches the base of the permeable soil material the emerging treated water is collected in the subsoil pipe system located at the base of the swale.

- In major rainfall events, when the capacity of the swale storage is reached overflow gullies connected to the pipe system will collect the excess stormwater overflow. The invert of the overflow gullies is set at the designed top water level of the swale.

Mead St is the main road identified for a bio-retention swale, but swales should be incorporated into other roads wherever possible. To protect the stands of existing trees it is not possible to construct swales in Doley Rd or Warrington Rd,

Bio-retention Storages

The bio-retention storages have been included in the design of the minor drainage system to provide treatment of excess stormwater runoff from both the road network and residential housing lots in minor rainfall events up to the 1 yr ARI 1 hour duration (16.9mm/hr intensity). A typical section of a bio-retention storage is shown in Figure 17. The key design elements to the function of the bio-retention storages are as follows;

- Stormwater inflow is limited to the capacity of the pipe system from the diversion structure to minimise the maintenance requirements of the storage.

- The design top water level is the same level (m AHD) as the overflow level of the diversion structure to create a backwater effect that assists the operation of the diversion structure.

- Outflow from the storage is via soakage through a layer of permeable material under the storage, which is to be a minimum of 0.5 m thick. Water soaking into the permeable soil is improved by a combination of chemical and biological processes. Water soaking into the permeable soil is available to vegetation for evapotranspiration, which reduces the outflow from the system.

- If the wetting front of the infiltrated water reaches the base of the permeable soil material the emerging treated water is collected in the subsoil pipe system located at the base of the storage.

- If the intended function of the storage fails for any reason a high level overflow spillway is provided to control the maximum water level in the storage. The overflow discharges directly to the receiving tributary and is not in anyway connected to the POS detention storage area located adjacent. The spillway should not flow under normal operating conditions, only as an emergency failsafe in large rainfall events.

Specific details of 1 in 1 year treatment measures will be documented in the relevant UWMP.

4.5 Groundwater Management

Design Criteria (from DWMP);
Protection of infrastructure and assets from flooding and inundation by high seasonal groundwater levels, perching and/or soil moisture;

Managing and minimising changes in groundwater levels and groundwater quality following development.

4.5.1 Managing Groundwater levels to protect infrastructure

To protect infrastructure from high seasonal groundwater levels the watertable design level has been calculated by measurement of the watertable as described in Section 3.7.4. The watertable design level contours are presented in Figure 6 and the depth of the contours below existing natural surface level in Figure 16. With reference to Figures 6 and 16, the criteria for the installation of subsoil pipes will be as follows;

- Where a perched watertable exists or the predicted watertable design level is at or within 1.2 m of natural surface, clean fill and/or the provision of subsoil drainage will be provided. In such instances subsoil pipes will be placed at or above the watertable design level.

- Unless otherwise negotiated with the Shire, development should ensure finished lot levels are a minimum of 0.5 m above the level of any groundwater mounding between subsoil pipes.

- Subsoil pipe systems must be designed with free draining outlets.

Based on these criteria and the presence of clay soils over the site that will cause a perched watertable to form, subsoil pipes will be required for all significant building sites as part of this development.

4.5.2 Managing changes to groundwater levels

Shallow groundwater in the area is limited and currently used only for domestic water supply purposes. The estimated water balance for the site presented in Table 6 indicates that as a result of urban development the recharge to the Superficial Aquifer will be reduced slightly. This is not considered to be a significant negative impact for 3 reasons;

1. The Superficial Aquifer is a limited resource in this area and does not support significant abstraction.

2. There are no REW or CCW wetlands located within the study area dependant on the watertable. Wetlands adjacent to the study area are located up-gradient and changes to groundwater recharge at The Glades are unlikely to impact up-gradient areas.

3. Base flows will be maintained in the watercourses, maintaining the hydrology of the watercourses, in particular Cardup Brook.

The abstraction from the confined aquifer for irrigation of the parks is significant in the context of the sites overall water balance, but this abstraction is unlikely to alter the watertable levels evident over the site as this deeper aquifer is hydraulically disconnected from the overlying Superficial Aquifer.

4.6 Wetland Management

Design Criteria (from DWMP);
To maintain the pre-development hydrological regime of the wetlands;

Protect wetlands from the impacts of urban runoff.

4.6.1 Maintaining the hydrological regime

As discussed in Section 4.1 the natural condition of the site is limited recharge due to the clay sediments, with a high proportion for rainfall runoff. The hydrology of the wetlands are therefore characterised by rainfall recharge directly onto the surface of the wetland and surface runoff into the wetland. This is supported by the high seasonal fluctuation in the watertable shown in the groundwater monitoring data (Appendix B).

The hydrological regime of the wetlands will be maintained post-development by the following measures;

- The wetland areas will be preserved. The surface area for rainfall recharge directly onto the wetland will therefore remain unchanged.

- The watertable design level has been determined to allow the watertable to fluctuate up to the average annual maximum level in low lying areas where the seasonal maximum level is close to the existing natural surface level.

- Drainage inverts will be set at or above the watertable design level, although existing inverts below may remain.

There are no water level criteria for significant wetlands in the region presented in the Byford Townsite DWMP.

4.6.2 Protection of wetlands and watercourses from the impacts of urban runoff

For the five watercourses located within the Study Area, all runoff up to the 1 yr ARI 1 hour duration event will be treated prior to discharge into the waterways. Peak flows will be maintained to pre-development rates for 1yr, 5yr and 100 yr ARI with scour protection included as part of the restoration works of the waterways within the study area.

4.7 Water Quality Management

Design Criteria (from DWMP):

Compared to a development that does not actively manage water quality a 60% reduction in TP and 45% reduction in TN should be achieved.

To minimise and manage TP and TN inputs consistent with the targets of the Peel Harvey WSUD Local Planning Policy (2006).

4.7.1 Nutrient Source Controls

The effective implementation of the structural and non-structural controls as part of the urban development will enhance the improvements in water quality from this site as a result of the land use change.

4.7.1.1 Non Structural Controls

Non structural source controls to reduce nutrient export from the site need to focus on reducing the need for nutrient inputs into the landscape. The following strategies are proposed;

- Local native plants make up a minimum 50% of the landscape and streetscape treatments.
- Street sweeping and GPT education, co-ordinated with the Shire of Serpentine-Jarrahdale.
- Promotion of local native plants and drought tolerant gardens to lot purchasers via a landscape package.
- Promotion of Fertilise Wise practices to new residents coordinated with the Shire of Serpentine-Jarrahdale.

4.7.1.2 Structural Controls

Structural source controls are proposed to compliment the non-structural source controls and provide a complete treatment train for stormwater movement through the development. The following structural controls are considered appropriate for the development area;

- The use of bio-retention swales preferentially over pipe systems where design constraints permit. The swale should have capacity to treat the 1 yr ARI 1 hr flow and convey the 5 yr ARI critical flow.
- The use of bio-retention systems to treat road runoff. A minimum treatment capacity of approximately 2% of connected impervious area should be provided.
- A GPT will be installed upstream of any outlets to detention/bio-retention storages sized to treat the 3 month ARI but with capacity to bypass the 5 yr ARI.

The minimum specifications for all bio-retention systems (swales and storages) will be as follows;

Item	Specification
Amended soil media	Minimum 500 mm thick PRI > 5 Hydraulic Conductivity (sat) > 6 m/day pH 5.5-7.5 Total clay and silt fraction < 3% in total (w/w) Organic matter content <5% (w/w) Phosphorus content <100 mg/kg Light compaction only. Infiltration testing of material prior to installation and again once construction is complete. Ongoing testing as per the monitoring program. Where insufficient depth is not available for a Transition soil layer, soil layers should be separated by shade cloth.
Plant selection	Tolerant of periodic inundation and extended dry periods. Spreading root system. Preferential selection of endemic and local native species. Planting to provide 70-80% coverage at plant maturity.
Planting density and distribution	Planting density appropriate for species selection. Even spatial distribution of plant species.

The bio-retention systems should be sized to function correctly with a Ksat of 3, so a factor of 2 is provided for clogging that will occur in the first few years. Recent research conducted by the Facility for Advancing Water Biofiltration (FAWB, 2008) indicates that the desired Ksat is in the range of 2.5 to 7 m/day, to fulfil the drainage requirements as well as retain sufficient moisture to support the vegetation. The FAWB (2008) research also specifies that for vegetated systems some clogging will occur in the first few years until the vegetation is established. Once the plants are established, the roots and associated biological activity maintain the conductivity of the soil media over time.

It should be recognised that data currently guiding the design of bio-retention systems is only recent and largely based on laboratory testing. Details of plant selection, maintenance and likely nutrient uptake in the Byford environment are not well known at this stage. The specifications provided in this document should be considered as the best available information at the time. Some flexibility in the specifications will be required as the knowledge base increases.

4.7.2 Land Use Change Nutrient Impacts

To assess the likely impact of the change in land use to the proposed urban landscape the NiDSS model has been used to help quantify the nutrient inputs for the pre-development and post-development scenarios. The NiDSS model measures inputs only for Total Phosphorus and Total Nitrogen on the premise that ‘prevention is better than a cure’ i.e. nutrients that are not put into the system cannot be transported through the system as a contaminant.

The NiDSS analysis shows that the changes in land use from rural (pasture) to a built urban environment will result in an increase in the nutrient load on the catchment. This increase needs to be reduced using WSUD principles. With the implementation of the proposed structural and non-structural controls, a reduction of 53% for Phosphorus and 34% for Nitrogen is achieved compared to urban development without WSUD. Compared to the pre-development nutrient inputs, this is a reduction of 51% for Phosphorus and no change for Nitrogen. The modelled input rates of 10 kg/ha/yr for Phosphorus and 63 kg/ha/yr for Nitrogen are within the targets of the Peel Harvey WSU Planning Policy (2006) which specifies input rates of 15 kg/ha/yr for Phosphorus and 150 kg/ha/yr for Nitrogen.

5. IMPLEMENTATION

5.1 Urban Water Management Plan (Subdivision)

Processes defined in Better Urban Water Management (WAPC, 2008) are referred to in the Byford Townsite DWMP (2008), which requires an Urban Water Management Plan (UWMP) at subdivision stage. With an approved LWMS, a UWMP is required as a condition of subdivision and prior to any ground disturbing activities.

Specific issues raised in this LWMS that need to be addressed by the relevant UWMP include;

- Details of 1 yr ARI water quality treatment designs (BMP's).
- Monitoring of Village Centre 5 yr ARI bio-retention storage outflow water quality. A conclusion on the suitability of the treated stormwater runoff for the lake should be reported as part of the UWMP post-development monitoring reporting.
- Monitoring of specific BMP structures performance to be included as part of the post-development monitoring programme within the relevant UWMP. The long-term impacts of urban development are included as the post-development monitoring within this LWMS (see section 5.3), therefore only development stages with new design concepts or alternative BMP structures will require post-development monitoring specified within the UWMP.

5.2 Construction Management

5.2.1 Dewatering

Dewatering will be required for some elements of subdivision construction given the depth of construction, dewatering will only be in the Superficial Aquifer. Site conditions dictate that construction is limited over the winter period, so that the majority of major earthworks will occur in the summer period when the watertable is naturally lower.

Prior to the commencement of any dewatering, the construction contractor will apply for and obtain from DoW a "Licence to Take Water". All dewatering will be carried out in accordance with the conditions of this licence. Where possible, construction will be timed to minimise impacts on groundwater and any dewatering requirement.

5.2.2 Acid Sulphate Soils

Management of Acid Sulphate Soils (ASS) will be addressed as a separate process to the urban water management document approvals process (LWMS/UWMP).

ASS will be investigated and managed in accordance with the applicable DEC Acid Sulphate Soil Guideline Series and requirements of dewatering licences as they arise.

5.2.3 Construction of MUC's

The MUC's will be constructed with capacity to convey flood flows for ultimate development of the catchment, including upstream catchments. Where online flood storage is proposed for a sub-catchment, the control point within the MUC tributary should be constructed prior to the development of the sub-catchment, otherwise addition offline storage must be provided for the sub-catchment in the interim.

5.3 Stormwater System Operation and Maintenance

The operation and maintenance of the drainage system will initially be the responsibility of the developer, ultimately reverting to the local authority, Shire of Serpentine-Jarrahdale.

The surface and subsoil drainage system will require regular maintenance to ensure its efficient operation. It is considered the following operating and maintenance practices will be required periodically:

- Removal of debris to prevent blockages
- Street sweeping to reduce particulate build up on road surfaces and gutters
- Maintenance of vegetation in Bio-retention Systems/ Storages as outlined in the UWMP
- Cleaning of sediment build up and litter layer on the bottom of Storages as specified in the UWMP
- Mowing of grassed open channel sections monthly and grassed clippings removed
- Application of slow release/low phosphorus fertilisers for maintenance of swales
- Undertake education campaigns regarding source control practices to minimise pollution runoff into stormwater drainage system
- Checks on subsoil drainage function

5.4 Monitoring Programme

The monitoring program has been designed to allow a quantitative assessment of hydrological impacts of the proposed development within the Study Area. The monitoring programme will complement the district water quality monitoring program currently proposed by the Shire, which indicates monthly water quality grab sampling at 12 surface water sites. The period of the district monitoring program is not yet defined.

The post-development monitoring program for the Glades LSP area will commence in October 2009 and is designed to operate until completion of the development to allow for time lags of impacts on the receiving environment to occur. This is likely to be a period of 12 years based on current projections. The program will be periodically reviewed to ensure suitability and practicality.

All water quality sample testing will be conducted by a NATA approved laboratory.

A summary of the proposed monitoring program and reporting schedule is shown in Table 9, with the frequency of water quality target review and the contingency action plan detailed in Table 10.

It is proposed that post-development monitoring for groundwater and surface will continue to monitor the sites established for the pre-development monitoring program. The locations of the monitoring sites are shown in Figure 6.

5.4.1 Reporting Mechanisms

The preparation of monitoring reports is to be co-ordinated by the developer and submitted to the Department of Water/Shire of Serpentine Jarrahdale for review. The report will compare the monitoring results with the design criteria and performance objectives and determine what, if any, further actions are necessary consistent with contingency planning measures detailed in Table 10.

The proposed reporting schedule is detailed in Table 9.

TABLE 9: POST-DEVELOPMENT MONITORING SCHEDULE AND REPORTING

Monitoring Type	Location	Method	Frequency & Timing	Responsibility	Parameter	Reporting
Groundwater Level	12 Bores	Electrical depth probe or similar	2 times/year, April and October to coincide with the annual high and low water levels. Commence October 2009 and continue until completion of the final stage of development	Developer	Water Level (m AHD)	Reports to be provided by the developer every 3 years until completion of the monitoring program. Reports will be submitted to DoW/SSJ within 3 months of completion of the reporting period.
Surface Water Quantity	4 Locations	Continuous logger	Downloaded 2 times/year (April and October). Commence October 2009 and continue until completion of the final stage of development	Developer	Stage (flow inferred)	
Groundwater Quality	12 Bores	Pumped bore samples	2 times/year (April and October). Commence October 2009 and continue until completion of the final stage of development.	Developer	In-situ: pH, EC, temp Lab: TN, TKN, NO_X, TP, FRP	
Surface Water Quality	4 Locations	Collected grab samples	2 times/year (April and October). Commence October 2009 and continue until completion of the final stage of development	Developer	In-situ: pH, EC, temp Lab: TN, TKN, NO_X, TP, FRP, TSS	

TABLE 10: CONTINGENCY PLANNING

Monitoring Type	Criteria for Assessment	Criteria Assessment Frequency	Contingency Action
			1. Assess if an isolated, development area or regional occurrence. 2. Determine if due to the development or other external factors. 3. Perform appropriate contingency action as required (examples provided below) 4. Record and report in the annual report any breach and action taken. 5. If necessary, inform residents of any required works and their purpose.
Groundwater Level	Groundwater levels not to exceed design water level plus 0.7m.	After monitoring occasion	1. Review annual rainfall total 2. Review design and operation of subsoil and stormwater drainage system. 3. Perform maintenance as required.
Surface Water Quantity	Hydrograph to be within range of pre-development monitoring.		1. Review recent rainfall ARI's 2. Review design and construction of detention storage areas 3. Perform maintenance as required
Groundwater Quality	Nutrient concentrations in shallow bores to be similar or better than predevelopment values on an annual average basis.	Annual review of water quality targets	1. Identify and remove any point sources. 2. Reinforce Community Education/Awareness program. 3. Review operational and maintenance (e.g. fertilising) practices. 4. Consider alterations to POS areas including landscape regimes and soil amendment. 5. Consider modifications to the stormwater system. 6. Consider initiation of community based projects.
Surface Water Quality	Nutrient concentrations in tributaries to be similar or better than predevelopment values on an annual average basis.		

6. REFERENCES

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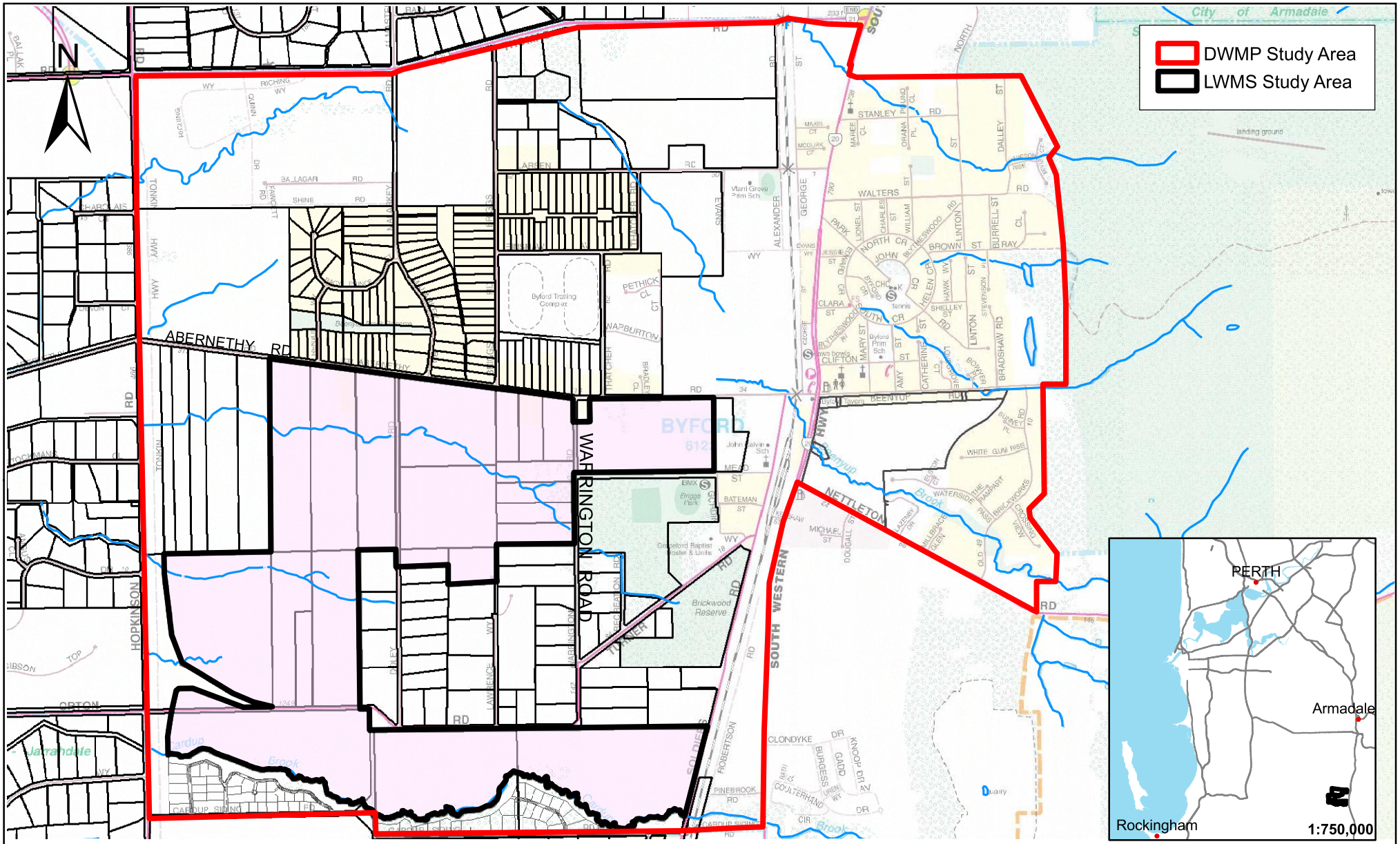
FIGURES



Data Source: DoW (2008) Byford townsite drainage and water management plan.

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Job No. J4320
Scale: 1:26,000

0 200 400 600 800 1,000 Meters

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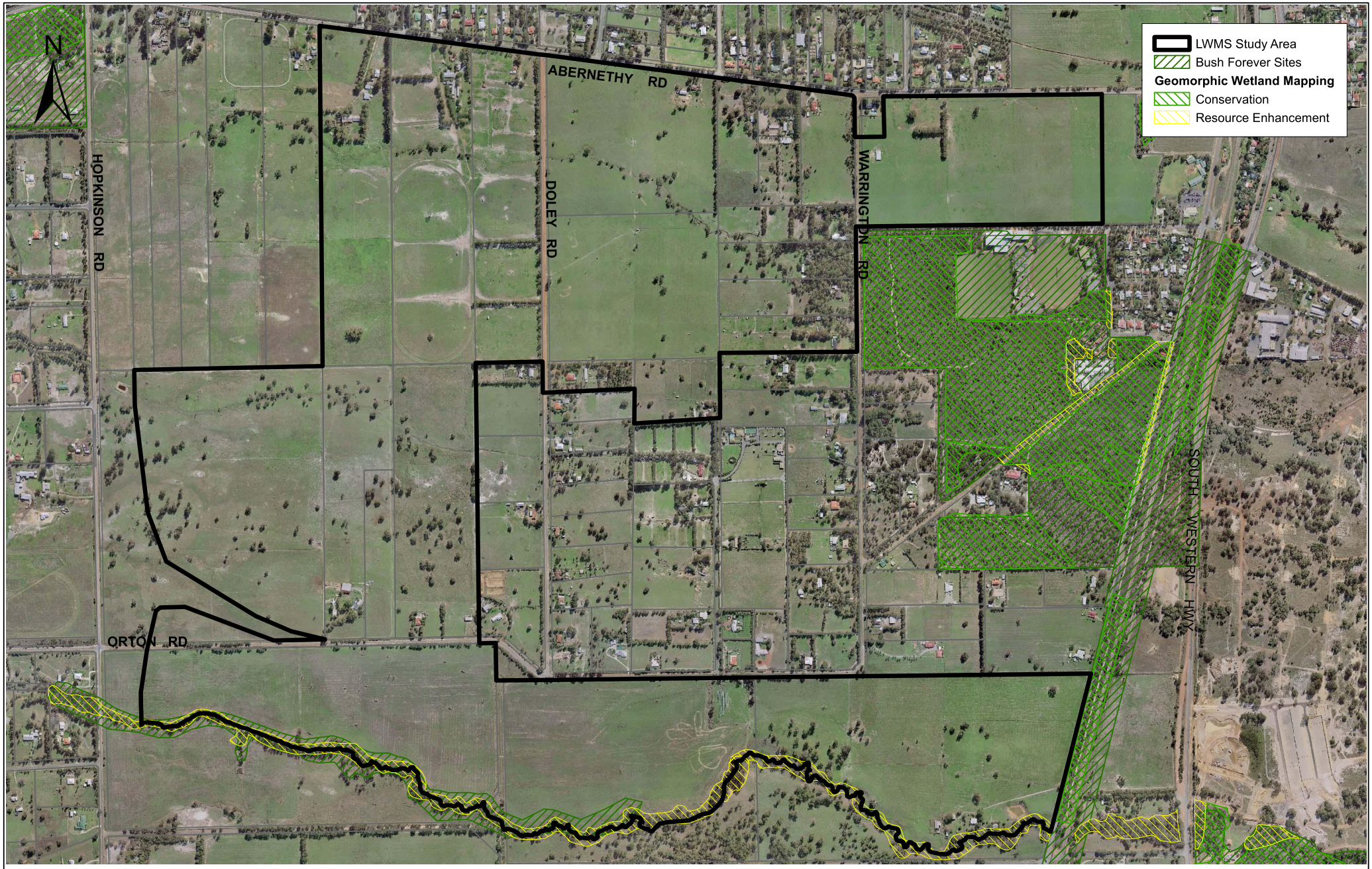
Figure 1: Location Plan



Data Source: DEC (2009) Geomorphic Wetlands of the Swan Coastal Plain

Job No. J4320
Scale: 1:10,000
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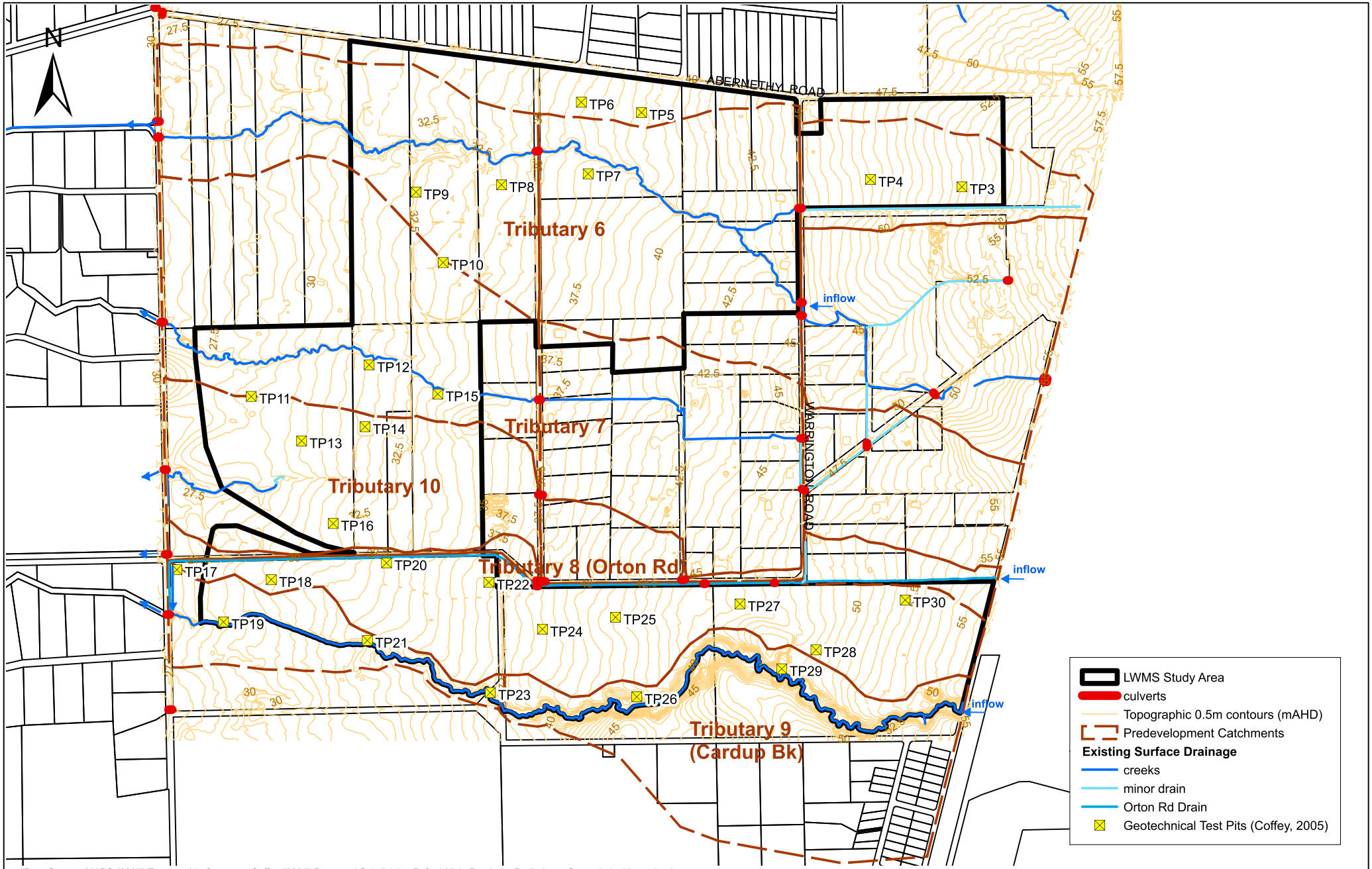
Figure 2: Existing Land Use, Bush Forever and Geomorphic Wetland Mapping.



