



PROPOSED STRUCTURE PLAN

**LOT 2 (NO. 163), LOT 23 (NO. 155) AND LOT 24 (NO. 135) HOLMES STREET
AND
LOT 1 (NO. 1), LOT 1600 (NO. 1600) AND LOT 1601 (NO. 1601) BALFOUR STREET
SOUTHERN RIVER**

TABLE OF AMENDMENTS

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

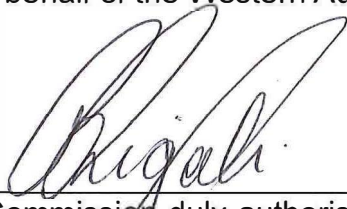
TABLE OF DENSITY PLANS

Density Plan No.	Area of Density Plan Application	Date Endorsed by WAPC

This structure plan is prepared under the provisions of the City of Gosnells Town Planning Scheme No.6

IT IS CERTIFIED THAT THIS STRUCTURE PLAN WAS APPROVED BY RESOLUTION OF THE WESTERN AUSTRALIAN PLANNING COMMISSION ON: 27 October 2016

Signed for and on behalf of the Western Australian Planning Commission



an officer of the Commission duly authorised by the Commission pursuant to Section 16 of the *Planning and Development Act 2005* for that purpose, in the presence of:



Witness

27 October 2016

Date

Date of Expiry: 27 October 2029

EXECUTIVE SUMMARY

This submission, prepared on behalf of Guce Holdings Pty Ltd, the proponent of Lot 2 (No. 163), Lot 23 (No. 155) and Lot 24 (No. 135) Holmes Street and Lot 1 (No. 1), Lot 1600 (No. 1600) and Lot 1601 (No. 1601) Balfour Street, Southern River (herein referred to as the 'subject site') seeks support from the planning authorities to approve the proposed Structure Plan (SP).

The SP provides a framework for the future development of the subject land and a context for the consideration and approval of future subdivision applications.

The SP has been prepared for 22.97 hectares of land located within the Southern River Precinct 2 for adoption under the provision of the City of Gosnells, Town Planning Scheme No. 6.

Item	Data		Structure Plan Reference (Section Number)
Total area covered by Structure Plan	22.97ha		Part 1 Section 1.0
Area of each land use proposed:	Hectares	Lot Yield	Part 2 Section 3.1
- Residential (including roads)	12.768ha	223 lots	
- Public Open Space	1.419ha	4 lots	
- Parks and Recreation	5.53ha	1 lot	
Estimated Lot Yield	230 lots		Part 2 Section 3.1
Estimated Number of Dwellings	223 dwellings		Part 2 Section 3.1
Estimated Residential Site Density	R25 & R40		Part 2 Section 3.1
Estimated Population*	624		Part 2 Section 3.1
Number of High Schools	0		N/A
Number of Primary Schools	0		N/A
Estimated Commercial Floor Space	0		N/A
Estimated Area and Percentage of Public Open Space given over to:	Hectares	Percentage/Number of Parks	Part 2 Section 3.2
- Regional Open Space	5.53ha	24.07%	
- District Open Space	0	0%	
- Neighbourhood Parks	0	0 parks	
- Local Parks	1.419ha	4 parks	
Estimated Percentage of Natural Area:	Hectares	Percentage	Part 2 Section 2.2
	3.253ha	14.16%	

* Based on Australian Bureau of Statistics, Census of Population and Housing 2011 which states average household size in the City of Gosnells to be 2.76 per dwelling.

TABLE OF CONTENTS

PART ONE – IMPLEMENTATION	1
1.0 Structure Plan Area	1
2.0 Structure Plan Content	1
3.0 Interpretation and Planning Scheme Regulations Relationship	1
4.0 Operation	1
5.0 Subdivision and Development Requirements	2
5.1 Land Use Permissibility	2
5.2 Residential	2
5.2.1 Dwelling Target	2
5.3 Public Open Space	2
5.4 Bushfire Hazard	2
5.5 Transport Noise	3
PART TWO – EXPLANATORY SECTION AND TECHNICAL APPENDICES	4
1.0 Planning Background	4
1.1 Introduction and Purpose	4
1.2 Land Description	4
1.2.1 Location	4
1.2.2 Area and Land Use	4
1.2.3 Legal Description and Land Ownership	5
1.3 Planning Framework	8
1.3.1 Zoning and Reservations	8
1.3.2 Regional and Sub-Regional Structure Plan	8
1.3.3 Planning Strategies	9
1.3.3.1 State Planning Strategy 2050	9
1.3.3.2 Directions 2031 and Beyond – A Spatial Framework for Perth and Peel	10
1.3.3.3 Liveable Neighbourhoods	10
1.3.3.4 State Planning Policy No. 5.4 - Road and Rail Transport Noise and Freight Considerations in Land Use Planning	11
1.3.3.5 City of Gosnells – Local Housing Strategy	11
2.0 Site Conditions and Constraints	11
2.1 Surface and Ground Water	11
2.1.1 Surface Water	11
2.1.2 Ground Water	12
2.2 Wetlands	15
2.3 Landform and Soil	16
2.4 Biodiversity	18
2.5 Bushfire Hazard	17
2.6 Heritage	20
3.0 Land Use and Subdivision Requirements	19
3.1 Design and Land Use	19
3.2 Open Space	20
3.3 Residential	25
3.4 Movement Network	25
3.4.1 Vehicle Access	25
3.4.2 Parking Provision	25
3.4.3 Traffic Volumes	26
3.4.4 Public Transport	26
3.4.5 Pedestrian and Cycle Access	26
3.4.6 Service Vehicles	26
3.5 Water Management	27

PLANS

PLAN 1:	LOCATION PLAN
PLAN 2:	AERIAL PHOTOGRAPH
PLAN 3:	STRUCTURE PLAN
PLAN 4:	CONSTRAINTS PLAN
PLAN 5:	CONCEPT SUBDIVISION PLAN
PLAN 6:	PUBLIC OPEN SPACE PLAN
PLAN 7:	LANDSCAPE MASTERPLAN
PLAN 8:	DRAINAGE MANAGEMENT PLAN

APPENDICES

APPENDIX 1:	CERTIFICATES OF TITLE
APPENDIX 2:	LOCAL WATER MANAGEMENT STRATEGY
APPENDIX 3:	WETLAND MANAGEMENT PLAN
APPENDIX 4:	GEOTECHNICAL INVESTIGATION
APPENDIX 5:	FLORA AND VEGETATION STUDY
APPENDIX 6:	BUSHFIRE MANAGEMENT PLAN
APPENDIX 7:	SHAWMAC MOVEMENT NETWORK ASSESSMENT

PART ONE – IMPLEMENTATION

1.0 Structure Plan Area

This Structure Plan (SP) shall apply to Lot 2 (No. 163), Lot 23 (No. 155) and Lot 24 (No. 135) Holmes Street and Lot 1 (No. 1), Lot 1600 (No. 1600) and Lot 1601 (No. 1601) Balfour Street, Southern River, being the land contained within the inner edge of the line denoting the SP boundary of the SP map (Plan 3).

2.0 Structure Plan Content

This SP comprises:

- a) Part One – Implementation
This section contains the SP map and statutory planning provisions and requirements.
- b) Part Two – Explanatory Section and Technical Appendices
This section is to be used as a reference guide to interpret and justify the implementation of Part One.
- c) Appendices – Technical reports, supporting plans and maps.

3.0 Interpretation and Scheme Relationship

Unless otherwise specified in this part, the words and expressions used in this SP shall have the respective meanings given to them in the Planning and Development (Local Planning Schemes) Regulations 2015.

The SP map (Plan 3) outlines land use, zones and reserves applicable within the SP map area. The zones and reserves designated under this SP apply to the land within it as if the zones and reserves were incorporated into the Scheme.

Pursuant to Section 2, Clause 15 of the Planning and Development (Local Planning Schemes) Regulations 2015:

A SP in respect of an area of land in the Scheme area may be prepared if:

- (a) The area is
 - a. All or part of a zone identified in this Scheme as an area suitable for urban or industrial development; and
 - b. Identified in this Scheme as an area requiring a structure plan to be prepared before any future subdivision or development is undertaken.

4.0 Operation

In accordance with Schedule 2, Clause 22 of the Planning and Development (Local Planning Schemes) Regulations 2015, this SP shall come into operation when it is certified by the Western Australian Planning Commission (WAPC).

5.0 Subdivision and Development Requirements

5.1 Land Use Permissibility

The SP map (Plan 3) outlines land use, zones and reserves applicable within the SP area. The zones and reserves designated under this SP apply to the land within it as if the zones and reserves were incorporated into the Scheme.

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

5.2 Residential

5.2.1 Dwelling Target

Objective: To provide for a minimum of 223 dwellings within the SP area.

5.3 Public Open Space

The provision of a minimum of 10 percent public open space being provided in accordance with the WAPC's Liveable Neighbourhoods Policy.

Public Open Space is to be provided generally in accordance with Plan 3 and Table 2, with an updated public open space schedule to be provided at the time of subdivision for determination by the WAPC, upon the advice of the City of Gosnells.

POS Site	Size (HA)
POS 1	0.891ha
POS 2	0.14ha
POS 3	0.2123ha
POS 4	0.1757ha

5.4 Bushfire Hazard

The Constraints Plan (Plan 4) indicates the bushfire hazard assessment levels applicable within the SP area. The bushfire risk to the proposed development is not considered unreasonable and should not prohibit development of the site subject to the measures detailed in this Bushfire Management Plan being complied with (Appendix 6).

5.5 Transport Noise

In accordance with State Planning Policy 5.4 'Road and Rail Transport Noise and Freight Considerations in Land Use Planning' if a Transport Noise Assessment is required, this assessment is to be submitted in conjunction with any future subdivision application/s.

PART TWO – EXPLANATORY SECTION AND TECHNICAL APPENDICES

1.0 Planning Background

1.1 Introduction and Purpose

The key objectives of the Structure Plan are as follows:

- To provide a statutory framework to guide the use, subdivision and development of land to create a high quality urban environment.
- Capitalise on the natural amenity of the area afforded through the established Parks and Recreation reservations abutting the SP area.
- To achieve an optimum lot yield with an emphasis of introducing a diverse product and associated housing choice into the area.
- Maximise opportunities for surveillance of the Public Open Space to enhance to amenity of the public realm and quality of living of the future residents.

1.2 Land Description

1.2.1 Location

The subject site is located within the suburb of Southern River, within the municipality of the City of Gosnells.

The subject site is located approximately 20 kilometres south-east of the Perth City Centre, approximately 6 kilometres from the Gosnells Town Centre and approximately 1.5 kilometres from the existing Southern River Neighbourhood Centre which provides a range of services including retail, community and entertainment uses.

Plan 1 illustrates the subject site's location.

1.2.2 Area and Land Use

The subject site is bound by Holmes Street to the north and Balfour Street to the east.

The subject land has previously been partly cleared. There are areas of bushland (including wetland vegetation located across the site which ranges in condition from 'Completely Degraded' to 'Excellent'. More recently, parts of the site have been filled with clean sand. These areas can be clearly seen in Plan 2 – Aerial located below.

Currently, the subject site is drained through a series of shallow spoon drains and surface sheet flow which discharges into the onsite wetland and into the Balfour Street drain.

An area of wetland is located through the middle section of the subject site which connected to a wider wetland system to the north and south. The onsite wetlands have been classified as Multiple Use, Resources Enhancement and Conservation Category.

1.2.3 Legal Description and Land Ownership

The subject site has a total area of approximately 22.97 hectares. The lots forming the SP area and the respective ownership details are outlined in the table below.

Lot	Certificate of Title	Land Ownership	Lot Area
2	1401 / 594	Abernethy Land Company Pty Ltd	3.3126ha
23	2852 / 898	Oceans Keys (WA) Pty Ltd	1.3776ha
24	2854 / 661	Flynn Drive Holdings Pty Ltd	1.0854ha
1	1250 / 145	115 Cambridge Street Pty Ltd	3.4241
1600	1101 / 219	Gucce Holdings Pty Ltd	6.4837ha
1601	1895 / 935	Domenico Guadagnino Linda Maree Guadagnino	7.2865ha

[illegible]

Plan 2 – Aerial Photograph



1.3 Planning Framework

1.3.1 Zoning and Reservations

The subject site is predominately zoned 'Urban' under the Metropolitan Region Scheme (MRS) with the southern portion reserved for the purpose of 'Parks and Recreation'.

Under the provisions of the City of Gosnells Town Planning Scheme No. 6 (TPS No. 6) the subject site (with the exception of the abovementioned 'Parks and Recreation' reservation) is zoned 'Residential Development'.

The objective of the 'Residential Development' zone is:

'To provide for the progressive and planned development of future urban areas for residential purposes and for commercial and other uses normally associated with residential development and generally in accordance with an Structure Plan adopted pursuant to Clause 7.4'

Although explained in much greater detail in Section 3 of this report, the SP aims to introduce an increased mix of residential densities to the Southern River area in order to meet housing demands and affordability needs whilst introducing newer housing typologies to the market.

1.3.2 Regional and Sub-Regional Structure Plan

The subject site falls within the City of Gosnells Structure Precinct 2 – Southern River (Southern River SP).

The subject site falls within Phase 3 of the Southern River SP and is designated a 'Residential' zoning with an applicable density coding of 'R20' along the northern, southern and eastern boundaries with local Public Open Space reservations along the western boundary as illustrated below in Figure 1.

The subject site is also subject to the Development Contribution Plan relating to Southern River SP. Whilst not discussed in detail within the report, the future subdivision of the area may be subject to the payment of contribution and/or receipt of reimbursements towards Common Infrastructure Works and Public Open Space.

The proposed SP represents a departure from the Southern River SP in that it proposes lots with a density coding of 'R25' and 'R40' in lieu of 'R20'. Justification for the increased density is provided within the following sections of this report.

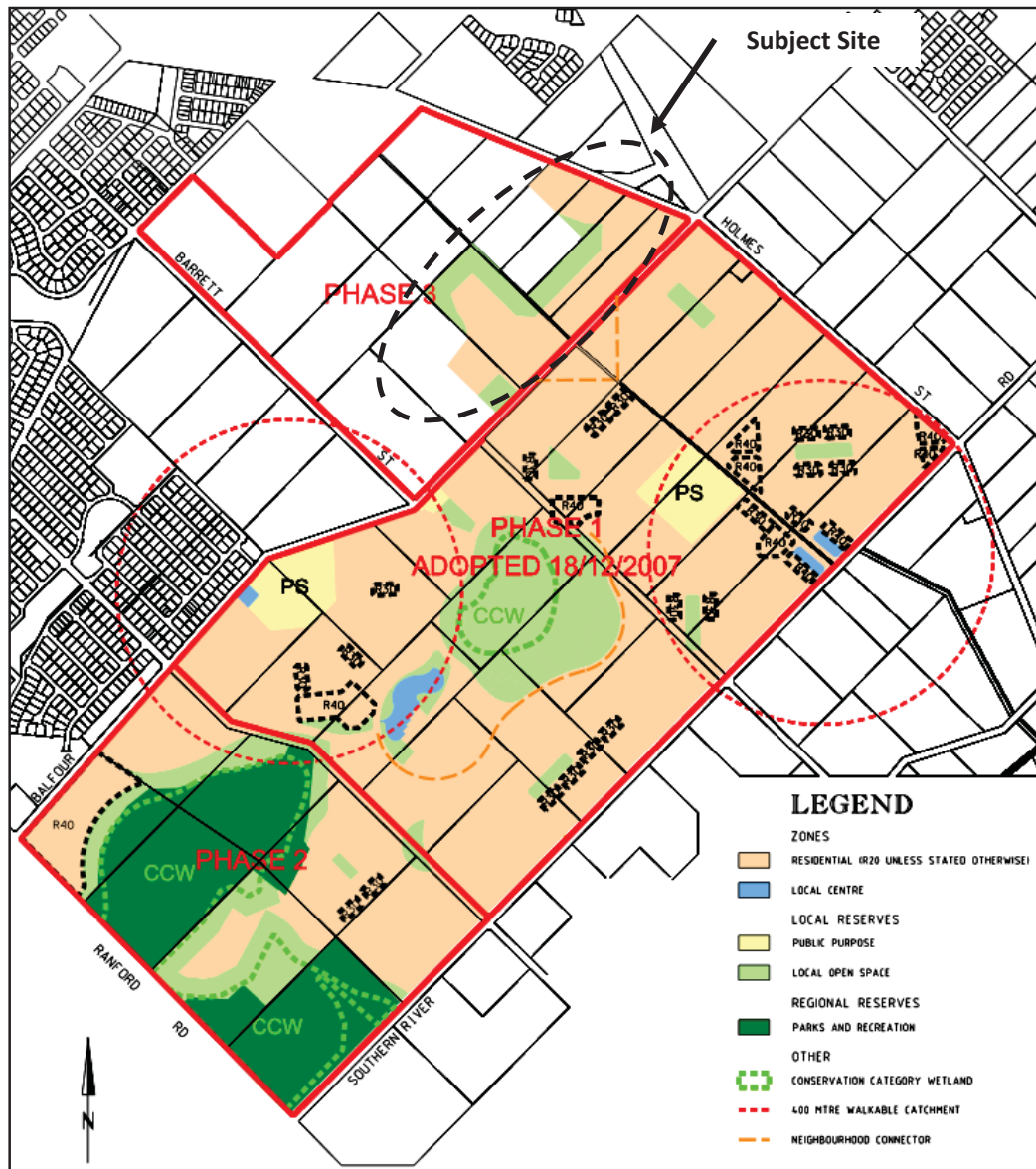


Figure 1 - Structure Plan Precinct 2 – Southern River

1.3.3 Planning Strategies

1.3.3.1 State Planning Strategy 2050

The State Planning Strategy 2050, was prepared by the WAPC and provides a strategic planning response to the challenges that Western Australia is likely to face in the future.

It envisages that by 2050 Western Australia will double its current population and will have a diverse range of well-connected and vibrant communities of the highest quality in the world.

The SP will allow for the future development of currently vacant land for residential purposes which will contribute towards the goal to double the State's current population.

1.3.3.2 Directions 2031 and Beyond – A Spatial Framework for Perth and Peel

Directions 2031 provides the overarching strategic framework for the Perth and Peel Regions. The subject site is located within the 'North-West Sub-Region,' which is identified as requiring an additional 65,000 dwellings by 2031.

Directions 2031 notes there is a need to introduce greater diversity in the new housing market to accommodate families. Directions 2031 seeks a 50% increase in the current average residential density, increasing from 10 dwellings per gross urban zoned hectare to 15 dwellings per gross urban hectare of land (which equates to approximately 23 dwellings per residential hectare of land) in new development areas. The SP proposes densities of 25 dwellings per hectare and 40 dwellings per hectare, which will contribute to meeting the forecast housing needs of the City of Wanneroo and wider South East Region and assist in increasing the current average residential density per hectare of the wider Perth and Peel region.

Further to this, the SP will introduce needed housing diversity to meet housing demand and affordability within the Southern River locality.

1.3.3.3 Liveable Neighbourhoods

Liveable Neighbourhoods is the State Government's key policy for the design and assessment of structure plans (i.e. SPs). The policy sets out a number of objectives and principle aims to ensure the design and layout of new developments:

- Facilitate ease of access, in particular walking and cycling through a network of connected streets that are safe, efficient and pleasant;
- Foster a sense of community, place and local identity;
- Support an efficient public transport system;
- Provide a variety of lot sizes, housing types and densities that support the diverse housing needs;
- Conserve and incorporate key environmental areas into designs;
- Integrate the design of open space and stormwater management systems; and
- Maximise the use of land for housing.

The implementation of these elements is fundamental to ensuring structure planning and resultant subdivisions occur in a well-considered and sustainable manner. Application of the Liveable Neighbourhoods principles is therefore relevant to all levels of planning for the site from the proposed SP through to detailed lot and building design.

Liveable Neighbourhoods specifically seeks densities in new urban areas to be at least 15 dwellings per urban hectare with an average of 22 dwellings per site hectare.

The below table compares the dwelling output for the density coding of 'R20' required under the Southern River SP and the proposed 'R25' and 'R40' density coding's with the targets set by Directions 2031 and Liveable Neighbourhoods. It clearly confirms that the proposed 'R25' and 'R40' density coding's achieve the objectives of the aforementioned strategic planning framework and as such, it considered appropriate and acceptable.

Policy Requirement	Lot/Dwelling Numbers
Direction 2031	253
Liveable Neighbourhoods	242
Maximum Yield at 'R20'	244
Maximum Yield at 'R25'	314
Maximum Yield at 'R40'	500
Proposed 'R25' & 'R40' Concept Plan Yield	226

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

State Planning Policy No. 5.4 'Road and Rail Transport Noise and Freight Considerations in Land Use Planning' aims to promote a system in which sustainable land use and transport are mutually compatible.

The policy applies address transport noise from major transport corridors and its impact on proposals for new noise-sensitive developments, whereby a noise assessment is to be prepared and any recommendations implemented as part of the subdivision process.

1.3.3.5 City of Gosnells – Local Housing Strategy

The Local Housing Strategy (LHS) is a long term strategic project designed to increase residential development opportunities within the City.

The LHS identifies a deficiency in the number of medium density residential lots within the City noting that the typical lot sizes throughout the City are in excess of 500m².

As the proposed residential density coding is a combination of 'R25' and 'R40', the SP will foster the development of lots ranging from 192m² to 553m² in size, which will contribute towards satisfying the identified need for the introduction of medium density lots within the City of Gosnells.

2.0 Site Conditions and Constraints

2.1 Surface and Ground Water

A Local Water Management Strategy (LWMS) has been prepared by Calibre Consulting in support of the proposed SP which analyses the subject site's pre-development ground and surface water (based on monitoring undertaken by JDA in 2008). A copy of the LWMS is contained within Appendix 2.

2.1.1 Surface Water

Much of the rainfall that currently falls on the site percolates through to the groundwater. This means that there is initially little surface runoff from the site. Once this groundwater rises to the surface in the middle of the site, in the form of a wetland, it can potentially exit via a control pipe to Balfour Street. There is also some minor runoff onto the swale drain along Holmes Street and directly to Balfour Street.

The Balfour Street Drain enters the Sutherland Park Drain before eventually connecting to the Southern River.

There are 3 main sub-catchments within the subject land area.

- Sub-catchment 1 flows to Holmes Street directly.
- Sub-catchment 2 flows to Balfour Street directly.
- Sub-catchment 3 flows into the wetland complex.

Sub-catchment 1

This sub-catchment flows off the sand rise created by the on-site fill and natural features to Holmes Street directly. This is a thin catchment that stretches almost parallel to Holmes Street. Water that enters the swale along Holmes Street either infiltrates or flows south eastward and into the Balfour Street drain.

Sub-catchment 2

This sub-catchment has also been created by the introduction of fill, which loosely follows the original contours of the site. Flows from this area discharge to the Balfour Street reserve, before entering the recently installed drainage pits of the Balfour Street Drain.

Sub-catchment 3

This is the largest catchment on the site. The majority of the site flows directly into the central wetland complex. There is some overland flow after extreme events from the south western side of the fill and subject area that heads north into the wetland complex in Lot 1604. This is the same wetland complex as located on the subject land. Once the water in the wetland reaches 21mAHD, it discharges to the Balfour drain via a 225mm drainage pipe.

A number of shallow spoon drains cross this wetland complex, which assist with moving water across the wetland to the drain outlet.

Surface water features

The main surface water feature on site are the wetlands including two Conservation Category Wetlands, two Resource Enhancement Wetlands and two Multiple Use Wetlands. These wetlands in effect act as one wetland complex. These are all seasonal wetlands.

There are also a number of small constructed drains, which traverse the wetland area before discharging to the Balfour Street Drain.

2.1.2 Ground Water

Shallow Superficial Aquifer

Groundwater Monitoring of the superficial aquifer has been undertaken for the subject land area and the adjoining Lots 1742 and 1743 to the south east. This monitoring and analysis of the AAMGL was undertaken by JDA.

7 bores were installed in September 2008 on the subject land to a depth of around 5m and have been monitored over two (2) years.

Levels and AAMGL

Monitoring data collected over two years was analysed in reference to long term Department of Water bores. The effect of the site's landforms and drains was also considered.

Analysis of the long term data suggested that the 2 years of monitoring were slightly drier than average which may suggest that the groundwater levels may be higher in an average year. However the groundwater is more likely controlled by the on-site drain which allows for water in the wetland to exit to the Balfour Street drain. Given that in both years the groundwater for the site caused inundation of the wetland and flowed out through this drain, it is likely that the results recorded in both years are close to the maximum level for the site. Groundwater is unlikely to rise higher as it would generally run offsite through the open drainage system.

The depth to groundwater varies from 2.22m below the surface to ponding above the ground in the wetland areas.

The AAMGL falls from just over 21m AHD through the wetland and to the west and south of the site to just below 20m AHD in the north east corner close to the Balfour Street Drain. For most of the site, the contours are very flat. This is due to the wetland feature over the majority of the portion of the site and the influence of the small surface drain which controls the wetlands level. There is however a localised decline in the contours in areas near the Balfour Street drain.

Groundwater levels were also recorded as part of the geotechnical studies for the site. The results from the geotechnical study support the information found in the long term groundwater monitoring program.

Minimum groundwater levels were also recorded.

Quality

As part of the groundwater monitoring, a range of quality parameters were recorded. The following is a summary of the results contained within Part 6 of the LWMS and specifically, Figure 2 below.

pH

The pH tends to fluctuate between acidic (4.6) to almost neutral (6.85). This may indicate Acid Sulphate soils (ASS). It is recommended that further investigation be undertaken into ASS, which can be managed as part of a post subdivision approval. There was no general trend in pH levels between bores or throughout the season except for a general rise in pH between May 2008 and September 2008, with another rise between March 2009 and May 2009.

Electrical Conductivity

Electrical Conductivity was used as a reference for salinity. The conductivity for all bores other than H3 was fairly consistent throughout the monitoring period. For these bores the values fluctuated between 0.21mS/cm and 2.04mS/cm. Bores H4 and H7 tended to have the lowest readings through the sampling period. These conductivities are in the fresh to brackish category.

Bore H3 had significantly higher readings at every sampling period, with its conductivity ranging from 2.86 through to 20.08mS/cm which makes it brackish to saline.

Nutrients

The nitrogen levels were generally above the recommended levels of 1.0mg/L for Total Nitrogen with only 6 readings below or at 1mg/L (all in different bores). Nitrogen levels peaked at 11mg/L in bore H6 with most levels around 2-3mg/L. There was no clear trend in levels throughout the year or between bores.

Phosphorus levels were also generally above the recommended level of 0.1mg/L for Total Phosphorus, which has been set out in the Swan Canning WQIP. Bores H1, H5 and H7 tended to have levels around 0.1 to 2mg/L, while Bores H4 and H6 generally recorded higher levels between 2.4 and 6.9mg/L. Bore H2 was generally less than 1.1mg/L but did have a spike of 7mg/L once. The only bore that was consistently below the 0.1mg/L was H3 which fluctuated between <0.01 and 0.07mg/L. These values may suggest that the site's groundwater is being affected by past and current agricultural activities on the cleared farm land, both from the subject land and surrounding areas. The nutrients are most likely moving within the groundwater and through the wetland system.

Superficial Aquifer Allocation

The superficial aquifer in this region has some allocation available. As at July 2010 the allocation available was approximately 200,000 KI. As can be seen from the above data, the water quality may not be suitable for domestic use without further treatment.

Deeper Confined Aquifers

The Department of Water provided the following information on the deeper aquifers located under the subject land.

- Leederville aquifer: The Leederville is represented by the Perth South Confined Sub-area at this site. It tends to be around 700m in thickness and is located below the superficial aquifer which generally extends to around 29m deep. The aquifer is currently over allocated.
- Yarragadee Aquifer: The subject land is located in the Perth South Confined North Yarragadee sub area. The aquifer is approximately 3000m thick and is located below the Leederville. This aquifer is also over allocated.

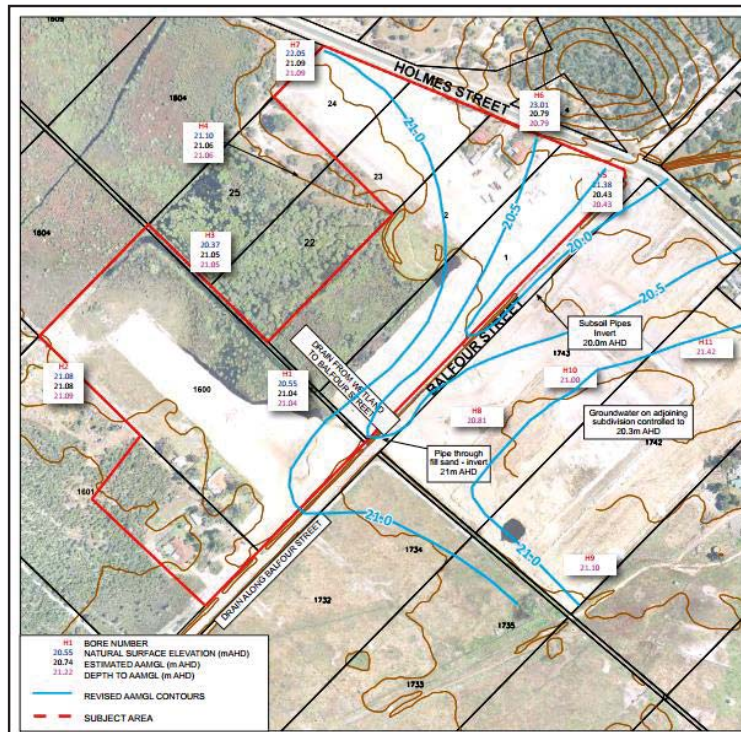


Figure 2 – Pre Development Ground Water (Calibre, 2014)

2.2 Wetlands

A Wetland Management Plan (WMP) has been prepared in support of the proposed SP by Endemic and identifies areas of wetland located within the subject site including, Multiple Use, Resource Enhancement and Conservation Management categories (illustrated below in Figure 3). A copy of the WMP is contained within Appendix 3.

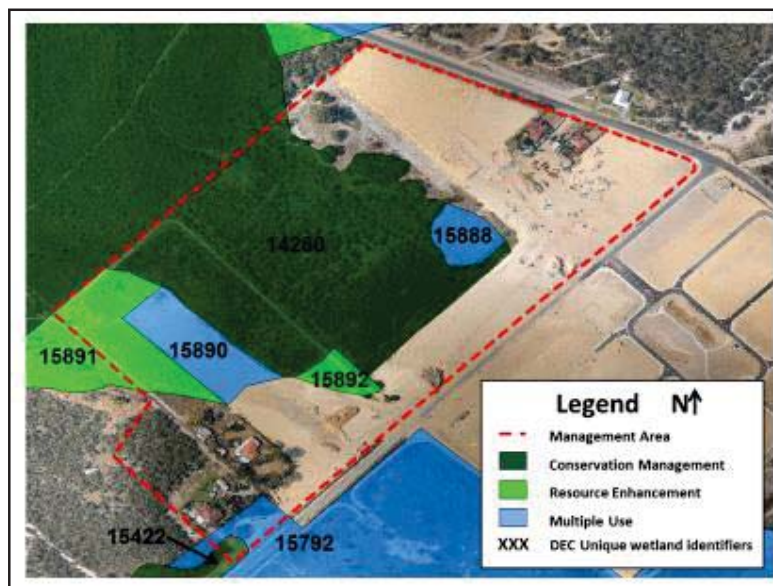


Figure 3 – DEC Wetland Categories (Endemic, 2015)

The WMP discusses the protection and management of the wetland habitat within the subject site and outlines specific management objectives. The management objectives outlined in the WMP have been incorporated into the design and management of the future development to ensure appropriate conservation of the Conservation Management wetland areas. The management of the wetland includes the following objectives:

- Ensure protection of the natural values and wetland functions of the Conservation Management Category wetland including to;
 - i. Protect water quality associated with the wetland;
 - ii. Maintain the hydrological regime;
 - iii. Identify key ecological habitats;
 - iv. Maintain and enhance corridor and habitat linkages.
- Outline measures to restore degraded wetland habitat and wetland buffer suitable for inclusion within a future 'Reservation for Conservation'.
- Provide educational, recreational and landscape amenity to residents and visitors to the area, while protecting the values and function of the wetland habitats; and
- Provide details for the ongoing management, monitoring and reporting requirements.

The overall SP has been designed to ensure the preservation and conservation of the Conservation Management wetland with the positioning of the proposed POS incorporating this area entirely. In addition, the majority of the Conservation Management wetland has been ceded to the Crown as a 'Parks and Recreation' reservation (under the MRS) and categorised as a Bush Forever site as part of a separate planning process. This reservation no longer forms part of the SP area.

2.3 Landform and Soil

Geotechnical investigations were undertaken by Brown Geotechnical and Environmental Pty Ltd. The results were outlined in the Geotechnical Investigation (refer Appendix 4). Field tests were undertaken on 22 and 23 January 2008 prior to the majority of the fill being laid.

A second investigation was undertaken to determine permeability of the fill sand on the 23 July 2010 by TME (who have since become part of Calibre Consulting), the findings of this are detailed in the Local Water Management Strategy contained in Appendix 2.

The geology of the subject site indicates Bassendean Sands with peaty sand deposits with details of the soil types outlined on Figure 4 below.

The location of the proposed residential areas of the SP are located within the areas of sand and fill sand which is considered to be an appropriate soil type for dwelling construction.

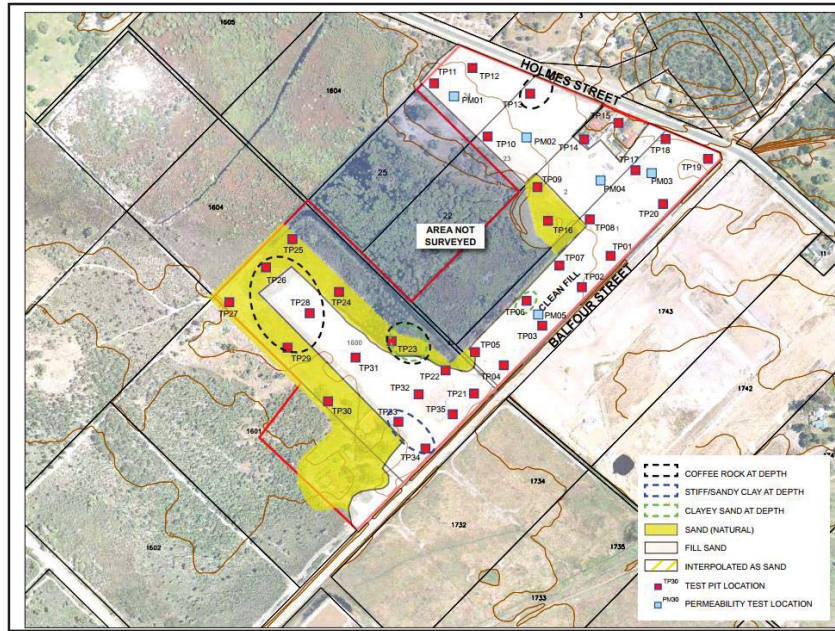


Figure 4 – Geotechnical Information (Endemic, 2015)

No Acid Sulphate soil testing has been undertaken at the subject site however, the Department of Environment Regulation (DER) mapping indicates a low to medium risk for the top 3m of the soil profile for the northern and southern parts of the subject site where the sand rises are located. A moderate to high risk is located centrally within the subject site which corresponds with the wetland area. The Acid Sulphate risk is illustrated in Figure 5 below.

The design of the SP and location of the associated wetland area has resulted in the incorporation of the high risk Acid Sulphate areas to be located within the proposed area of POS.

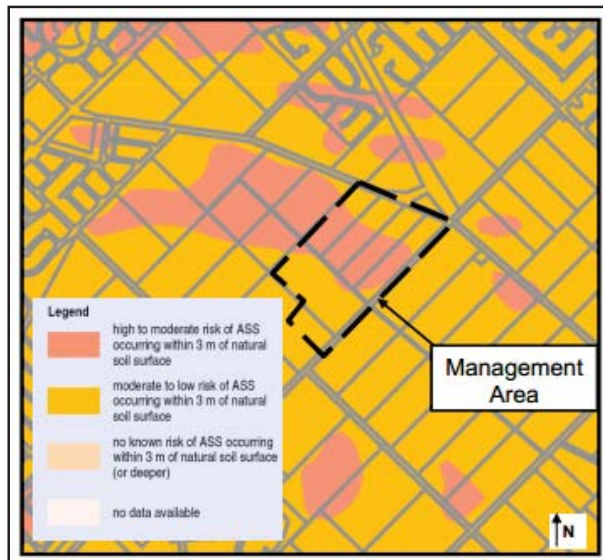


Figure 5 – Acid Sulphate Risk (Endemic, 2014)

2.4 Biodiversity

A Flora and Vegetation Survey was undertaken by Cardno BSD in 2007 including both autumn and spring surveys. As part of this, 91 taxa were identified during the site surveys, of which 50 were native species and classified into condition categories as illustrated in the below Vegetation Condition Figure 6. A copy of the Flora and Vegetation Study is contained within Appendix 5.

Furthermore, no Declared Rare Fauna (under the Wildlife Conservation Act 1950) or 'Threatened' plant taxa (under the Environmental Protection and Biodiversity Act 1999) were located on the subject site. However Priority Flora, listed by the DER, noted that Jackson sericea was recorded on Lot 1601.

With the presence of vegetation classified as 'Excellent' within the subject site, the SP has been designed to ensure that this area is incorporated into a proposed area of POS to ensure its retention into the future.

The Priority Flora within Lot 1601 has been predominantly incorporated into the 'Parks and Recreation' reservation and, in accordance with the recommendation of the Cardno Flora and Vegetation Survey, the removal of such species will be kept to a minimum.

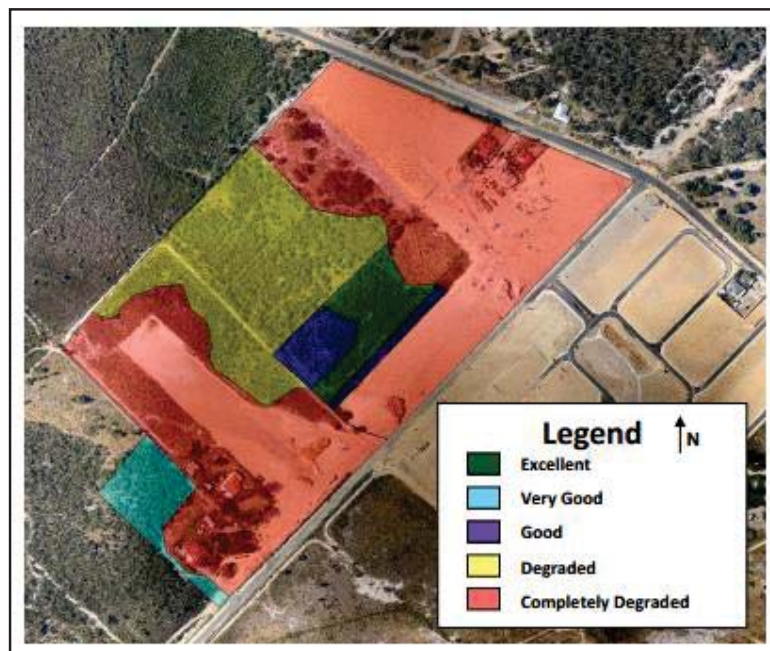


Figure 6 - Vegetation Condition (Cardino, 2007)

2.5 Bushfire Hazard

A Bushfire Management Plan (BMP) has been prepared by RUIC in support of the proposed SP which demonstrates compliance of the proposed SP with all applicable requirements of State Planning Policy 3.7 Planning in Bushfire Prone Areas and associated Guidelines for Planning in Bushfire Prone Areas.

A copy of the BMP is contained within Appendix 6.

The pre-development site is identified through the BMP as having a low hazard classification over 48.5% of the site, moderate hazard classification of 23.5% and extreme hazard classification for the remaining 28% (Refer to Figure 7 below).

In addition, the subject site is surrounded by several areas of bushfire prone vegetation including;

- The Bush Forever site to the east, with a total area of approximately 80.6ha in the greater area.
- A mixture of wetland scrub, shrub and banksia woodlands vegetation is present to the To the north eastern side of Holmes Street,
- A Banksia Woodland community adjoins the park to the north east of the intersection of Balfour and Holmes Streets.
- Vegetation to the north side of Holmes has been reduced through the subdivision
- Development of Lot 3 Holmes Street and further clearing through the extension of the Garden Street Road reserve to intersect with Holmes Street.

Given the presence of high risk bushfire hazard risks within the subject site, the design of the SP has incorporated the Bushfire engineering design parameters to ensure the development is not exposed to an unreasonable level of bushfire related risk or threat in accordance with the requirements detailed in the WAPC Bushfire Risk Management Guidelines (2014).

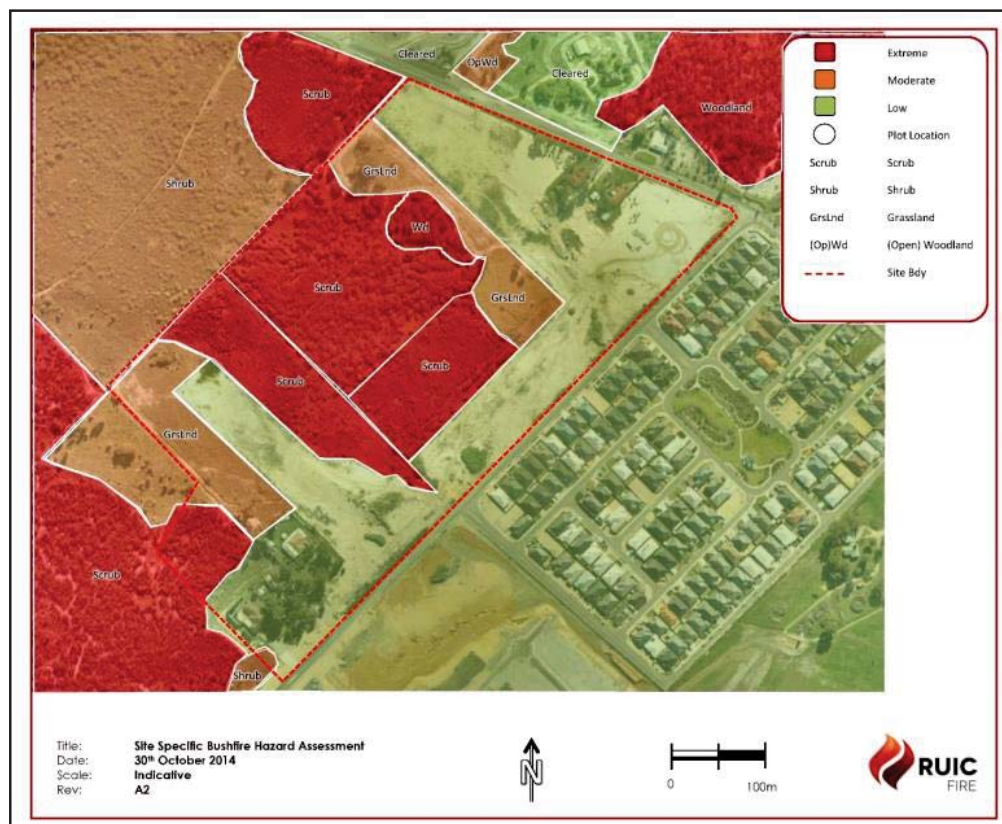


Figure 7 – Fuel Loads (RUIC, 2014)

2.6 Heritage

A review of the Aboriginal Heritage Online Inquiry System confirmed there are no Registered Aboriginal Sites of Other Heritage Places over the subject lot.

There are no European Heritage sites currently listed on the Heritage Council of WA's (HCWA) State Register of Heritage Places or the City of Gosnells Municipal Heritage Inventory.

3.0 Land Use and Subdivision Requirements

3.1 Design and Land Use

The proposed SP provides for residential land uses consistent with the policy framework for the site and the existing and planned development to the south and east.

The residential blocks have been configured to respond to the shape of the land, solar orientation and to maximise vistas. Specifically, where possible, streets have been aligned in a north east to south west direction to enable view corridors to the proposed POS and existing regional Parks and Recreation reserve surrounding the subject site to the west.

The unconventional shape of the subject site and the location of the Conservation Category Wetlands, Extreme Bushfire Risk and need to provide adequate drainage has dictated the location of four (4) Public Open Space (POS) pockets located within the SP boundary. In addition, the proposed movement network has been design in response to the Bushfire Risk in that 20 metre wide road reservations are proposed abutting areas of POS to ensure adequate separation distances are provided.

An overview of the SP land uses and its key elements is provided in Table 1.

Table 1 – SP Summary

Item	Data	
Total area covered by Structure Plan	22.97ha	
Area of each land use proposed:	Hectares	Lot Yield
- Residential	12.768ha	223lots
- Public Open Space	1.419 ha	4 lots
- Parks and Recreation	5.53ha	1 lot
Estimated Lot Yield	230 lots	
Estimated Number of Dwellings	223dwellings	
Estimated Residential Site Density	R25 & R40	
Estimated Population*	624	
Number of High Schools	0	
Number of Primary Schools	0	
Estimated Commercial Floor Space	0	
Number and % of Public Open Space:	Hectares	Percentage/Number of Parks
- Regional Open Space	5.53ha	24.07%
- District Open Space	0	0%
- Neighbourhood Parks	0	0 parks
- Local Parks	1.419ha	4 parks
Estimated Percentage of Natural Area:	Hectares	Percentage
	3.253ha	14.16%

* Based on Australian Bureau of Statistics, Census of Population and Housing 2011 which states average household size in the City of Gosnells to be 2.76 per dwelling.

3.2 Open Space

Liveable Neighbourhoods requires the following in respect to POS;

- Minimum 10% of a subdivision to be given up for POS with:
 - o Minimum 80% of the total POS required to be unrestricted; and
 - o Allowance for up to 20% of the total POS required to comprise restricted use POS.

In order to meet the 10% POS provision dictated by Liveable Neighbourhoods, four (4) areas of Public Open Space (POS) are proposed as part of the SP, the details of which are outlined below in Table 2.

LOT 1 POS
Scale 1:1000 @ A3

PLANTED BASIN
Scale 1:1000 @ A3

PARKLET
Scale 1:1000 @ A3

CONTEXT PLAN
Scale Not to Scale

SECTION A - A
Scale Not to Scale

LEGEND

- POS AREA
- PURPOSE OPEN SPACE (PROTECTED TYP)
- 2m WIDE PATHWAY
- Park bench
- ROAD RESERVE
- VEGETATION GARDEN
- VEGETATION (TUPPER)
- Grass area (20m²)
- Open lawn
- Slope 1:5
- Buffer Area
- (Minimum) Road Width Standard
- REVEGETATION AREA
- RESIDENTIAL LOTTS + POS
- RESIDENTIAL LOTTS + RD
- Agro Reserve

Page 21

Table 2 – Public Open Space Schedule

Structure Plan Area – Holmes Street and Balfour Street, Southern River	
Total Net Site Area	22.97ha
less	
Parks and Recreation Reservation (to be ceded)	5.53ha
less	
Conservation Management Wetlands	0.233ha
Lot 1	1.470ha
Lot 2	1.550ha
Lot 1600	
=	14.187ha
Gross Subdivisible Area	
Public Open Space Requirements	
Gross Subdivisible Area	14.187ha
Public Open Space @ 10%	1.419ha
- Unrestricted (80%)	- 1.135ha
- Restricted (20%)	- 0.284ha
Unrestricted Open Space Provided	
Lot 1	0.864ha
Lot 1600	0.1823ha
Lot 1601	0.1757ha
Total Unrestricted POS	1.222ha
Surplus in Unrestricted POS	+0.087ha
Restricted Open Space Provided	
Lot 1 – Bio Retention Area (1:5yr)	0.027ha
Lot 2 – Drainage Basin (1:5yr)	0.0744ha
Lot 2 – Multi Use Wetland	0.0656ha
Lot 1600 – Multi Use Wetland	0.0033ha
Lot 1600 – Resource Enhancement Wetland	0.0267ha
Total Restricted POS	0.197ha
Deficit in Restricted POS	-0.087ha
Total Public Open Space Provision	1.419ha

A total of 1.41987ha (10% of Gross Subdivisible Area) of POS is provided within the SP boundary, which comprises 80% unrestricted open space and 20% restricted open space, complying with the provisions of Liveable Neighbourhoods. The proposed SP also illustrates an area of Parks and Recreation reservation, which comprises 5.53ha in area and is subject to a separate acquisition with the WAPC.

It is important to note the subject site's close proximity to an abundance of other public open spaces comprising both Regional Parks and Recreation reservations and Local Open Space reservations.

The location of the Regional Parks and Recreation and Local Open Space reservations are illustrated below in Figures 9 to 10.

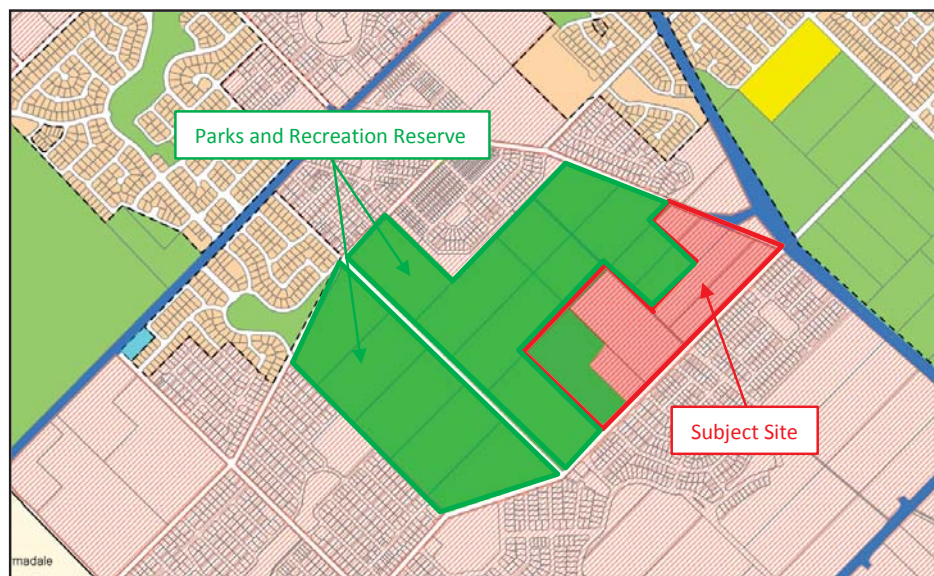


Figure 9 – Location of Regional Parks and Recreation Reservations

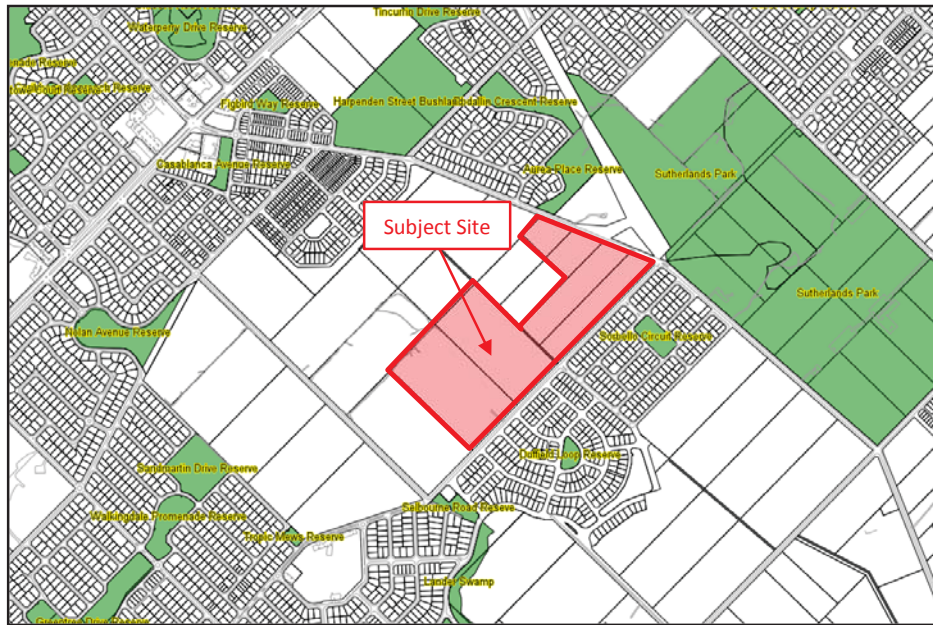


Figure 10 – Location of Local Open Space Reservations

3.3 Residential

The SP anticipates a minimum yield of 223 residential dwellings at residential density coding of 'R25' and 'R40'. The proposed density is intended to be sympathetic of the established residential character of Southern River whilst introducing diversity of lot sizes and housing typologies to meet market and affordability demands in accordance with the strategic planning provisions.

The street blocks have been designed to maximise solar orientation (where possible) as well as view corridors to the proposed POS areas within the SP area.

3.4 Movement Network

The north eastern portion of the SP has a local road network comprising a modified grid which is generally parallel to Balfour Road and the eastern boundary of the site. A realignment of Balfour Street is proposed, north of Marnbu Road, which will provide a connection through the subdivision to a new roundabout intersection with Holmes Street and the future Garden Street extension. The eastern connection to Holmes Street will be closed when the Garden Street extension is constructed. A four-way intersection is proposed at the existing Balfour Street/ Diego Entrance intersection, a roundabout intersection at Marnbu Road/Balfour Street, and two left-in, left-out intersections are proposed on Balfour Street.

All internal roads are proposed to meet the minimum standards of Liveable Neighbourhoods to accommodate, pedestrian pathways, on-street parking (if necessary) and street trees.

The road layout complies with the relevant standards and guidelines with respect to sight distances, geometric configuration and signage and pavement markings. In light of this, there should be no unacceptable risks.

Comment provided by Shawmac on the Movement Network is contained within Appendix 7.

3.4.1 Vehicle Access

Access to the subject site is proposed via several streets including four (4) roads intersecting with Holmes Street and five (5) intersections with Balfour Street. The road classification of a small portion of Holmes Street directly abutting Lot 23 is designated as an 'Other Regional' road under the provisions of the MRS. Only one (1) of the five (5) proposed junctions with Holmes Street abuts this portion of Holmes Street.

The indicative Concept Plan (Plan 5) proposes thirty three (33) lots are to have direct frontage to Balfour Street along the south eastern portion of the subject site. All other lots within the development are envisaged to have direct frontage to local streets.

3.4.2 Parking Provision

Parking is proposed to be accommodated on-site internally throughout the development.

There are also opportunities to include additional on-street bays adjoining public and regional open space which can be further examined through detailed engineering design of the subdivisional roads.

3.4.3 Traffic Volumes

As a result of the forecasted subdivision and future development, traffic is expected to increase on the roads leading to and from the development including Holmes Street and Balfour Street however will not anticipated that the capacity for these roads will be exceed.

The RTA NSW Guide to Traffic Generating Developments Version 2.2 (2002) indicates that approximately 5.5 vehicle trips per day (VPD) plus 0.8 per hour trips per dwellings will be generated from a development with an applicable density coding of R30.

The proposed Concept Plan indicates a total development yield of 226 lots/dwellings, it is anticipated that the VPD will be 1,424 VPD. Given that both Holmes Road and Balfour Street would most likely be classified as 'Neighbourhood Connector A' and 'Neighbourhood Connector B' roads under the provisions of Liveable Neighbourhoods, which have an indicated volume range of 7,000 and 3,000 VPD respectively, the future development of the subject site is expected to have an insignificant impact on the existing road network.

3.4.4 Public Transport

There is an existing bus stop approximately 600 metres north east of the subject site on the junction of Balfour Street and Gay Street. The stop is serviced by route 517 which provides a direct connection to both Murdoch and Thornlie Train Stations.

The extension of Balfour Street and increased population within the area as a result of the future development of the subject site offers logical opportunities for a new bus route to run through the subject site (along the Balfour Street extension) in the future.

3.4.5 Pedestrian and Cycle Access

It is intended that pedestrian and cycle access will be provided internally within the subject site to provide ease of movement, especially in and around the proposed POS areas.

3.4.6 Service Vehicles

The internal layout of the proposed development will support the access and egress of service vehicles such as waste removal trucks in a forward motion.

3.5 Water Management

As discussed above, a LWMS has been prepared by Calibre Consulting to support the proposed SP. The LWMS sets out management requirements for water management at the regional, local and lot scale, including specific targets (design objectives) for the management of surface and groundwater quantity and quality. The LWMS assists in integrating land and water planning as required by State Planning Policy 2.9 Water Resources and Better Urban Water Management.

The LWMS determines the flood extent for 1 in 1, 1 in 5 and 1 in 100 year average recurrence interval events (ARI) and outlines management objectives which have been incorporated into the overall design of the drainage system for the site.

The subject site has been divided into twelve (12) post development catchments, which form four (4) main catchment areas. The East Basin has a total storage capacity of 285m³, the West Basin has a total storage capacity of 96m³, the West Swale 1 has a total storage capacity of 135m³, and the West Swale 2 has a total storage capacity of 773m³. The location of the catchment areas are illustrated below in the Drainage Management Plan (Plan 8) in Figure 11.

The water management for the proposed SP and future development of the subject site is based upon the best practice water sensitive urban design which is achieved through maximising the sustainable use of water through the encouragement of water conservation and efficiency measures, managing stormwater to irrigate bio-retention gardens and recharge groundwater while controlling the flow of large storm events, managing the water quality and protecting and enhancing the wetlands located on the subject site.

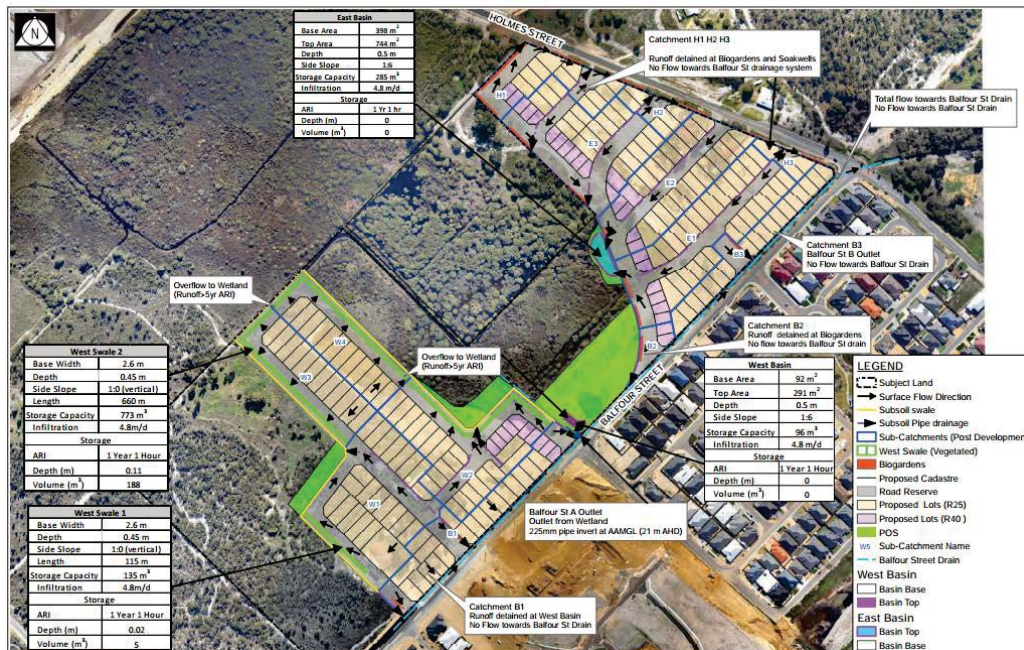


Figure 11 – Drainage Management Plan (TME, 2014)

PLAN 3
Structure Plan



**PROPOSED LOCAL
STRUCTURE PLAN**
LOTS 2, 23 & 24 HOLMES STREET &
LOT 1, 1600 & 1601 BALFOUR STREET
SOUTHERN RIVER

COPYRIGHT RESERVED BASE PLAN COURTESY OF LANDGATE



SCALE: 1:2500 @ A3
DATE: 7th JULY 2016
FILE: 359_07.07.2016.dwg
DRAW: -SB
CHECKED: -

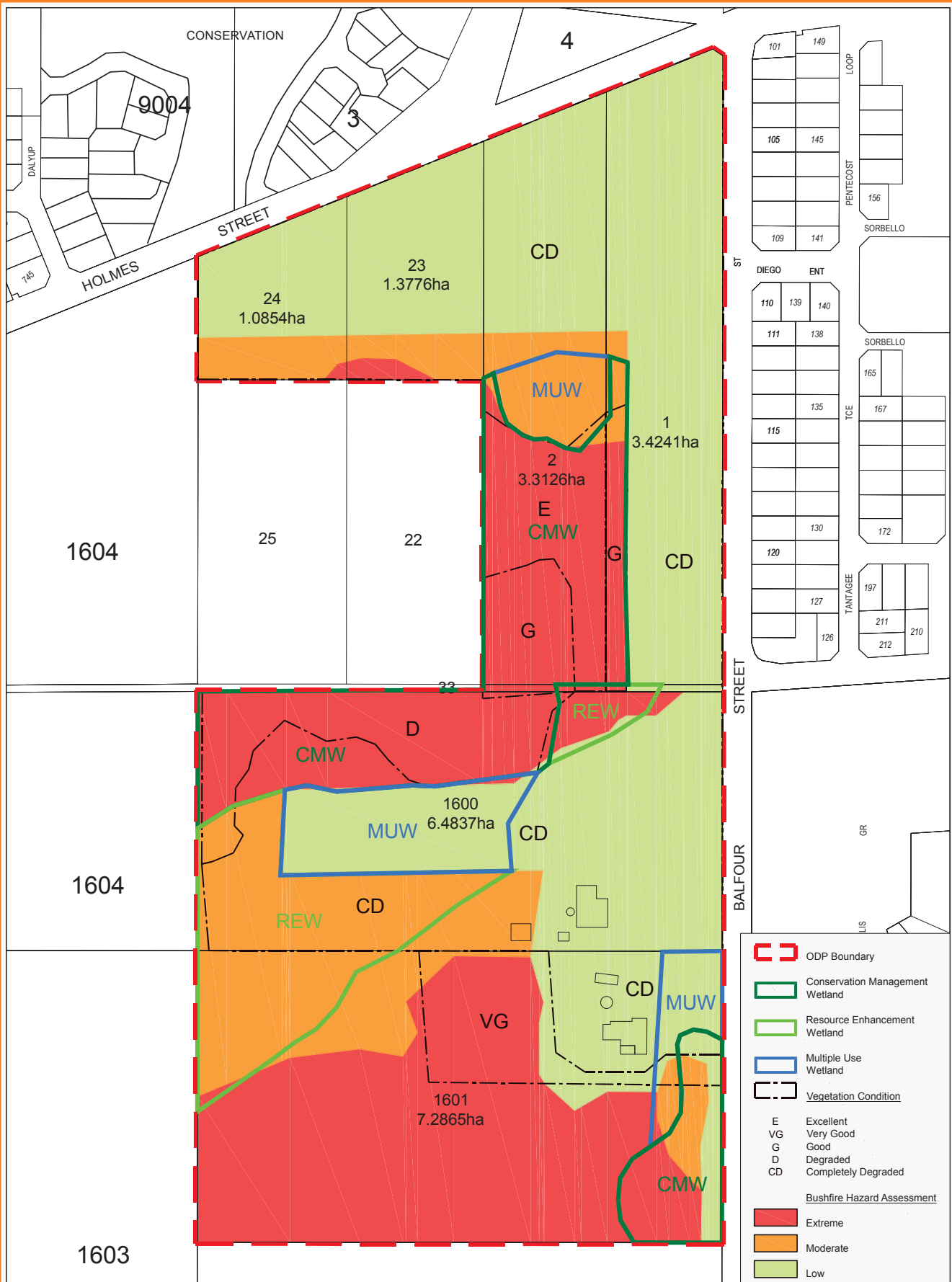


**DYNAMIC PLANNING
AND DEVELOPMENTS**

DISCLAIMER: This document is and remains the property of Dynamic Planning and Developments and may not be copied in whole or in part without the written consent of Dynamic Planning and Developments. All areas, distances and angles are approximate only and are subject to survey.



PLAN 4
Constraints Plan



CONSTRAINTS PLAN
LOTS 2, 23 & 24 HOLMES STREET &
LOT 1, 1600 & 1601 BALFOUR STREET
SOUTHERN RIVER

COPYRIGHT RESERVED BASE PLAN COURTESY OF LANDGATE



SCALE: 1:2500 @ A3
DATE: 3rd MARCH 2015
FILE: 359_03.03.2015.dwg
DRAW: - SB
CHECKED: -



DYNAMIC PLANNING AND DEVELOPMENTS
DISCLAIMER: This document is and remains the property of Dynamic Planning and Developments and may not be copied in whole or in part without the written consent of Dynamic Planning and Developments. All areas, distances and angles are approximate only and are subject to survey.

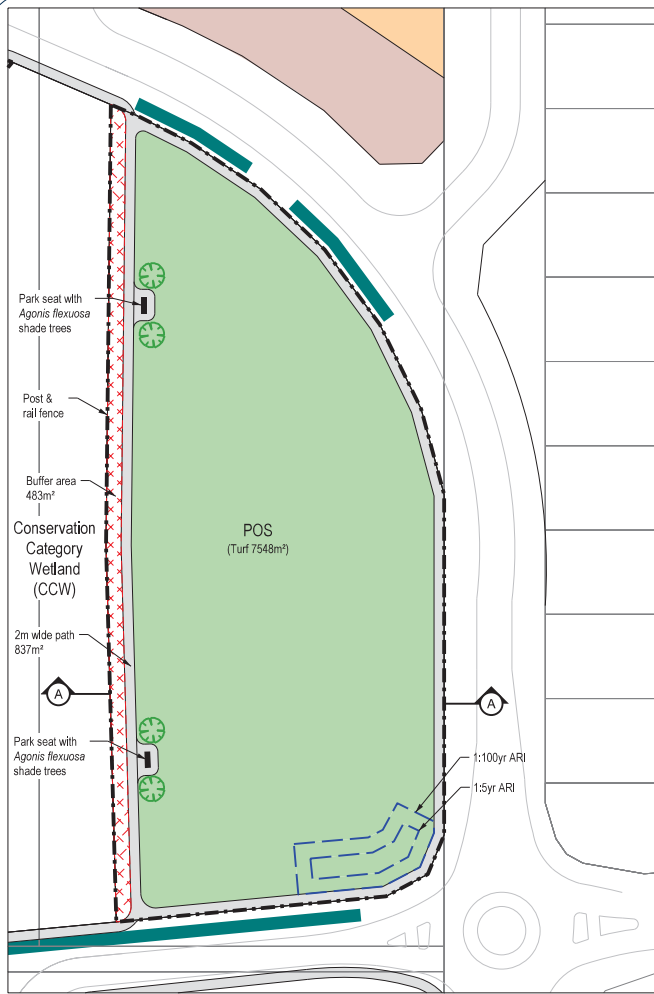
e: admin@dynamicplanning.net.au
t: (08) 9273 1700
f: (08) 9273 1744
m: (0433) 511 688
PO Box 688
INGLEWOOD WA 6052
UNIT 2C, 953 BEAUFORT STREET
INGLEWOOD WA 6052
ABN: 59 129 451 710



PLAN 5
Concept Subdivision Plan

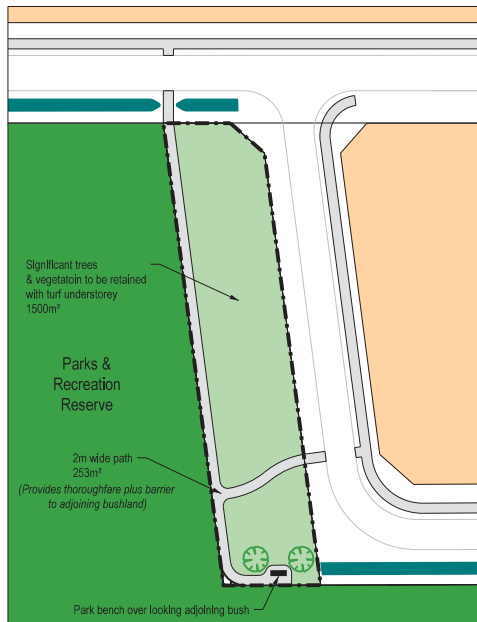
PLAN 6
Public Open Space Plan

PLAN 7
Landscape Concept Plan



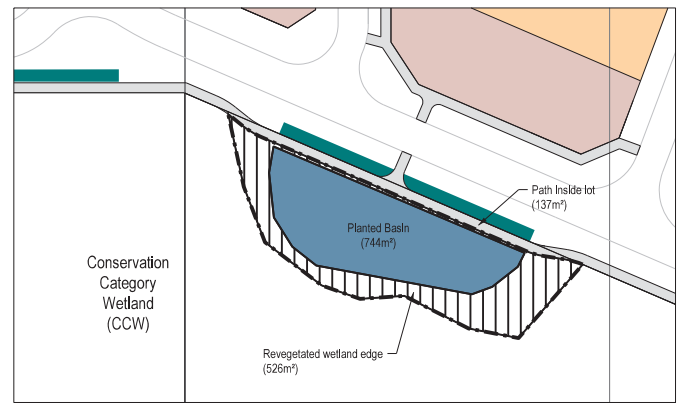
LOT 1 POS

Scale 1:1000 @ A3



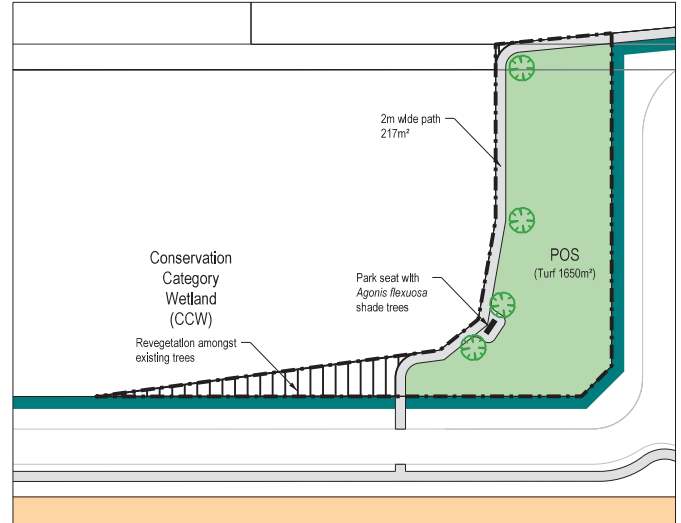
LOT 1601 POS

Scale 1:1000 @ A3



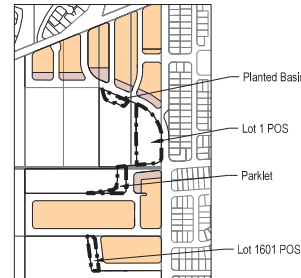
PLANTED BASIN

Scale 1:1000 @ A3



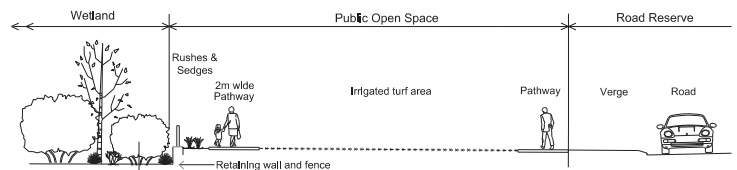
PARKLET

Scale 1:1000 @ A3



CONTEXT PLAN

Scale: Not to Scale



LEGEND



PLAN 8
Drainage Management Plan



APPENDIX 1
Certificates of Title

WESTERN



AUSTRALIA

REGISTER NUMBER N/A	
DUPLICATE EDITION 2	DATE DUPLICATE ISSUED 8/1/2014

RECORD OF CERTIFICATE OF TITLE

UNDER THE TRANSFER OF LAND ACT 1893

VOLUME
1401FOLIO
594

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

REGISTRAR OF TITLES



THIS IS A SHARE TITLE

LAND DESCRIPTION:

1/2 UNDIVIDED SHARES OF
LOT 2 ON DIAGRAM 21550

REGISTERED PROPRIETOR: (FIRST SCHEDULE)

ABERNETHY LAND COMPANY PTY LTD OF 48 WICKHAM STREET, EAST PERTH
AS SOLE PROPRIETOR OF THE SHARE SHOWN IN THE LAND DESCRIPTION
(T L253798) REGISTERED 10 MARCH 2010

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

- J250028 MORTGAGE TO SUNCORP-METWAY LTD REGISTERED 14.4.2005.
M421622 TRANSFER OF MORTGAGE J250028 , MORTGAGEE NOW MTGRP, L.L.C OF 200
WEST STREET, NEW YORK, NY 10282, UNITED STATES OF AMERICA
REGISTERED 4.10.2013.
- *L473057 MEMORIAL. TAXATION ADMINISTRATION ACT 2003, SECTION 76 (LAND TAX)
REGISTERED 8.11.2010.

Warning: A current search of the sketch of the land should be obtained where detail of position, dimensions or area of the lot is required.

* Any entries preceded by an asterisk may not appear on the current edition of the duplicate certificate of title.

Lot as described in the land description may be a lot or location.

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

STATEMENTS:

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

SKETCH OF LAND: D21550.
PREVIOUS TITLE: 1210-934.
PROPERTY STREET ADDRESS: 163 HOLMES ST, SOUTHERN RIVER.
LOCAL GOVERNMENT AREA: CITY OF GOSNELLS.

WESTERN



AUSTRALIA

REGISTER NUMBER
23/DP74597DUPLICATE
EDITION
1DATE DUPLICATE ISSUED
28/10/2014**RECORD OF CERTIFICATE OF TITLE**
UNDER THE TRANSFER OF LAND ACT 1893VOLUME
2852FOLIO
898

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

REGISTRAR OF TITLES

**LAND DESCRIPTION:**

LOT 23 ON DEPOSITED PLAN 74597

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

OCEAN KEYS (WA) PTY LTD OF 48 WICKHAM STREET, EAST PERTH
(AF M800016) REGISTERED 17 OCTOBER 2014

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

1. K447245 MORTGAGE TO SUNCORP-METWAY LTD REGISTERED 14.12.2007.
M421602 TRANSFER OF MORTGAGE K447245 , MORTGAGEE NOW MTGRP, L.L.C OF 200
WEST STREET, NEW YORK, NY 10282, UNITED STATES OF AMERICA
REGISTERED 4.10.2013.

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

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

STATEMENTS:

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

SKETCH OF LAND: DP74597.
PREVIOUS TITLE: 1251-380.
PROPERTY STREET ADDRESS: 155 HOLMES ST, SOUTHERN RIVER.
LOCAL GOVERNMENT AREA: CITY OF GOSNELLS.

WESTERN



AUSTRALIA

REGISTER NUMBER

24/DP74598DUPLICATE
EDITION**1**

DATE DUPLICATE ISSUED

29/10/2014**RECORD OF CERTIFICATE OF TITLE**
UNDER THE TRANSFER OF LAND ACT 1893VOLUME
2854FOLIO
661

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

REGISTRAR OF TITLES

**LAND DESCRIPTION:**

LOT 24 ON DEPOSITED PLAN 74598

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

FLYNN DRIVE HOLDINGS PTY LTD OF 48 WICKHAM STREET, EAST PERTH
(AF M800021) REGISTERED 17 OCTOBER 2014

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

1. K212761 MORTGAGE TO SUNCORP-METWAY LTD REGISTERED 1.6.2007.
M421597 TRANSFER OF MORTGAGE K212761 , MORTGAGEE NOW MTGRP L.L.C. OF 200
WEST STREET, NEW YORK, NY 10282, UNITED STATES OF AMERICA
REGISTERED 4.10.2013.

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

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

STATEMENTS:

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

SKETCH OF LAND: DP74598.
PREVIOUS TITLE: 1205-232.
PROPERTY STREET ADDRESS: 135 HOLMES ST, SOUTHERN RIVER.
LOCAL GOVERNMENT AREA: CITY OF GOSNELLS.

WESTERN



AUSTRALIA

RECORD OF CERTIFICATE OF TITLE
UNDER THE TRANSFER OF LAND ACT 1893

REGISTER NUMBER	
1/D21550	
Duplicate Edition	DATE Duplicate ISSUED
4	8/1/2014

VOLUME
1250FOLIO
145

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

REGISTRAR OF TITLES

**LAND DESCRIPTION:**

LOT 1 ON DIAGRAM 21550

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

115 CAMBRIDGE STREET PTY LTD OF 48 WICKHAM STREET, EAST PERTH
(T L253797) REGISTERED 10 MARCH 2010

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

1. J250028 MORTGAGE TO SUNCORP-METWAY LTD REGISTERED 14.4.2005.
M421622 TRANSFER OF MORTGAGE J250028 , MORTGAGEE NOW MTGRP, L.L.C OF 200
WEST STREET, NEW YORK, NY 10282, UNITED STATES OF AMERICA
REGISTERED 4.10.2013.

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

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

STATEMENTS:

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

SKETCH OF LAND: 1250-145 (1/D21550).
PREVIOUS TITLE: 1088-188.
PROPERTY STREET ADDRESS: NO STREET ADDRESS INFORMATION AVAILABLE.
LOCAL GOVERNMENT AREA: CITY OF GOSNELLS.

WESTERN



AUSTRALIA

REGISTER NUMBER

1600/P3316DUPLICATE
EDITION**2**

DATE DUPLICATE ISSUED

11/7/2006**RECORD OF CERTIFICATE OF TITLE**
UNDER THE TRANSFER OF LAND ACT 1893VOLUME
1101FOLIO
219

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

REGISTRAR OF TITLES

**LAND DESCRIPTION:**

LOT 1600 ON PLAN 3316

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

GUCCE HOLDINGS PTY LTD OF POST OFFICE BOX 1130, CANNING BRIDGE, APPLECROSS
(T J816284) REGISTERED 3 JULY 2006

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

1. J816285 MORTGAGE TO R.A.C. FINANCE LTD REGISTERED 3.7.2006.
2. *L034802 CAVEAT BY MUNITOR NOMINEES PTY LTD AS TO PORTION ONLY LODGED 7.8.2009.

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

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

STATEMENTS:

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

SKETCH OF LAND: 1101-219 (1600/P3316).
PREVIOUS TITLE: 1009-358.
PROPERTY STREET ADDRESS: LOT 1600 BALFOUR ST, SOUTHERN RIVER.
LOCAL GOVERNMENT AREA: CITY OF GOSNELLS.

WESTERN



AUSTRALIA

REGISTER NUMBER

1601/P3316DUPLICATE
EDITION**N/A**

DATE DUPLICATE ISSUED

N/A**RECORD OF CERTIFICATE OF TITLE**
UNDER THE TRANSFER OF LAND ACT 1893VOLUME
1895FOLIO
935

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

REGISTRAR OF TITLES

**LAND DESCRIPTION:**

LOT 1601 ON PLAN 3316

REGISTERED PROPRIETOR:
(FIRST SCHEDULE)

DOMENICO GUADAGNINO
LINDA MAREE GUADAGNINO
BOTH OF 6 CROFT STREET, GOSNELLS
AS JOINT TENANTS

(XA E547825) REGISTERED 11 FEBRUARY 1991

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

1. E544499 MORTGAGE TO COMMONWEALTH BANK OF AUSTRALIA REGISTERED 11.2.1991.

Warning: A current search of the sketch of the land should be obtained where detail of position, dimensions or area of the lot is required.

* Any entries preceded by an asterisk may not appear on the current edition of the duplicate certificate of title.

Lot as described in the land description may be a lot or location.

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

STATEMENTS:

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

SKETCH OF LAND: 1895-935 (1601/P3316).
PREVIOUS TITLE: 1101-910.
PROPERTY STREET ADDRESS: LOT 1601 BALFOUR ST, SOUTHERN RIVER.
LOCAL GOVERNMENT AREA: CITY OF GOSNELLS.

APPENDIX 2

Local Water Management Strategy



CITY OF GOSNELLS

2120 Albany Highway Gosnells WA 6110
Mail to: PO Box 662 Gosnells WA 6990

T 08 9397 3000
F 08 9397 3333
E council@gosnells.wa.gov.au
W www.gosnells.wa.gov.au
ABN 18 374 412 891

23 August 2016

Attention: Fox Tara
Department of Water
PO Box 117
SUBIACO WA 6904

Consultant Reference: 09440
Our Reference: PF15/00007
Enquiries: Dimal Kannangara
9397 3264

Dear Tara

**1, 2, 23, 24 Holmes Street 1600 & Pt 1610 Balfour Street Southern River
Local Water Management Strategy (LWMS)**

I hereby confirm the City has completed the assessment for the above addendum and now supports this development approval.

Please issue a formal approval if you are happy with the addendum.

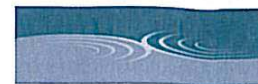
Should you wish to discuss the matter further, please contact Dimal Kannangara on 9397 3264.

Yours sincerely

Markus Botte
Manager Technical Services



18 MAR 2015



looking after all our water needs

Your ref: 09440

File ref: RF8397 SRS:28815

Enquiries: Tara Fox

Tel: 6250 8008

TME
PO Box 733
BUNBURY WA 6231

Attn: Brendan Oversby

Dear Mr Oversby,

**LOTS 1- 4 HOLMES ST & LOTS 1600 & 1601 BALFOUR ST - LOCAL WATER
MANAGEMENT STRATEGY**

The Department of Water (DoW) gives approval to the above mentioned Local Water Management Strategy (LWMS) dated January, 2015. The Department is now satisfied that the document is acceptable for this proposal to proceed to the next stage of development approval.

If you wish to discuss the matter further, please contact Tara Fox on 6250 8008 or via email - tara.fox@water.wa.gov.au.

Yours sincerely,

**James Mackintosh
Program Manager
Land Use Planning
Swan Avon Region**

17 March, 2015

Cc: City of Gosnells

LOTS 1, 2, 23, 24 HOLMES STREET, 1600 & Pt. 1601 BALFOUR STREET, SOUTHERN RIVER
LOCAL WATER MANAGEMENT STRATEGY
PREPARED FOR MAMMOTH NOMINEES

JULY 2016
09440
REV E



COMMERCIAL IN CONFIDENCE

All intellectual property rights, including copyright, in designs developed and documents created by Calibre Consulting (Aust) Pty Ltd remain the property of this company. Any use made of such design or document without the prior written approval of Calibre Consulting (Aust) Pty Ltd will constitute an infringement of the rights of the company which reserves all legal rights and remedies in respect of any such infringement.

The information, including any intellectual property, contained in this proposal is confidential and proprietary to the Company. It may only be used by the person to whom it is provided for the stated purpose for which it is provided and must not be imparted to any third person without the prior written approval of the Company. The Company reserves all legal rights and remedies in relation to any infringement of its rights in respect of its confidential information.

DOCUMENT CONTROL 09440				
ISSUE	DATE	ISSUE DETAILS	AUTHOR	CHECKED
A	04.01.2015	Issued for Approval	Brendan Oversby	
B	28.01.2015	Resubmission for Approval	Brendan Oversby	
C	26.08.2015	Resubmission for Approval	Brendan Oversby	
D	06.11.2015	Resubmission for Approval	Brendan Oversby	
E	28.07.2016	Resubmission for Approval	Brendan Oversby	

Calibre Consulting (Aust) Pty Ltd
Unit 5, 53 Victoria Street
Bunbury WA 6230

PO Box 733
Bunbury WA 6231

Tel: 08 9791 4411

© 2015

TABLE OF CONTENTS

EXECUTIVE SUMMARY	2
1. KEY ELEMENTS	4
2. ENVIRONMENTAL	6
3. GEOTECHNICAL INFORMATION	10
4. LANDFORM	12
5. SURFACE WATER (PREDEVELOPMENT)	14
6. GROUNDWATER PRE-DEVELOPMENT	16
7. DRAINAGE MANAGEMENT PLANS	18
7A. DRAINAGE MANAGEMENT PLAN - 1 IN 1 FLOOD	22
7B. DRAINAGE MANAGEMENT PLAN - 1 IN 5 FLOOD	24
7C. DRAINAGE MANAGEMENT PLAN - 1 IN 100 FLOOD	24
8. GROUNDWATER MANAGEMENT STRATEGY	28
9. WATER DEPENDENT ECO-SYSTEM MANAGEMENT	30
10. SUSTAINABLE WATER USE & SERVICING	32
11. MONITORING, MAINTENANCE & IMPLEMENTATION	34
REFERENCE	38

TABLES

TABLE 1 ON-SITE WETLANDS	6
TABLE 2 GROUNDWATER WATER LEVELS.....	17
TABLE 3 GROUNDWATER QUALITY	17
TABLE 4 1 YEAR 1 HOUR STORAGE AREAS.....	18
TABLE 4A ALLOWABLE FLOW	19
TABLE 5 RUN OFF COEFFICIENTS USED	20
TABLE 5A FLOWS	22
TABLE 5B STORAGE REQUIREMENTS	24
TABLE 6 POS IRRIGATION REQUIREMENTS.....	33
TABLE 7 WATER EFFICIENT DEVICES /CONSERVATION MEASURES.....	33
TABLE 8 DETAILED MONITORING & MAINTENANCE SCHEDULE.....	36

FIGURES

FIGURE 1 LOCATION PLAN	3
FIGURE 2 CONTEXT PLAN	3
FIGURE 3 KEY ELEMENTS PLAN	5
FIGURE 4 ENVIRONMENTAL CHARACTERISTICS	7
FIGURE 5 VEGETATION CONDITION PRIOR TO RECENT FILLING	8
FIGURE 6 VEGETATION TYPE PRIOR TO RECENT FILLING	9
FIGURE 8 ACID SULPHATE SOIL RISK	10
FIGURE 7 ENVIRONMENTAL GEOLOGY	10
FIGURE 9 GEOTECHNICAL INFORMATION	11
FIGURE 10 LIDAR MAPPING PRIOR TO FILLING	12
FIGURE 11 EXISTING LANDFORMS.....	13
FIGURE 12 REGIONAL DRAINAGE.....	15
FIGURE 13 SURFACE WATER	15
FIGURE 14 GROUND WATER	17
FIGURE 15 WATER TREATMENT CROSS SECTION FOR AREA NEAR WETLAND	19
FIGURE 16 BIO GARDEN CROSS SECTION	20
FIGURE 17 TYPICAL BIO GARDEN PERFORMANCE GRAPHS	21
FIGURE 18 1 IN 1 YEAR ARI WATER TREATMENT PLAN	23
FIGURE 19 1 IN 5 YEAR DRAINAGE MANAGEMENT PLAN	25
FIGURE 20 ORIGINAL JDA BALFOUR STREET DRAINAGE SYSTEM	26
FIGURE 21 1 IN 100 YEAR FLOOD EVENT PLAN	27
FIGURE 22A INDICATIVE SUBSOIL AND ROAD INVERTS -	28
FIGURE 23 SUBSOIL CONTROL EXAMPLE.....	29
FIGURE 22 POST DEVELOPMENT GROUND WATER MANAGEMENT PLAN.....	29
FIGURE 24 WATER DEPENDANT ECO-SYSTEM PLAN.....	31
FIGURE 25 WATER USAGE MODEL	33
FIGURE 26 LANDSCAPING PLAN	33
FIGURE 27 MONITORING PLAN.....	37

EXECUTIVE SUMMARY

This Local Water Management Strategy (LWMS) articulates the range of management practices that are being considered for the proposed subdivision of Lots 1, 2, 23, 24, Holmes Street and Lots 1600 and Part of Lot 1601 Balfour Street, Southern River. The LWMS supports the Outline Development Plan being undertaken for the site. For ease and clarity, this area will subsequently be referred to as the subject area. The proposed layout of the site, including lots are shown in *Figure 3*.

The LWMS is specifically for the above lots however, due to the related nature of the surrounding land, it takes into account water management issues for the entire related catchment. The site's relationship to the greater Southern River area can be seen in *Figure 1*.

The objective of this LWMS is to detail a development that manages the total water cycle in a sustainable manner. This includes water conservation, stormwater management, groundwater management and management of associated water dependent ecosystems. It also follows the water management strategies outlined in the Southern River integrated land and water management plan. A full summary of the water management strategies can be found in the Key Elements (Section 1). In brief the site will manage stormwater as per the design parameters of both the Holmes and Balfour drainage systems. Larger events will be detained within the on site wetland. Stormwater is to be treated through bioretention gardens. All lots are to be fully serviced and POS area will be irrigated from groundwater. Suitable protection of the wetland is also provided and enhanced through revegetation and setbacks.

SUBJECT LAND DETAILS

The subject land is situated in the locality of Southern River, within the municipality of the City of Gosnells. The subject land is located approximately 20 kilometres south-east of Perth and approximately 5 kilometres from the Gosnells City Centre.

The subject land is bounded by Holmes Street and Balfour Street, Lots 1604 and the remainder of Lot 1601. The subject land has a total area of approximately 17.56 hectares.

The subject land is zoned 'Residential Development' under the City of Gosnells Town Planning Scheme No. 6 (TPS No. 6).

Part of the subject land, as well as the adjoining areas on Lot 1601 and Lot 1604 is within Bush Forever Site No. 125, which is zoned Parks and Recreation under the Metropolitan Region Scheme.

The proposed development is predominantly for residential development, with two large areas given over for Wetland Conservation and Bush Forever.

The residential lots will consist primarily of R25 with some R40 Lots. The POS and Reserve areas maximise protection and enhancement of the wetland system on the subject land and adjoining lots. These wetland areas also assist with flood storage and natural drainage of the sites stormwater.

The subject land has previously been partly cleared with agricultural activities taking place. There are some areas of bushland (including wetland vegetation) present across the site which is in a range of condition from Completely Degraded to Excellent. Parts of the site have recently been filled with clean sand.

The land is currently drained through a series of shallow spoon drains and surface sheet flow which discharge water into and through the onsite wetland and eventually into the Balfour Street Drain. This then drains to the Sutherland Drain and ultimately the Southern River.

The wetland system covers the middle sections of the subject land and interconnects with a broader wetland chain to the north and south. These wetlands have been classified as Multiple Use, Resource Enhancement and Conservation Category.

The key water management aspects relating to the subject land are detailed in the following Key Elements section. The Key Elements section summarises the design elements being adopted for the proposed development to comply and achieve the required design objectives for total water cycle management.

SUPPORTING DOCUMENTATION

The LWMS designs and models were compiled using information contained within the detailed assessments and reports undertaken for the subject land, they are listed below:

- Proposed Outline Development Plan Southern River Precinct 2 – Phase 3 Lots 1-4 , 1600 And Pt Lot 1601 Balfour And Holmes Street, Southern River. RPS
- Wetland Management Plan Lots 1-4 Holmes Street and Lot 1600 Balfour Street, Southern River. Endemic
- Lots 1-4 Holmes St and Lots 1600 and Pt Lot 1601 Balfour St, Southern River Flora and Vegetation Survey and Wetland Assessment. Cardno BSD
- Lots 1- 4 Holmes St and Lots 1600 &1601 Balfour Street, Southern River Review of Groundwater Levels
- Lots 1- 4 Holmes St and Lots 1600 &1601 Balfour Street, Southern River Conceptual Stormwater Modelling
- Lots 1,2,3,4 and 1600 Balfour Street Southern River Western Australia Geotechnical Investigation. Brown Geotechnical and Environmental
- Southern River integrated land and water management plan. Department of Water



Figure 1 - Location Plan

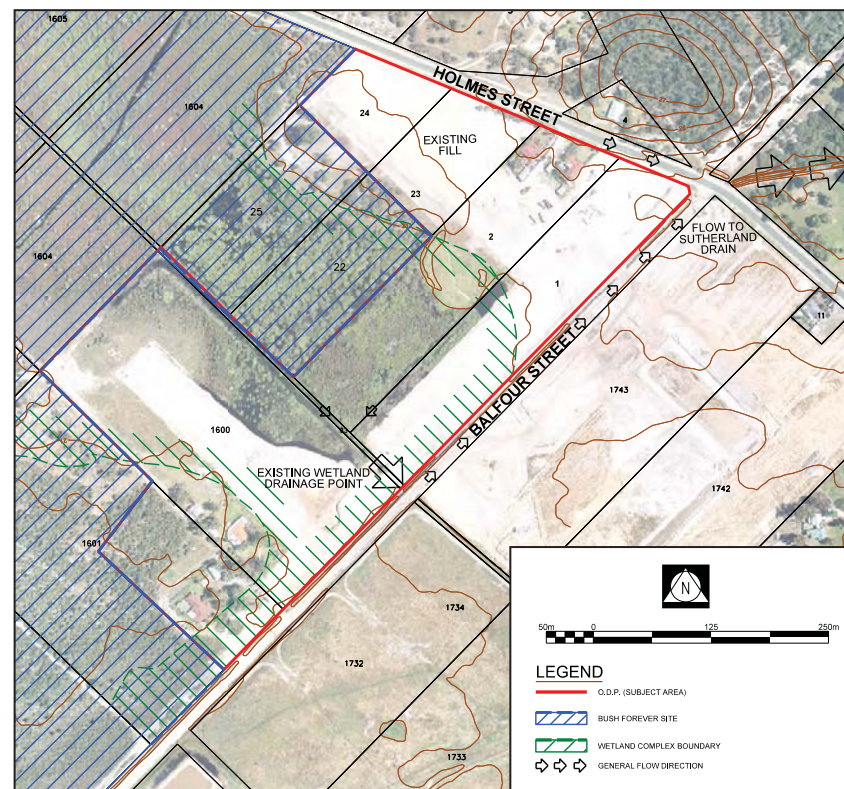


Figure 2 - Context Plan

1. KEY ELEMENTS

Water management for the proposed subdivision of the subject land is based on best practice water sensitive urban design. This is achieved through maximising the sustainable use of water through the encouragement of water conservation and efficiency measures, managing stormwater to irrigate bioretention gardens and recharge groundwater while controlling the flow of large storm events, managing the water quality reaching the area's significant ecosystems, as well as protecting and enhancing the sites wetlands.

A summary of the design elements and compliance with the best management practices objectives are outlined below with more detail provided in the sections that follow.

SUMMARY OF DESIGN ELEMENTS AND COMPLIANCE

WATER CONSERVATION

- The State Water Plan target of 100 KL per person per annum has been set for the subdivision.
- Encouragement of water efficient fixtures and fittings for all buildings constructed. Data suggests that a household on average per annum could save between 31 and 46 KL inside the house alone using adequate water efficient appliances and fixtures.
- Lot owners will be encouraged to install a minimum 3,000 litre rainwater tank that is plumbed into the toilet and laundry. The tank could reduce the quantity of mains potable water required for gardens and other outdoor purposes by 30KL per annum.
- Provision of awareness raising material on water saving measures and benefits for new residents, including Waterwise information booklets.
- Public open spaces and street landscaping will have a strong focus on using suitable local native Waterwise species and the retention of existing remnant native vegetation which require minimal irrigation.

FLOOD PROTECTION

- Finished floor levels are to be a minimum of 300mm above the kerb level and 500mm above the 1:100 ARI flood level of the adjoining wetland.
- The drainage network (designed for 1:5 ARI) will flow at capacity during the 1:100 ARI flood event and excess water will be directed down the road reserves to protect houses. Flows will be directed to the POS wetland area in the middle of the subdivision as well as onto Holmes and Balfour Street as currently happens in the pre development state. The POS area and associated wetland system, will store part of the 1:100 ARI flood event and help control the flow off the site onto Balfour Street and its drain.

STORMWATER MANAGEMENT

- Bioretention gardens and associated road batters are to be installed within the road reserves of the site. These will store and treat all flows up to the 1 year 1 hour 1:1ARI storm event.
- Soak wells, will be utilised for excess roof runoff for lots above 350m². A shared lot connection is to be supplied to all lots 350m² and less.
- Shallow swales/basins will hold and infiltrate flows up to and including the 1:5 ARI event around the central wetland. Perimeter catchments will discharge their flows above the 1:1 to the Holmes and Balfour Street drains at the rates set by previous modelling.

- All lots will manage the 1 in 20 year 5min ARI within the lot.
- The wetland system on site and on adjoining properties will assist with containing and releasing stormwater from events above the 1:5 ARI.
- Sediment and erosion management plans are to be produced and implemented in relation to construction works.

WATER QUALITY

- Water sensitive urban designs are to be installed including bioretention gardens and swales. These will remove sediments, large debris and nutrients from all stormwater generated within the road reserve.
- The public open space landscaping will focus on utilising native species with low nutrient requirements to reduce nutrient leaching.
- Households will be informed regarding nutrient wise garden practices, and be given packages to educate themselves about minimising lawn area and construction of Waterwise and nutrient wise gardens.

GROUNDWATER MANAGEMENT

- Groundwater levels will be maintained to the pre-development state through the use of subsoil piping set at the AAMGL.
- The function performed by the outlet drain from the central wetland to Balfour Street in controlling peak groundwater (and wetland) levels will be maintained by a piped outlet set at the same invert level. This will allow for groundwater levels to be maintained at their current AAMGL.
- Fill is to be used to maintain appropriate separation from the groundwater level to necessary infrastructure, with a minimum of 500mm clearance provided after mounding during 1:5 ARI events.
- Subsoils are to incorporate a filter media to treat inflowing groundwater for pollutants, including nutrients hydrocarbons and excessive metals.

ECOSYSTEM MANAGEMENT

- The site's wetland systems will be protected and enhanced through an appropriate buffer system including revegetation with appropriate native species.
- Stormwater will be treated and infiltrated on site to allow for maintenance of the groundwater level and quality that currently feed the wetland.

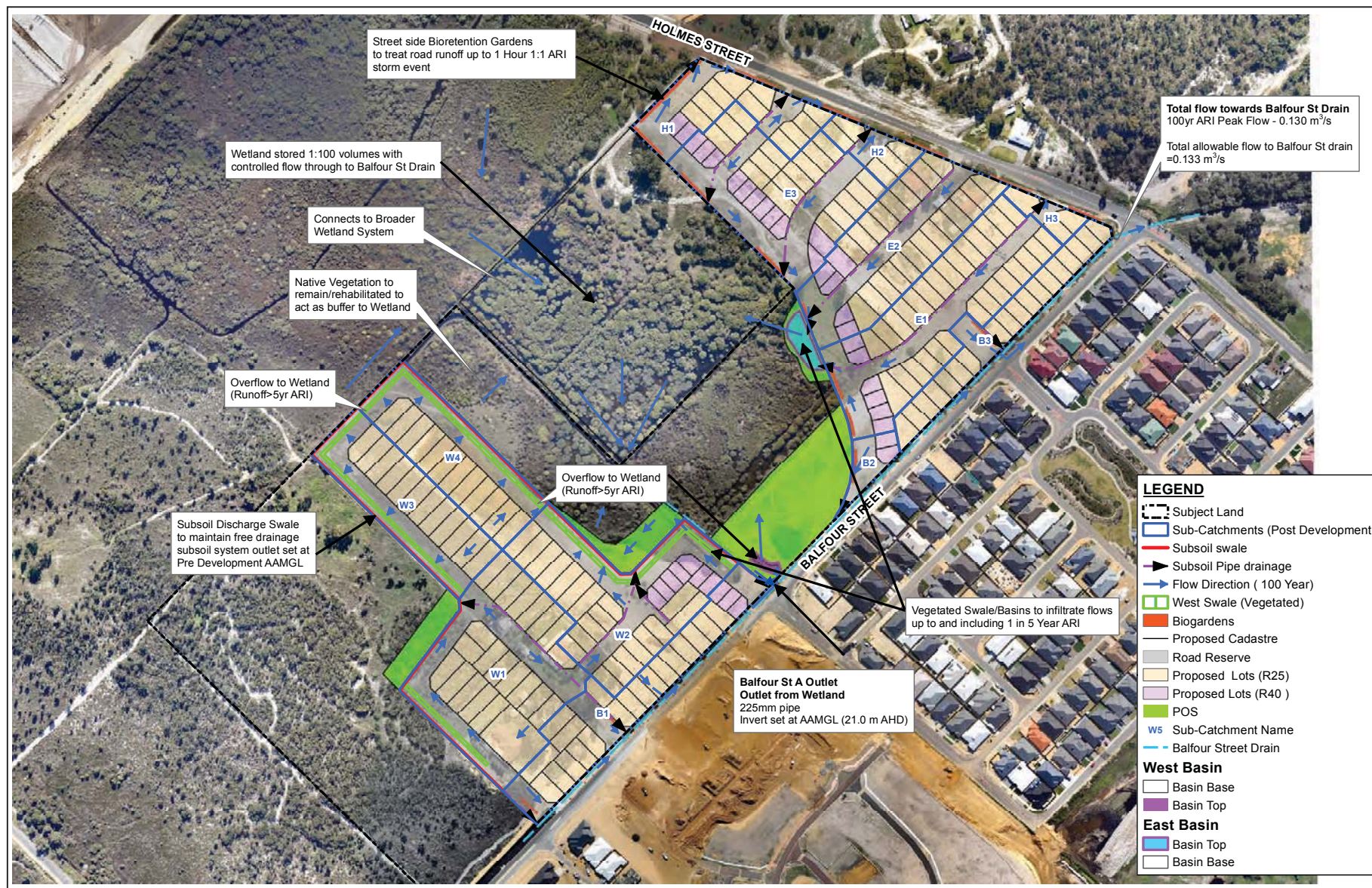


Figure 3 - Key Elements Plan

2. ENVIRONMENTAL

A Flora and Vegetation Survey and Wetland Assessment: Lots 1-4 Holmes St and Lot 1600 and Pt Lot 1601 Balfour St, Southern River was undertaken by Cardno BSD in 2007. This included both autumn and spring surveys. It is recognised that some of the condition assessments in this report are not fully supported by the City. However later reports (see below) address the management of environmental matter in more detail. The condition assessments have changed due to works on site since 2007.

Further management strategies for the site were then outlined in the Wetland Management Plan Lots 1-4 Holmes St and Lot 1600 Balfour St, Southern River, which was written by Endemic in 2008 and updated in 2010. This report has been used to determine appropriate management of the wetland area rather than relying solely on the Cardno report. The following is a summary of this information as well as a site visit undertaken by Calibre Consulting.

Large portions of the site have historically been cleared or partly cleared then grazed by stock, which has resulted in degradation of the vegetation. The condition of the vegetation prior to filling can be seen in *Figure 5*. The subsequent fill areas have had all vegetation removed. The better quality vegetation tends to be in Lot 1601 (including areas outside of the original vegetation surveys) and the wetland system through the middle of the site.

WETLANDS

A wetland system occurs on the site that is composed of a number of different wetlands as defined by DPaW. These are outlined in *Figure 4* and *Table 1*.

This wetland system continues to the north west of the site on adjoining lots. This area is also part of Bush Forever Number 125.

WATERWAYS

There are no natural waterways on site.

Surface water discharges from the site via a shallow open drain network to the Sutherland Park Branch Drain System that then flows to Southern River and eventually the Swan Canning system. The Southern river is an seasonal flowing system that is known to experience poor water quality, mainly from high nutrient loads, from time to time.

FLORA

91 taxa were identified during the three site surveys, of which 50 were native species.

No Declared Rare Flora were located. The only Priority Flora noted was *Jacksonia sericea* which was located in Lot 1601 and out of the wetland habitats.

4 main plant communities occur on the site, two mainly composed of native species and two that have been cleared and developed for rural pursuits.

The following two communities are associated with the wetland habitats. These are:

S1 Community - Thicket to Shrubland of *Melaleuca raphiophylla* over *M. incana subsp incana* and *M. teretifolia* over *Lepidosperma longitudinale* and *Juncus pallidus*.

R2 Community - Composed of pasture grasses with isolated *Melaleucas*. This area has historically been heavily grazed.

These areas can be seen in *Figure 6*, shows the site conditions prior to fill being applied.

FAUNA

There are no dedicated fauna studies for the site however the wetland assessment has covered element of likely fauna present.

Species likely to be associated with the wetland habitats on site include :

Amphibians - *Crinia Georgiana* (Quacking Frog), *C glauert* (Glauert's froglet), and *C. insignifera* (Sign bearing frog)

Reptiles - *Cryptoblepharus plagioccephalus* (Skink), *Lerista elegans* (Four toed leristas), *Menetia greyii* (Skink), *Tiliqua rugosa* (Shingleback), *Lialis burtonis* (Burton's legless lizard), *Morethia obscura* (Skink) and *Acritoscincus trilineatum* (Skink).

Mammals – *Isodon obesulus fusciventer* (Quenda), (Western Brush Wallaby), (Water Rat) and to a lesser extent the (Western Grey Kangaroo), *Chalinolobus gouldii* (Gould's Wattled Bat) and *Nyctophilus geoffroyi* (Lesser Long-eared Bat)

Birds – Australasian Grebe, Pelican, Eurasian Coot, Purple Swamp Hen, Little Black Comorant, Little Pied Cormorant, White Necked Heron, White Faced Heron, Nankeen Night Heron, Straw Necked Ibis and Australia White Ibis. Some other more terrestrial species may also use the wetland habitats during dry periods.

Bush Forever Site 125, which extends into the subject site, has been identified as an important breeding site for waterbirds including the Freckled Duck.

Wetland Number	Classification	Vegetation Condition/ Community
14280	CCW	Degraded (Lots 3 & 4), Excellent and Good (Lot 2). S1 Community
13985	REW	Degraded. S1 Community
13986	REW	Good. S1 Community
13987	REW	Completely Degraded. R2 Community

Table 1 - On-site Wetlands

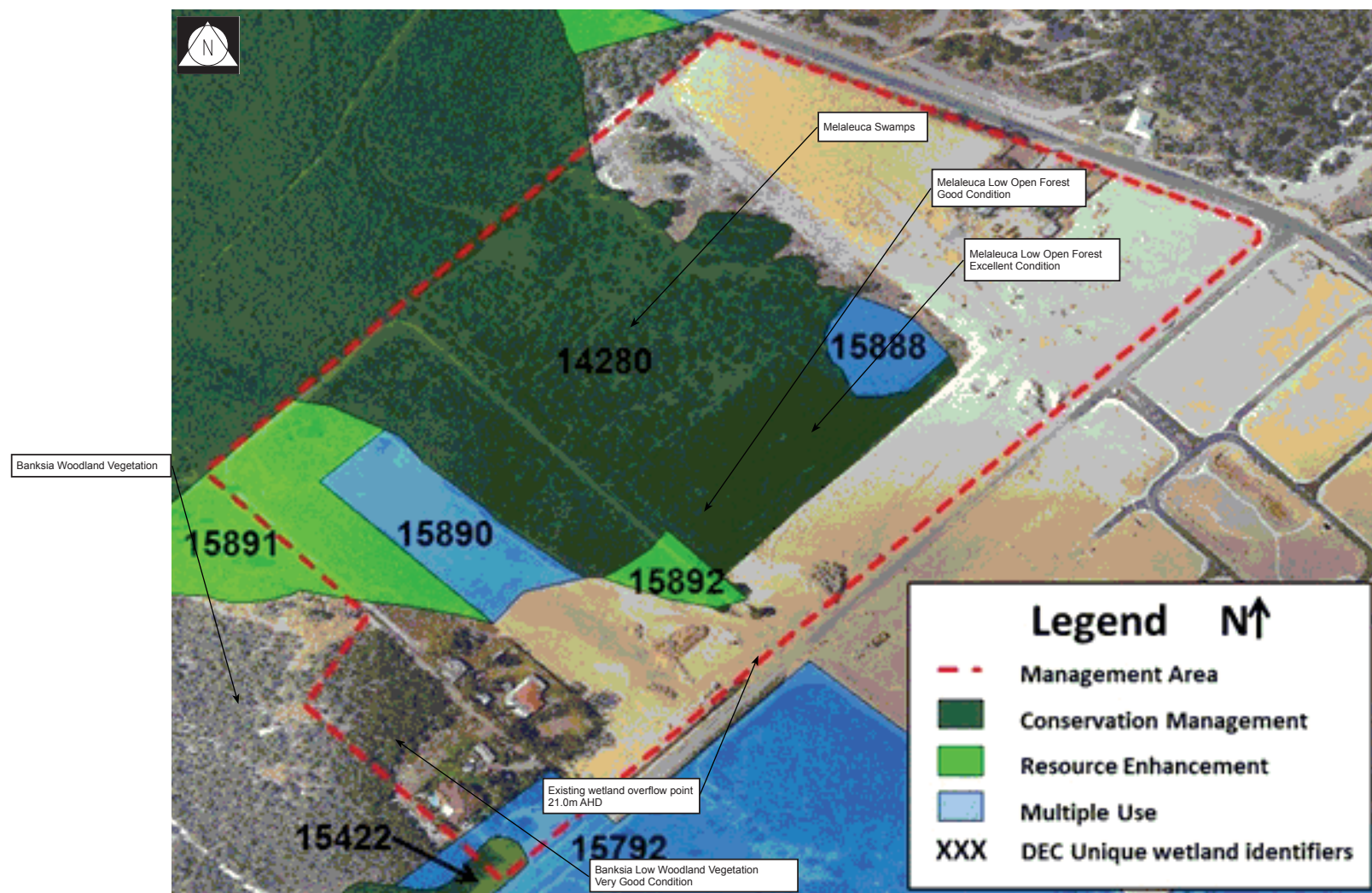
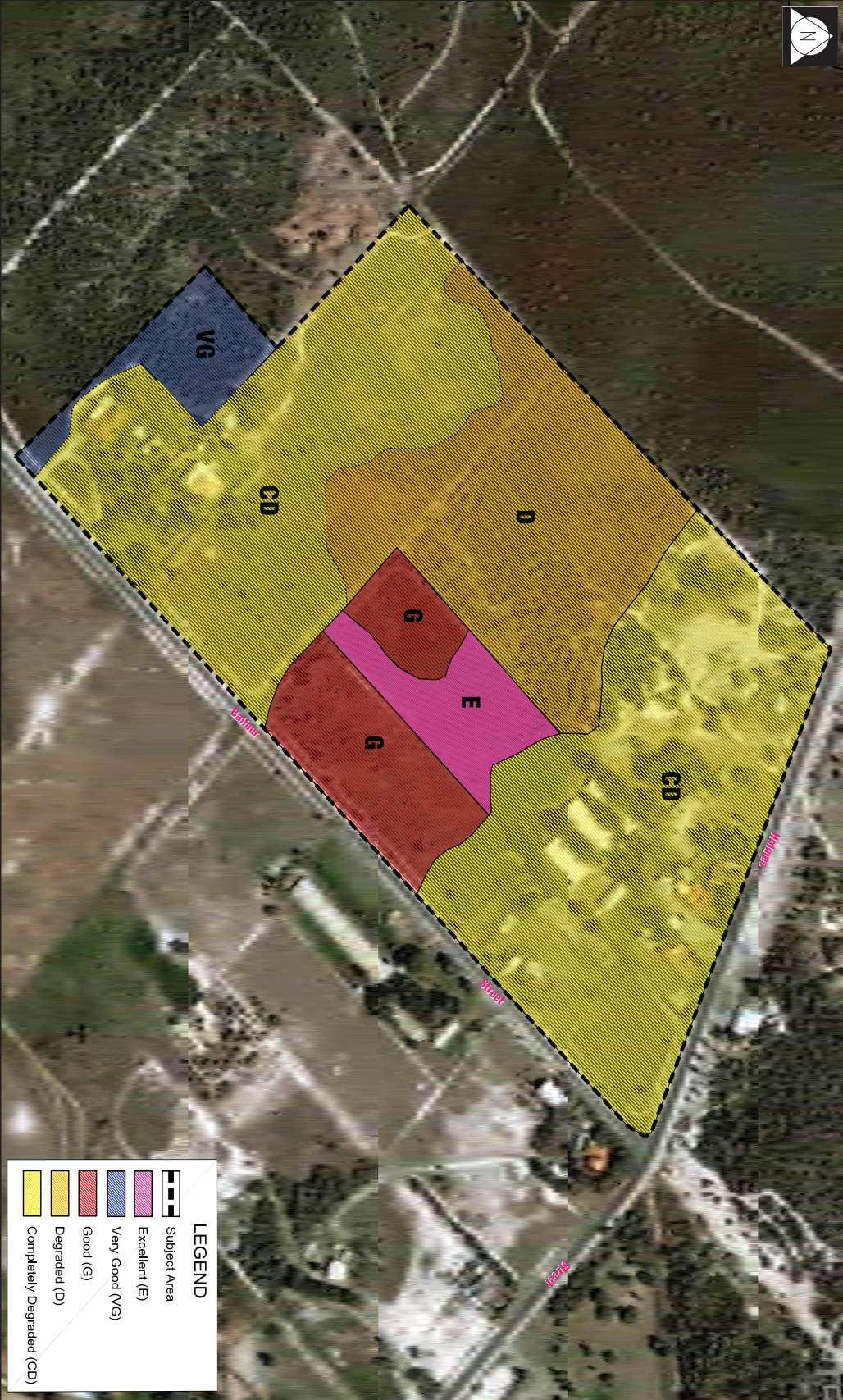


Figure 4 - Environmental characteristics



(Original Information, Cairns 2007)/Re Referenced from Wetland Management Plan, Lot 1-4 Holmes St & Lot 1600 Balfour St, Southern River, 2015)

Figure 5 - Vegetation Condition prior to recent filling



(Original Information, Cardno 2007)(Re Referenced from Wetland Management Plan, Lot 1-4 Holmes St & Lot 1600 Balfour St, Southern River, 2015)

Figure 6 - Vegetation Type prior to recent filling

3. GEOTECHNICAL INFORMATION

Geotechnical investigations were undertaken by Brown Geotechnical and Environmental Pty Ltd. The results were outlined in the report Lots 1,2,3,4 & 1600 Balfour Street Southern River Geotechnical Investigation. Field tests were undertaken on the 22nd and 23rd January 2008. 35 test pits were excavated using a 5 tonne excavator to a maximum depth of 2.9m. The investigations were undertaken prior to the majority of the fill being laid.

A second investigation was undertaken to determine permeability of the fill sand on the 23 July 2010 by TME.

LOCAL AND REGIONAL GEOLOGY

The environmental Geology sheets for the area indicate Bassendean Sands as well as deposits of peaty sands.

SOIL TYPES

The field studies showed the site to be generally underlain by a thin layer of topsoil, which is predominately grey sand with some roots. Under this there is a medium dense to dense grey sand of medium grain to approximately 1m depth. Below 1m there are areas where thin horizons of silty sand and gravel occur.

In the south west corner of the site and adjacent to the Bush Forever area there are soils composed of sand with gravel and/or silt over sandy clay/clayey sand below 1.5m.

There were isolated patches of coffee rock encountered across the site at depths from 1m to 2.4m.

ACID SULPHATE SOILS

No acid sulphate soil testing has been undertaken

Department of Environment and Conservation ASS mapping of the site indicates a low to moderate risk for the top 3m of the soil profile for the northern and southern parts of the site where the sand rises are located. A moderate to high risk is indicated for the middle of the site, which corresponds to the wetland area.

Further investigation may be needed in areas where excavation will take place below the groundwater, or dewatering is to be undertaken.

SITE CLASSIFICATION

The sandy nature of the site gives the majority of the site a classification of Class A. A small area of Class S has been identified in the southern corner. This can be brought up to Class A using appropriate fill and laying methods.

PHOSPHORUS RETENTION INDEX:

The Phosphorus Retention Index for the sites soils was not tested. It is likely to be low based on the soil type of Bassendean sands.

INFILTRATION/PERMEABILITY

The sand fill on site has a permeability of between $5.09 \times 10^{-5} \text{ m/s}$ and $8.88 \times 10^{-5} \text{ m/s}$ (4.39 to 7.66 m/d). This is adequate for seepage from soakwells. The location of the permeability test pits can be seen in Figure 9. (Page 3 of permeability report with the result of each underneath)

FILL CHARACTERISTICS

Since the completion of the first Geotechnical Investigation, fill has been laid over parts of the subject land. This fill is composed of clean sand and is on average 1.2m deep.

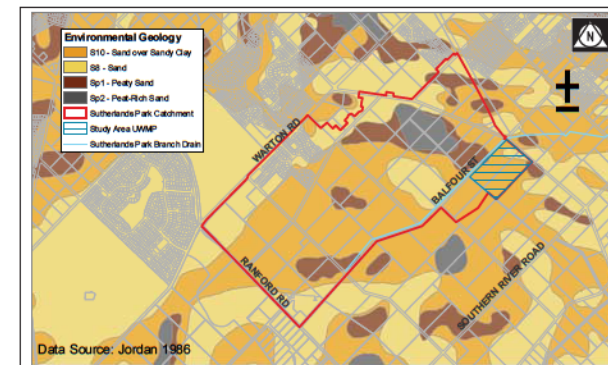


Figure 7 - Environmental geology

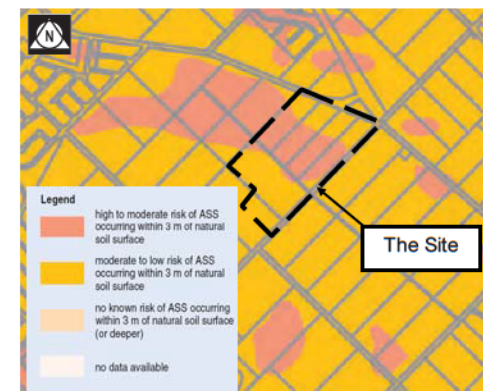


Figure 8 - Acid Sulphate Soil Risk

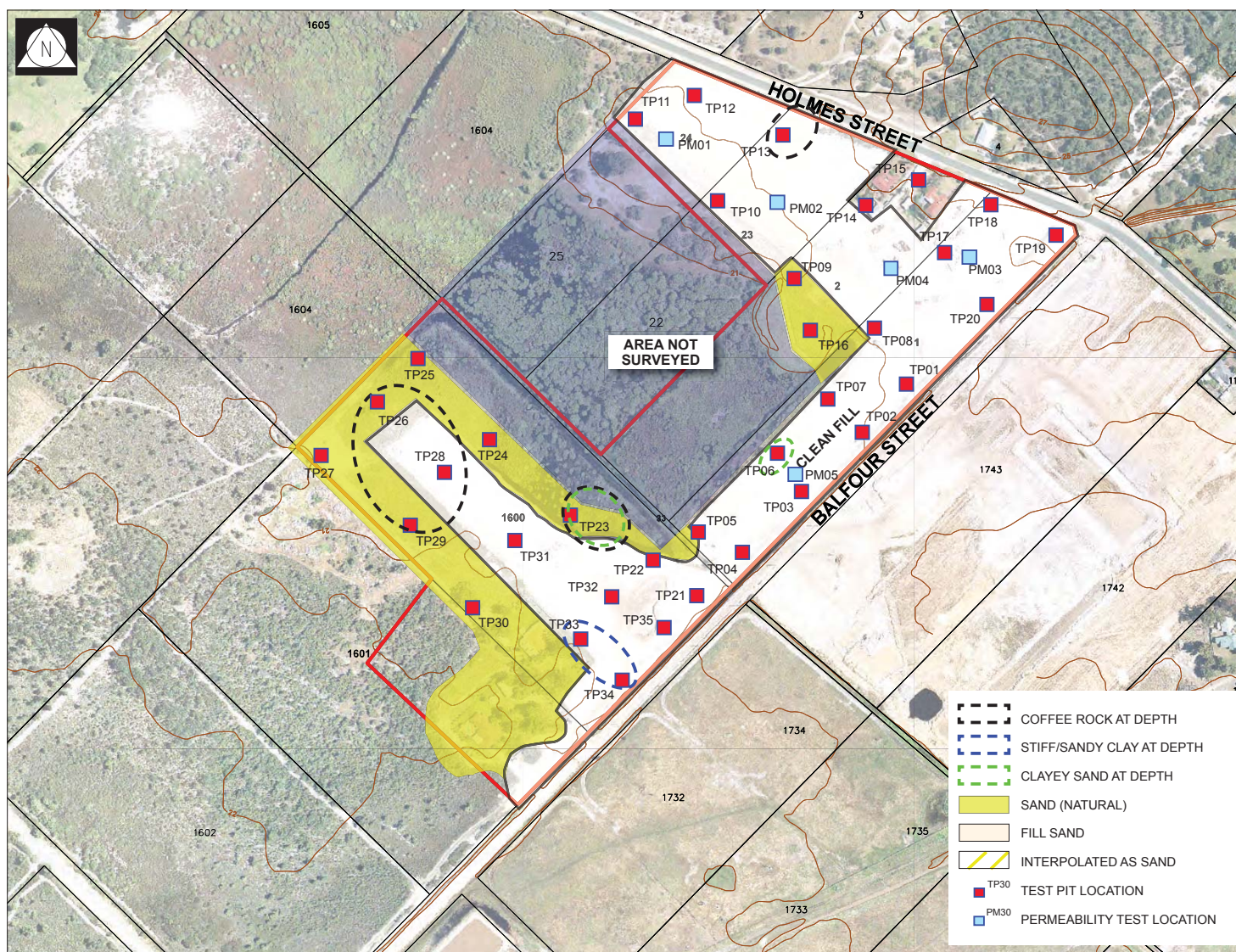


Figure 9 - Geotechnical Information

4. LANDFORM

The subject area is composed of two main landforms, seasonal wetlands and sand rises.

A natural sand rise occurs along the north – north east section of the site. Prior to fill this was approximately 23m AHD in height. The majority of this sand rise is now covered with sand fill with an average height of 23 -23.5m AHD,

Another small sand rise is located within Lot 1600 and 1601 with a maximum height of approximately 22m AHD. A thin portion of Lot 1601 now contain sand fill, with the fill height being 23.5m AHD.

The central portion of the site is a seasonally inundated wetland. This wetland is relatively flat in nature with an average height of 20.5m AHD. The lowest point is around 19.8m AHD. The wetland continues to the north west at a similar height.

The slopes between the wetland edges and the top of the sand rises are mainly between 1 and 5%.

The location of the sites landforms can be seen in *Figure 11*.

The sand rises will tend to have low runoff rates due to the soil type and flat nature. The run off rates for the wetland will be low until the groundwater has risen to the surface, due to the very flat nature and sandy soils of this landform. Once the wetlands are inundated, the flow rate will increase, however it is controlled by the exit drain on site. The majority of rainfall that falls on the inundated wetland will flow from the wetland to the drain during these periods of inundation.

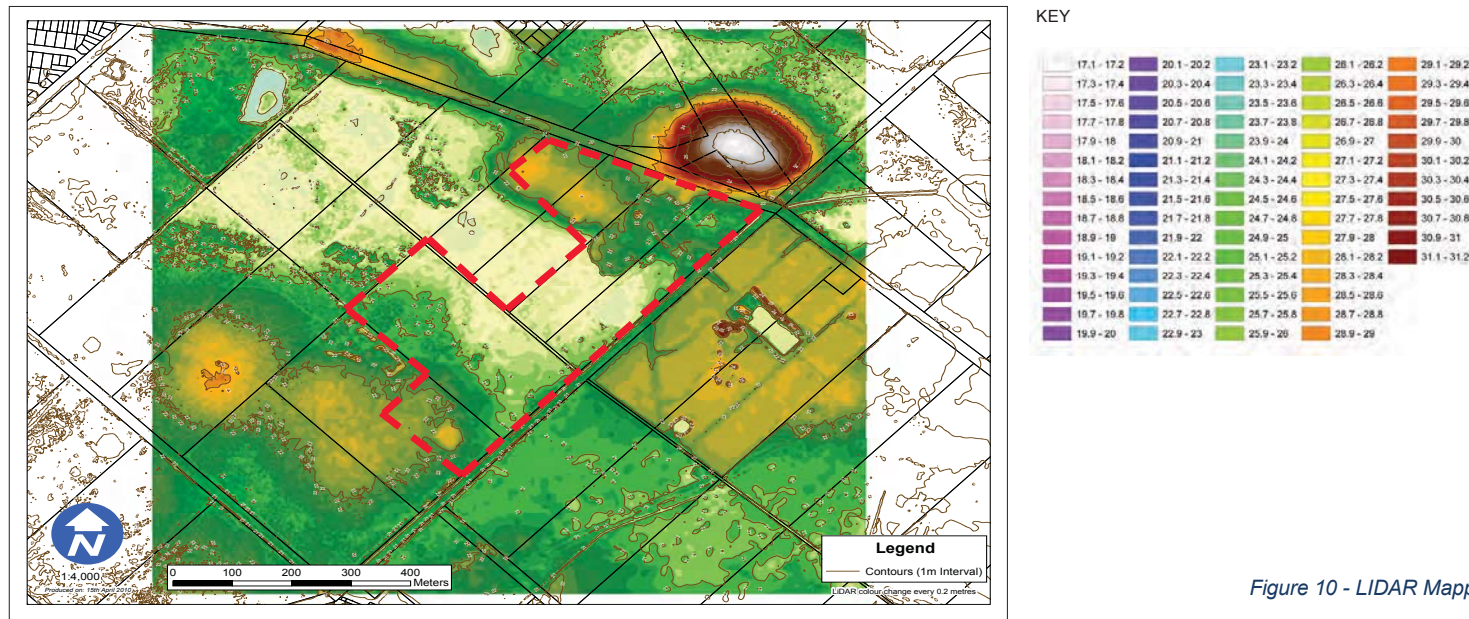


Figure 10 - LIDAR Mapping prior to filling

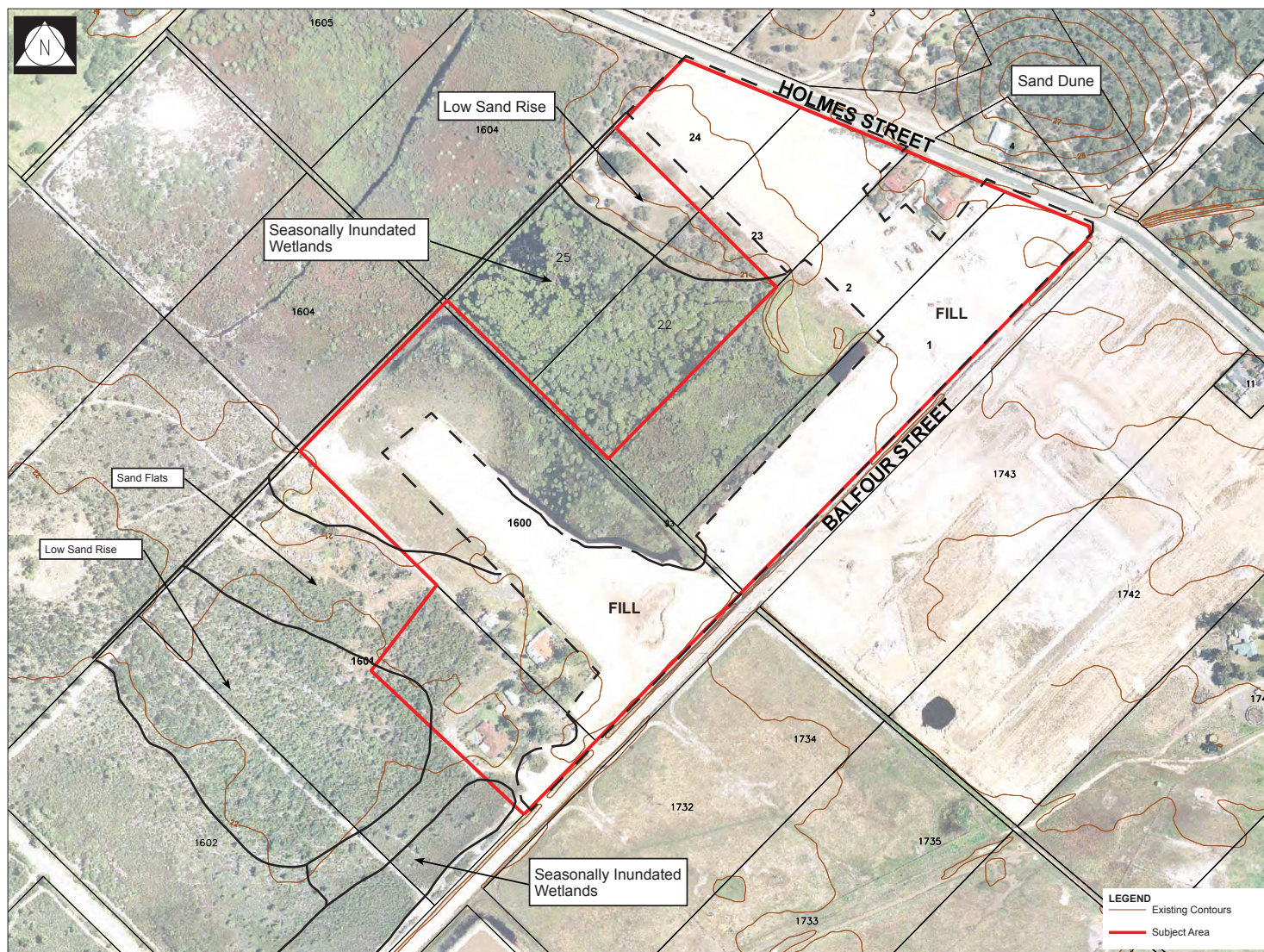


Figure 11 - Existing Landforms

5. SURFACE WATER (PREDEVELOPMENT)

Drainage analysis was undertaken by JDA as part of assessment of the capacity of the Balfour St and Sutherland Park Drains. This work was further refined for the structure plan area and summarised in the Lot 1-4 Holmes St and Lots 1600 and 1601 Balfour St, Southern River Conceptual Stormwater Modelling (attached). The report investigated pre development runoff and the current capacity of Balfour Street Drain. The modelling included both INFIL and XP-STORM.

The following is a summary of this information and on site assessments in relation to the pre development scenario for the subject land.

Much of the rainfall that currently falls on the site percolates through to the groundwater. This means that there is initially little surface runoff from the site. Once this groundwater rises to the surface in the middle of the site, in the form of a wetland, it can potentially exit via a control pipe to Balfour Street. There is also some minor runoff onto the swale drain along Holmes Street and directly to Balfour Street.

The Balfour Street Drain enters the Sutherland Park Drain before eventually connecting to the Southern River. This can be seen in *Figure 12*.

There are 3 main sub-catchments within the subject land area.

Sub-catchment 1 flows to Holmes Street directly.

Sub-catchment 2 flows to Balfour Street directly

Sub-catchment 3 flows into the wetland complex.

Indicative catchment boundaries can be seen in *Figure 13*.

SUB-CATCHMENT 1

This sub-catchment flows off the sand rise created by the on site fill and natural features to Holmes street directly. This is a thin catchment that stretches almost parallel to Holmes Street. Water that enters the swale along Holmes Street either infiltrates or flows south eastward and into the Balfour Street drain.

SUB-CATCHMENT 2

This sub-catchment has also been created by the introduction of fill, which loosely follows the original contours of the site. Flows from this area discharge to the Balfour Street reserve, before entering the recently installed drainage pits of the Balfour Street Drain.

SUB-CATCHMENT 3

This is the largest catchment on the site. The majority of the site flows directly into the central wetland complex. There is some overland flow after extreme events from the south western side of the fill and subject area that heads north into the wetland complex in Lot 1604. This is the same wetland complex as located on the subject land. Once the water in the wetland reaches 21mAH_D, it discharges to the Balfour drain via a 225mm drainage pipe.

A number of shallow spoon drains cross this wetland complex, which assist with moving water across the wetland to the drain outlet.

SURFACE WATER FEATURES

The main surface water feature on site are the wetlands including two Conservation Category Wetlands, three Resource Enhancement Wetlands and two Multiple Use Wetlands. These wetlands in effect act as one wetland complex. The wetland boundaries can be seen in *Figure 4*. The total wetland boundary can be seen in *Figure 2*. These are all seasonal wetlands.

There are also a number of small constructed drains, which traverse the wetland area before discharging to the Balfour Street Drain. Their location can be seen in *Figure 13*.

SURFACE WATER QUALITY

No quality data has been collected from the site. The lack of waterways means that the only surface water, except for during storm events, is the wetland. This is connected directly to the regional groundwater and is therefore likely to have a similar quality to that shown in *Table 3*. Pre development information needs to be collected prior to the production of the UWMP.



Drain from wetland to Balfour Street

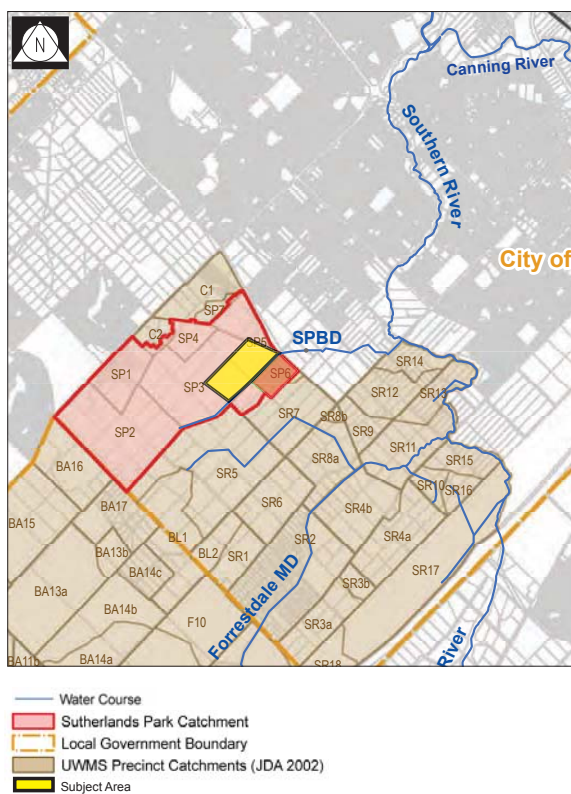


Figure 12 -Regional Drainage

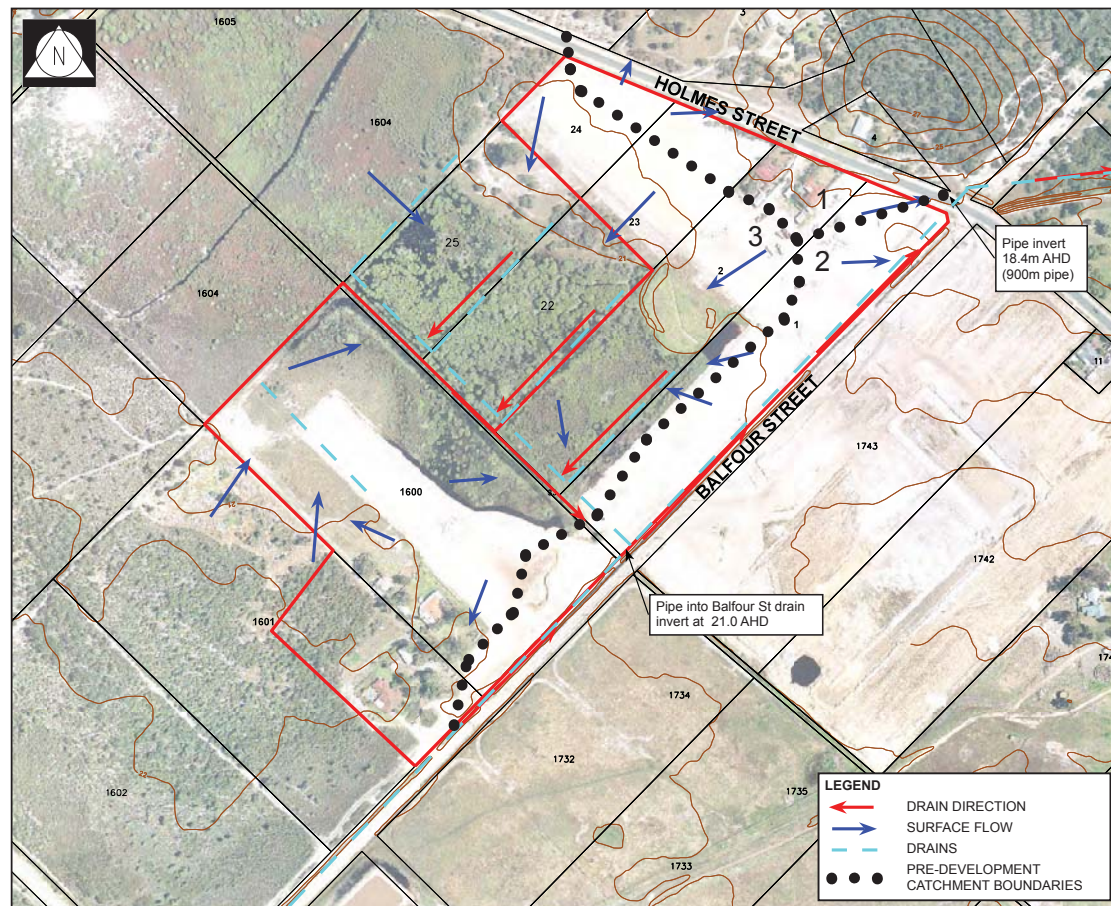


Figure 13 -Surface Water

6. GROUNDWATER PRE-DEVELOPMENT

SHALLOW SUPERFICIAL AQUIFER

Groundwater Monitoring of the superficial aquifer has been undertaken for the subject land area and the adjoining Lots 1742 and 1743 to the south east. This monitoring and analysis of the AAMGL was undertaken by JDA.