Data Source: MAPS (2007) Topographic Contours; Coffey (2005) Proposed Subdivision Byford Main Precinct - Preliminary Geotechnical Investigation.

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Scale: 1:12,000
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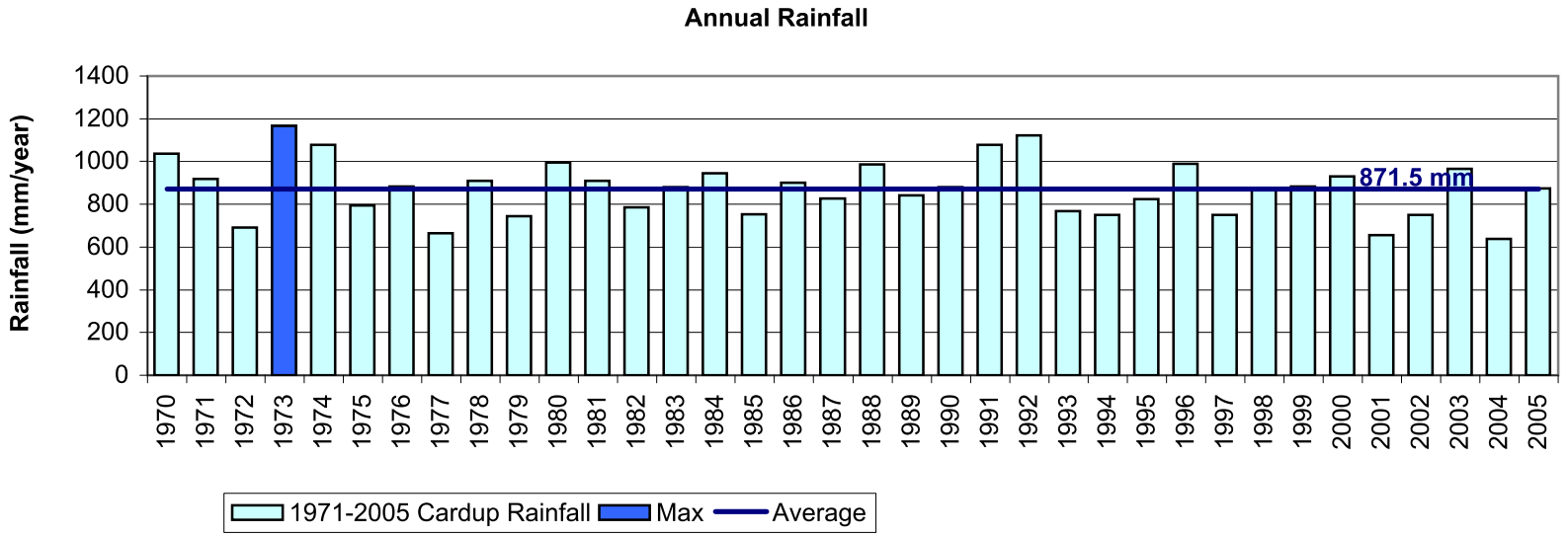
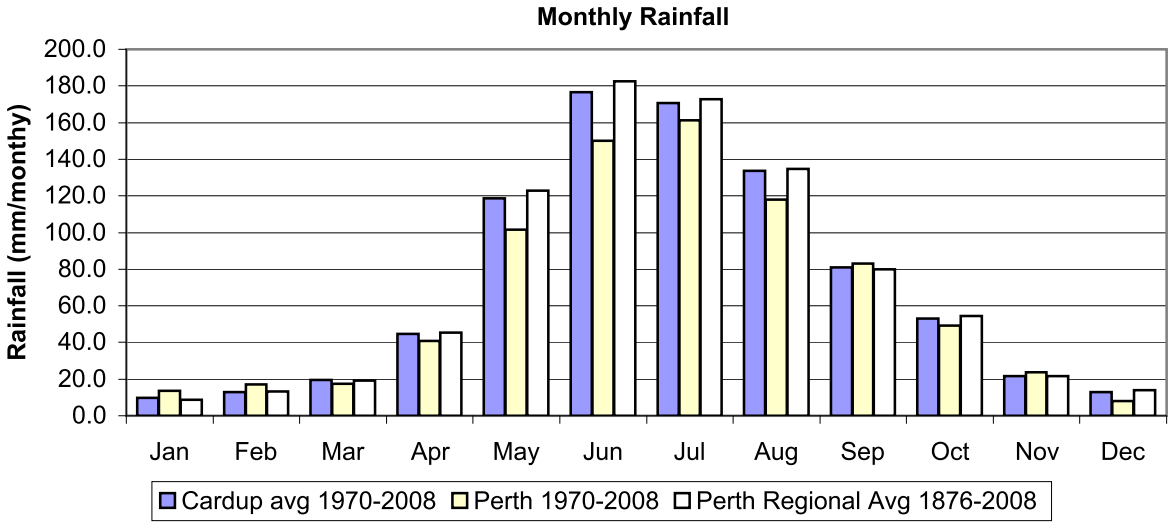
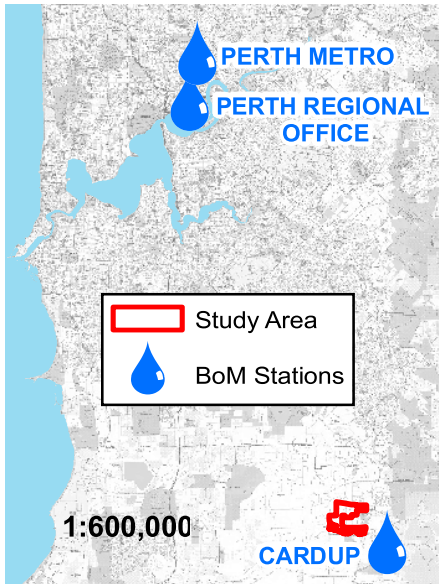
Figure 3: Topography, Existing Surface Drainage and Geotechnical Test Pit locations







Data Source: Bureau of Meterology (2009)

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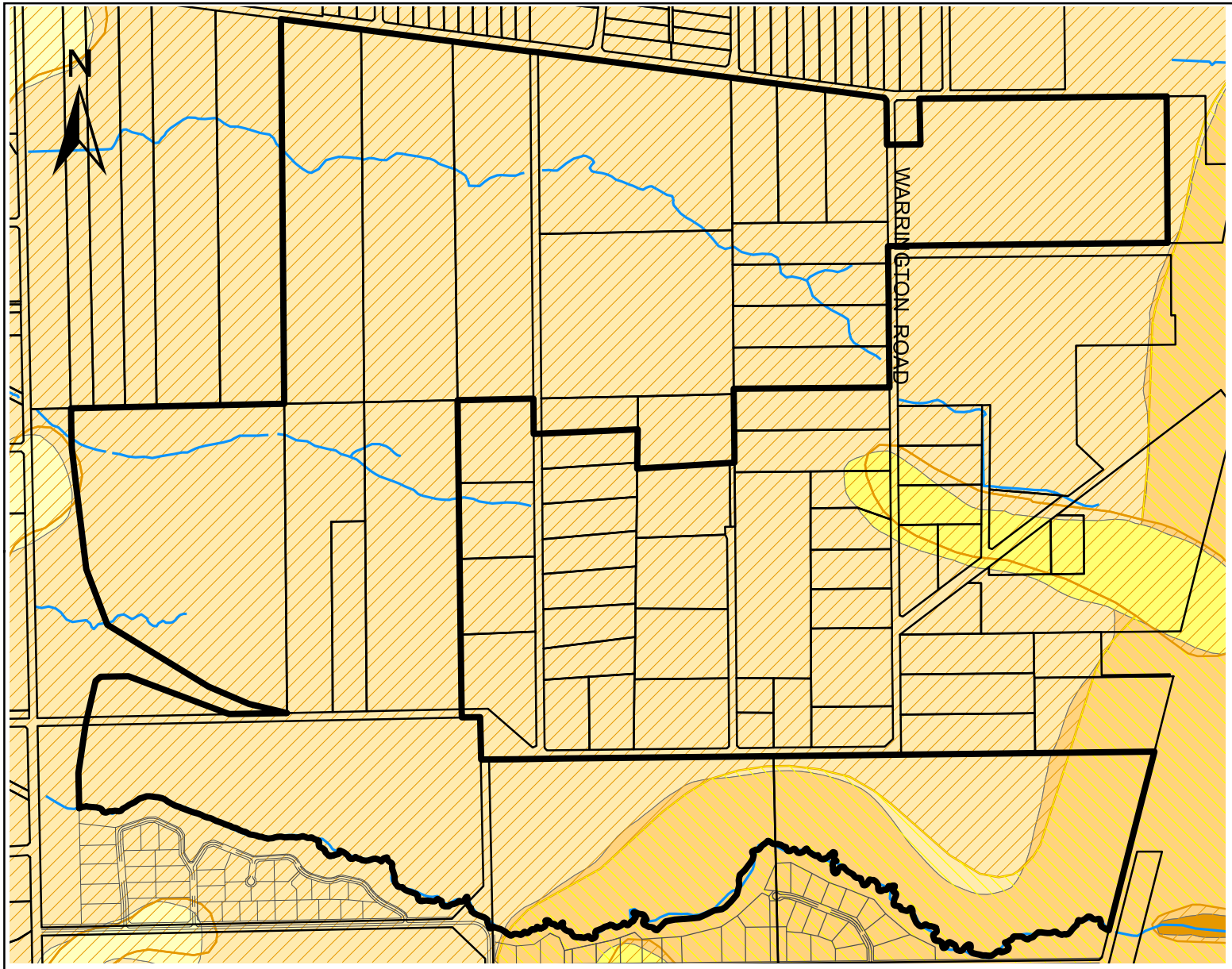
Figure 4: Annual and Average Monthly Rainfall Data



LWMS Study Area

Acid Sulphate Soils

- Class 2 Risk
- Class 3 Risk

Surface Geology

- S8 - Sand
- S10 - Sand
- Cs - Sandy Clay
- Csg - Sandy gravely Clay
- Msc1 - Clayey Sandy Silt

Notes:

ASS Class 2 - Moderate to high risk of ASS or PASS occurring >3 m from soil surface; no risk of occurrence <3m from soil surface

ASS Class 3 - Low to nil risk of ASS or PASS occurring >3 m from soil surface; no risk of occurrence <3m from soil surface

Data Source: Jordan J.E. (1986) Armadale part Sheets 2033 I and 2133 IV, Perth Metropolitan Region, Environmental Geology Series, GSWA.

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Scale: 1:15,000

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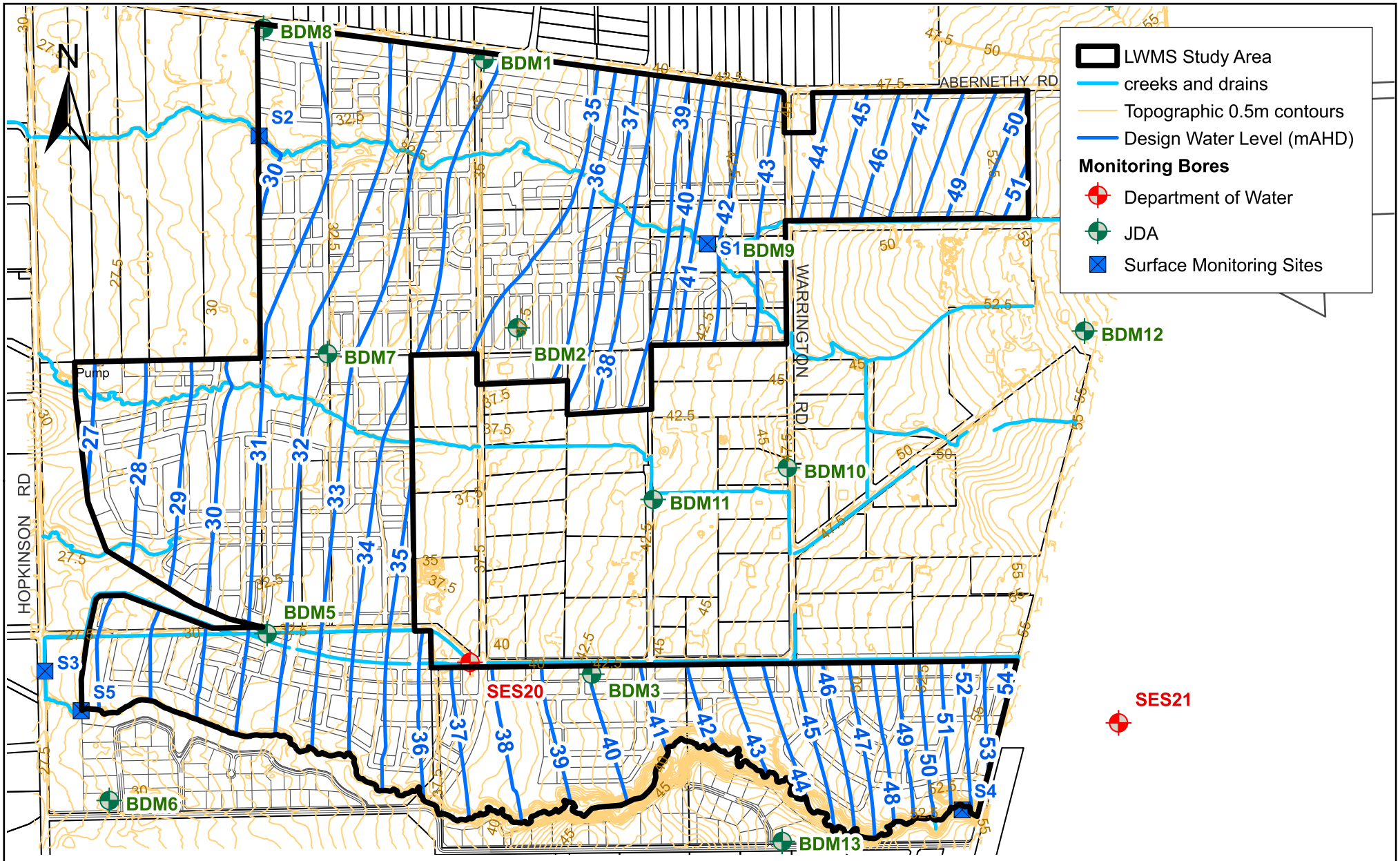
Figure 5: Surface Geology and ASS Risk Mapping



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Scale: 1:15,000

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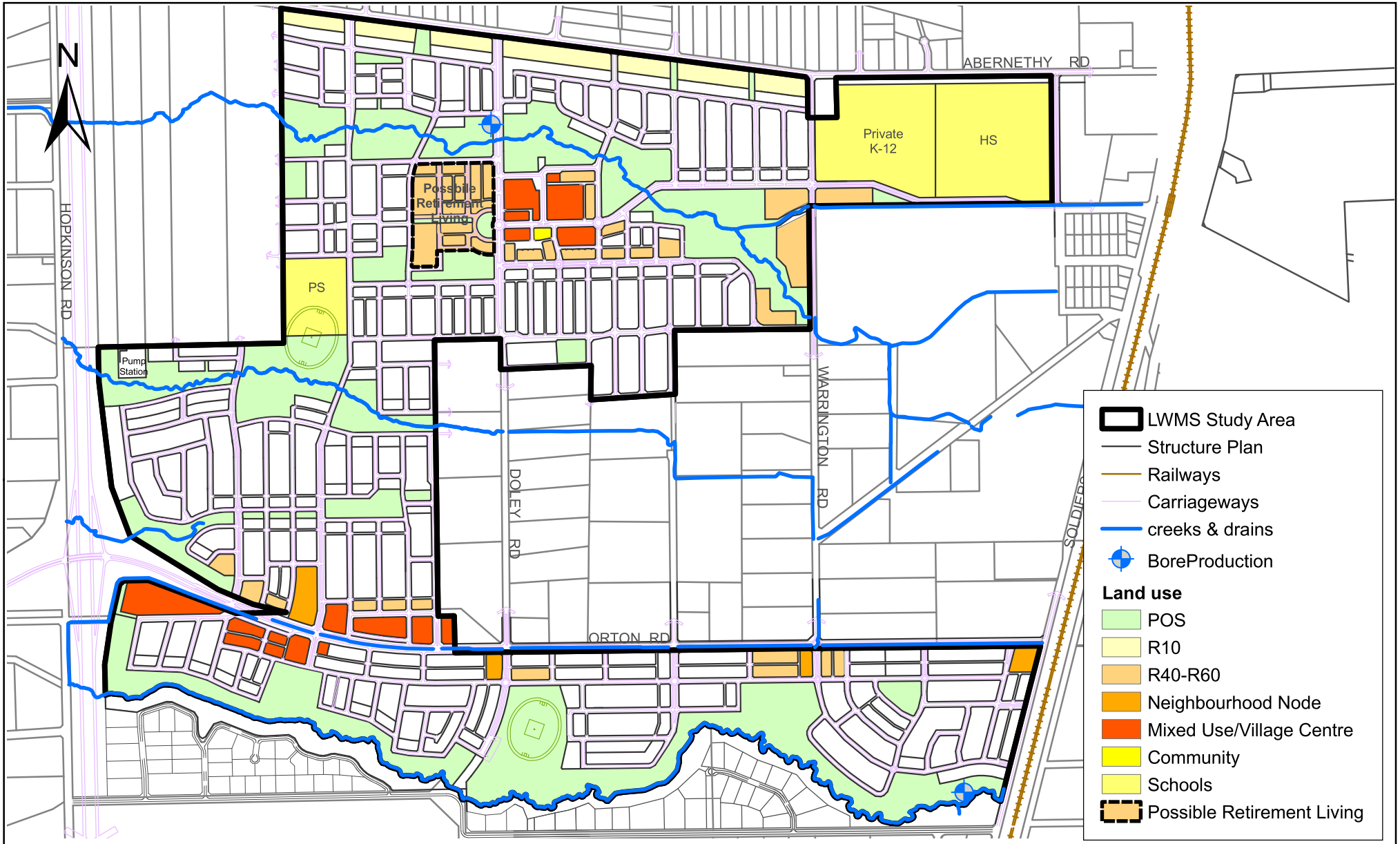
Figure 6: Estimated Watertable Design Levels and JDA Monitoring Locations



Data Source: TBB (2009) Byford Main Precinct Local Structure Plan. Ref Plan 06/014/012F.

Job No. J4320
Scale: 1:15,000

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Figure 7: Proposed Structure Plan and Land Uses

Data Source: Plan E (2009)

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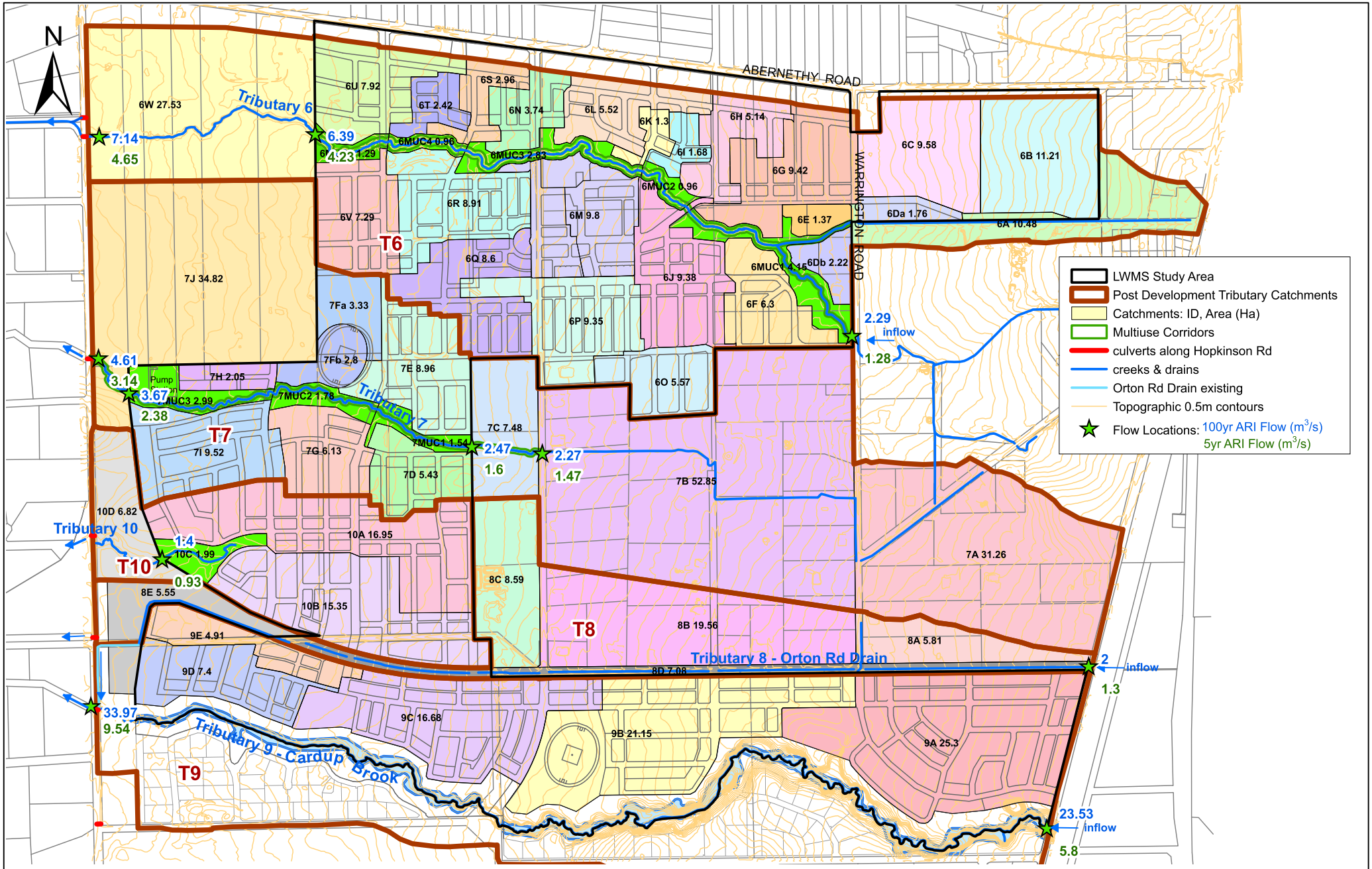
Figure 8: Village Centre Masterplan



Data Source: TBB (2009) Structure Plan; MAPS (2007) Topographic 0.5m Contours.

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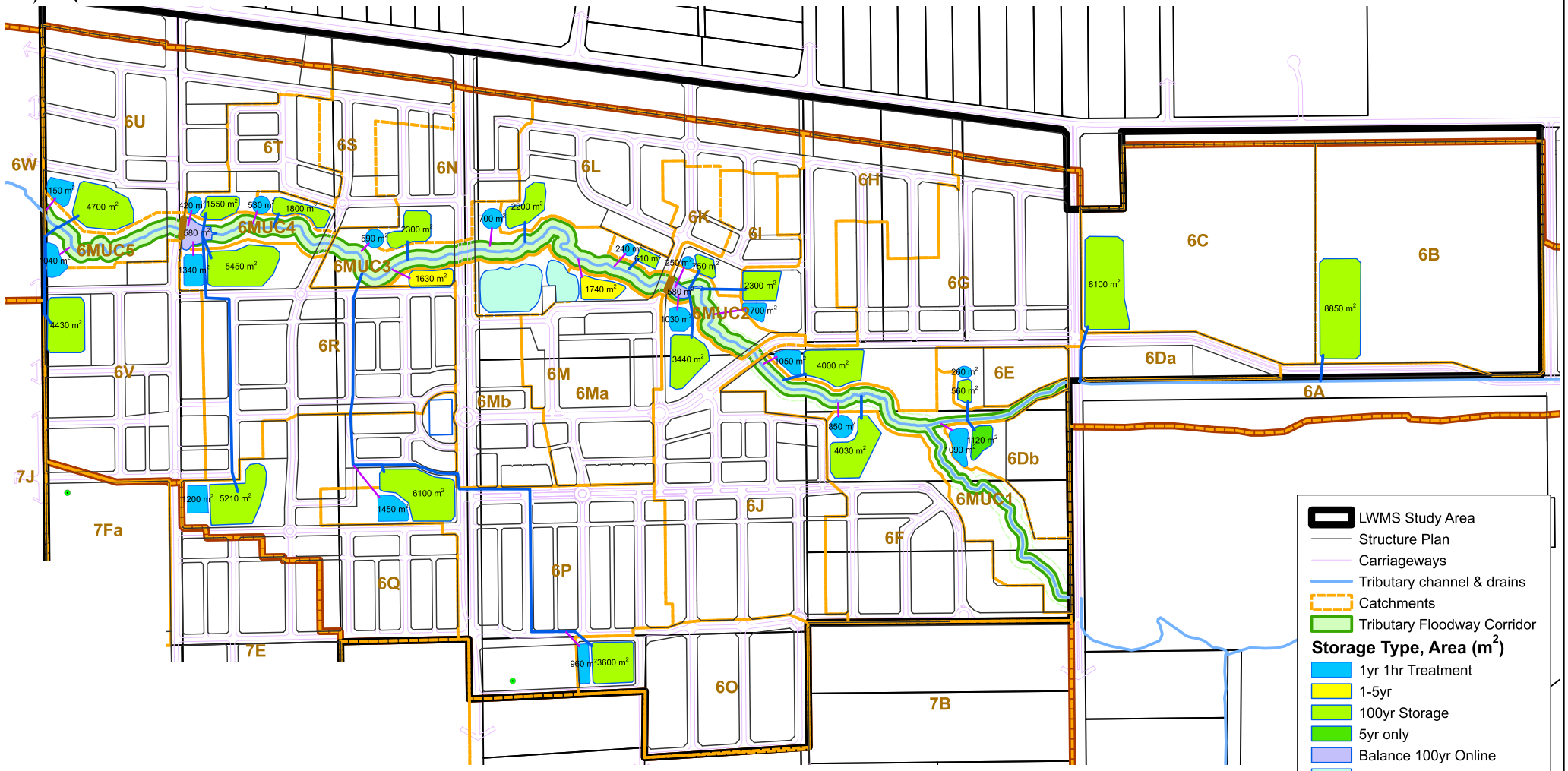
Figure 9: Catchment Plan and Multiple Use Corridors (MUC)