7 bores were installed in September 2008 on the subject land to a depth of around 5m and have been monitored over two years. The bore field can be seen in *Figure 14*.

LEVELS AND AAMGL

Monitoring data collected over two years was analysed in reference to longterm Department of Water Bores. The effect of the site's landforms and drains was also considered.

Analysis of the longterm data suggested that the 2 years of monitoring were slightly drier than average which may suggest that the groundwater levels may be higher in an average year. However the groundwater is more likely controlled by the on-site drain which allows for water in the wetland to exit to the Balfour Street drain (invert at 21m AHD). Given that in both years the groundwater for the site caused inundation of the wetland and flowed out through this drain, it is likely that the results recorded in both years are close to the maximum level for the site. Groundwater is unlikely to rise higher as it would generally run offsite through the open drainage system.

Table 2 shows a summary of the AAMGL levels for each bore on the site and its relationship to the surface of the site. The depth varies from 2.22m below the surface to ponding above the ground in the wetland areas.

The AAMGL falls from just over 21m AHD through the wetland and to the west and south of the site to just below 20m AHD in the north east corner close to the Balfour Street Drain. For most of the site the contours are very flat. This is due to the wetland feature over the majority of the portion of the site and the influence of the small surface drain which controls the wetlands level. There is however a localised decline in the contours in areas near the Balfour Street drain as can be seen in *Figure 14*.

Groundwater levels were also recorded as part of the Geotechnical studies for the site. The results from the geotechnical study support the information found in the long term groundwater monitoring program.

Minimum groundwater levels were also recorded and are outlined in *Table 3*.

QUALITY

As part of the groundwater monitoring, a range of quality parameters were recorded. The following is a summary of the results from the subject land. Full details can be found in the CD of attachments. Further monitoring that identifies the predevelopment organic nutrient status is to be undertaken prior to the UWWP being produced.

pH

The pH tends to fluctuate between acidic (4.6) to almost neutral (6.85). This may indicate Acid Sulphate soils (ASS). It is recommended that further investigation be undertaken into ASS as part of future planning for the site. There was no general trend in pH levels between bores or throughout the season except for a general rise in pH between May 2008 and September 2008, with another rise between March 2009 and May 2009.

ELECTRICAL CONDUCTIVITY

Electrical Conductivity was used as a reference for salinity. The conductivity for all bores other than H3 was fairly consistent throughout the monitoring period. For these bores the values fluctuated between 0.21mS/cm and 2.04mS/cm. Bores H4 and H7 tended to have the lowest readings through the sampling period. These conductivities are in the fresh to brackish category.

Bore H3 had significantly higher readings at every sampling period, with its conductivity ranging from 2.86 through to 20.08mS/cm which makes it brackish to saline.

NUTRIENTS

The nitrogen levels were generally above the recommended levels of 1.0mg/L for Total Nitrogen with only 6 readings below or at 1mg/L (all in different bores). Nitrogen levels peaked at 11mg/L in bore H6 with most levels around 2-3mg/L. There was no clear trend in levels throughout the year or between bores.

Phosphorus levels were also generally above the recommended level of 0.1mg/L for Total Phosphorus, which has been set out in the Swan Canning WQIP. Bores H1, H5 and H7 tended to have levels around 0.1 to 2mg/L, while Bores H4 and H6 generally recorded higher levels between 2.4 and 6.9mg/L. Bore H2 was generally less than 1.1mg/L but did have a spike of 7mg/L once. The only bore that was consistently below the 0.1mg/L was H3 which fluctuated between <0.01 and 0.07mg/L. These values may suggest that the site's groundwater is being affected by past and current agricultural activities on the cleared farm land, both from the subject land and surrounding areas. The nutrients are most likely moving within the groundwater and through the wetland system.

SUPERFICIAL AQUIFER ALLOCATION

The superficial aquifer in this region has some allocation available. As at July 2010 the allocation available was approximately 200,000 Kl. As can be seen from the above data, the water quality may not be suitable for domestic use without further treatment.

DEEPER CONFINED AQUIFERS

The Department of Water provided the following information on the deeper aquifers located under the subject land.

Leederville aquifer: The Leederville is represented by the Perth South Confined Sub-area at this site. It tends to be around 700m in thickness and is located below the superficial aquifer which generally extends to around 29m deep. The aquifer is currently over allocated.

Yarragadee Aquifer: The subject land is located in the Perth South Confined North Yarragadee sub area. The aquifer is approximately 3000m thick and is located below the Leederville. This aquifer is also over allocated.

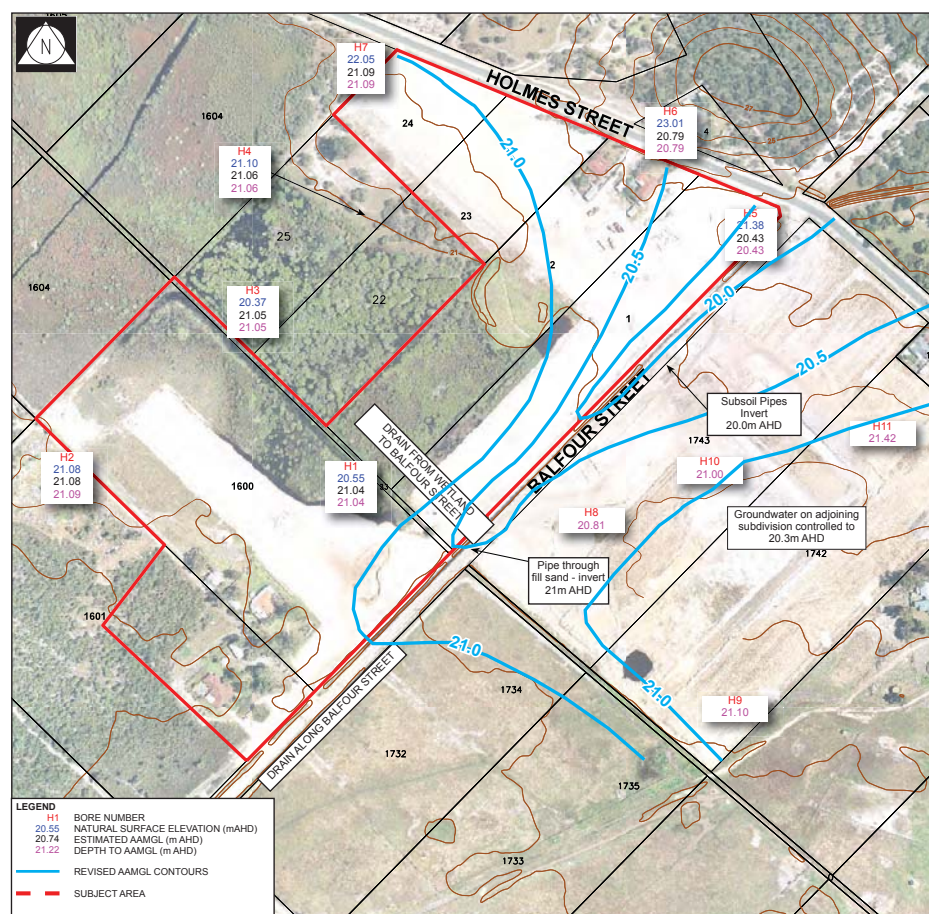


Figure 14 - Ground Water

Bore	Natural Surface level (mAHD)	Estimated AAMGL (mAHD)	Depth to AAMGL(m)	Depth to deepest recorded water level (m)
H1	20.55	21.04	Ponding above surface	1.80
H2	21.08	21.08	At natural surface	2.43
H3	20.27	21.05	Ponding above surface	2.54
H4	21.1	21.06	.04	2.48
H5	21.35	20.43	.95	2.9
H6	23.01	20.79	2.22	4.57
H7	22.05	21.09	.96	3.65

Table 2 - Groundwater Water Levels

Bore	Electrical conductivity (mS/cm)		pH		Total N (mg/L)		Total P (mg/L)		Total Suspended Solids (mg/L)	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
H1	0.41	1	5.4	6.85	0.07	9.4	0.16	0.47	150	230
H2	0.28	2.04	4.65	6.45	1.5	9.1	0.58	7	9	960
H3	2.86	20.08	4.97	6.29	0.47	4.1	0.01	0.07	160	900
H4	0.16	0.27	5.1	5.86	0.6	3.3	3.7	6.9	110	120
H5	0.19	1.16	4.6	5.56	0.83	9.1	0.09	2	16	210
H6	0.31	1.14	5.59	6.24	0.86	11	3.1	6.3	20	530
H7	0.21	0.32	5.06	5.8	1	2	0.38	1.4	21	78

Table 3 - Groundwater Quality

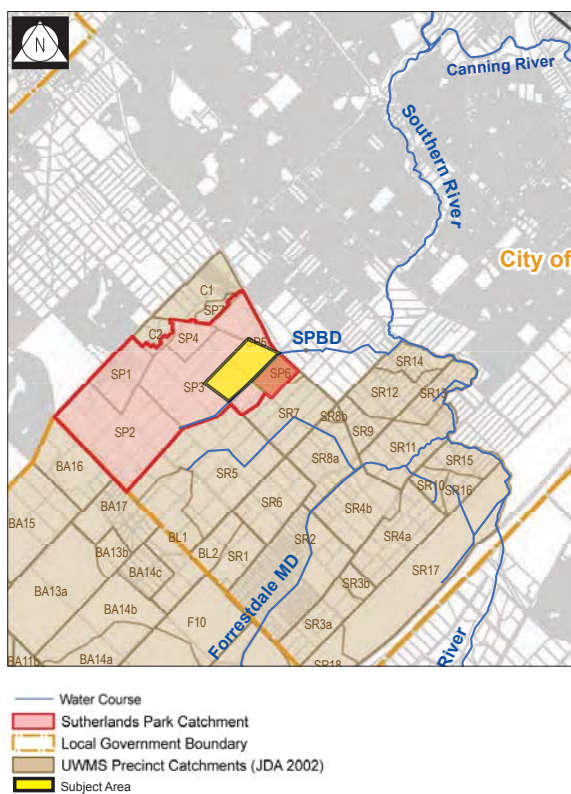


Figure 12 -Regional Drainage

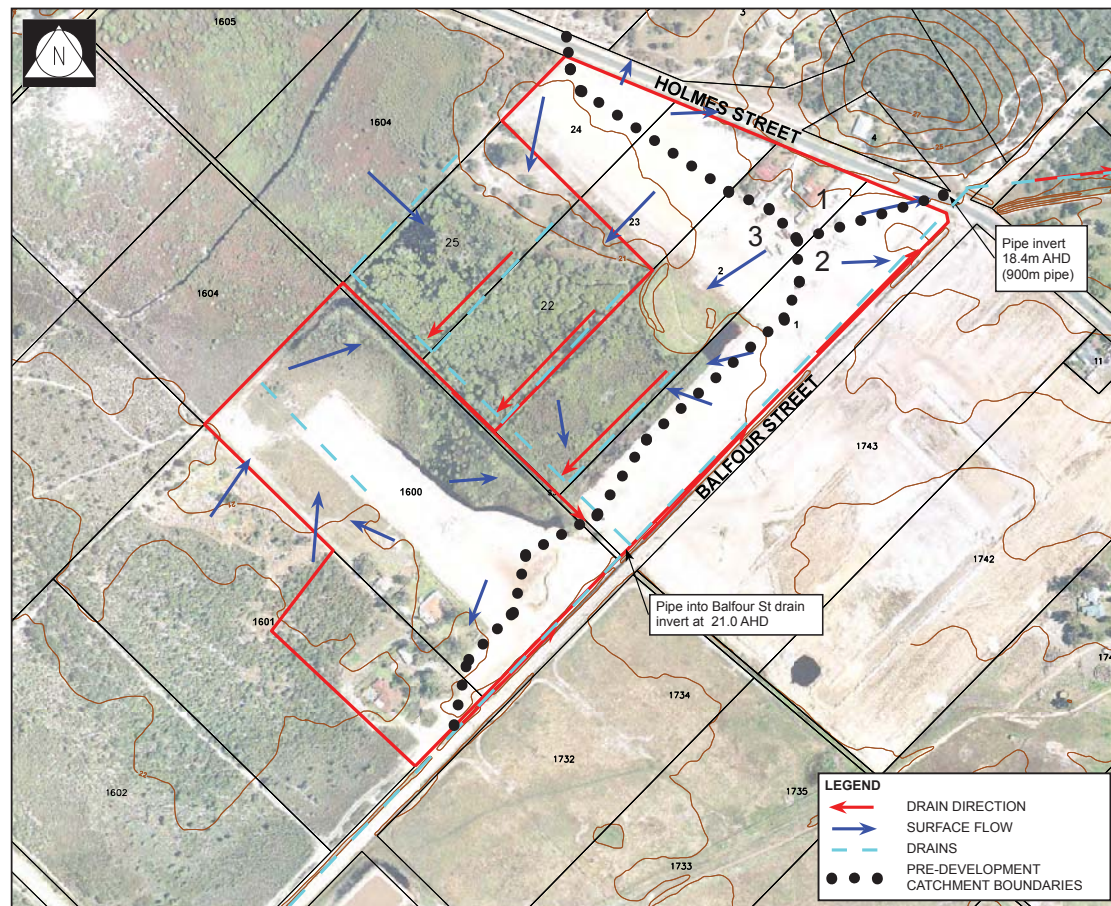


Figure 13 -Surface Water

6. GROUNDWATER PRE-DEVELOPMENT

SHALLOW SUPERFICIAL AQUIFER

Groundwater Monitoring of the superficial aquifer has been undertaken for the subject land area and the adjoining Lots 1742 and 1743 to the south east. This monitoring and analysis of the AAMGL was undertaken by JDA.

7 bores were installed in September 2008 on the subject land to a depth of around 5m and have been monitored over two years. The bore field can be seen in *Figure 14*.

LEVELS AND AAMGL

Monitoring data collected over two years was analysed in reference to longterm Department of Water Bores. The effect of the site's landforms and drains was also considered.

Analysis of the longterm data suggested that the 2 years of monitoring were slightly drier than average which may suggest that the groundwater levels may be higher in an average year. However the groundwater is more likely controlled by the on-site drain which allows for water in the wetland to exit to the Balfour Street drain (invert at 21m AHD). Given that in both years the groundwater for the site caused inundation of the wetland and flowed out through this drain, it is likely that the results recorded in both years are close to the maximum level for the site. Groundwater is unlikely to rise higher as it would generally run offsite through the open drainage system.

Table 2 shows a summary of the AAMGL levels for each bore on the site and its relationship to the surface of the site. The depth varies from 2.22m below the surface to ponding above the ground in the wetland areas.

The AAMGL falls from just over 21m AHD through the wetland and to the west and south of the site to just below 20m AHD in the north east corner close to the Balfour Street Drain. For most of the site the contours are very flat. This is due to the wetland feature over the majority of the portion of the site and the influence of the small surface drain which controls the wetlands level. There is however a localised decline in the contours in areas near the Balfour Street drain as can be seen in *Figure 14*.

Groundwater levels were also recorded as part of the Geotechnical studies for the site. The results from the geotechnical study support the information found in the long term groundwater monitoring program.

Minimum groundwater levels were also recorded and are outlined in *Table 3*.

QUALITY

As part of the groundwater monitoring, a range of quality parameters were recorded. The following is a summary of the results from the subject land. Full details can be found in the CD of attachments. Further monitoring that identifies the predevelopment organic nutrient status is to be undertaken prior to the UWWP being produced.

pH

The pH tends to fluctuate between acidic (4.6) to almost neutral (6.85). This may indicate Acid Sulphate soils (ASS). It is recommended that further investigation be undertaken into ASS as part of future planning for the site. There was no general trend in pH levels between bores or throughout the season except for a general rise in pH between May 2008 and September 2008, with another rise between March 2009 and May 2009.

ELECTRICAL CONDUCTIVITY

Electrical Conductivity was used as a reference for salinity. The conductivity for all bores other than H3 was fairly consistent throughout the monitoring period. For these bores the values fluctuated between 0.21mS/cm and 2.04mS/cm. Bores H4 and H7 tended to have the lowest readings through the sampling period. These conductivities are in the fresh to brackish category.

Bore H3 had significantly higher readings at every sampling period, with its conductivity ranging from 2.86 through to 20.08mS/cm which makes it brackish to saline.

NUTRIENTS

The nitrogen levels were generally above the recommended levels of 1.0mg/L for Total Nitrogen with only 6 readings below or at 1mg/L (all in different bores). Nitrogen levels peaked at 11mg/L in bore H6 with most levels around 2-3mg/L. There was no clear trend in levels throughout the year or between bores.

Phosphorus levels were also generally above the recommended level of 0.1mg/L for Total Phosphorus, which has been set out in the Swan Canning WQIP. Bores H1, H5 and H7 tended to have levels around 0.1 to 2mg/L, while Bores H4 and H6 generally recorded higher levels between 2.4 and 6.9mg/L. Bore H2 was generally less than 1.1mg/L but did have a spike of 7mg/L once. The only bore that was consistently below the 0.1mg/L was H3 which fluctuated between <0.01 and 0.07mg/L. These values may suggest that the site's groundwater is being affected by past and current agricultural activities on the cleared farm land, both from the subject land and surrounding areas. The nutrients are most likely moving within the groundwater and through the wetland system.

SUPERFICIAL AQUIFER ALLOCATION

The superficial aquifer in this region has some allocation available. As at July 2010 the allocation available was approximately 200,000 Kl. As can be seen from the above data, the water quality may not be suitable for domestic use without further treatment.

DEEPER CONFINED AQUIFERS

The Department of Water provided the following information on the deeper aquifers located under the subject land.

Leederville aquifer: The Leederville is represented by the Perth South Confined Sub-area at this site. It tends to be around 700m in thickness and is located below the superficial aquifer which generally extends to around 29m deep. The aquifer is currently over allocated.

Yarragadee Aquifer: The subject land is located in the Perth South Confined North Yarragadee sub area. The aquifer is approximately 3000m thick and is located below the Leederville. This aquifer is also over allocated.

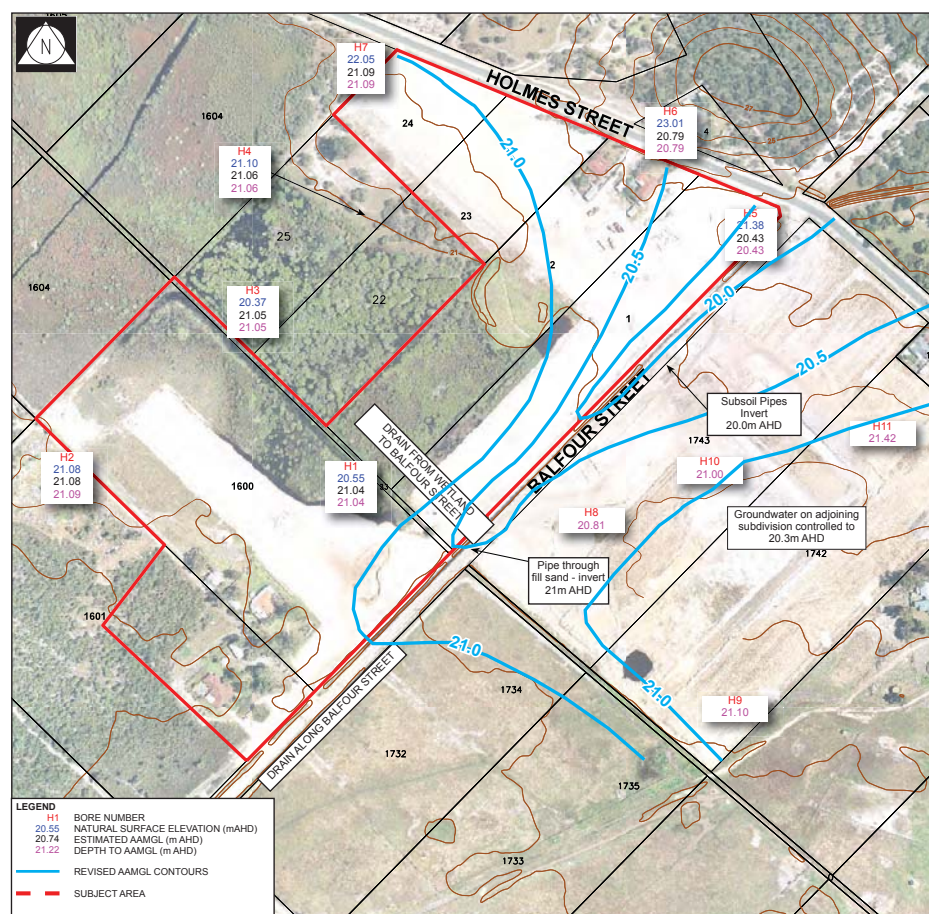


Figure 14 - Ground Water

Bore	Natural Surface level (mAHD)	Estimated AAMGL (mAHD)	Depth to AAMGL(m)	Depth to deepest recorded water level (m)
H1	20.55	21.04	Ponding above surface	1.80
H2	21.08	21.08	At natural surface	2.43
H3	20.27	21.05	Ponding above surface	2.54
H4	21.1	21.06	.04	2.48
H5	21.35	20.43	.95	2.9
H6	23.01	20.79	2.22	4.57
H7	22.05	21.09	.96	3.65

Table 2 - Groundwater Water Levels

Bore	Electrical conductivity (mS/cm)		pH		Total N (mg/L)		Total P (mg/L)		Total Suspended Solids (mg/L)	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
H1	0.41	1	5.4	6.85	0.07	9.4	0.16	0.47	150	230
H2	0.28	2.04	4.65	6.45	1.5	9.1	0.58	7	9	960
H3	2.86	20.08	4.97	6.29	0.47	4.1	0.01	0.07	160	900
H4	0.16	0.27	5.1	5.86	0.6	3.3	3.7	6.9	110	120
H5	0.19	1.16	4.6	5.56	0.83	9.1	0.09	2	16	210
H6	0.31	1.14	5.59	6.24	0.86	11	3.1	6.3	20	530
H7	0.21	0.32	5.06	5.8	1	2	0.38	1.4	21	78

Table 3 - Groundwater Quality

7. DRAINAGE MANAGEMENT PLANS

The objectives of the drainage management of surface flows for the subject area is to mimic as close as possible the pre-development flows leaving the subject land and the wetland system while treating the necessary volumes prior to discharge. Stormwater discharged into the groundwater will similarly incorporate designs to mimic as close as possible the pre-development infiltration volumes and reduce nutrient and sediment loads entering the groundwater resource. Modelling has been undertaken by JDA as to the capacity of the existing stormwater drainage adjoining the site and predicted pre-development flows of the subject land. A summary of this modelling is attached (Lots 1-4 Holmes St and Lots 1600 & 1601 Balfour St, Southern River Conceptual Stormwater Modelling). Further modelling, by Calibre Consulting, for the internal catchments has also been undertaken. This was used to determine that the development can meet the latest City of Gosnells' discharge requirement of 132 l/s which is based on JDA modelling and presented in table 4A. This is significantly less than the original JDA drainage discharge rate, which looked at the actual pipe capacity.

The primary objective of the 1:1 annual recurrence interval (ARI) event drainage designs are to treat the stormwater to reduce nutrients and sediments prior to any discharge to the natural system. The priority for storm events above the 1:1 are to control the flow of drainage water throughout the subdivision and release the water from the subdivision in a controlled manner, whilst not creating any impacts to surrounding infrastructure or environments. These are represented by the 1:5 ARI and 1:100 ARI storm event scenarios.

The following three sections discuss and provide greater details of how water is proposed to be treated and conveyed in three different ARI scenarios. Also catchment boundaries, discharge points and volumes of flow are described within the respective sections.

- Section 7A – Up to and including the 1:1 event
- Section 7B – The 1:5 storm event
- Section 7C – The 1:100 flood event

The site has been divided into 13 post development catchments. The catchment boundaries can be seen in *Figure 19 and 21*.

- Catchments B1 and B3 drain to Balfour Street
- Catchments H1-H3 drain to Holmes Street
- Catchments B2, W1-W4 and E1-E3 drain to the central wetland.

These catchments have been further consolidated for modelling purposes for the 1:5 and 1:100 ARI events. More information on this can be found in the respective sections.

Catchment details including total sizes and flows can be seen in *Table 5A*.

Non-structural controls discussed in the Stormwater Management Manual of WA will be further investigated at subdivisional stages to determine appropriate and effective controls that can be implemented as part of the best management practice designs at the different stages of the development. Possible non-structural controls that may be implemented in the future have been outlined in the implementation section of the LWMS.

Name	Catchment Area (ha.)	Road Reserve Area (ha.)	Equivalent Imp. Area (80% of Road Reserve) (m ²)	Minimum Biogarden Area Required (3.5%) of Equiv. Imp. Area (m ²)	Bio-garden area provided
W1	1.7995	0.6535	5228	183	2015 m ² Provided as West Swale 1 and 2
W2	1.5433	0.5974	4779	167	
W3	1.004	0.4305	3444	121	
W4	1.0006	0.427	3416	120	
B1	1.0679	0.2629	2103	74	90
B2	0.1631	0.1151	921	32	75
B3	0.677	0.1001	801	28	60
E1	1.6078	0.4827	3862	135	135
E2	1.3361	0.3772	3018	106	106
E3	1.491	0.6178	4942	173	175
H1	0.7122	0.3082	2466	86	450
H2	0.2505	0.0663	530	19	160
H3	0.1438	0.0312	250	9	

Table 4 - 1 Year 1 Hour Storage Areas

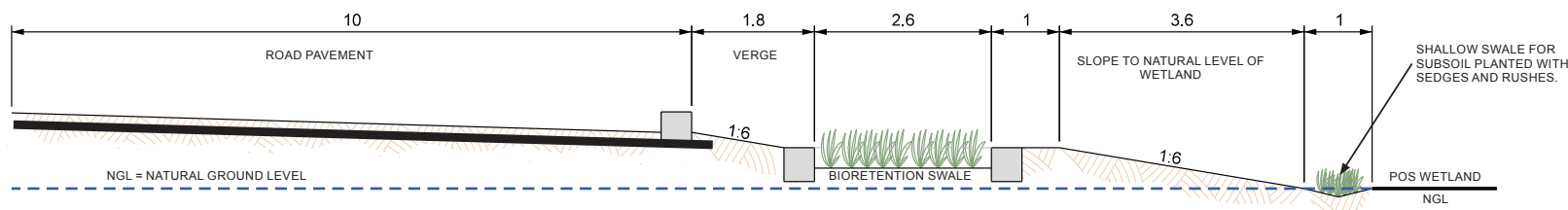


Figure 15 - Water Treatment Cross Section for area near Wetland
e.g. Catchment WS - Entire area including batters within Road Reserve

As per JDA extended area model		Allowable flow to the Balfour Street drain			
Catchments	Area (ha.)	10 Year Flow (m ³ /s)	100 Year Flow (m ³ /s)	Flow per ha. (10 Year ARI)	Flow per ha. (100 Year ARI)
SP3	86	0.197	0.456	0.00229	0.00530
SP5	37.5	0.088	0.257	0.00235	0.00685

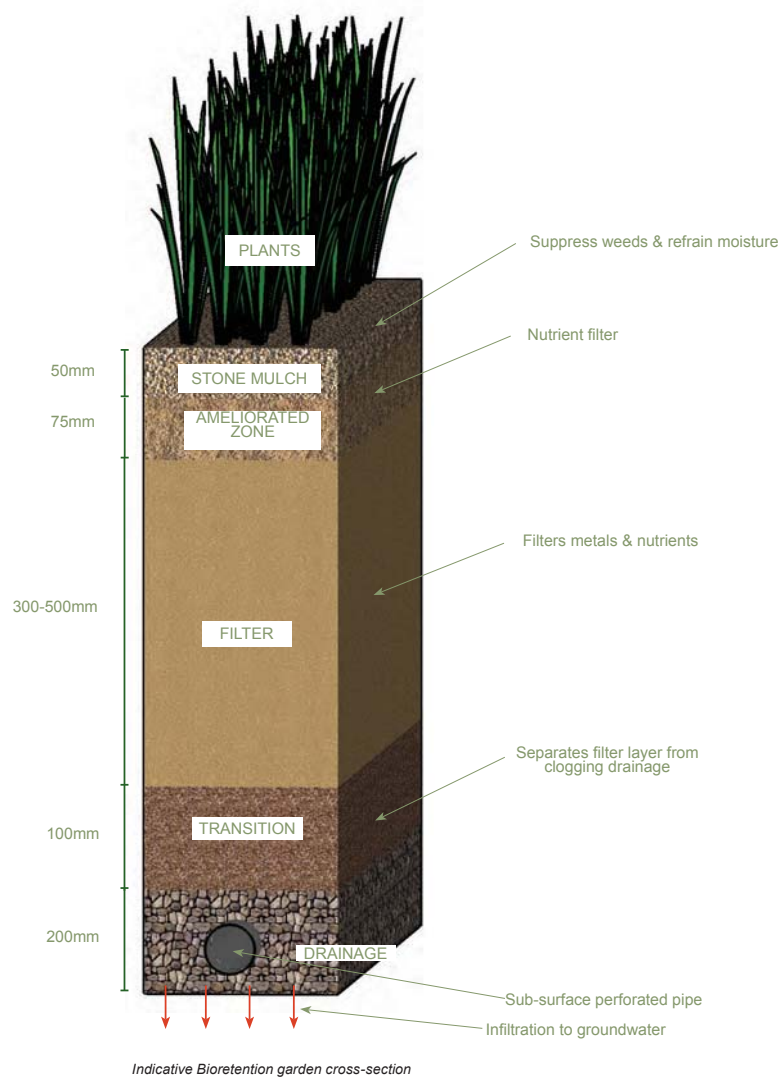
Allowable flow from the Subject Land					
Catchments	Subject Land Area (ha.)	Flow per ha. (10 Year ARI)	Flow per ha. (100 Year ARI)	Allowable Flow (10 Year ARI, m ³ /s)	Allowable Flow (100 Year ARI, m ³ /s)
SP3 (SP3-2)	7.87	0.00229	0.00530	0.01803	0.04173
SP5 (SP5-1)	13.32	0.00235	0.00685	0.03126	0.09129
Total	21.19			0.04929	0.13302

Summary

Allowable Flow to Balfour Street Drain from the Subject Land (10 Year ARI) = 0.04929 m³/s (49 l/s)

Allowable Flow to Balfour Street Drain from the Subject Land (100 Year ARI) = 0.13302 m³/s (133 l/s)

Table 4a - Allowable Flow



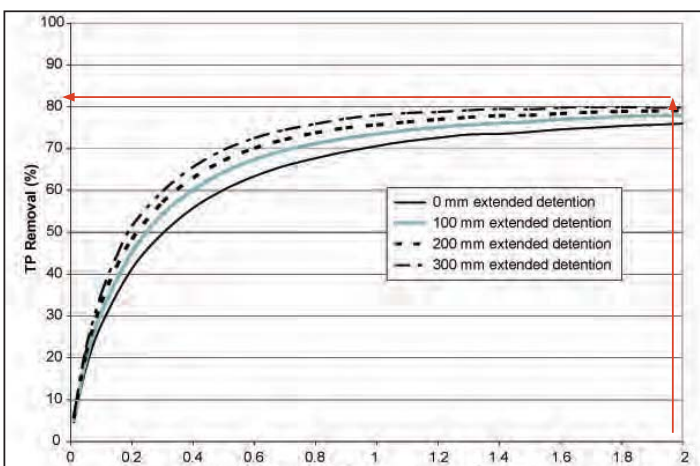
Runoff Coefficients assumed for calculations

ARI	Runoff Coefficients		
	Lot (R25)	Lot (R40)	Road Reserve
1	0.56	0.64	0.64
5	0.665	0.76	0.76
100	0.84	0.96	0.96

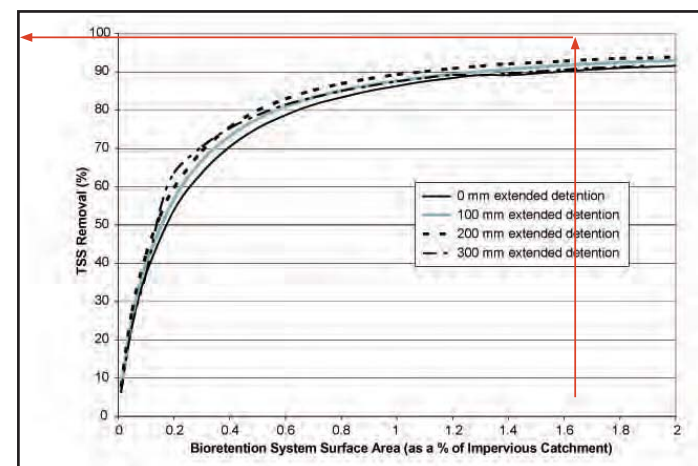
*Note Runoff coefficients are based on 0.7 for lots and 0.8 for road reserves and lots (R40) for 10 year ARI.

Table 5 - Run off Coefficients used

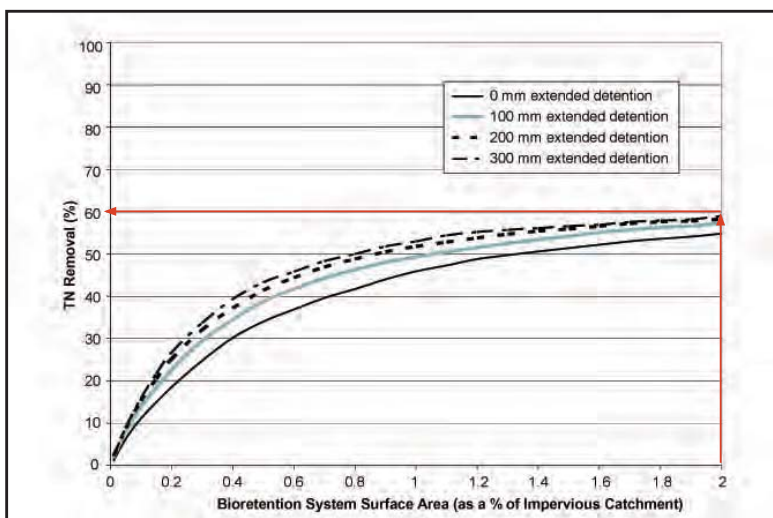
Figure 16 - Bio Garden Cross Section



Bioretention System total phosphorus removal performance



Bioretention System total suspended solids removal performance



Bioretention System total nitrogen removal performance

Figure 17 - Typical Bio Garden Performance Graphs

7A. DRAINAGE MANAGEMENT PLAN - 1 IN 1 FLOOD

The drainage management system for the subject area has been designed to capture and provide treatment up to the 1 hour, 1 in 1 year average recurrence interval (ARI) event.

The drainage catchment and drainage points and flow direction for a 1 hour 1 in 1 ARI event are shown in *Figure 18*. The volume capacities of the bioretention gardens and swale have been designed to store and infiltrate stormwater for the 60 minute interval during the 1 in 1 ARI event. The storage of the 1yr 1 hour event provides a bioretention treatment area equivalent to 3.5%, well above the 2% area required. Indicative bioretention treatment sites are shown, subject to detail design at subdivision stage. All large swales/basins will also incorporate bioretention media and plants to achieve treatment of the 1 yr 1 hour event. All basin and soakwell infiltration has assumed a permeability of 4.8m/day to be conservative.

All lots are to manage on site the 5 minute 1:20 ARI event. This volume has been factored into the overall storage requirements for the site.

There are two main directions that drainage water will take in the proposed area; infiltration to the groundwater and surface run off. To deal with these different flow paths, two separate treatment trains have been designed.

INFILTRATION TO GROUNDWATER

The majority of the water that falls on pervious surfaces in the development area in events up to the 1:1ARI will infiltrate through to the shallow groundwater because of the high hydraulic conductivity of the proposed and existing imported clean, free draining, cohesionless sand fill over the entire site. The fines content of any additional fill should be restricted to less than 5% to promote drainage across the site.

Approximately 1.2 to 1.5 metres of fill will be required across the development to ensure that adequate separation is achieved over the static groundwater level to allow for the site's infrastructure and soak wells to be the required distances above the groundwater. All fill will be contained within the road reserves where they abut the bushland/ wetlands areas. This will be by way of retaining walls or ensuring that the toe of any batter is within the road reserve.

Subsoil pipes will be designed to control the groundwater levels and ensure soakage at the source and the conveyance of treated flows to the pipe and swale network. These are to be set at or above the AAMGL.

Rainwater tanks for each household that are sized at 2 to 3KL as a minimum will be encouraged for the development. Overflow from these or direct runoff from the roofs of houses will be directed to infiltration systems. The permeability of the fill is appropriate for shallow soak wells (actual size to be determined in UWMP based on final controlled groundwater level) on the subject land. The base of the soak wells will be installed 300mm above the Controlled Groundwater Level. Soakwells are likely to therefore be around 1m in depth. Water that enters the soak wells will infiltrate into the soil profile and ultimately the groundwater.

For modelling purpose, 300m² of average impervious area has been assumed per lot and 3.7m³ of on lot storage has been provided which could be by means of rainwater tank or soak wells etc. For road reserve, a typical model for 100m² equivalent impervious area with 35 m² bio-garden of 0.3m deep has been modelled which was able to accommodate 1 year 1 hour rainfall. Hence, result shows that bio-garden with 3.5% of impervious area with 0.3m deep is capable of storing and treating 1 year 1 hour rainfall. Therefore 3.5% of equivalent impervious area (for road reserve 80% assumed) has been provided as bio-gardens. For sub-catchments draining to west swale 1 and 2, no extra bio-gardens have been proposed as west swale 1 and west swale 2 will be constructed as bio-gardens with depth 0.45m.

To assist with the movement of water off lots to the road network, all lots will be graded at 0.5 - 1% towards the road. Full earthworks models will be undertaken as part of detailed engineering design.

SURFACE FLOW

For the majority of the site, water flowing off impervious surfaces, including roads, pathways and driveways, and excess runoff from pervious areas will be directed to the edge of the roads. Here it will flow into bioretention gardens. The sizing of the bioretention gardens for each catchment can be seen in *Table 4*. These areas are based on capturing all flows generated in the 1 hour 1:1 ARI Storm event for the road reserves. To store the 1:1 1 hour event requires a storage area of 3.5% as mentioned above in infiltration and groundwater section. The total detention garden area is therefore more

than 3.5% with a minimum of 2% bioretention treatment area. This storage includes a portion of the swales and basin system. The bioretention gardens will either be located part way along the edge of a road or at the end of a street or sub catchment. The indicative location for the bioretention gardens are shown in *Figure 18* with the majority located on the long side boundary of lots.

The bioretention gardens will be designed according to the FAWB Adoption Guidelines for Filter Media in Biofiltration Systems and the Stormwater Management Manual of WA guidelines and will be capable of treating all flows up to the 1hour duration 1:1ARI flood event. The typical design will be as per *Figure 16* and contain a 300mm detention depth, planted with suitable native species including sedge and rush species. Water will then infiltrate through a mulch layer and into a filter media designed to remove pollutants. Subsoil pipes will be located directly underneath or at the base of the bioretention garden. These are to be set at or above the AAMGL. Full Details of the bioretention systems will be provided in the UWMP.

The media is designed to remove nutrients, metals, suspended solids and other pollutants. This water then continues to infiltrate to the groundwater or flows into the perforated subsoil pipe below the bioretention garden. The water that enters the subsoil is then directed to the minor spoon swales adjacent to the wetland or directly into the Holmes and Balfour Street drains.

Predicted typical treatment results for the bioretention gardens can be seen in *Figure 17*.

Catchments	Total Area (ha.)	Flows (m ³ /s) before Attenuation	
		5 Year ARI	100 Year ARI
Catchments Contributing to West Basin			
Cat-B1	1.0679	0.029	0.15
Catchments (Runoff retained in biogarden)			
Cat-B2	0.1631	0.025	0.06
Cat-H1	0.7122	0.08	0.21
Cat-H2	0.2505	0.029	0.07
Cat-H3	0.1438	0.017	0.04
Catchments Contributing to Balfour St drain			
Cat-B3	0.677	0.078	0.15
Catchments Contributing to East Basin			
Cat-E1	1.6078	0.155	0.39
Cat-E2	1.3361	0.126	0.32
Cat-E3	1.491	0.148	0.38
Catchments Contributing to West Swale -2			
Cat-W1N	1.1484	0.118	0.32
Cat-W2	1.5433	0.164	0.46
Cat-W3	1.004	0.095	0.24
Cat-W4	1.0006	0.095	0.24
Catchments Contributing to West Swale -1			
Cat-W1S	0.6511	0.067	0.1

Table 5A - Flows

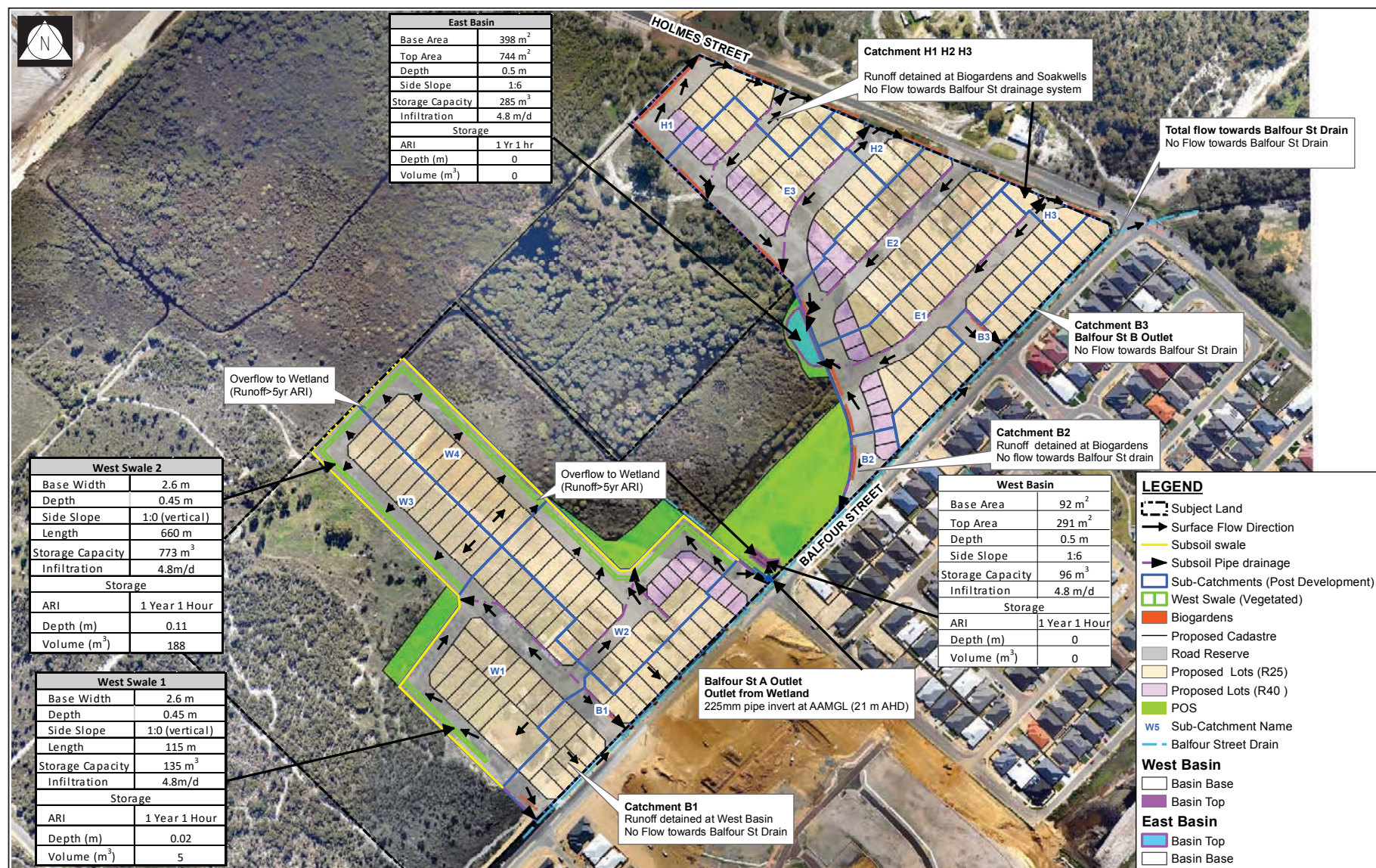


Figure 18 - 1 in 1 Year ARI Water Treatment Plan

7B. DRAINAGE MANAGEMENT PLAN - 1 IN 5 FLOOD

The drainage management system for the subject area has been designed to manage the 1:5 ARI event utilising a pipe/pit system and swales, with some extra storage in street side soak wells for catchments feeding Holmes Street and Balfour Street. The main functions during events up to and including the 1:5 events are to convey the excess water into the drainage network and away from the roads and house lots. The drainage system is designed to slow the water flow, allow for partial infiltration of water, and discharge water out of the site's residential areas in a controlled manner.

For the 1:5 event, all 13 post development catchments were analysed for their rate of runoff. This was compared to the pre-development runoff scenario and capacity of the existing drainage infrastructure. The catchments and generalised flow directions are illustrated in *Figure 19*. The volumes generated, as well as the required storage are seen on *Figure 19*.

During rainfall events between the 1:1 and 1:5ARI event, flood waters will flow along the roads, flood out the bioretention gardens, where they have been incorporated within the road reserves, then flow into the pit and pipe network. This water will then flow along the pipe system to one of three systems; depending on the catchments. These catchments relate to the outlet point and are:

- West Swale 1 and 2 (W1 – W4)
- West Basin (B1)
- East Basin (E1 - E3)
- Runoff will be retained within property sized bio gardens for catchment B2, H1, H2 and H3

The following is a summary of these drainage paths.

DISCHARGE TO SWALE AROUND WETLAND

The storage devices around the wetland include the following catchments

Catchments W1-W4 (drain to the west swale)

Catchment B1 (drains to west Basin)

Catchments E1-E3 (drain to the east basin).

The swale system is located around part of the wetland, along the edge of the road reserve. The West Swale1 and West Swale 2 are located directly to the west of the Conservation Category (CC) Wetland. The east basin is located to the east of the CC Wetland in the POS area. The west basin is on the edge of the POS area in the road reserve. The location of these systems can be seen in *Figure 19* and *Table 5B*.

Stormwater runoff above the 1:1 flows to these bio-retention swales. These swales will have a flat base, and vertical sides. The West swale1 is 115m long with a base width of 2.6m, West Swale 2 is 660m long with a base width of 2.6m and the East Swale has a base area of 398m² and top area of 744m².

The swales are designed to hold the entire 1:5 ARI flow and infiltrate it. There will be no overtopping of the swale in all events up to the 1:5 ARI event.

This will mimic what currently happens in the pre development state, where much of the water is trapped on site in the short term, with infiltration to the groundwater.

An infiltration rate of 4.8m/d has been adopted for the structures as recommended in geo tech report. Stormwater runoff for events >5yr ARI critical storm overflows the bio-retention swale directly into the wetland.

Flows from the wetland outlet has been modelled as a 225mm diameter low flow pipe with invert at the estimated winter groundwater level of 21.0m AHD. Utilising this system will protect the wetland from direct stormwater runoff, while still providing the necessary injection of water to feed the groundwater upon which the wetland relies.

DISCHARGE TO EXTERNAL PIPE SYSTEM

The External Pipe system includes:

Catchments B3 drain to Balfour St

Catchments H1-H3 drain to Holmes St.

As street side bioretention has been sufficiently sized for catchment H1-H3 there will be no runoff discharging to Balfour St drain system. However, there will be limited overflow in 100 year event ultimately maintaining allowable flow at Balfour St drainage system.

The storage is provided in a combination of the streetside bioretention gardens and soakwells.

All stormwater above that contained in the bioretention gardens and soakwells flows into the Holmes and Balfour St drainage system.

Based on the pre-development discharge rate set by the City of Gosnells, storage is provided for each external draining catchment to reduce flows down to this amount (refer to *Table 4A* for allowable rates). The peak 5 year event includes all of these external draining catchments plus the controlled flow from the wetland.

It is not an objective of managing 1:5 storm events to treat for quality, however the soak wells, bioretention gardens and swales will allow for some trapping and settling of suspended sediments, especially after the flood peak has passed. This is due to the slowing of water and eventual filtering processes in the soakwells, swales and bioretention gardens. This means that the water that enters the wetland later through groundwater flow will have received some treatment.

RUN OFF COEFFICIENTS

Run off coefficients for all events and land uses are shown in *Table 5B*.

Catchments	Storage Provided (m ³)				Storage Required (m ³)		Remarks
	Storage Basins	Bio-gardens	Lot Retention	Total Storage Provided	5 Year ARI	100 Year ARI	
Catchments Contributing to West Basin							
Cat-B1	96	123	70	289	269	289	100 Year overflows to Wetland
Catchments (Runoff retained in biogarden)							
Cat-B2		22.5		21	18	21	100 Year overflows to Wetland
Cat-H1			37				5Year/100 Year overflow's to Balfour St drainage system limiting flow to allowable limit
Cat-H2		246	18.5	313	128	313	
Cat-H3			11.1				
Catchments Contributing to Balfour St drain							
Cat-B3		18	63	81	72	81	5Year/100 Year overflow's to Balfour St drainage system limiting flow to allowable limit
Catchments Contributing to East Basin							
Cat-E1			103				100 Year overflows to Wetland
Cat-E2	285	125	81	660	620	660	
Cat-E3			66				
Catchments Contributing to West Swale -2							
Cat-W1N			60				100 Year overflows to Wetland
Cat-W2			74	997	997	997	
Cat-W3	773		45				
Cat-W4			45				
Catchments Contributing to West Swale -1							
Cat-W1S	135		26	161	161	161	100 Year overflows to West Swale 2
Total	1289	409.5	699.6	2522	2265	2522	

Table 5B - Storage Requirements



Figure 19 - 1 in 5 Year Drainage Management Plan

7C DRAINAGE MANAGEMENT PLAN - 1 IN 100 FLOOD

Modelling has been undertaken by JDA to determine the flood extent of the 1:100 ARI storm event for the subject land. This has focused on protection of the proposed infrastructure, the capacity of the wetland complex to store flood waters and the capacity of the existing drainage system on Balfour Street to take the 1:100 ARI discharge from the site. Further modelling has been undertaken by Calibre Consulting to check the flood level generated on site, including the wetland system. This modelling takes into account the modelled out flow rate for the site set by JDA. More critically however, is the modelling takes into account the rate of discharge determined by the City for the site of 0.132m³/s. The actual post development peak flow rate for the 1:100ARI has been determined as 0.130m³/s.

The proposed design of the subject land based on this information will allow for the safe conveyance the 1:100 ARI flood event so that impacts on infrastructure, the environment and people's safety are minimised.

Flood waters are to be transported through the subject land via the pit and pipe network (designed for 1:5 ARI) as well as overland flow down roads. The road system is to be designed to work in conjunction with the pipe network to allow a safe flood route for 1:100 ARI flows. Flow paths down roads have been marked and can be seen in 21. All lots will have a finished floor level 500mm above any potential flooding from the 1:100 ARI event.

Flood waters will be discharged from the subject land through the same points of discharge as the 1:5 ARI event. Catchments feeding the wetland will flood out the bioretention gardens and 1:5 system before topping over into the wetland area. This wetland area has the capacity to store over 100,000m³ of water from the subject area and surrounds. This water will be able to continuously discharge via the 225mm culvert at the end of the wetland into Balfour Street Drain. This is due to the culvert having an invert of 21m AHD and the hydraulic head of the Balfour Street Drain being only 20.72m AHD as seen in *Figure 20*. Due to large amount of retention and travel time involve, the peak 1:100 ARI event for the wetland catchments is the 72 hour event. This is after the critical 1:100 ARI event for the Pipe which is the 48 hour event. The effect of the residential development on the 1:100 ARI level of the wetland is to raise the wetland level by 10mm. This is in keeping with the Wetland Management Plan.

Catchments feeding Holmes and Balfour directly are able to discharge their waters directly into the Balfour Street drain system. The current design in the Balfour Street Drain has capacity to take these flood waters directly. This can be seen in *Figure 20*. More details can be found in the attached Conceptual Stormwater Modelling.

Due to the site discharging water from the site both prior to and after the critical event for the Balfour Street Pipe, the pipe will have a lower critical event flow post development.

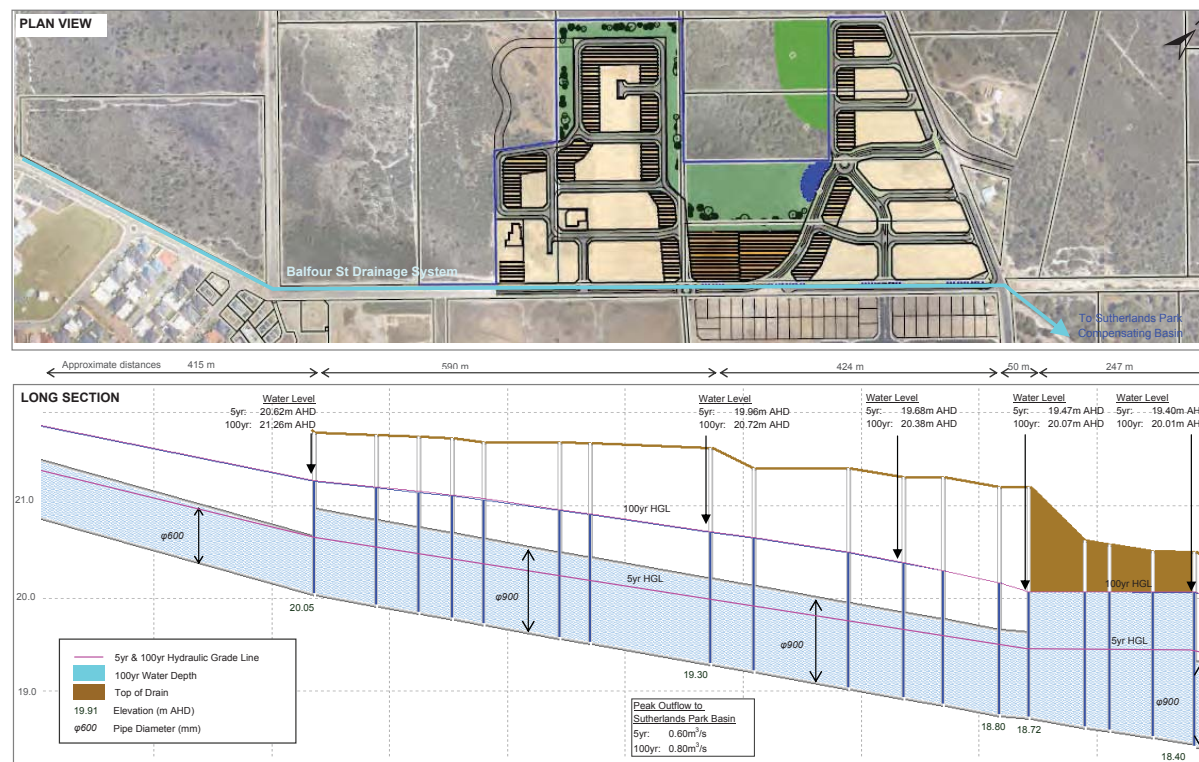


Figure 20 - Original JDA Balfour Street Drainage system (Sutherlands Park Branch Drain) - 5yr & 100yr ARI Modelling Results

7A. DRAINAGE MANAGEMENT PLAN - 1 IN 1 FLOOD

The drainage management system for the subject area has been designed to capture and provide treatment up to the 1 hour, 1 in 1 year average recurrence interval (ARI) event.

The drainage catchment and drainage points and flow direction for a 1 hour 1 in 1 ARI event are shown in *Figure 18*. The volume capacities of the bioretention gardens and swale have been designed to store and infiltrate stormwater for the 60 minute interval during the 1 in 1 ARI event. The storage of the 1yr 1 hour event provides a bioretention treatment area equivalent to 3.5%, well above the 2% area required. Indicative bioretention treatment sites are shown, subject to detail design at subdivision stage. All large swales/basins will also incorporate bioretention media and plants to achieve treatment of the 1 yr 1 hour event. All basin and soakwell infiltration has assumed a permeability of 4.8m/day to be conservative.

All lots are to manage on site the 5 minute 1:20 ARI event. This volume has been factored into the overall storage requirements for the site.

There are two main directions that drainage water will take in the proposed area; infiltration to the groundwater and surface run off. To deal with these different flow paths, two separate treatment trains have been designed.

INFILTRATION TO GROUNDWATER

The majority of the water that falls on pervious surfaces in the development area in events up to the 1:1ARI will infiltrate through to the shallow groundwater because of the high hydraulic conductivity of the proposed and existing imported clean, free draining, cohesionless sand fill over the entire site. The fines content of any additional fill should be restricted to less than 5% to promote drainage across the site.

Approximately 1.2 to 1.5 metres of fill will be required across the development to ensure that adequate separation is achieved over the static groundwater level to allow for the site's infrastructure and soak wells to be the required distances above the groundwater. All fill will be contained within the road reserves where they abut the bushland/ wetlands areas. This will be by way of retaining walls or ensuring that the toe of any batter is within the road reserve.

Subsoil pipes will be designed to control the groundwater levels and ensure soakage at the source and the conveyance of treated flows to the pipe and swale network. These are to be set at or above the AAMGL.

Rainwater tanks for each household that are sized at 2 to 3KL as a minimum will be encouraged for the development. Overflow from these or direct runoff from the roofs of houses will be directed to infiltration systems. The permeability of the fill is appropriate for shallow soak wells (actual size to be determined in UWMP based on final controlled groundwater level) on the subject land. The base of the soak wells will be installed 300mm above the Controlled Groundwater Level. Soakwells are likely to therefore be around 1m in depth. Water that enters the soak wells will infiltrate into the soil profile and ultimately the groundwater.

For modelling purpose, 300m² of average impervious area has been assumed per lot and 3.7m³ of on lot storage has been provided which could be by means of rainwater tank or soak wells etc. For road reserve, a typical model for 100m² equivalent impervious area with 35 m² bio-garden of 0.3m deep has been modelled which was able to accommodate 1 year 1 hour rainfall. Hence, result shows that bio-garden with 3.5% of impervious area with 0.3m deep is capable of storing and treating 1 year 1 hour rainfall. Therefore 3.5% of equivalent impervious area (for road reserve 80% assumed) has been provided as bio-gardens. For sub-catchments draining to west swale 1 and 2, no extra bio-gardens have been proposed as west swale 1 and west swale 2 will be constructed as bio-gardens with depth 0.45m.

To assist with the movement of water off lots to the road network, all lots will be graded at 0.5 - 1% towards the road. Full earthworks models will be undertaken as part of detailed engineering design.

SURFACE FLOW

For the majority of the site, water flowing off impervious surfaces, including roads, pathways and driveways, and excess runoff from pervious areas will be directed to the edge of the roads. Here it will flow into bioretention gardens. The sizing of the bioretention gardens for each catchment can be seen in *Table 4*. These areas are based on capturing all flows generated in the 1 hour 1:1 ARI Storm event for the road reserves. To store the 1:1 1 hour event requires a storage area of 3.5% as mentioned above in infiltration and groundwater section. The total detention garden area is therefore more

than 3.5% with a minimum of 2% bioretention treatment area. This storage includes a portion of the swales and basin system. The bioretention gardens will either be located part way along the edge of a road or at the end of a street or sub catchment. The indicative location for the bioretention gardens are shown in *Figure 18* with the majority located on the long side boundary of lots.

The bioretention gardens will be designed according to the FAWB Adoption Guidelines for Filter Media in Biofiltration Systems and the Stormwater Management Manual of WA guidelines and will be capable of treating all flows up to the 1hour duration 1:1ARI flood event. The typical design will be as per *Figure 16* and contain a 300mm detention depth, planted with suitable native species including sedge and rush species. Water will then infiltrate through a mulch layer and into a filter media designed to remove pollutants. Subsoil pipes will be located directly underneath or at the base of the bioretention garden. These are to be set at or above the AAMGL. Full Details of the bioretention systems will be provided in the UWMP.

The media is designed to remove nutrients, metals, suspended solids and other pollutants. This water then continues to infiltrate to the groundwater or flows into the perforated subsoil pipe below the bioretention garden. The water that enters the subsoil is then directed to the minor spoon swales adjacent to the wetland or directly into the Holmes and Balfour Street drains.

Predicted typical treatment results for the bioretention gardens can be seen in *Figure 17*.

Catchments	Total Area (ha.)	Flows (m ³ /s) before Attenuation	
		5 Year ARI	100 Year ARI
Catchments Contributing to West Basin			
Cat-B1	1.0679	0.029	0.15
Catchments (Runoff retained in biogarden)			
Cat-B2	0.1631	0.025	0.06
Cat-H1	0.7122	0.08	0.21
Cat-H2	0.2505	0.029	0.07
Cat-H3	0.1438	0.017	0.04
Catchments Contributing to Balfour St drain			
Cat-B3	0.677	0.078	0.15
Catchments Contributing to East Basin			
Cat-E1	1.6078	0.155	0.39
Cat-E2	1.3361	0.126	0.32
Cat-E3	1.491	0.148	0.38
Catchments Contributing to West Swale -2			
Cat-W1N	1.1484	0.118	0.32
Cat-W2	1.5433	0.164	0.46
Cat-W3	1.004	0.095	0.24
Cat-W4	1.0006	0.095	0.24
Catchments Contributing to West Swale -1			
Cat-W1S	0.6511	0.067	0.1

Table 5A - Flows

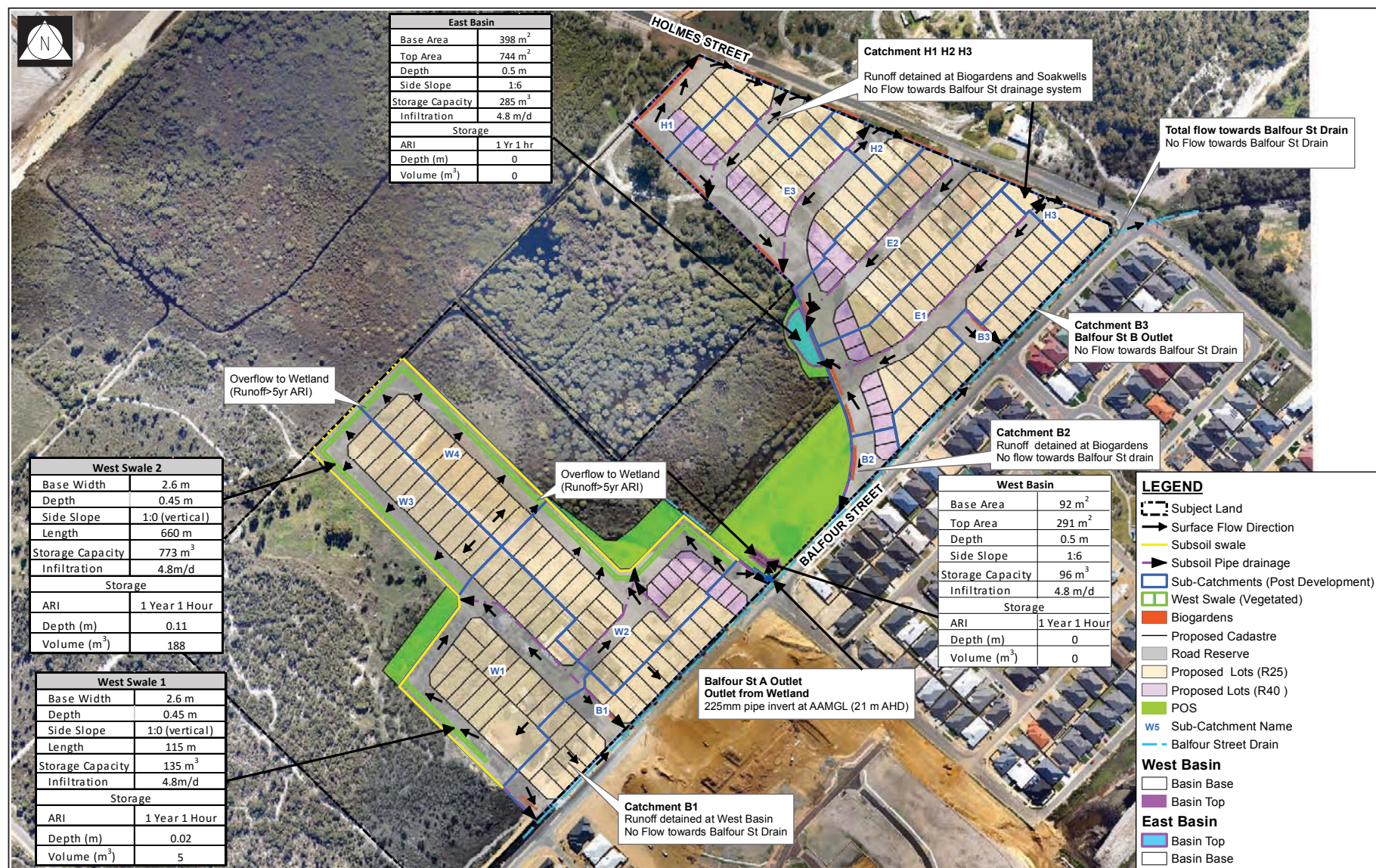


Figure 18 - 1 in 1 Year ARI Water Treatment Plan

7B. DRAINAGE MANAGEMENT PLAN - 1 IN 5 FLOOD

The drainage management system for the subject area has been designed to manage the 1:5 ARI event utilising a pipe/pit system and swales, with some extra storage in street side soak wells for catchments feeding Holmes Street and Balfour Street. The main functions during events up to and including the 1:5 events are to convey the excess water into the drainage network and away from the roads and house lots. The drainage system is designed to slow the water flow, allow for partial infiltration of water, and discharge water out of the site's residential areas in a controlled manner.

For the 1:5 event, all 13 post development catchments were analysed for their rate of runoff. This was compared to the pre-development runoff scenario and capacity of the existing drainage infrastructure. The catchments and generalised flow directions are illustrated in *Figure 19*. The volumes generated, as well as the required storage are seen on *Figure 19*.