Data Source: TBB (2009) Structure Plan & Carriageways

Job No. J4320
Scale: 1:6,000
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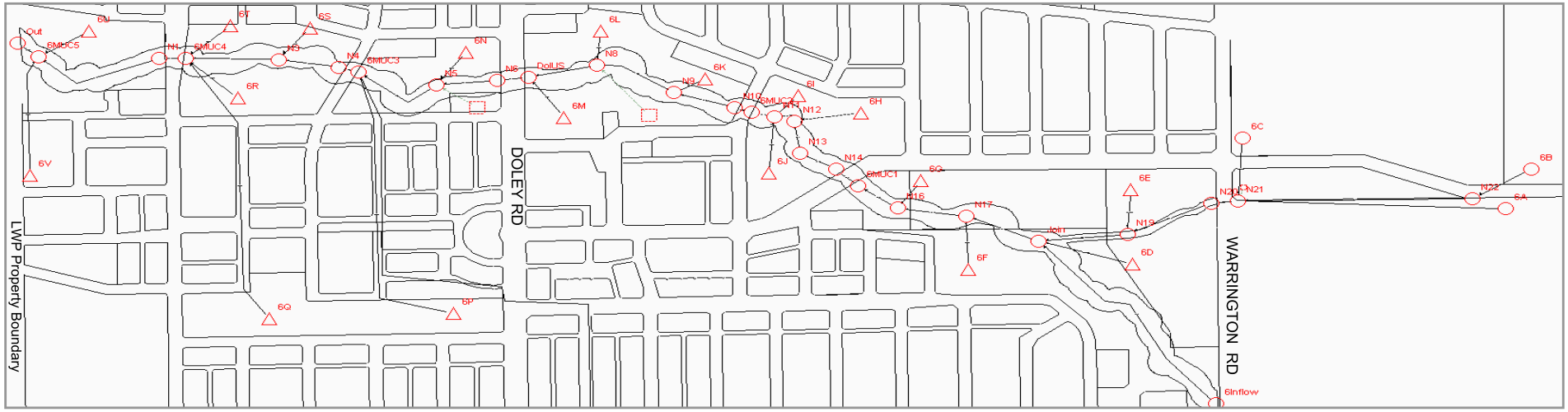
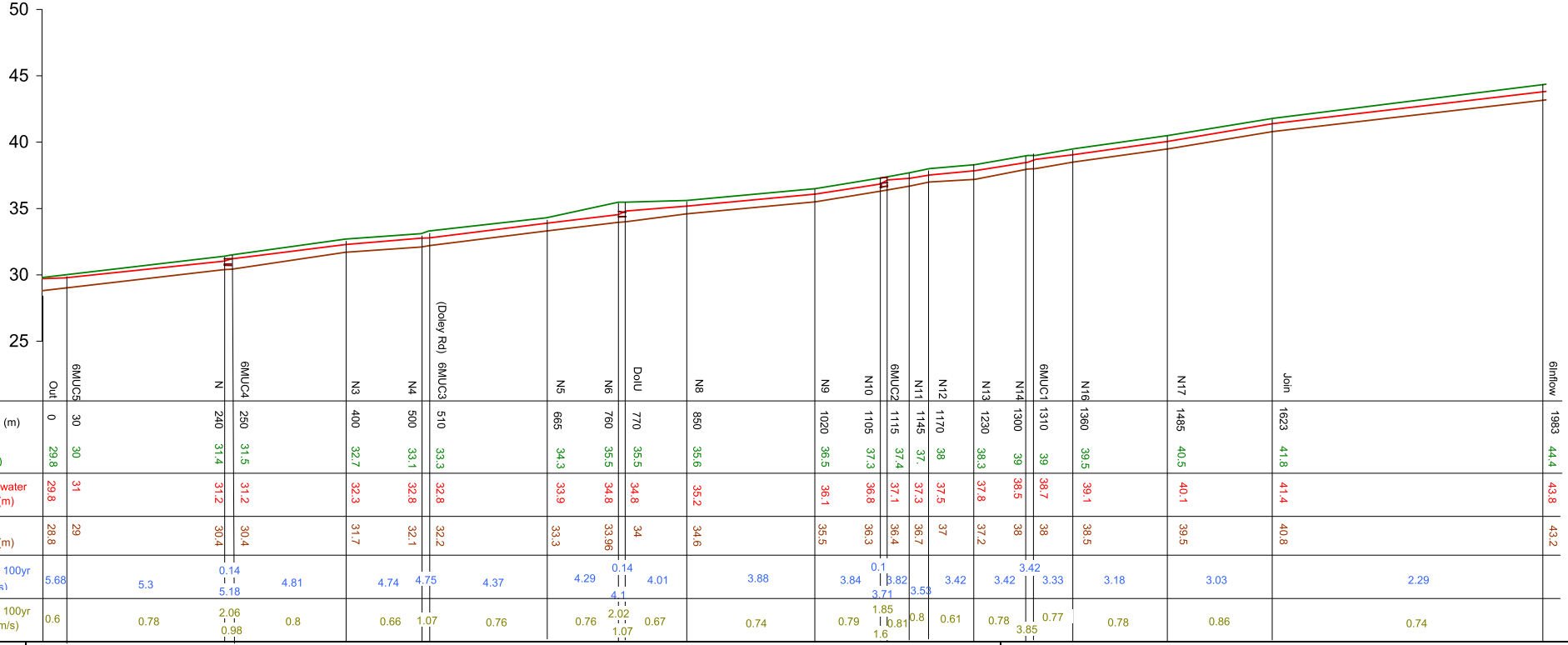
The Glades at Byford LWMS

Figure 10: Proposed Tributary 6 Stormwater Management Concept





	Out	6MUC5	N	6MUC4	N3	N4	(Doley Rd) 6MUC3	N5	N6	DolU	N8	N9	N10	6MUC2	N11	N12	N13	N14	6MUC1	N16	N17	Join	6Inflow
Chainage (m)	0	30	240	250	400	500	510	665	760	770	850	1020	1105	1115	1145	1170	1230	1300	1310	1360	1485	1623	1983
Ground Level (m)	29.8	30	31.4	31.5	32.7	33.1	33.3	34.3	35.5	35.5	35.6	36.5	37.3	37.4	37.	38	38.3	39	39	39.5	40.5	41.8	44.4
Maximum water Elevation (m)	29.8	31	31.2	31.2	32.3	32.8	32.8	33.9	34.8	34.8	35.2	36.1	36.8	37.1	37.3	37.5	37.8	38.5	38.7	39.1	40.1	41.4	43.8
Invert Elevation (m)	28.8	29	30.4	30.4	31.7	32.1	32.2	33.3	33.96	34	34.6	35.5	36.3	36.4	36.7	37	37.2	38	38	38.5	39.5	40.8	43.2
Maximum 100yr Flow (m^3/s)	5.68	5.3	0.14 5.18	4.81	4.74	4.75	4.37	4.29	0.14 4.1	4.01	3.88	3.84	0.1 3.71	3.82	3.53	3.42	3.42	3.42	3.33	3.18	3.03	2.29	
Maximum 100yr Velocity (m/s)	0.6	0.78	2.06 0.98	0.8	0.66	1.07	0.76	0.76	2.02 1.07	0.67	0.74	0.79	1.85 1.6	0.81	0.8	0.61	0.78	3.85	0.77	0.78	0.86	0.74	

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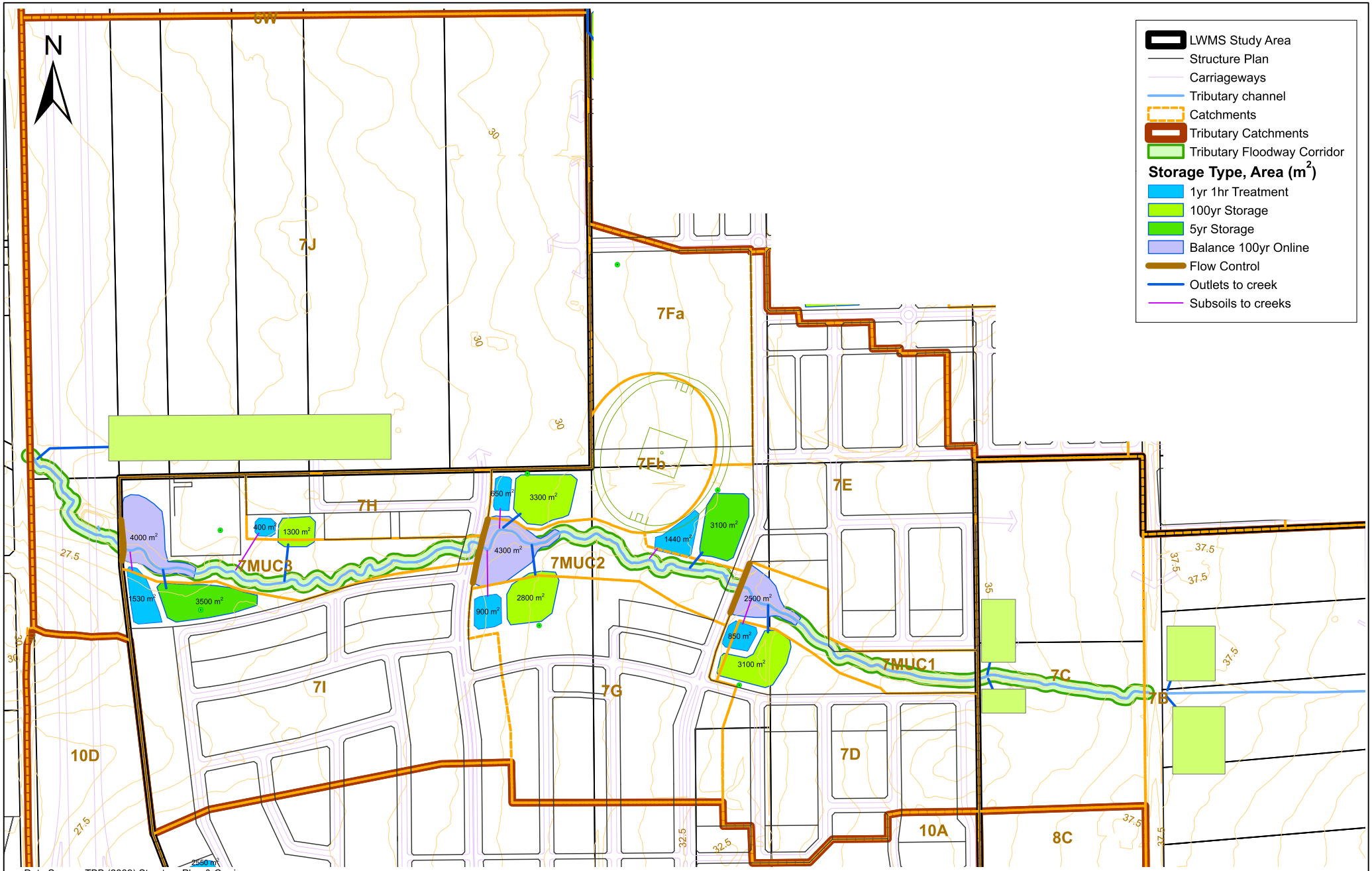
Figure 11: Tributury 6 Longsection and Hydraulic Grade Line Concept



Data Source: TBB (2009) Structure Plan & Carriageways

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Scale: 1:4,000

0 100 200 300 400 500 Meters

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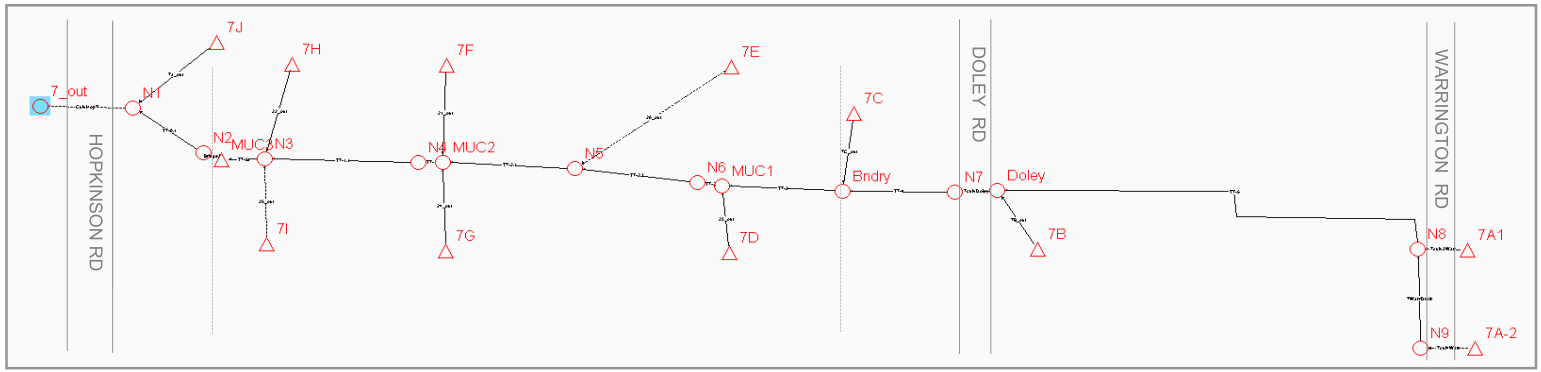
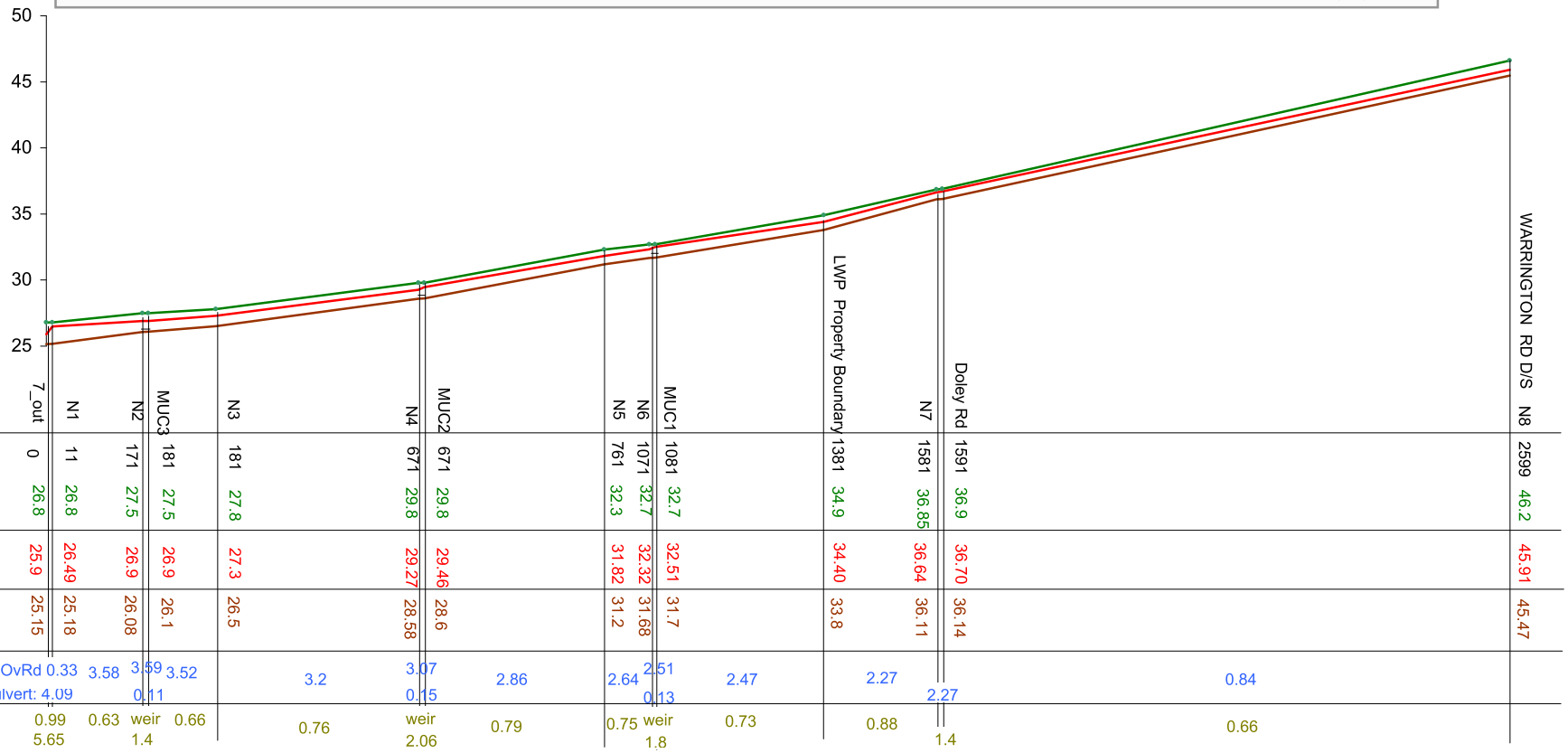
Figure 12: Proposed Tributary 7 Stormwater Management Concept





	7_out	N1	N2	MUC3	N3	N4	MUC2	N5	N6	MUC1	LWP Property Boundary	N7	Doley Rd	WARRINGTON RD D/S	N8
Chainage (m)	0	11	171	181	181	671	671	761	1071	1081	1381	1581	1591	2599	
Ground Level (m)	26.8	26.8	27.5	27.5	27.8	29.8	29.8	32.3	32.7	32.7	34.9	36.85	36.9	46.2	
Maximum water Elevation (m)	25.9	26.49	26.9	26.9	27.3	29.27	29.46	31.82	32.32	32.51	34.40	36.64	36.70	45.91	
Invert Elevation (m)	25.15	25.18	26.08	26.1	26.5	28.58	28.6	31.2	31.68	31.7	33.8	36.11	36.14	45.47	
Maximum 100yr OvRd	0.33	3.58	3.59	3.52	3.2	3.07	2.86	2.64	2.51	2.47	2.27	2.27	0.84		
Flow (m^3/s) culvert:	4.09		0.11			0.15			0.13						
Maximum 100yr Flow (m^3/s)	0.99	0.63	weir	0.66	0.76	weir	0.79	0.75	weir	0.73	0.88	1.4	0.66		
	5.65		1.4			2.06			1.8						

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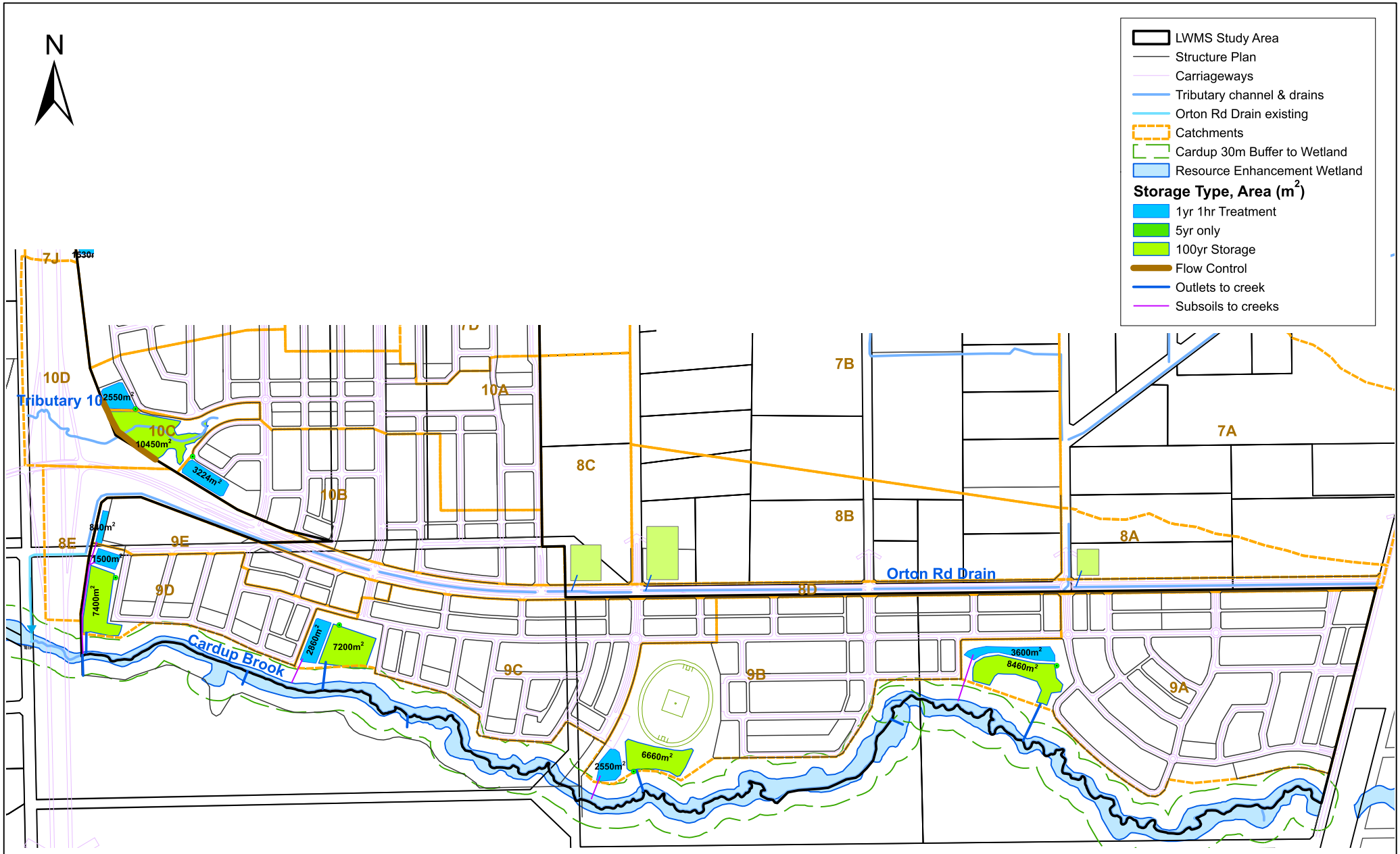
The Glades at Byford LWMS

Figure 13: Tributary 7 Long Sections and Hydraulic Grade Line Concept



Data Source: TBB (2009) Structure Plan & Carriageways

Job No. J4320
Scale: 1:7,500

0 200 400 600 800 1,000 Meters

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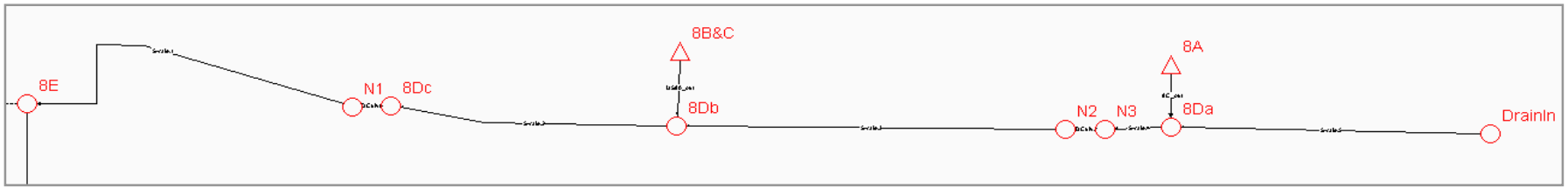
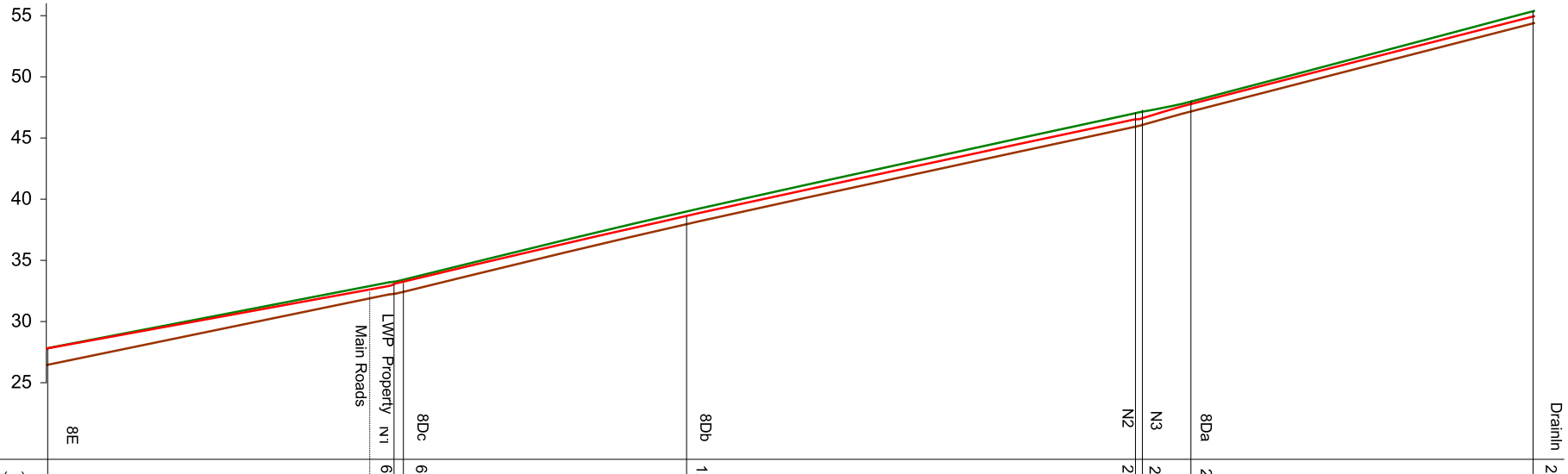
The Glades at Byford LWMS

Figure 14: Proposed Tributary 10 & Cardup Brook Stormwater Management Concept





	8E	Main Roads	LWP Property	N1	8Dc	8Db	N2	N3	8Da	DrainIn
Chainage (m)	0		660		665	1215	2065	2075	2175	2825
Ground Level (m)	27.8		33.2		33.3	39	47	47.	48	55.4
Maximum water Elevation (m)	27.8		32.91		33.12	38.63	46.51	46.53	47.8	54.96
Invert Elevation (m)	26.45		32.2		32.3	37.95	45.9	46	47.2	54.4
Maximum 100yr Flow (m^3/s)		3.2		3.2	3.18	2.34	2.34	2.34	2.0	
Maximum 100yr Velocity (m^3/s)		0.92		3.3	0.98	0.89	1.81	0.96	0.92	

Job No. J4320

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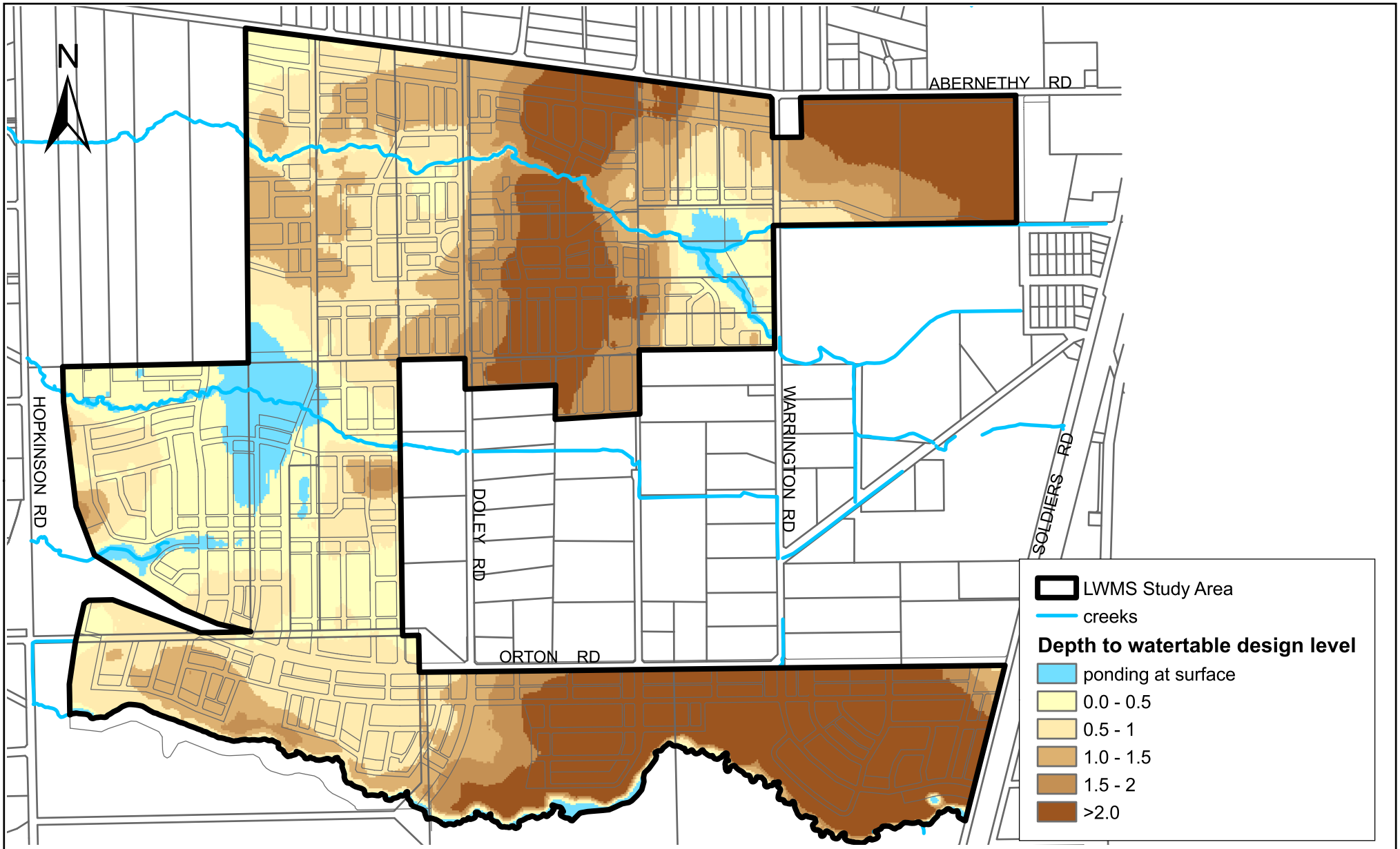
The Glades at Byford LWMS

Figure 15: Orton Rd Long Sections and Hydraulic Grade Line Concept



Data Source: based on Maps (2007) Topographic 0.5 m interval Contours, and JDA estimated watertable design level

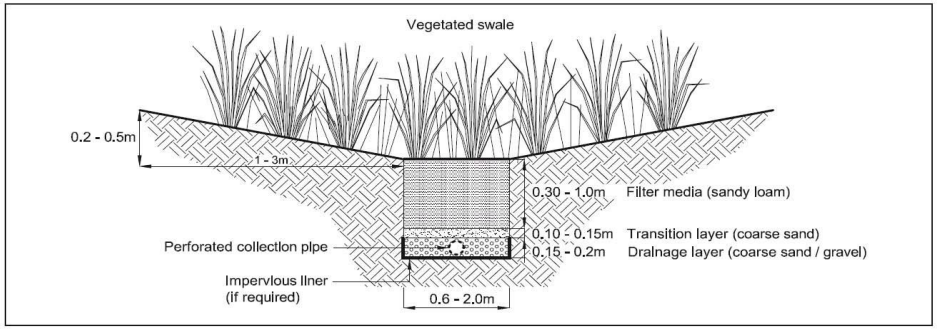
JDA Consultant Hydrologists

Job No. J4320
Scale: 1:15,000

0 100 200 300 400 500 Meters

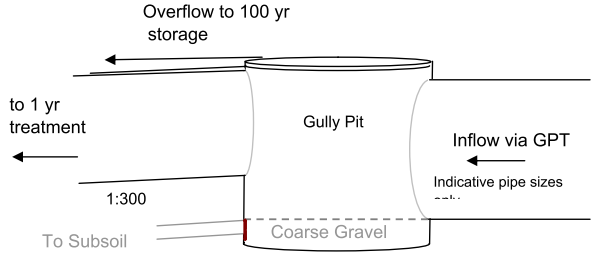
LWP Property Group Pty Ltd
The Glades at Byford LWMS

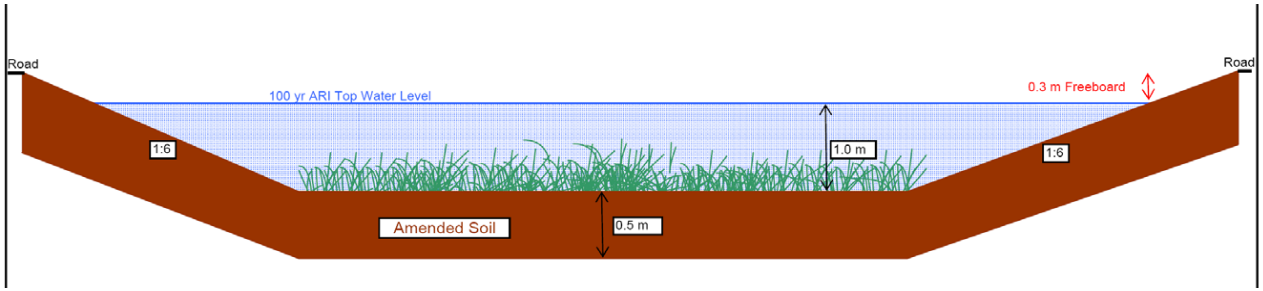
Figure 16: Depth to Groundwater Mapping



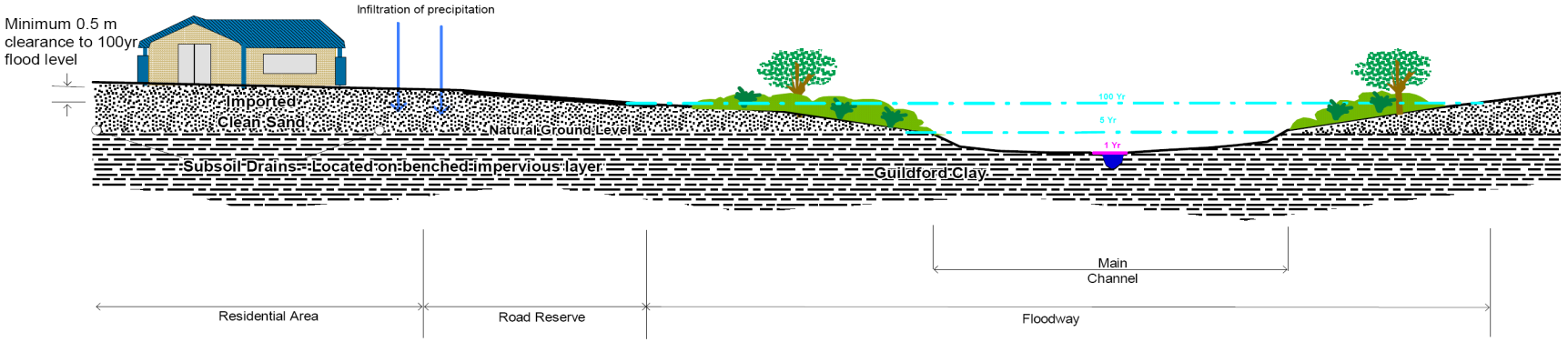
Typical bio-retention swale arrangement for impervious soils. (Source: DoW, 2007)

Diversion Structure Schematic





Example arrangement of bio-retention storage.



Indicative section of a tributary channel and floodway

Not to scale, all dimensions vary

Source: Byford Townsite DWMP (DoW, 2008)

LWP Property Group Pty Ltd
The Glades at Byford LWMS
Figure 17: Typical Sections for Water Management Structures

APPENDIX A

Lithological Logs

JDA Consultant Hydrologists
Suite 1, 27 York Street
Subiaco WA 6008
Tel: 9388 2436
Fax: 9381 9279

LITHOLOGICAL LOG

Client:	LWP Property Group	Job No:	J3690
Project:	Byford by the Glade	Hole commenced:	06/09/05
Bore location:	404522, 6434630	Hole completed:	06/09/05
Datum:	MGA94/AHD	Logged by:	SW
Bore Name:	BDM 1	Total Depth:	7.5 m BNS
Drill type:	Air Core	R.L. TOC:	35.45 m AHD
Hole diameter:	100 mm	Natural Surface:	34.88 m AHD

method	1 2 3 penetration	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
AC		PVC (Class 9)	▽		1 m	Light grey to cream	Medium	Sand	Low	Slightly moist	
						Light grey and red	Coarse to fine	Gravelly clay			Gravel to 30 mm size
					2 m	Red				Dry	Well cemented. Gravel content decreasing with depth
					3 m						
					4 m	Light grey to cream. Blue/grey mottling	Fine	Clay			
					5 m						
					6 m					Moist	
					7 m					Saturated	*End of Hole*
					8 m						
					9 m						
					10 m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
Medium :	Brown, Red, Orange, Yellow, Grey, Blue	
Light :	Brown, Red, Orange, Yellow, Grey, Blue	

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: ……

WL below TOC ……

Stickup above NS: ……m

WL …….. m below NS

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LITHOLOGICAL LOG

Client:	LWP Property Group	Job No:	J3690
Project:	Byford by the Glade	Hole commenced:	06/09/05
Bore location:	404622, 6433850	Hole completed:	06/09/05
Datum:	MGA94/AHD	Logged by:	SW
Bore Name:	BDM 2	Total Depth:	7.0 m BNS
Drill type:	Air Core	R.L. TOC:	38.07 m AHD
Hole diameter:	100 mm	Natural Surface:	37.34 m AHD

method	1 2 3 penetration	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
AC		PVC (Class 9)	▽		1 m	Light grey	Medium to fine	Sandy Clay	Low	Moist	
					2 m	Light brown to yellow	Fine	Clay			
					3 m						
					4 m						
					5 m						
					6 m	Light grey to cream		Sandy Clay		Very moist	
					7 m					Saturated	*End of Hole*
					8 m						
					9 m						
					10 m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
Dark : Brown, Red, Orange, Yellow, Grey, Blue Tones : solid colour, blemish or mottle
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Light : Brown, Red, Orange, Yellow, Grey, Blue

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: ……

WL below TOC ……

Stickup above NS: ……m

WL …….. m below NS

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LITHOLOGICAL LOG

Client:	LWP Property Group	Job No:	J3690
Project:	Byford by the Glade	Hole commenced:	06/09/05
Bore location:	404834, 6432867	Hole completed:	06/09/05
Datum:	MGA94/AHD	Logged by:	SW
Bore Name:	BDM 3	Total Depth:	6.0 m BNS
Drill type:	Air Core	R.L. TOC:	42.98 m AHD
Hole diameter:	100 mm	Natural Surface:	42.38 m AHD

method	1 2 3 penetration	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
AC		PVC (Class 9)	▽		1 m	Light grey to cream	Medium	Sand	Low	Slightly moist	
					2 m	Light grey to yellow	Medium to fine	Clayey Sand		Moist	
					3 m	Light brown to yellow	Coarse to fine	Gravelly clay			
					4 m	Orange	Fine	Clay			
					5 m	Yellow	Fine	Sandy clay		Very moist	
					6 m					Saturated	*End of Hole*
					7 m						
					8 m						
					9 m						
					10 m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
Dark : Brown, Red, Orange, Yellow, Grey, Blue Tones : solid colour, blemish or mottle
Medium : Brown, Red, Orange, Yellow, Grey, Blue
Light : Brown, Red, Orange, Yellow, Grey, Blue

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: ……

WL below TOC ……

Stickup above NS: ……m

WL …….. m below NS

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LITHOLOGICAL LOG

Client:	LWP Property Group	Job No:	J3690
Project:	Byford by the Glade	Hole commenced:	06/09/05
Bore location:	406320, 6434804	Hole completed:	06/09/05
Datum:	MGA94/AHD	Logged by:	SW
Bore Name:	BDM 4	Total Depth:	8.5 m BNS
Drill type:	Air Core	R.L. TOC:	52.84 m AHD
Hole diameter:	100 mm	Natural Surface:	52.17 m AHD

method	1 2 3 penetration	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
AC		PVC (Class 9)	▽		1 m	Light brown	Medium to fine	Sandy clay	Low	Slightly moist	
					2 m	Yellow/Orange	Coarse to fine	Gravelly clay			
						Dark Orange					
					3 m	Very hard laterite layer					
					4 m	Red	Coarse to fine	Gravelly clay	Low	Dry	Well cemented
					5 m		Fine	Clay			
					6 m						
					7 m	Light grey to cream with grey/blue mottling				Moist	Stiff clay
					8 m					Saturated	*End of hole*
					9 m						
					10 m						

NOTES ON BORELOG

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Medium : Brown, Red, Orange, Yellow, Grey, Blue
Light : Brown, Red, Orange, Yellow, Grey, Blue

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: ……

WL below TOC ……

Stickup above NS: ……m

WL …….. m below NS

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LITHOLOGICAL LOG

Client:	LWP Property Group	Job No:	J3690
Project:	Byford by the Glade	Hole commenced:	07/09/05
Bore location:	403901, 6432972	Hole completed:	07/09/05
Datum:	MGA94/AHD	Logged by:	SW
Bore Name:	BDM 5	Total Depth:	5.5 m BNS
Drill type:	Air Core	R.L. TOC:	32.63 m AHD
Hole diameter:	100 mm	Natural Surface:	31.97 m AHD

method	1 2 3 penetration	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
AC		PVC (Class 9)	▽		1 m	Grey	Fine	Sandy silty clay	Medium	Very moist	
						Cream		Sandy clay		Saturated	
						Red/Orange				Moist	
					2 m	Orange to yellow	Coarse to fine	Gravelly clay		Saturated	Ironstone and feldspar gravel 3 mm size
					3 m	Yellow	Fine	Clay	Low		
					4 m	Red with white peds					
					5 m	White with blue/grey mottling					*End of Hole*
					6 m						
					7 m						
					8 m						
					9 m						
					10 m						

NOTES ON BORELOG

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Dark : Brown, Red, Orange, Yellow, Grey, Blue Tones : solid colour, blemish or mottle
Medium : Brown, Red, Orange, Yellow, Grey, Blue
Light : Brown, Red, Orange, Yellow, Grey, Blue

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: ……

WL below TOC ……

Stickup above NS: ……m

WL …….. m below NS

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LITHOLOGICAL LOG

Client:	LWP Property Group	Job No:	J3690
Project:	Byford by the Glade	Hole commenced:	07/09/05
Bore location:	403449, 6432502	Hole completed:	07/09/05
Datum:	MGA94/AHD	Logged by:	SW
Bore Name:	BDM 6	Total Depth:	5.0 m BNS
Drill type:	Air Core	R.L. TOC:	29.63 m AHD
Hole diameter:	100 mm	Natural Surface:	29.12 m AHD

method	1 2 3 penetration	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
AC		PVC (Class 9)	▽		1 m	Dark brown	Medium to fine	Sandy clay	Low	Moist	
						Yellow	Fine	Clay			
					2 m		Coarse to fine	Gravelly clay		Saturated	
							Fine	Clay			
					3 m						
					4 m	Yellow to light brown	Coarse to fine	Gravelly clay			Ironstone gravel 3 mm size
						Cream with blue/grey mottling	Medium to fine	Sandy clay			*End of Hole*
					5 m						
					6 m						
					7 m						
					8 m						
					9 m						
					10 m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
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Light :	Brown, Red, Orange, Yellow, Grey, Blue	

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TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: ……

WL below TOC ……

Stickup above NS: ……m

WL …….. m below NS

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LITHOLOGICAL LOG

Client:	LWP Property Group	Job No:	J3690
Project:	Byford by the Glade	Hole commenced:	07/09/05
Bore location:	404080, 6433782	Hole completed:	07/09/05
Datum:	MGA94/AHD	Logged by:	SW
Bore Name:	BDM 7	Total Depth:	5.0 m BNS
Drill type:	Air Core	R.L. TOC:	33.38 m AHD
Hole diameter:	100 mm	Natural Surface:	32.73 m AHD

method	1 2 3 penetration	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
AC		PVC (Class 9)	▽		1 m	Cream	Medium to fine	Loamy sand	Medium	Moist	
								Sandy clay			
					2 m	Yellow to light brown	Coarse to fine	Gravelly clay	Low		Well cemented. Ironstone anfd feldspar gravel
					3 m	Pink/Red				Saturated	
					4 m	Cream with blue/grey mottling	Fine	Clay			
					5 m						*End of Hole*
					6 m						
					7 m						
					8 m						
					9 m						
					10 m						

NOTES ON BORELOG

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Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
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MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: ……

WL below TOC ……

Stickup above NS: ……m

WL …….. m below NS

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LITHOLOGICAL LOG

Client:	LWP Property Group	Job No:	J3690
Project:	Byford by the Glade	Hole commenced:	07/09/05
Bore location:	403890, 6434716	Hole completed:	07/09/05
Datum:	MGA94/AHD	Logged by:	SW
Bore Name:	BDM 8	Total Depth:	5.5 m BNS
Drill type:	Air Core	R.L. TOC:	31.30 m AHD
Hole diameter:	100 mm	Natural Surface:	30.62 m AHD

method	1 2 3 penetration	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
AC		PVC (Class 9)	▽		1 m	Grey	Medium to fine	Clayey sand	Low	Moist	
					2 m	Cream	Coarse to fine	Gravelly clay			Ironstone and feldspar gravel
					3 m	Pink/Red				Saturated	
					4 m	Red with grey blue mottling	Fine	Clay			
					5 m	Cream to light grey with grey/blue mottling					*End of Hole*
					6 m						
					7 m						
					8 m						
					9 m						
					10 m						

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Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: ……

WL below TOC ……

Stickup above NS: ……m

WL …….. m below NS

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LITHOLOGICAL LOG

Client:	LWP Property Group	Job No:	J3690
Project:	Byford by the Glade	Hole commenced:	07/09/05
Bore location:	405218, 6434087	Hole completed:	07/09/05
Datum:	MGA94/AHD	Logged by:	SW
Bore Name:	BDM 9	Total Depth:	5.5 m BNS
Drill type:	Air Core	R.L. TOC:	42.72 m AHD
Hole diameter:	100 mm	Natural Surface:	42.06 m AHD

method	1 2 3 penetration	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
AC		PVC (Class 9)	▽		1 m	Light brown to grey	Coarse to fine	Gravelly clay	Low	Very moist	
					2 m	Red				Slightly moist	
					3 m					Moist	
					4 m	Cream with grey/blue mottling	Fine	Clay		Saturated	
					5 m						*End of Hole*
					6 m						
					7 m						
					8 m						
					9 m						
					10 m						

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Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: ……

WL below TOC ……

Stickup above NS: ……m

WL …….. m below NS

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LITHOLOGICAL LOG

Client:	LWP Property Group	Job No:	J3690
Project:	Byford by the Glade	Hole commenced:	08/09/05
Bore location:	405400, 6433458	Hole completed:	08/09/05
Datum:	MGA94/AHD	Logged by:	SW
Bore Name:	BDM 10	Total Depth:	6.0 m BNS
Drill type:	Air Core	R.L. TOC:	47.00 m AHD
Hole diameter:	100 mm	Natural Surface:	47.00 m AHD

method	1 2 3 penetration	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
AC		PVC (Class 9)	▽		1 m	Yellow	Medium to fine	Sand	Low	Moist	
					2 m		Coarse to fine	Gravelly sand			Gravel to 5 mm size
					3 m	Yellow to light brown		Gravelly sandy clay			Ironstone and feldspar gravel
					4 m	Red with mix of red/yellow and grey/blue mottling				Saturated	
					5 m						
					6 m	Light brown with grey/blue mottling	Fine	Clay			*End of Hole*
					7 m						
					8 m						
					9 m						
					10 m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
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Light :	Brown, Red, Orange, Yellow, Grey, Blue	

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TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: ……

WL below TOC ……

Stickup above NS: ……m

WL …….. m below NS

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LITHOLOGICAL LOG

Client:	LWP Property Group	Job No:	J3690
Project:	Byford by the Glade	Hole commenced:	08/09/05
Bore location:	405008, 6433362	Hole completed:	08/09/05
Datum:	MGA94/AHD	Logged by:	SW
Bore Name:	BDM 11	Total Depth:	6.0 m BNS
Drill type:	Air Core	R.L. TOC:	41.88 m AHD
Hole diameter:	100 mm	Natural Surface:	41.88 m AHD

method	1 2 3 penetration	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
AC		PVC (Class 9)	▽		1 m	Cream	Medium to fine	Sandy clay	Low	Moist	
					2 m	Light brown	Coarse to fine	Gravelly clay			Very gravelly 2.5 to 3.0m depth
					3 m						
					4 m	Orange	Fine	Clay		Saturated	
					5 m						
					6 m	Red with grey blue mottling					Stiff clay *End of Hole*
					7 m						
					8 m						
					9 m						
					10 m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE

Dark :	Brown, Red, Orange, Yellow, Grey, Blue	Tones : solid colour, blemish or mottle
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TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: ……

WL below TOC ……

Stickup above NS: ……m

WL …….. m below NS

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LITHOLOGICAL LOG

Client:	LWP Property Group	Job No:	J3690
Project:	Byford by the Glade	Hole commenced:	08/09/05
Bore location:	406254, 6433850	Hole completed:	08/09/05
Datum:	MGA94/AHD	Logged by:	SW
Bore Name:	BDM 12	Total Depth:	7.5 m BNS
Drill type:	Air Core	R.L. TOC:	56.06 m AHD
Hole diameter:	100 mm	Natural Surface:	56.07 m AHD

method	1 2 3 penetration	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS: COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
AC		PVC (Class 9)	▽		1 m	Grey	Medium to Fine	Clayey sand			
					2 m	Light brown to yellow	Coarse to fine	Gravelly clay	Low	Moist	Ironstone and feldspars gravel < 3 mm
					3 m						
					4 m	Light grey to cream					
					5 m	Green claystone with feldspar grains					
					6 m						
					7 m	Olive with grey blue clay mottling	Coarse to fine	Gravelly clay	Low	Saturated	*End of Hole*
					8 m						
					9 m						
					10 m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
Dark : Brown, Red, Orange, Yellow, Grey, Blue Tones : solid colour, blemish or mottle
Medium : Brown, Red, Orange, Yellow, Grey, Blue
Light : Brown, Red, Orange, Yellow, Grey, Blue

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: ……

WL below TOC ……

Stickup above NS: ……m

WL …….. m below NS

JDA Consultant Hydrologists
Suite 1, 27 York Street
Subiaco WA 6008
Tel: 9388 2436
Fax: 9381 9279

LITHOLOGICAL LOG

Client:	LWP Property Group	Job No:	J3690
Project:	Byford by the Glade	Hole commenced:	08/09/05
Bore location:	405380, 6432373	Hole completed:	08/09/05
Datum:	MGA94/AHD	Logged by:	SW
Bore Name:	BDM 13	Total Depth:	9.0 m BNS
Drill type:	Air Core	R.L. TOC:	51.57 m AHD
Hole diameter:	100 mm	Natural Surface:	50.88 m AHD

method	1 2 3 penetration	support	water	Slot / Screen Depth	Depth (metres)	SOIL CHARACTERISTICS					
						COLOUR	PARTICLE SIZE	TEXTURE	ORGANIC CONTENT	MOISTURE	COMMENTS
AC		PVC (Class 9)			1 m	Yellow	Medium	Sand	Low	Moist	
					2 m						
					3 m	Light brown	Coarse to fine	Gravelly clay			
					4 m						
					5 m	Red with white mottling	Fine	Clay		Dry	
					6 m	Pink	Coarse to fine	Gravelly clay		Moist	Feldspar gravel <1 mm
					7 m					Dry	Very stiff clay
			▽		8 m	Red with grey mottling	Fine	Clay		Moist	
										Saturated	
					9 m						*End of Hole*
					10 m						

NOTES ON BORELOG

COLOURS: Solid colours are BLACK, WHITE, BEIGE
Dark : Brown, Red, Orange, Yellow, Grey, Blue Tones : solid colour, blemish or mottle
Medium : Brown, Red, Orange, Yellow, Grey, Blue
Light : Brown, Red, Orange, Yellow, Grey, Blue

PARTICLE SIZE : Particles are either FINE, MEDIUM or COARSE

TEXTURE : Sand, Loamy Sand, Clayey Sand
Silt, Loam, Sandy Loam, Clay Loam
Clay, Sandy Clay