During rainfall events between the 1:1 and 1:5ARI event, flood waters will flow along the roads, flood out the bioretention gardens, where they have been incorporated within the road reserves, then flow into the pit and pipe network. This water will then flow along the pipe system to one of three systems; depending on the catchments. These catchments relate to the outlet point and are:

- West Swale 1 and 2 (W1 – W4)
- West Basin (B1)
- East Basin (E1 - E3)
- Runoff will be retained within properly sized bio gardens for catchment B2, H1, H2 and H3

The following is a summary of these drainage paths.

DISCHARGE TO SWALE AROUND WETLAND

The storage devices around the wetland include the following catchments

Catchments W1-W4 (drain to the west swale)

Catchment B1 (drains to west Basin)

Catchments E1-E3 (drain to the east basin).

The swale system is located around part of the wetland, along the edge of the road reserve. The West Swale1 and West Swale 2 are located directly to the west of the Conservation Category (CC) Wetland. The east basin is located to the east of the CC Wetland in the POS area. The west basin is on the edge of the POS area in the road reserve. The location of these systems can be seen in *Figure 19* and *Table 5B*.

Stormwater runoff above the 1:1 flows to these bio-retention swales. These swales will have a flat base, and vertical sides. The West swale1 is 115m long with a base width of 2.6m, West Swale 2 is 660m long with a base width of 2.6m and the East Swale has a base area of 398m² and top area of 744m².

The swales are designed to hold the entire 1:5 ARI flow and infiltrate it. There will be no overtopping of the swale in all events up to the 1:5 ARI event.

This will mimic what currently happens in the pre development state, where much of the water is trapped on site in the short term, with infiltration to the groundwater.

An Infiltration rate of 4.8m/d has been adopted for the structures as recommended in geo tech report. Stormwater runoff for events >5yr ARI critical storm overflows the bio-retention swale directly into the wetland.

Flows from the wetland outlet has been modelled as a 225mm diameter low flow pipe with invert at the estimated winter groundwater level of 21.0m AHD. Utilising this system will protect the wetland from direct stormwater runoff, while still providing the necessary injection of water to feed the groundwater upon which the wetland relies.

DISCHARGE TO EXTERNAL PIPE SYSTEM

The External Pipe system includes:

Catchments B3 drain to Balfour St

Catchments H1-H3 drain to Holmes St.

As street side bioretention has been sufficiently sized for catchment H1-H3 there will be no runoff discharging to Balfour St drain system. However, there will be limited overflow in 100 year event ultimately maintaining allowable flow at Balfour St drainage system.

The storage is provided in a combination of the streetside bioretention gardens and soakwells.

All stormwater above that contained in the bioretention gardens and soakwells flows into the Holmes and Balfour St drainage system.

Based on the pre-development discharge rate set by the City of Gosnells, storage is provided for each external draining catchment to reduce flows down to this amount (refer to *Table 4A* for allowable rates). The peak 5 year event includes all of these external draining catchments plus the controlled flow from the wetland.

It is not an objective of managing 1:5 storm events to treat for quality, however the soak wells, bioretention gardens and swales will allow for some trapping and settling of suspended sediments, especially after the flood peak has passed. This is due to the slowing of water and eventual filtering processes in the soakwells, swales and bioretention gardens. This means that the water that enters the wetland later through groundwater flow will have received some treatment.

RUN OFF COEFFICIENTS

Run off coefficients for all events and land uses are shown in *Table 5B*.

Catchments	Storage Provided (m ³)				Storage Required (m3)		Remarks
	Storage Basins	Bio-gardens	Lot Retention	Total Storage Provided	5 Year ARI	100 Year ARI	
Catchments Contributing to West Basin							100 Year overflows to Wetland
Cat-B1	96	123	70	289	269	289	
Catchments (Runoff retained in biogarden)							
Cat-B2		22.5		21	18	21	100 Year overflows to Wetland
Cat-H1		246	37	313	128	313	5Year/100 Year overflow's to Balfour St drainage system limiting flow to allowable limit
Cat-H2			18.5				
Cat-H3			11.1				
Catchments Contributing to Balfour St drain							
Cat-B3		18	63	81	72	81	5Year/100 Year overflow's to Balfour St drainage system limiting flow to allowable limit
Catchments Contributing to East Basin							
Cat-E1	285	125	103	660	620	660	100 Year overflows to Wetland
Cat-E2			81				
Cat-E3			66				
Catchments Contributing to West Swale -2							
Cat-W1N	773		60	997	997	997	100 Year overflows to Wetland
Cat-W2			74				
Cat-W3			45				
Cat-W4			45				
Catchments Contributing to West Swale -1							
Cat-W1S	135		26	161	161	161	100 Year overflows to West Swale 2
Total	1289	409.5	699.6	2522	2265	2522	

Table 5B - Storage Requirements

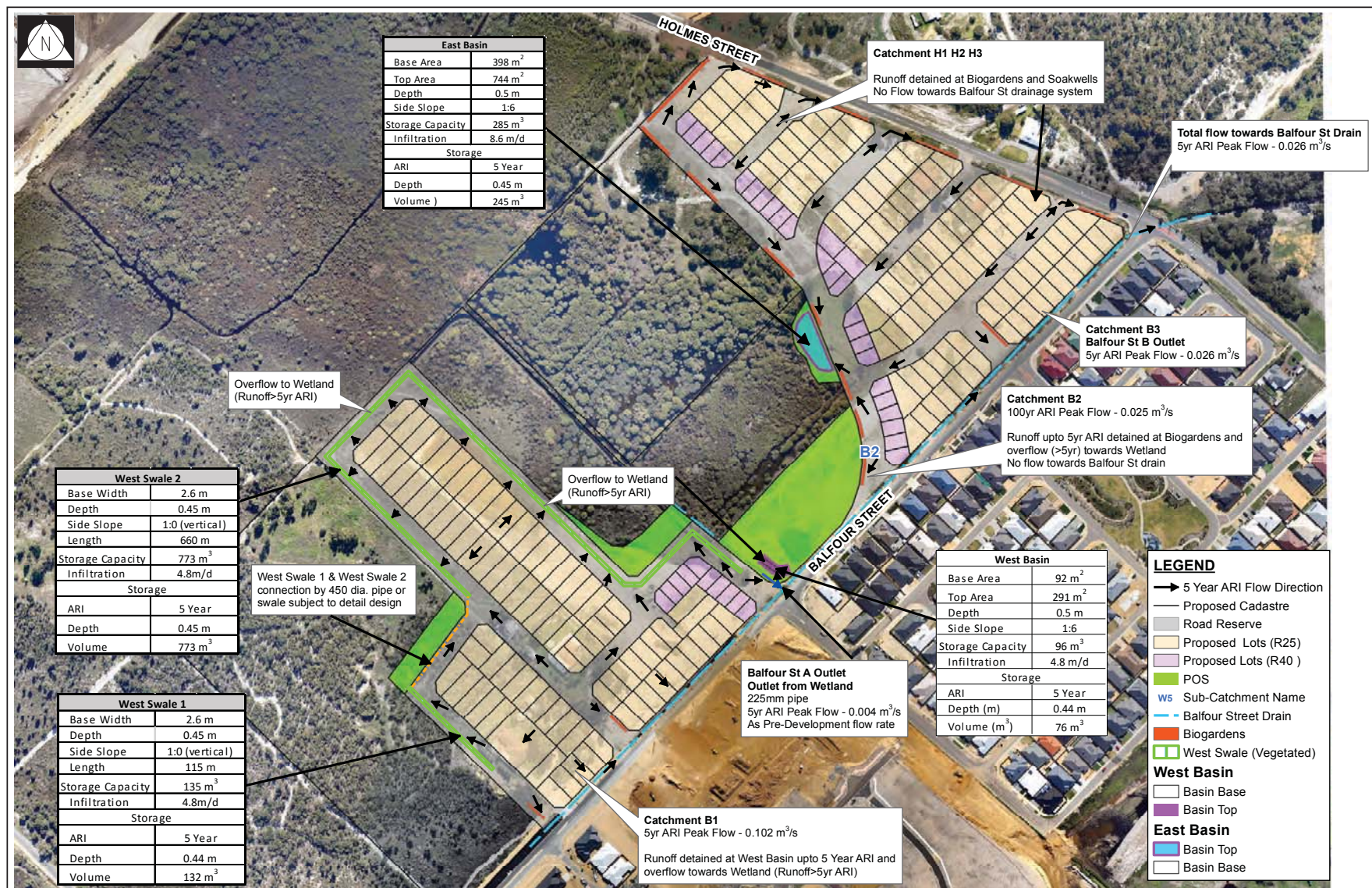


Figure 19 - 1 in 5 Year Drainage Management Plan

7C DRAINAGE MANAGEMENT PLAN - 1 IN 100 FLOOD

Modelling has been undertaken by JDA to determine the flood extent of the 1:100 ARI storm event for the subject land. This has focused on protection of the proposed infrastructure, the capacity of the wetland complex to store flood waters and the capacity of the existing drainage system on Balfour Street to take the 1:100 ARI discharge from the site. Further modelling has been undertaken by Calibre Consulting to check the flood level generated on site, including the wetland system. This modelling takes into account the modelled out flow rate for the site set by JDA. More critically however, is the modelling takes into account the rate of discharge determined by the City for the site of 0.132m³/s. The actual post development peak flow rate for the 1:100ARI has been determined as 0.130m³/s.

The proposed design of the subject land based on this information will allow for the safe conveyance the 1:100 ARI flood event so that impacts on infrastructure, the environment and people's safety are minimised.

Flood waters are to be transported through the subject land via the pit and pipe network (designed for 1:5 ARI) as well as overland flow down roads. The road system is to be designed to work in conjunction with the pipe network to allow a safe flood route for 1:100 ARI flows. Flow paths down roads have been marked and can be seen in 27. All lots will have a finished floor level 500mm above any potential flooding from the 1:100 ARI event.

Flood waters will be discharged from the subject land through the same points of discharge as the 1:5 ARI event. Catchments feeding the wetland will flood out the bioretention gardens and 1:5 system before topping over into the wetland area. This wetland area has the capacity to store over 100,000m³ of water from the subject area and surrounds. This water will be able to continuously discharge via the 225mm culvert at the end of the wetland into Balfour Street Drain. This is due to the culvert having an invert of 21m AHD and the hydraulic head of the Balfour Street Drain being only 20.72m AHD as seen in Figure 20. Due to large amount of retention and travel time involve, the peak 1:100 ARI event for the wetland catchments is the 72 hour event. This is after the critical 1:100 ARI event for the Pipe which is the 48 hour event. The effect of the residential development on the 1:100 ARI level of the wetland is to raise the wetland level by 10mm. This is in keeping with the Wetland Management Plan.

Catchments feeding Holmes and Balfour directly are able to discharge their waters directly into the Balfour Street drain system. The current design in the Balfour Street Drain has capacity to take these flood waters directly. This can be seen in Figure 20. More details can be found in the attached Conceptual Stormwater Modelling.

Due to the site discharging water from the site both prior to and after the critical event for the Balfour Street Pipe, the pipe will have a lower critical event flow post development.

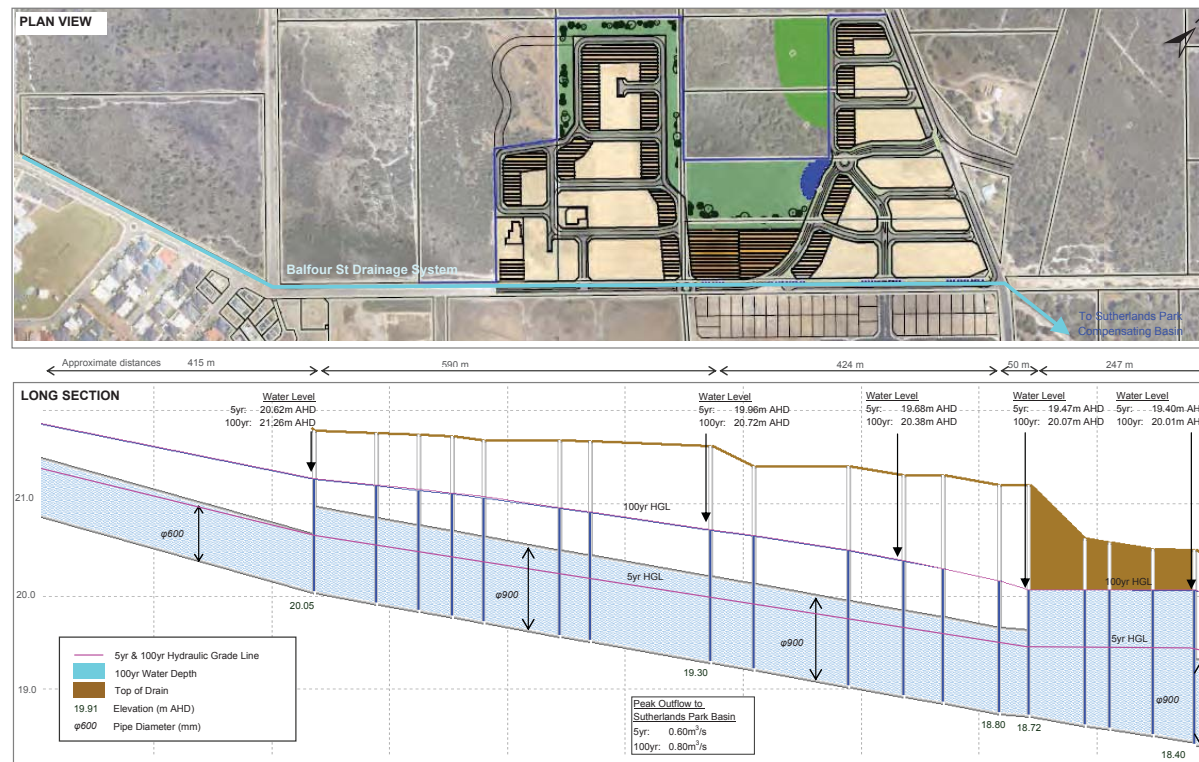


Figure 20 - Original JDA Balfour Street Drainage system (Sutherlands Park Branch Drain) - 5yr & 100yr ARI Modelling Results

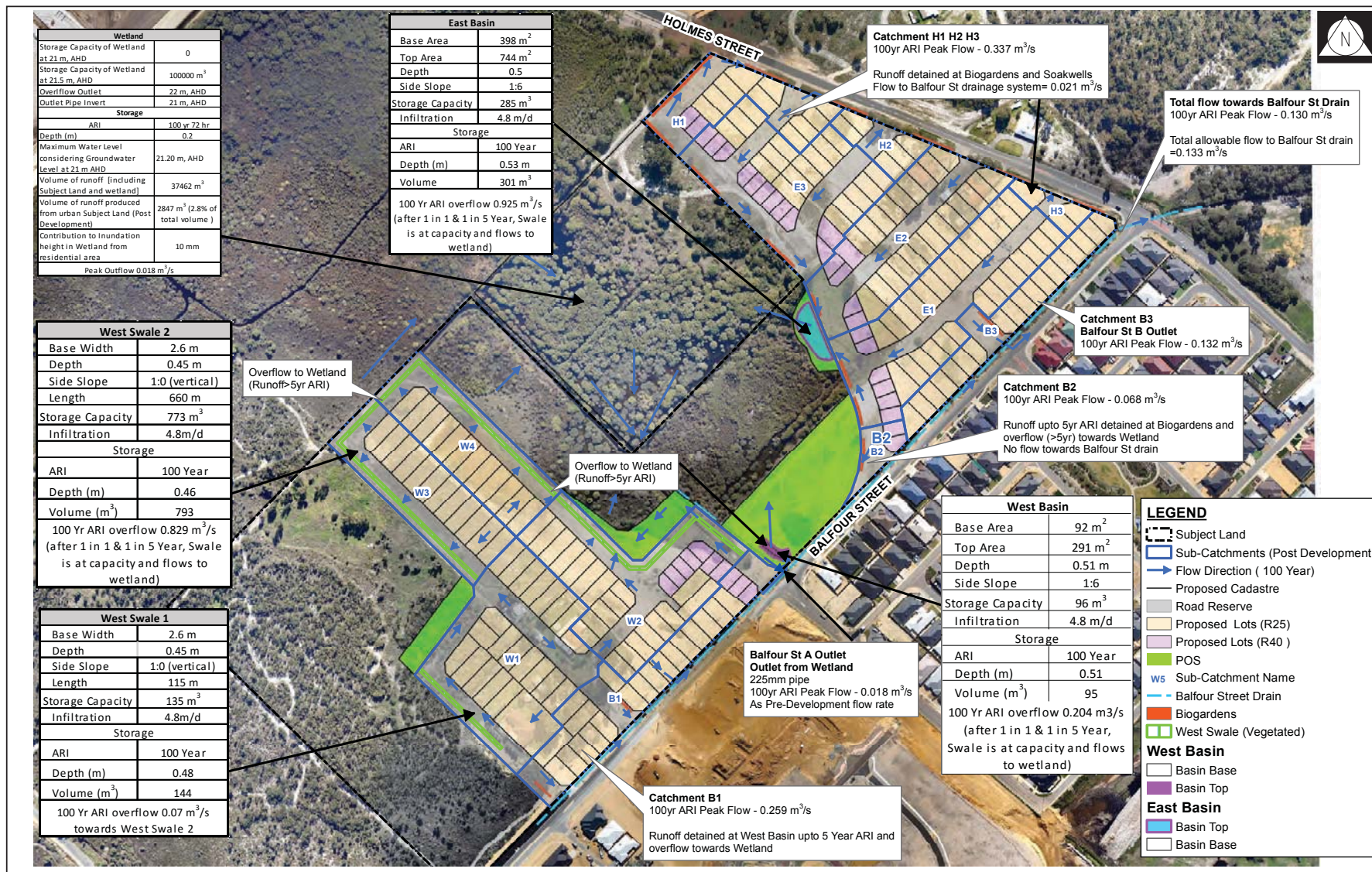


Figure 21 - 1 in 100 Year Flood Event Plan

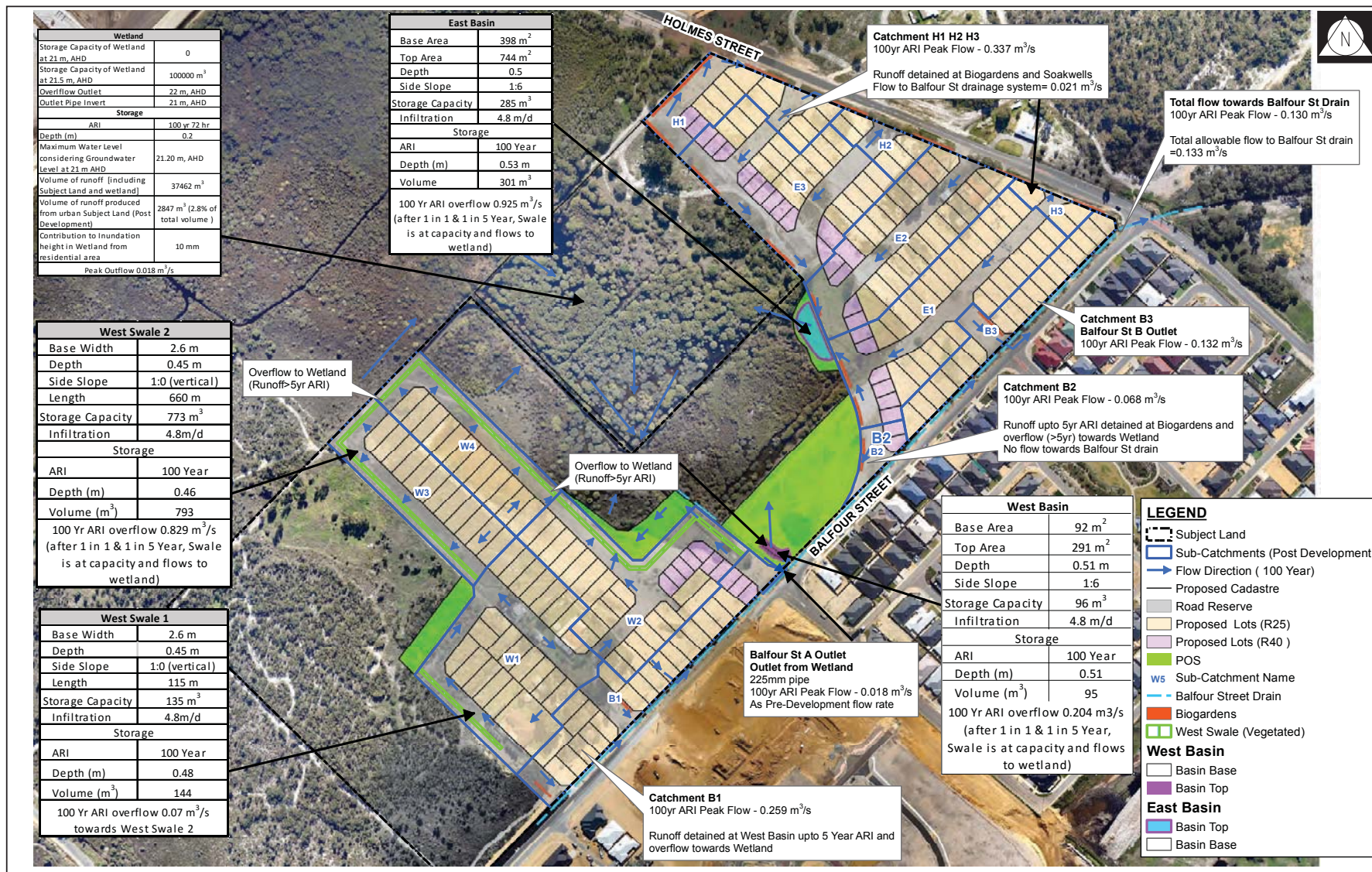


Figure 21 - 1 in 100 Year Flood Event Plan

8. GROUNDWATER MANAGEMENT STRATEGY

The focus of groundwater management for the development site is to maintain groundwater at existing levels within the wetland system, while maintaining appropriate separation from built infrastructure. In this instance, existing levels refer to the control level of pipe discharging to Balfour Street drain, which is set at the base of the historical open drain constructed in the wetland. Furthermore groundwater will be managed to achieve no reduction in water quality entering the wetlands. *Figure 22A* illustrates a cross section of how groundwater will be managed in relation to the residential and natural areas on site.

GROUNDWATER LEVEL MANAGEMENT

The subsoil will be set predominately at the AAMGL, especially in close proximity to the wetland. Subsoil pipes will then grade at 1:300 back under the residential fill areas. The subsoils will be located in the road reserves.

Mounding will occur between the subsoil pipes, with groundwater mounding to a maximum of 500mm below houses after a 1:5 ARI event in the wettest month of the year. This mounding will rapidly drain to the subsoil system to bring the water level under the lots back close to the pre development AAMGL. The post development CGL can be seen in *Figure 22A*. With the CGL set at 21m AHD around the wetland, there will be no change to wetland groundwater levels.

The use of free draining fill and distance between the subsoil pipes throughout the development will assist with holding the mounding to this height. The permeability of the sand used in the fill is between 5.09×10^{-5} and 5.88×10^{-5} m/s. For all drainage calculations the permeability has been set at 4.8m / day.

Modelling of the fill permeability and subsoil drainage spacing for the site shows there is a need for an average of 1.2m of fill above the subsoil invert at the kerb, with approximately 1.5m under the lot. This will achieve the required 0.5m separation at the mid point between subsoil pipes.

To reflect this separation distance to groundwater, soakwells and other infiltrating systems will be at the front of lots and shallow in nature e.g. 1m.

The subsoils will free drain to a number of points. These include, the subsoil swale parallel to the west swale (as per *Figure 15*) and the pipe network of Holmes and Balfour Street and east basin. The general flow direction for the subsoil system will be the same as the surface drainage catchments.

The subsoils that drain to the wetland will bubble up in a small spoon swale along the edge of the wetland (this is a separate swale to the one which will hold the 1:5 ARI stormwater). The water from the subsoil drain can then enter the wetland system by soaking into the soil profile within and around the spoon drain.

The catchments where the subsoil system drains to Holmes and Balfour Street will enter the stormwater drainage pipes, for discharge to the street side drainage.

Figure 22A shows the indicative subsoil layout and inverts including indicative road levels.

The wetland water level will also be maintained by retaining the controlled surface water outlet pipe for the wetland into the Balfour Street drain. This in effect will continue to hold groundwater levels at an AAMGL of 21m AHD within and around the wetland. This is the wetland level set by the historical drain that took water from the wetland to the open Balfour Street drain. When Lot 1 was filled, the open drain was replaced with a pipe set at 21m AHD (old drain invert). By maintaining the groundwater at a level similar to the current level next to and within the wetland system, this development will have minimal impact on the groundwater dependent ecosystems that rely on water from the site.

Where ever possible water will be infiltrated on site to maintain similar overall infiltration volumes to the pre development scenario. This is to be achieved through the use of pervious surfaces, bioretention gardens, swales and soakwells, which are designed to infiltrate water.

No domestic bores are to be used in the development, due to the potential to impact on the adjoining wetland systems. This is to be achieved through restrictive covenants on lots.

GROUNDWATER QUALITY MANAGEMENT

All stormwater up to the 1 year 1 hour storm event will be treated in bioretention gardens. This means that the stormwater entering the subsoil system from the filtered stormwater should be treated to Department of Water guidelines. The bioretention gardens and swales will be designed and constructed according to the latest FAWB Adoption Guidelines for Filter Media in Biofiltration Systems and the Stormwater Management Manual for WA design guidelines. The graphs provided in *Figure 16* demonstrate the potential capabilities of bioretention gardens in the removal of total phosphorus, total nitrogen and total suspended sediments, and provide the reasoning for adopting bioretention gardens to assist in the protect of groundwater quality. More information on the bioretention garden design can be found in Section 7A.

Roof runoff directed to soakwells, is another major source of groundwater. This water is relatively clean, which will assist with keeping groundwater pollutant concentrations within acceptable limits.

Suitable soil amelioration products will be laid within gardens and POS areas, to assist with binding nutrients in the soil profile. This will reduce potential movement of nutrients to the groundwater.

Furthermore an amended filter media will be used in conjunction with the subsoil pipes to treat in flowing groundwater. The Filter media will remove nutrients prior to the groundwater entering the subsoil pipe. The exact details will be provided in the UWMP, however based on recent research by the Department of Water, it is likely to be a 10% Iron man Gypsum / 90% Coarse Sand mix. This has shown significant reduction in nutrients and other pollutants entering the subsoil.

MONITORING

Sufficient pre development groundwater information has been collected to allow for design and construction of the development. The Department of Water has advised that post development monitoring of groundwater levels will be required. Full details of the monitoring will be outlined in the UWMP. Monitoring will be for both levels and quality for at least two years after the last lot is constructed. More information can also be found in Section 11 Monitoring and Implementation. The monitoring undertaken needs to follow the Australian Standard AS/NZ 5667 series of Water Quality Sampling Guidance Notes and a National Association of Testing Authorities accredited laboratory undertakes the water quality sample tests.

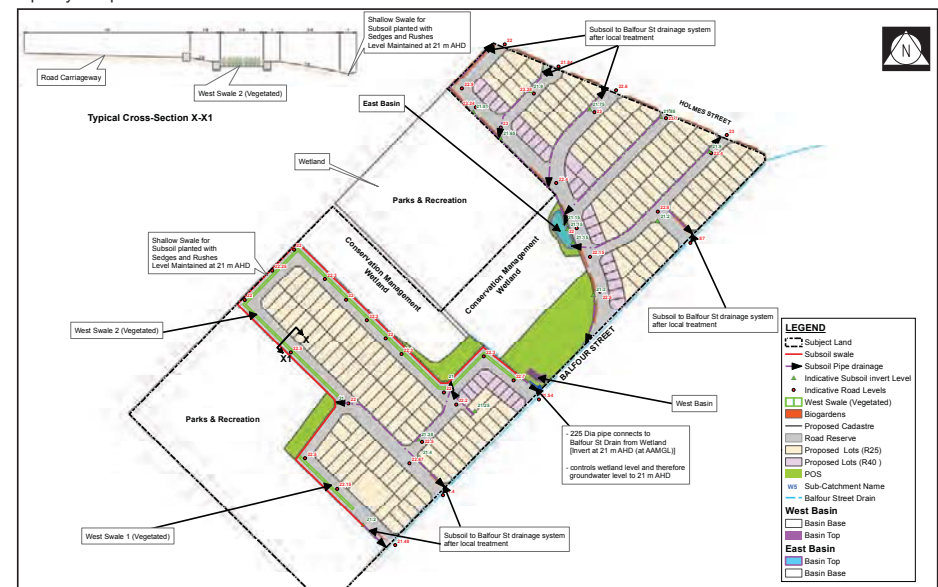


Figure 22A - Indicative subsoil and Road Inverts -

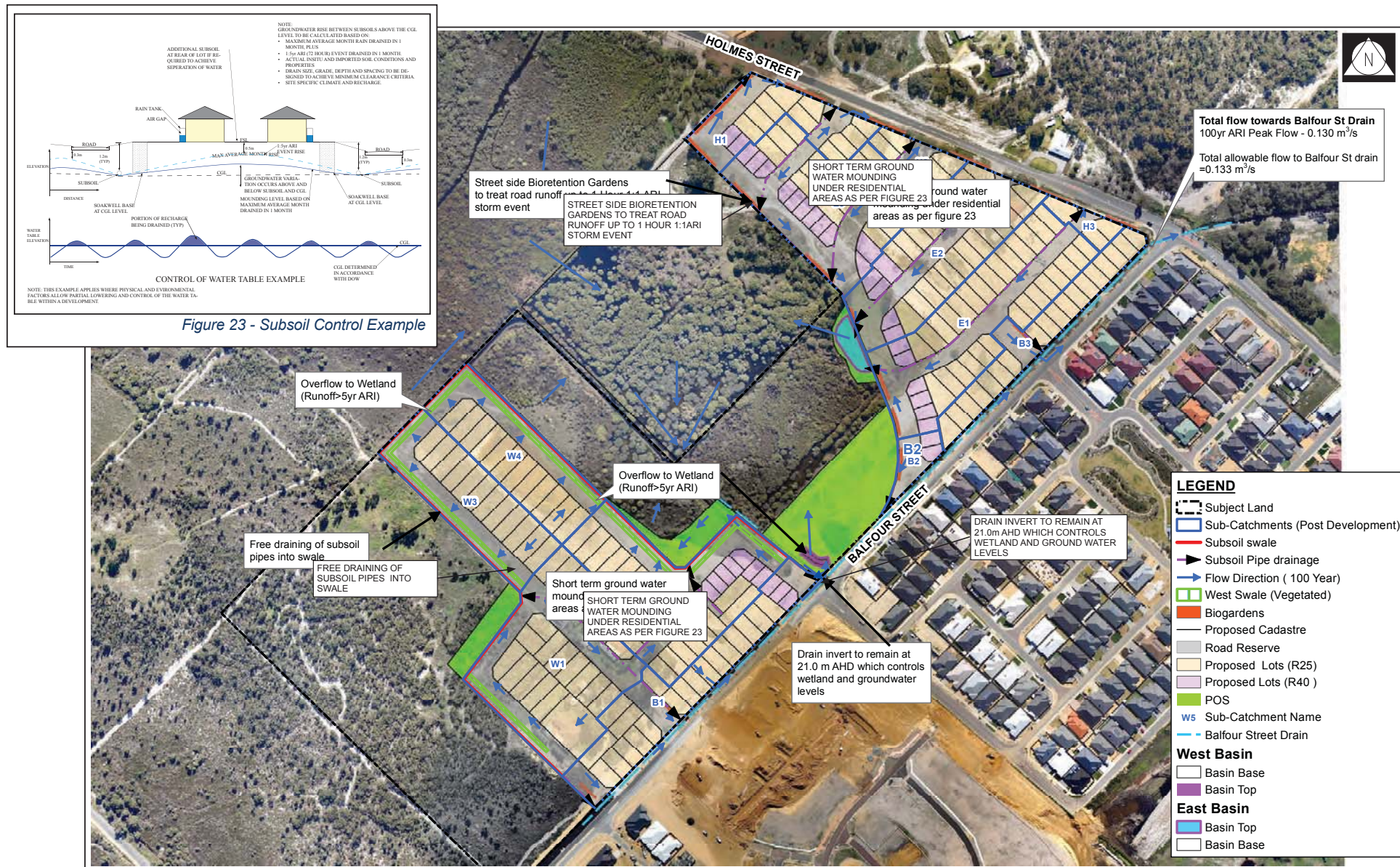


Figure 22 - Post Development Ground Water Management Plan

9. WATER DEPENDENT ECO-SYSTEM MANAGEMENT

Management of water is to be undertaken so that the significant wetlands within and near the subject land are protected and enhanced. The methods on how this is to be achieved are outlined below. Further details on wetland management for the site are contained in the Wetland Management Plan (WMP) Lots 1, 2, 23, 24 Holmes St and Lot 1600 Balfour St, Southern River. The most relevant information can be found in Section 8 of the WMP. This plan provides sufficient information to outline the required protection and enhancement processes for the current structure planning phase.

Buffers are to be incorporated around the Conservation Category Wetland. The buffers reflect adequate separation distances between the future residential landuses and the wetlands, as well as incorporation of on site vegetation that is already present. The buffer distance has been set in negotiation between the developer, Department of Parks and Wildlife and Council. Some wider areas will also be included to reflect the sites existing vegetation. These buffers will allow for protection of the ecological functioning of the site by controlling public and providing areas that can be planted with suitable endemic native species. The buffers also assist with filtering any stormwater runoff from residential areas. Final and full Wetland Management Details will be reflected in the UWMP. This will take direction from the Wetland Rehabilitation Plan which is to be done as part of the subdivision process.

In general the planting of suitable native species along the edge of the wetland systems will assist with linking up areas of vegetation on the site and surrounding land. This will also improve the ecological functioning of the wetland including assisting with fauna habitat creation. Drainage infrastructure such as bioretention gardens constructed near these buffers are to be planted with appropriate native species including sedges and rushes to assist with the movement of fauna. Weeds will also be controlled. Disturbed areas within the wetland, such as the historical spoon drains will also be revegetated. This will help to slow and therefore manage the flow and infiltration of water across the wetland area.

The water that flows into the onsite wetlands is to be managed so that the post development rate matches the pre development situation. This is to be achieved through detention and infiltration of all flows up to and including the 1:5 ARI Storm event that feed the wetland catchment. The details of how this water is to be managed is contained in Section 7B: Drainage Management. This management of flows will assist with maintaining the hydro regimes to which the ecosystems have evolved. It will also minimise the chance for erosion of sediment and leaching of nutrients and other contaminants into the system.

Water quality is also to be managed so that the surface water entering these ecosystems is treated to sufficient standards. This is to be achieved through the use of bioretention gardens, swales, and soakwells. These will assist with removing sediment, gross pollutants, nutrients and other contaminants. More details on these options can be found in Section 7A.

The wetland system is also highly dependent on groundwater. Groundwater on the site is to be managed to achieve the required water quality and levels to maintain and improve the wetlands health. This is to be achieved through the use of amended soils, encouragement of small and native private gardens, well managed POS areas including effective nutrient budgeting and extensive use of native species. Furthermore, the subsoil system is to incorporate an amended soil filter to bind nutrients and other pollutants. This will reduce organic and other nutrients being discharged from the development as well as potential legacy nutrients. Water quality management for road reserve stormwater will ensure all infiltrating stormwater is treated prior to entering the groundwater. These strategies will assist in managing the water entering the groundwater and moving through to the significant ecosystems to the required quality.

The post development groundwater level regime will also match the pre development scenario. The high infiltration rate on the subject land means that presently most of the water on site enters the groundwater and does not flow off site via the surface until there is significant surface water in the wetland. This high infiltration volume is to be maintained by detaining and infiltrating surface runoff wherever possible through bioretention gardens and soakwells. The permeable fill soils on site will continue to infiltrate at similar rates to the pre development rate. The level will also be controlled through the use of subsoil drainage set at the AAMGL around the wetland. The subsoil will drain to both the onsite wetlands and the existing Holmes Balfour St drains as deemed appropriate. Furthermore there will be careful management of any potential groundwater extraction from the superficial aquifer to minimise any localised drawdown. More details on these strategies can be found in Section 8 Groundwater Management.

It is acknowledged that the area is located in close proximity to wetlands which have the ability to support mosquito and midge breeding. Mosquito and midge management is to be an important objective in the planning, design, operation and maintenance of any proposed drainage systems. The developer is committed to implementing a mosquito and midge plan during the pre-development stage and for 2 years following practical completion of the subdivision. The design of the water management infrastructure will be done in a manner that ensures that the opportunities for nuisance insect breeding and movement are minimised, including:

- Bioretention gardens which reduce nutrient inputs to the wetland and have no standing water.
- Landscaping to reduce movement of nuisance insects to residential area.
- Rehabilitation of the wetland buffer so that the system is not degrade, which will therefore support predatory species and minimise nutrient rich stormwater.

The City of Gosnells will respond to any reports of mosquito or midge issues with appropriate monitoring and response. A detailed mosquito and midge plan is to accompany and inform the UWMP.

The POS areas have been designed so that they will generally retain native vegetation. Bordering these areas, a zone of locally native plants will be used, that are subject to minimal irrigation. Between these landscaped native plant areas and lawn, a concrete path will be used. This system will provide good protection to the ecologically significant wetland systems. A POS Nutrient Management Plan is to be developed as part of detailed design.

The wide road reserve in the southern portion of the site that incorporated a bioretention swale and subsoil discharge swale will also assist with providing a buffer to the wetland. An indicative design for this area is shown in *Figure 15*, however this will be modified as is practical to accommodate existing significant vegetation in this area. This is to be incorporated into the UWMP.

All of these management strategies will ultimately improve the water quality that enters the downstream environments outside of the subject land including the Southern River, and Swan Canning system. These management options will assist with the site meeting the water quality recommendation of 1.0mg/l for total nitrogen and 0.1mg/L for Total Phosphorus as recommended for the Swan Canning system.

DEWATERING

For any required dewatering, an assessment is to be undertaken to review volumes, quality and potential impacts on surface water level, especially in relation to nearby significant wetlands.

Local recharge, outside of the wetland area is the preferred method of disposal. This is to be reviewed in more detail as part of the UWMP and detailed engineering design.



Figure 24 - Water Dependant Eco-system Plan

10. SUSTAINABLE WATER USE & SERVICING

The sustainable usage and management of water within the subject land area requires consideration of the provision of services and the conservation of water. The following is a description of the aspects to enhance the sustainable management of water within the development and general servicing.

WATER SUPPLY

Mains potable water will be provided by the Water Corporation from existing infrastructure on Balfour Road. The entire site is within the Water Corporation licence area. Discussions with the Water Corporation are being undertaken and further details regarding provision of mains potable services will be investigated at relevant planning stages of the development.

The majority of water used both within and outside the individual houses will be from the mains potable source. Using the State Water Plan annual target of 100kl/annum per person and an average household size of 2.3 people, a total of 230KL/annum of mains potable water has been estimated per household. Of this, 150KL will be used inside with a further 80KL being allocated for gardens and other outside uses.

SEWERAGE MANAGEMENT

Sewerage will be maintained by the Water Corporation via their existing gravity system located within Balfour Street. All wastewater will be transported to the existing Water Corporation's treatment plant. Discussions with the Water Corporation are being undertaken and further details regarding provision of reticulated sewerage disposal services will be investigated at relevant planning stages of the development.

There are no plans at this point to bring the treated wastewater back into the structure plan area. On average 150KL per annum will be sent to the sewer from each household.

WATER USAGE

For the State Water Plan of 2007 water use target of 100 kilolitres per person a year to be met, conservation methods will need to be employed throughout the subject area.

The Water Corporation's Options for Our Water Future provides comparative data to the average Perth household water use of 246KL per annum since 2002, the average household usage peaked in 2000/01 to approximately 290KL per annum.

To achieve the necessary reduction, a number of water conservation strategies will be incorporated. These measures will both reduce overall water usage as well as specifically reduce potable mains water.

The table illustrates water savings that can be made in comparison to 'normal' and average water using devices, based on data collected between 1998 and 2001 from Perth households. Builders and house owners will be encouraged to install water efficient devices and participate in the water conservation methods outlined in *Figure 25* to achieve the potential savings. Information will also be provided to lot purchasers informing them about Waterwise devices and practices.

RAINWATER TANKS

Houses will be encouraged to install rainwater tanks to reduce the consumption of water from the Water Corporation mains supply. Encouragement will be via provision of written material on the benefits of rainwater tank. More details on this will be provided in the UWMP. The encouragement of their use will be for internal toilets and laundry as well as garden and outdoor purposes. Outdoor water usage in Perth households is typically slightly below 50% of total water usage.

For modelling rainwater runoff and capture, the following data sources were used and assumptions were made:

- Average tank size of 3000L
- Rainfall figures between 2000 and 2009 derived from the Bureau of Meteorology weather station.
- Average roof catchment percentage value of 50% (125m²).
- Efficiency of collection value of 0.85 (85% efficiency).
- Loss associated with absorption and wetting of surface value of 24mm per year.
- First flush value of 0.2L per m².

Encouraging the installation of an average tank could potentially capture a maximum collection volume of approximately 80KL per annum for each household with a 3kl tank and inside usage. Much of this potential capture will however be unused if supply is solely for outside usage. With outside usage, total actual usable collection is likely to be around 30KL/year. With internal usage, this could increase to approximately 60KL per annum.

As the installation of rainwater tanks has not been mandated for the subdivision the volumes have been shown as alternative factors in the modelled water balance volumes (*Figure 25*). More details as to the use of rainwater tanks is to be provided in the UWMP.

ONSITE INFILTRATION AND STORMWATER DISCHARGE

Excess roof runoff of around 162KL per annum will be directed to a property connection soak well for lots over 350m² and to the stormwater system for lots under 350m². This would be reduced with the installation of a rainwater tank by approximately 10,000-80,000L, depending on the size and usage, with 30,000L as an average. The soils at the site will predominantly infiltrate all of the runoff water into the soil profile and groundwater below. Runoff from the gardens and hard surfaces around the house will be directed predominately to the road drainage network discussed in the drainage management sections. The remainder will infiltrate into the soil and groundwater within the lot. This will assist with conserving water on site and maintaining the current groundwater regime.

WATERWISE GARDEN AND OTHER OUTSIDE USAGE

The water savings from planning and implementing Waterwise gardens and practicing other outdoor Waterwise techniques can vary from approximately 50 to 200KL per household per annum.

Natural rainfall alone should be sufficient to maintain Waterwise gardens. However, additional water for gardens, in particular lawns, and other outdoor use has been factored into the subject area's water balance model. To achieve the necessary target of 230KL per household per annum, an achievable target of 80KL per annum has been allocated to garden and other outside usage. The installation of a rainwater tank could be used to supplement or possibly even substitute for the use of mains potable water for usage on garden and other outdoor requirements.

Lot owners will be provided with information outlining the benefits of minimising lawn and incorporating Waterwise gardens. Educational material raising awareness of Waterwise gardens will be offered to new residents, including the Water Corporation's Garden Tips for the South West brochure. This will be further explored in details as part of the UWMP.

GREYWATER USE

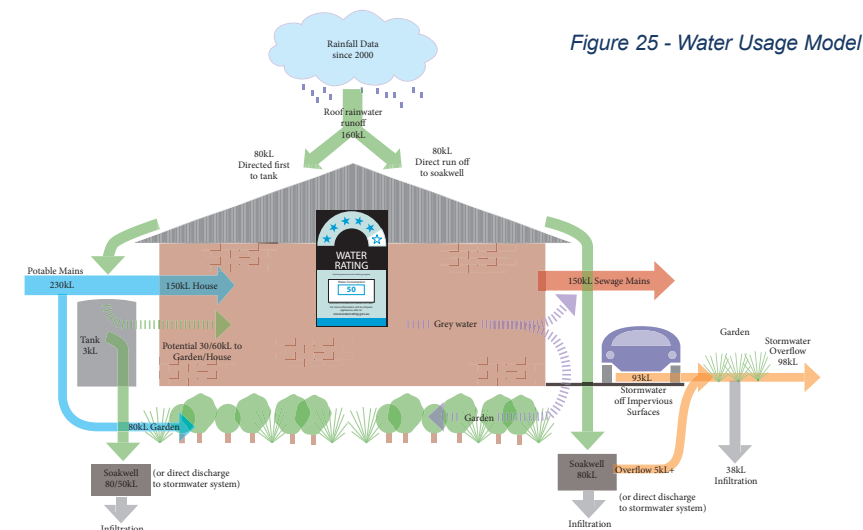
Greywater use is a possibility for the subject area. However, as it will not be mandated, it has not been shown in the water balance model. Greywater, if well managed, could provide for most if not all of the Waterwise gardens water needs. This would reduce the amount going to the effluent disposal system by 45 - 120KL per annum, as well as saving up to 80KL per annum of mains potable water.

GROUNDWATER AND BORES

Bore water use has not been shown in the model as there will be restrictive covenants placed on the lots that bores are to be precluded.

POS WATERING

The reticulated POS area will be kept to a minimum through the choice of landscaping and plant selection. If an irrigation allocation from the confined aquifers is needed, this will be sought through water trading. More detail is to be supplied on POS irrigation as part of the UWMP. *Table 6* provides an indication of the likely POS irrigation requirements. The overall lawn and other irrigation areas are low compared to the total POS area, which includes the restricted area to native vegetation. Lawn areas will also be separated from existing native vegetation areas via a concrete path and locally native landscaping.



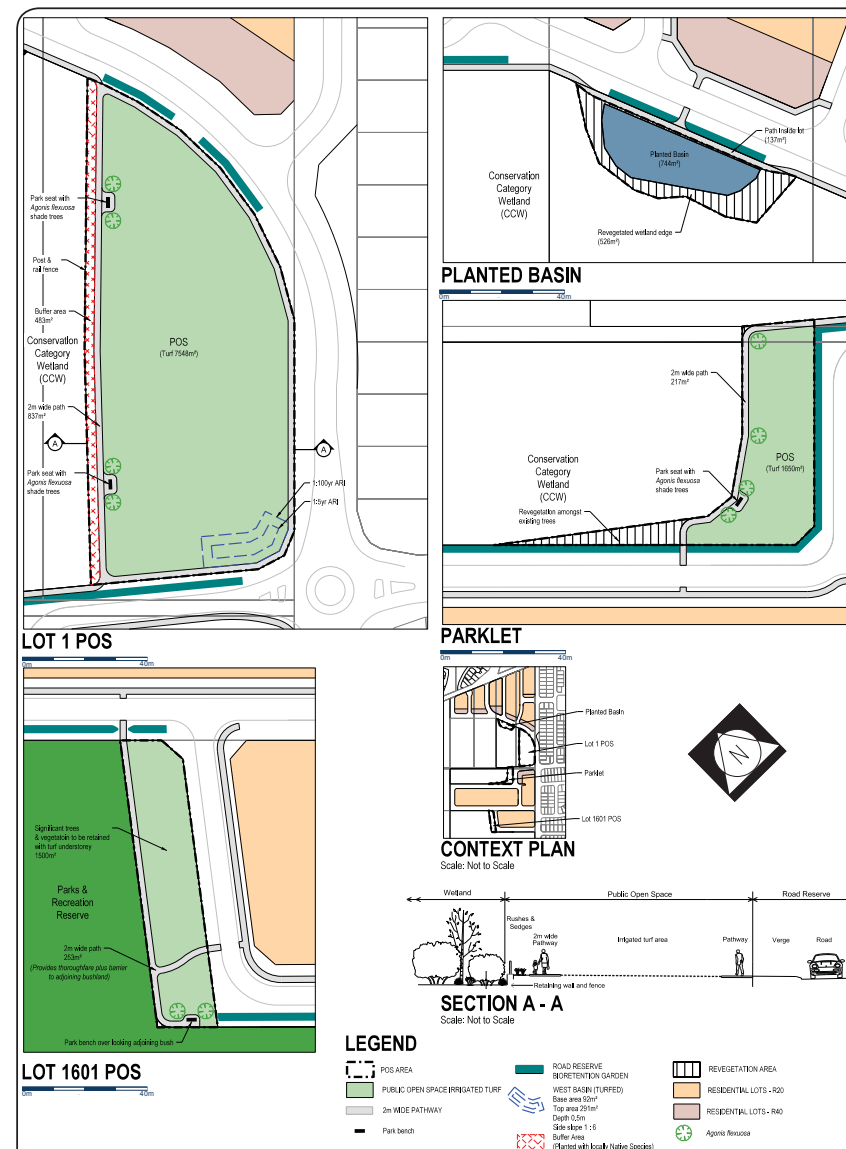
TYPE OF POS	AREA (ha)	IRRIGATION RATE (kL/ha/Annum)	TOTAL IRRIGATION PER ANNUM (kL)
Lawn Area	1.7	7 000	11 900
Native Gardens Areas	0.1	4 000	400
TOTAL			12 300

Table 6 - POS Irrigation Requirements

DEVICE/MEASURE	AVERAGE AMOUNT SAVED IN KLI/HOUSEHOLD/ANNUM. (SAVING ARE BASED ON AVERAGE PERTH WATER USAGE FOR 1998-2001)
WASHING MACHINES (AUTOMATIC FRONT LOADER)	10-13
SHOWER HEAD	6-12
TAP AERATORS	15-22
TOILETS (DUAL FLUSH)	7-11
WATER WISE GARDENING (INCLUDES DRIPIRRIGATION AND LOW WATER USE PLANTS)	50-200
TOTAL AMOUNT SAVED:	88-258

Data based on average Perth household Usage between 1998 and 2001 from Loh & Coghlan's Domestic Water Use Study, Water Corporation 2003

Table 7 - Water Efficient Devices / Conservation measures



11. MONITORING, MAINTENANCE & IMPLEMENTATION

MONITORING PROGRAM

Monitoring within the subject land and the contingency actions to address any related problems are shown in *Table 8*. The following is a summary of the monitoring that has been and will be undertaken in relation to water management.

GROUNDWATER

Pre-development monitoring of groundwater levels and quality has been undertaken since May 2008. The full details can be seen in the previous groundwater sections.

The parameters tested include depth, pH, electrical conductivity, total suspended solids, as well as a range of nitrogen and phosphorus based chemicals. These parameters and the number of samples taken meet Department of Water guidelines for pre development monitoring.

Further monitoring is to be undertaken post development for a further 2 years after completion of subdivisional works. Monitoring is to be monthly for levels and quarterly for quality.

Trigger values set at 10% above the pre-development rates will be set in place. Should these trigger values be reached, contingency actions will be undertaken to rectify the issue.

WSUD AND OTHER INFRASTRUCTURE

Monitoring of the actual stormwater system will also be undertaken when the opportunity arises after significant rainfall. This sampling and analysis will provide a snapshot of the pollutant load and treatment effectiveness. A major monitoring point will be the exit point to the Balfour street drain.

The monitoring of surface water in the stormwater system and wetlands will continue for 2 years after the completion of subdivisional works.

The condition and operation of the WSUD measures should be inspected and monitored for an agreed upon time between developers and the Council (a minimum of 12 months after the completion of works). The tasks that should be undertaken quarterly after completion of the works should include:

- Visual assessment of vegetation growth and health;
- Assessment of sediment build-up at entry points to the systems;
- In-situ permeability testing of bioretention media;
- Monitoring of protection measures during construction phases of housing and implementation of sediment and erosion control by builders; and
- When possible observation of bioretention systems operating during rainfall events.

The post-development monitoring data may be used to quantify the impact, if any, on surface water quality, surface water flows and ground water quality and water level fluctuations. Pre-development base-line monitoring data will be used for post-development comparisons to target design objectives and criteria, including re-assessment of the validity of the monitoring program, setting triggers for contingency action and quantifying the performance of the WSUD system. The pre-development monitoring is to happen prior to the UWMP being approved and will follow the schedule outlined in *Table 6*. This would require comparative parameters to be collected pre and post development.

Monitoring of sediment control across the site is also to be undertaken during subdivisional works.

WATER DEPENDENT ECOSYSTEMS

Basic pre-development monitoring of the wetlands health has been undertaken as part of the assessment work for the subject land. Level monitoring has also happen by default through the groundwater monitoring of the site.

The Wetland Management Plan Lots 1-4 Holmes St, Lot 1600 and Pt Lot 1601 Balfour St Southern River outlines the post development monitoring regime for surface water within the wetland system. This is the major surface water feature on site with only sporadic occurrence of surface water after rainfall for the rest of the site. The monitoring parameters locations and regime can be seen in *Figure 27* and *Table 8* of this LWMS.

The monitoring will include;

- water level monitoring, using a sensor installed in the Conservation Category wetland
- opportunistic sampling for chemical parameters with a focus on organic nutrients, sediments and metals

Any monitoring undertaken needs to follow the Australian Standard AS/NZ 5667 series of water quality sampling guidance notes and a National Association of Testing Authorities accredited laboratory undertake the water quality tests.

More detailed monitoring information related to the site's wetland can be found in the Wetland Management Plan

The monitoring of the health of the water dependent ecosystems on the subject land is also to be undertaken for up to two years after practical completion of subdivisional works. This monitoring will be to allow for the analysis of the ecosystem's overall health compared to its current condition as detailed for previous vegetation and wetland assessments. A summary of the monitoring includes;

- Assessment of revegetation survival
- Assessment of weed encroachment
- Assessment of wetland vegetation health

Further details can be found in *Figure 26* and the report Wetland Management Plan Lots 1-4 Holmes St and Lot 1600 Balfour Street, Southern River.

Post Development monitoring of Water Quality and Wetland health will be provided to the City of Gosnells for review on an annual basis. Should there be issues identified, the Developer will also notify the Department of Environment and Conservation within 72 hours.

IMPLEMENTATION PLAN

The following information details the implementation schedule for the subject land and the organisation responsible. Further detail can be seen in *Table 8*.

Implementation of the strategies outline in this report will be undertaken prior to developmental works, as part of subdivisional works and into the post development phase. To assist with this implementation, an Urban Water Management Plan (UWMP) will be completed as part of subdivisional works. The UWMP will provide more detailed information on the relevant implementation of the water management aspects. The following is a summary of activities and responsibilities that are to be detailed in the UWMP.

THE DEVELOPER WILL BE RESPONSIBLE FOR:

- Construction of the bioretention gardens and swales.
- Construction of overall drainage system.
- The maintenance of bioretention gardens and swales including weed control, litters and sediment removal, plant replacement and any localise scouring until handover to the Council.
- Appropriate fill used across the site.
- Wetland management including revegetation and weed control within and around the onsite wetland system as necessary.
- Provide lot owners with information regarding Waterwise practices inside and outside the house.
- Provide lot owners with information regarding nutrient wise practices and designs for gardens.
- Undertake any further relevant geotechnical investigation, including acid sulphate soils tests, over the areas of the subject land.
- Undertake more detailed drainage analysis of the site as a part of subdivisional work.
- The preparation of Urban Water Management Plans as part of subdivision conditions.
- Monitoring of the sites water and associated ecosystems as outlined in the monitoring regime.
- Sediment control during construction
- Street sweeping for 2 years following practical completion to manage sediment arising from housing construction activities.

The City of Gosnells will have the following responsibilities:

- Maintenance of entire drainage network system after handover.
- Street sweeping after developers two year maintenance period.
- Enforcement of construction standards for WSUD infrastructure.
- Assessment of the UWMP in line with the Better Urban Water Management Framework.

The Water Corporation will need to provide the necessary potable water supply and sewage system.

The Department of Water will be required to assess the UWMP in conjunction with the City of Gosnells.

The lot owners will need to construct their dwellings and landscaping in keeping with the guidelines set out in the UWMP.

Function	Item to Monitor	Purpose of Monitoring	Trigger for Immediate Action	Maintenance Action Required	Monitoring Frequency	Responsibility
Drainage Management Systems	Structural Effectiveness (inlets, traps and outlets)	Inspection for debris, litter and sediments surrounding structural components.	Debris, litter or sediments causing blockages or impairing functions.	Remove any debris or blockages. Inspect system for any erosion related issues.	Every 3 months	Developer until handover to Council
	Erosion	Inspection for erosion.	Presence of severe erosion or erosion impairing functions.	Investigate, identify and rectify the cause of the erosion. Replace filter media as required.	Every 3 months	Developer until handover to Council
	Sediment Build Up	A) Inspection for sediment accumulation within pits, on the surface of bioretention systems and within soakwells. B) Inspection of sediment build up on roadways.	A) Accumulation of large volumes of sediments in pits or on the surface or greater than 50% of the basins depth. B) Accumulation of sediment on roadway	A) Investigate, identify and stabilise cause of sediment source. Remove accumulated sediments and replace filter media or plants removed. B) Street sweeping to remove sediment	Every 3 months	A) Developer until handover to Council
	Compaction	Inspection of filter media for compaction, could include being driven on.	Water remains ponding longer than designed in bioretention system after a storm event.	Investigate cause of compaction. If localised, remove top 500mm of filter media, break up the filter and then return to system without any compaction. If extensive seek expert advice.	Every 3 months	Developer until handover to Council
	Weeds	Inspection for the presence of weeds.	Weeds are noxious or highly invasive or if weeds cover more than 25% of area.	Manual removal or targeting herbicide application, with waterway approved products.	Monthly	Developer until handover to Council
	Plant Condition	Inspection of vegetation health and cover, and presence of dead plants.	Plants dying or a pattern of plant deaths.	Investigate cause of plant deaths and rectify. Infill plantings may be required.	Monthly	Developer until handover to Council
	Organic Litter	Inspection for the presence of organic litter (e.g. leaves) on surface.	Litter coverage is thick or extensive, or detracting from the visual appearance of the system.	Investigate source of litter and undertake appropriate response, e.g. alter landscaping maintenance practices, community education). Remove litter.	Monthly	Developer until handover to Council
	Permeability	Inspection to determine that infiltration rate is maintained between 150mm and 400mm/hour	Infiltration rate is outside of these values.	If within the first 2 years, wait for settling and establishment of plant roots. After this period, enhance plant growth or remove media as necessary	Every 6 months for first 2 years then annually	Developer until handover to Council
	Rubbish/Litter	Inspection for the presence of litter.	Litter is blocking structures or detracting from the visual appearance of the system.	Identify source of litter and undertake appropriate responses. Remove litter.	Monthly	Developer until handover to Council
Groundwater	Pre development levels (Pre development)	To acquire baseline for wetland protection and to allow for effective post development management strategies. Eg fill levels	NA	NA as pre development base line.	Monitoring has been completed to DoW requirements already.	Developer (has already undertaken monitoring)).
	Pre Development Quality	To acquire baseline for wetland protection and to allow for effective post development management strategies. Eg subsoil flow treatment.	NA as pre development base line.	NA as pre development base line.	Organic nutrients 3 times during period of groundwater present eg Autumn to Spring)	Developer (has already undertaken monitoring of most aspects. Organic nutrients to be sampled still).
	Post development quality	To determine that pH, EC, TN, TP and Organic Nutrients are maintained at predevelopment levels or improved.	Results above agreed upon standards and or 10% variation from pre development monitoring results..	Investigate and identify source of contaminant. Undertake appropriate responses to rectify the contamination.	Quarterly for two year after final stage of construction.	Developer
	Post development levels	To determine that levels are maintained at pre development levels	Results above agreed upon standards and or 10% variation from pre development monitoring results..	Investigate and identify source of change. Undertake appropriate responses to rectify the level change if not due to extreme weather conditions.	Quarterly for two year after final stage of construction. Annually there after if necessary	Developer until handover to the Council
Surface Water/Wetlands	Surface Water Quality (Pre development)	Sampling of water quality (pH, TDS, N & P and Organic nutrients) at subject land drain outlet point and within wetland.	Results above agreed upon standards.	Investigate and identify source of contaminant. Undertake appropriate responses to rectify the contamination as part of development process.	Every 3 months (1 year duration)	Developer
	Surface Water Quality (Post development)	Sampling of water quality (pH, TDS, N & P) at subject land, bubble ups, drain outlet point and within wetland.	Results above agreed upon standards and or 10% variation from pre development monitoring results..	Investigate and identify source of contaminant. Undertake appropriate responses to rectify the contamination.	Every 3 months (for 2 years after practical completion)	Developer until handover to the Shire
	Wetland rehabilitation work	Determine if rehabilitation work has been successful as detailed in Wetland Management Plan	A) Death of plants above 20%. B) Weed invasion at a level where it hinders native regeneration, species composition maintained.	A) Replanting of native vegetation, irrigation if necessary. B) Removal of weeds,	Every 3 months (for 2 years after practical completion)	Developer until handover to Council
	Overall health	Allows for assessment of the existing wetland and its associated vegetation community	Deterioration in condition of existing vegetation or fauna plus other aspect as outlined in the Wetland Management Plan.	Rectifying of causes of degradation	Every 3 months (3 years)	Developer until handover to Council
	Levels pre development	Provides baseline for wetland and drain water levels	Extreme levels of flooding	Investigate and identify source of flooding. Undertake appropriate responses to rectify the flooding if not due to extreme rainfall.	Monthly for at least 1 year	Developer
	Levels post development	Allows for assessment of wetland and drain levels in comparison to predevelopment state	Results above agreed upon standards and or 10% variation from pre development monitoring results..	Investigate and identify source of change. Undertake appropriate responses to rectify the level change if not due to extreme weather conditions.	Quarterly for two year after final stage of construction.	Developer until handover to the Shire

Table 8 - Detailed Monitoring & Maintenance Schedule



Figure 27 - Monitoring Plan



REFERENCE

C. Arono BSD (2007) *Flora and Vegetation Survey & Wetland Assessment: Lots 1 - 4 Holmes St & Lot 1600 and Pt Lot 1601 Balfour St, Southern River*

Function	Item to Monitor	Purpose of Monitoring	Trigger for Immediate Action	Maintenance Action Required	Monitoring Frequency	Responsibility
Drainage Management Systems	Structural Effectiveness (inlets, traps and outlets)	Inspection for debris, litter and sediments surrounding structural components.	Debris, litter or sediments causing blockages or impairing functions.	Remove any debris or blockages. Inspect system for any erosion related issues.	Every 3 months	Developer until handover to Council
	Erosion	Inspection for erosion.	Presence of severe erosion or erosion impairing functions.	Investigate, identify and rectify the cause of the erosion. Replace filter media as required.	Every 3 months	Developer until handover to Council
	Sediment Build Up	A) Inspection for sediment accumulation within pits, on the surface of bioretention systems and within soakwells. B) Inspection of sediment build up on roadways.	A) Accumulation of large volumes of sediments in pits or on the surface or greater than 50% of the basins depth. B) Accumulation of sediment on roadway	A) Investigate, identify and stabilise cause of sediment source. Remove accumulated sediments and replace filter media or plants removed. B) Street sweeping to remove sediment	Every 3 months	A) Developer until handover to Council
	Compaction	Inspection of filter media for compaction, could include being driven on.	Water remains ponding longer than designed in bioretention system after a storm event.	Investigate cause of compaction. If localised, remove top 500mm of filter media, break up the filter and then return to system without any compaction. If extensive seek expert advice.	Every 3 months	Developer until handover to Council
	Weeds	Inspection for the presence of weeds.	Weeds are noxious or highly invasive or if weeds cover more than 25% of area.	Manual removal or targeting herbicide application, with waterway approved products.	Monthly	Developer until handover to Council
	Plant Condition	Inspection of vegetation health and cover, and presence of dead plants.	Plants dying or a pattern of plant deaths.	Investigate cause of plant deaths and rectify. Infill plantings may be required.	Monthly	Developer until handover to Council
	Organic Litter	Inspection for the presence of organic litter (e.g. leaves) on surface.	Litter coverage is thick or extensive, or detracting from the visual appearance of the system.	Investigate source of litter and undertake appropriate response, e.g. alter landscaping maintenance practices, community education). Remove litter.	Monthly	Developer until handover to Council
	Permeability	Inspection to determine that infiltration rate is maintained between 150mm and 400mm/hour	Infiltration rate is outside of these values.	If within the first 2 years, wait for settling and establishment of plant roots. After this period, enhance plant growth or remove media as necessary	Every 6 months for first 2 years then annually	Developer until handover to Council
	Rubbish/Litter	Inspection for the presence of litter.	Litter is blocking structures or detracting from the visual appearance of the system.	Identify source of litter and undertake appropriate responses. Remove litter.	Monthly	Developer until handover to Council
Groundwater	Pre development levels (Pre development)	To acquire baseline for wetland protection and to allow for effective post development management strategies. Eg fill levels	NA	NA as pre development base line.	Monitoring has been completed to DoW requirements already.	Developer (has already undertaken monitoring)).
	Pre Development Quality	To acquire baseline for wetland protection and to allow for effective post development management strategies. Eg subsoil flow treatment.	NA as pre development base line.	NA as pre development base line.	Organic nutrients 3 times during period of groundwater present eg Autumn to Spring)	Developer (has already undertaken monitoring of most aspects. Organic nutrients to be sampled still).
	Post development quality	To determine that pH, EC, TN, TP and Organic Nutrients are maintained at predevelopment levels or improved.	Results above agreed upon standards and or 10% variation from pre development monitoring results..	Investigate and identify source of contaminant. Undertake appropriate responses to rectify the contamination.	Quarterly for two year after final stage of construction.	Developer
	Post development levels	To determine that levels are maintained at pre development levels	Results above agreed upon standards and or 10% variation from pre development monitoring results..	Investigate and identify source of change. Undertake appropriate responses to rectify the level change if not due to extreme weather conditions.	Quarterly for two year after final stage of construction. Annually there after if necessary	Developer until handover to the Council
Surface Water/Wetlands	Surface Water Quality (Pre development)	Sampling of water quality (pH, TDS, N & P and Organic nutrients) at subject land drain outlet point and within wetland.	Results above agreed upon standards.	Investigate and identify source of contaminant. Undertake appropriate responses to rectify the contamination as part of development process.	Every 3 months (1 year duration)	Developer
	Surface Water Quality (Post development)	Sampling of water quality (pH, TDS, N & P) at subject land, bubble ups, drain outlet point and within wetland.	Results above agreed upon standards and or 10% variation from pre development monitoring results..	Investigate and identify source of contaminant. Undertake appropriate responses to rectify the contamination.	Every 3 months (for 2 years after practical completion)	Developer until handover to the Shire
	Wetland rehabilitation work	Determine if rehabilitation work has been successful as detailed in Wetland Management Plan	A) Death of plants above 20%. B) Weed invasion at a level where it hinders native regeneration, species composition maintained.	A) Replanting of native vegetation, irrigation if necessary. B) Removal of weeds,	Every 3 months (for 2 years after practical completion)	Developer until handover to Council
	Overall health	Allows for assessment of the existing wetland and its associated vegetation community	Deterioration in condition of existing vegetation or fauna plus other aspect as outlined in the Wetland Management Plan.	Rectifying of causes of degradation	Every 3 months (3 years)	Developer until handover to Council
	Levels pre development	Provides baseline for wetland and drain water levels	Extreme levels of flooding	Investigate and identify source of flooding. Undertake appropriate responses to rectify the flooding if not due to extreme rainfall.	Monthly for at least 1 year	Developer
	Levels post development	Allows for assessment of wetland and drain levels in comparison to predevelopment state	Results above agreed upon standards and or 10% variation from pre development monitoring results..	Investigate and identify source of change. Undertake appropriate responses to rectify the level change if not due to extreme weather conditions.	Quarterly for two year after final stage of construction.	Developer until handover to the Shire

Table 8 - Detailed Monitoring & Maintenance Schedule



Figure 27 - Monitoring Plan



REFERENCE

C. Arono BSD (2007) *Flora and Vegetation Survey & Wetland Assessment: Lots 1 - 4 Holmes St & Lot 1600 and Pt Lot 1601 Balfour St, Southern River*

APPENDIX 3

Wetland Management Plan

Wetland Management Plan

Lots 1-4 Holmes St and Lots 1600-1601 Balfour St, Southern River.