ORGANIC CONTENT: VOLUME: High, Medium, Low
SIZE: Fine, Medium, Coarse

MOISTURE: Soil Moisture can be either: DRY, SLIGHTLY MOIST, MOIST or SATURATED

STATIC WATER LEVEL

Date: ……

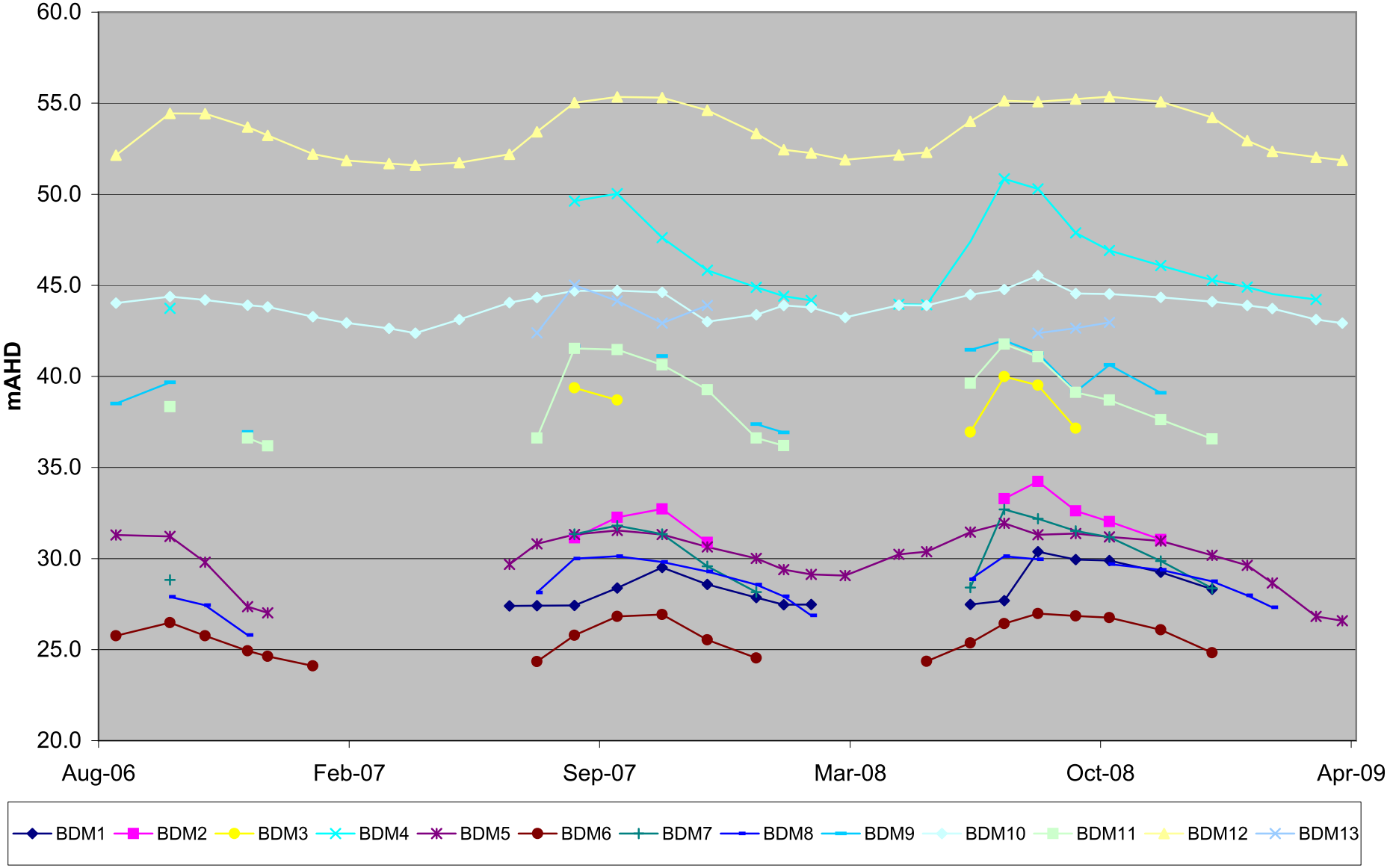
WL below TOC ……

Stickup above NS: ……m

WL …….. m below NS

APPENDIX B

Groundwater Monitoring Bore Hydrographs and Nutrient Concentrations

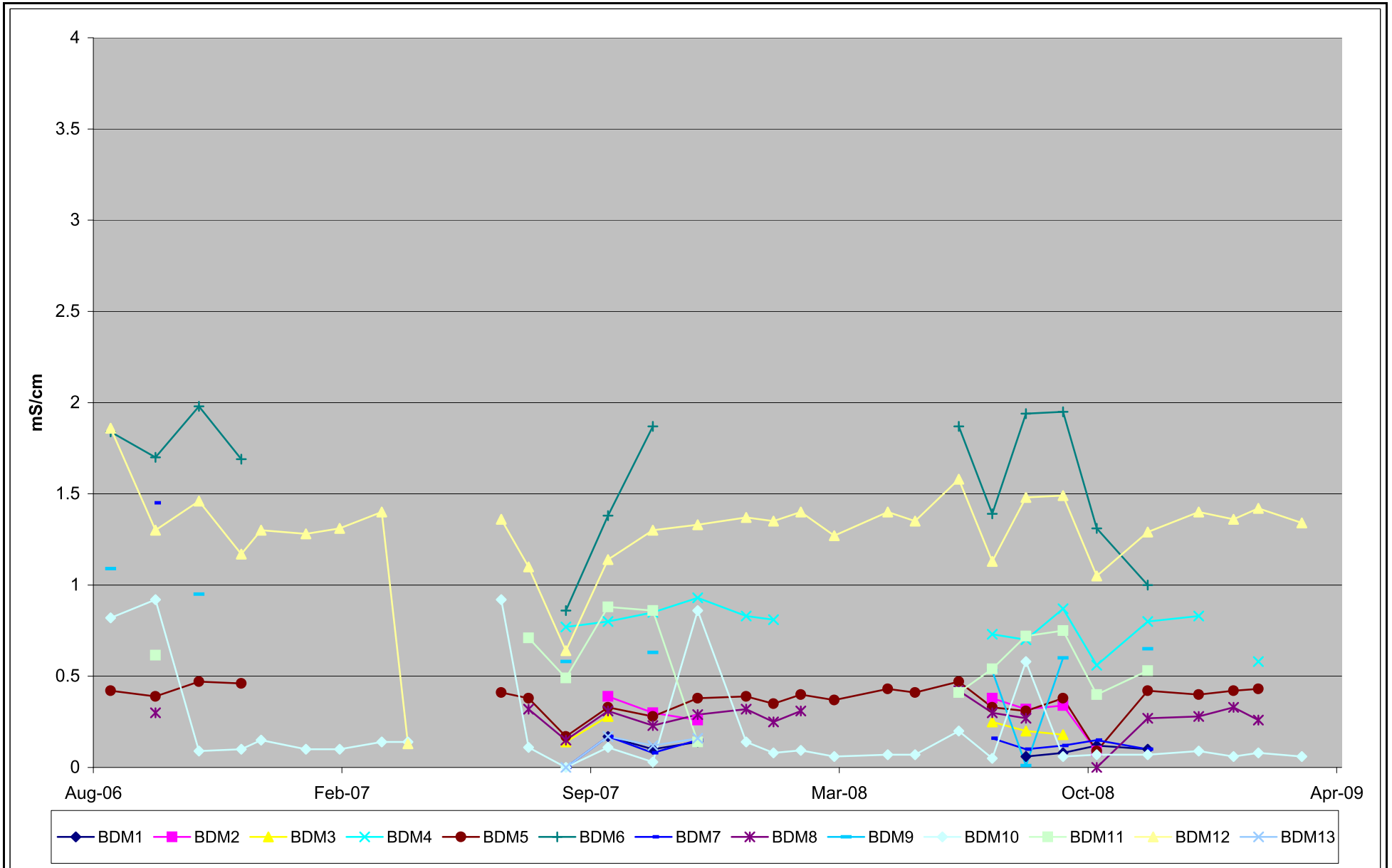


Job No. J4320

LWP Property Group Pty Ltd

Glades at Byford LWMS

Appendix B1: Time Series Plot of water levels in JDA Bores

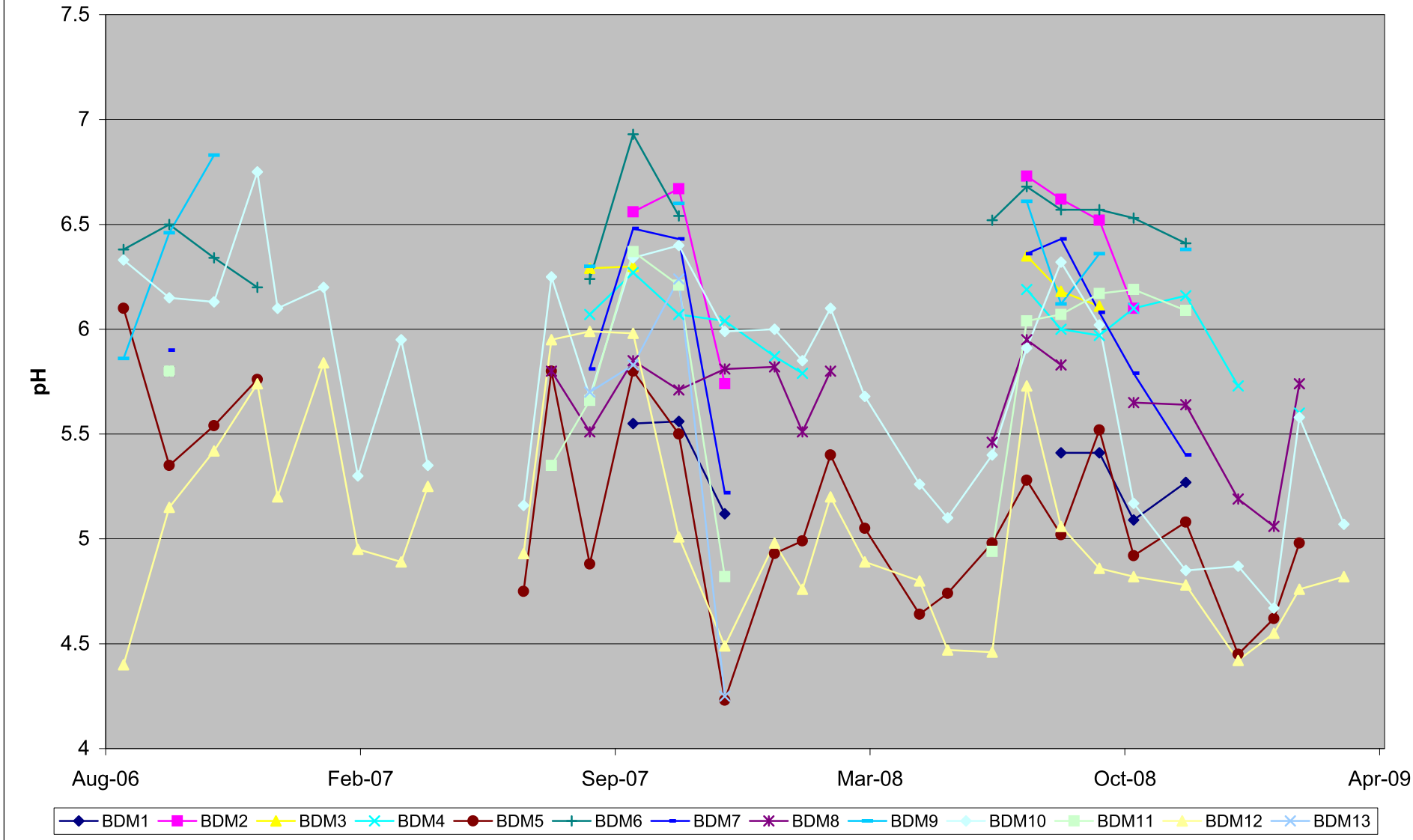


Job No. J4320

LWP Property Group Pty Ltd

Glades at Byford LWMS

Appendix B2: Electrical Conductivity for JDA Bores

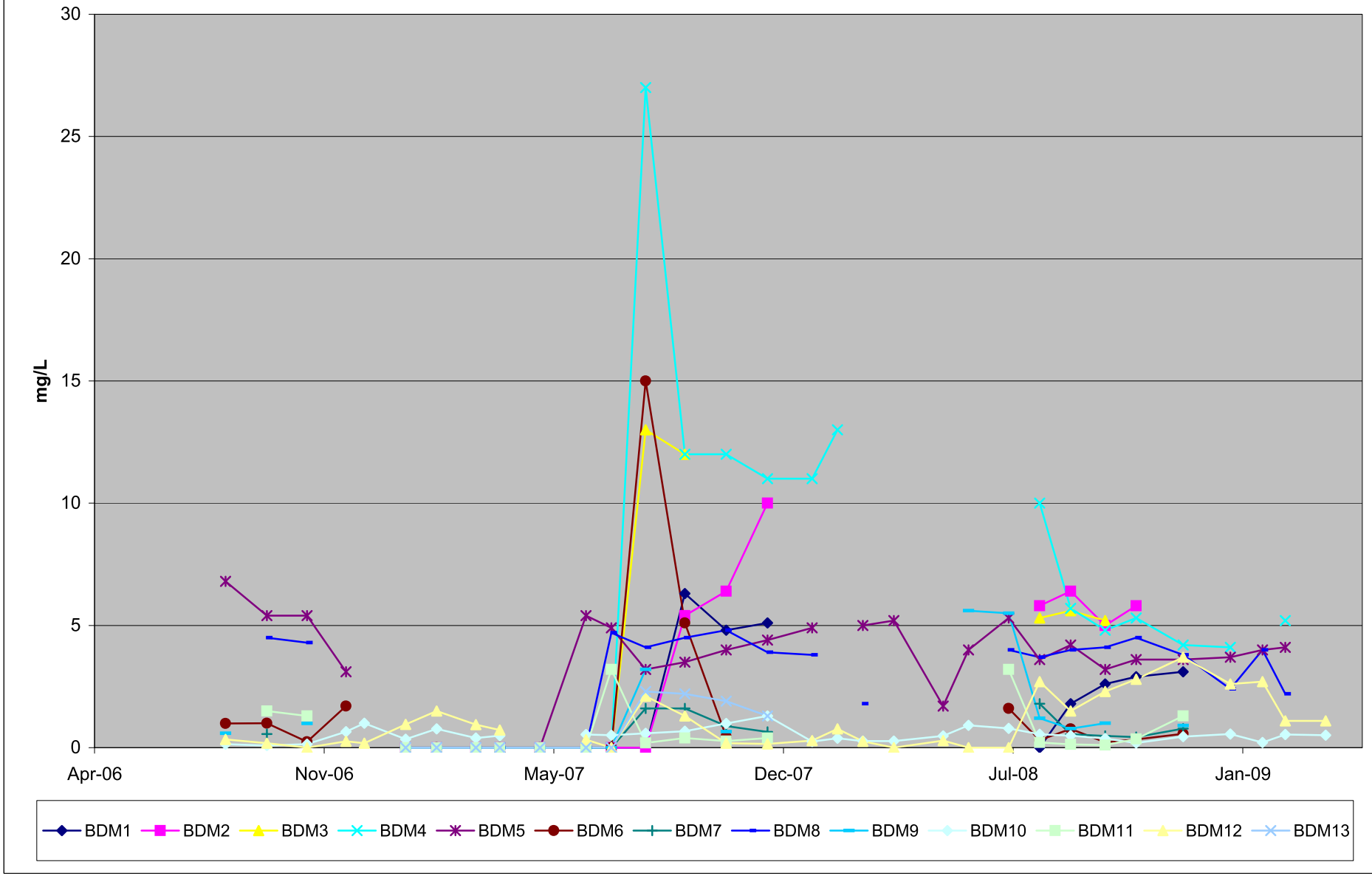


Job No. J4320

LWP Property Group Pty Ltd

Glades at Byford LWMS

Appendix B3: pH for JDA Bores

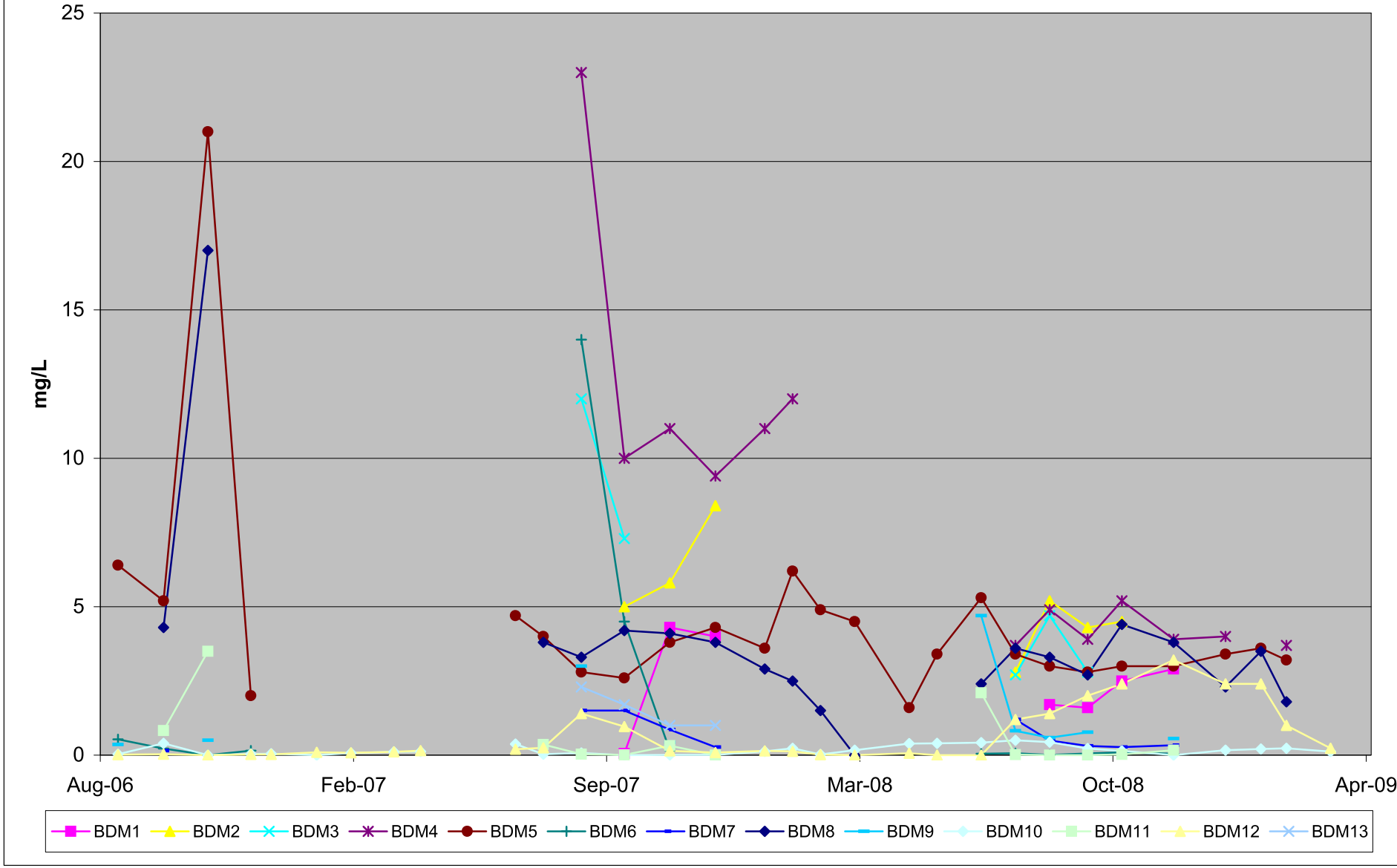


Job No. J4320

LWP Property Group Pty Ltd

Glades at Byford LWMS

Appendix B4: Total Nitrogen Concentrations for JDA Bores

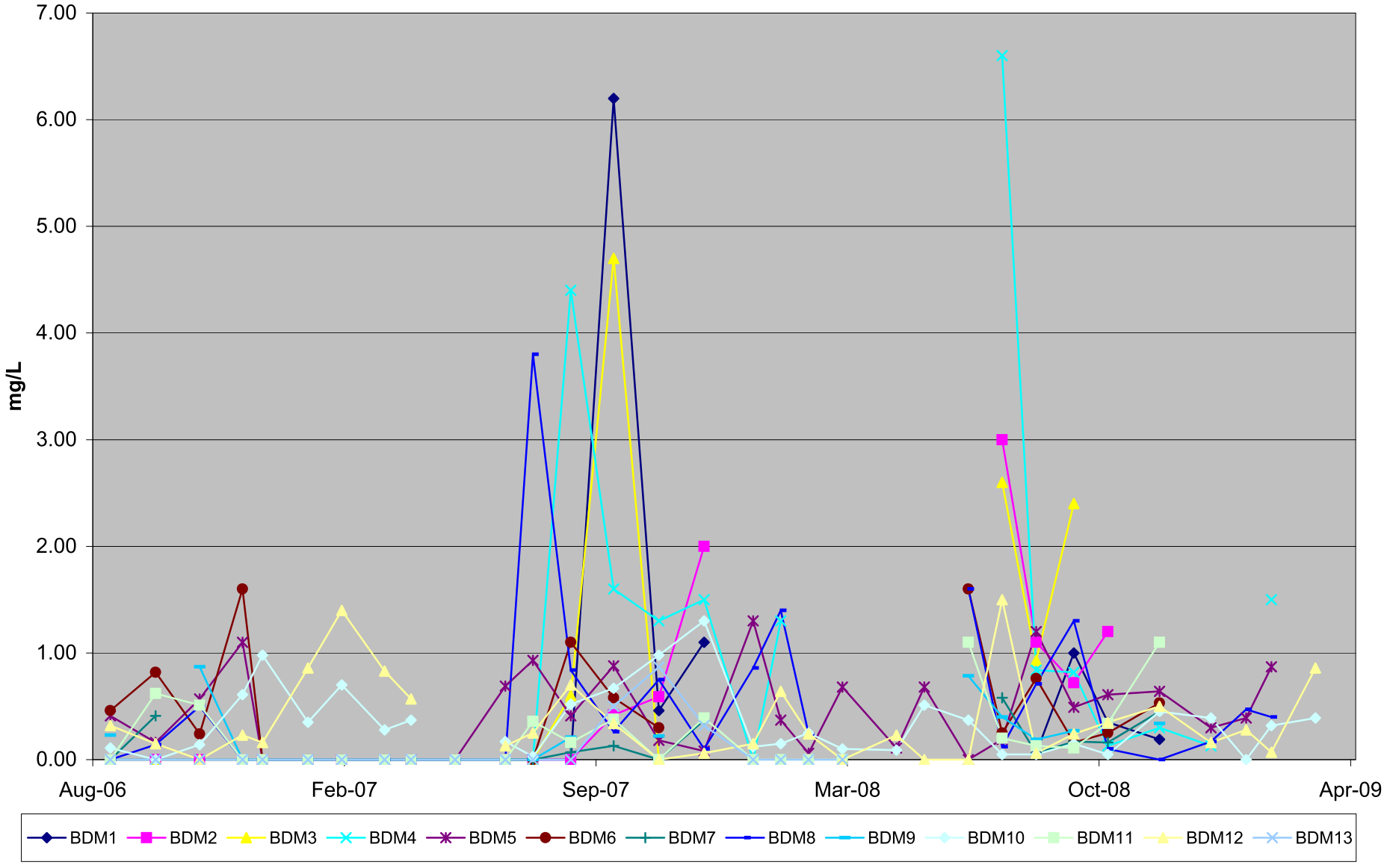


Job No. J4320

LWP Property Group Pty Ltd

Glades at Byford LWMS

Appendix B5: Nitrate/Nitrite Concentrations for JDA Bores



Job No. J4320

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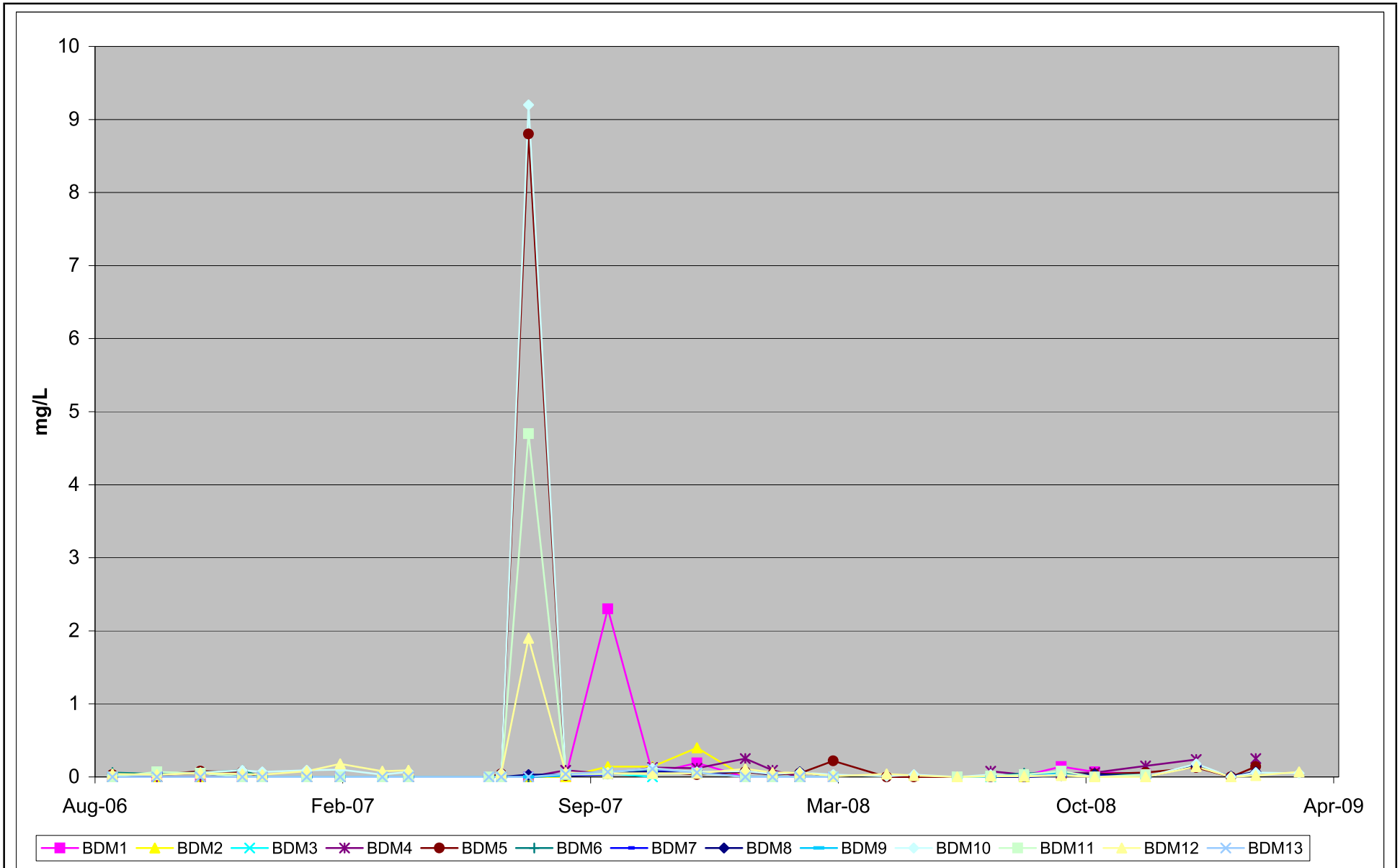
Glades at Byford LWMS

Appendix B6: Total Kjeldahl Nitrogen Concentrations for JDA Bores

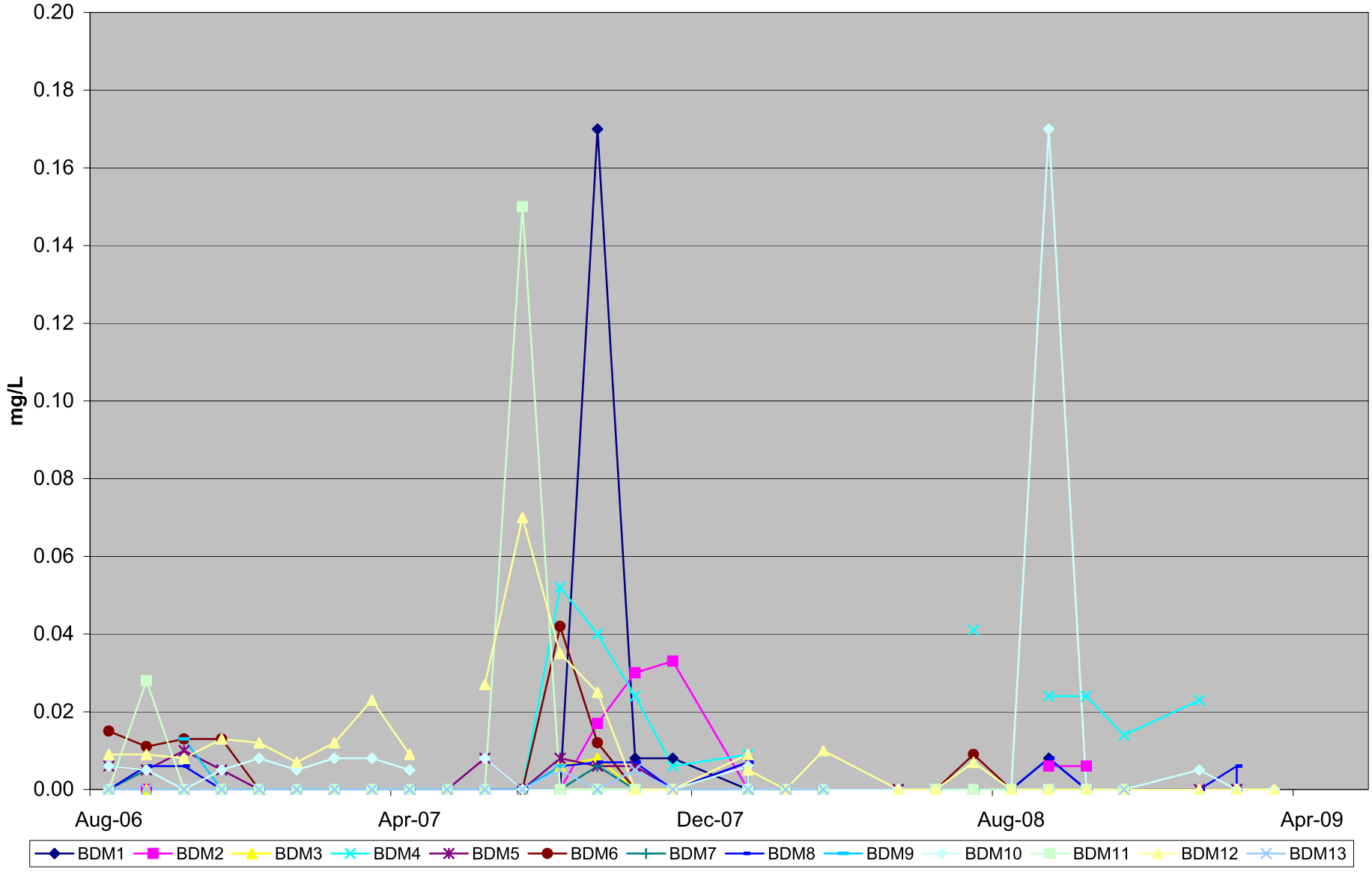


Job No. J4320

LWP Property Group Pty Ltd

Glades at Byford LWMS

Appendix B7: Total Phosphorus Concentrations for JDA Bores

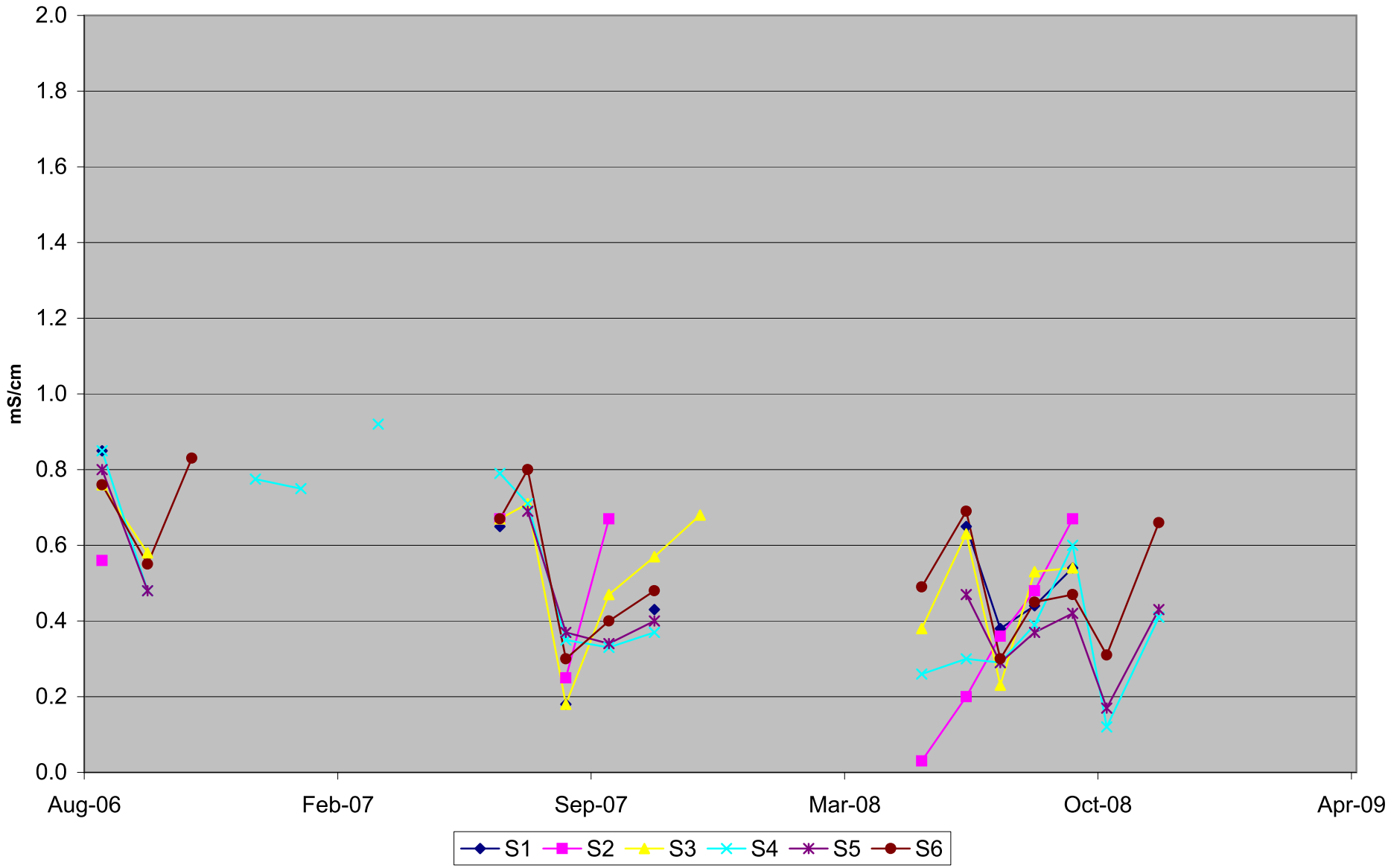


Job No. J4320

LWP Property Group Pty Ltd

Glades at Byford LWMS

Appendix B8 Filterable Reactive Phosphous Concentrations for JDA Bores



Job No. J4320

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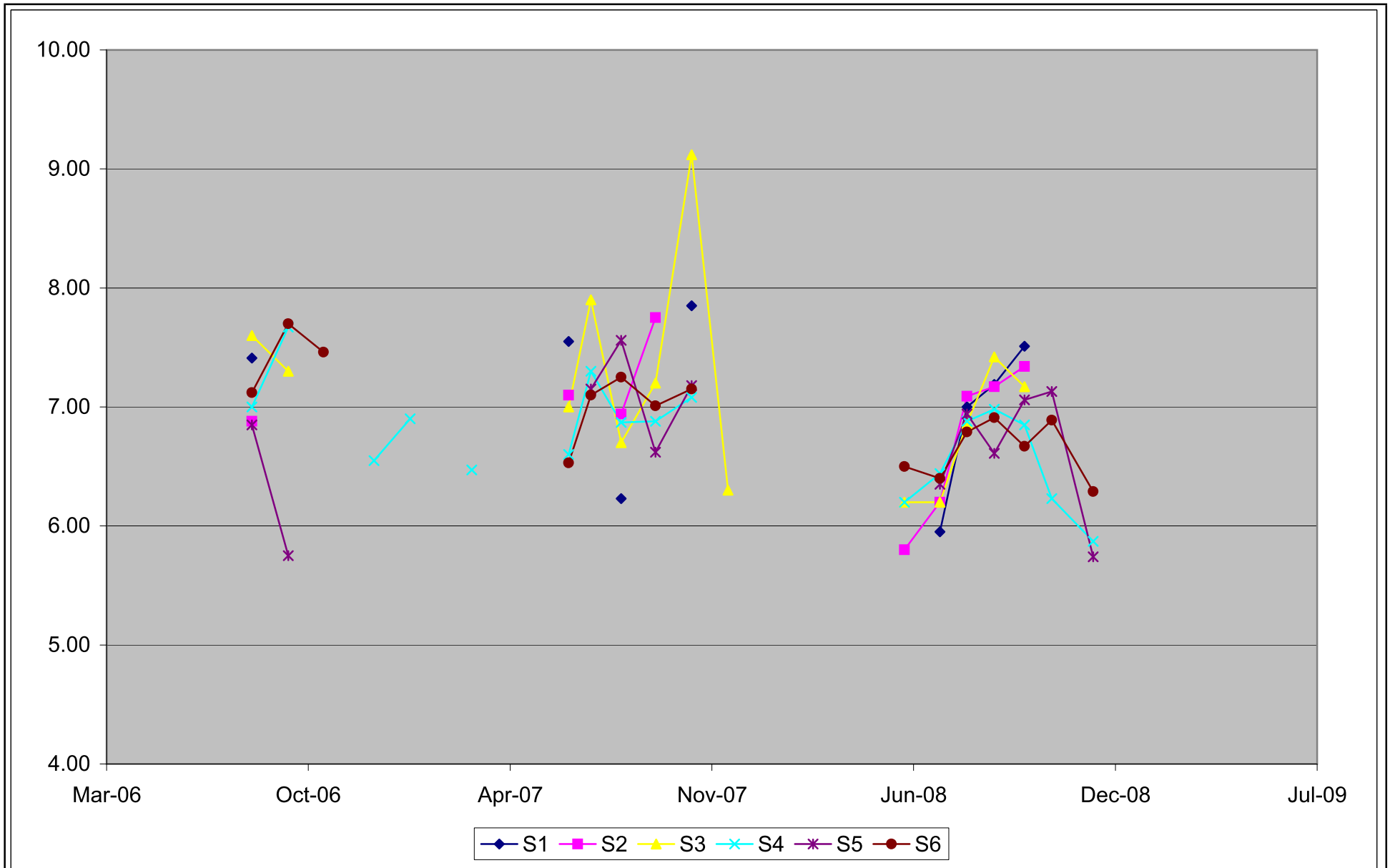
Glades at Byford LWMS

Appendix B9: Electrical Conductivity for Surface Water Sites

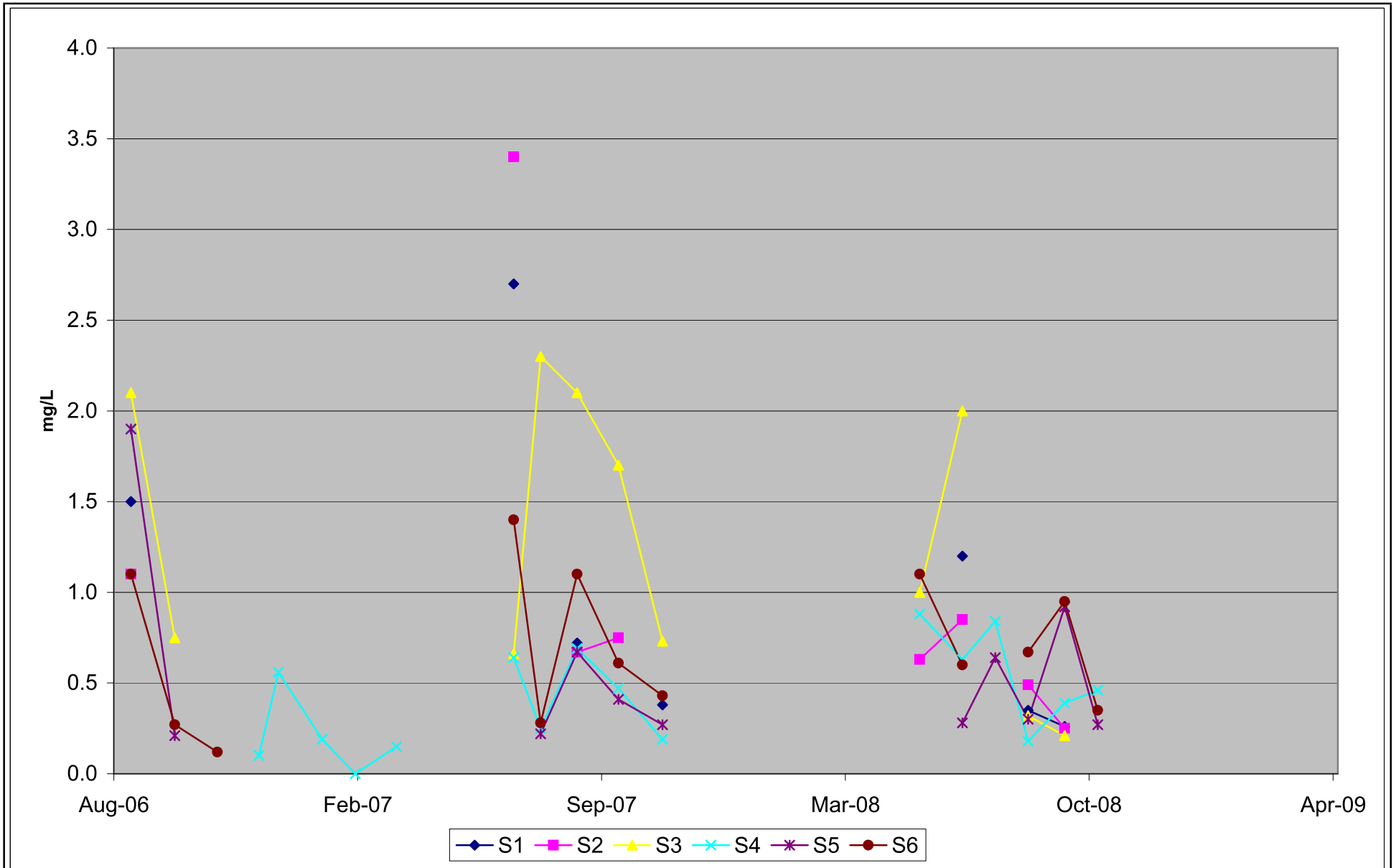


Job No. J4320

LWP Property Group Pty Ltd

Glades at Byford LWMS

Appendix B10: pH for Surface Water Sites

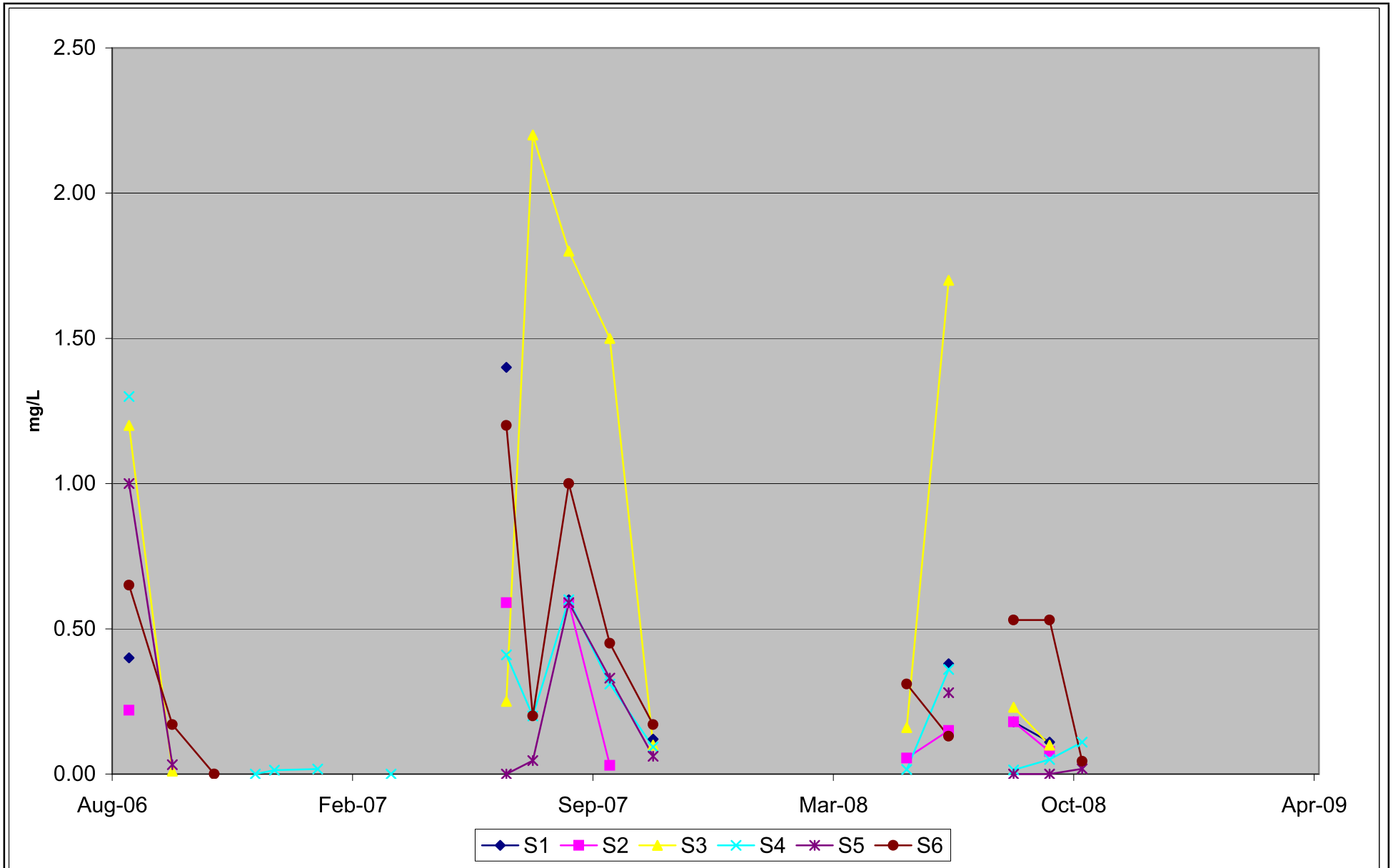


Job No. J4320

LWP Property Group Pty Ltd

Glades at Byford LWMS

Appendix B11: Total Nitrogen Concentrations for Surface Water Sites

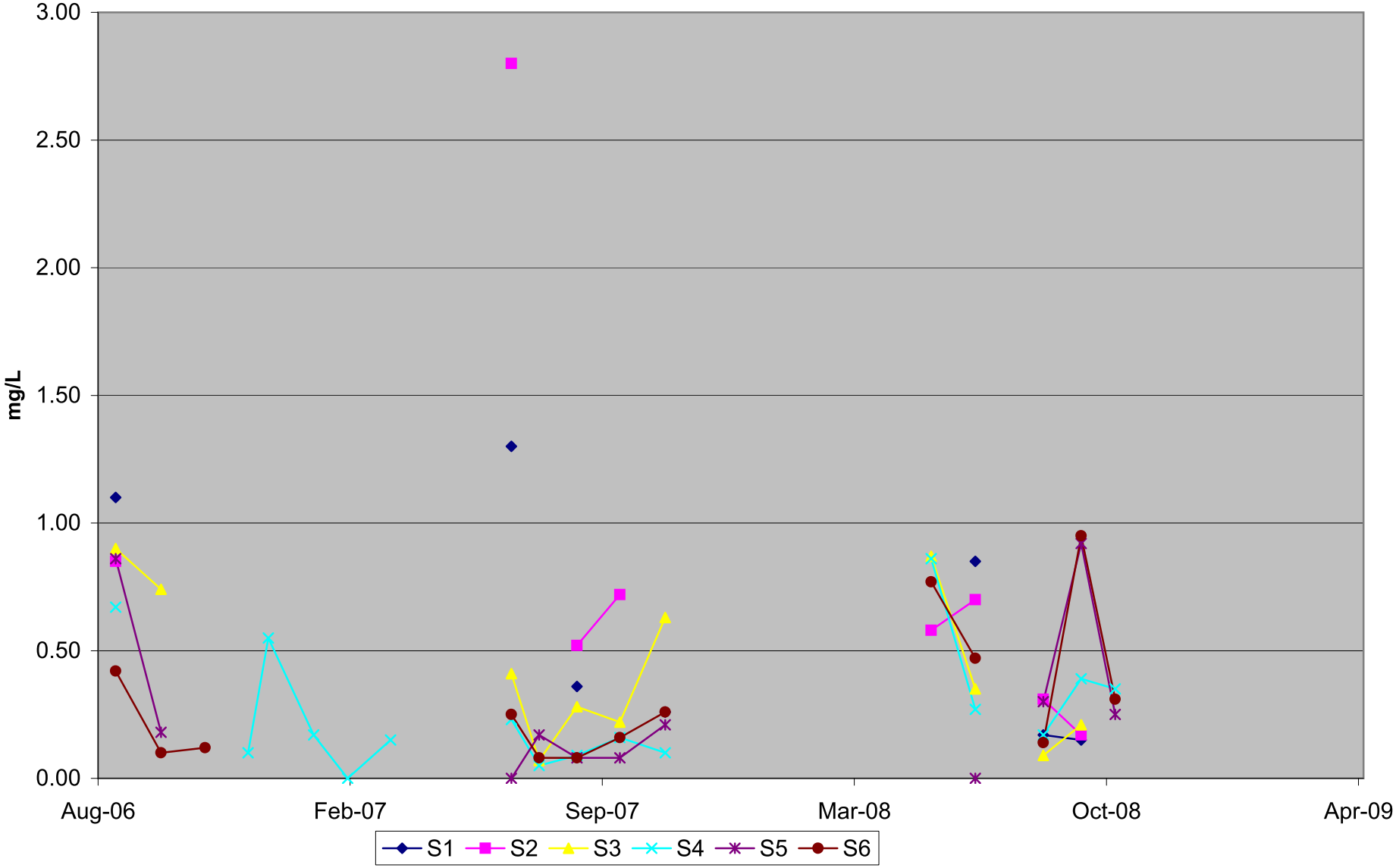


Job No. J4320

LWP Property Group Pty Ltd

Glades at Byford LWMS

Appendix B12: Nitrate/Nitrite Concentrations for Surface Water Sites

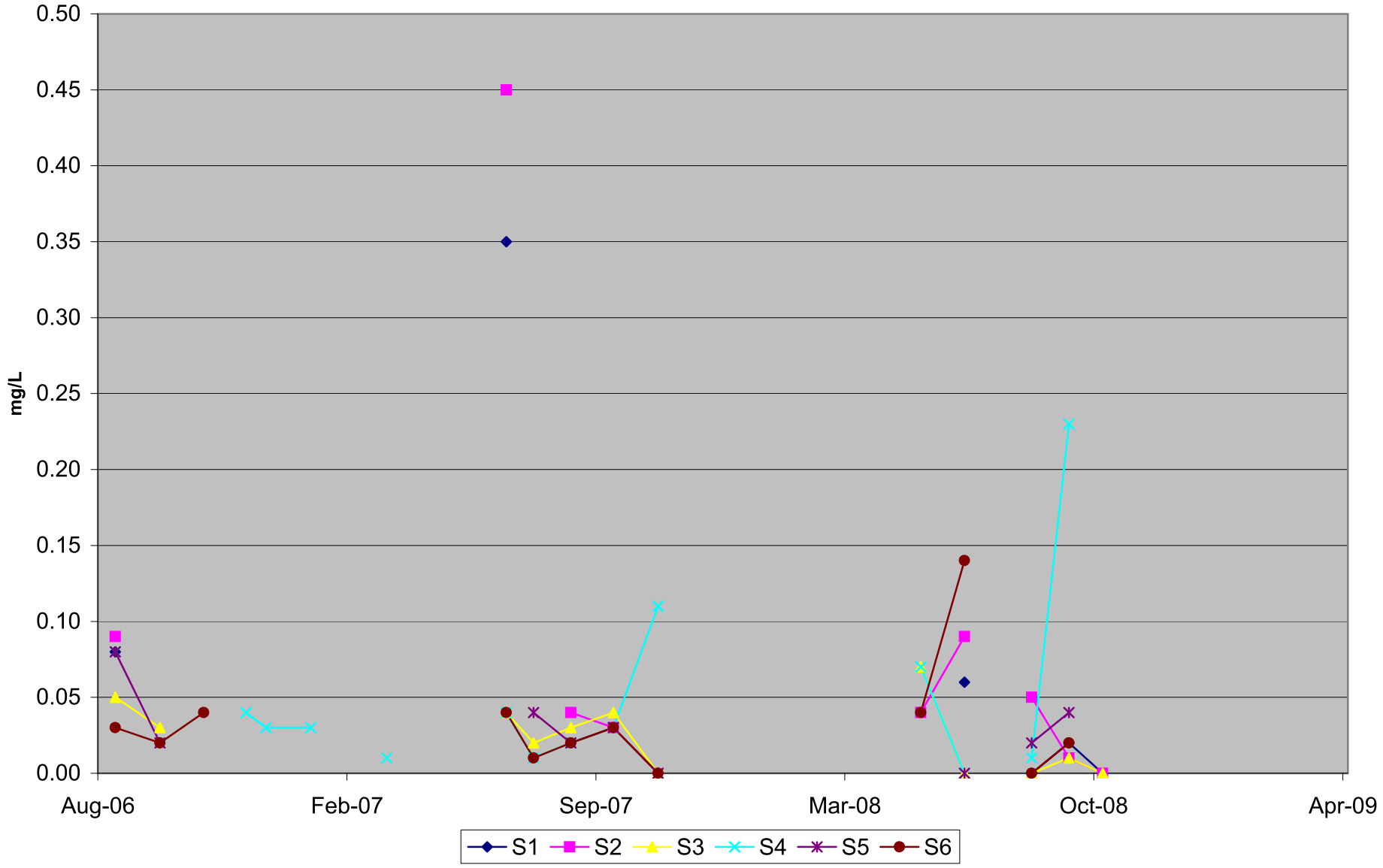


Job No. J4320

LWP Property Group Pty Ltd

Glades at Byford LWMS

Appendix B13: Total Kjeldahl Nitrogen Concentrations for Surface Water Sites

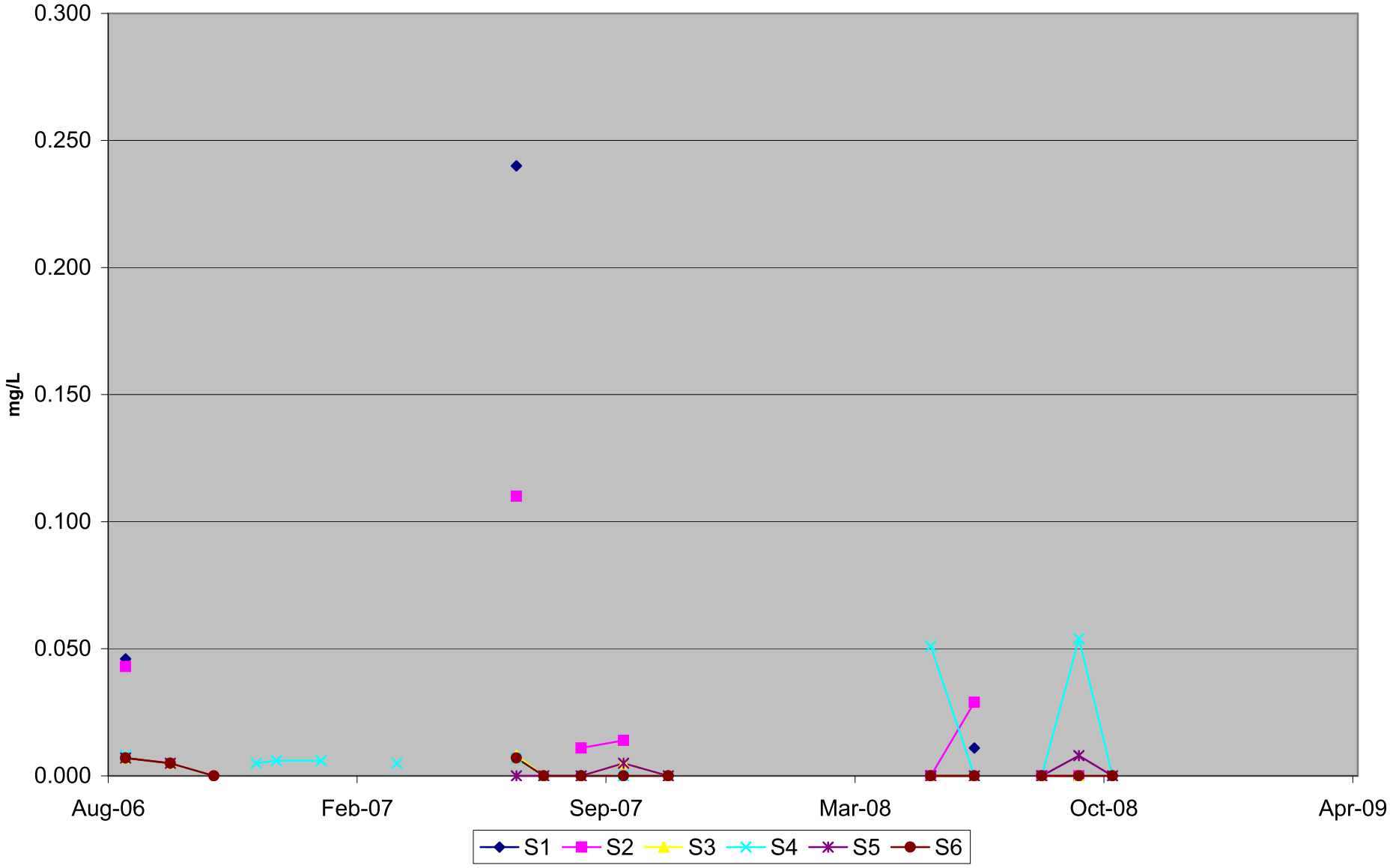


Job No. J4320

LWP Property Group Pty Ltd

Glades at Byford LWMS

Appendix B14: Total Phosphorus Concentrations for Surface Water Sites

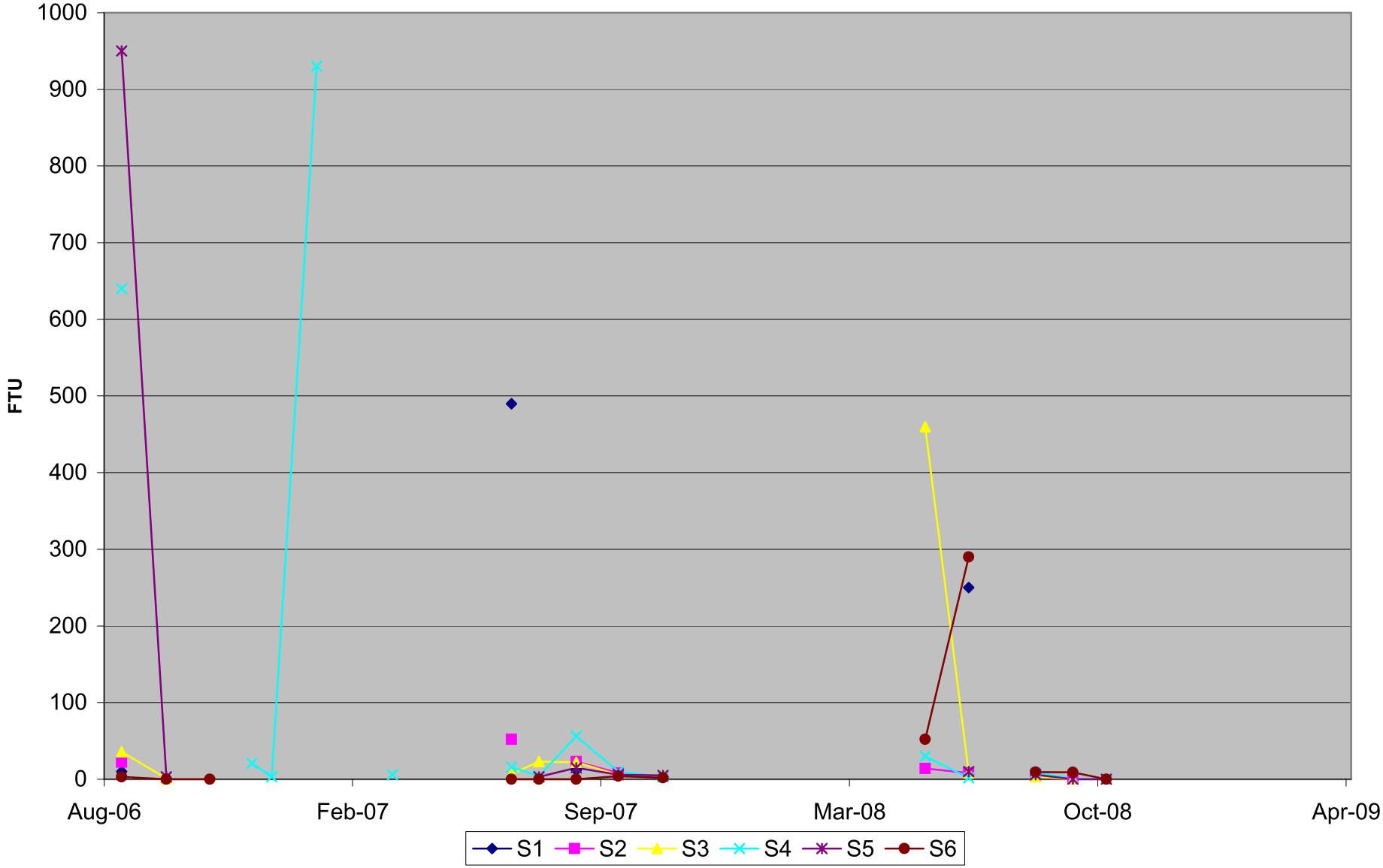


Job No. J4320

LWP Property Group Pty Ltd

Glades at Byford LWMS

Appendix B15: Filterable Reactive Phosphorus Concentrations for Surface Water Sites