Prepared for
Gucce Holdings Pty Ltd

by
Endemic & Associates Pty Ltd

July, 2016



Endemic

Contents

	Page Number
1. Summary of Management Commitments	1
Introduction	6
1.1 Planning context	6
1.2 Purpose of the Wetland Management Plan	6
1.3 Wetland Management Plan objectives	7
1.4 Wetland Values & Functions	7
2. Site description	9
2.1 Bush Forever Site 125 boundaries	10
2.2 Wetlands	11
3. Geology, Geomorphology and Soils	13
3.1 Topography	13
3.2 Geomorphological setting	13
3.2.1 <i>Soil Descriptions</i>	13
3.2.2 <i>Stratigraphy</i>	16
4. Hydrology	19
4.1 Surface hydrology	19
4.2 Groundwater	20
4.3 Wetland Water Levels	21
5. Vegetation	23
5.1 Broad Scale Vegetation Classification	23
5.2 Vegetation Complexes	23
5.3 Threatened Ecological Communities (TEC's)	26
5.4 Wet forests and Woodlands (FCT 11)	26
5.5 Central Banksia woodlands' (FCT 23a)	27
5.6 Priority flora and Declared Rare Flora	27
6. Fauna	28
7. Wetland definition, retention and enhancement	32
7.1 Wetland area and management objectives	32
7.2 Wetland values, processes, functions and attributes	35
7.3 Wetland Retention and Buffer	37
8. Potential development impacts and associated management strategies	38
8.1 Geology, Geomorphology and Soils	39
8.1.1 <i>Acid Sulfate Soils</i>	39
8.1.2 <i>Site contamination</i>	40
8.2 Hydrology	41
8.2.1 <i>Wetland Hydrology</i>	41
8.2.2 <i>Water Quality Protection</i>	43
8.3 Vegetation	45
8.3.1 <i>Wet forests and Woodlands (FCT 11)</i>	45
8.3.2 <i>Central Banksia Woodlands (FCT 23a)</i>	45
8.3.3 <i>Priority flora Jacksonia sericea (P4)</i>	46
8.3.4 <i>Ecological Linkages</i>	46
8.3.5 <i>Wetland Rehabilitation Plan</i>	46
8.4 Fauna	49
8.4.1 <i>Mosquitoes and Midge Management Plan</i>	49
8.5 Fire	50
8.5.1 <i>Physical Separation Controls</i>	52
8.5.2 <i>Landscape Design Controls</i>	52
8.6 Community use and appreciation	52
8.6.1 <i>Natural landscape amenity</i>	52

8.6.2	<i>Increased Human Use</i>	53
8.6.3	<i>Signs and Notices</i>	53
8.6.4	<i>Controlled Public Access</i>	54
8.7	Minimising the risk of phytophthora dieback	55
8.8	Land use change and nutrient budget	56
8.9	Construction Management Plan	59
9.	Monitoring and Reporting	60
9.1	Water Monitoring Program	60
9.2	Assessing change to water levels and water quality and associated trigger values	62
9.3	Vegetation Monitoring and Reporting	62
9.4	Responsiveness and Contingency measures	63
9.4.1	<i>Contingencies</i>	63
9.4.1	<i>Responsiveness</i>	63
9.4.2	<i>Annual Reporting</i>	64
10.	Implementation, Timing and Review	65
10.1	Implementation Strategy	65
10.2	Responsibilities	66
10.3	Timing	67
10.4	Review	68
11.	Roles and Responsibilities	69
11.1	Acid Sulfate Soils	69
11.2	Wetland Hydrology	69
11.3	Drainage and Water Quality Strategy	70
11.1	Maintaining wetland buffer	70
11.2	Ecological corridors and linkages	70
11.3	Wetland Rehabilitation and Weed Management Strategy	71
11.4	Fauna	72
11.5	Mosquitoes and Midges	72
11.6	Fire management	73
11.7	Natural Landscape Amenity	74
11.8	Increased Human Use	74
11.9	Signage	75
11.10	Controlled public access	75
11.11	Managing the risk of Phytophthora Dieback	76
11.12	Construction management	76
11.13	Monitoring and Reporting	77
12.	References	78

1. Summary of Management Commitments

The key wetland management commitments outlined within this Wetland Management Plan are summarised in Table 1.

In preparing this report, Endemic Pty Ltd has taken due recognition of the Department of Water, Department of Environment and Conservation, Department of Planning and Infrastructure and City of Gosnells guidelines and policies to ensure the WMP meets the information requirements of the relevant authorities. These local policies include:

- Environmental Guidance for Planning and Development (EPA Guidance Statement No. 33)
- Environmental Protection of Wetlands – Position Statement No. 4) (EPA, 2004)

The report has been compiled to support the Outline Development Plan (Appendix A) being undertaken for the site and to address the following Western Australian Planning Commission (WAPC) conditions of approval of development:

- Condition 3 of the City of Gosnells Development Approval (DA07/02505)
- Condition 4 of the City of Gosnells Development Approval (DA07/02505)

Additionally, this Wetland Management Plan has been prepared in fulfilment of the comments relevant to the WMP, as recommended by the (then) Department of Environment and Conservation in a letter sent to the City of Gosnells dated 10th December, 2007 (Appendix A).

Table 1: Summary of Environmental Management Commitments

Environmental Factor	Objectives and Relevant Information	Management Commitments
Acid Sulfate Soils and Dewatering Management Plan	The acid sulfate soils risk map outlined in DEC (2007) identified that the CCW area has a high to moderate ASS disturbance risk. Regardless, the areas where Acid Sulphate Soils are potentially present pose a minimum threat to the surrounding environment if left undisturbed.	The developers are committed to • Undertaking an ASS Self-Assessment in accordance with WAPC and DER requirements. • Preparing a Detailed Acid Sulphate Soils and Dewatering Management Plan (DASSDMP) to the requirements of the DER, prior to subdivision approval. This is a common WAPC condition and is expected to be imposed following approval of the LSP. The DASSDMP is then implemented during civil works. The DASSDMP will address ASS management issues as well as dewatering, water treatment, water quality protection, discharge and surface water and groundwater monitoring.
Site contamination	The Preliminary Site Investigation (ACE Environmental 2008) confirmed that there was no soil contamination within any of the wetlands or wetland catchment areas. Therefore, no additional management strategies are required.	Site contamination issues are most appropriately addressed within the LSP, or under the Contaminated Sites Act. The development area does not contain known or suspected contaminated sites, therefore there is no reportable action.
Hydrology	Increased stormwater runoff as a result of urbanisation can cause increased groundwater levels and impact on the seasonal flooding cycles and peak water levels in the wetlands. Common symptoms of urbanisation include 'drowning' of wetlands and the death of fringing natural vegetation. The hydroperiod and water level of the wetland area is now largely regulated by the invert and size of the drainage culvert underneath Balfour St. It is therefore important to ensure development (and drainage design) for the area seeks to mimic (if not retain) this hydraulic control in order to maintain a consistent post-development wetland water level regime	Management of increased runoff A detailed water balance has been prepared for the site which complements this WMP and is detailed in the Local Water Management Strategy (Calibre, 2016). The developers are committed to ensuring that post-development flow rates are similar to the pre-development flow rates by providing: • Bioretention gardens have been designed to contain and infiltrate peak flows from the 1:1 year ARI event. Flows associated with <1:5 year ARI event will be retained and treated onsite via biofiltration swales. • There will be no direct discharge of stormwater to the wetland in <1:5 ARI event • A 1:100 year overland flow path has been designed to direct flows toward roadways, the Balfour Street Drain, wetlands and their buffers and away from residences in accordance with Australian Rainfall and Runoff (Canterford <i>et al.</i>, 2001) and the Decision Process for Stormwater Management in WA (DoW 2009). Maintenance of existing hydrological regimes has been reflected in the accompanying LWMS (Calibre, 2016): • Drainage design for the site is to ensure that the invert of the culvert at Balfour Street remains unchanged and retains the hydrologic control of the Balfour Street Brach Drain outlet in its pre-development form • The installation of domestic bores in the superficial aquifer within the management area will be prohibited via the use of a Restrictive Covenant, to be placed on titles. A clause in the relevant sale contracts will be inserted to address the covenant and the underlying environmental need for it. • Controlled Groundwater Level (CGL) dictated by subsoil drainage will be at the same level or above as AAMGL, historically dictated by the invert of the Balfour Street Brach Drain. • Modelling undertaken and documented within the LWMS shows that the 1:100yr ARI will increase the post development peak wetland water level by 1cm. This increase is very small and would be of short duration and unlikely to adverse impact the hydrology of the wetland. This assumes re-connection of the outlet to the Balfour Street Drain. • The UWMP is to consider the hydrological impacts on the wetland of re-connecting the outlet to the Balfour Street Drain.
Vegetation and Linkages	Development of the site should seek to enhance and restore natural habitats and ecological linkages.	The developers are committed to: • Preparing a Landscape Management Plan and submitting this prior to subdivision. The LMP will identify landscape treatments and irrigation and nutrient regimes for biofiltration swales and areas of active recreation within the estate.

Environmental Factor	Objectives and Relevant Information	Management Commitments
		Preparing a Wetland Rehabilitation Plan (WRP) and submitting this prior to subdivision. See WRP.
Weed Management		A Wetland Rehabilitation Plan will be prepared prior to subdivision outlining detail on weed management actions to be undertaken pre, during and post development. See WRP and CMP.
Wetland Rehabilitation Plan	The goal of all revegetation works within the conservation area to be retained (as identified by the OEPA) is to establish locally indigenous species to a level where over time they dominate weeds.	A detailed Wetland Rehabilitation Plan will be developed and submitted prior to subdivision providing detail on plant selection, density, location and supply, and an implementation and monitoring schedule for wetland areas located on Lot 1 and 2 Holmes St and Lot 1600 Balfour St. The developers are committed to conducting revegetation and rehabilitation for wetland habitats identified by the OEPA within these areas. For all revegetation works, the 2 year post-development target is to achieve a $\geq 70\%$ surface cover of locally indigenous vegetation and $\leq 5\%$ weed coverage.
Fauna	Domestic pets are to be managed and excluded as far as practicable in order to protect native fauna.	Suitable fencing will be erected around the conservation area. Fencing will be designed in line with City of Gosnells fencing specifications for conservation areas. The fencing requirements will be specified in the Wetland Rehabilitation Plan.
Mosquito and Midge Management Plan	Wetlands, waterways and pools (natural, modified and constructed) within the wetland complex may support significant Mosquito and Midge populations. Mosquitoes are known to severely reduce the amenity in residential areas and present serious health risks to humans by acting as transmitters or vectors of pathogenic arbovirus (Environmental Protection Authority 2000).	The developers are committed to preparing and submitting a Mosquito and Midge Management Plan (MMMP) prior to subdivision and implementing this for 2 years following practical completion of the subdivision in consultation with the Department of Health, Western Australia (DHWA) and City of Gosnells Environmental Health staff. The MMMP is to manage the potential breeding sites and will include direct and indirect intervention strategies. The MMMP is to be prepared in accordance with the Department of Health Mosquito Management Manual (DOH, 2006). The LWMS demonstrates how the pre-development water level regime (seasonal drying) of the CCW sumpland will be maintained. This will serve to reduce the mosquito nuisance during the summer months. Biofiltration swales have been designed in the LWMS to ensure standing water occurs for <96hrs over the spring/summer mosquito breeding season, as recommended by the DoH.
Fire Management Plan	Fire needs to be carefully managed to maintain wetland function, plant and animal communities and landscape character The increased activity of machinery and vehicles as a result of construction activities and future residents has the potential to increase the likelihood of fires. The prevailing winds during the summer months are generally from the east (mornings) and south west (afternoon sea breeze), thus the highest fire risk is likely to be associated with households and infrastructure located in and between the Balfour/Holmes Street wetland.	The developers will prepare a Fire Management Plan (FMP) as part of the subdivision application and submit this for the approval of WAPC. Also see Construction Management Plan.
Natural Landscape Amenity	The development of the site has the potential to detract from the rural character (naturalness, visual, landscape and recreational amenity) of the area and the naturalness of the CCW	The visual impact of the residential development will be mitigated to some extent by the revegetation, rehabilitation and weed management proposed. The rehabilitation and/or revegetation proposed will enhance environmental values and functions of the CCW and adjacent Bush Forever site. See Wetland Rehabilitation Plan and Landscape Management Plan.
Increased Human Use and Controlled Public Access	The uncontrolled access of humans within the wetland catchments may cause direct (trampling) and indirect (spread of weeds) impacts on the wetlands For ecological and safety reasons, it is important to discourage children and pedestrians from trampling the CCW sumpland or worse, establishing 'shortcuts' through the habitat.	The developers are committed to: - Developing a Landscape Management Plan for areas outside the conservation area, biofiltration swales and active POS within the estate. - Developing a Wetland Rehabilitation Plan for the conservation areas identified by the OEPA. This will detailing fencing, paths and regulated access to the wetland. The WRP will identify limited pedestrian access points whilst maintaining sufficient access for general maintenance and bushfire response.

Environmental Factor	Objectives and Relevant Information	Management Commitments
		- Constructed biofiltration swales at the end of road runs will be used as a means of controlling public access to the conservation area. A number of limited crossover points along the swale will be included and integrated into a walkway design for this purpose, where appropriate and subject to consultation with the City of Gosnells and DPaW. - A Construction Management Plan will be prepared that will exclude vehicular access to conservation areas during construction of paths, fences and biofiltration swales. The alignment of any path will be selected so that it does not intrude upon or traverse CCW wetland habitat. Contractors will be inducted and instructed upon the importance of minimising disturbance and staying within flagged areas prior to commencement of onsite construction activities.
Signage	Signs and notices play an invaluable public relations role in minimizing the potential for ecological impacts to the CCW wetland complex. Environmental education is crucial to developing awareness, increasing knowledge, teaching skills and changing attitudes of the community to the impacts that urban development may have on the environment (and wetlands in particular). It facilitates behavioural change and environmentally responsible practices.	The developers are committed to designing and installing signage to raise the awareness of the conservation values and importance of the habitat and the need to protect the wetland: - Interpretative signage will be installed to help residents and visitors identify the key flora and fauna of the Conservation wetland, the goals/targets for conservation and explain the Water Sensitive Urban Design elements of the development. - Marketing of the residential lots within the site will focus on the landscape amenity of the Conservation wetland. Signage within the estate will seek to build upon raising public awareness and appreciation of the wetland and the need for protection. - Signage will also provide information regarding prohibited activities that may otherwise adversely impact the natural values of the wetland (e.g. littering, dumping, fire, domestic pets, etc). Signage will be located at interpretation nodes corresponding with entry points, directional shifts of any future path and widenings for seating or viewing points. Incidental signs along a walkway enhance and reinforce the environmental messages. Signage will be detailed within the Wetland Rehabilitation Plan and developed in consultation with the City of Gosnells.
Phytophthora Management	The development of the site has the potential to spread dieback (<i>Phytophthora cinnamomi</i>) to the wetland vegetation communities. Human activity has caused the widespread distribution of this disease through road construction, earth moving and driving vehicles on infested bush roads.	The developers are committed to minimising the potential for spreading dieback into the vegetation communities in the wetland and associated buffer by: - Preparing a Construction Management Plan (CMP) prior to subdivision application which contains dieback management instructions. Dieback management during the construction phase will be undertaken in line with Managing Phytophthora Dieback: Guidelines for Local Government, produced by the Dieback Working Group. - Conducting periodic surveys post-construction to monitor the "Reservation for Conservation" for signs of Dieback. In the event that Dieback is identified, immediate action will be undertaken to determine the appropriate management response. Also see Construction Management Plan and Wetland Rehabilitation Plan.
Landuse change and Nutrient Budget	Urbanisation has the potential to increase nutrient loadings to the wetlands and impact on their trophic status and ecological functioning. Urbanisation incorporating Water Sensitive Urban Design principles provides a significant opportunity to both reduce nutrient export from existing broadscale agricultural practices and to secure and protect existing remnant vegetation and wetland and foreshore habitats.	The developers have calculated pre and post urbanisation nutrient budgets from an early stage of the development based upon innovative drainage and landscape design. Based upon the likely pre and post-development scenarios, nutrient loading rates to the site (and the CCW sumpland) can be expected to be reduced by 94% and 75% for nitrogen and phosphorus, respectively. The magnitude of the reduction in nutrient inputs to the site following land use change provides a high degree of confidence that nutrient discharge from the site and the CCW sumpland will not be adversely impacted following urbanisation. Aspects associated with stormwater and water quality protection are addressed within the LWMS (Calibre, 2016). A detailed drainage design and water quality monitoring program will be presented within an Urban Water Management Plan to be prepared and lodged with each subdivision application. Monitoring and reporting commitments relating to the wetland habitat are outlined within the Monitoring and Reporting Management section 9 of this WMP.
Construction Management Plan	Construction activities have the potential to cause direct (eg. trampling) and indirect impacts (eg. spread of weeds) which can adversely effect the wetland areas.	The developers are committed to minimising the impacts of construction activities on the conservation area identified by the OEPA by: - Preparing a Construction Management Plan (CMP) prior to subdivision application and inducting all contractors prior to undertaking site works - Erecting appropriate fencing and flagging to delineate conservation areas and conducting contractor site inductions prior to

Environmental Factor	Objectives and Relevant Information	Management Commitments
		the commencement of civil works • Not conducting unauthorised ground disturbing activities (associated with the urban development) within the Balfour/Holmes Street conservation area • Avoiding water erosion and sedimentation impacts on the conservation area; • Managing onsite fuel storage and spill management • Ensuring that construction vehicles have preventative cleaning to eliminate the spread of weed seeds / phytophthora. • Ensuring that construction contractors comply with the Bushfires Act 1954 (e.g. fire prevention and control requirements) and provide details of fire access requirements. See also ASS and Dewatering Management Plan
Monitoring and Reporting	Monitoring of vegetation, ground and surface water quality is required to ensure: • successful weed control and revegetation of degraded areas within the reservation for conservation; and • the hydrologic regime (water level) of the CCW sumpland is maintained. The monitoring programs outlined within this Wetland Management Plan refer only to those specifically related to the environmental performance of the CCW sumpland habitat and at key locations within the stormwater treatment trains that may potentially enter the wetland system.	The developers are committed to: • Undertaking water quality monitoring quarterly, with annual reporting to the City of Gosnells for a period of no less 2 years post development (to coincide with the landscaping maintenance period). Annual reporting will be provided to the City of Gosnells summarising the results of monitoring for the preceding 12 months and making management recommendation as appropriate. Specifically, water monitoring of the CCW sumpland will entail the following: • Installation of a water level recording sensor or staff gauge within the CCW sumpland. This will be sited and installed to minimise visual intrusion and vandalism. • Monitoring of continuous water levels within the CCW. • Monthly surface water quality monitoring (when standing water is present in the wetland) of pH, EC, temp, DO, redox, TSS, TN, NOx, TP and FRP and ammonia. Water levels will initially be screened against the 10% change threshold advocated under the Marine and Freshwater Quality Guidelines (ANZECC/ARMCANZ 2000), whereby any exceedances of this relative to JDA Pre-development monitoring (2009) will trigger a management response. The developer is committed to developing a Wetland Rehabilitation Plan which will detail a monitoring schedule for success of rehabilitation and weed management including • Undertaking vegetation monitoring, with annual reporting to the City of Gosnells for a period of no less than 2 years post development (to coincide with the landscaping maintenance period). Annual reporting will be provided to the City of Gosnells summarising the results of monitoring for the preceding 12 months and making management recommendation as appropriate. Specifically, vegetation monitoring of the CCW sumpland will entail the following: • Monitoring revegetation survival rate target: ≥70% coverage within first 2 years. • Inspection for invasive weeds (target ≤5% coverage) and recording of spot treatments, slashing or hand weeding undertaken (as appropriate).

Introduction

1.1 Planning context

Southern River is a suburb within the City of Gosnells and was included under the Southern River/Forrestdale/Brookdale/Wungong District Structure Plan released by the Western Australian Planning Commission (WAPC) in January 2001.

Mammoth Nominees Pty Ltd is proposing to develop a residential subdivision in Southern River comprising Lots 1-4 Holmes Street, Lot 1600 and part Lot 1601 Balfour Street (the site). The current Metropolitan Region Scheme Map sheet 20 zoning for the site is urban, with approximately 19 percent reserved for Parks and Recreation (WAPC, 2014).

An Outline Development Plan has been developed for the site which is bound by Holmes Street to the north, Balfour Street to the east, Lot 1601 Balfour Street to the south and Bush Forever Site 125, to the west (Appendix B).

1.2 Purpose of the Wetland Management Plan

In 2007 Mammoth Nominees submitted a Development Application for the site to the City of Gosnells. Approval was issued by City of Gosnells (DA07/02505) subject to a range of conditions including the following:

- Identification and protection of any vegetation on the site worthy of retention (Condition 3); and
- Preparation and implementation of a Wetland Management Plan (WMP, Condition 4).

A Wetland Management Plan (WMP) was prepared on behalf of Mammoth Nominees Pty Ltd in order to fulfil these conditions. Since this time Endemic has received feedback from both City of Gosnells and the DEC (now DPaW) regarding the WMP and it has undergone a number of revisions in response to these comments.

Most recently, advice has been received from the OEPA relating to the acceptability of reduced buffers for the wetland. A copy of this correspondence is attached (Appendix C). A revised Local Structure Plan (LSP) and LWMS (Calibre, 2016) has been developed for the site based upon the advice received from the OEPA. This WMP is submitted in support of the revised LSP.

The key purposes of the WMP are to guide preparation of the revised LSP and to inform and guide the preparation of civil engineering designs, subdivision-level Wetland Rehabilitation Plan(s), Construction Environmental Management Plan(s) and Landscape Plans by identifying and addressing at a broad level wetland management issues. The WMP outlines the processes for transferring the WMP's information and guidance to these subordinate plans.

1.3 Wetland Management Plan objectives

This wetland management plan has been prepared as supporting documentation to the proposed LSP, addressing the protection and management of wetlands habitat within the project area.

The aim of the Wetland Management Plan is to:

- Recognise, protect and enhance wetland values and functions located in, or adjacent to, the site; and
- Protect water quality within the Wungong/Southern River system to meet the objectives of the Swan and Canning Rivers EPP and Swan Canning Cleanup Program (as identified by the Swan River Trust).

The specific management objectives for the Wetland Management Plan are to:

- Ensure adequate protection of the natural values and wetland functions of the Conservation management category wetland (CCW), including to;
 - protect water quality associated with the CCW;
 - maintain a hydrological regime that will protect the CCW;
 - identify and protect key ecological habitats; and
 - maintain and enhance corridor and habitat linkages;
- Outline measures to restore degraded wetland habitat and wetland buffer suitable for inclusion within a future “Reservation for Conservation”;
- Provide educational, recreational and landscape amenity to residents and visitors to the area, while protecting the values and functions of the wetland habitats; and
- Provide details of ongoing management, monitoring and reporting requirements.

The need to integrate irrigation demand, nutrient and fertiliser usage, weed and fire management, wetland rehabilitation, public access, walkability, traffic management, visual impacts and drainage design to meet ecological and hydrological objectives for the Balfour Street Wetland complex should also be recognised. Accordingly, the Wetland Management Plan (this document) should also be read in conjunction with the Local Water Management Strategy (Calibre, 2016).

1.4 Wetland Values & Functions

The following five categories of significant environmental values and functions of wetlands are recognised as described in Environmental Protection of Wetlands EPA Position Statement No. 4 (EPA, 2004) and have been considered in the preparation of this document.

- Primary production

- Recreational and landscape amenity
- Hydrological balance
- Water quality protection
- Wildlife habitat

Additional detail on wetland values and functions specific to the management area is provided in discussion of the site in section 8.

2. Site description

The management area covered by this Wetland Management Plan comprises Lots 1-4 Holmes St and Lot 1600 and part Lot 1601 Balfour St, within City of Gosnells' Southern River Precinct 2 of the Southern River/Forrestdale/Brookdale/Wungong District Structure Plan Area located at Southern River, Western Australia. Lot 33 Balfour Street, a drain owned by City of Gosnells, intersects the site and separates Lots 1, 2, 3 and 4 from Lot 1600.

The site is bounded by Lot 4 Holmes St and Lot 1600 Balfour to the northwest, Holmes Street to the northeast, Balfour Street to the southeast and a portion of Lot 1601 to the southwest (Figure 1).

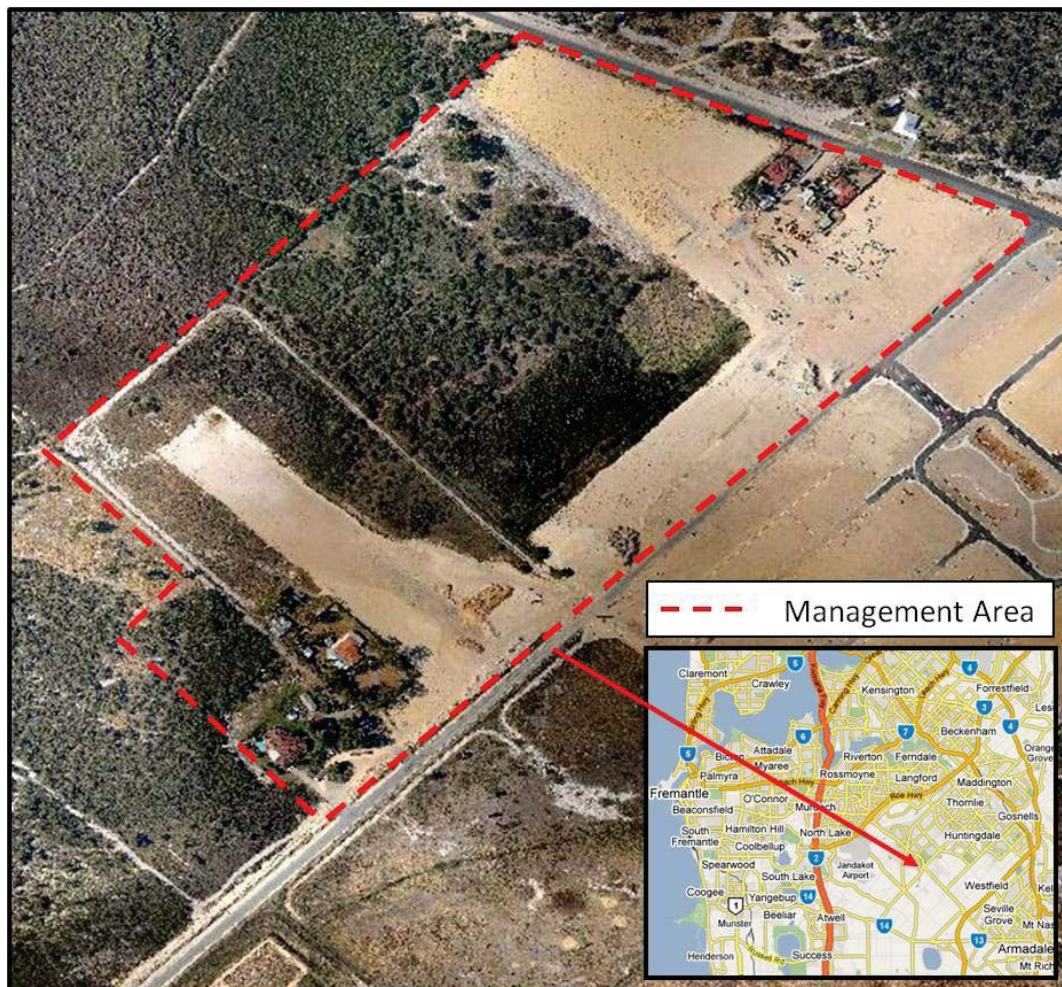


Figure 1: Site location for this Wetland Management Plan.

The total area of Lots 1-4 Holmes St, Lot 1600 and Pt Lot 1601 Balfour St is 21.7 hectares. Historical and current landuses within the site include residences, inert landfill, agricultural landuses including a former poultry farm and significant areas of wetland habitat and dryland (remnant) vegetation.

Approximately 4.14 hectares of the area is occupied by Bush Forever site 125. This area is reserved for parks and recreation under the metropolitan regional scheme (Figure 2).

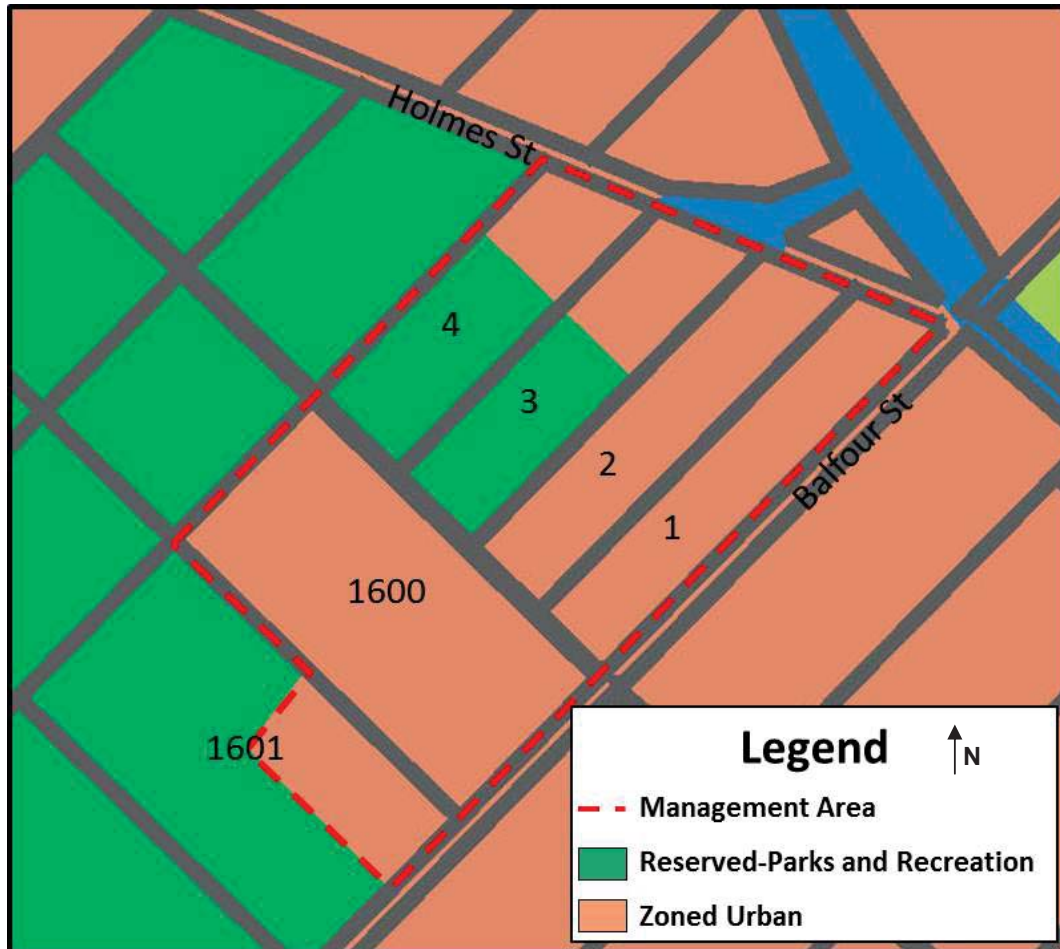


Figure 2: Management area zoning under the Metropolitan Region Scheme showing lot details

2.1 Bush Forever Site 125 boundaries

The Bush Forever Strategy is a ten year strategic plan which formally commenced in 2000 to protect approximately 51,200 ha of regionally significant bushland within approximately 290 Bush Forever Sites, representing where achievable, a target of at least 10 percent of each of the original 26 vegetation complexes of the Swan Coastal Plain portion of the Perth Metropolitan Region (Government of Western Australia, 2000). Bush Forever represents an update of the earlier System Six study and recommendations in the Perth Metropolitan Region and is the final version of the draft Perth Bush Plan.

Bush Forever Site 125 is partially located within the management area, where it has been assessed to be in a Degraded to Completely Degraded condition (Cardno 2007b). The boundaries of Bush Forever Site 125 were determined following negotiations with landholders, when 5.2 Ha was removed from the originally proposed reserve (on Lots 1 and 2 Holmes St, and 1600 Balfour St). MRS amendment 1082/33 in 2010 saw the rezoning of some Bush Forever sites to Parks and Recreation Reserve, including parts of Bush Forever site 125. The boundaries of Bush Forever Site 125 are presented as Figure 3.



Figure 3: Boundaries of Bush Forever Site 125
(Government of Western Australia, accessed online at
<https://www2.landgate.wa.gov.au/bmvf/app/waatlas/>, December 2010).

2.2 Wetlands

Much of the central portion of the management area is identified as wetland in the Department of Parks and Wildlife (DPaW) wetland database. Figure 4 below shows current DPaW mapping. The wetland delineation and categorisation is discussed in further detail in Section 8 of this Wetland Management Plan.

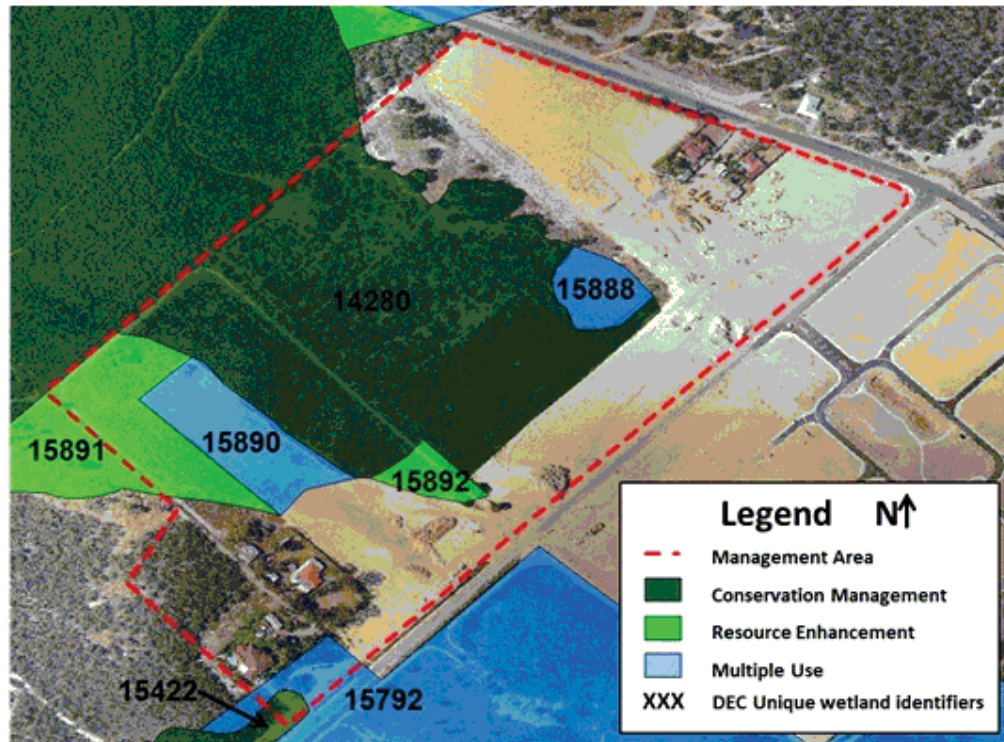


Figure 4: DPaw wetland categories and boundaries (DPaw, accessed online at <https://www2.landgate.wa.gov.au/bmvf/app/waatlas/>, October 2014)

DPaw mapping of UFI 14280 and 15422 as Conservation Category Wetlands designates these wetlands as Environmentally Sensitive Area as declared under Environmental Protection (Environmentally Sensitive Areas) Notice 55 (2005) under section 51B of the Environmental Protection Act 1986. Accordingly, the bulk of the LSP area is designated as ESA.

3. Geology, Geomorphology and Soils

3.1 Topography

The topography of the site and surrounding area is described as generally flat, sloping gently to the south with natural surface level ranging from 21.0 – 24.0 meters AHD. Superimposed on the northern (on the site) and southern (off the site) sections of this landform are dunal features typical of the Bassendean Sand formation.

3.2 Geomorphological setting

The Swan Coastal Plain consists of a series of geomorphological elements which are sub-parallel to the present coastline (McArthur and Bettenay, 1960). Each of these geomorphic elements has distinctive geology, vegetation, topography and soils. The Southern River area straddles two of these elements, the Guildford Formation and the Bassendean Sands System (McArthur and Bettenay, 1960).

The Bassendean Sands are the easternmost of three main ancient aeolian (or dunal) deposits found on the Swan Coastal Plain that increase in age sequence eastward of the present day coastline. The Bassendean Sands generally consist of pale siliceous unconsolidated dunal sands, however, organic-rich phases are commonly found in interdunal and deflation depressions associated with present-day wetland features such as the management area.

Evidence provided by test pits undertaken by Brown Geotechnical and Environmental (BGE, 2008) for the purposes of acid sulphate soil and geotechnical investigations shows Bassendean Sands commonly overlying clays and loams of the fluvial Guildford Formation at the site. This formation is generally flat in terms of topographic relief (or very slightly sloping) and exhibits low permeability due to the presence of clay fractions and is commonly subject to waterlogging during the winter months. The Guildford Formation is closely associated with palusplain wetlands on the eastern margins of the Swan Coastal Plain between Gosnells and Harvey. These clays and loams have been extensively cleared and drained for agricultural purposes in the past.

3.2.1 Soil Descriptions

Guildford Formation

The Guildford Formation has been deposited as an alluvial plain and commonly exhibits two facies within the site:

Sandy Clay (Cs) - found in the east towards the Darling Scarp and comprised of medium plasticity clays interbedded with silts and lenses of sand. This soil unit is believed to form much of the basement underlying the wetland complex on the site.

Clayey Sand (Sc) - Much of the finer grained component found in the Cs facies has been removed by alluvial reworking to produce a dominantly sandy facies interbedded with discontinuous lenses of silt and clay. Logs from BGE test pits (2008) show these clayey sands were encountered at a depth of 1.4 to 1.8 meters in the southern portion of Lot 1600.

Bassendean Sand Formation

The study area is located within the Bassendean Dunes geomorphic system, comprising systems of degraded parabolic dunes and inter-dunal sand plains located between the dune arms. Commonly referred to as the Bassendean Dunes, the dunes are comprised of the Bassendean Sand formation, which is of desert origin and composed of medium to fine quartz sand with a variable component of interstitial silt and clay (Table 2). The individual facies of the Bassendean Dunes identified in the study area are detailed as follows:

White to Grey Bassendean Sand (S8/S10) - This sand is the product of leaching of the yellow coating from the quartz grains from the original dune sand by infiltration of rainfall through the vadose zone into the water table below. The sand is thus white to grey, medium to fine grained quartz with no interstitial fine grained material. The white to grey sand was encountered in all soil bores adjacent to the site (PB, 2007) and down to at least 2 meters bgl in most test pits dug onsite (BGE, 2008). This unit is present as degraded dunes and inter-dunal sand plains overlying the Guildford Formation.

Hard Pan Layers Formed in Bassendean Sand - Hard pan layers can form at the summer water table in the Bassendean Sand. They are mostly recognised as ferricrete, or “coffee-rock”, where an indurated (cemented) layer is formed through the accumulation of interstitial iron oxide silt and clays. Ferricrete in the vicinity of the study area is weakly to moderately cemented and was encountered at a depth of 1 to 1.5 meters in the northern portion of Lot 1600. Ferricrete can act as a significant aquitard thus promoting perching and wetland formation. Based upon the results of test pit sampling (BGE, 2008), the site is underlain by a series of discontinuous layers of ferricrete and clays which restrict the vertical movement of water and promote groundwater perching.

Swamp Deposits - The swamp deposits (Sp1 and Sp2) have developed through the accumulation of vegetation in areas of shallow groundwater and surface water inundation. The majority of swamp deposits in the region coincide with areas that have been mapped as aeolian deflation hollows that have formed during the Late Holocene by wind erosion of Bassendean Sands. The erosion has occurred after the deposition of the Bassendean Sand, but prior to saturation of the sand by groundwater. The hollow remains as a topographic depression that accumulates surface water as an expression of a rising groundwater table, promoting localised vegetation growth.

Table 2: Geomorphic and Geological Unit Relationships

Geomorphic Symbol	Geomorphic Description	Geological Symbol	Geological Description	Geological Unit	Comment
<i>Eh</i>	Aeolian deflation hollows	<i>Sp₁</i>	Peaty Sand - grey to black, fine to medium grained, moderately sorted quartz sand, slightly peaty, of lacustrine origin.	Swamp Deposits	Swamp deposits that have formed as an expression of the water table on a surface of Guildford Formation exposed by aeolian deflation processes.
		<i>Sp₂</i>	Peat Rich Sand - fine to medium grained quartz sand with much brown to black organic material, grades to peat, of lacustrine origin		
<i>Ed</i>	Degraded surface of aeolian origin, Bassendean Dunes	<i>S₈</i>	Sand - white -pale grey at surface, yellow at depth, fine to medium grained, moderately sorted, sub-angular to sub-rounded, minor heavy minerals, or aeolian origin.	Bassendean Sand	Present as topographic highs at the site, degraded Bassendean Sand Dunes.
		<i>S₁₀</i>	As for <i>S₈</i> over sandy clay to clayey sand of the Guildford Formation, of aeolian origin.	Thin Bassendean Sand over Guildford Formation	Formed by aeolian erosion, transportation of Bassendean Sand dunes and deposition as sand plains.
<i>Fp</i>	Alluvial Plain	<i>Sc</i>	Clayey Sand - silty in part, pale grey to brown, medium to coarse grained, poorly sorted, sub-angular to sub-rounded, frequent heavy minerals, rare feldspar, of alluvial origin.	Guildford Formation	Present at site as dominantly sandy facies of Guildford Formation, with complex interbedded lenses of silt and clay.
		<i>Cs</i>	Sandy Clay - white-grey to brown, fine to coarse grained, sub-angular to rounded sand, clay of moderate plasticity, gravel and silt layers near scarp.		

Source: Geological Survey of Western Australia (GSWA), 1986: Gosnells Map Sheet (Part Sheets 2033 I and 2133 IV) Perth Metropolitan Region 1:50,000 Environmental Geology Series.

3.2.2 Stratigraphy

The Balfour Street Wetland complex is bordered on the north and south sides by ridges of deep grey (Bassendean) sands of dunal (aeolian) origin which have been superimposed over a basement of underlying Guildford Association (clays and loams). The thickness of these dunal deposits is variable and the reduced infiltration capacity of the underlying Guildford Soils has resulted in groundwater perching and seasonal waterlogging and formation of an ephemeral sumpland in the topographic lowest point of this interface (the CCW sumpland UFI 14280) within the management area and also immediately to the north of the site. Small areas of peaty sands are also evident, associated with these low lying interdunal wetland areas.

According to test pits by Brown Geotechnical and Environmental (BGE) in 2008, within the Balfour Street Wetland complex the Bassendean Sand unit generally occurs within the top 1.5-2.5 meters below ground level and is characterised as white to pale grey sand, fine to medium grained, sub-angular to sub-rounded and moderately sorted.

The pits show the Guildford Formation unit generally occurring from 2.0 meters below ground level in the vicinity of the wetland functional area. It is characterised as clayey sand (moderate plasticity) that is white-grey to blue-grey in colour and fine to coarse grained and contains gravels in some locations.

The Peaty Sands unit, comprising swamp deposits, is present in the central part of the site including the core area of the Balfour Street Wetland. It is characterised as peat-rich sands originating from swamp deposits, grey to black colour and of lacustrine origin. This area has been previously assessed as being of high to moderate risk of both Actual Acid Sulfate Soils (AASS) and Potentially Acid Sulfate Soils (PASS) within 3m of the ground surface (WAPC, 2003). The WAPC potential Acid Sulfate Soils risk map covering the site is presented as Figure 5.

During May 2011 Endemic staff hand-augered 4 additional soil bores within the wetland functional area for the purpose of investigating possible groundwater perching beneath the wetland. SB3 and SB4 intercepted clayey sand with high plasticity at 0.5m bgl and 1.0m bgl, respectively. These soil bores correspond to the topographically lowest portion of the wetland functional area (being in the vicinity of the main onsite drain and towards the south of Lot 4 Holmes Street).

Correlation of BGE test pit logs (2008) and Endemic soil bore logs (2011) show Guildford Formation clays and gravel underlie the wetland functional area at approximately 19.2 to 19.7m AHD.

A map showing locations of BGE and Endemic test pits which suggest a shallow confining layer in the vicinity of the wetland is shown below in Figure 6.

In addition to the underlying clays, excavations on adjoining land for earthworks and laying of the Balfour Street Drain provide evidence that coffee rock is also likely to underlie much of the site and surrounding area.

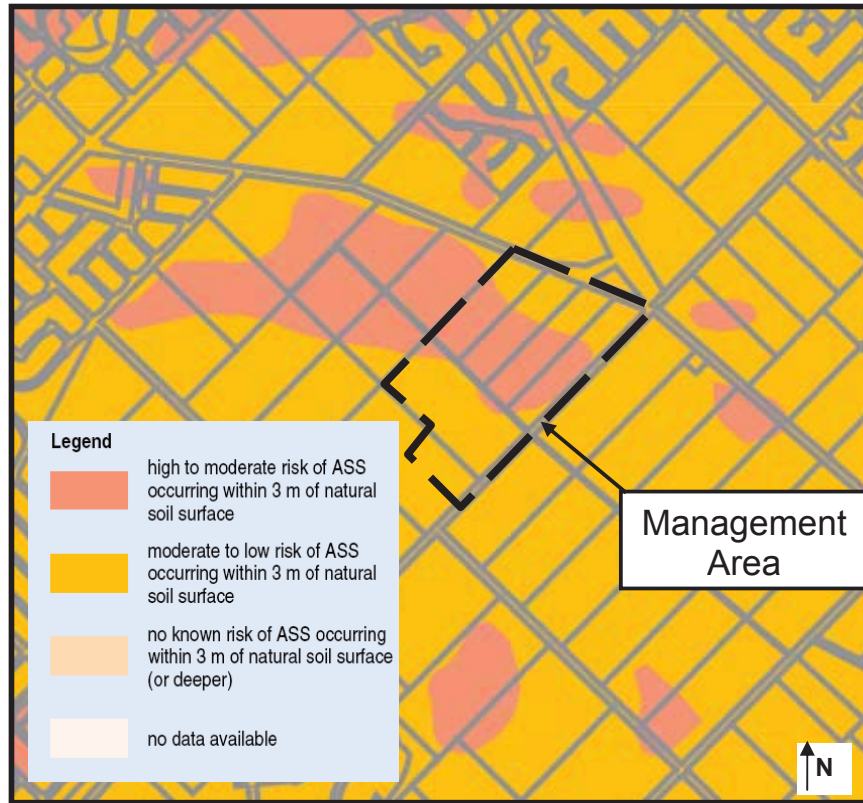


Figure 5: Potential risk of ASS occurrence within the 3 m of the natural soil surface on the site (WAPC, 2003).

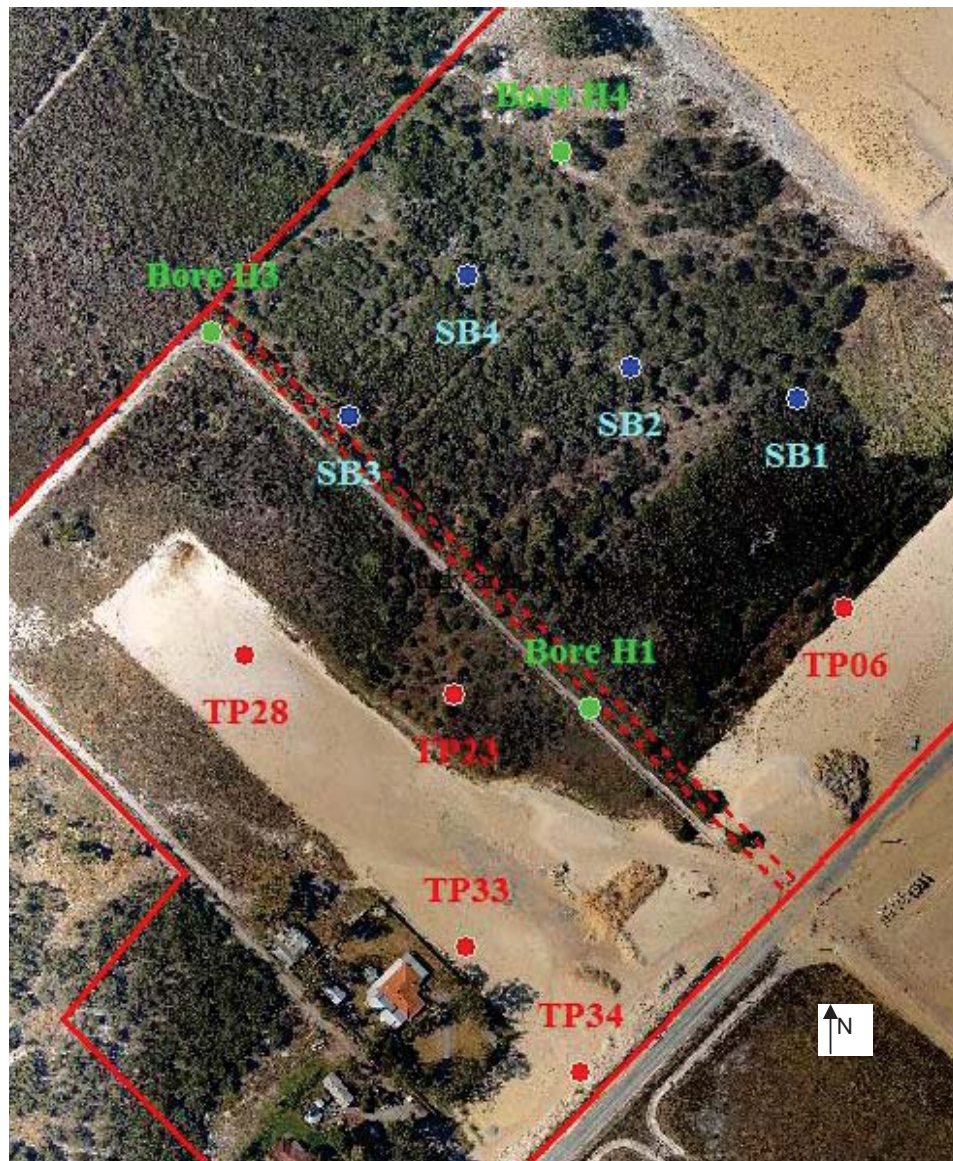


Figure 6: Aerial photo of the site showing Endemic bores (blue); BGE test pits (red) showing evidence of Guildford formation at shallow depth; and JDA groundwater monitoring bores in the vicinity of the wetland (green).

4. Hydrology

The site sits within the Gosnells Area superficial aquifer, an unconfined aquifer that occupies an area of approximately 68 km², bordered by the Canning River to the north, the Darling Scarp to the east, the Byford Area to the south and has flowlines terminating in the Southern River and Lake Forrestdale to the west.

The nearest permanent surface water is the Southern River, which is located approximately 1.5 km to the east of the site.

4.1 Surface hydrology

There are surface drains present on the site, with four drains running in an east/west direction along the northern cadastral boundaries of Lots 1, 2, 3 and 4 Holmes St. These drains join a more prominent drain running in a north-west/south-east direction along the eastern cadastral boundary of Lot 1600 Balfour St. Drains present within the management area flow into the Balfour Street Drain. However, the invert level of the Balfour Street Drain (Figure 7) has historically been higher than the groundwater level and therefore the drain intercepts stormwater surface flows, but not groundwater flows (Calibre, 2016). Once the wetland becomes sufficiently inundated, the drain 'reverses' flow direction and discharge via the Balfour Street Drain occurs. As a consequence, the hydroperiod of the core wetland area has been largely regulated by the invert and size of the drainage culvert underneath Balfour St. It is therefore important to ensure development (and drainage design) for the area seeks to mimic (if not retain) this hydraulic control in order to maintain a consistent post-development wetland water level regime. The simplest option is to ensure that the invert of the culvert at Balfour Street remains unchanged, as this controls peak wetland water levels within the project site.

Recently, the piping and sinking of the Balfour Street Brach Drain was undertaken with no allowance in either the original design or in the installation for a connection to the Lot 33 Balfour St drain. This has resulted in a significant change in the on-site hydrological condition. A re-establishment of this connection is proposed as outlined in section 9.2.

Notwithstanding, modelling undertaken during the course of preparing the Local Water Management Strategy (Calibre, 2016) shows events <1:5yr ARI will be retained and infiltrated within lots and biofiltration swales located within the development. This modelling also shows that the 1:100yr ARI will increase peak wetland water levels in the adjoining CCW by a mere 1cm (Calibre, 2016). This is largely an artefact of the large spatial extent this wetland and hence its large (yet shallow) flood storage capacity and the dominance of meteoric (direct) rainfall on the hydrology of the wetland.

Endemic is of the opinion that a 1cm increase in the wetland water level (over and above the pre-development regime) arising from a 1:100yr event is of short duration and inconsequential and not likely to result in an adverse impact to the CCW.

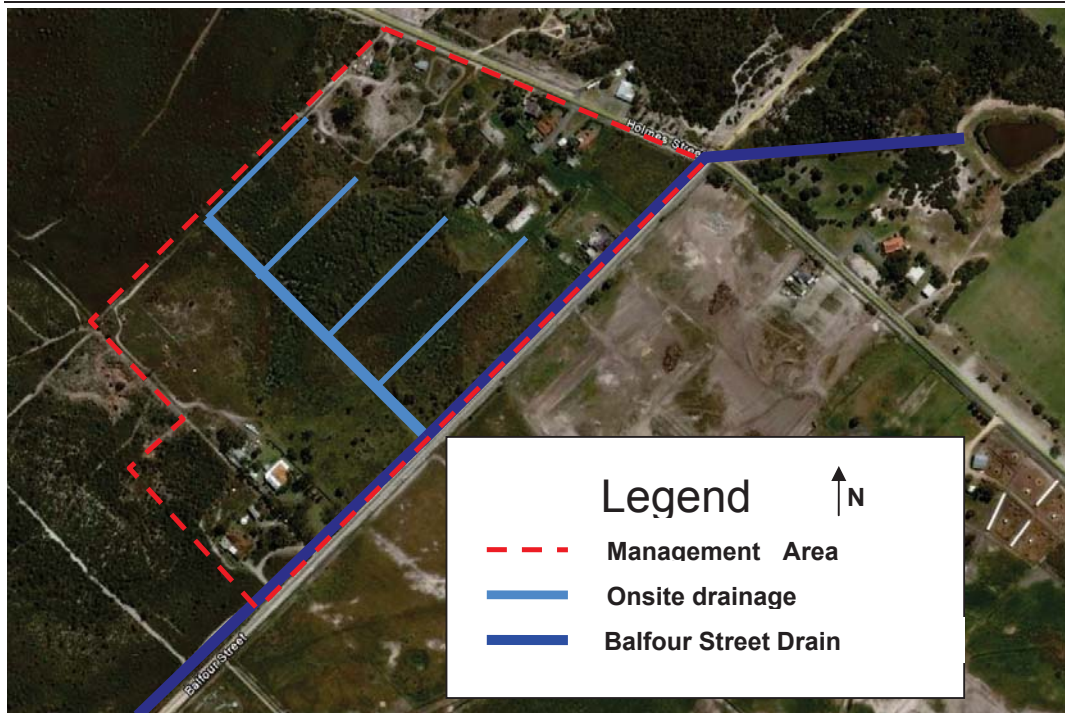


Figure 7: Existing watercourses and drainage in the immediate vicinity of the site

4.2 Groundwater

Several studies and reports have detailed the hydrogeology in close proximity of the development area and have been used as a source of information and data. The reports are summarised below:

- The Perth Groundwater Atlas (Department of Environment, 2004);
- Hydrogeology and Groundwater Resources of the Perth Region (Davidson 1995);
- The WRC Urban Water Management Strategy Volumes 1 and 2 for the Southern River/Forrestdale/Brookdale/Wungong Structure Plan (WRC 2002); and
- DoW AQWA database bore search.

In addition, a Groundwater Investigation study covering part of the site was undertaken by Parsons Brinkerhoff on behalf of Prestige Developments Pty Ltd in 2007. This study identified patterns of regional groundwater movement in the area. Subsequent to this JDA undertook pre-development monitoring over 2008 and 2009 involving the installation of seven shallow monitoring bores across the management area (JDA, 2009). These bores were screened 3 m into the water table and several of them were within the wetland. Details of the location and the resulting groundwater level data from this monitoring are included in Appendix D. Water quality parameters were also measured on a quarterly basis over this period. Measured parameters included pH, Electrical

Conductivity, Total Suspended Sediments, Total Nitrogen, Total Kjeldahl Nitrogen, NO_x, Total Phosphorus and Filterable Reactive P.

The regional and local hydrogeological conditions are summarised from information contained in these reports as follows:

- the site is underlain by up to 4 meters of Bassendean Sands above approximately a 14 meter thickness of Guilford Formation which together form the superficial aquifer (Davidson, 1995; DEC, 2004; PB, 2007);
- the Perth Groundwater Atlas identifies the superficial aquifer is unconfined with median water levels around 2.0 to 4.0 meters bgl across the site.
- the 2007 Parsons Brinkerhoff Groundwater Investigation defined groundwater levels between 1 – 2.7m bgl (PB, 2007). This was added to by the 2008-2009 JDA study which saw an increased number of bores measuring groundwater levels across the site between 4.0 m bgl and the natural ground surface (in the wetland area). Maximum groundwater levels ranged between approximately 20.1 and 20.8 m AHD (JDA, 2009).
- groundwater recharge occurs mainly via rainfall infiltration of the sandy sediments of the Bassendean Sands. During periods of heavy rainfall and saturation of the near subsurface, waterlogging occurs and surface water flows towards the Southern River via the Balfour Street Drain;
- minimum groundwater tables were measured between January and June, and maximums from September to October.
- concentrations of Total Nitrogen measured in pre-development monitoring ranged from 0.07 mg/L to 11 mg/L with all bores showing considerable variation over the sample period. Total Phosphorus levels ranged from 0.16 mg/L to 7 mg/L and similarly showed considerable variation over the sample period (JDA, 2009).

4.3 Wetland Water Levels

Multiple lines of evidence support the suggestion that the Balfour St wetland, occupying the central portion of the site, exists as a result of groundwater perching and seasonal waterlogging in the topographic lowest point of the interface between Bassendean Sands and the Guilford Formation at around 2 m bgl (~19.2m AHD).

Both BGE and Endemic investigations encountered shallow groundwater immediately overlying the Guildford horizon (which was observed at approximately 19.2 to 19.7m AHD) within the wetland functional area. The base of the main onsite drain is between 20.0 and 20.1m AHD, and given the lack of routine maintenance and slumping of the banks evident, the drain is inferred as having been originally excavated to the depth of the underlying Guildford Formation. This conclusion is consistent with common local drain construction techniques, which are designed to alleviate winter waterlogging.

Due to the connection between shallow groundwater and the wetland water levels, wetland water level monitoring was undertaken in the course of groundwater investigations carried out by JDA for the period of May 2008 to October 2009. Bore H4 is located centrally on Lot 4 Holmes St, 17m outside the wetland functional area, approximately 80m north-east of the lowest point of the wetland, at 21.1m AHD (see Figure 6). Figure 8 shows shallow groundwater levels at Bore H4 over two winters. Given the permeable nature of the Bassendean Sands in the area, a line has been imposed on this data to indicate ground level at the lowest point in the wetland and demonstrate static water level. This indicates that the wetland at its deepest point contained standing water for eight months of 2008.

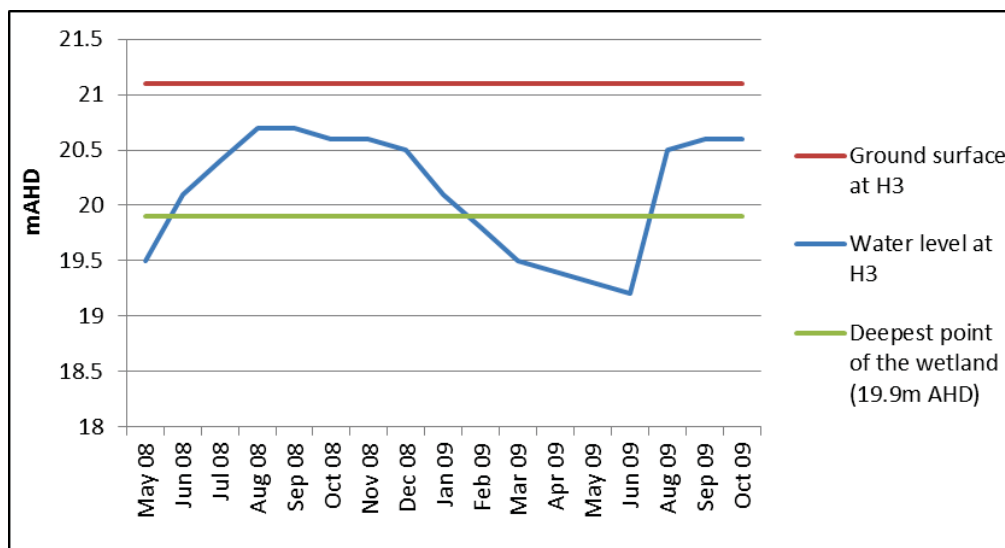


Figure 8: Water levels (mAHD) measured in the core sumpland area by at Bore H4 (JDA, 2009).

In the period subsequent to the pre-development groundwater monitoring the hydrological connection between on-site drains and the Balfour Street Drain has been lost, as described in Section 5.1. As a result, the wetland hydroperiod has been altered with the wetland currently holding more water and for an extended period, relative to historical levels which were governed by the invert of the drain outlet. There has also been the recent influence of dewatering programs undertaken for drainage works associated with Balfour Street and adjacent sewer installations. It is therefore thought that the JDA data from 2008-2009 is reflective of the predevelopment baseline wetland hydrological regime.

JDA found that peak groundwater within the wetland is likely to be controlled by the on-site drain which allows for water in the wetland to exit to the Balfour Street drain. Given that in both years peak groundwater for the site was nearly identical (at 20.7m AHD), it is apparent that onsite drains have historically controlled peak groundwater/ wetland water levels.

5. Vegetation

5.1 Broad Scale Vegetation Classification

The project area is located in the Swan Coastal Plain bioregion (McKenzie *et al.*, 2003). The Swan Coastal Plain is a low lying coastal plain, mainly covered with woodlands and is dominated by *Banksia* or *Tuart* on sandy soils, *Casuarina* on outwash plains and *Melaleuca* in swampy areas. The Swan Coastal Plain subregion is part of the South-West Botanical Province which has a very high degree of species diversity. The site lies within the Drummond Botanical Subdistrict within the South West Botanical Province (Beard, 1990).

According to broad scale mapping, vegetation within the project area belongs to the Southern River Vegetation Complex and is described by Heddle *et al.* (1980) as follows:

- Southern River Vegetation Complex: Open woodland of Marri (*Corymbia calophylla*) - Jarrah (*Eucalyptus marginata*) - *Banksia* species with fringing woodland of Flooded Gum (*Eucalyptus rudis*) - Paperbark (*Melaleuca raphiophylla*) along creek beds. This vegetation complex have been extensively cleared and are now poorly represented in the conservation estate (10% or less of the original extent is protected) on the Swan Coastal Plain (Government of Western Australia, 2000).

Typical sequences of vegetation on the site comprise mainly *Banksia* low woodland on leached sand with *Melaleuca* swamps where ill-drained; woodland of *Tuart*, Jarrah and Marri on less leached soils.

5.2 Vegetation Complexes

A large portion of the site has been historically cleared and developed as an intensive poultry farm and some residential housing. Accordingly, the vegetation that remains in this area varies widely in both species composition and condition. Areas of remnant vegetation exist with varying degrees of vegetation quality from Completely Degraded to Excellent.

The vegetation complex types and conditions were surveyed during August and November 2007 (Level 1 vegetation survey: Cardno BSD 2007a&b), and have been used as the basis for the following vegetation condition summary. Vegetation communities as mapped by Cardo are shown in Figures 9. The full Spring Survey report (Cardno 2007b) has been included in the appendices of the LSP (DP&D, 2016).

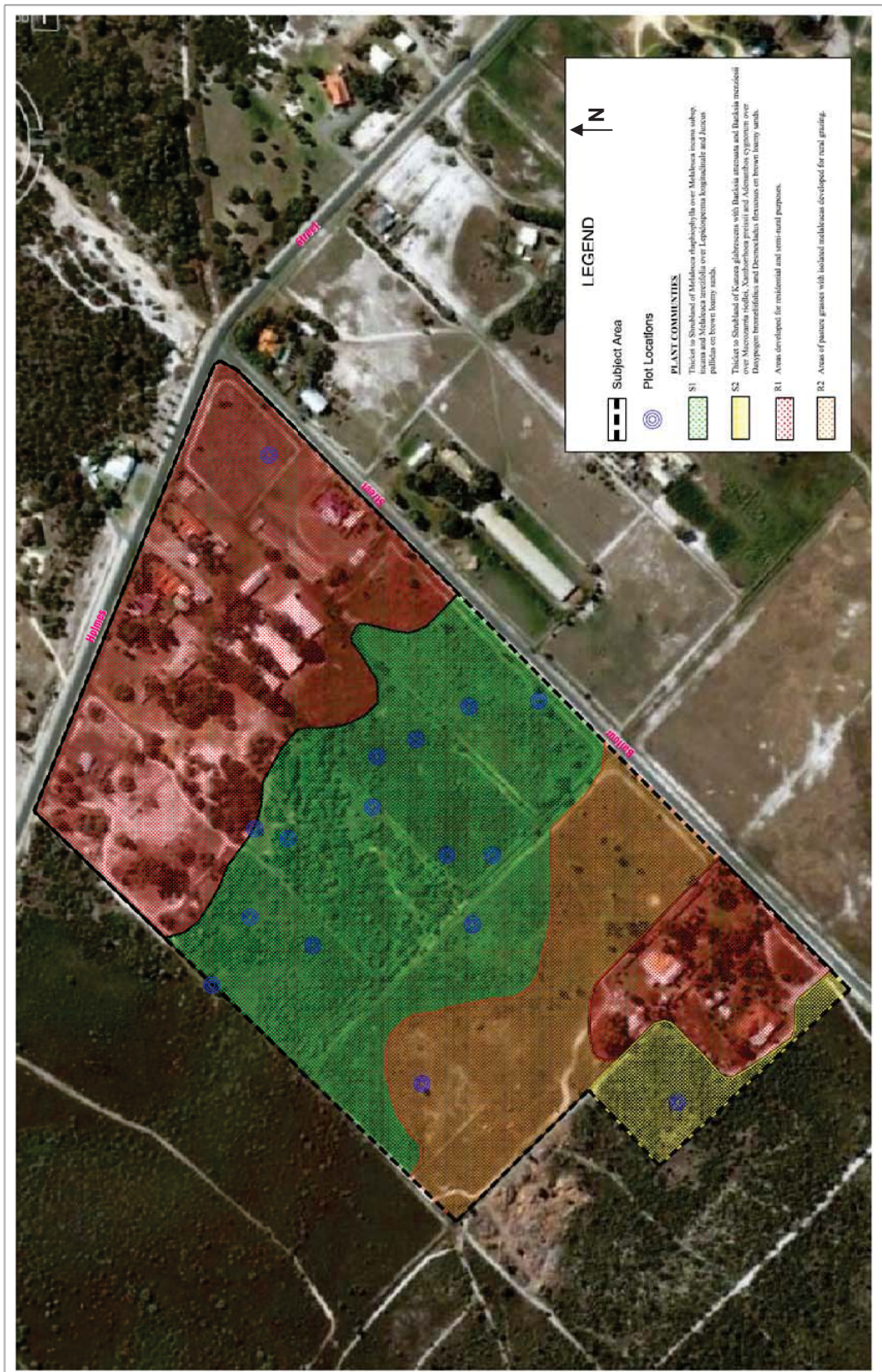


Figure 9: Cardno vegetation communities mapping (2007)



Figure 10: Vegetation condition (after Cardno, 2007b)

The basis for vegetation condition mapping in Figure 10 is provided in Cardno 2007b, and has been adapted by Endemic to reflect recent landuse changes within the management area.

This was required as the original survey undertaken by Cardno in April 2007 was not undertaken during the optimum time for the South-West Province. EPA Guidance Statement 51 advises that 'Appropriate timing ensures that the majority of the plant species in an area are flowering, fruiting and have foliage that allows identification. This is particularly important where ephemeral or cryptic species of interest may occur (e.g. geophytes, orchids)'. It is also important when assessing vegetation condition.

Further, as Cardno did not have access to Lots 3 and 4 at that time, the evaluation was based on observations from neighbouring properties. This was noted by Cardno as a limitation of their study.

Additionally, Cardno's assessment of the condition of remnant vegetation along the north-eastern side of Lot 1600 as degraded to completely degraded does not accord with the recent classification of that area by DPaW as CCW (see Figure 4).

Figure 10 provides an update to Cardno's (2007) vegetation condition assessment and is largely related to vegetation clearing that has occurred since the 2007 survey, and is not based on further field work related to vegetation condition. The vegetation condition mapping is therefore 8 years old, and vegetation condition may have changed (ie improved or degraded) since the 2007 survey.

It is recommended that preparation of a detailed Wetland Rehabilitation Plan (WRP) be informed by new and updated vegetation condition mapping in the areas to be retained.

Local and regional vegetation complexes vary from *Banksia* low Woodlands on leached sands with *Melaleuca* swamps and Woodlands of *Eucalyptus* spp. on less leached soils. The best quality native vegetation within this site generally occurs in and around the wetland areas in the centre of the site (community S1: 'Wet forests and Woodlands') and followed by vegetation on the southern portion of Lot 1601 (community S2: 'Central *Banksia attenuata*-*Banksia menziesii* woodlands').

Vegetation community S1 was inferred to be floristic community FCT11 'Wet forests and Woodlands'. The vegetation consisted of thickets to shrublands of *Melaleuca raphiophylla* over *Melaleuca lateritia* and *Melaleuca teretifolia* over *Lepidosperma longitudinale* and *Juncus pallidus* on seasonally wet brown loamy sands. Parts of this community occur on all Lots. Vegetation community S1 is in variable condition, ranging from "Completely Degraded" to "Excellent" within the management area.

Vegetation community S2 was inferred to be floristic community FCT23a 'Central *Banksia attenuata*- *Banksia menziesii* woodlands'. This vegetation consists of thickets to shrublands of *Kunzea glabrescens* with *Banksia attenuata*, *Banksia menziesii* over *Macrozamia riedlei*, *Xanthorrhoea preissii* and *Adenanthos cygnorum* over *Dasypogon bromeliifolius* and *Desmocladus flexuosus* on brown loamy sands. Vegetation community S2 was classified as in "Very Good" condition on Lot 1601 as it retains its original structure and a high diversity of plants, but the ground layer of S2 is dominated by aggressive weeds such as *Ehrhata calycina*.

Outside of these vegetation communities, the remainder of the site (R1 and R2) has been extensively cleared with R1 now consisting of exotic trees and introduced grasses and R2 consisting of pasture grasses and occasional *Melaleucas*. Vegetation communities R1 and R2 were classified as "Completely Degraded" and weeds are prevalent.

5.3 Threatened Ecological Communities (TEC's)

The Department of Parks and Wildlife has developed a procedure for identifying 'Threatened Ecological Communities' (Government of Western Australia 2000; English and Blythe 1997). Threatened ecological communities (TEC's) are assigned to one of four categories: 'Presumed Totally Destroyed'; 'Critically Endangered'; 'Endangered' or 'Vulnerable' (Government of Western Australia, 2000).

On the Swan Coastal Plain, twenty five potential threatened ecological communities, delineated by a number of floristic and other studies, have been assessed for threatened ecological community status. Of these, twenty four have been confirmed as 'threatened'. Sixteen of these Threatened Ecological Communities (TEC's) are floristic community types (FCT's) as identified by Gibson *et al.* (1994).

No TEC's have been identified within the site (Cardno BSD 2007a&b).

5.4 Wet forests and Woodlands (FCT 11)

Although no TECs exist within the site, there is a community of *Melaleuca* Low Open Forrest which has large areas of vegetation in an Excellent to Good Condition (see Figures 9 and

10). This was interpreted to belong to Floristic Community Type 11 (Cardno BSD 2007a&b) associated with *Melaleuca* Woodland and is considered well reserved (Cardno 2007b). The dominant species of this community are common in seasonal wetlands (Gibson et al 1994). Parts of this community occur on all lots, except 1601, in varying vegetation from degraded to excellent (Cardno 2007b).

5.5 Central *Banksia* woodlands' (FCT 23a)

There is a community of Central *Banksia attenuata* – *Banksia menziesii* woodlands (BaBmLOF) which has large areas of vegetation in a Very Good Condition (Figures 9 and 10). This was interpreted to belong to Floristic Community Type 23a (Cardno BSD 2007a/b) associated with Central *Banksia attenuata*- *Banksia menziesii* Woodland and is considered well reserved (Cardno 2007b). BaBmLOF is not considered to be an obligate wetland floristic community.

5.6 Priority flora and Declared Rare Flora

One Priority Flora, as listed by DPaW, *Jacksonia sericea* (P4) was recorded on pt Lot 1601 in a *Kunzea glabrescens* shrubland during the level 1 flora survey (Cardno 2007).

No species of Declared Rare Flora (DRF) under the *Wildlife Conservation Act 1950* or 'Threatened' plant taxa under the *Environmental Protection and Biodiversity Act 1999* were located during any of the site surveys.

6. Fauna

In 2012, a Level 1 Fauna Study consistent with EPA Guidance Statement 56, *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* (2004), was undertaken for the site by Endemic. The resulting report is included as Appendix E (Endemic 2013). A summary of the findings of the study are included below.

The study found that the area of highest value to fauna at the site centres on the wetland habitat in the central portion of the site. In particular the wetland area represents suitable habitat for a large number of birds, potentially including some migratory bird species protected under international agreements. The major significance of this area for fauna is that it adjoins significant tracts of habitat on the adjoining lots. The link, however, is degraded with large areas of kikuyu and couch infestations.

The study site generally is quite disturbed and fragmented with a high weed burden. Despite being somewhat degraded, given that most of the Swan Coastal Plain had been largely cleared there is some habitat value in this remnant which can be considered of local significance.

Faunal assemblages at this site are expected to be in line with that found in other remnants on the Swan Coastal Plain. These assemblages are relatively well known.

A search was requested of the Department of Environment and Conservation's Threatened Fauna database for species recorded within a 3km radius of the site. This dataset includes species which are declared as '*Rare or likely to become extinct* (Schedule 1)', '*Birds protected under an international agreement* (Schedule 3)', and '*Other specially protected fauna* (Schedule 4)'. According to results of the search, the following threatened fauna species have been recorded within this range:

- Carnaby's Cockatoo (*Calyptorhynchus latirostris*): Rare or likely to become extinct
- Eastern Great Egret (*Ardea modesta*): Protected under an International Agreement
- Rainbow Bee Eater (*Merops ornatus*): Protected under an International Agreement
- Southern Brown Bandicoot (*Isodon obesulus subsp. Fusciventer*): (Priority 5)

Searches were also undertaken of the following on-line databases in order to capture additional species which may not have been recorded in close proximity to the site, but which nonetheless have the potential to occur at the site:

- Department of Environment and Conservation's Naturemap database; and
- Commonwealth's *Environmental Protection and Biodiversity Conservation Act* Protected Matters Search Tool.

Additional protected and priority species which may potentially occur within the project area are listed in Table 2.

Table 1: Additional protected or priority species which may occur within the project area

	COMMON NAME	SCIENTIFIC NAME	EPBC DATABASE COMMENT	EPBC LISTING
BIRDS	Australasian Bittern	<i>Botaurus poiciloptilus</i>	Species or species habitat known to occur within area	Endangered
	Baudin's Black-Cockatoo	<i>Calyptorhynchus baudinii</i>	Roosting known to occur within area	Vulnerable
	Forest Red-tailed Black-Cockatoo	<i>Calyptorhynchus banksii naso</i>	Species or species habitat may occur within area	Vulnerable
	Malleefowl	<i>Leipoa ocellata</i>	Species or species habitat may occur within area	Vulnerable
	Australian Painted Snipe	<i>Rostratula australis</i>	Species or species habitat may occur within area	Vulnerable
	Fairy Tern (Australian)	<i>Sternula nereis nereis</i>	Species or species habitat may occur within area	Vulnerable
	Masked Owl	<i>Tyto novaehollandiae subsp. novaehollandiae</i>		None, DPaW Priority 3
	Barking Owl	<i>Ninox connivens subsp. connivens</i>		None, DPaW Priority 2
INSECTS	Graceful Sun Moth	<i>Synemon gratiosa</i>	Species or species habitat may occur within area	None, DPaW Priority 4 (downgraded since the time of the fauna study)
MAMMALS	Chuditch, Western Quoll	<i>Dasyurus geoffroii</i>	Species or species habitat likely to occur within area	Vulnerable
	Red-tailed Phascogale	<i>Phascogale calura</i>	Species or species habitat may occur within area	Endangered
	Quokka	<i>Setonix brachyurus</i>	Species or species habitat may occur within area	Vulnerable
	Woylie	<i>Bettongia penicillata ogilbyi</i>	Species or species habitat may occur within area	Endangered
	Western Brush Wallaby	<i>Macropus irma</i>		None DPaW Priority 4
	Southern Brush-tailed Phascogale	<i>Phascogale tapaotafa subsp. tapaotafa</i>		None, Schedule 1 WA Wildlife Conservation Act
REPTILES	Southern Death Adder	<i>Acanthophis antarcticus</i>		None DPaW P3
	Lined Skink	<i>Lerista lineata</i>		None, DPaW P3
	Carpet Python	<i>Morelia spilota</i>		None, Schedule 4 WA Wildlife Conservation Act
MIGRATORY	Fork-tailed Swift	<i>Apus pacificus</i>	Species or species habitat likely to occur within area	International Agreement

White-bellied Sea-Eagle	<i>Haliaeetus leucogaster</i>	Species or species habitat likely to occur within area	International Agreement
Great Egret, White Egret	<i>Ardea alba</i>	Species or species habitat may occur within area	International Agreement
Cattle Egret	<i>Ardea ibis</i>	Species or species habitat may occur within area	International Agreement
Painted Snipe	<i>Rostratula benghalensis (sensu lato)</i>	Species or species habitat may occur within area	Vulnerable, International Agreement
Rainbow Bee-eater	<i>Merops ornatus</i>		International Agreement

It should be noted that these lists often include species that have been recorded in the region, but are vagrants (as suitable habitat is absent) and can also include species that are now locally extinct. Many of the bird, mammal and reptile species have specific habitat requirements which may be present in the general region but not in the specific project area. A level 2 fauna survey would be required to confirm the presence or absence of these species within the borders of the project site. The likelihood of these species occurring at the study site is considered below.

Birds

With the exception of one tall introduced Eucalypt on the sand dune to the north of the wetland area, there are no tall trees remaining on the site. For this reason, the site is largely unsuitable for Black Cockatoo breeding or roosting. Baudins and Red-tailed Forest Cockatoos are unlikely to frequent the site. The Banksia woodland area (S2) at the southern end of the site may present possible Carnaby's feeding area habitat.

It is possible that the Australasian Bittern visits the site during non-breeding periods. They require large, relatively undisturbed areas of inundated rushes and sedges in which to nest however, and it is therefore not likely that these birds breed at the site.

It is possible that the Australian Painted Snipe could utilise the site, and the Fairy Tern may also use the area, though it is generally found in more coastal areas.

Malleefowl have not been recorded in the area since the 1970s and are thought to be locally extinct. It is therefore unlikely that malleefowl would utilise the site.

It is possible that the Masked Owl and Barn Owl may utilise the site for foraging, though the absence of tall trees with hollows means that these species are not likely to be breeding at the site. The site does not represent prime habitat as the species are usually found in proximity of forested areas.

Insects

Graceful Sun Moth has specific habitat requirements which are not present on the site, based on results of flora surveys (Cardno 2007a&b).

Reptiles

It is unlikely that the Carpet Python or Southern Death Adder are present at the site, as both species prefer relatively undisturbed and intact bushland. The Perth Lined Skink (*Lerista lineata*) inhabits white or pale sands (specifically landforms S7 and S8) which support *Banksia* associated woodlands, heathlands and shrublands on the Bassendean and Spearwood dune vegetation complexes. It is therefore possible that the Priority 3 species may be found in the small area of Kunzia/ Banksia thicket to shrubland at the south of the site.

Mammals

Whilst suitable habitat may exist and historically these species had a wide ranging distribution, the Quoll, Woylie, Quokka and Red-tailed Phascogale are believed to be extinct from most or all of the Swan Coastal Plain and unlikely to inhabit the site.

The site is unlikely to support Western Brush Wallaby due to the fragmented nature of the remnant and close proximity of surrounding urban areas.

The site is unlikely to support Brush-tailed Phascogales due to an absence of suitable nesting trees with hollows and the fragmented nature of the remnant.

The Southern Brown Bandicoot is likely to inhabit the site, closely associated with the open woodlands of Melaleuca. Though no diggings were found during a recent site visit, these have been noted previously within the site, and Bandicoots have been reported at the adjoining Bush Forever site (Government of Western Australia 2000). It is likely that Bandicoots frequent the site during the summer months after the wetland water levels have receded sufficiently to enable access from the adjoining Holmes St Wetland.

Migratory species

It is possible that a range of migratory species frequent the wetland areas of the site including species protected under international treaties such as the China Australia Migratory Bird Agreement (CAMBA), the Japan Australia Migratory Bird Agreement (JAMBA) and the Bonn Convention (The Convention on the Conservation of Migratory Species of Wild Animals).

Rainbow Bee-eater is the only species listed under these treaties to have been recorded within 5 km of the study site in the DPaW Naturemap database. Rainbow Bee-eaters are distributed across much of mainland Australia and have been recorded in a wide variety of habitats including open forests and woodlands, shrublands, and in various cleared or semi-cleared habitats, including farmland and areas of human habitation, generally in close proximity to permanent water. The study site has potentially suitable habitat for this species.

7. Wetland definition, retention and enhancement

A key objective of this Wetland Management Plan is to provide for the recognition, protection and enhancement of wetland values and functions both on and adjacent to the site. Sections 8 and 9 provide information on the recognition of wetland habitat and values, and the strategies that will be undertaken for their protection and enhancement prior to, during and post construction.

7.1 Wetland area and management objectives

The DPaW maintains a Geomorphic Wetland Dataset which classifies all recorded wetlands into specific management categories based on their ecological attributes and functions. The management categories include Conservation management category (CCW), Resource Enhancement (RE) and Multiple Use (MU) wetlands. Figure 11 depicts the DPaW's wetland mapping for the subject site as of October 2014.

DPaW mapping identifies two CCW's that extend onto the site, being:

- UFI 14280 sumpland over the southern portion of lots 3 and 4 Holmes St and portions of Lots 1 & 2 Holmes Street & Lot 1600 Balfour Street; and
- UFI 15422 dampland which extends marginally onto part Lot 1601 Balfour St.

The Water and River Commission Wetland Position Statement (WRC, 2001) identifies CCWs as the 'highest priority wetlands'. Their management objective is 'preservation of wetland attributes and functions through various mechanisms'.

In addition, there are two Resource Enhancement (RE) wetlands which DPaW identified and re-mapped in 2014 as occurring on the site:

- RE UFI 15891, also being located in part on Lot 1600 Balfour St; and
- RE UFI 15892, being located on Lot 1600 Balfour St;

RE wetlands are 'wetlands which may have been partially modified but still support substantial ecological attributes and functions' (WRC, 2001). RE wetlands have the potential to be restored to conservation category habitat and rehabilitation is encouraged, where practicable. The EPA urges that all reasonable measures are taken to minimise the potential impacts on RE wetlands and appropriate buffers (EPA, 2008).

Land to the south-west of the drain has been subject to rural activities, filling and clearing and the vegetation condition in this area is "Degraded" to "Completely Degraded" (Figure 10).

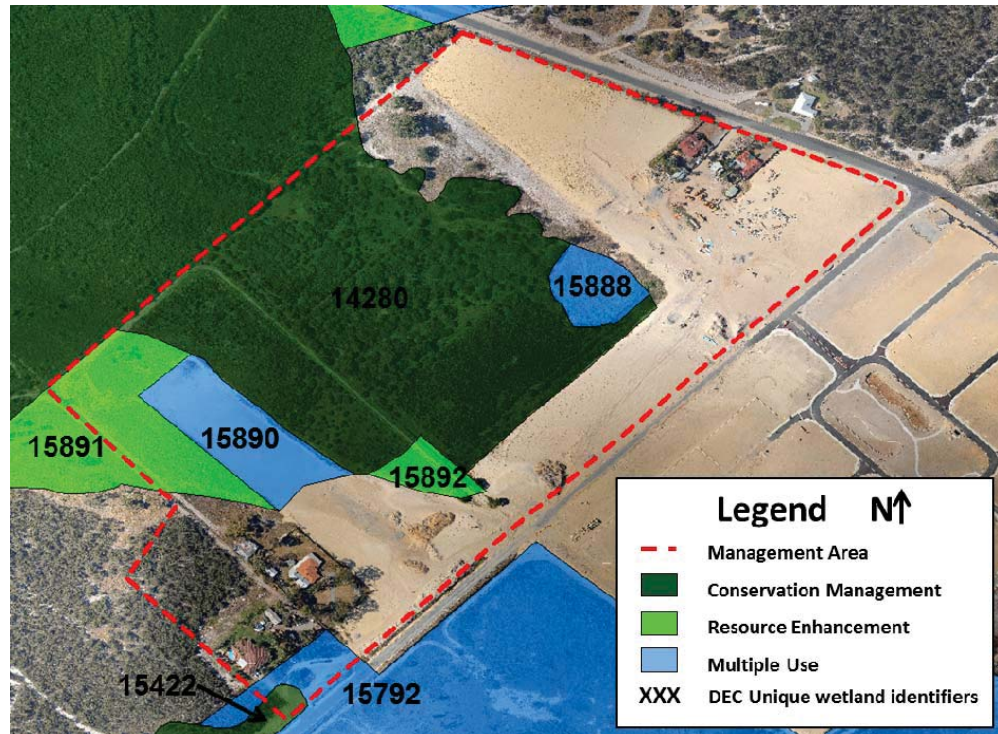


Figure 11: DPaW revised wetland categories and boundaries (DPaW, 2014)

There are also areas of Multiple Use (MU) wetland identified in the database, UFI 15792, which extends onto Lot 1601; UFI 15888 which has been the site of historical fill placement; and UFI 15890 where fill has been placed more recently. MU wetlands are described as 'wetlands with few important ecological attributes and functions remaining' (WRC 2001).

Additional site specific information has been collected which has further informed the definition and values of the wetland complex for the purposes of this Management Plan.

Figure 12 shows LiDAR imagery (Feb 2008) for the management area. The image confirms that the CCW habitat located on the site is geomorphically and hydrologically an extension of the same sumplands located on the adjoining land to the northwest of the site (within Bush Forever Site 125).

The imagery clearly shows the drainage easement (Lot 33 Balfour St) running along the north-eastern boundary of Lot 1600, which dissects the site and represents a significant hydrological feature. The hydrological integrity of UFI 14280 has been disrupted by the presence of this drain. This drain represents a significant hydrological disturbance between portions of UFI 14280 located south of the drain, and that located to the north. This is discussed in detail in Section 9.2. Numerous sub-drains also cross the sumpland area.

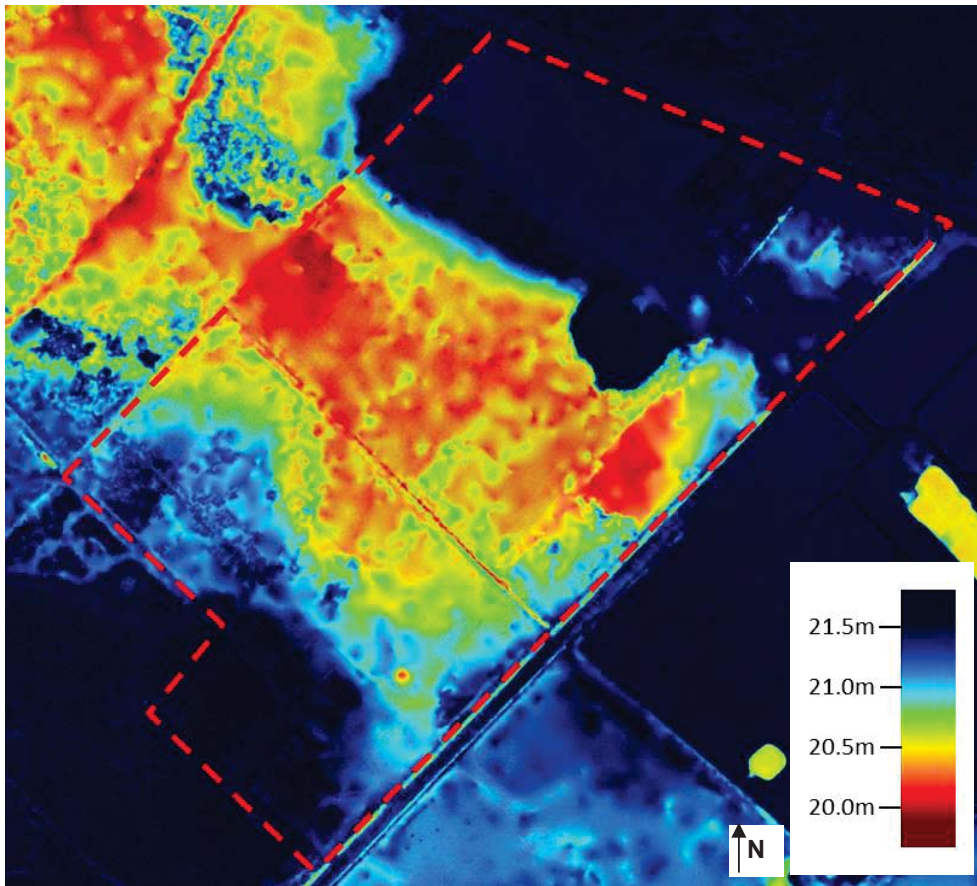


Figure 12: Digital elevation model (m AHD) of the site using LiDAR data, aiding definition of the wetland area

Figure 13 shows vegetation condition as mapped by Cardno (2007b), updated by Endemic to reflect recent landuse changes within the management area. Vegetation condition across the sumpland area varies from Completely Degraded (i.e. pastured paddock) to Excellent. The varying vegetation condition reflects varying wetland management objectives including historical clearing for agriculture.

The vegetation condition mapping illustrates that the best quality vegetation remaining in the management area exists outside the boundaries of Bush Forever site 125. This condition data would support the case for extending the conservation reserve to include the hydrologically connected areas of Very Good and Excellent condition vegetation on Lot 2 Holmes St.

An area immediately to the north-east of Excellent condition vegetation on Lot 2, marked in the DPaW database as being an RE wetland (UFI 15888) has been subject to historical filling, which now protrudes into the wetland habitat and is clearly visible on the DEM (Figure 11). The vegetation condition for this filled area is “Completely Degraded” and is not considered to be now wetland habitat.

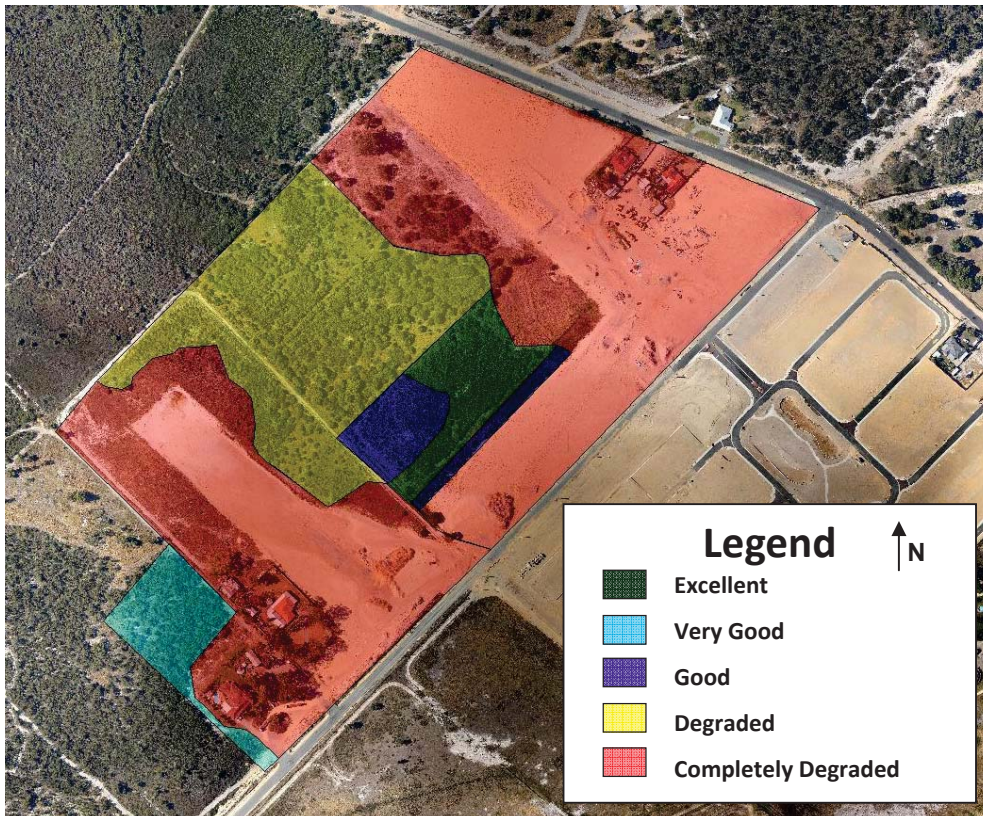


Figure 13: Vegetation condition (after Cardno, 2007b)

According to the 2007 Cardno Autumn Flora Survey (Cardno, 2007a), areas of Completely Degraded vegetation located within Lot 1600 'could not be rehabilitated to an acceptable level without intensive and expensive management.' Based upon the condition of the vegetation in this area and the impact of the local drain on the hydrology, Endemic concurs with this conclusion. This area was, however, re-mapped by DPaW as conservation category wetland in 2014.

There is a very small portion (760 m²) of UFI 15422 (CCW) mapped as extending onto Lot 1601, however, this largely corresponds with a driveway and vehicle turning area. Where vestiges of vegetation remain, this has been mapped as inferred FCT23a (Cardno 2007b, see Figure 9). FCT23a is not an obligate wetland community.

7.2 Wetland values, processes, functions and attributes

The existing hydrological regime of the wetland complex is highly modified by virtue of the Balfour Street Drain (BSD) and historical land clearing. As such, the wetland has 'evolved' in response to these hydrological changes. As a consequence it is imperative that the current wetland hydroperiod and water level regime remain largely unchanged post-development. Most importantly, the invert of the culvert connecting the (onsite) local drain to the BSD is to be retained to ensure that the hydrological control exerted on the wetland habitat remains unchanged post-development.

Although not pristine, some areas of wetland habitat on the site exhibit a number of features which support their (general) Conservation management objective, namely:

- UFI 14280 is an ecological and hydrological extension and contiguous with the adjoining highly-valued CCW. Further detail can be found within Bush Forever (site 125) regarding this adjoining habitat, but most notably the site provides breeding habitat for Freckled Duck and contains vegetation of Excellent condition. [This author considers the wetland to be one of the most important wetlands within the Perth Metropolitan Area. Its large size, seasonal inundation, dense vegetation and lack of ready vehicular access serve to limit the degree of human disturbance to the majority of the wetland habitat.];
- Resilience to changes in water level regimes, as evidenced by impacts from (historical) drain construction and agricultural pursuits;
- Have formed as a result of groundwater perching on the underlying Guildford Formation, meaning the wetland habitat is most likely disconnected from the underlying regional aquifer and therefore largely unimpacted by changes in regional groundwater levels or water quality;
- Manageability of a seasonal wetland system within an urban setting and its ability to assimilate nutrients without incurring algal proliferations (due in part to seasonal drying);
- Retention of these areas would maintain continuity with Good to Excellent wetland vegetation located on Lot 2 (currently outside Bush Forever Site 125); and
- Revised wetland mapping undertaken by DPaW in 2014 now extends the CCW (UFI 14280) from the adjoining Bushforever site 125 onto Lot 2 and part Lot 1.

Additional information and references supporting these functions and attributes can be found in sections 4 to 7 of this document.

The salient aspects of the Balfour Street Wetland complex are summarised below:

- For the most, CCW UFI 14280 exhibits a moderate to high degree of naturalness. Although subjected to agricultural landuse pressures in the past, this wetland retains significant ecological and hydrological connectivity with the adjoining Bush Forever Site 125.
- UFI 14280, unlike the surrounding RE and MU wetland areas, commonly exhibits inundation between June and October;
- Test pit and soil bore log information has been reviewed and infers that UFI 14280 coincides with a topographic low point (or depression) within the underlying clays and that formation of the wetland habitat is most likely the consequence of seasonal groundwater perching (above the Guildford Formation / Bassendean Sands interface).

Seasonal peak water levels within the greater Balfour Street Wetland Complex are perched (see discussion in Section 5.3) and thus wetland water levels are expected to be largely the result of direct (highly localised) rainfall and recharge and not likely to be substantially influenced by fluctuations in the (deeper) regional aquifer.

7.3 Wetland Retention and Buffer

In response to a request from the Department of Planning, the Office of the Environmental Protection Authority (OEPA) advised in correspondence of 30/01/2014 that it “has reviewed the (then) ODP and has been working with the Department of Parks and Wildlife and the landowner in regard to the reduced wetland buffer”. As a result of this review and consultation, the OEPA advised that it has no objection to the proposed (now) LSP, including buffer provisions (Appendix C).

The proposed LSP will see areas of Completely Degraded to Degraded vegetation on Lot 1600 retained and restored. Conservation category wetland habitat (UFI 14280) located within Lot 2 and a portion of Lot 1 will be retained, as will be the existing connectivity through Lots 3 & 4 to the adjoining Bushforever Site 125.

Due to the irregular nature of the wetland mapping, there are small areas of recently mapped CCW which are overlain by roads on the proposed LSP. This includes a small area in the northern corner of Lot 1600 and another along the boundary of Lots 1 and 2. These areas are small and have been previously mapped as Degraded to Completely Degraded and their exclusion from the conservation area is not considered detrimental to the overall wetland values. This was considered during the process undertaken by the OEPA and was found to be acceptable (Appendix C).

The small area of native vegetation that remains within the mapped wetland UFI 15422 on Lot 1601 (not an obligate wetland community) will not be retained and is consistent with the OEPA advice regarding wetland habitat suitable for retention (see Appendix C).

The wetland retention and enhancement strategy is supported by other environmental measures described in section 8, including the consolidation of a contiguous corridor of wetland habitat, revegetation, weed eradication, fencing, development restrictions and the application of Water Sensitive Urban Design techniques.

The residential development detailed in the Outline Development Plan will not result in a detrimental impact to UFI 14280 (CCW habitat) but will have beneficial effects through restoration of degraded wetland areas and removal of historical landuse pressures and invasive weeds.

Supporting the wetland strategy, additional mitigative restrictions or considerations for development include:

- a boundary road to be established for the purposes of separating residential lots from wetland habitat (to be retained) and to construct a biofiltration swale to infiltrate stormwater (see LWMS, Calibre, 2016).
- A number of scattered large remnant trees and planted trees will be retained along subdivision lot and road boundaries, where practicable; and
- Fencing and controlled access to Conservation value wetland habitat.

8. Potential development impacts and associated management strategies

In addition to wetland buffer provisions this Wetland Management Plan outlines a range of strategies that will be adopted in association with the development of the site to prevent direct and indirect impacts on the sumpland.

Potential threats associated with development within the catchment of the sumpland which have been considered include

- Influence of stormwater including
 - Introduction of nutrients, hydrocarbons, sediments and litter into the wetland
 - Alteration of water level regimes and water permanency;
- Loss of wetland function and habitat modification of the CCW through:
 - Loss of fringing vegetation important to wetland flora and fauna values.
 - Fringe effects from differing land-use:
 - Weed infestation and spread of disease.
 - Traffic and human noise affecting fauna during construction and operation.
 - Edge disturbance of wetland through increased activity.
 - Encroachment during construction.
 - Dust generation and spills during construction.
- Loss or degradation of important adjoining and associated habitats, vegetation, corridors and linkages which could affect the contiguous CCW habitats outside of the management area within Bush Forever Site 125;
- Hydromodification that may either adversely affect water levels regimes of the wetland (particularly the period and frequency of inundation and drying) through:
 - Filling of low lying areas;
 - Removal of perennial vegetation and/or developing areas of hardstand and buildings;
 - Subsoil drainage systems; and
 - Groundwater abstraction.

- Disturbance of Acid Sulphate Soils (ASS) potentially leading to contamination of the CCW;
- Effects of increased human use damaging the wetland and buffer through vehicle and pedestrian access (erosion, noise, water pollution, vegetation trampling), introducing domestic animals (dogs and cats), littering and dumping of rubbish;

The following considerations are relevant:

- No urban development is proposed within the area delineated as Bush Forever Site 125;
- Reservation of suitable wetland and buffer habitat for conservation has been agreed through the ODP/LSP planning process;
- Rehabilitation and replanting using locally indigenous species will be undertaken to augment and enhance the condition and functions of the existing native vegetation and wetland buffer;
- Stormwater run-off and drainage controls will be designed to ensure the existing hydrological regime of the CCW habitat is retained and that potential nutrient and contaminant inputs to the CCWs are minimised (see LWMS, Calibre 2016);
- Modelling shows that 1:100 year event is predicted to increase the peak wetland water level by 1cm (Calibre, 2016). This change is likely to be of short duration (transient) and is unlikely to result in adverse wetland impacts;
- Opportunities to employ Total Water Cycle Management at the site through the use of Water Sensitive Urban Design practices, including options for stormwater harvesting, storage and re-use for non-potable purposes will be utilised.

The following sections describe how the development will be designed and managed through specific environmental management strategies.

8.1 Geology, Geomorphology and Soils

8.1.1 Acid Sulfate Soils

The acid sulfate soils risk map included as Figure 5 identified that the Peaty Sands unit in the Balfour Street wetland has a high to moderate risk ASS disturbance risk and the other areas within the site have a moderate to low ASS disturbance risk. Regardless, the areas where Acid Sulphate Soils are potentially present would pose minimum threat to the surrounding environment if left undisturbed or subjected to fill (rather than excavation). There will be no ground disturbing activities within the retained Conservation Category wetlands or Bush Forever site, and therefore the risk associated with ASS is considered to be low.

Peaty Sands unit, comprising swamp deposits, is present in the central part of the site and includes the core area of the Balfour Street Wetland.

The management of acid sulfate soils associated with the residential development outside of the wetland management area will be undertaken as part of the ASS Management Plan and is largely contingent upon placement of infrastructure and dewatering requirements.

Dewatering associated with extension of the sewer main along Balfour St (within the road reserve) has recently been completed and has not resulted in ASS impacts. This dewatering has been the subject of a DER-approved ASS and Dewatering Management Plan.

Onsite sewer construction is not expected to require dewatering, as the level of fill used means this can be constructed within the imported sandfill profile.

The need to prepare an ASS Management Plan for the site will be evaluated using the WAPC's ASS Self-Assessment Form and DER ASS Management Series guidelines once the invert of buried infrastructure (in particular, the sewer) is known.

8.1.2 Site contamination

Any known and potential contaminated sites within the precinct will be managed so that they do not pose a significant risk to wetland health. Soil investigation criteria adopted for site assessments are based on the DER's Site Classification Scheme (Contaminated Sites Management Series, December 2003 V3 - Table 1 Assessment Levels for Soils). Sites will (initially) be assessed against the Ecological Investigation Levels (EILs) to determine the potential for environmental impact.

Current landuses within the site include residential properties, open paddocks, vacant pasture land, controlled fill, a former poultry farm and regions of remnant vegetation.

These uses are not considered to be potentially contaminating landuses when undertaken in accordance with 'best practice', however, the presence of a poultry farm and market gardens raises the prospect of residual chemicals in the soils and groundwater. The soils may contain residual concentrations of organochlorine and organophosphate pesticides, TPH, BTEX, nutrients and metals (As, Cd, Cr, Cu, Hg, Pb, Ni and Zn) above background levels.

Notably, these areas are not in proximity to the CCW wetland habitat as they are associated with residences which front onto Holmes Street. Further, these issues have been addressed separately under a Preliminary Site Investigation (PSI) undertaken in accordance with the DER's Contaminated Sites Management Series guidelines.

The Preliminary Site Investigation (ACE Environmental, 2008) confirmed that there was no soil contamination within any of the wetlands or wetland catchment areas. Therefore, no additional management strategies or roles and responsibilities tables are required within this WMP at this time.

8.2 Hydrology

8.2.1 Wetland Hydrology

Urbanisation commonly results in a significant increase in impervious areas due to an increase in roof, pavement, footpath, paving and road surfaces which, in turn, results in a significant increase in runoff and hence stormwater. Typically, in the sandy soil areas of Perth a large proportion of this stormwater is infiltrated via soakwells where it recharges the superficial aquifer. This practise increases groundwater recharge and can result in a significant rise in groundwater levels to the detriment of groundwater-dependent wetlands. Common symptoms of urbanisation include 'drowning' of the wetland and the death of fringing natural vegetation.

A significant area of urban development is to be located within the immediate vicinity of the Balfour/Holmes Street CCW sumpland habitat. An LWMS for the area has been prepared for the site in conjunction with this Wetland Management Plan in support of the LSP, based upon a detailed water balance. The objective of the management of surface flows and infiltration of stormwater for the subject area is to mimic as closely as possible the pre-development flows leaving the subject land and the wetland system (Calibre, 2016).

The LWMS for the Balfour Street Wetland complex has been prepared in accordance with:

- Stormwater Management Manual for Western Australia (Department of Water 2004-2007)
- Environmental Guidance for Planning and Development – Guidance Statement 33 (EPA, 2008);

Historically the outlet to the Balfour Street Drain (BSD) at approximately 21m AHD has controlled the peak wetland water level. Recently however, the hydrological connection between the drain and the wetland was lost when the BSD was piped and sunk with no allowance in the design for a connection. It is proposed to re-establish this hydrological connection with a 225mm pipe at 21m AHD and return the wetland to its long-standing historical hydrological regime. This is specified in the LWMS and replicated in the LSP.

Subsoil drainage systems are proposed in the LWMS at a Controlled Groundwater Level (CGL) of 21m AHD. As this is the same level as the historical invert of the outlet to the Balfour Street Drain, which has regulated wetland water levels, the impact of sub-soil drainage will not impact the wetland water level regime.

As a precautionary approach in the case that perched and superficial aquifers are not totally hydrologically disconnected (that is the extent of the aquitard is not contiguous), a prohibition on the use of shallow domestic bores will be imposed. This will be implemented through the placement of a Restrictive Covenant on titles that prohibits the use of bores for groundwater extraction from the superficial aquifer and that notes any proposal for removal of the covenant cannot be progressed without the express consent of City of Gosnells. A clause will be included in the relevant sale contracts to address the covenant and the underlying environmental need for it.

To minimise the potential for adverse drainage impacts on the CCW sumpland, the following strategies will be implemented:

- Bioretention gardens and swales have been designed to store and infiltrate stormwater for the 60 minute interval during the 1 in 1 ARI event.
- In events between the 1:1 and 1:5 year ARI event, a portion of the stormwater from the development will flow via a pit and pipe network to swales around the wetland, where it will be held and infiltrated (Calibre, 2016). This will mimic what currently happens in the pre development state, where much of the water is trapped on site in the short term, with infiltration to the onsite shallow (perched) groundwater.
- In the case of a 1:100 year ARI event, stormwater will overtop the 1:5 year swale and flood the local onsite drain, overflow to the wetland and outlet to the Balfour Street Drain once the connection is re-established (Calibre, 2016).

Discharge of the 1:100 year ARI via overtopping of the 1:5 year swale into the wetland will require re-connection of the outlet to the Balfour Street Drain. This implications of this connection will be discussed further within a future UWMP to be prepared for the site.

Modelling undertaken during the course of preparing the Local Water Management Strategy (Calibre, 2016) shows the <1:5yr event will be retained and infiltrated within lots and biofiltration swales located within the development. This modelling also shows that the 1:100yr event will increase peak wetland water levels in the adjoining CCW by a mere 1cm over and above the pre-development hydrological regime (Calibre, 2016).

Endemic is of the opinion that a 1cm increase in the wetland water level (over and above the pre-development regime) arising from a 1:100yr event is of short duration and inconsequential and not likely to result in an adverse impact to the CCW.

Figure 15 below details how the proposed drainage design relates to wetland water levels.

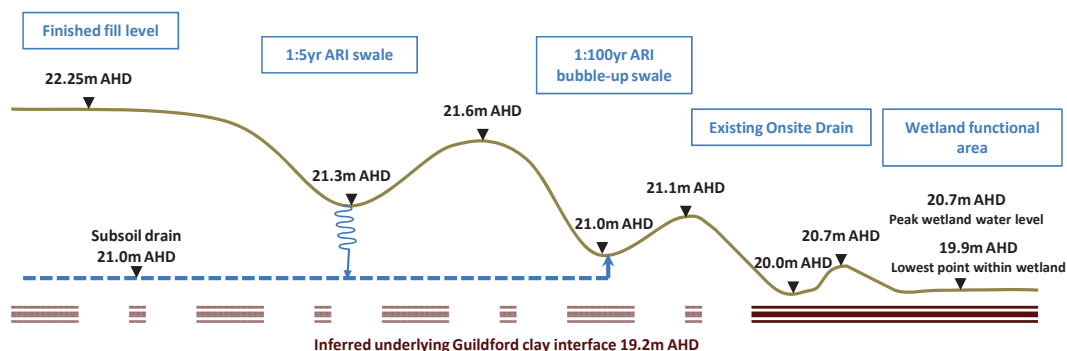


Figure 15: Proposed drainage design and levels relative to the wetland area and existing onsite drain. Section is across Lot 1600 and Lot 3 Balfour St from south-west to north-east.

The monitoring program outlined in Section 10 requires that wetland water levels be recorded for 2 years post-development to advise management planning for the CCW and Bush Forever Site.

8.2.2 Water Quality Protection

Stormwater runoff can carry pollutants such as litter, organic material, sediments, oils and metals collected from roads and property which can affect the quality of the receiving wetland. Sources of stormwater pollutants and their impact are listed in Table 5.

A detailed drainage design for the estate has been prepared. The following summarises the key elements of this drainage design which have been adopted to protect the downstream receiving environment including the wetland.

- Water sensitive urban designs are to be installed including bioretention gardens and swales. These will remove sediments, large debris and nutrients from all stormwater generated within the road reserve.
- Within this swale, soil amendment, bio-filtration and denitrification processes will be employed to enhance phosphorus and nitrogen removal within the interception system. These are discussed in within the LWMS (Calibre, 2016).
- No direct discharge of stormwater to the retained CCW area (<1:5 year ARI storm event) will be permitted (onsite infiltration only).
- Areas of wetland conservation identified by the OEPA (see Appendix C) will be subject to rehabilitation using locally indigenous species and detailed within a Wetland Rehabilitation Plan, to be guided by the City of Gosnells Policy 6.2.2 (Rehabilitation and Revegetation of Natural Areas).
- POS treatments within the development area will be the subject of a Landscape Management Plan, to be prepared prior to subdivision.
- Potential for nutrient uptake will be further enhanced by rehabilitation of buffers and degraded wetland areas.
- The developer will prepare new homeowner information packs regarding nutrient and wise garden practices to raise awareness of potential adverse environmental impacts and to identify opportunities for minimising water and nutrient use through the establishment of Waterwise gardens.

A Detailed ASS and Dewatering Management Plan (DASSDWMP) is commonly imposed as a WAPC condition of subdivision approval and reflects the requirements of the DER's ASS Management Guideline Series under the Contaminated Sites Act. Depending upon the time of the year and groundwater conditions, a Licence to Take Water may also be required from the Department of Water. All aspects of ASS management and dewatering, groundwater treatment, discharge and monitoring will be addressed in a future DASSDWMP to the approval of the DER.

Table 5: Major stormwater pollution sources

Pollutant	Sources	Examples	Impact
Hydrocarbons	Road surfaces, commercial and industrial processes, service stations, motor repair shops	Oil, petrol	Toxic to aquatic organisms Visual slicks and scums
Nutrients	Fertilisers, detergents, wastewater	Phosphorus, nitrogen, fertilisers from household gardens, public open space and animal faeces	Excessive growth of aquatic vegetation, algal blooms and nuisance midge
Pesticides	Pesticides and herbicides	Garden and agricultural products, weed control	May accumulate in food chain, toxic to aquatic organisms
Metals	Vehicle emissions and road surface runoff	Lead, mercury, zinc and copper	Toxic to aquatic organisms and may concentrate in sediments and bio-accumulate in living organisms
Bacteria and viruses	Defective sewage systems, animal faeces	Faecal coliforms and faecal streptococci	Sickness and infections in wildlife, increased human health risk
Sediments	Building sites	Sand, sediment, cement	Destroy habitats by smothering plants and benthic habitats
Inorganic litter	Roads, parks, paths, bushland	Fast food packaging, plastics, aluminium cans, paper and cigarette butts	Aesthetically unpleasing and can entangle wildlife causing death
Organic litter		Leaves, twigs and garden waste	Decreases sunlight penetration in water and destroys habitats

8.3 Vegetation

Native (including wetland) vegetation identified by the OEPA for conservation (see Appendix C) will be retained and rehabilitated using locally indigenous species. A Wetland Rehabilitation Plan will be prepared to include, but not be limited to, detail regarding individual species, planting methods, planting densities, monitoring and weed management.

A Construction Management Plan will be prepared prior and lodged to subdivision. This will incorporate aspects such as:

- Waste management (generally);
- Fuel and chemical storage;
- Hazardous waste, contaminated Soils and spills;
- Dust and wind erosion;
- Surface water runoff erosion;
- Noise and vibration management;
- Phytophthora (Dieback disease) management;
- Vegetation clearing controls, including fencing, flagging, site inductions for contractors; and
- Native vegetation retention, based upon a revised Vegetation Condition Assessment (to be included with a Wetland Rehabilitation Plan).

8.3.1 Wet forests and Woodlands (FCT 11)

The Outline Development Plan provides for the protection of vegetation deemed suitable for retention by the OEPA (see Appendix C).

A large proportion of inferred FCT11 (vegetation type S1) that remains in Good to Excellent condition is located within Lot 2, 3 and 4 Holmes St (Cardno BSD 2007b; see Figures 9 and 10 above). The vegetation identified by the OEPA and located within Lots 3 & 4 will be retained within Bushforever. Similarly, vegetation type S1 within Lots 1 & 2 and Lot 1600 and identified for conservation by the OEPA will be retained and conserved through an appropriate vesting.

8.3.2 Central Banksia Woodlands (FCT 23a)

This vegetation community is currently identified for development under the LSP.

A proposal has previously been raised for a land swap with degraded areas of bushland outside the management area immediately to the north-west of part Lot 1601 and within Bush Forever site 125. This proposal was made prior to the gazettal of the State Planning Policy for Bushland, however, as this land is not in the control of the proponent of the LSP this option has not been progressed further.

It is reasonable to expect that any amendment to the SPP is likely to be a lengthy process and would necessitate negotiation with the landholder in question. This could occur once the

LSP is approved and involve the affected landowner, which could ultimately result in a Negotiated Planning Solution (under Bush Forever policy) and an MRS amendment in the future.

8.3.3 Priority flora *Jacksonia sericea* (P4)

Jacksonia sericea (P4) was recorded on Pt Lot 1601 in Very Good condition in inferred FCT23a (Figures 9 and 10). Protection of *Jacksonia sericea* could potentially be achieved by a land swap for degraded land currently included in State Planning Policy for Bushland (Bush Forever site 125) as detailed above in section 8.3.2.

It is reasonable to expect that any amendment to the SPP is likely to be a lengthy process and would necessitate negotiation with the landholder in question. This could occur once the LSP is approved and involve the affected landowner, which could ultimately result in a Negotiated Planning Solution (under Bush Forever policy) and an MRS amendment in the future.

8.3.4 Ecological Linkages

The proposed LSP seeks to enhance ecological linkages with the adjoining Bush Forever site by retaining and rehabilitating a contiguous corridor of wetland habitat, in accordance with the OEPA's determination of areas that are worthy of conservation (see Appendix C). The functionality of this linkage will be enhanced through revegetation using locally indigenous species and weed eradication measures, where appropriate. Details of these actions will be detailed within a Wetland Rehabilitation Plan to be provided prior to subdivision.

Endemic understands that areas of CCW UFI 14280 located on Lots 3 & 4 has more recently been acquired by the WAPC under provisions of Bush Forever. Whilst responsibility of management of Lots 3 & 4 has now transferred with this change of ownership, it is recommended that a Wetland Rehabilitation Plan be prepared for all wetland habitats to be retained within the LSP area as a matter of priority. Accordingly, preparation of a Wetland Rehabilitation Plan will necessitate consultation and liaison with the affected landowners.

8.3.5 Wetland Rehabilitation Plan

Areas of wetland conservation identified by the OEPA (see Appendix C) will be subject to rehabilitation using locally indigenous species and detailed within a Wetland Rehabilitation Plan, to be guided by the City of Gosnells Policy 6.2.2 (Rehabilitation and Revegetation of Natural Areas).

Revegetation will be undertaken for degraded wetland areas within the LSP area, which will include a large area on Lot 1600, as well as smaller areas on Lots 1 and 2. Works will include weed control necessary and as far as practicable, establishment of vegetation replicating that which would have been present prior to clearing, based on remnants observed in the area, as described in Cardno BSD (2007a/b) and the Government of Western Australia (2000).

A Wetland Rehabilitation Plan is to be developed by a suitably qualified and experienced consultant and lodged prior to subdivision. Implementation of the WRP is to be undertaken following subdivision approval by suitably qualified consultants.

Aspects to be addressed in the Wetland Rehabilitation Plan include

- Species lists detailing plant selection (see Appendix F for species list)
- Planting density
- Planting locations (approximate)
- Supply (eg. Tube stock, direct seeding etc)
- Weed control
- Schedule covering planting and maintenance
- Monitoring in support of a 2 year post-development target to achieve a minimum of 60-80 % surface cover with endemic vegetation.

To avoid any potential impact to fauna, such as frogs and reptiles that inhabit the degraded wetland areas that will be subject to restoration, the revegetation program will be staged with each area to allow for gradual restoration. Restoration works will commence in a selected stage within each area until the entire area is rehabilitated. It is anticipated that the program will take place over approximately two years.

The developer will consult with the City of Gosnells and DPaW, who have detailed guidelines for the application of herbicides, regarding the spraying of weeds within wetland and upland areas. The staged approach to revegetation works should reduce the risk of herbicide application impact on the Balfour/Holmes Street CC wetland. Due to the currently highly infested condition of the wetland south of the Balfour St Drain, it is unlikely that all weeds will be able to be eliminated from restored areas.

The aim of all revegetation works within the wetland buffer is to establish endemic species to a level where over time they dominate weeds.

Species richness within the biofiltration swales will be limited as some species may fail while others predominate, depending upon the final hydroperiod. The best suited species can be expected to spread very quickly and dominate the site.

Weed Management

Invasive weeds represent a major management issue and their control and eradication will require a significant and ongoing effort from developers, Council and landowners well beyond short-term development of the site. Weed management will be a major component of the Wetland Rehabilitation Plan. Guidance is provided below on aspects to be included in the plan relating to weed management.

The weed management aims of the rehabilitation plan should be to:

- Control weeds to a level that they do not dominate endemic species and are, over time, dominated by endemic species;

- Protect and enhance existing site vegetation including management of existing weed species;
- Limit potential threats of weed invasion; and
- Limit potential threat of weed establishment to rehabilitation areas of the site that are to be planted/seeded with endemic and indigenous plant species.

The site is a matrix of vegetation conditions, ranging from very good to completely degraded. Areas that will require the most significant treatment are areas where there is little or no locally indigenous vegetation. These areas will require significant treatment of weeds in order to re-establish native vegetation. These areas will receive broad scale weed treatment prior to revegetation works.

Human activity is a key pathway for the spreading of weeds. General guidelines for weed management for the site include:

- Preventative cleaning to eliminate the spread of weed seeds
 - all tools, equipment, machinery, vehicles (especially tyres), clothing and footwear should be assessed and cleaned of seeds prior to use in and around wetland areas;
 - all vehicles must be assessed for weeds prior to entry to the site (use wash down facility if required);
- Minimise site disturbance (particularly soil disturbance)
 - clearing of areas for construction activities should be staged, to limit the area available for weed establishment (minimise the extent and duration of ground disturbance);
 - disturbance of areas vulnerable to weed infestation is to be minimised or avoided;
 - assess imported fill and landscape soil for weed seeds before using on site;
 - progressively rehabilitate disturbed areas to limit the spread of weeds;
- Periodic surveys to determine if weeds are a problem and address any infestations
 - controlling weeds during the early growth phase is easier and more effective than attempting to remove plants that have matured and seeded;
 - removal of isolated infestations is easier and requires less resources than tackling it when it gets larger and established;
- Landscape treatments should utilise locally indigenous species.

All revegetation areas are to be periodically monitored for weeds within the first 2 years following establishment. Weeds are to be either manually removed or spot sprayed with appropriate herbicide. Only 'frog friendly' herbicide is to be used in areas adjacent to waterbodies.

During and following revegetation planting, maintenance weed control aims to restrict the impact of weeds on the success of establishing and existing endemic vegetation.

All revegetation areas will be monitored to determine whether satisfactory germination and development of locally indigenous vegetation has occurred. Where native vegetation is failing, further revegetation works are to occur. This may include both planting and seeding.

Where weeds are dominating or restricting the establishment of locally indigenous vegetation, weeds are to be identified and treated. Weed growth is to be kept to a minimum by the implementation of a maintenance programme through this period. Weed removal is to be targeted to the particular species present and may include hand removal and/or herbicide control.

Weed management, generally, is to be guided by the City of Gosnells Policy 6.2.2 (Rehabilitation and Revegetation of Natural Areas), which includes revegetation survival rates and weed cover objectives and infill planting requirements.

8.4 Fauna

It was found that rehabilitation of the link between the remaining vegetation at the study site and the adjoining bushland of Bush Forever site 125 would increase the habitat value of the remnant. This will rely on a Wetland Rehabilitation Plan to be prepared for the area ceded to WAPC under the provisions of Bush Forever.

The majority of the site outside of that reserved for Parks and Recreation has been historically cleared. The development of urban landuse is therefore not expected to severely impact faunal assemblages at the site. Clearing of the small area of Kunzea thicket to shrubland with associated Banksia species may result in the loss of a small area of potential Carnaby's Black Cockatoo feeding habitat. Vegetation on the site is not suitable for nesting or roosting, however, and the loss of this small and previously disturbed remnant is not likely to affect the survival of the species.

Increased human presence resulting from higher density housing may lead to increased numbers of domestic pets close to conservation areas. Dogs have caused problems for waterbirds and bandicoots through disturbance and predation in other parts of Perth, while cats may prey on smaller birds and other wildlife.

In line with the recommendations of the Fauna Study, lengths should be taken to manage the impact of domestic pets, including suitable fencing around the wetland area for exclusion of domestic animals. Fencing should be designed in line with City of Gosnells fencing specifications for conservation areas.

8.4.1 Mosquitoes and Midge Management Plan

Midges (family *Chironomidae*) form dense swarms and are nuisance insects that may severely impact on the amenity in residential areas but are not considered to be disease vectors.

Mosquitoes are known to severely reduce the amenity in residential areas and present serious health risks to humans by acting as transmitters or vectors of pathogenic arbovirus (Environmental Protection Authority, 2000). In Western Australia, they are known to be carriers of a number of diseases including Ross River virus (RRv) disease, Barmah Forest virus (BFv) disease. The only way humans can catch these diseases is by being bitten by a

virus-carrying mosquito. Ross River and Barmah Forest viruses cause non-fatal but potentially debilitating chronic diseases of humans. Both viruses occur throughout WA when conditions are warm enough for the virus to be active and when it is wet enough for mosquitoes to be active.

There is the potential for the wetlands, waterways and pools (natural, modified and constructed) within the Balfour Street Wetland Complex to support habitat for midges and mosquitoes. The physical attributes of water bodies including nutrient enrichment and water quality degradation are known to be major factors in the density of midge and mosquito larvae found in wetlands and stagnant pools. These conditions are more likely to occur when indiscriminate use of garden fertilisers occurs in close proximity to wetlands. Clearing of native sedges around wetland and riparian edges also encourages midge and mosquito breeding.

Given favourable conditions, there is the potential for mosquitoes breeding onsite to have an impact on residents. Notwithstanding, considerable numbers of mosquitoes would already occur within the development site that originate from external breeding locations within the recognised adult mosquito range of 5 km (EPA, 2000).

Generally, the hydrology of the wetland area will be maintained post-development (see LWMS, Calibre 2016) so the system will continue to be seasonally dry. Seasonal drying, particularly during the warmer months, will help restrict midge populations and reduce nutrient enrichment and algal proliferations (a food source for midge larvae). The retention, restoration and conservation of sedgeland habitat will also enhance avian predation.

In order to protect the health, welfare and amenity of residents from disease vectors (mosquitoes) and nuisance insects (midges), the developer will develop and implement a Mosquito and Midge Management Plan (MMMP) during the predevelopment phase and for 2 years following practical completion of the subdivision in consultation with the Department of Health, Western Australia (DHWA). The MMMP is designed to manage the potential breeding sites and will include direct and indirect intervention strategies.

These strategies are discussed in detail within the Department of Health Mosquito Management Manual (DOH, 2006). Based on field investigations undertaken and management measures proposed, it is considered that the health, welfare and amenity of future residents can be effectively protected from disease vectors (mosquitoes) and nuisance insects (midges) within the site. The proposed MMMP will be developed in liaison with the City of Gosnells Environmental Health section.

Structural aspects of mosquito management, such as ensuring that bioswales and bioretention gardens do not retain standing water for >72hours during the mosquito breeding season, will be detailed within a future UWMP. Vegetation of these areas will similarly be detailed within a future UWMP and guided by 'Vegetation Guidelines for Stormwater Biofilters in the South-west of Western Australia' (Monash University, 2014).

8.5 Fire

The prevention of bushfire requires a holistic approach, including understanding fire behaviour and risk, existing topography and vegetation systems, site planning, landscape design, maintenance and community education and involvement.

Fires are generally caused by lightning strike, accidental means, or deliberate arson. The most likely source of fire post urbanisation of the site is from arson within bushland and wetland areas.

Fire needs to be carefully managed to maintain wetland function, plant and animal communities and landscape character. The increased activity of machinery and vehicles as a result of construction activities and future residents has the potential to increase the likelihood of fires. Fire management and weed control are closely associated, as weeds make a significant contribution to fuel loads. Weed eradication has been flagged by the developer as being one of the first tasks to be implemented in the development of the site. A Fire Management Plan is to be developed as part of subdivision application.

The main purpose of the Fire Management Plan is to:

- protect life, property, community assets and natural values from the adverse impacts of fire;
- implement clear & co-ordinated fire management strategies;
- provide ongoing management until handover and a highly fire-controlled landscape;
- establish perimeter roads and setbacks prior to human habitation;
- identify fire breaks, evacuation routes and provision for emergency vehicular access.

With respect to this Wetland Management Plan, the objectives of fire management are to:

- minimise the risk of fire occurring within the “Reservation for Conservation”;
- ensure that adequate measures and controlled access is provided to allow fire fighting; and
- monitor and adapt the effectiveness of fire management measures.

Management actions to address fire risk include:

- develop a maintenance regime and fire management plan to protect the bushland (use the *Fire Management Planning for Urban Bushland* guide published by Fire and Emergency Services and Urban Bushland Council, WA);
- ensure construction contractors comply with the *Bushfires Act 1954* (e.g. fire prevention and control requirements) and provide details of fire access requirements; and
- establish a non-smoking site, with smoking to be prohibited from the site entry point;

A range of statutory fire prevention and control requirements will be imposed upon the contractors during and post estate development. Compliance with these requirements will reduce the risk of fire.

Full fire management inductions will be given to construction and Council maintenance personnel as required by FESA at handover

8.5.1 Physical Separation Controls

Physical separation between bushfire hazards zones and development areas is required and will greatly assist in reducing fire intensity should a bushfire threaten or impact buildings within a subdivision. These setbacks are to be detailed in the Fire Management Plan.

Perimeter roads and biofiltration swales separate residential properties from bushland, wetland and open space areas. The use of perimeter roads also provides emergency vehicle access and evacuation routes in case of fire (as well as a number of other precinct design objectives).

8.5.2 Landscape Design Controls

The landscape design of the public domain will include design measures and species selection to facilitate a practical and effective fire prevention strategy. Specific details are to be provided in a Landscape Management Plan to be developed by a suitably qualified and experienced consultant. The Landscape Management Plan will address, amongst other things:

- planting of fire retardant species
- appropriate landscape maintenance regimes to ensure that fuel levels minimised
- provision of an adequate number of appropriately located fire hydrants around the conservation area

8.6 Community use and appreciation

A Landscape Masterplan will be developed prior to development approval by a suitable qualified and experienced consultant. This plan will serve to provide further detail on aspects of the proposed development such as fencing, paths, access points and signage.

8.6.1 Natural landscape amenity

Visual impacts are derived from a change to the visual amenity of an area that affects the character and quality of the existing views. Any urban development project has the potential to detract from the natural character of an area and hence the visual, landscape amenity and should be considered during the approval process. Urbanisation has the potential to adversely impact the naturalness and visual amenity of the adjacent CCW sumpland areas. It is important to note that large areas of vegetation surrounding the CCW on the site are currently in a degraded state (Cardno BSD, 2007) and provides a negligible contribution to the natural visual amenity of the site.

The residential development (as proposed) will ultimately result in this degraded land being restored and protected through Reservation for Conservation. This in itself will enhance wetland values and functions and improve buffering of the existing CCW and restore

connectivity and continuity with the adjoining and highly valued Bush Forever wetland habitat.

8.6.2 Increased Human Use

The uncontrolled access of humans within the wetland catchments has the potential to cause direct disturbance to habitats (trampling) as well as being vectors for the spread of weed and disease within the CCW sumpland. Increased human use also has potential to increase the risk of fire and rubbish dumping within wetland areas.

There are also possible positive impacts that could result, such as an increased sense of ownership and benefits of passive surveillance.

In many instances biofiltration swales will be installed at the downslope end of road runs (within an extension of the road batter) to protect downstream wetlands and provide treatment and infiltration. These swales will be densely planted with wetland vegetation (including sedges) and will be largely unpassable to pedestrians and vehicles once the vegetation becomes established. Thus the biofiltration swales will be used as a means of controlling public access to the wetland reserve and will prevent trampling of the vegetation communities within the CCW sumplands.

Pedestrian paths will also help to keep human impacts to designated areas. These will be aligned so as not to intrude upon or traverse CCW wetland habitat. Further detail on the location and construction material of these paths will be specified in the Landscape Masterplan.

Vehicular access during construction of the path and biofiltration swales will be strictly controlled and the alignment of these structures will be clearly flagged. Contractors will be inducted and instructed upon the importance of minimising disturbance and staying within flagged areas prior to commencement of construction activities.

Fencing around the wetland will be detailed in the Landscape Masterplan. Fencing should direct pedestrians to limited access points whilst allowing access for routine maintenance and fire management.

8.6.3 Signs and Notices

Signs and notices play an invaluable public relations role for wetland education. They introduce people to the wetland, identify key features, provide directions, outline management issues and clarify safe usage.

Signs provide the means of giving visitors the full benefit of the experience. They allow them to geographically orient themselves, protect their safety, and enhance their enjoyment of the environment by providing them with an understanding of the wetland.

Effective signs can also play a role in minimizing the ecological impact of path users.

Signs are to be designed and installed by landscape architects. The following text provides general guidance in aspects relevant to wetland management.

Interpretative signage should be installed to help residents and visitors identify the key flora and fauna of the Conservation wetland, the goals/targets for conservation and explain the Water Sensitive Urban Design elements of the development.

Marketing of the residential lots within the site should focus on the landscape amenity of the Conservation wetland. Signage within the estate will seek to build upon raising public awareness and appreciation of the wetland and the need for protection.

Signage should also provide information regarding prohibited activities that may otherwise adversely impact the natural values of the wetland (e.g. littering, dumping, fire, domestic pets, etc).

Signage should be located at interpretation nodes corresponding with entry points, directional shifts of the dual use path and widenings for seating or viewing points. Incidental signs along the walkway will enhance and reinforce the environmental messages.

The entry points to the proposed pedestrian path should have signage to reinforce the following messages:

- No-smoking within the “Reservation for Conservation” (butts create a fire hazard and adversely impact the habitat values of the wetland);
- Fire danger/hazard level;
- Place litter in bins provided or take items home for disposal (litter within the wetland will be due to residents and visitors disposing of their items along the walkway, rather than due to stormwater runoff);
- Weeds and invasive plants can degrade the natural value and function of the wetland (stay to the paths, assess clothing and footwear for weed seeds and remove them before entering walkway/conservation zone, identify/notify any weed species that are a particular nuisance to the area to appropriate contact—e.g. local government environment officer);
- Areas where access is not permitted (e.g. stay to the paths, areas where the wetland is being rehabilitated, areas with particularly sensitive flora/fauna species, etc);
- Dogs (and any domestic animal) are prohibited within the “Reservation for Conservation”; and
- State of the pedestrian path (e.g. if any section is under construction or repair).

Environmental education is crucial to developing awareness, increasing knowledge, teaching skills and changing attitudes of the community to the impacts that urban development may have on the environment (and wetlands in particular). It facilitates behavioural change and environmentally responsible practices. In addition to informational signage around wetland access points, the advanced drainage design itself could be a useful teaching tool for Water Sensitive Urban Design practitioners.

Signage for the reserve should be developed in consultation with the City of Gosnells and reflect the general style and format of signage in the broader area.

8.6.4 Controlled Public Access

For ecological and safety reasons, it is important to discourage school children and pedestrians from trampling the CCW or worse, establishing ‘shortcuts’ through the habitat. The alignment of any path should be selected so that it does not intrude upon or traverse CCW wetland habitat.

Along the south-western edge of the wetland/ POS area, a biofiltration swale will be installed to protect downstream wetlands and provide treatment and infiltration. This swale will be densely planted with wetland vegetation (including sedges) and will be largely unpassable to pedestrians and vehicles once the vegetation becomes established. Thus the biofiltration swale will be used as a means of controlling public access to the wetland reserve and will prevent trampling of the vegetation communities within the CCW sumpland.

Vehicular access during construction of pathways and biofiltration swales will be strictly controlled and the alignment of these structures will be clearly flagged. Contractors will be inducted and instructed upon the importance of minimising disturbance and staying within flagged areas prior to commencement of construction activities. Under no circumstances should contractors intrude into the core area of the wetland during construction of the path or swale.

Fencing around the wetland will be detailed in the Landscape Masterplan. Fencing should direct pedestrians to limited access points whilst allowing access for routine maintenance and fire management.

8.7 Minimising the risk of phytophthora dieback

Phytophthora dieback is an introduced plant disease caused by *Phytophthora cinnamomi* (water mould). Over 40% of native WA plant species are susceptible to *P. cinnamomi*. Warm, moist soil provides the best conditions for Phytophthora dieback to produce millions of spores that attach to plant roots.