Job No. J4320

LWP Property Group Pty Ltd

Glades at Byford LWMS

Appendix B16: Total Suspended Solids for Surface Water Sites

APPENDIX C

Correspondence

Jim Davies & Associates Pty Ltd
ACN 067 295 569
Suite 1, 27 York Street, Subiaco
PO Box 117, Subiaco WA 6008
Telephone (08) 9388 2436
Facsimile (08) 9381 9279
Email info@jdahydro.com.au
www.jdahydro.com.au

JDA CONSULTANT HYDROLOGISTS

Our Ref: J4320a

19 February 2009

Bill Till
Drainage and Waterways Branch
Department of Water
168 St Georges Terrace
PERTH WA 6000

Dear Bill,

BYFORD TOWNSITE LOCAL STORMWATER MANAGEMENT

Further to our meeting on Tuesday 16 February 2009 to discuss the progress of the LWMS covering the LWP Property Group land in Byford, based on the discussions of the meeting it is my understanding that in addition to the design criteria provided in the DWMP DoW will support the following design strategies;

1) Flood detention storage for the subdivision should be provided offline to the floodway corridor for all events up to the 5 yr ARI.

2) The floodway corridor for each Tributary as defined in the DWMP can be utilised for detention storage for events greater than the 5yr ARI provided it is demonstrated that this will not adversely affect the conveyance of the district flood flow.

3) Flood detention in the floodway for events greater than the 5 yr ARI is permissible provided the peak flow and HGL at Hopkinson Rd for each tributary is consistent with the values presented in the DWMP.

Can you please confirm that these strategies will be acceptable to DoW if proposed in the LWMS we are currently preparing.

If you have any queries, please do not hesitate to contact Scott Wills

Yours sincerely,

JDA Consultant Hydrologists

cc. Craig Wansbrough (Shire of Serpentine-Jarrahdale)

Scott Wills

From: TILL Bill [Bill.TILL@water.wa.gov.au]
Sent: Monday, 9 March 2009 9:58 AM
To: 'Scott Wills'
Cc: 'Phil Cuttone'; DUNN Brett; Craig Wansbrough
Subject: Byford - The Glades Development
Attachments: J4320a.pdf; ATT00004.txt

Scott

Further to our meeting and subsequent emails it is confirmed that the strategies outlined in the attached letter are acceptable for further development/refinement in the updated LWMS for this development.

Regards

Bill Till
Supervising Engineer
Drainage and Waterways Branch
Department of Water
168 St Georges Terrace Perth Western Australia 6000
PO Box K822 Perth Western Australia 6842
Phone:(08) 6364 6626
Fax: (08) 6364 6516
Mobile:0409 106 438
Email: bill.till@water.wa.gov.au

From: Scott Wills [mailto:scott@jdahydro.com.au]
Sent: Friday, 20 February 2009 3:38 PM
To: TILL Bill
Cc: Craig Wansbrough; 'Phil Cuttone'
Subject:

Hi Bill,

Further to our meeting Tuesday regarding local flood management design in Byford, please find attached a letter summarising the outcomes of our discussions for your response.

Regards,

Scott Wills | Senior Environmental Hydrologist

JDA CONSULTANT HYDROLOGISTS
Suite 1/27 York St, Subiaco WA 6008 | PO Box 117, Subiaco WA 6904 |
Direct: (08) 6380 3425 | Reception: (08) 9388 2436 | Fax: (08) 9381 9279 | www.jdahydro.com.au

All enquiries to Richard Gorbunow on 9526 1111
Our ref: A1305/10 CW:jm
Electronic Ref: OC09/3103

serpentine jarrahdale shire

1 May 2009

Scott Wills
JDA Consultant Hydrologist
PO Box 117
SUBIACO WA 6904

Dear Mr Wills

RE THE GLADES LOCAL WATER MANAGEMENT STRATEGY - ABERNETHY ROAD & DRAINAGE DESIGN

The final road cross-sectional designs for the major east-west distributor roads in the Byford District Structure Plan area (i.e. Thomas Road, Abernethy Road and Orton Road) are not yet finalised, nor are they approved by either the Shire's Leadership Team or Council, both steps which is required prior to us releasing any information providing details to developers in the District. This is not a desirable position for Shire Officers at this late stage in the new District Structure Plan Review process, but further issues have recently (this week) been identified, which means that we need to undertake a bit of additional detailed investigation before the designs can be finalised.

For the purposes of preparing the Local Water Management Strategy for the Glades estate, there are only three points that need to be considered for inclusion in your calculations and design. These are:

1. The Abernethy Road Reserve will have a final width of 40.0 metres along the full frontage of The Glades Estate;
2. The drainage requirements for the estate, with respect to outflow to Abernethy Road will be the same as those stipulated in the Byford Townsite Drainage and Water Management Plan (DWMP). That is, all stormwater in the estate must be contained, treated for nutrient stripping, and detained sufficiently *within the Estate* to ensure that all outflows to Abernethy Road (or Orton Road) do not exceed pre-development rates. As this is a Local Water Management Strategy (as opposed to an Urban Water Management Plan) further detailed design will not be required. May we recommend you be guided by the Byford Townsite DWMP checklist for preparation of a Local Water Management Strategy for the Byford urban area.
3. Any points of outflow should be designed such that they can be connected to a median swale at a time when the road upgrade design is finalised and the construction undertaken. It is unlikely that there will be any roadside table drain along the southern side of Abernethy Road into which discharge can be directed (beyond what is currently there to cater for existing flows, but this may change with the ultimate road upgrade design).

You should also note that the Shire has not engaged any consultants to prepare draft road designs for any roads through the town centre beyond the works being undertaken to prepare the Byford Townsite Structure Plan, a project which is being managed by the Shire's Strategic Community Planning Directorate. The Shire may, however, decide to engage consultants to undertake such works, but until after the finalisation and formal adoption and WAPC approval of that Structure Plan, as any design works prior to that time would be premature.

Yours sincerely

Uwe Striepe
EXECUTIVE MANAGER ENGINEERING

Scott Wills

From: Craig Wansbrough [cwansbrough@sjshire.wa.gov.au]
Sent: Tuesday, 26 May 2009 5:31 PM
To: Scott Wills
Cc: Helen.Brookes@ghd.com.au
Subject: Cardup Brook Flows

Hi Scott,

As discussed, Helen has provided the following advice with regard to Cardup Brook:

I have now completed adding the JDA provided storage volumes and revised subcatchment arrangements for Cardup Brook and can confirm that the proposed design as built into the InfoWorks model does result in maintaining the predevelopment flow rates predicted by the current InfoWorks model and in accordance with the DWMP. Whilst a direct comparison of the volumes against those published in the DWMP is impossible given the extensive redistribution of subcatchments, the overarching principle, to maintain predevelopment flow rates for the 5 and 100 year ARI events, is complied with.

From the meeting we had at GHD on 16/4/2009 a longitudinal cross section of Cardup Brook was also required. Scott, please liaise with Helen to progress this work and Cc me into correspondence.

Kind regards,

Craig Wansbrough | Project Manager - Water Sensitive Urban Design
Serpentine Jarrahdale Shire
ph: (08) 9526 1178
fax: (08) 9525 5441
Mob: 0448 795 864
cwansbrough@sjshire.wa.gov.au
6 Paterson Street, Mundijong 6123
'we're delivering the vision'

www.sjshire.wa.gov.au

APPENDIX D

LWP Sustainability Contract

Annexure G
Sustainability Checklist

Lot _____BYFORD WA 6122

NB: This form is to be completed in full and attached to building plans for prior approval by LWP Property Group Pty Ltd. Please send to LWP Property Group Pty Ltd. 34 Main Street Ellenbrook 6069

5.1 Social Sustainability

Compulsory Items– INCLUDE ALL

- ☐ The main living area and at least one bedroom and bathroom are located at ground level and can be accessed from the garage, carport or front boundary.
- ☐ Secure connections to rear laneways through the installation of lockable garage doors and gateways have been provided. (Compulsory for laneway homes only.)
- ☐ A legible and welcoming entry with clear pedestrian pathways, driveways and good external lighting is provided.

Optional Items – SELECT ONE

- ☐ The home is designed to have good surveillance over the street. For double storey homes, include a balcony with views over the street.
- ☐ Front gardens and rear outdoor areas at laneways are well lit; possibly incorporating motion activated light fittings.

5.2 Energy Efficiency

Compulsory Items – INCLUDE ALL

- ☐ Eaves to a minimum of 450mm have been included throughout. (Refer to section 3.9.1 “Eaves” for excepted areas.)
- ☐ A minimum of 50% of all light fixtures are fitted with fluorescent lighting either in the form of tubes or compact, fluorescent globes. [1]
- ☐ At least one internal living area has a major opening facing north.
- ☐ Glazing that faces east or west is shaded by awnings, louvres or similar.
- ☐ Where an air conditioner is installed it has a minimum energy rating of 4 stars and permits separate thermostat controls for living and sleeping areas.

Optional Items – SELECT FOUR

- ☐ A very light coloured roofing material is selected. (Colorbond¨ Surfmist, Shale Grey, Classic Cream, Dune, Zincalume or corresponding roof tile colours.)
- ☐ Outdoor living areas are located to the north.
- ☐ The north facade has a solar pergola or a pergola with deciduous vines growing on it.
- ☐ Roof ventilation is provided (rotary or static ventilators) to cool the home.
- ☐ Any mechanical heating or cooling system is sized to match the affected spaces and has a minimum energy efficiency rating of 5 stars.
- ☐ The home is zoned to maximise the efficiency of heating and cooling. Different living areas are capable of being closed off from one another to create easily heated or cooled zones. E.g. doors to close off living areas from hallways and bedrooms.
- ☐ Chimneys are fitted with dampers to prevent warm air escaping from the house when the fireplace is not in use.
- ☐ Cavities within double brick areas are fitted with insulation to east and west walls.
- ☐ Reverse Brick Veneer 3 construction has been used for north facing walls.[2]
- ☐ Installation of Photovoltaic panels to the roof as a supplementary source of electricity.
- ☐ If a new refrigerator is installed it should have a high energy efficiency rating (above 3.5 stars). [3]

Annexure G
Sustainability Checklist continued……

5.3 Sustainable Water Usage

Optional Items – SELECT ONE

☐ Opportunities for grey-water recycling internally and externally have been provided. (Provide details.)

☐ A rainwater tank(s) is installed and fitted to provide an alternative water source for laundry and toilet areas. (please refer to section 3.11.3 of this document for more detail relating to the tank provided to you by LWP)

☐ Dishwashers and clothes washing machines have a minimum waterwise rating of AAA.

5.4 Sustainable Landscape Design – Backyard (for information only)

Optional Items - If you would like to reduce water and nutrient requirements for your backyard landscaping and assist the passive heating and cooling of your home, you may consider the following suggestions;

☐ Subterranean and rain sensor irrigation systems to reduce water evaporation are included. (Irrigation systems installed must meet Irrigation Association of Australia standards.)

☐ Landscaping with plants to complement the passive solar requirements of the home, e.g. shading to east/west and deciduous creepers or solar pergolas to the north is included.

☐ More than 50% of all plants used in the backyard are selected from the list located within Appendix 2 of this document.

1 Installing compact fluorescent light fittings in lieu of incandescent and halogen down-lights can equate to annual savings in the hundreds of dollars every year.

2 "Reverse Brick Veneer"' refers to the construction of external walls where the internal leaf of brickwork is complemented by an external stud framed wall rather than traditional 'double brick' construction. For areas with a direct solar load this form of construction can contribute to energy efficiency. Insulated wall framing clad in a reflective material can provide more satisfactory insulating characteristics than double brick walls which tend to store heat during hot days and radiate it into the home at night. Reverse brick veneer can also have the added advantage of introducing an element of variety to the elevations through the use of an additional wall material.

3 The refrigerator is the most energy hungry appliance in the home. It operates 24 hours per day, 7 days per week and hence it is important to select a high star rating to cut costs and energy use.

Rain Water Tanks

Building Provisions

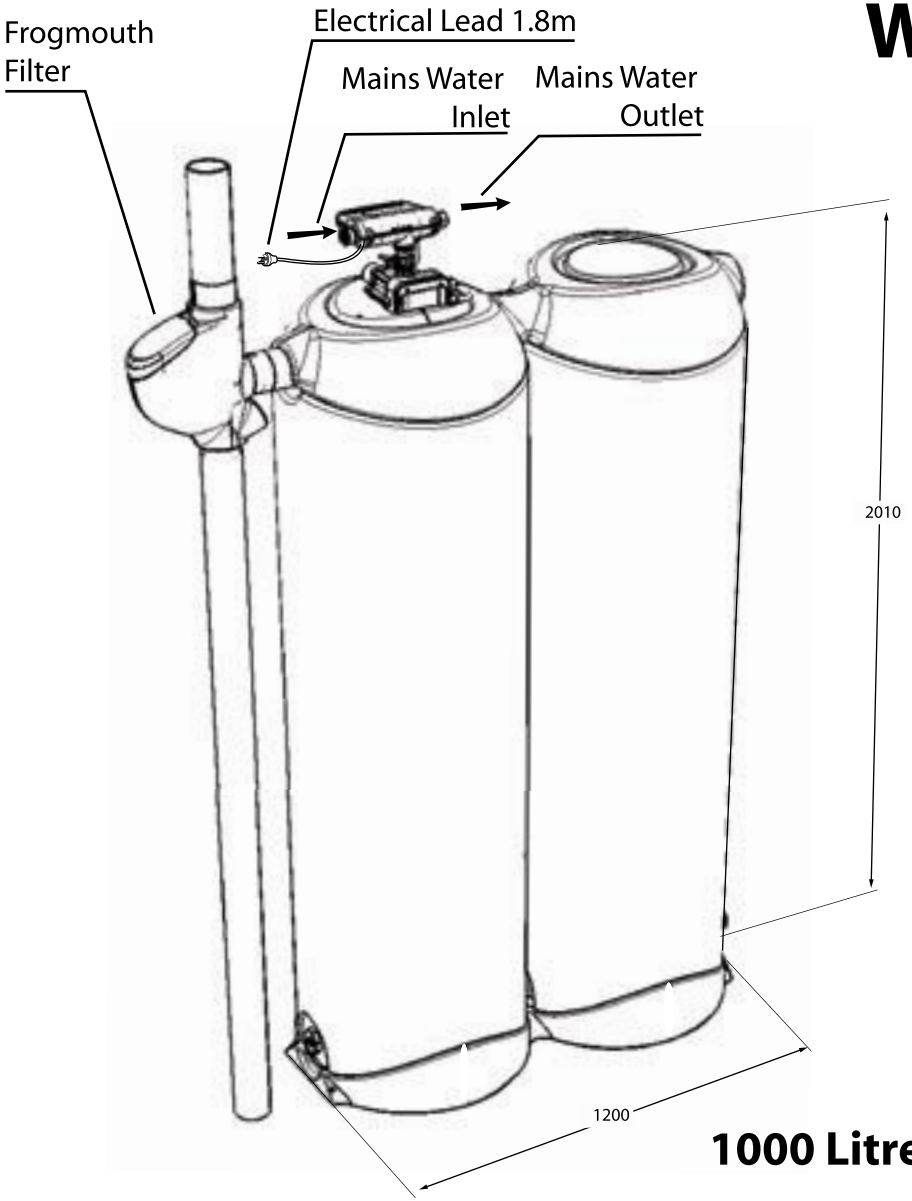
Installation of the 2,000 litre under eaves rain water tanks will be carried out by the Seller's contractor at completion of the home subject to the Buyer making provision, via the builder, to ensure the following is allowed for in the design and construction of the home:

- A minimum of wall length of 2,500mm with no openings located in close proximity to the Laundry and Toilet;
- A minimum floor to under eaves height of 2,200mm;
- Builder's plumber to separately connect from the rainwater tank to the toilet cistern and cold laundry washing machine during roughin stage of construction;
- Provide at the tank location a mains water supply (refer to attached plans for the location of the water inlet and outlet to the toilet and washing machine on the rainwater tank);
- A roof water minimum catchment area of 40sqm is required;
- Provide a 10AMP water proof GPO outside (refer to attached plans for location);
- Provide a hardstand for the rainwater tanks prior to installation of the rainwater tanks. Paved or slabs are adequate.

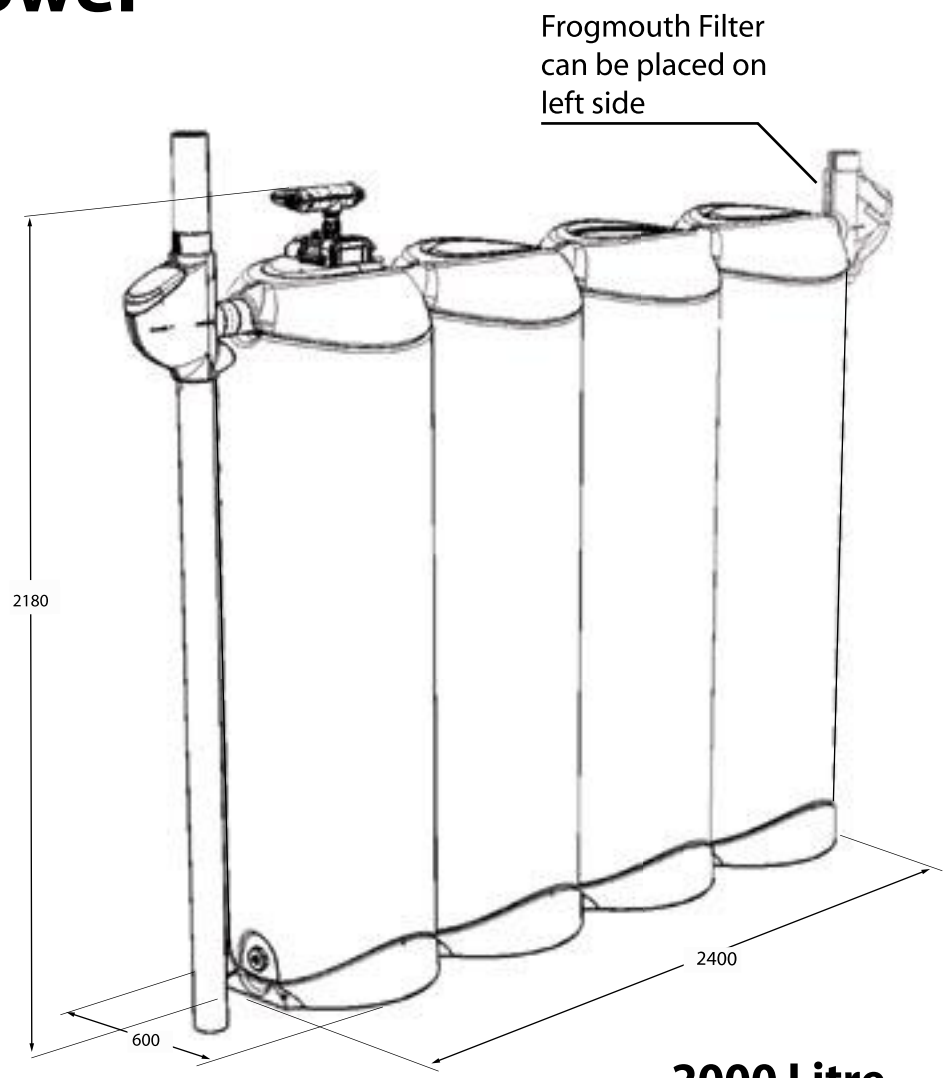
Please note that the above provisions should be read in conjunction with the rain water tank plans and details provided.

the glades
AT BYFORD

Water Tower

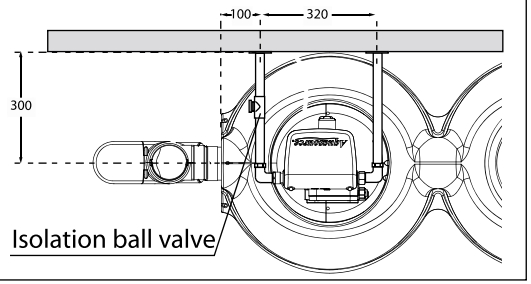


1000 Litre



2000 Litre

Note:
Layout shown with 3/4 MF elbow each side (not supplied).

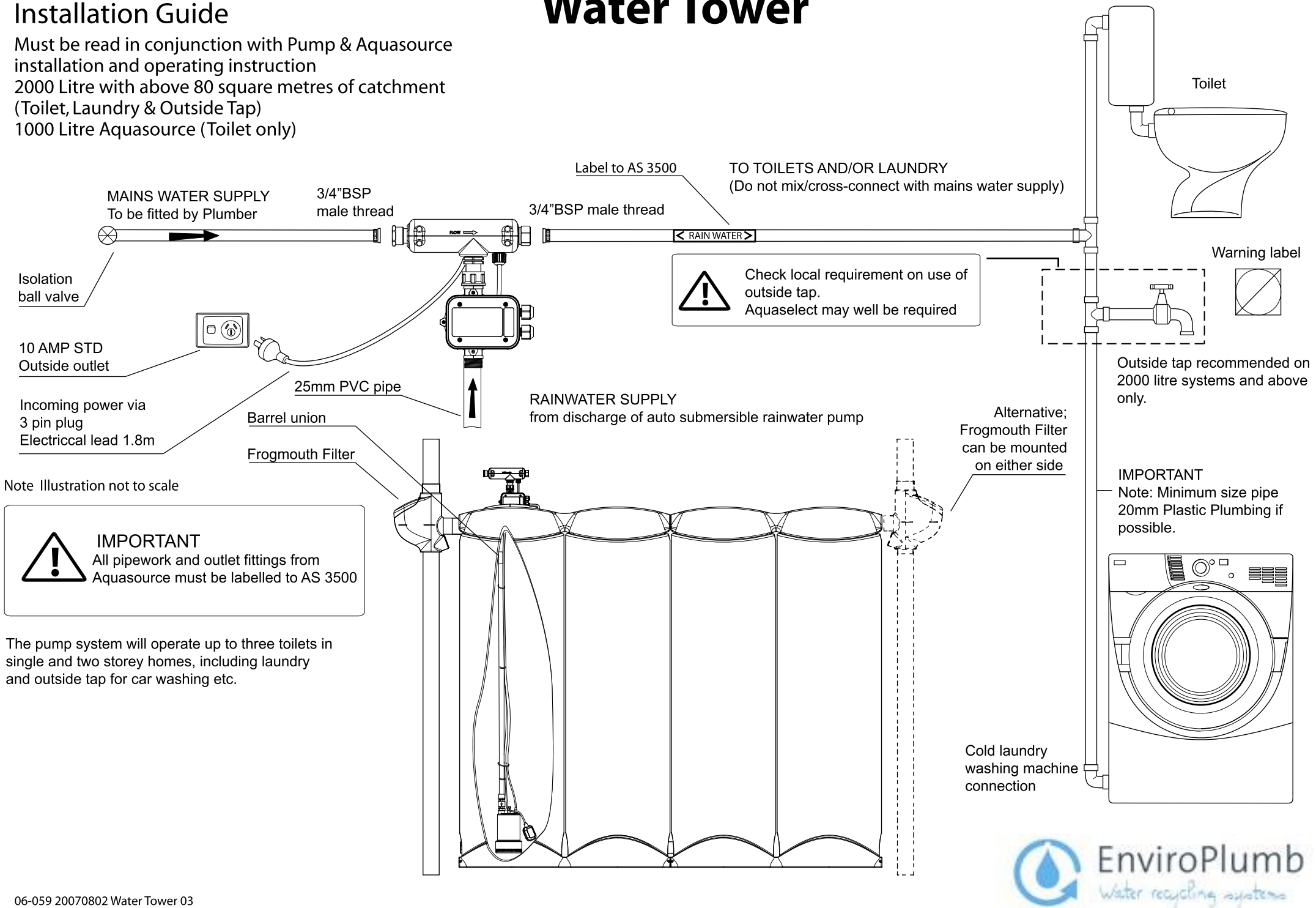


EnviroPlumb
Water recycling systems

Water Tower

Installation Guide

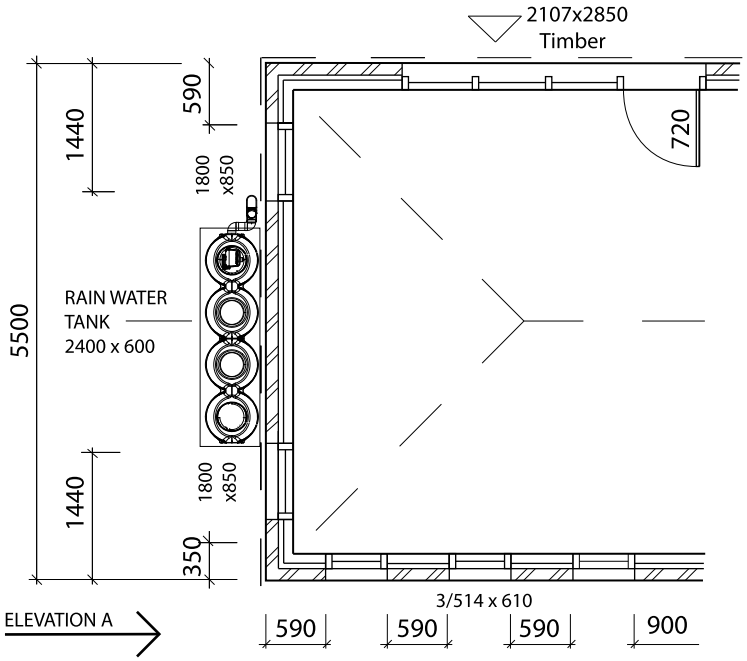
Must be read in conjunction with Pump & Aquasource installation and operating instruction
2000 Litre with above 80 square metres of catchment (Toilet, Laundry & Outside Tap)
1000 Litre Aquasource (Toilet only)



The pump system will operate up to three toilets in single and two storey homes, including laundry and outside tap for car washing etc.