Human activity has caused the widespread distribution of this disease through road construction, earth moving and driving vehicles on infested bush roads. Dieback management during the construction phase will therefore be undertaken in line with Managing Phytophthora Dieback: Guidelines for Local Government, produced by the Dieback Working Group. Dieback management should be a key component of a Construction Environmental Management Plan, to be developed prior to development approval.

The primary pathway for Phytophthora to enter the wetland area is through vehicular access during construction of the linear biofiltration swale, pedestrian paths or revegetation activities or through the importation of contaminated fill. The following guidelines for cleaning and sterilising vehicles should be included in the CEMP to be employed during the construction/rehabilitation phase of the project:

- ensure all earthmoving equipment and construction vehicles are cleaned and sterilised at an appropriate wash down facility prior to entering the site;
- wash down of equipment at the site is to be undertaken on a hard surface (e.g. road);
- remove soil and mud when it is dry using a brush to minimise the amount of water used;
- do not allow mud and wash down effluent to drain into bushland or the wetland; and
- use methylated spirits (undiluted) for sterilising small hand tools and footwear in the field.

Periodic surveys will be conducted post-construction to monitor the “Reservation for Conservation” for signs of Dieback. In the event that Dieback is identified, appropriate measures will be taken to manage the threat.

8.8 Land use change and nutrient budget

Urbanisation presents a significant opportunity to both enhance and protect existing remnant vegetation, wetlands and their buffers through restoration and by securing an appropriate vesting for conservation purposes.

In addition, through the application of Water Sensitive Urban Design (WSUD) best practices the developers have sought to apply innovative drainage and landscape designs to protect water quality and environmental water requirements associated with the CCW sumpland habitat.

Nutrient application rates for the soils of the Swan Coastal Plain have been historically as high as 200kg N/ha/yr and 18kg P/ha/yr for dryland grazing (typically ‘a bag to the acre’ of soluble superphosphate). In addition, regulation of fertiliser use within the agricultural industry remains problematic (not just within Australia) despite being identified as a significant cause of eutrophication in our coastal waterways.

Pre-development water quality monitoring (see LWMS, Calibre 2016) identified high nutrient concentrations across the board, and in particular at Bore H6 (TN up to 11 mg/L and TP up to 6.3mg/L). Phosphorus was also highly elevated (up to 7mg/L) at H4, in the vicinity of the wetland functional area. These levels far exceed groundwater nutrient levels that would typically be expected under urban landuse. It is likely that these elevated nutrient levels can be attributed to past rural landuse in the area; in particular the poultry sheds which stood in close proximity to Bore H6 and have now been removed. Agricultural drains designed to alleviate winter waterlogging, fencing, and reference in Cardno flora survey reports (Cardno 2007) referring to evidence of grazing activity, provide further support to suggest broadscale and/or intensive agricultural landuses have dictated historical nutrient inputs on the site and nutrient concentrations in the wetland. Changing landuse from rural to urban presents both a risk and an opportunity in terms of managing future nutrient losses to receiving waterways.

Given a pre-development grazing area of approximately 4.3 ha in the total area of the site, the annual nitrogen and phosphorus input to the site under pre-development (agricultural) conditions is estimated to be as much as 860 kg N/yr and 77 kg P/yr. This is based upon the assumption that degraded wetland areas have been, or could be, fertilised without constraint.

Based upon the likely pre and post-development scenarios (3.8 ha of total residential area), nutrient loading to the site can be expected to be reduced by 94% and 75% for nitrogen and phosphorus, respectively (Table 7). These figures will vary depending upon public awareness raising within the future estate and the (likely) predominance in the use of organic fertilisers (over pre-development soluble chemical fertilisers such as superphosphate applied to winter wet areas).

Even if pre-development agricultural fertiliser applications are applied only every third year (say, based upon soil phosphorus testing) the reductions following urbanisation are still likely to be substantial (estimated to be 84% N and 24% P) if the recommended fertiliser rate can be achieved.

The likely reduction in nutrient inputs to the site following land use change provides a high degree of confidence that nutrient loadings within the catchment of the CCW sumpland will not be adversely impacted following urbanisation.

Implementation of a managed WSUD program based on a combination of at-source (land use planning, POS landscaping and design, infiltration at source, street sweeping, native plantings, education campaigns) and structural controls would reduce phosphorus input to below existing inputs associated with rural land use.

In addition to significantly reducing the use of nutrients through the proposed change in land use, the application of WSUD techniques appropriate to the geomorphology and nutrient transport mechanisms of the site afford an additional opportunity to attenuate nutrient export and further reduce the risk of adverse water quality impacts arising from urban development. These elements are outlined further in Sections 9.2 and 9.3.4, and incorporate the following WSUD design elements:

- Bioretention gardens within the residential areas using amended sub-soils treating all stormwater up to the 1 hour 1:1 ARI event
- Biofiltration swales designed to hold and infiltration stormwater up to the 1 hour 1:5 ARI event adjacent to the wetland; and
- Groundwater levels to be maintained at pre-development levels via the use of subsoil piping at AAMGL

An LWMS has been prepared for the site and more detail on drainage design is to be presented within an Urban Water Management Plan (UWMP) to be prepared for the development and lodged with the subdivision application.

Additionally, retention, restoration and conservation of a significant portion of Degraded CCW/Bush Forever wetland habitats will provide enhanced phosphorus and nitrogen retention through increased biological uptake within the restored wetland system, prior to offsite discharge via the Balfour Street Drain to the Southern River.

In summary, de-stocking and the corresponding reduction in the use of fertilisers on the site and the application of Water Sensitive Urban Design practices can be expected to reduce both nitrogen and phosphorus inputs and export from the development area (from typical pre-development agricultural levels).

Table 7: Estimated nutrient inputs pre- and post-development for the site

Land Unit	Pre-development				Post-development			
	Area fertilised (ha)		Areal Loading (tonne/yr)		Area fertilised (ha)		Areal Loading (tonne/yr)	
			N (200 kg N/ha/yr ²)	P (18 kg P/ha/yr ²)			N (30 kg N/ha/yr ³)	P (12.5 kg P/ha/yr ³)
Dryland Grazing ¹	4.3	860	77	-	-	-	-	-
Active POS (est 8% of total residential area)	-	-	-	-	0.30	9	3.8	
Verge (est 5% of total residential area)	-	-	-	-	0.19	6	2.4	
Residential Gardens/Landscaping (est 28% of total residential area)	-	-	-	-	1.06	32	13	
Total	4.3	860	77		1.56	47	20	(-75%)

Notes:

- (1) Pre-development assumes 4.3 ha of the site is degraded vegetation that has been historically fertilised for grazing (excludes Good and better vegetation)
- (2) Assume pre-development agricultural fertiliser rates of 200 kg N/ha/yr N and 18 kg P/ha/yr for dryland grazing
- (3) Assume BMP fertiliser application rate for N (12%) & P (5%) at 25g/m² for new lawns (SRT, 2004). Average urban lot is 350m², assumes 100m² fertilised; average suburban lot is 700m² assumes 350m² fertilised.
- (4) Revegetation of wetland buffers may require slow-release osmicote during establishment phase, considered to be temporary and negligible input.

8.9 Construction Management Plan

A Construction Management Plan (CMP) is to be developed prior to development approval and implemented over the time of construction. The Construction Contractor/s will be required to minimise the impacts of construction and rehabilitation activities on the wetland and associated buffer.

The key principles to be included in the CMP:

- low impact construction;
- minimising vehicular access, for earthworks only;
- clearly delineate and demarcate conservation areas to avoid vehicular movement in or disturbance of these areas. Contractor inductions to occur prior construction;
- use of manual labour for rehabilitation plantings within the wetland wherever practicable to avoid large vehicles/machinery movements in and around the wetland;
- limit the use of pesticides and fertilisers in landscape establishment, however noting the need to control invasive species such as kikuyu and castor oil plant;
- use fertilisers, pesticides and herbicides sparingly. Fertilisers contain toxicants and nutrients which can pollute waterways. Pesticides and herbicides can harm native fauna, insects and aquatic life. 'Bioactive' formulations to be used wherever possible to reduce impacts of surfactants;
- use of a low maintenance landscape design employing drought tolerant native species indigenous to the local area; and
- soil and fill imported to the site should be assessed for pathogens and weed seeds prior to being use on the site (e.g. through a hygiene certificate).
- minimise soil and water contamination from chemical/fuel spills
- bund fuel, oil, hazardous chemical storage and washdown areas to prevent contamination of runoff and ideally ensure they are located at least 100m away from the wetland habitat (however the size of the development site itself may restrict this separation distance in some cases);
- all maintenance activities completed in defined areas in order to contain any spillages and facilitate effective clean up; and
- in the event of accidental spills, all contaminated soil and spill material will be removed from the area and disposed of to an approved waste disposal facility.
- The risk of spread of phytophthora should be minimised by employing management actions outlined in Section 9.7.

9. Monitoring and Reporting

Monitoring will be undertaken quarterly, with annual reporting to the City of Gosnells for a period of no less than 2 years following practical completion of the development (to coincide with the landscaping maintenance period, or handover to the City of Gosnells – whichever is the later). Annual reporting will be provided to the City of Gosnells summarising the results of monitoring for the preceding 12 months and making management recommendations as appropriate.

The objectives of the monitoring will be to ensure:

- successful weed control and revegetation of degraded areas within the reservation for conservation;
- the hydrologic regime (water level and period of inundation) of the CCW sumpland are maintained; and
- maintenance and/or improvement of water quality within the CCW sumpland.

The monitoring programs outlined within this Wetland Management Plan refer only to those specifically related to the environmental performance of the sumpland and wetlands within the site. The monitoring program for performance of stormwater treatment trains, groundwater and surface waters outside the wetland catchment boundaries are discussed within the LWMS and will be further specified within a future UWMP.

9.1 Water Monitoring Program

Pre-development monitoring was completed in accordance with the DoW pre-development monitoring guideline requirements at the time. The aim of monitoring outlined in this WMP is to enable quantitative assessment of the post-development impact of development on the area's hydrology and water quality.

The monitoring program will focus on monitoring the water level regime and water quality within the CCW sumpland (UFI 14280).

This WMP should also be read in conjunction with the LWMS (Calibre, 2016). The performance of stormwater treatment trains and nutrient retention performance of the biofiltration swales post-development is outlined in the LWMS and will be further detailed in a future UWMP. Groundwater monitoring programs are also detailed in the LWMS, however where groundwater monitoring coincides with the objectives of the WMP this has been detailed.

Table 8: Wetland Water Monitoring Schedule

Monitoring	Parameter	Frequency	Duration	Analytes
Wetland	Water Level	Continuous water level recorder	2 years after practical completion of the development	Water level
Wetland	Water Quality	Monthly when standing water is present	2 years after practical completion of the development	<i>in situ</i> : temp, DO, pH, EC, redox and TSS Sample: TN, NOx, ammonia, TP and FRP

The monitoring program for the CCW sumplands outlined in this document has been prepared in accordance with the National Water Quality Management Strategy (ANZECC/ARMCANZ, 2000).

Specifically, monitoring will entail the following:

- Installation of a water level recording sensor within the Conservation wetland areas. This will be sited and installed to provide seasonal (pedestrian) access for servicing and to minimise visual intrusion and vandalism. This data will provide a measure of the effects of increased recharge following an increase in impervious areas and onsite infiltration via soakwells and biofiltration swales;
- Monthly surface water quality monitoring (when standing water is present in the wetland) of pH, EC, temp, DO, redox, TSS, TN, NOx, TP and FRP and ammonia.

Water quality samples will be collected and labelled with a unique identifier that can be related to the surveyed sample location and preserved (where required) according to relevant Australian Standard (AS/NZS 5667.11:1998). All analytical chemistry will be undertaken by a NATA accredited laboratory (for low level detection). Chain of custody documentation indicating the sampling date, sample identification, container size, medium, preservative and analysis required will be submitted along with the samples and the required QA/QC samples for laboratory analysis.

Primary, QA/QC samples will be analysed to ensure the relative percentage difference (RPD) is acceptable. Acceptable RPDs include 20% for samples with concentrations greater than 10 times the detection limit and 50% for samples with concentrations less than 10 times the detection limit. If RPDs are found to be outside this range further investigation will be undertaken as to the possible cause and nature of this variation (including a possible inter-laboratory comparison and/or inclusion of a standard solution of known concentration).

9.2 Assessing change to water levels and water quality and associated trigger values

Drainage design for the management area outlined in the LWMS has been based on a detailed water balance assessment and aims to maintain post development water regimes in the wetland at pre-development levels. DPaW currently recommends water level changes for CCW sumpland habitat post-urbanisation should ideally be sustained at $\pm 10\%$ of pre-development levels. Accordingly, this standard will be used to compare results of post-development water level monitoring with monitoring undertaken by JDA over an 18 month period in 2008-2009. Any exceedances beyond a $\pm 10\%$ variation from pre-development will trigger a management response as outline in Section 10.4.

During this period of monitoring, monthly groundwater quality samples were collected and analysed for pH, Electrical Conductivity, Total Suspended Sediments, Total Nitrogen, Total Kjeldahl Nitrogen, NO_x, Total Phosphorus and Filterable Reactive P as required by DoW pre-development monitoring guidelines. This data was found to be highly variable with existing elevated nutrient levels and should therefore not be used as a sole basis for inferring wetland water quality.

Given the elevated concentration of gilvin (naturally brown staining) observed in the wetland a better trigger for management action to address wetland water quality would be based on visual observation (see ANZECC Guidelines table 3.3.6). Visual observations will be used in conjunction with post-development water quality monitoring to inform decision making. Triggers for management action should include visual symptoms of degraded water quality including algal blooms, slicks or scums. The observation of any of these visual symptoms should trigger a management response, as outlined in Section 10.4.

9.3 Vegetation Monitoring and Reporting

The objective of the vegetation monitoring program is to guide and evaluate the success of revegetation and weed management within the reservation for conservation (post development). Vegetation monitoring will be further detailed in a Wetland Rehabilitation Plan to be prepared and submitted to the City of Gosnells prior to development.

Monitoring will entail the following (Table 9):

- Monitoring revegetation survival rates (target: $\geq 70\%$ survival rate for each species in all plantings) within the first 2 years after substantive completion of revegetation works); and
- Inspection for invasive weeds (target: $\leq 5\%$ weed cover) and recording of spot treatments, slashing or hand weeding undertaken (as appropriate).

Vegetation monitoring and reporting shall have regards to the 'Natural Areas: Rehabilitation and Revegetation Guidelines' (City of Gosnells, 2014).

Responsibilities for vegetation monitoring and reporting is identified in section 11.3

Table 9: Vegetation Monitoring Schedule

Monitoring	Area	% Cover	Frequency	Duration (post development)	Parameters
Revegetation success	✓	✓	6 monthly	2 years after practical completion of the development	Species, survival rate and % cover
Weed monitoring and management	✓	✓	6 monthly	2 years after practical completion of the development	Species and % cover

Monitoring of wetland vegetation within the adjoining Bush Forever property is not proposed.

Visual inspection will be undertaken to monitor the potential introduction of dieback disease within the reserve for conservation. Preventative measures for dieback control have been outlined in earlier sections of this Plan, however, should dieback become evident a separate report with recommended management actions will be prepared and implemented (in consultation with the City of Gosnells).

9.4 Responsiveness and Contingency measures

9.4.1 Contingencies

Any exceedance of trigger values as outlines in Sections 10.2 and 10.3 will trigger investigation into the reason followed by the appropriate management response to rectify the exceedance.

In the case of water quality, investigations will be undertaken to identify the source of the contaminant and rectify or contain the contamination. Where water levels exceed the $\pm 10\%$ variation, investigation will be undertaken to identify the source of the level change and appropriate responses to rectify the level change will be made if not due to extreme weather events.

In a failure to meet vegetation trigger values, management action to be undertaken will include removal of weeds or further revegetation as required.

9.4.1 Responsiveness

The developer will notify City of Gosnells within 72 hours of becoming aware of any exceedance of trigger values for wetland water levels, water quality or vegetation health as specified above in Section 10.2 and 10.3.

9.4.2 Annual Reporting

The developer will submit written reports to the City of Gosnells on an annual basis which summarises and interprets the results of the monitoring, and provides a summary of management actions undertaken or proposed. The final report will also include recommendations regarding performance measures and ongoing monitoring, and management.

10. Implementation, Timing and Review

10.1 Implementation Strategy

The implementation strategy for the Wetland Management Plan will ensure a systematic approach to optimising environmental performance (to ensure that the developer's environmental objectives and management standards are achieved) and the CCW sumpland habitats are protected during the development of the site. The implementation strategy for the project comprises the following key components:

- Comprehensive pre-tender planning;
- Comprehensive and sufficiently detailed 'scope of works' used as the basis for tendering and appointment of contractors
- Development of appropriately detailed operational procedures using a risk-based approach;
- Adequate supervision, contractor induction and procedural controls to be employed; and
- Fortnightly onsite meetings and compliance reporting.

Planning

Environmental planning is undertaken prior to tendering. The specific environmental sensitivities of the area are determined via both desktop evaluations of local environmental resources and consultations with stakeholders. The outcomes of these investigations are incorporated into the scheduling and design of the proposed works.

Contractual controls

All contractors will be required to comply with the developer's pre-qualification process. Only companies with the proven experience and capacity to complete the project to the developer's requirements and standards will be considered for the proposed operation.

Environmental conditions will be included in contracts, including a requirement for the contractor to prepare an OHSE Plan to meet the developers' requirements.

An Environmental Commitment Register will be prepared containing the specific environmental requirements and other relevant documents such as regulatory conditions and guidelines. This register will also be included in the Contractor's requirements.

Development of appropriate procedures

All contractor procedures will be subject to review by the developers' project team, including environmental personnel, prior to finalisation and issue. The HAZID process will be used to identify if/where further detailed procedures are required to address environmental risks.

10.2 Responsibilities

All personnel managing or working on construction of the development shall be responsible in some form for environmental management. All personnel associated with the project shall at least undergo some basic environmental management training as part of the initial safety and environmental induction to inform them of their responsibilities.

The proponent has overall responsibility for development of the precinct and implementation of the WMP. The person responsible is the Project Manager or Officer assigned to the Holmes-Balfour St development. It shall be the proponent's responsibility to report serious environmental incidents to government agencies where appropriate.

Contractor engineers will have overall responsibility for administration of the contract for construction of the development. Although all contractor personnel will be responsible for proper environmental conduct, which will include the reporting of environmental incidents, the developer may appoint a person responsible for monitoring the on-site environmental compliance and management of the project. The environmental functions of this person(s) may include:

- Conducting initial safety and environmental inductions for on-site personnel
- Completing construction inspections
- Reporting environmental incidents to relevant supervisors
- Conducting monitoring as described in component plans of the WMP and to be prescribed in the Wetland Rehabilitation Plan.

A flow diagram is included below in Figure 16 depicting a possible structure for environmental (including wetland) management responsibilities.

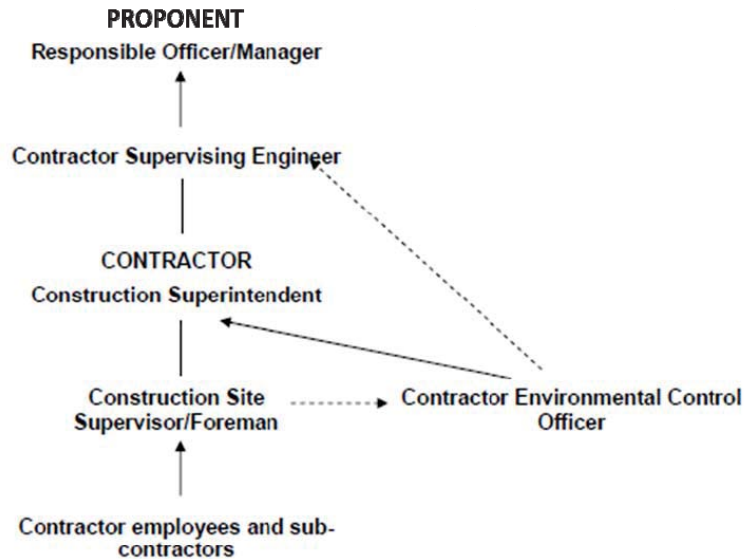


Figure 16: Possible structure for environmental management responsibilities showing the direction for reporting of environmental issues.

10.3 Timing

Implementation of the Wetland Management Plan will require pre, during and post development tasks as identified in Section 12. Ultimate responsibility for ensuring that management commitments are undertaken in the required timeframe sits with the developer.

In order to minimise the potential impacts associating with developing the site, the timing of the following activities should be regimented as follows:

- Rehabilitation of wetland habitat will be required to be undertaken following the onset of autumn/winter rains to improve survival rates. This will necessitate preparation initially of a Wetland Rehabilitation Plan. Hand planting of appropriate species will then be undertaken and likely exclude vehicular access to wetland rehabilitation areas at the time;
- Post-emergent weed control treatment of wetland and buffer areas subject to rehabilitation will be conducted in autumn. Care is to be taken to ensure herbicides are not used in proximity to wetland areas and that spray drift is kept to a minimum (not applied during strong wind conditions); and
- The proposed subdivision development should be constructed during summer months where the groundwater levels are lowest, thereby reducing the incidence and severity of Acid Sulphate Soil formation. Where this is not possible, lime dosing response measures should be maintained onsite to allow for neutralisation of any Acid Sulphate Soil formation generated.

10.4 Review

Project environmental performance will be reviewed in the above manner by the developer both during and following completion of the subdivision works. Possible improvements to practices or procedures will be identified and, where appropriate, implemented immediately.

The Wetland Management Plan will be reviewed and updated at the key changeover points, namely completion of landscaping, wetland rehabilitation works, drainage and handover of responsibilities to the City of Gosnells.

Performance review to be undertaken annually by way of reporting to CoG on management initiatives and monitoring results.

11. Roles and Responsibilities

11.1 Acid Sulfate Soils

Table 10 defines the responsibility for ensuring the items relating to acid sulfate soils are actioned as described in section 9.1.1.

Table 10: Acid sulfate soils management responsibilities

Item	Timing	Responsibility
Preparation of an ASS and Dewatering Management Plan	Pre development	Developer
Further detailed site investigations, as required	Pre development	Completed
Best practice soil excavation, stockpiling, handling, dewatering and/or disposal strategies	Pre development	Superintendent
Site groundwater monitoring program	Pre, during and post development	Developer

11.2 Wetland Hydrology

Table 11 defines the responsibility for ensuring the items relating to wetland hydrology are actioned as described in section 9.2.1.

Table 11: Wetland hydrology responsibilities

Item	Timing	Responsibility
Design residential development and stormwater drainage systems to appropriately manage nutrients and water within the site.	Pre-construction	Developer
No direct discharge dewatering discharge to the CCW sumplands during construction.	During construction	Superintendent
Maintenance of pre-development hydrological regimes post-development through appropriate drainage design and construction	Pre development During construction	Drainage engineers Superintendent
Prohibition on the installation of domestic shallow groundwater bores	Restrictive Covenant on Titles	Developer
Monitor CCW water levels and	During	Developer/subcontractor

surrounding groundwater levels for 2 years post-development	construction/post construction
--	-----------------------------------

11.3 Drainage and Water Quality Strategy

Table 12 defines the responsibility for ensuring the items relating to water quality protection and maintaining appropriate drainage within the site are actioned as described in section 9.2.2 and 9.2.3.

Table 12: Drainage and water quality management responsibilities

Item	Timing	Responsibility
Incorporation of WSUD into drainage designs for the site	Pre development	Drainage engineers
Construction of lots, swales in accordance with the drainage design	During construction	Superintendent
Monitoring of water quality within the wetland (see Monitoring & Reporting section)	Post construction	Developer

11.1 Maintaining wetland buffer

Table 13 defines the responsibility for ensuring the items relating to wetland buffer are actioned.

Table 13: Wetland buffer and drainage management responsibilities

Item	Timing	Responsibility
Wetland Rehabilitation Plan to be prepared and Implemented	Pre, during and post construction	Developer
Staged revegetation program and weed eradication	Pre, during and post construction	Developer

11.2 Ecological corridors and linkages

Table 13 defines the responsibility for ensuring the items relating to maintaining ecological corridors and linkages are actioned as described in section 9.3.4.

Table 13: Ecological corridors and linkages management responsibilities

Item	Timing	Responsibility
Preparation of the Outline Development Plan incorporating drainage system, wetland restoration and wetland buffer consolidation strategy.	Pre development	Developer
Rehabilitate approximately 2.5 Ha of largely degraded conservation category wetland habitat located on Lots 2 and 1600.	During and Post construction	Developer
Consolidation of remnant wetland habitat and rehabilitation to provide contiguous corridors of vegetation.	Pre, During and Post construction	Developer
Preparation of a management and rehabilitation plan for degraded vegetation on Lots 3 and 4 on land to be ceded to WAPC under the provisions of Bush Forever.	Unspecified	WAPC

11.3 Wetland Rehabilitation and Weed Management Strategy

The monitoring and management of the rehabilitated areas shall continue until a satisfactory cover of locally indigenous species is achieved. Quarterly maintenance / management inspections will be undertaken by the developer's landscape consultant and continue for a period of 2 years to monitor the success of the rehabilitation process. Annual reports shall be provided to the City of Gosnells detailing specific weeds on site, their locations and methods of treatment and/or removal.

Monitoring and reporting shall have regards to the 'Natural Areas: Rehabilitation and Revegetation Guidelines' (City of Gosnells, 2014).

Following this initial period, it is recommended that the site continue to be monitored quarterly and appropriate weed treatment be implemented to target identified weed species.

Wetland management responsibilities are outlined in Table 14.

Table 14: Wetland rehabilitation responsibilities

Item	Timing	Responsibility
Wetland Rehabilitation Plan to be prepared and implemented for wetland areas on Lots 1,2 and 1600, including aspects outlined in Section 9.3.5	Prior to development approval	Suitable qualified and experienced consultant
Staged revegetation program and weed eradication	Pre, during and post construction	Suitable qualified and experience consultant
Landscape design to include non-invasive, locally indigenous native species	Pre-construction	Developer's landscape architect in consultation with City of Gosnells
Minimise extent and duration of ground disturbance	During construction	Superintendent
Preventative cleaning of machinery, vehicles and tools to eliminate weed seeds	During construction, prior to site entry	Superintendent
Periodic surveillance of wetland and buffers to identify and remove weed infestations	Post-construction	Construction contractor on advice of developer's landscape architect

11.4 Fauna

Table 15 defines the responsibility for ensuring the items relating to fauna protection are actioned as described in section 9.4.

Table 15: Fauna responsibilities

Item	Timing	Responsibility
Suitable fencing will be erected around the wetland area for exclusion of domestic animals. Fencing should be designed in line with City of Gosnells fencing specifications for conservation areas.	During and post construction.	Developer

11.5 Mosquitoes and Midges

Table 16 defines the responsibility for ensuring the items relating to mosquito and midge control are actioned as described in section 9.4.1.

Table 16: Mosquito and midge control responsibilities

Item	Timing	Responsibility
Development and implementation of a Mosquito and Midge Management Plan	Pre and Post development	Developer for predevelopment and 2 years following practical completion of the subdivision, then City of Gosnells
Storm water management, landscaping and vegetation management, design of roads and prevention of animal / vehicle access are undertaken in such a way as to minimise the potential for mosquito breeding	During-construction	Superintendent
Targeted larvicide application on an as needs basis under direction of the City of Gosnells	Pre and post development	Developer for predevelopment and 2 years following practical completion of the subdivision, then City of Gosnells
Biofiltration swales designed to contain a base of aggregate such that the water level remains below ground level during the spring/summer mosquito breeding season with no standing water for more than 48 hours	During-construction	Superintendent
Provision of adequate buffers around wetlands (for biofiltration, light attenuation and screening),	At design and Construction	Developer
Education and ensuring house designs are appropriate.	Pre development	Developer then City of Gosnells

11.6 Fire management

During construction, the construction superintendent is responsible for ensuring fire management procedures and actions are completed on site by contractors.

Pre-development, a Fire Management Plan shall be prepared by the developer (or its consultant) and submitted for the approval of FESA. As ongoing fire management will ultimately become the responsibility of FESA and the City of Gosnells, the Fire Management Plan will be developed in close consultation with these bodies.

Post-establishment, bushfire/emergency services and local government will be responsible for addressing fire management within the Reserve.

Roles and responsibilities for the management actions that will be implemented to reduce the risk of fire as per section 9.5 are outlined in Table 17.

Table 17: Management actions for fire management

Item	Timing	Responsibility
Contractors shall demonstrate compliance with the <i>Bushfires Act 1954</i> (eg. fire prevention and control requirements).	During construction	Supervising Engineer, Contractors
A Fire Management Plan shall be prepared and submitted for the approval of FESA. The plan will, amongst the normal matters, detail fire access requirements.	Pre- development	Suitably qualified and experienced consultant in consultation with FESA and City of Gosnells
All on-site personnel shall be provided with basic fire fighting training	Prior to construction	Contractor Supervising Engineer
Dual use pathway to be constructed between wetland/buffer and precinct lots	During construction	Supervising Engineer

11.7 Natural Landscape Amenity

Table 18 defines the responsibility for ensuring the items relating to visual amenity are actioned as described in section 9.6.1.

Table 18: Visual amenity management responsibilities

Item	Timing	Responsibility
Wetland Rehabilitation Plan to restore and enhance visual amenity of degraded wetland areas	Prior to development approval	Suitably qualified and experienced consultant

11.8 Increased Human Use

Table 19 defines the responsibility for ensuring the items relating to public access are actioned as described in section 9.6.2.

Table 19: Public access responsibilities

Item	Timing	Responsibility
Preparation of a Landscape Masterplan outlining detailed design for fencing and paths in and around the wetland limiting access to the CCW except where designed	Prior to development approval	Suitably qualified and experienced consultant

11.9 Signage

Table 20 defines the responsibility for ensuring the items relating to signage are actioned as described in section 9.6.3.

Table 20: Signage responsibilities

Item	Timing	Responsibility
Design and develop interpretive signage	Pre-construction	Developer in consultation with City of Gosnells
Incorporate signage into reserve	Pre-construction	Developer in consultation with City of Gosnells
Monitor and repair signage as needed	Periodically, post-construction as needed	Developer and then City of Gosnells
Environmental education to develop awareness and increase knowledge to local school children and residents of value and function of the wetlands.	Periodically, post-construction as needed	Local government

11.10 Controlled public access

Table 21 defines the responsibility for ensuring the items relating to public access are actioned as described in section 9.6.4.

Table 21: Public access responsibilities

Item	Timing	Responsibility
Preparation of a Landscape Masterplan outlining detailed design for fencing and paths in and around the wetland limiting access to the CCW except where designed	Prior to development approval	Suitably qualified and experienced consultant
Develop uniform signage to reinforce message that public access is only permitted in certain locations	Pre-construction	Developer in consultation with City of Gosnells

11.11 Managing the risk of Phytophthora Dieback

Table 22 defines the responsibility for ensuring the actions to manage the risk of Phytophthora Dieback are completed as described in section 9.7.

Table 22: Phytophthora Dieback responsibilities

Item	Timing	Responsibility
Construction Environmental Management Plan to be developed prior to construction outlining phytophthora management to be undertaken during construction such as vehicle and machinery hygiene inspection and inspection to ensure clean fill	Prior to development approval	Developer
Periodic surveys to monitor for Phytophthora Dieback	Ongoing, post construction	Developer
Wetland Rehabilitation Plan to be developed to include management of dieback risks and monitoring pre, during and post rehabilitation	Prior to starting rehabilitation	Developer

11.12 Construction management

Table 23 defines the responsibility for ensuring the above construction management items are actioned, as described in section 9.9.

Table 23: Construction management responsibilities

Item	Timing	Responsibility
Develop and implement a Construction Environmental Management Plan including aspects listed in Sections 9.9 and 9.7	Prior to development approval	Developer
Low impact construction, site flagging and contractor induction	During construction	Superintendent
Prohibit or limit the use of pesticides and fertilisers in landscape establishment	During construction	Developer's landscape architect
Assess the hygiene of imported fill and soil	During construction, prior to site entry	Superintendent
Minimise likelihood of soil and water contamination	During construction	Superintendent
Treat and dispose of dewatering water to infiltration pits, as appropriate (Dewatering and Acid Sulfate Soils Management Plan)	During construction	Superintendent.

11.13 Monitoring and Reporting

Table 24 defines the responsibility for ensuring the items relating to monitoring are actioned, as described in section 9.

Table 24: Monitoring responsibilities

Item	Timing	Responsibility
Post development surface and groundwater monitoring as outlined in Section 10.1	2 years after practical completion of the development	Suitably qualified and experienced consultant
Vegetation and weed monitoring as outlined in a Wetland Rehabilitation Plan	2 years after practical completion of the development	Suitably qualified and experienced consultant
Annual reporting of water quality monitoring, weed monitoring and revegetation success monitoring to City of Gosnells	Pre and post development	Developer
Contingencies where management response is triggered as described in 10.4.1	Post-development	Developer
Reporting of exceedance to triggers to City of Gosnells and proposed management actions	Post-development	Developer

12. References

Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, (ANZECC & ARMCANZ) 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality.

Beard, J. S., 1990. Plant Life of Western Australia. Kangaroo Press, Perth

Brown Geotechnical and Environmental (2008). Lots 1,2,3,4 & 1600 Balfour Street, Southern River: Geotechnical Investigation. Unpublished report prepared for Mammoth Nominees.

Calibre, 2016. Local Water Management Strategy - Lots 1-4 Holmes Street and Lots 1600 & P1601 Balfour Street, Southern River.

CALM, 2007. FaunaBase. Western Australian Museum's FaunaBase and WA FaunaList Database. The database was accessed on the internet (<http://www.museum.wa.gov.au/faunabase/prod/index.htm>) on the 8th July, 2007 using the Lat and Long grid coordinates bordering the site.

Canterford, R.P., Pescod, N.R., Pearce, H.J. and Turner, L.H. (2001) Design Intensity-Frequency-Duration Rainfall, Chapter 2, Australian Rainfall and Runoff: A Guide to Flood Estimation, Institution of Engineers Australia

Cardno BSD, 2007a. Lots 1-4 Holmes St and Lot 1600 and Pt Lot 1601 Balfour St, Southern River. Flora and Vegetation Survey and Wetland Assessment. Report prepared for Mammoth Nominees Pty Ltd, August, 2007.

Cardno BSD, 2007b. Lots 1-4 Holmes St and Lot 1600 and Pt Lot 1601 Balfour St, Southern River. Flora and Vegetation Survey and Wetland Assessment: Spring Update. Report prepared for Mammoth Nominees Pty Ltd, November, 2007.

Davidson, W.A., (1995), Hydrogeology and Groundwater Resources of the Perth Region, Western Australia. Geological Survey of Western Australia, Bulletin 142

Department of Environment and Conservation (2007), Re: Flora and Vegetation Survey and Wetland Assessment for Lots 1-4 Holmes St and Lot 1600 and pt Lot 1601 Balfour St, Southern River. Letter reference 2695 V3 issued 10th December, 2007, 5pp.

Department of Environment (2004) Perth Groundwater Atlas, Department of Environment, Second Edition, December 2004.

Department of Health Western Australia (2006) Mosquito Management Manual: a general reference on mosquito management and the official manual for the mosquito management course held in Mandurah 25 - 29 September 2006. Perth, Western Australia: Department of Health Western Australia, September 2006.

Department of Parks and Wildlife (DPaW) (2014) Geomorphic Wetlands of the Swan Coastal Plain Dataset. Accessed online at <https://www2.landgate.wa.gov.au/bmvf/app/waatlas/> October 2014.

Department of Water (2009) Decision Process for Stormwater Management in Western Australia, a component of Chapter 4: Integrating stormwater management approaches, *Stormwater management manual for Western Australia*, Perth.

Dieback Working Group (2000) Managing Phytophthora Dieback: Guidelines for Local Government, Dieback Working Group, Perth WA.

Dynamic Planning and Development (2016) Proposed Local Structure Plan - Lots 2, 23 & 24 Holmes Street & Lots 1, 1600 & 1601 Balfour Street, Southern River, Perth WA.

English, V., and Blyth, J. (1997) *Identifying and conserving threatened ecological communities (TECs) in the South West Botanical Province*. ANCA National Reserves System Cooperative Program: Project Number N702, Australian National Conservation Agency, Canberra.

Environmental Protection Authority, (2008). *Environmental Guidance for Planning and Development* - Guidance Statement No. 33. Environmental Protection Authority, Perth.

Environmental Protection Authority (EPA) (2004) Guidance No. 56: *Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia* Environmental Protection Authority, Perth.

Environmental Protection Authority (2000) Guidance Statement No. 40: *Management of Mosquitoes by Land Developers*. June 2000.

Geological Survey of Western Australia (1986) 1:50,000 Environmental Geology Series, Gosnells, part Sheets 2033 (I) & 2133 (IV).

Gibson, N., Keighery, B.J., Keighery, G.J., Burbidge, A.H., and Lyons, M.N. (1994) *A Floristic Survey of the Southern Swan Coastal Plain*. Unpublished report for the

Australian Heritage Commission prepared by the Department of Conservation and Land Management and the Conservation Council of Western Australia (Inc).

Government of Western Australia, 2000. Bush Forever- Keeping the Bush in the City, Volumes 1 and 2. Department of Environmental Protection, Perth Western Australia.

Heddl, E.M., Loneragan, O.W. and Havell, J.J., (1980). Vegetation of the Darling System. IN: Atlas of Natural Resources, Darling System, Western Australia, Department of Conservation and Environment, Perth, Western Australia.

JDA (2009) Lots 1,2,3,4 and 1600 Holmes St, Southern River; Lots 1742 and 1743 Holmes St and Balfour St, Southern river; Predevelopment Monitoring, Unpublished Report.

McArthur, W.M., and Bettenay, E. (1960) *The development and distribution of soils on the Swan Coastal Plain, Western Australia*. CSIRO Soil Publication No 16.

McKenzie, N.L., May, J.E. and McKenna, S., (2003). Bioregional Summary of the 2002 Biodiversity Audit for Western Australia, Department of Conservation and Land Management, Perth.

Parsons Brinckerhoff, (2007). Groundwater Investigation: Lots 1, 2 1742 and 1743 Holmes and Balfour Street, Southern River, WA. Report prepared for Prestige Developments Pty Ltd, 2007.

Swan River Trust (2004) Growing a Better Lawn and Garden in an Area Containing Eastern Coastal Plain Soils, Fertilise Wise, Perth WA.

Western Australian Planning Commission, (2014). Metropolitan Regional Scheme Map 20. Map current as at 26 September 2014. Accessed on the web at <http://www.planning.wa.gov.au/5246.asp> on 14 October 2014.

WAPC, 2003. Acid Sulfate Soils. Planning Bulletin No 64. Western Australian Planning Commission. ISSN 1324-9142, November 2003

Waters and Rivers Commission, (2002). Urban Water Management Strategy Volumes 1 and 2 for the Southern River/Forrestdale/Brookdale/Wungong Structure Plan. Waters and Rivers Commission, Perth.

Waters and Rivers Commission, (2001). Position Statement: Wetlands, Water and Rivers Commission, 6th June 2001.

Appendix A

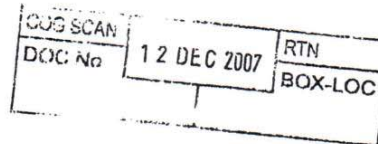
DEC letter to City of Gosnells
10th December 2007



Department of
Environment and Conservation

Your ref: V7030
Our ref: 2695 V3
Enquiries: Melissa Rogers
Phone: 9219 8710
Fax:
Email:

Wayne van Lieven
City of Gosnells
PO Box 662
GOSNELLS WA 6990



Dear Wayne,

RE: FLORA AND VEGETATION SURVEY AND WETLAND ASSESSMENT FOR LOTS 1 - 4 HOLMES ST AND LOT 1600 AND PT LOT 1601 BALFOUR ST, SOUTHERN RIVER.

The following report was received by the Department of Environment and Conservation's (DEC's) Wetlands Program on 15 October 2007:

- *Flora and Vegetation Survey and Wetland Assessment for Lot 1-4 Holmes St, Lot 1600 and 1601 Balfour St, Southern River (Cardno BSD August 2007) (herein 'plan').*

As requested by the City of Gosnells, DEC's Wetlands Program has reviewed the plan prepared as a requirement of Condition 4 of City of Gosnells Development Application DA07/02506.

Condition 4:

A wetland management plan is to be prepared and implemented to the satisfaction of the Western Australian Planning Commission prior to the commencement of any site works in order to protect the wetland from detrimental impacts and conserve it and its dependent vegetation.

Comments

1. The plan does not meet DEC's requirements for a wetland management plan. Chapter B4 Wetlands and in particular, Attachment B4-5 of the Environmental Protection Authority (EPA) (draft) Guidance Statement No. 33 *Environmental Guidance for Planning and Development* (EPA 2005) (herein 'Guidance Statement No. 33') provides detailed guidance regarding the information and format required in wetland management plans.
2. It appears that the plan contains information pertaining to DA Conditions 3 and 4 which has resulted in an ambiguous document which does not emphasis wetland management requirements. The document should be revised to clearly address the requirements of condition 4. The determination of the area to be protected and managed should be undertaken separate and prior to the preparation of the wetland management plan for the protected area.
3. Wetlands assigned a Conservation management category support important values, attributes and functions and are recognised by the EPA as of high conservation

DIRECTOR GENERAL AND ENVIRONMENTAL SERVICES DIVISIONS: The Atrium, 168 St Georges Terrace, Perth, Western Australia
Phone: (08) 6364 6500 Fax: (08) 6364 6520 TTY: 1880 555 630

PARKS AND CONSERVATION SERVICES DIVISIONS: Executive: Corner of Australia II Drive and Hackett Drive, Crawley, Western Australia
Phone: (08) 9442 0300 Fax: (08) 9386 1578 Operations: 17 Dick Perry Avenue, Technology Park, Kensington, Western Australia
Phone: (08) 9334 0333 Fax: (08) 9334 0498 Teletype: (08) 9334 0546

POSTAL ADDRESS FOR ALL DIVISIONS: Locked Bag 104, Bentley Delivery Centre, Western Australia 6983
www.dec.wa.gov.au

DataWorks Document Number: 1637985

significance. Proposals likely to have an impact on a wetland of high conservation significance are required to be referred to the EPA for formal assessment.

4. Wetlands that are to be conserved require a buffer between them and any proposed development, to protect them from potential adverse impacts and, maintain ecological processes and functions within the wetland. The width of the buffer should be determined based on the values of the wetland to be protected and the threats posed by the adjacent land use, 50m being the minimum buffer distance applied. The plan has insufficiently addressed the importance of wetland buffers and has not justified that the proposed 25m wetland buffer distance will maintain if not improve the values of the wetland. DEC does not support the proposed 25m wetland buffer distance.
5. A site specific wetland buffer study should be conducted for the wetland within the proposal in accordance with the information outlined in Chapter B4 of Guidance Statement No. 33 (EPA 2005). The draft *Guideline for the Determination of Wetland Buffer Requirements* (Essential Environment Services 2005) also provides guidance on determining wetland buffers however, its methodology has not been endorsed.
6. The plan includes a proposed subdivision plan. As the proposed subdivision layout has not been approved, it is not considered relevant to the plan.
7. The plan states that a portion of Resource Enhancement wetland UFI 13986 supports vegetation in Excellent condition and should be assessed for reclassification (sic) to a Conservation management category. Modifications to wetland management categories should be conducted in accordance with the *Protocol for proposing modification to the Geomorphic Wetlands Swan Coastal Plain dataset* (DEC 2007). Requests should be submitted to DEC Wetlands Program prior to any development or subdivision proposals.
8. Wetland UFI 13986 should be managed and protected in accordance with its described values, including the provision of an appropriate buffer.
9. The site contains two portions of wetlands not acknowledged in the plan. Conservation management category wetland UFI 14141 located on pt Lot 1601 and Multiple Use management category wetland UFI 13501 located on Lot 1600 and pt Lot 1601 should be acknowledged in the plan with adequate management strategies proposed.
10. The plan currently lacks fundamental information relevant to its management commitments including management objectives, specific timings and priorities for individual strategies and actions, a management authority responsible for implementation and performance criteria (see Attachment B4-5 of Guidance Statement No. 33 (EPA 2005)).
11. It is recommended that the overall management goal for the wetlands within the site be revised to 'retain and enhance the environmental values of the wetland and bushland areas during earthworks on site'.
12. The following comments refer to the proposed management actions:
 - MA1 – DEC supports this management action and suggests that government authorities involved in the maintenance of the management area and its surrounds should be provided a copy of the plan. It is also recommended that monitoring be undertaken to ensure the plan's strategies are implemented by land managers, contractors and volunteers.
 - MA2 – Refer to comment 13.
 - MA3 – Specific information on where and how the surface drainage water will be channelled and proposed techniques to minimise erosion should be outlined.

MA4 – Information on the location of the firebreaks and proposed access routes should be included. In addition, clarification is required as to whether additional firebreaks will be created in the management area for the construction and development phases.

MA5 – Repeat of MA3.

13. The plan has been prepared for the earthworks phase only and once complete it is proposed to be reviewed to cover the period of construction and development. Additional information including term of the plan, timelines on when earthworks and reviewing will occur and the responsible managing authority ensuring implementation and review should be outlined.

14. It is noted that throughout the plan the terms 'the site' and 'the reserve' are used interchangeably. The plan should use terminology consistent with the purposes of the plan, it is recommended the term 'management area' be adopted for proposal area.

15. The vegetation and flora survey of the site was undertaken in April 2007. EPA *Guidance Statement No. 51* (EPA 2004) states that the primary flora and vegetation survey should be conducted following the season which normally contributes to the most rainfall, in this case Spring. The April survey is therefore inadequate and it is advised that an additional Spring survey be conducted to accurately identify all species within the management area. This will also ensure that appropriate strategies to protect and management the wetland vegetation are determined. An adequate vegetation and flora survey should be undertaken before DA Condition No. 4 is approved.

16. The plan states that a Level 1 Field Survey was undertaken in accordance with EPA *Guidance Statement No. 51* (EPA 2004). A Level 1 Field Survey does not allow for the detailed collection of site specific flora and vegetation information which can be used to propose strategies and priorities for management. According to Appendix 2 of *Guidance Statement No. 51* (EPA 2004), a Level 2 Field Survey should be the minimum level survey undertaken due to its location within the South-West Botanical Province and the moderate to high impact of the proposal on the environment.

17. The plan states that Lots 3 and 4 Holmes St were not directly accessible at the time of the survey and observations were made from the boundary of neighbouring lots. A wetland management plan should be specific and describe the values of the whole management area. A site specific survey of Lots 3 and 4 Holmes St should be undertaken and the results incorporated into the plan.

18. The management of weeds is inadequately addressed in the plan. Additional strategies should be implemented which will identify the main areas and occurrences of weed species and propose adequate removal techniques and monitoring within the management area.

19. Figure 3 should be revised to include:

- Management area of the plan
- Wetland classification
- Wetland UFI's
- Relevant distances
- Correct labels (e.g. 'Conservation management category wetland' not 'Conservation Category Wetland Vegetation (Mapped)') and references of data.

20. The plan states that the Semeniuk (1987) classification system allocates individual wetlands with shared characteristics into wetland suites. It is advised that Semeniuk 1987 does not allocate wetlands into suites but into wetland classifications (wetland types), Semeniuk (1988) describes and allocates wetlands into consanguineous suites. The plan is required to use the correct wetland terminology and references when describing wetlands on the Swan Coastal Plain.
21. The plan provides regional information on the Swan Coastal Plain's landforms, soils and vegetation however, it does not provide sufficient information specific to the management area and its surrounds. Additional specific information including figures and information on geology, geomorphology and topography should be included (see Attachment B4-5 of Guidance Statement No. 33 (EPA 2005)).
22. All proposed stormwater management systems should be designed in accordance with the objectives, principles and delivery approach outlined in the *Stormwater Management Manual for Western Australia* (Department of Water 2004 – 2007) and the *Decision Process for Stormwater Management in WA* (Department of Environment and Swan River Trust 2005).
23. DEC's *Geomorphic Wetlands Swan Coastal Plain* dataset should be correctly referenced.
24. Correct and consistent wetland spelling, terminology, definitions and management objectives should be used in the plan for example for the terms 'wetland classification/classified', 'plant community/vegetation community' and 'weed/exotic/introduced'. Refer to Guidance Statement No. 33 Chapter B4 for a detailed explanation of these terms.
25. All documents referred to in the text should be listed in the reference page for example, Government of Western Australia (1998).
26. It is recommended that 'Wetland Management Plan' be incorporated into the title of the document.

Please undertake additional investigations and amend the plan to address the above points. Please contact Melissa Rogers on 9219 8710 if you require further information of any of the issues raised.

Yours sincerely



Natalie Thorning
Wetlands Program Coordinator

10 December 2007

Cc: Shane Chalwell, Cardno BSD
Jacqui Maguire, Department of Environment and Conservation, Swan Region

References

Environmental Protection Authority 2004, *EPA Guidance Statement No. 51 Terrestrial Flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia*, Environmental Protection Authority, Perth.

Environmental Protection Authority 2005, *Environmental Guidance for Planning and Development*, Draft Guidance Statement No. 33, Environmental Protection Authority, Perth.

Essential Environmental Services 2004, *A Land Use Planning Guide for the Determination of Wetland Buffer Requirements*, Department for Planning and Infrastructure, Perth.

Government of Western Australia 2000, *Bush Forever Volume 2: Directory of Bush Forever Sites*, Department of Environmental Protection, Perth.

Semeniuk CA 1987, Wetlands of the Darling System – a geomorphic approach to habitat classification, *Journal of the Royal Society of Western Australia* 69: 95-111.

Semeniuk CA 1988, Consanguineous wetlands and their distribution in the Darling System, Southwestern Australia, *Journal of the Royal Society of Western Australia* 70 (3): 69-87.

Appendix B

Proposed Local Structure Plan
(DP&D, July 2016)



**PROPOSED LOCAL
STRUCTURE PLAN**
LOTS 2, 23 & 24 HOLMES STREET &
LOT 1, 1600 & 1601 BALFOUR STREET
SOUTHERN RIVER

COPYRIGHT RESERVED BASE PLAN COURTESY OF LANDGATE



SCALE: 1:2500 @ A3

DATE: 7th JULY 2016

FILE: 359_07.07.2016.dwg

DRAW: -SB

CHECKED: -



**DYNAMIC PLANNING
AND DEVELOPMENTS**

DISCLAIMER: This document is and remains the property of Dynamic Planning and Developments and may not be copied in whole or in part without the written consent of Dynamic Planning and Developments. All areas, distances and angles are approximate only and are subject to survey.

e: admin@dynamicplanning.net.au
t: (08) 9271 1700
f: (08) 9271 1744
m: 0432 121 6559
PO Box 688
INGLEWOOD WA 6952
UNIT 2C, 903 BALFOUR STREET
INGLEWOOD WA 6952
ABN: 59 169 441 705



Appendix C

Letter from the Office of the
Environmental Protection Authority
to Department of Planning 30th
January 2014



Mr Craig Shepherd
Planning Manager
Department of Planning
Locked Bag 2506
PERTH WA 6001

Your Ref: dp/1200253/1
Our Ref: CR 17-2013-0014
Enquiries: Liesl Rohl 6145 0858
Email: Liesl.rohl@epa.wa.gov.au

Dear Mr Shepherd

**PROPOSED OUTLINE DEVELOPMENT PLAN PRECINCT SOUTHERN RIVER -
Holmes & Balfour Streets, Southern River (dated 20 May 2013 - attachment 1).**

I refer to your letter dated 19 July 2013 and my letter of 7 October 2013 regarding the above mentioned Outline Development Plan (ODP).

The Office of the Environmental Protection Authority (OEPA) has reviewed the ODP and has been working with the Department of Parks and Wildlife and the landowner in regard to the reduced wetland buffer to the Conservation Category Wetland (CCW) for the Outline Development plan (ODP).

Given the history of the site, including the urban zoning and despite the recent reclassification of the wetland to a CCW the OEPA has no objection to the reduced buffer subject to:

- A BAL-29 rating for the lots opposite the native vegetation with a 21m Building Protection Zone (BPZ), a 20m road reserve plus house setback (normally 4-6m), which achieves the required BPZ as detailed in "Bush Fire Setback Plan" (attachment 2).
- Part of Lot 2, which contains the conservation category wetland to the south east, which is to be reserved as Public Open Space (POS) not be subject to any clearing or other POS activities that may have detrimental impacts on wetland and bushland values.
- POS within the northern corner of the Bush forever site (crossed hatched in red in the attachment 3) be excluded from POS as it has been acquired by the WAPC.

- POS within Lot 1600, which contains wetland vegetation, be protected as a reserve with no clearing of vegetation for recreation purposes.

Please contact Liesl Rohl on 6145 0858 if you require further assistance.

Yours sincerely



Darren Foster
A/General Manager

30 January 2014

Att:

Attachment 1 - Outline

Development Plan (ODP) for the land on Holmes & Balfour Streets, Southern River (dated 20 May 2013).

Attachment 2 - Bush Fire Setback Plan

Attachment 3 - Development Plan Balfour/Holmes Road, Southern River

cc: Tina Bazzo, PO Box 6913, East Perth WA 6892
Aminya Ennis, DPaW



DEVELOPMENT PLAN BALFOUR/HOLMES ROAD, SOUTHERN RIVER

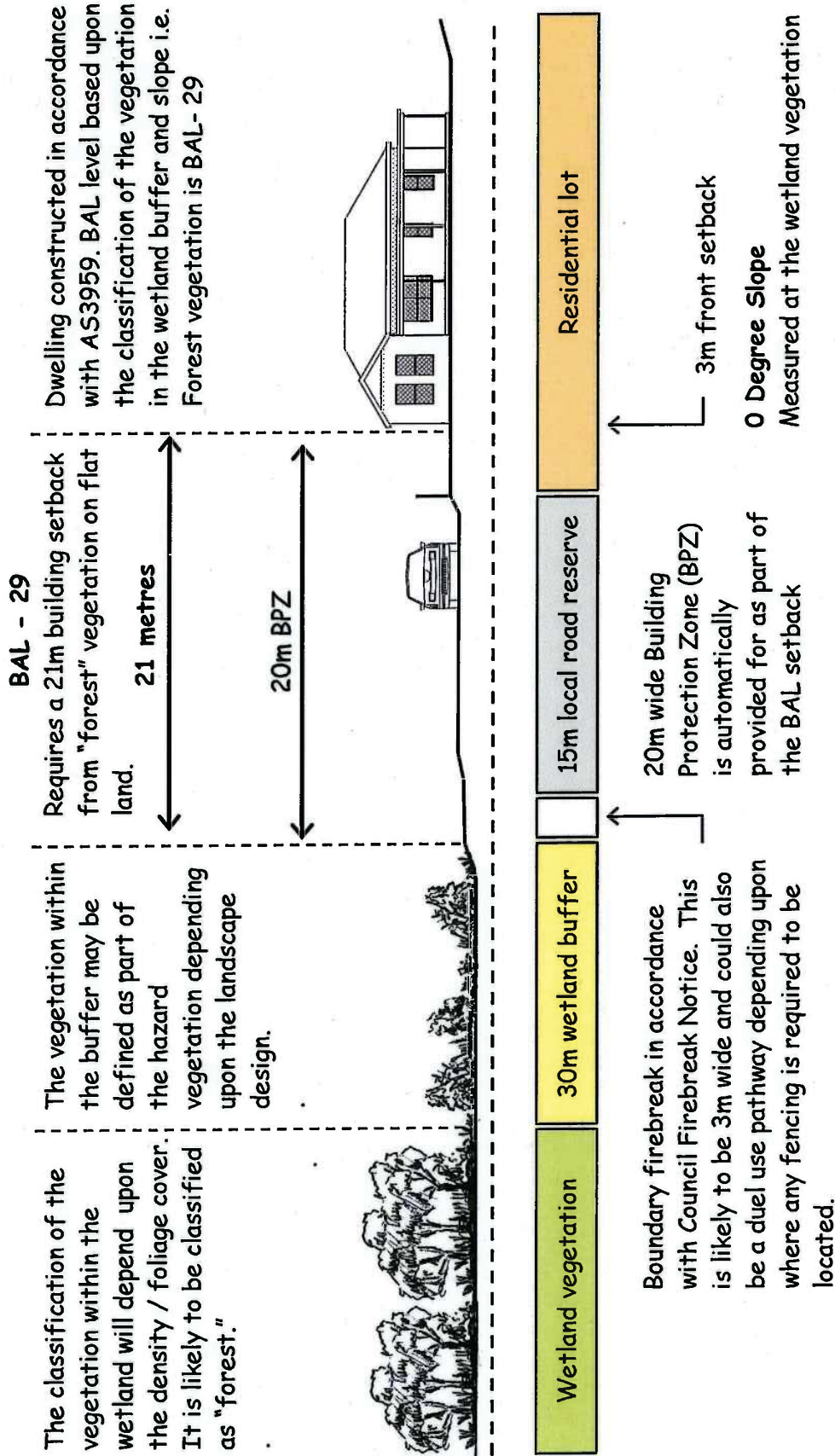


1:1000 @ A1 & 1:7000 @ A3 ALL DISTANCES ARE IN METRES			
REVISION	DESCRIPTION	DRAFTER	DATE
J			
I			
H			
G			
F			
E			
D			
C			
B			
A	LOT LAYOUT UPDATED	TMB	10/05/2013

COPYRIGHT THIS DOCUMENT IS AND SHALL REMAIN THE PROPERTY OF THE TOWN PLANNING MANAGEMENT ENGINEERING PTY LTD. THE CONSULTANT MAY ONLY BE USED FOR THE PURPOSES FOR WHICH IT WAS COMMISSIONED AND IN ACCORDANCE WITH THE TERMS OF ENGAGEMENT FOR THE CONSULTANT. UNLAWFUL USE OF THIS DOCUMENT IN ANY FORM WILL BE PROSECUTED.	
ORIGINAL PLANNER:	SW
ORIGINAL DRAFTER:	TMB
CREATED DATE:	20/05/2013
AERIAL DATA:	N/A
CADASTRAL DATA:	N/A
TOPOGRAPHIC DATA:	N/A



10038P-MP-01



BAL 29	BAL 19	BAL 12.5
21 - < 31m	31 - < 42m	42 - < 100m

BAL setbacks for "forest" vegetation on flat land.

Bush Fire Attack Level Setbacks from Wetland

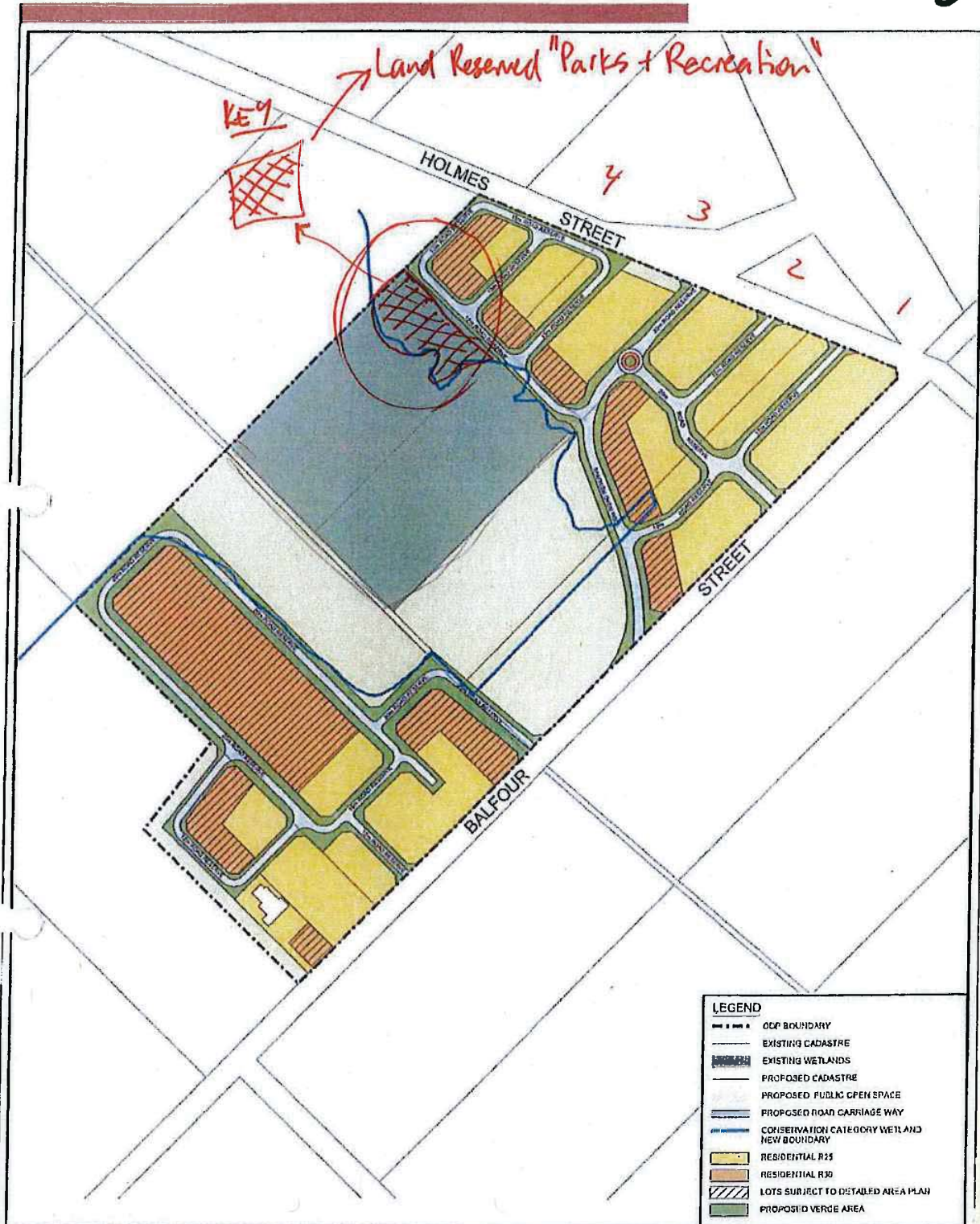


THIS DOCUMENT AND ALL INFORMATION CONTAINED HEREIN ARE THE PROPERTY OF TME (THE TOWN PLANNING MANAGEMENT ENGINEERING PTY LTD). THE DOCUMENT MAY ONLY BE USED FOR THE PROJECT AND SITE SPECIFICALLY COMMISSIONED AND IN ACCORDANCE WITH THE TERMS OF ENGAGEMENT FOR THE COMMISSION. ANY REUSE OR REPRODUCTION OF THE DOCUMENT IN ANY FORM IS PROHIBITED.

REVISION	DESCRIPTION	AUTHOR	DATE
A			
B			
C			
D			
E			
F			

THIS PLAN HAS BEEN PREPARED FOR PLANNING PURPOSES. AREAS, COORDINATES AND DIMENSIONS SHOWN ARE SUBJECT TO SURVEY.