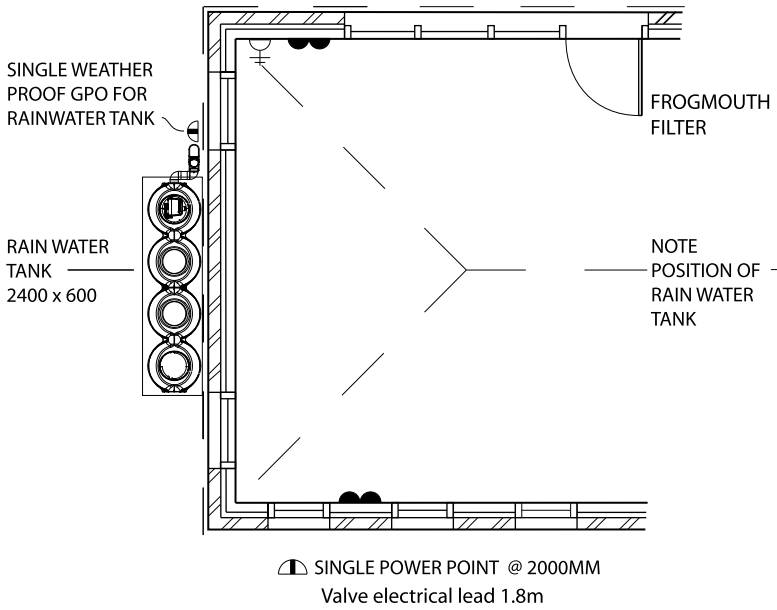
EnviroPlumb
Water recycling systems

Water Tower

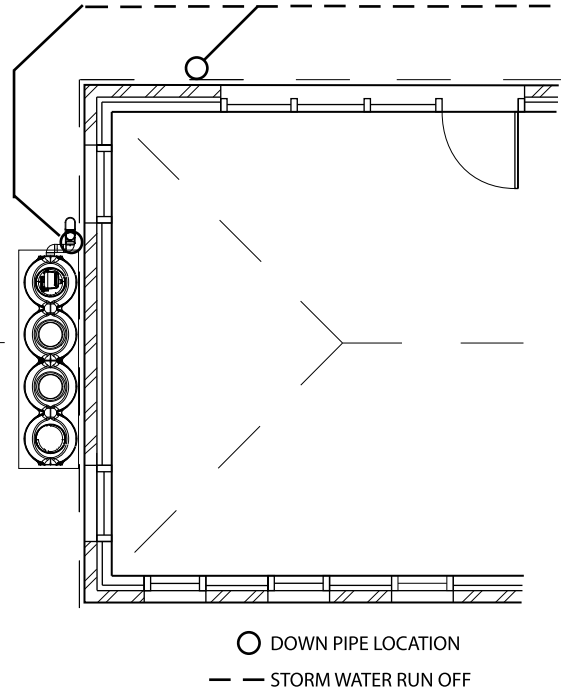


SITE PLAN

Our preferred method of providing the concrete slab is to detail it on the site plan and pour as part of the house slab.

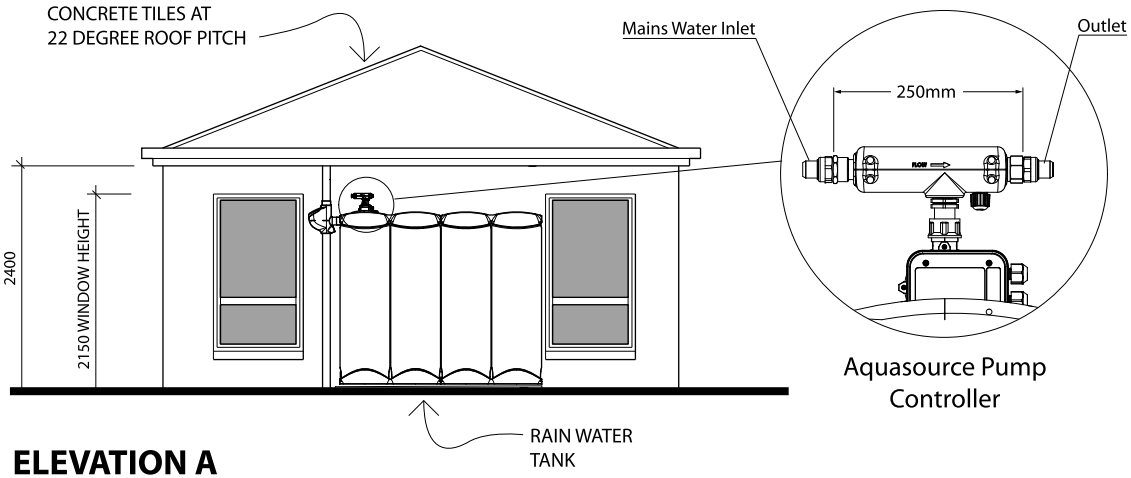


WIRING PLAN



DRAINAGE PLAN

Overflow socket is provided for connection to stormwater drainage and inlet from Frogmouth Filter.



ELEVATION A

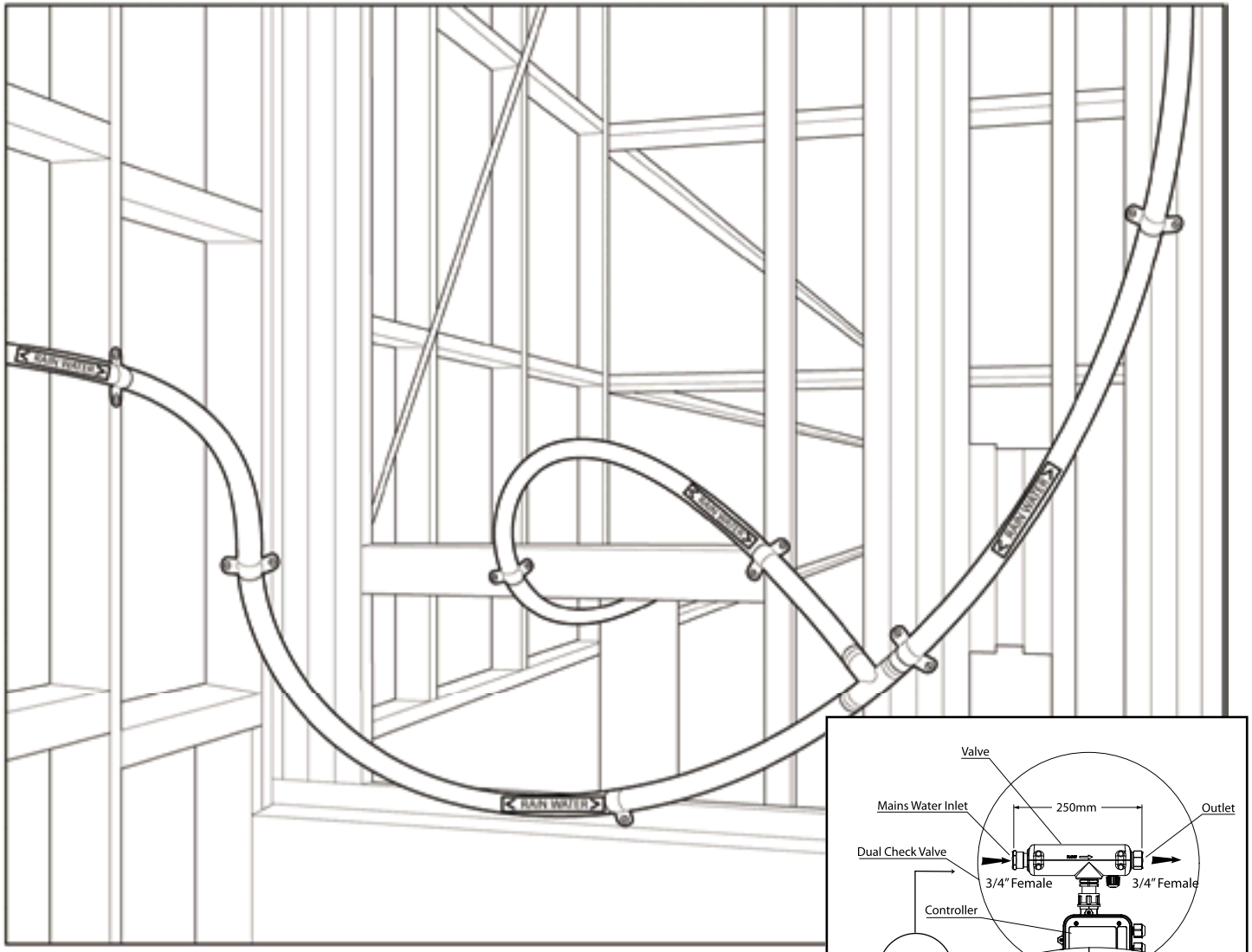
Aquasource requires your plumber to separately connect from the toilet cisterns to tank location at roughing in stage. A mains water supply is also required at the tank location.

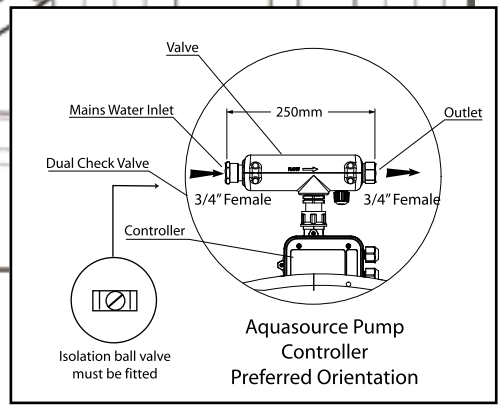
The modular system is very easy to handle at fit out, each unit weighing only 35kg and fitting through a normal doorway.

Examples of site plan, electrical wiring main building plan and drainage plan
showing rainwater tank position, wiring requirements and rainwater drainage.

EnviroPlumb
Water recycling systems

Water Tower





Aquasource Pump Controller Preferred Orientation

Aquasource requires your plumber to separately connect from the rainwater tank to the toilet cisterns during the roughin stage. Also required at the tank location is a mains water supply. Please see separate drawing for the location of mains water inlet and outlet to the toilet on the rainwater tank.

A separate instruction sheet is given for final connection at the time of fitting out.

Aquasource comes complete with a 3/4 "BSP female threaded dual check valve on the incoming mains connection. This is the side that is connected to the mains water supply.

Note: It is highly recommended that an isolation valve is installed on this pipe to facilitate easier servicing if required.

Aquasource has a 3/4" female connection to supply water to the toilet and/or laundry outlet.

EnviroPlumb recommends the use of REHAU green piping for designated rainwater lines.

PIPE CONNECTIONS
Follow AS 3500.1 guidelines for pipework and tapware markings for rainwater.

EnviroPlumb
Water recycling systems

APPENDIX E

Nutrient Input (NiDSS) Results

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005

JDA Consultant Hydrologists

Report Date : 20-May-09

The Glades, Byford	
Total Nutrient Input - No WSUD (kg/yr)	6,455
Reduction due to WSUD (kg/yr)	0
Percentage Overall Reduction	0.0%
Pecentage Development Reduction	0.0%
Cost of Selected Program ($/kg/yr)	$0

(•) Total Phosphorus
( ) Total Nitrogen

Catchment Name	The Glades, Byford
Option Description	Pre-Development Scenario
Catchment Area	328 ha

Land Use Breakdown

Residential : ~R15	0.0%	lower density residential areas (excludes road reserve area)
Residential : ~R35	0.0%	higher density residential areas (excludes road reserve area)
Road Reserves : Minor	1.0%	maintainance of verge by landowners
Road Reserves : Major	0.0%	maintainance of verge by local authority
POS : Active	0.0%	grassed areas
POS : Passive / Basins	0.0%	native vegetation
Rural : Pasture	97.0%	general pasture
Rural : Residential ~R2.5/R5	2.0%	low density
Rural : Poultry	0.0%	specific high nutient input land use
Commercial/Industrial	0.0%	town centre etc

Total Residential	0.0%
Total Area	100.0%

Nutrient Input Without WSUD

Residential	Garden	0.00	kg/net ha/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Lawn	0.00		0.00		0		0.0%
	Pet Waste	0.00		0.00		0		0.0%
	Car Wash	0.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
POS	Garden/Lawn	2.60	kg/ha POS/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Pet Waste	0.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
Road	Major Roads	1.04	kg/ha RR/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
Reserve	Minor Roads	20.00		0.20		66		1.0%
	Sub Total			0.20		66		1.0%
Rural	Pasture	20.00	kg/ha Rural/yr	19.40	kg/gross ha/yr	6,363	kg/yr	98.6%
	Poultry Farms	75.00		0.00		0		0.0%
	Residential (R2.5/R5)	4.00		0.08		26		0.4%
	Sub Total			19.48		6,389		99.0%
			Total	**19.68**	kg/gross ha/yr	**6,455**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☐ Native Gardens (Lots - Garden) ☐ Native Gardens (Lots - Lawn) ☐ Native Gardens (POS) ☐ Street Sweeping
☐ Community Education : Fertiliser ☐ Community Education : Pet Waste ☐ Community Education : Car Wash

Education Effectiveness 0%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (POS)	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Fertiliser	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Pet Waste	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Car Wash	0%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	0%	0.00	0	0.0%	$0	$0	$0.0
Totals		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☐ Gross Pollutant Trap ☐ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	0%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	0%	0.00	0	0.0%	$0	$0	$0.0
Total		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%
Nutrient Input : Residential Area without WSUD	0.20	66	1.0%
Nutrient Input : Rural Area	19.48	6,389	99.0%

				Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Removal via Source Control	0.00	0	0.0%	$0	$0	$0.0
Removal via In-Transit Control	0.00	0	0.0%	$0	$0	$0.0
Total Removal	0.00	0	0.0%	$0	$0	$0.0
Net Nutrient Input	**19.68**	**6,455**	**100.0%**			

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005

JDA Consultant Hydrologists
Report Date : 20-May-09

The Glades, Byford	
Total Nutrient Input - No WSUD (kg/yr)	19,622
Reduction due to WSUD (kg/yr)	0
Percentage Overall Reduction	0.0%
Pecentage Development Reduction	0.0%
Cost of Selected Program ($/kg/yr)	$0

○ Total Phosphorus
◉ Total Nitrogen

Catchment Name	The Glades, Byford	
Option Description	Pre-Development Scenario	
Catchment Area	328	ha

Land Use Breakdown

Residential : ~R15	0.0%	lower density residential areas (excludes road reserve area)
Residential : ~R35	0.0%	higher density residential areas (excludes road reserve area)
Road Reserves : Minor	1.0%	maintainance of verge by landowners
Road Reserves : Major	0.0%	maintainance of verge by local authority
POS : Active	0.0%	grassed areas
POS : Passive / Basins	0.0%	native vegetation
Rural : Pasture	97.0%	general pasture
Rural : Residential ~R2.5/R5	2.0%	low density
Rural : Poultry	0.0%	specific high nutient input land use
Commercial/Industrial	0.0%	town centre etc

Total Residential	0.0%
Total Area	100.0%

Nutrient Input Without WSUD

Residential	Garden	0.00	kg/net ha/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Lawn	0.00		0.00		0		0.0%
	Pet Waste	0.00		0.00		0		0.0%
	Car Wash	0.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
POS	Garden/Lawn	73.40	kg/ha POS/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Pet Waste	0.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
Road	Major Roads	29.36	kg/ha RR/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
Reserve	Minor Roads	132.00		1.32		433		2.2%
	Sub Total			1.32		433		2.2%
Rural	Pasture	60.00	kg/ha Rural/yr	58.20	kg/gross ha/yr	19,090	kg/yr	97.3%
	Poultry Farms	175.00		0.00		0		0.0%
	Residential (R2.5/R5)	15.20		0.30		100		0.5%
	Sub Total			58.50		19,189		97.8%
			Total	**59.82**	kg/gross ha/yr	**19,622**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☐ Native Gardens (Lots - Garden) ☐ Native Gardens (Lots - Lawn) ☐ Native Gardens (POS) ☐ Street Sweeping
☐ Community Education : Fertiliser ☐ Community Education : Pet Waste ☐ Community Education : Car Wash

Education Effectiveness 0%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (POS)	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Fertiliser	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Pet Waste	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Car Wash	0%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	0%	0.00	0	0.0%	$0	$0	$0.0
Totals		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☐ Gross Pollutant Trap ☐ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	0%	0.00	0	0.0%	$0	$0	$0.0
Water Pollution Control Ponds	0%	0.00	0	0.0%	$0	$0	$0.0
Total		**0.00**	**0**	**0.0%**	**$0**	**$0**	**$0.0**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%
Nutrient Input : Residential Area without WSUD	1.32	433	2.2%
Nutrient Input : Rural Area	58.50	19,189	97.8%

				Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Removal via Source Control	0.00	0	0.0%	$0	$0	$0.0
Removal via In-Transit Control	0.00	0	0.0%	$0	$0	$0.0
Total Removal	0.00	0	0.0%	$0	$0	$0.0
Net Nutrient Input	**59.82**	**19,622**	**100.0%**			

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005

JDA Consultant Hydrologists
Report Date : 20-May-09

The Glades, Byford	
Total Nutrient Input - No WSUD (kg/yr)	7,087
Reduction due to WSUD (kg/yr)	3,763
Percentage Overall Reduction	53.1%
Pecentage Development Reduction	53.1%
Cost of Selected Program ($/kg/yr)	$13

(•) Total Phosphorus
( ) Total Nitrogen

Catchment Name	The Glades, Byford	
Option Description	Post-Development Scenario	
Catchment Area	328	ha

Land Use Breakdown

Residential : ~R15	32.0%	lower density residential areas (excludes road reserve area)		
Residential : ~R35	19.0%	higher density residential areas (excludes road reserve area)		
Road Reserves : Minor	15.0%	maintainance of verge by landowners		
Road Reserves : Major	7.0%	maintainance of verge by local authority		
POS : Active	12.0%	grassed areas		
POS : Passive / Basins	5.0%	native vegetation		
Rural : Pasture	0.0%	general pasture		
Rural : Residential ~R2.5/R5	0.0%	low density	Total Residential	51.0%
Rural : Poultry	0.0%	specific high nutient input land use	Total Area	100.0%
Commercial/Industrial	10.0%	town centre etc		

Nutrient Input Without WSUD

Residential	Garden	21.65	kg/net ha/yr	11.04	kg/gross ha/yr	3,622	kg/yr	51.1%
	Lawn	10.09		5.15		1,688		23.8%
	Pet Waste	2.81		1.43		469		6.6%
	Car Wash	0.13		0.07		22		0.3%
	Sub Total			17.69		5,801		81.9%
POS	Garden/Lawn	2.60	kg/ha POS/yr	0.31	kg/gross ha/yr	102	kg/yr	1.4%
	Pet Waste	4.47		0.54		176		2.5%
	Sub Total			0.85		278		3.9%
Road	Major Roads	1.04	kg/ha RR/yr	0.07	kg/gross ha/yr	24	kg/yr	0.3%
Reserve	Minor Roads	20.00		3.00		984		13.9%
	Sub Total			3.07		1,008		14.2%
Rural	Pasture	20.00	kg/ha Rural/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Poultry Farms	75.00		0.00		0		0.0%
	Residential (R2.5/R5)	4.00		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
		Total		**21.61**	kg/gross ha/yr	**7,087**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

- [x] Native Gardens (Lots - Garden)
- [ ] Native Gardens (Lots - Lawn)
- [x] Native Gardens (POS)
- [x] Street Sweeping
- [ ] Community Education : Fertiliser
- [ ] Community Education : Pet Waste
- [ ] Community Education : Car Wash

Education Effectiveness: 0%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	100%	11.04	3,622	51.1%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (POS)	100%	0.31	102	1.4%	$0	$0	$0.0
Community Education : Fertiliser	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Pet Waste	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Car Wash	0%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	50%	0.08	27	0.4%	$0	$14,883	$546.5
Totals		**11.44**	**3,752**	**52.9%**	**$0**	**$14,883**	**$4.0**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

- [x] Gross Pollutant Trap
- [x] Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	19%	0.02	6	0.1%	$105,445	$4,038	$1,766.9
Water Pollution Control Ponds	19%	0.02	6	0.1%	$310,012	$4,306	$3,911.8
Total		**0.04**	**12**	**0.2%**	**$415,458**	**$8,344**	**$2,838.4**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%
Nutrient Input : Residential Area without WSUD	21.61	7,087	100.0%
Nutrient Input : Rural Area	0.00	0	0.0%

				Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Removal via Source Control	11.44	3,752	52.9%	$0	$14,883	$4.0
Removal via In-Transit Control	0.04	12	0.2%	$415,458	$8,344	$2,838.4
Total Removal	11.47	3,763	53.1%	$415,458	$23,227	$12.8
Net Nutrient Input	**10.13**	**3,324**	**46.9%**			

NiDSS

Nutrient Input Decision Support System
Version 2.0 March 2005

JDA Consultant Hydrologists
Report Date : 20-May-09

The Glades, Byford	
Total Nutrient Input - No WSUD (kg/yr)	**31,679**
Reduction due to WSUD (kg/yr)	**10,957**
Percentage Overall Reduction	**34.6%**
Pecentage Development Reduction	**34.6%**
Cost of Selected Program ($/kg/yr)	**$5**

○ Total Phosphorus
◉ Total Nitrogen

Catchment Name	The Glades, Byford	
Option Description	Post-Development Scenario	
Catchment Area	328	ha

Land Use Breakdown

Residential : ~R15	32.0%	lower density residential areas (excludes road reserve area)		
Residential : ~R35	19.0%	higher density residential areas (excludes road reserve area)		
Road Reserves : Minor	15.0%	maintainance of verge by landowners		
Road Reserves : Major	7.0%	maintainance of verge by local authority		
POS : Active	12.0%	grassed areas		
POS : Passive / Basins	5.0%	native vegetation		
Rural : Pasture	0.0%	general pasture		
Rural : Residential ~R2.5/R5	0.0%	low density	Total Residential	**51.0%**
Rural : Poultry	0.0%	specific high nutient input land use	Total Area	**100.0%**
Commercial/Industrial	10.0%	town centre etc		

Nutrient Input Without WSUD

Residential	Garden	47.32	kg/net ha/yr	24.13	kg/gross ha/yr	7,915	kg/yr	25.0%
	Lawn	66.58		33.96		11,138		35.2%
	Pet Waste	11.14		5.68		1,864		5.9%
	Car Wash	0.04		0.02		6		0.0%
	Sub Total			63.79		20,923		66.0%
POS	Garden/Lawn	73.40	kg/ha POS/yr	8.81	kg/gross ha/yr	2,889	kg/yr	9.1%
	Pet Waste	17.76		2.13		699		2.2%
	Sub Total			10.94		3,588		11.3%
Road	Major Roads	29.36	kg/ha RR/yr	2.06	kg/gross ha/yr	674	kg/yr	2.1%
Reserve	Minor Roads	132.00		19.80		6,494		20.5%
	Sub Total			21.86		7,169		22.6%
Rural	Pasture	60.00	kg/ha Rural/yr	0.00	kg/gross ha/yr	0	kg/yr	0.0%
	Poultry Farms	175.00		0.00		0		0.0%
	Residential (R2.5/R5)	15.20		0.00		0		0.0%
	Sub Total			0.00		0		0.0%
		Total		**96.58**	kg/gross ha/yr	**31,679**	kg/yr	**100.0%**

Residential Areas (R15-R35) : Nutrient Removal via Source Control

☑ Native Gardens (Lots - Garden) ☐ Native Gardens (Lots - Lawn) ☑ Native Gardens (POS) ☑ Street Sweeping
☐ Community Education : Fertiliser ☐ Community Education : Pet Waste ☐ Community Education : Car Wash

Education Effectiveness 0%

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Native Gardens (Lots - Garden)	100%	24.13	7,915	25.0%	$0	$0	$0.0
Native Gardens (Lots - Lawn)	0%	0.00	0	0.0%	$0	$0	$0.0
Native Gardens (POS)	100%	8.81	2,889	9.1%	$0	$0	$0.0
Community Education : Fertiliser	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Pet Waste	0%	0.00	0	0.0%	$0	$0	$0.0
Community Education : Car Wash	0%	0.00	0	0.0%	$0	$0	$0.0
Street Sweeping	50%	0.25	81	0.3%	$0	$14,883	$183.6
Totals		**33.19**	**10,885**	**34.4%**	**$0**	**$14,883**	**$1.4**

Residential Areas (R15-R35) : Nutrient Removal via In-Transit Control

☑ Gross Pollutant Trap ☑ Water Pollution Control Pond

	% Area of Influence	Removal kg/gross ha/yr	Removal kg/yr	Removal %	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Gross Pollutant Traps	19%	0.11	36	0.1%	$105,445	$4,038	$286.1
Water Pollution Control Ponds	19%	0.11	36	0.1%	$432,374	$6,005	$883.5
Total		**0.22**	**72**	**0.2%**	**$537,820**	**$10,044**	**$584.6**

Net Nutrient Input

	kg/gross ha/yr	kg/yr	%	Capital Cost $	Operating Cost $/yr	Cost $/kg/yr
Nutrient Input : Residential Area without WSUD	96.58	31,679	100.0%			
Nutrient Input : Rural Area	0.00	0	0.0%			
Removal via Source Control	33.19	10,885	34.4%	$0	$14,883	$1.4
Removal via In-Transit Control	0.22	72	0.2%	$537,820	$10,044	$584.6
Total Removal	33.41	10,957	34.6%	$537,820	$24,927	$5.2
Net Nutrient Input	**63.18**	**20,722**	**65.4%**			