REF NO 11035



**DEVELOPMENT PLAN
BALFOUR/HOLMES ROAD,
SOUTHERN RIVER**



REVISION	DESCRIPTION	DATE
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		
21		
22		
23		
24		
25		
26		
27		
28		
29		
30		
31		
32		
33		
34		
35		
36		
37		
38		
39		
40		
41		
42		
43		
44		
45		
46		
47		
48		
49		
50		
51		
52		
53		
54		
55		
56		
57		
58		
59		
60		
61		
62		
63		
64		
65		
66		
67		
68		
69		
70		
71		
72		
73		
74		
75		
76		
77		
78		
79		
80		
81		
82		
83		
84		
85		
86		
87		
88		
89		
90		
91		
92		
93		
94		
95		
96		
97		
98		
99		
100		

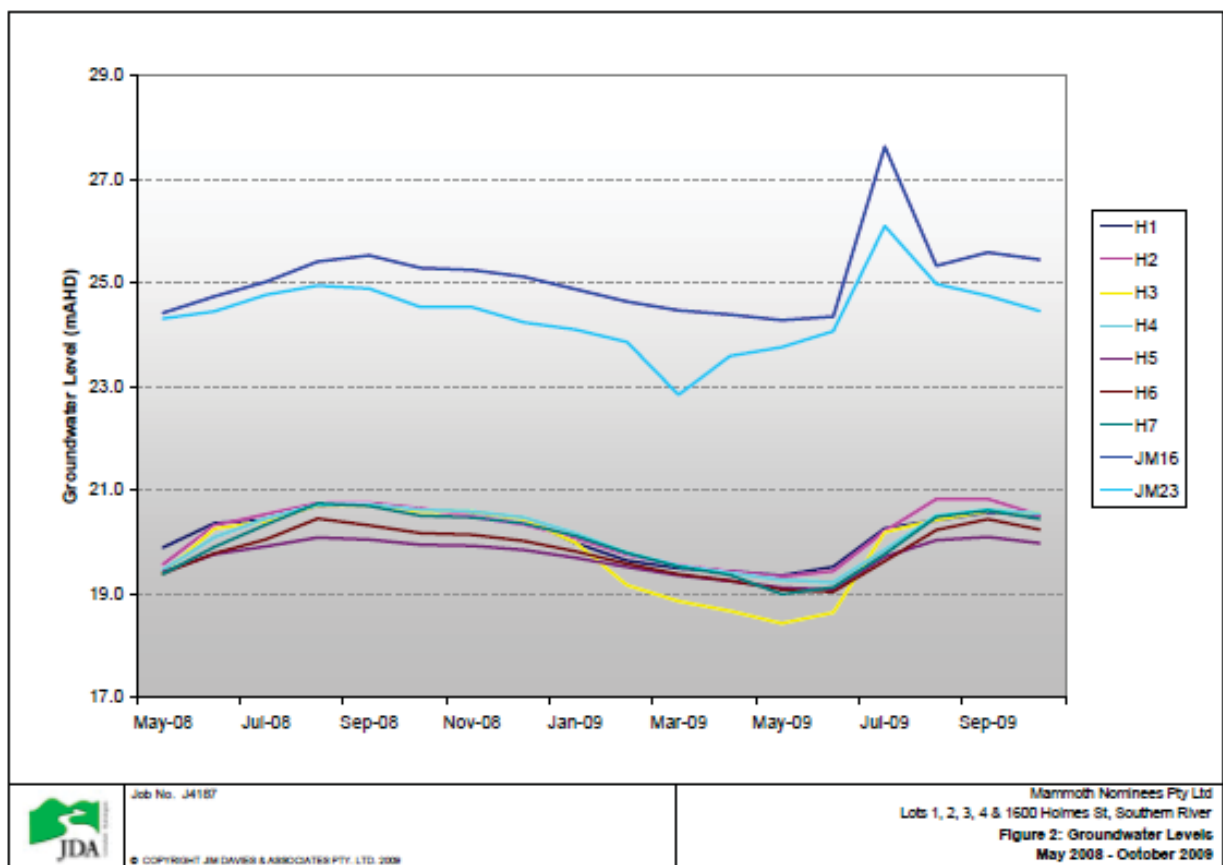
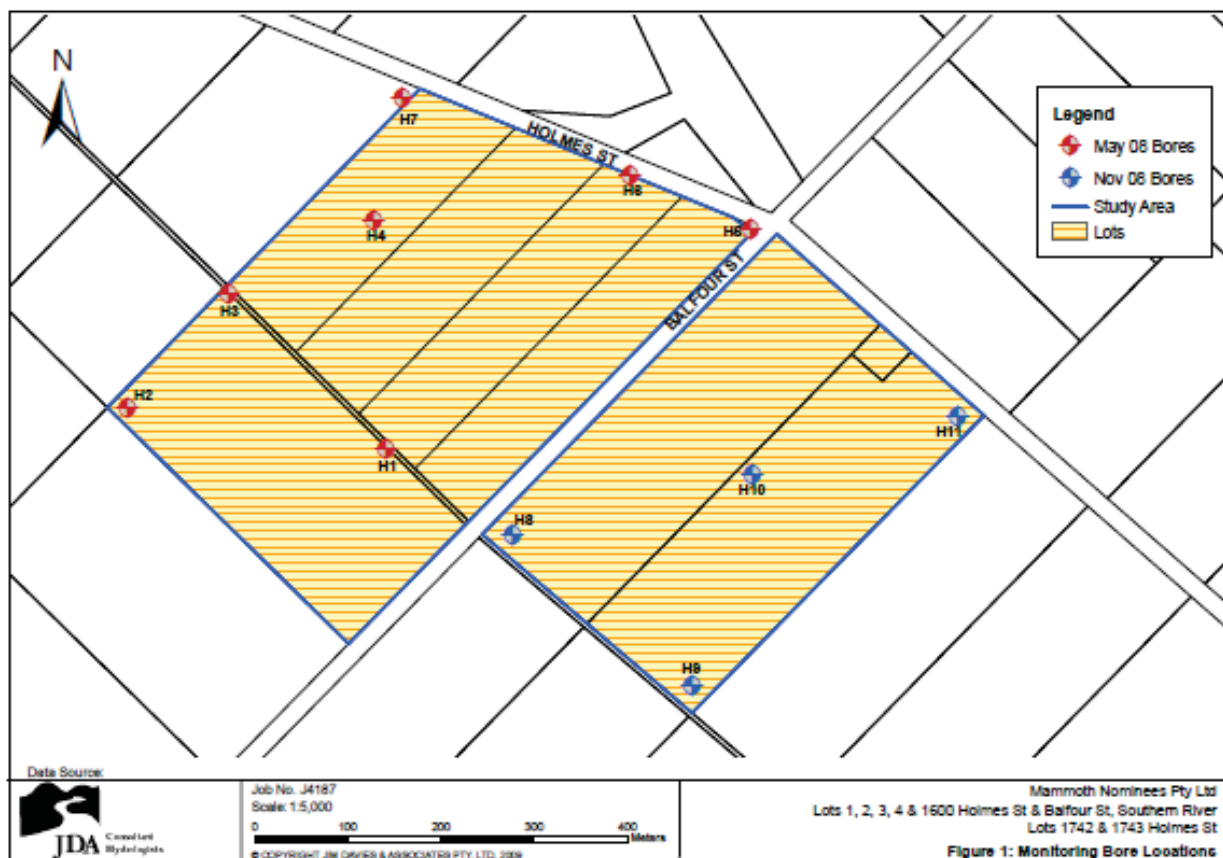
DESIGNED BY	DATE
DRAWN BY	DATE
CHECKED BY	DATE
APPROVED BY	DATE
DATE	

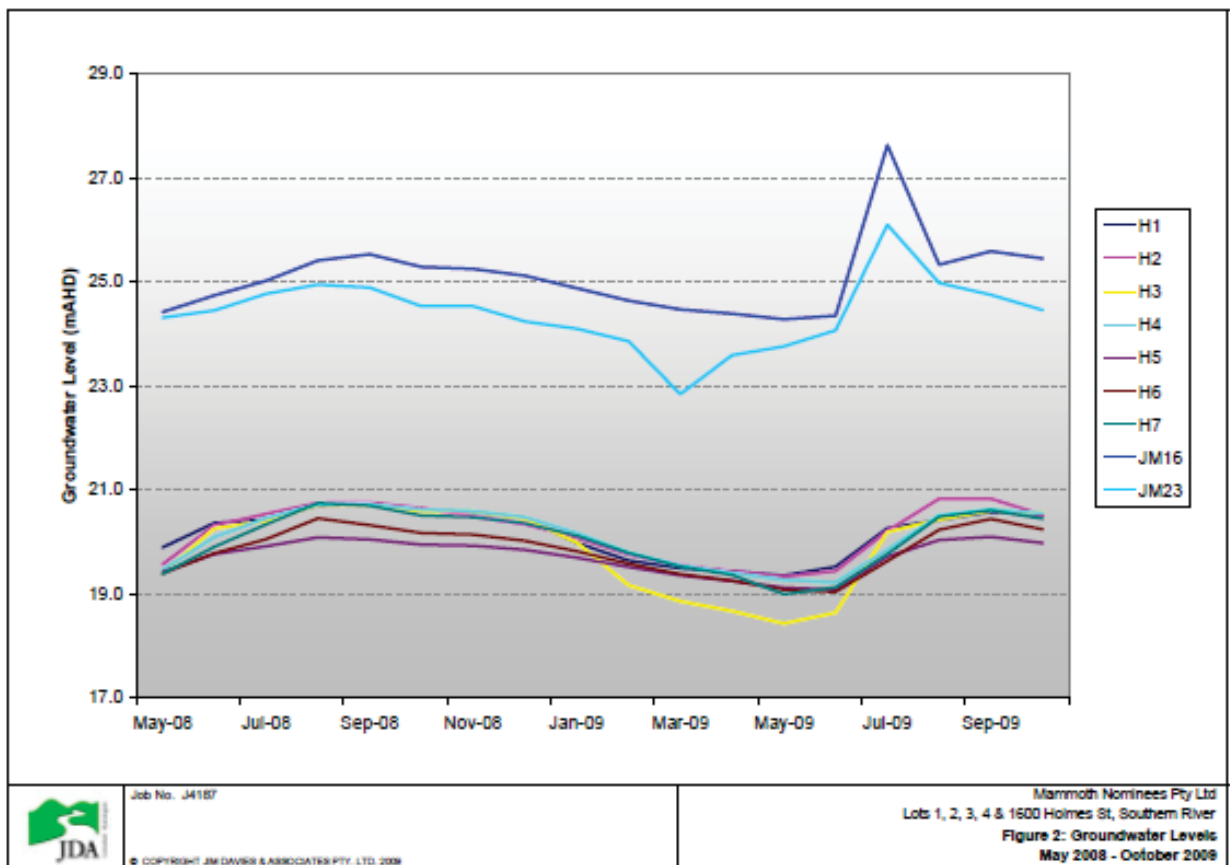
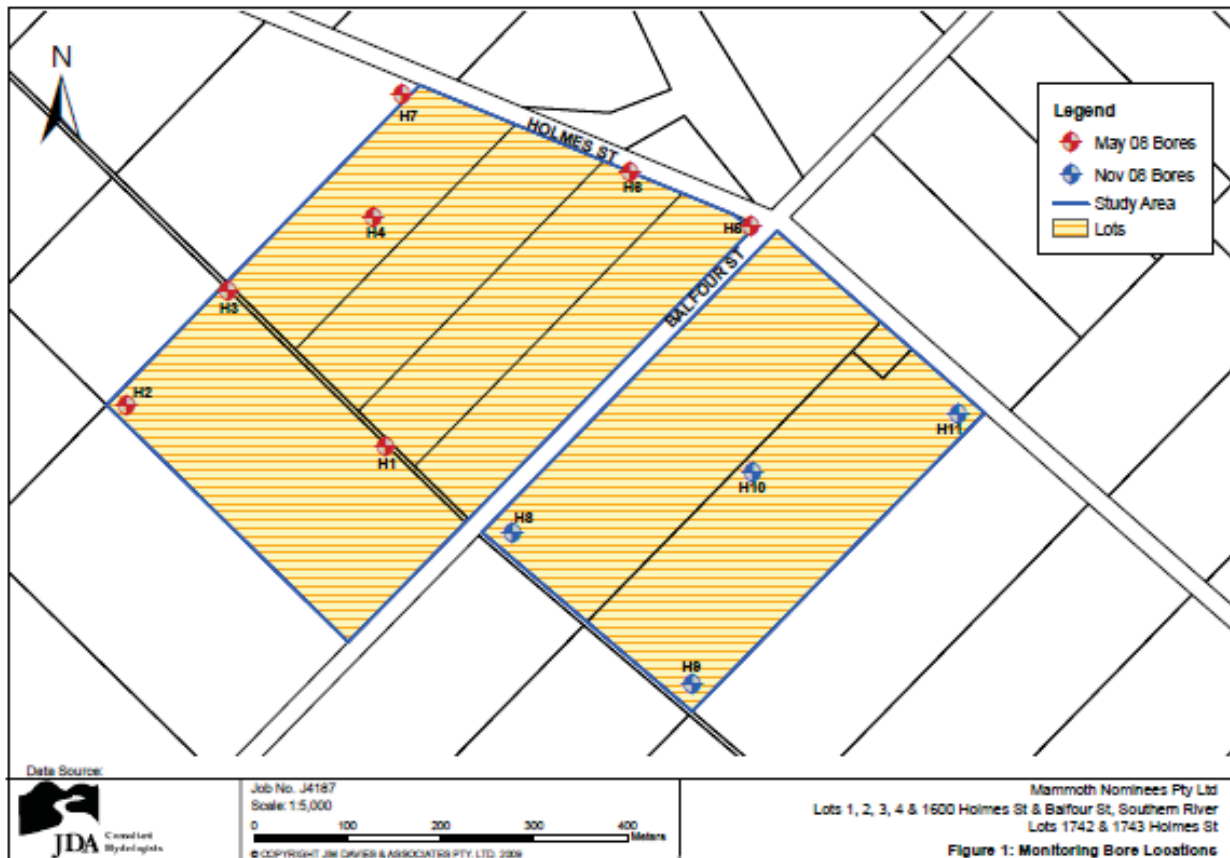


10038P-MP-01

Appendix D

2008 and 2009 Pre-development
groundwater monitoring bore
locations and recorded levels (JDA,
unpublished)





Appendix E

Fauna and Faunal Assemblages
Study

FAUNA AND FAUNAL ASSEMBLAGE STUDY

LOTS 1-4 HOLMES ST, LOT 1600 AND PART LOT 1601 BALFOUR ST SOUTHERN RIVER

Prepared for

Mammoth Nominees Pty Ltd

by Endemic

January 2013



*Endemic Pty Ltd
130 Churchill Ave
Subiaco WA 6008*

*office: + 8 9381 7900
mobile: +0418 111 236
email: endemic@endemic.net.au
ABN: 73692395972*

DISCLAIMER

This document is published in accordance with and subject to an agreement between Endemic Pty Ltd (“**Endemic**”) and mammoth Nominees Pty Ltd (“**Client**”) for whom it has been prepared. Use of this report is restricted to those issues that have been raised by the client in its engagement of Endemic and prepared using the standard of skill and care ordinarily exercised by Environmental Scientists in the preparation of such Documents.

© **Endemic Pty Ltd (Endemic) [2013]**.

Copyright in the drawings, information and data recorded in this document (the information) is the property of Endemic. This document and the information are solely for the use of the authorised recipient and this document may not be used, copied or reproduced in whole or part for any purpose other than that for which it was supplied by Endemic. Endemic makes no representation, undertakes no duty and accepts no responsibility to any third party who may use or rely upon this document or the information.

Table of Contents

	Page Number
1. Introduction	3
1.1 Planning context	3
1.2 Methodology	3
2. Site description	5
2.1 Bush Forever Site 125 boundaries	6
2.2 Wetlands	7
2.3 Topography	8
2.4 Broad Scale Vegetation Classification	8
2.5 Vegetation Complexes	9
3. Fauna	12
3.1 Species of Conservation Significance	12
3.1 Fauna assemblages	15
4. Discussion	18
4.1 Recommendations	18
References	20

Table of Figures

Figure 1: Location of the Fauna Study Area	5
Figure 2: Study area zoning under the Metropolitan Region Scheme	6
Figure 3 Boundaries of Bush Forever Site 125 (Government of Western Australia, 2010).	7
Figure 4: DEC wetland categories and boundaries (2011)	8
Figure 5: Vegetation communities (after Cardno, 2007b)	10
Figure 6 Vegetation condition (after Cardno, 2007b)	11

Table of Tables

Table 1: Additional protected or priority species which may occur within the project area	13
---	----

1. Introduction

1.1 Planning context

Southern River is an outer suburb of Perth and is located within the City of Gosnells. In response to the Southern River/Forrestdale/Brookdale/Wungong District Structure Plan released by the Western Australian Planning Commission (WAPC) in January 2001, the City of Gosnells divided the Southern River area into four precincts. The study site for this Fauna Survey is located within a proposed development area in Precinct 2.

An Outline Development Plan (ODP) has been adopted for the area bounded by Lakey Street, Southern River Road, Ranford Road and Holmes Street, Southern River. Since the adoption of the original ODP by Council on 8 November 2005, the ODP has been revised a number of times, with the most recent revision being adopted by Council at its meeting of 11 August 2009, approved by the WAPC on 15 January 2010 and finally adopted by Council at its meeting of 9 March 2010.

Within Precinct 2, Prestige Project Management Pty Ltd, on behalf of Mammoth Nominees Pty Ltd is planning to develop a residential subdivision comprising Lots 1-4 Holmes St and Lot 1600 and part Lot 1601 Balfour St.

The current Metropolitan Region Scheme Map sheet 20 zoning for the site is urban, with approximately 19% reserved for Parks and Recreation (WAPC, 2011). The site has been zoned “residential development” under the Town Planning Scheme No.6 for the Southern River Precinct 2 Outline Development Plan (adopted 8 November, 2005).

Prestige Developments Pty Ltd submitted a Development Application for the site to the City of Gosnells, who referred the application to the WAPC for assessment. Arising from its assessment, the WAPC recommended conditions of approval of the Development Application (DA07/02505) including preparation and implementation of a Wetland Management Plan (Condition 4). This Fauna and Faunal Assemblage Survey has been prepared in support of a Wetland Management Plan and at the request of the Department of Environment and Conservation in September 2012.

1.2 Methodology

This Fauna and Faunal Assemblage Survey has been undertaken in accordance with EPA Guidance No. 56, Terrestrial Fauna Surveys for Environmental Impact Assessment in Western Australia (2004), at the intensity of a Level 1 Survey.

This involved undertaking a background study including review of available sources for literature, data and map-based information and a site inspection. A follow up site visit was undertaken on 26 November 2012 in order to verify the desktop study and assess potential impacts.

Key aims of the Fauna Assemblage and Faunal Study are to:

- Determine the likely presence of any fauna of conservation significance based on fauna assemblages;
- Identify any key faunal habitats; and
- Propose recommendations to minimise impacts on fauna.

2. Site description

The study area for this fauna study comprises Lots 1-4 Holmes St and Lot 1600 and part Lot 1601 Balfour St, within City of Gosnells' Southern River Precinct 2 of the Southern River/Forrestdale/Brookdale/Wungong District Structure Plan Area located at Southern River, Western Australia. Lot 33 Balfour Street, a drain owned by City of Gosnells, intersects the site and separates Lots 1, 2, 3 and 4 from Lot 1600.

The site is bounded by Lot 4 Holmes St and Lot 1600 Balfour to the northwest, Holmes Street to the northeast, Balfour Street to the southeast and a portion of Lot 1601 to the southwest (Figure 1).

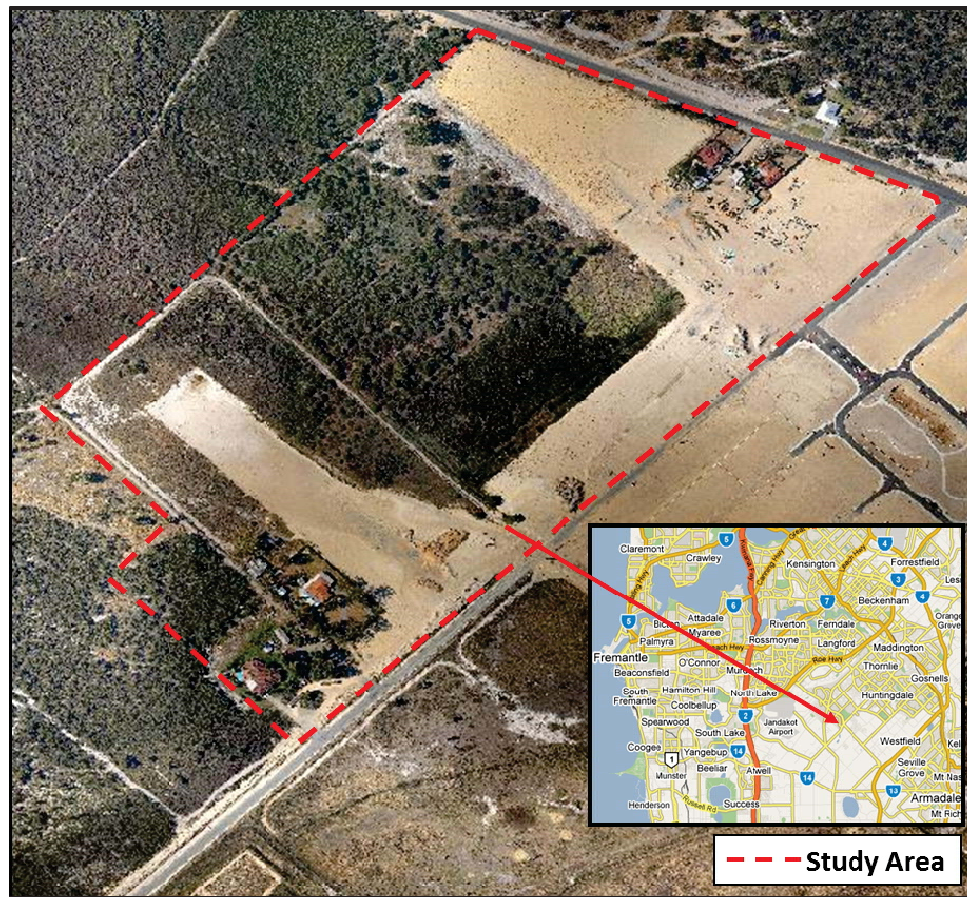


Figure 1: Location of the Fauna Study Area

The total area of Lots 1-4 Holmes St, Lot 1600 and Pt Lot 1601 Balfour St is 21.7 hectares. Historical and current landuses within the site include residences, inert landfill, agricultural landuses including a former poultry farm and areas of wetland habitat and dryland (remnant) vegetation.

Approximately 4.14 hectares of the area is occupied by Bush Forever site 125. This area is reserved for Parks and Recreation under the Metropolitan Region Scheme (Figure 2).

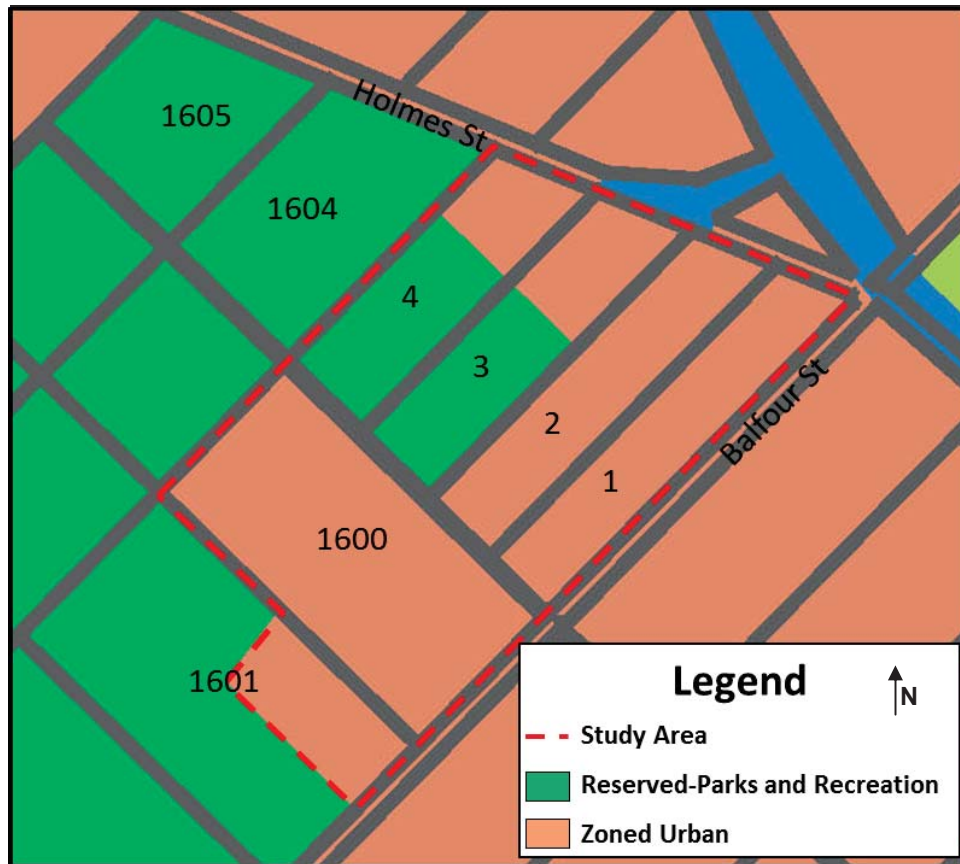


Figure 2: Study area zoning under the Metropolitan Region Scheme

2.1 Bush Forever Site 125 boundaries

The Bush Forever Strategy is a ten year strategic plan which formally commenced in 2000 to protect approximately 51,200 ha of regionally significant bushland within approximately 290 Bush Forever Sites, representing where achievable, a target of at least 10 percent of each of the original 26 vegetation complexes of the Swan Coastal Plain portion of the Perth Metropolitan Region (Government of Western Australia, 2000). Bush Forever represents an update of the earlier System Six study and recommendations in the Perth Metropolitan Region and is the final version of the draft Perth Bush Plan.

Bush Forever Site 125 is partially located within the study area, where it has been assessed to be in a Degraded to Completely Degraded condition (Cardno 2007b). The boundaries of Bush Forever Site 125 were determined following negotiations with landholders, when 5.2 Ha was removed from the originally proposed reserve (on Lots 1 and 2 Holmes St, and 1600 Balfour St). MRS amendment 1082/33 in 2010 saw the rezoning of some Bush Forever sites to Parks and Recreation Reserve, including parts of Bush Forever site 125. The boundaries of Bush Forever Site 125 are presented as Figure 3 (Government of Western Australia, 2010).



Figure 3 Boundaries of Bush Forever Site 125 (Government of Western Australia, 2010).

2.2 Wetlands

Much of the central portion of the management area is identified as wetland in the Department of Environment and Conservation (DEC) Geomorphic Wetlands of the Swan Coastal Plain database. Figure 4 below shows DEC wetland mapping as of November 2012. The wetland delineation and categorisation is discussed in further detail in a complementary Wetland Management Plan prepared in 2011 (Endemic, 2011).

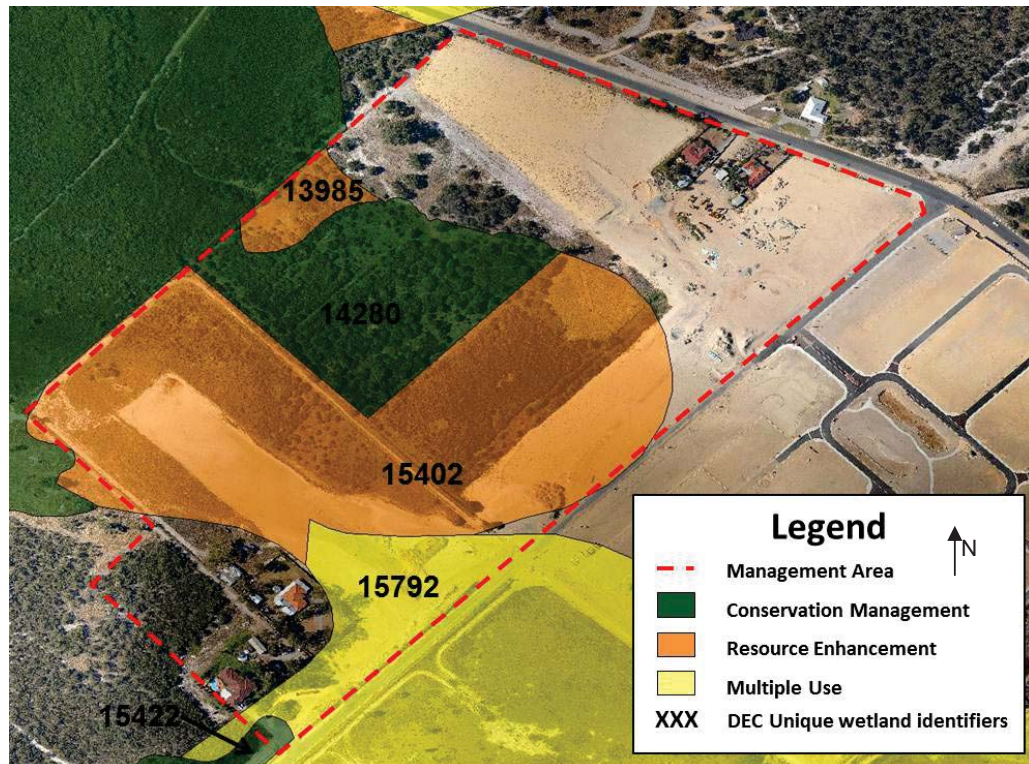


Figure 4: DEC wetland management categories and boundaries (as of November 2012)

The DEC mapping of UFI 14280 and 15422 as Conservation Category Wetlands designates these wetlands as an Environmentally Sensitive Area as declared under Environmental Protection (Environmentally Sensitive Areas) Notice 55 (2005) under section 51B of the Environmental Protection Act 1986.

As detailed in the Wetland Management Plan (Endemic, 2011), areas currently depicted as being wetland habitat in the DEC's Geomorphic Wetlands of the Swan Coastal Plain database (as of November 2012) are clearly not wetland habitat and include areas of fill, roads, etc. Endemic understands the DEC undertook field surveys of the site in September 2011 with a view to remapping this area.

2.3 Topography

The topography of the site and surrounding area is generally flat, sloping gently to the south with natural surface level ranging from 21.0 – 24.0 meters AHD. Superimposed on the northern (on the site) and southern (off the site) sections of this landform are dunal features typical of the Bassendean Sand formation.

2.4 Broad Scale Vegetation Classification

The project area is located in the Swan Coastal Plain bioregion (McKenzie et al., 2003). The Swan Coastal Plain is a low lying coastal plain, mainly covered with woodlands and is dominated by Banksia or Tuart on sandy soils, Casuarina on outwash plains and Melaleuca in swampy areas. The Swan Coastal Plain subregion is part of the South-West Botanical Province which has a very high

degree of species diversity. The site lies within the Drummond Botanical Subdistrict within the South West Botanical Province (Beard, 1990).

According to broad scale mapping, vegetation within the project area belongs to the Southern River Vegetation Complex and is described by Heddle *et al.* (1980) as follows:

- Southern River Vegetation Complex: Open woodland of Marri (*Corymbia calophylla*) - Jarrah (*Eucalyptus marginata*) - Banksia species with fringing woodland of Flooded Gum (*Eucalyptus rudis*) - Paperbark (*Melaleuca raphiophylla*) along creek beds. This vegetation complex has been extensively cleared and is now poorly represented in the conservation estate (10% or less of the original extent is protected) on the Swan Coastal Plain (Government of Western Australia, 2000).

Typical sequences of vegetation on the site would have comprised mainly *Banksia* low woodland on leached sand with *Melaleuca* swamps where ill-drained; woodland of Tuart, Jarrah and Marri on less leached soils.

2.5 Vegetation Complexes

A large portion of the site has been historically cleared and developed as an intensive poultry farm and some residential housing. Accordingly, the vegetation that remains in this area varies widely in both species composition and condition. Areas of remnant vegetation exist with varying degrees of vegetation quality from Completely Degraded to Excellent.

The vegetation complex types and conditions were surveyed during August and November 2007 (Level 1 vegetation survey: Cardno BSD 2007a&b), and have been used as the basis for the following figures. The full Spring Survey report (Cardno 2007b) is included in the appendices of the ODP. The vegetation communities reported in Cardno 2007b, have been updated by Endemic to reflect recent landuse changes within the management area.

The majority of native vegetation at the site generally occurs in and around the wetland areas in the centre of the site (Community S1), with a small area on the southern portion of Lot 1601 (Community S2).

Vegetation community S1 was inferred to be floristic community FCT11 'Wet forests and Woodlands'. The vegetation consists of thickets to shrubland of *Melaleuca raphiophylla* over *Melaleuca lateritia* and *Melaleuca teretifolia* over *Lepidosperma longitudinale* and *Juncus pallidus* on seasonally wet brown loamy sands. Parts of this community occur on all Lots. Vegetation community S1 is in variable condition, ranging from "Completely Degraded" to "Excellent" within the management area.

Vegetation community S2 was inferred to be floristic community FCT23a 'Central *Banksia attenuata*- *Banksia menziesii* woodlands'. This vegetation consists of thickets to shrublands of *Kunzea glabrescens* with *Banksia attenuata*, *Banksia menziesii* over *Macrozamia riedlei*, *Xanthorrhoea preissii* and *Adenanthos cygnorum* over *Dasypogon bromeliifolius* and *Desmocladius flexuosus* on brown loamy sands. Vegetation community S2 was classified as in "Very Good" condition on Lot 1601 as it retains its original structure and a high diversity of plants, but the ground layer of S2 is dominated by aggressive weeds such as *Ehrhata calycina*.

Historical aerial images from 2001 indicate that the canopy was more open in the past and that the vegetation is in a recovery phase. This is supported by the fact that the overstorey is dominated by a thicket of *Kunzea glabrescens* and open areas have been invaded by introduced grasses (Cardno 2007b).

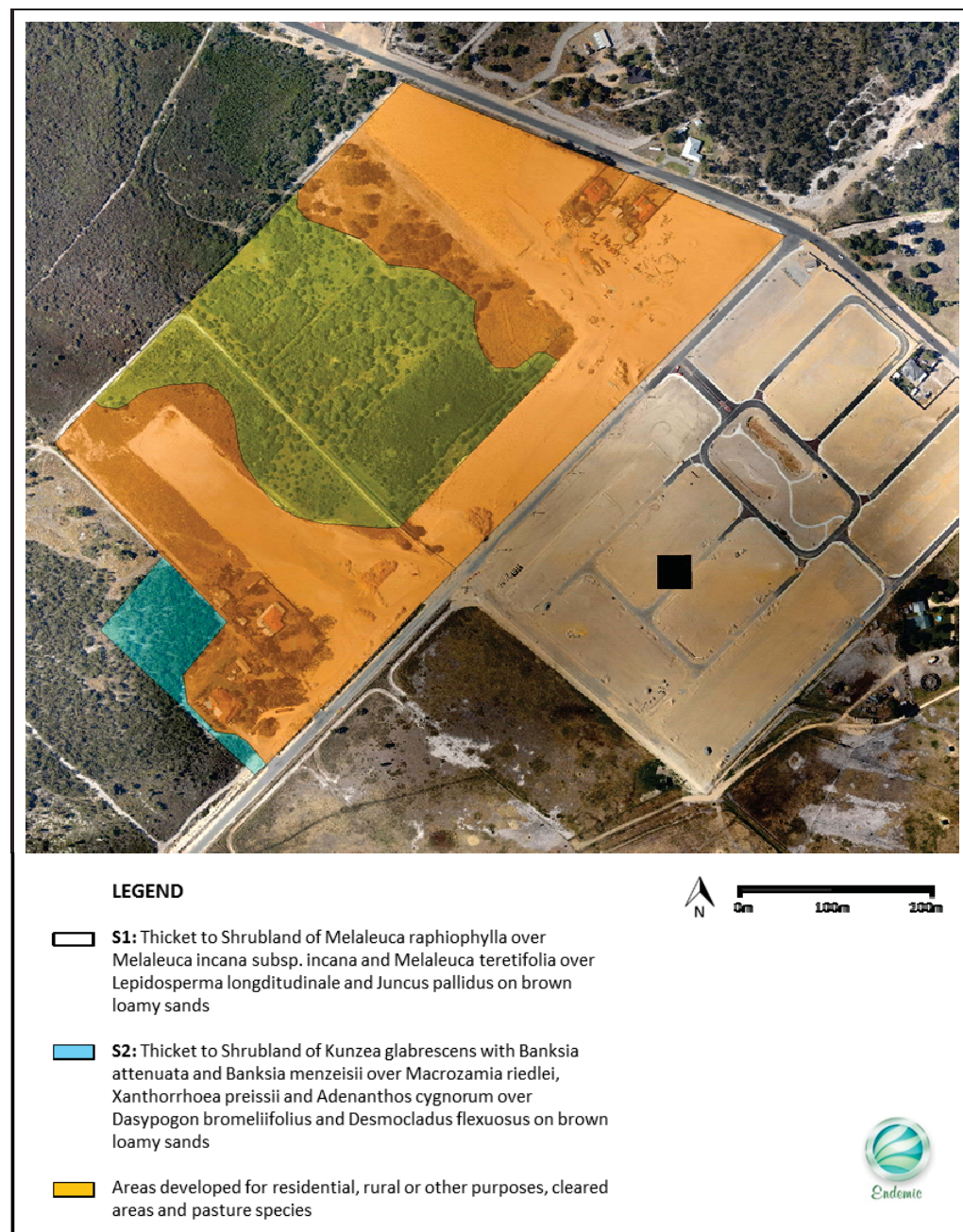


Figure 5: Vegetation communities (after Cardno, 2007b)

Outside of these vegetation communities, the remainder of the site has been extensively cleared for rural and residential purposes. Vegetation was classified as “Completely Degraded”. A number of *Melaleuca preissiana* were reported on Lot 1600 Balfour St in proximity of the residences and a site visit by Endemic staff also identified a number of *Agonis flexuosa* and one large introduced Eucalypt located on Lots 2 and 3 Holmes St abutting the wetland area immediately north of S1. Apart

from these occasional trees the remainder of this cleared area was reported to be comprised of pasture and weed species.

The basis for vegetation condition mapping in Figure 6 is provided in Cardno 2007b, and has been updated by Endemic to reflect recent landuse changes within the management area. Vegetation condition ratings were assigned according to the scale of Keighery (1994).

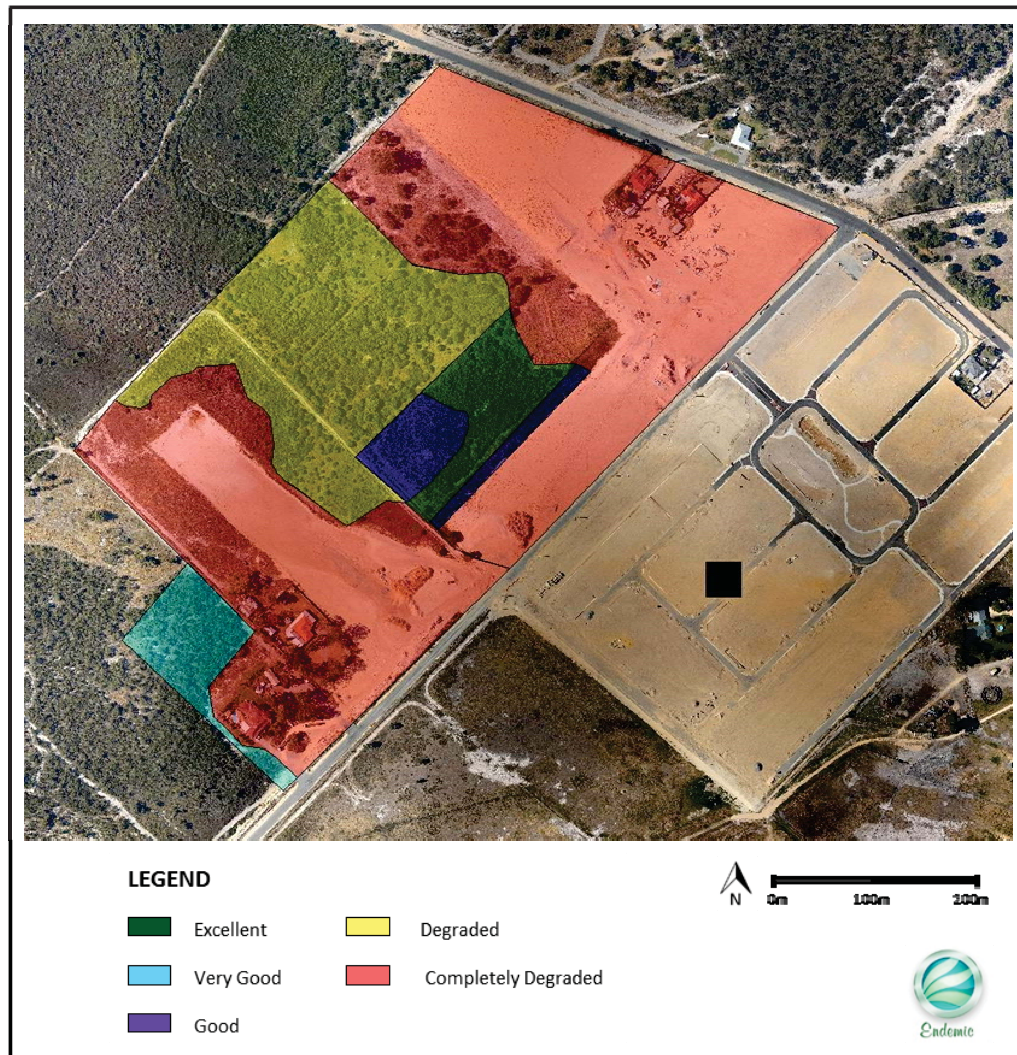


Figure 6 Vegetation condition (after Cardno, 2007b)

3. Fauna

3.1 Species of Conservation Significance

A desktop review of various literature and databases was undertaken in order to assess the potential for protected fauna to occur at the site.

A search was requested of the Department of Environment and Conservation's Threatened Fauna database for species recorded within a 3km radius of the site. This dataset includes species which are declared as '*Rare or likely to become extinct* (Schedule 1)', '*Birds protected under an international agreement* (Schedule 3)', and '*Other specially protected fauna* (Schedule 4)'. According to results of the search, the following threatened fauna species have been recorded within this range:

- Carnaby's Cockatoo (*Calyptorhynchus latirostris*): Rare or likely to become extinct
- Eastern Great Egret (*Ardea modesta*): Protected under an International Agreement
- Rainbow Bee Eater (*Merops ornatus*): Protected under an International Agreement
- Southern Brown Bandicoot (*Isodon obesulus subsp. Fusciventer*): (Priority 5)

Searches were also undertaken of the following on-line databases in order to capture additional species which may not have been recorded in close proximity to the site, but which nonetheless have the potential to occur at the site:

- Department of Environment and Conservation's Naturemap database; and
- Commonwealth's *Environmental Protection and Biodiversity Conservation Act* Protected Matters Search Tool.

Additional protected and priority species which may potentially occur within the project area are listed in Table 2.

Table 1: Additional protected or priority species which may occur within the project area

	COMMON NAME	SCIENTIFIC NAME	EPBC DATABASE COMMENT	EPBC LISTING
BIRDS	Australasian Bittern	<i>Botaurus poiciloptilus</i>	Species or species habitat known to occur within area	Endangered
	Baudin's Black-Cockatoo	<i>Calyptorhynchus baudinii</i>	Roosting known to occur within area	Vulnerable
	Forest Red-tailed Black-Cockatoo	<i>Calyptorhynchus banksii naso</i>	Species or species habitat may occur within area	Vulnerable
	Malleefowl	<i>Leipoa ocellata</i>	Species or species habitat may occur within area	Vulnerable
	Australian Painted Snipe	<i>Rostratula australis</i>	Species or species habitat may occur within area	Vulnerable
	Fairy Tern (Australian)	<i>Sternula nereis nereis</i>	Species or species habitat may occur within area	Vulnerable
	Masked Owl	<i>Tyto novaehollandiae subsp. novaehollandiae</i>		None, DEC Priority 3
	Barking Owl	<i>Ninox connivens subsp. connivens</i>		None, DEC Priority 2
INSECTS	Graceful Sun Moth	<i>Synemon gratiosa</i>	Species or species habitat may occur within area	Endangered
MAMMALS	Chuditch, Western Quoll	<i>Dasyurus geoffroii</i>	Species or species habitat likely to occur within area	Vulnerable
	Red-tailed Phascogale	<i>Phascogale calura</i>	Species or species habitat may occur within area	Endangered
	Quokka	<i>Setonix brachyurus</i>	Species or species habitat may occur within area	Vulnerable
	Woylie	<i>Bettongia penicillata ogilbyi</i>	Species or species habitat may occur within area	Endangered
	Western Brush Wallaby	<i>Macropus irma</i>		None DEC Priority 4
	Southern Brush-tailed Phascogale	<i>Phascogale tapaotafa subsp. tapaotafa</i>		None, Schedule 1 WA Wildlife Conservation Act
REPTILES	Southern Death Adder	<i>Acanthophis antarcticus</i>		None DEC P3
	Lined Skink	<i>Lerista lineata</i>		None, DEC P3
	Carpet Python	<i>Morelia spilota</i>		None, Schedule 4 WA Wildlife Conservation Act
MIGRATORY	Fork-tailed Swift	<i>Apus pacificus</i>	Species or species habitat likely to occur within area	International Agreement
	White-bellied Sea-Eagle	<i>Haliaeetus leucogaster</i>	Species or species habitat likely to occur within area	International Agreement
	Great Egret,	<i>Ardea alba</i>	Species or species habitat	International

	White Egret		may occur within area	Agreement
	Cattle Egret	<i>Ardea ibis</i>	Species or species habitat may occur within area	International Agreement
	Painted Snipe	<i>Rostratula benghalensis (sensu lato)</i>	Species or species habitat may occur within area	Vulnerable, International Agreement
	Rainbow Bee-eater	<i>Merops ornatus</i>		International Agreement

It should be noted that these lists often include species that have been recorded in the region, but are vagrants (as suitable habitat is absent) and can also include species that are now locally extinct. Many of the bird, mammal and reptile species have specific habitat requirements which may be present in the general region but not in the specific project area. A level 2 fauna survey would be required to confirm the presence or absence of these species within the borders of the project site. The likelihood of these species occurring at the study site is considered below.

Birds

With the exception of one tall introduced Eucalypt on the sand dune to the north of the wetland area, there are no tall trees remaining on the site. For this reason, the site is largely unsuitable for Black Cockatoo breeding or roosting. Baudins and Red-tailed Forest Cockatoos are unlikely to frequent the site. The Banksia woodland area (S2) at the southern end of the site may present possible Carnaby's feeding area habitat.

It is possible that the Australasian Bittern visits the site during non-breeding periods. They require large, relatively undisturbed areas of inundated rushes and sedges in which to nest however, and it is therefore not likely that these birds breed at the site.

It is possible that the Australian Painted Snipe could utilise the site, and the Fairy Tern may also use the area, though it is generally found in more coastal areas.

Malleefowl have not been recorded in the area since the 1970s and are thought to be locally extinct. It is therefore unlikely that malleefowl would utilise the site.

It is possible that the Masked Owl and Barn Owl may utilise the site for foraging, though the absence of tall trees with hollows means that these species are not likely to be breeding at the site. The site does not represent prime habitat as the species are usually found in proximity of forested areas.

Insects

Graceful Sun Moth has specific habitat requirements which are not present on the site, based on results of flora surveys (Cardno 2007a&b).

Reptiles

It is unlikely that the Carpet Python or Southern Death Adder are present at the site, as both species prefer relatively undisturbed and intact bushland. The Perth Lined Skink (*Lerista lineata*) inhabits white or pale sands (specifically landforms S7 and S8) which support *Banksia* associated woodlands, heathlands and shrublands on the Bassendean and Spearwood dune vegetation complexes. It is therefore

possible that the Priority 3 species may be found in the small area of Kunzia/Banksia thicket to shrubland at the south of the site.

Mammals

Whilst suitable habitat may exist and historically these species had a wide ranging distribution, the Quoll, Woylie, Quokka and Red-tailed Phascogale are believed to be extinct from most or all of the Swan Coastal Plain and unlikely to inhabit the site.

The site is unlikely to support Western Brush Wallaby due to the fragmented nature of the remnant and close proximity of surrounding urban areas.

The site is unlikely to support Brush-tailed Phascogales due to an absence of suitable nesting trees with hollows and the fragmented nature of the remnant.

The Southern Brown Bandicoot is likely to inhabit the site, closely associated with the open woodlands of Melaleuca. Though no diggings were found during a recent site visit, these have been noted previously within the site, and Bandicoots have been reported at the adjoining Bush Forever site (Government of Western Australia 2000). It is likely that Bandicoots frequent the site during the summer months after the wetland water levels have receded sufficiently to enable access from the adjoining Holmes St Wetland.

Migratory species

It is possible that a range of migratory species frequent the wetland areas of the site including species protected under international treaties such as the China Australia Migratory Bird Agreement (CAMBA), the Japan Australia Migratory Bird Agreement (JAMBA) and the Bonn Convention (The Convention on the Conservation of Migratory Species of Wild Animals).

Rainbow Bee-eater is the only species listed under these treaties to have been recorded within 5 km of the study site in the DEC Naturemap database. Rainbow Bee-eaters are distributed across much of mainland Australia and have been recorded in a wide variety of habitats including open forests and woodlands, shrublands, and in various cleared or semi-cleared habitats, including farmland and areas of human habitation, generally in close proximity to permanent water. The study site has potentially suitable habitat for this species.

3.1 Fauna assemblages

The more common fauna and faunal assemblages on the Swan Coastal Plain are quite well known, particularly for vertebrates, with general information on the distribution and habitats available for frogs, reptiles, mammals and birds. The region has also been well surveyed with comprehensive fauna survey information available for Whiteman Park (Arnold et al., 1991), Bold Park (How, 1998), and Perth Airport (Western Australian Museum surveys; Alan Tingay & Associates, 1993a), as well as a number of small remnants of native vegetation in urban areas (How & Dell, 2000; How *et al.*, 1996; Cooper, 1995; Harvey *et al.*, 1997; Western Australian Museum, 1978). More recently, a Level 2 fauna survey was conducted for the Brookdale Redevelopment Area (ATA, 2007), within 10 km of the study site and covering the same Melaleuca vegetation complexes. These sources of information were used to create lists of species expected to utilise the project area.

Amphibians

Large number of amphibians would be expected to inhabit the site due to the presence of wetland habitat. Amphibians expected to occur within the project area include quacking frogs (*Crinia georgiana*), Glauert's froglets (*Crinia glauerti*), sign-bearing froglets (*Crinia insignifera*), burrowing frogs (*Heleioporus eyrie*) and pobblebonks (*Limnodynastes dorsalis*). With the exceptions of *L. dorsalis* and *H. eyrie*, all of the frog species are expected to be associated with the Melaleuca woodlands or wetland areas and all of these frog species rely on wetlands for breeding. *Limnodynastes dorsalis* and *H. eyrei* may also be encountered within the Banksia woodland area where they may move during non-breeding times.

Reptiles

Reptiles expected to occur within the project area include Burton's legless lizards (*Lialis burtonis*), various skinks (*Acriscincus trilineatus*, *Cryptoblepharus plagiocephalus*, *Menetia greyii*, *Morethia obscura*, *Acriscincus trilineatus* and possibly *Lerista lineata*), the four-toed leristas (*Lerista elegans*), shinglebacks (*Tiliqua rugosa*), marbled geckos (*Christinus marmoratus*), worm lizards (*Aprasia repens*), dugites (*Pseudonaja affinis*) and Australian blindsnakes (*Ramphotyphlops australis*). Some of these species such as *C. plagiocephalus*, *L. elegans*, *M. greyii*, *T. rugosa*, *L. burtonis*, *M. obscura* and *A. trilineatus* would also make use of the wetter open woodlands of Melaleuca associated with the wetlands.

Mammals

Mammals expected within the project area include the House Mouse (*Mus musculus*), Black Rat (*Rattus rattus*), Southern Brown Bandicoot (*Isododon obesulus* subsp. *Fusciventer*), Gould's Wattled Bat (*Chalinolobus gouldii*), Lesser Long-eared Bat (*Nyctophilus geoffroyi*), Feral Fox (*Vulpes vulpes*), Feral Cat (*Felis catus*), and Rabbit (*Oryctolagus cuniculus*). It is also possible that the Brush-tail Possum (*Trichosurus vulpecular*) may be found at the site. The House Mouse and Black Rat would be expected to be widespread across the project area. The Gould's Wattled Bat and Lesser Long-eared Bat are expected to occur within the Melaleuca woodland habitat of the project area.

Birds (Including Migratory Species)

The adjoining Bush Forever site 125 (Holmes St Wetland) has been reported to support a "good assemblage of ducks and waterbirds including 15 breeding species" (Government of Western Australia, 2000). It represents an important breeding site for waterbirds, including some with restricted distributions or declining populations, such as the Freckled Duck.

The higher levels of disturbance and early summer drying means many of the waterbird species observed in the adjoining Bush Forever site 125 are not expected to be found within the project area. This is particularly likely to be the case for secretive species, such as Freckled Duck.

As well as waterbirds, the densely vegetated wetland areas provide suitable habitat for a number of smaller birds.

Avifaunal species expected within the project area include the Australasian Grebe, Eurasian Coot, Purple Swamphen, two species of cormorant Little Black Cormorant and Little Pied Cormorant, three species of heron (White-necked heron, White-

faced Heron and Nankeen Night Heron) and two species of ibis (Straw-necked ibis and Australian White Ibis). The Splendid Fairy-wren is expected to be relatively abundant in proximity of the wetland area and was heard calling during an on-site visit. The Barn Owl, Southern Boobook owl, Tawny Frogmouth, and Sacred Kingfisher also may occur within the more open areas of the site.

The most abundant species expected within the area are generally species that have benefited from land clearing and habitat fragmentation on the Swan Coastal Plain including the Straw-necked Ibis, Silvereye, Galah, Brown Honeyeater, Red Wattlebird, Magpie-lark, Australian Magpie and Australian Raven.

It is possible that Carnaby's Cockatoo may on occasion feed in the small area of Kunzea thicket with associated Banksia species at the south of the site, however no suitable habitat for roosting or breeding is present.

4. Discussion

The area of highest value to fauna at the study site centres around the wetland habitat in the central portion of the site. In particular the wetland area represents suitable habitat for a large number of birds, potentially including some migratory bird species protected under international agreements. The major significance of this area for fauna is that it adjoins significant tracts of habitat on the adjoining lots. The linking, however, is degraded with large areas of kikuyu and couch infestations. The study site generally is quite disturbed and fragmented with a high weed burden.

Rehabilitation of the link between the remaining vegetation at the study site and the adjoining bushland of Bush Forever site 125 would increase the habitat value of the remnant.

Despite being somewhat degraded, as most of the Swan Coastal Plain had been largely cleared there is some habitat value in this remnant which can be considered of local significance.

Faunal assemblages at this site are expected to be in line with that found in other remnants on the Swan Coastal Plain. These assemblages are relatively well known.

The majority of the site outside of that reserved for Parks and Recreation has been historically cleared. The development of urban landuse is therefore not expected to severely impact faunal assemblages at the site. Clearing of the small area of Kunzea thicket to shrubland with associated Banksia species may result in the loss of a small area of potential Carnaby's Black Cockatoo feeding habitat. Vegetation on the site is not suitable for nesting or roosting, however, and the loss of this small and previously disturbed remnant is not likely to affect the survival of the species.

Increased human presence resulting from higher density housing may lead to increased numbers of domestic pets close to conservation areas. Dogs have caused problems for waterbirds and bandicoots through disturbance and predation in other parts of Perth, while cats may prey on smaller birds and other wildlife. Measures should be taken therefore to manage this increased threat.

4.1 Recommendations

A key factor for the protection of fauna on the study site is the retention of the central wetland habitat. This area has the potential to support numerous bird species as well visitations by Southern Brown Bandicoot during the summer months. A concerted effort should be made to manage the weed burden which is significant in the more open and degraded areas of the wetland.

The value of this wetland remnant is heightened due to its connection with wetland habitat on the adjoining land parcel to the west, comprising the bulk of Bush Forever site 125 (Holmes St Wetland). This link should be maintained and improved where possible.

There are only a small number of tall trees on the site, most of those in cleared areas surrounding the established residences. One tall introduced Eucalypt sp. is present on the northern sand dune in close proximity to the boundary of the wetland vegetation. This tree should be retained if possible as it may have some value to fauna in the area (and also provides significant landscape amenity).

It is recommended that a land swap be considered for the small area of Kunzea thicket to shrubland in Very Good condition at the south of the site. Cleared areas exist within Bush Forever boundary to the north of this remnant which may be suitable for this purpose.

Lengths should be taken to manage the impact of domestic pets, should the surrounding area be developed for urban landuse. This would include suitable fencing around the wetland area for exclusion of domestic animals.

References

Alan Tingay and Associates, (1993a). Report of a Fauna Survey of the Perth Airport, Unpublished report to Federal Airports Corporation.

Arnold, G.W., Smith, G.T. and Brooker, M.G., (1991). Whiteman Park Fauna Survey Final Report, May 1991, Unpublished report for the State Planning Commission Whiteman Park, Western Australia.

Beard, J. S., 1990. Plant Life of Western Australia. Kangaroo Press, Perth

CALM, 2007. FaunaBase. Western Australian Museum's FaunaBase and WA FaunaList Database. The database was accessed on the internet (<http://www.museum.wa.gov.au/faunabase/prod/index.htm>) on the 8th July, 2007 using the Lat and Long grid coordinates bordering the site.

CALM, 2002. Swan Coastal Plain 2 (SWA2 – Swan Coastal Plain subregion). Paper prepared by David Mitchell, Kim Williams and Anthony Desmond. Department of Conservation and Land Management, January, 2002

Cardno BSD, 2007a. Lots 1-4 Holmes St and Lot 1600 and Pt Lot 1601 Balfour St, Southern River. Flora and Vegetation Survey and Wetland Assessment. Report prepared for Mammoth Nominees Pty Ltd, August, 2007.

Cardno BSD, 2007b. Lots 1-4 Holmes St and Lot 1600 and Pt Lot 1601 Balfour St, Southern River. Flora and Vegetation Survey and Wetland Assessment: Spring Update. Report prepared for Mammoth Nominees Pty Ltd, November, 2007.

Cooper, N.K., (1995). Vertebrate Fauna of an Isolated Bushland Reserve (No 18325) in Inner Perth, Western Australian Naturalist 20, 21-28.

Conservation Commission and Department of Conservation and Land Management (2005) *Forrestdale Lake Nature Reserve Management Plan 2005*. Management Plan No. 53. Perth, Western Australia.

Department of Environment and Conservation (2007a), Re: Flora and Vegetation Survey and Wetland Assessment for Lots 1-4 Holmes St and Lot 1600 and pt Lot 1601 Balfour St, Southern River. Letter reference 2695 V3 issued 10th December, 2007, 5pp.

Department of Environment and Conservation (2007b), Geographic Data Atlas – Perth Groundwater Atlas, Department of Environment and Conservation. Accessed on the internet at <http://apostle.environment.wa.gov.au/idelve/gwa/index.jsp>.

Department of Environment (2004), Perth Groundwater Atlas, Department of Environment, Second Edition, December 2004.

Department of Environmental Protection (2000). Bush Forever. Western Australian Planning Commission, Perth, WA.

Environmental Protection Authority, (2005). Environmental Guidance for Planning and Development - Guidance Statement No. 33. Environmental Protection Authority, Perth.

Environmental Protection Authority, (1992). Environmental Protection (Swan Coastal Plain Lakes) Policy, Environment Protection Authority, Perth.

Geological Survey of Western Australia (1986) 1:50,000 Environmental Geology Series, Gosnells, part Sheets 2033 (I) & 2133 (IV).

Gibson, N., Keighery, B.J., Keighery, G.J., Burbidge, A.H., and Lyons, M.N. (1994) *A Floristic Survey of the Southern Swan Coastal Plain*. Unpublished report for the Australian Heritage Commission prepared by the Department of Conservation and Land Management and the Conservation Council of Western Australia (Inc).

Government of Western Australia, 2000. Bush Forever- Keeping the Bush in the City, Volumes 1 and 2. Perth, Western Australia.

Harvey, M.S., Dell, J., How, R.A. and Waldock, J.M., (1997). Ground Fauna of Bushland Remnants on the Ridge Hill Shelf and Pinjarra Plain Landforms, Perth, Report to the Australian Heritage commission NEP Grant N95/49, Unpublished report, Perth.

Hedde, E.M., Loneragan, O.W. and Havell, J.J., (1980). Vegetation of the Darling System. IN: Atlas of Natural Resources, Darling System, Western Australia, Department of Conservation and Environment, Perth, Western Australia.

Hill, A. L, Semeniuk, C. A, Semeniuk, V and A Del Marco (1996). Wetland Mapping, Classification and Evaluation – Wetland Atlas. Volume 2B of the Wetlands of the Swan Coastal Plain. Report prepared for the Department of Environmental Protection and Water and Rivers Commission.

How, R.A., (1998). Long-term Sampling of a Herpetofaunal Assemblage on an Isolated Urban Bushland Remnant, Bold Park, Perth, Journal of the Royal Society of Western Australia 81, 143-148.

How, R.A. and Dell, J., (2000). Ground Vertebrate Fauna of Perth's Vegetation Remnants: Impact of 170 Years of Urbanization, Pacific Conservation Biology 6, 198-217.

How, R.A., Harvey, M.S., Dell, J., and Waldock, J.M., (1996). Ground Fauna of the Urban Bushland Remnants in Perth, Report to the Australian Heritage Commission NEP Grant N93/04, Unpublished report, Perth.

McArthur, W.M., and Bettenay, E. (1960) *The development and distribution of soils on the Swan Coastal Plain, Western Australia*. CSIRO Soil Publication No 16.

McKenzie, N.L., May, J.E. and McKenna, S., (2003). Bioregional Summary of the 2002 Biodiversity Audit for Western Australia, Department of Conservation and Land Management, Perth.

Thomson McRoberts Edgeloe Group (2010). Local Water Management Strategy – Lots 1-4 Holmes Street and Lots 1600 & P1601 Balfour Street, Southern River.

Trudgen, M and Keighery, B. (1995). A Survey of Remnant Vegetation in the City of Gosnells West of the Darling Scarp. Unpublished Report to the City of Gosnells and Australian Nature Conservation Agency.

Western Australian Museum, (1978). Faunal Studies of the Northern Swan Coastal Plain: A Consideration of Past and Future Changes, Western Australian Museum, Perth.

Western Australian Planning Commission, (2007). Metropolitan Regional Scheme Map 20. Map amended to 31 December 2010. Accessed on the web at <http://www.planning.wa.gov.au/The+planning+system/Region+schemes/Metropolitan+Region+Scheme/25+000+Series/default.aspx> on 8 July 2011.

Appendix 1: Results from DEC Threatened and Priority Fauna Search

NAME	COMMON NAME	CODE	LOCALITY	SITE	YEAR
<i>Calyptorhynchus latirostris</i>	Carnaby's Cockatoo	T	HUNTINGDALE	Huntingdale	2007
<i>Calyptorhynchus latirostris</i>	Carnaby's Cockatoo	T	HARRISDALE	Harrisdale Reserve	2008
<i>Calyptorhynchus latirostris</i>	Carnaby's Cockatoo	T	SOUTHERN RIVER	Gosnells P3	2005
<i>Calyptorhynchus latirostris</i>	Carnaby's Cockatoo	T	CANNING VALE	Shreeve Road Wetland Reserve	2003
<i>Ardea modesta</i>	Eastern Great Egret	IA	CANNING VALE	Shreeve Road Wetland Reserve	2003
<i>Merops ornatus</i>	Rainbow Bee-eater	IA	SOUTHERN RIVER	Gosnells P3	2005
<i>Merops ornatus</i>	Rainbow Bee-eater	IA	SOUTHERN RIVER	Gosnells P1	2005
<i>Merops ornatus</i>	Rainbow Bee-eater	IA	SOUTHERN RIVER	Southern River Area	2002
<i>Merops ornatus</i>	Rainbow Bee-eater	IA	CANNING VALE	Shreeve Road Wetland Reserve	2003
<i>Merops ornatus</i>	Rainbow Bee-eater	IA	CANNING VALE	Shreeve Road Wetland Reserve	2003
<i>Merops ornatus</i>	Rainbow Bee-eater	IA	CANNING VALE	Wetland Reserve, Canning Vale	2003
<i>Merops ornatus</i>	Rainbow Bee-eater	IA	CANNING VALE	Shreeve Road swamp	1998
<i>Isodon obesulus subsp. fusciventer</i>	Quenda, Southern Brown Bandicoot	5	SOUTHERN RIVER	Lakey Rd, Southern River	2010
<i>Isodon obesulus subsp. fusciventer</i>	Quenda, Southern Brown Bandicoot	5	SOUTHERN RIVER	Furley Rd, Southern River	1991
<i>Isodon obesulus subsp. fusciventer</i>	Quenda, Southern Brown Bandicoot	5	SOUTHERN RIVER	Lakey Road, Southern River	2010
<i>Isodon obesulus subsp. fusciventer</i>	Quenda, Southern Brown Bandicoot	5	SOUTHERN RIVER	Harpenden Street	2005

Appendix F

Existing Plant Species List to inform
the Rehabilitation Program (Cardno,
2007)

VASCULAR PLANT SPECIES RECORDED ON LOTS 1, 2, 3, 4 HOLMES ST AND LOTS 1600 AND 1601 BALFOUR ST, SOUTHERN RIVER, 2007

Note: * signifies introduced (weed) taxa

FAMILY	SPECIES
Zamiaceae	<i>Macrozamia riedlei</i>
Typhaceae	* <i>Typha orientalis</i>
Juncaginaceae	<i>Triglochin linearis</i>
Poaceae	* <i>Alopecurus myosuroides</i> * <i>Avena barbata</i> * <i>Briza maxima</i> * <i>Briza minor</i> * <i>Bromus diandrus</i> * <i>Cortaderia selloana</i> * <i>Cynodon dactylon</i> * <i>Ehrharta calycina</i> * <i>Eragrostis curvula</i> * <i>Phalaris paradoxa</i> * <i>Lolium perenne</i> * <i>Lolium rigidum</i> * <i>Myuros</i> sp. * <i>Paspalum distichum</i> * <i>Stenotaphrum secundatum</i>
Cyperaceae	<i>Baumea juncea</i> * <i>Isolepis marginata</i> <i>Isolepis producta</i> <i>Lepidosperma longitudinale</i> <i>Lepidosperma pubisquameum</i>
Lemnaceae	<i>Lemna disperma</i>
Restionaceae	<i>Desmocladus flexuosus</i> <i>Hypoleana exsulca</i> <i>Lyginia barbata</i> <i>Meeboldina roycei</i> ms
Juncaceae	* <i>Juncus bufonius</i> <i>Juncus pallidus</i>
Dasypogonaceae	<i>Dasypogon bromeliifolius</i> <i>Lomandra caespitosa</i>
Xanthorrhoeaceae	<i>Xanthorrhoea preissii</i>
Anthericaceae	<i>Thysanotus multiflorus</i>

VASCULAR PLANT SPECIES RECORDED ON LOTS 1, 2, 3, 4 HOLMES ST AND LOTS 1600 AND 1601 BALFOUR ST, SOUTHERN RIVER, 2007

Note: * signifies introduced (weed) taxa

FAMILY	SPECIES
Colchicaceae	<i>Burchardia congesta</i>
Haemodoraceae	<i>Anigozanthus manglesii</i> <i>Conostylis aculeata</i> subsp. <i>aculeata</i> <i>Conostylis juncea</i> <i>Phlebocarya ciliata</i>
Iridaceae	* <i>Gladiolus caryophyllaceus</i> <i>Patersonia occidentalis</i> * <i>Romulea rosea</i> * <i>Watsonia meriana</i> var. <i>bulbelifera</i>
Orchidaceae	* <i>Disa bracteata</i> <i>Microtis media</i>
Casuarinaceae	<i>Allocasuarina fraseriana</i>
Proteaceae	<i>Adenanthos cygnorum</i> subsp. <i>cygnorum</i> <i>Banksia attenuata</i> <i>Banksia menziesii</i> <i>Petrophile linearis</i>
Polygonaceae	* <i>Acetosella vulgaris</i> * <i>Rumex crispus</i>
Chenopodiaceae	* <i>Chenopodium glaucum</i>
Aizoaceae	* <i>Carpobrotus edulis</i>
Molluginaceae	<i>Macarthuria australis</i>
Lauraceae	<i>Cassytha glabella</i> forma <i>glabella</i>
Mimosaceae	<i>Acacia pulchella</i>
Papilionaceae	<i>Bossiaea eriocarpa</i> <i>Gompholobium tomentosum</i> <i>Hovea trisperma</i> <i>Jacksonia furcellata</i> <i>Jacksonia sericea</i> (P4) * <i>Lotus subbiflorus</i> * <i>Ornithopus compressus</i> * <i>Trifolium arvense</i> * <i>Trifolium subteranneum</i>

VASCULAR PLANT SPECIES RECORDED ON LOTS 1, 2, 3, 4 HOLMES ST AND LOTS 1600 AND 1601 BALFOUR ST, SOUTHERN RIVER, 2007

Note: * signifies introduced (weed) taxa

FAMILY	SPECIES
Myrtaceae	<i>Agonis flexuosa</i> <i>Calytrix fraseri</i> * <i>Eucalyptus grandis</i> <i>Eucalyptus todtiana</i> <i>Kunzea glabrescens</i> <i>Melaleuca lateritia</i> <i>Melaleuca preissiana</i> <i>Melaleuca raphiophylla</i> <i>Melaleuca seriata</i> <i>Melaleuca teretifolia</i> <i>Melaleuca thymoides</i> <i>Scholtzia involucrata</i>
Apiaceae	<i>Centella asiatica</i>
Boraginaceae	* <i>Echium plantagineum</i>
Lamiaceae	<i>Hemiandra pungens</i>
Solanaceae	* <i>Solanum nigrum</i>
Campanulaceae	* <i>Wahlenbergia capensis</i>
Goodeniaceae	<i>Dampiera linearis</i>
Asteraceae	* <i>Conyza albida</i> * <i>Cotula coronopifolia</i> * <i>Hypochaeris glabra</i> * <i>Sonchus asper</i> * <i>Sonchus oleraceus</i> * <i>Symphotrichum squamatum</i> * <i>Ursinia anthemoides</i>

APPENDIX 4

Geotechnical Investigation

**LOTS 1, 2, 3, 4 & 1600 BALFOUR STREET
SOUTHERN RIVER**

WESTERN AUSTRALIA

GEOTECHNICAL INVESTIGATION

**MARCH 2008
Ref: J08002.01**

**FOR
MAMMOTH NOMINEES**



Brown Geotechnical & Environmental Pty Ltd
Suite 4, 47 Monash Avenue
Como WA 6152
Tel (08) 9368 2615

CONDITIONS RELATING TO THIS REPORT

1. This report has been prepared for the sole use of Mammoth Nominees Pty Ltd. It has been issued in accordance with the agreed terms and scope detailed in the proposal for the investigation. No responsibility or liability to any third party is accepted for any damages arising out of the use of this report.
2. This report has been prepared by suitably qualified and experienced personnel for the purposes stated herein. Every care is taken with the report as it relates to interpretation of sub-surface conditions, discussion of findings and recommendations given. No responsibility for the consequences of extrapolation by others is accepted by the company.
3. Findings and conclusions produced in the report are based on the investigation of the sub-surface through isolated locations. Conditions between investigated sites are based on extrapolation, interpretation and professional estimates. Unexpected variations in ground conditions often occur which cannot always be anticipated. The conclusions and recommendations in the report were considered accurate at the time of issue and based on certain assumptions at the time. Conditions and assumptions change with time and may affect the accuracy of the report.
4. Certain content within this report is based on information provided by the client and/or other parties and the accuracy of this information cannot be guaranteed.
5. These conditions must be read as part of the report and must be reproduced with all future copies.
6. The recommendations of this report should be considered a starting point. Recommendations should be continuously reviewed during the earthworks stage as sub-surface information and results from monitoring become available. It is strongly recommended that the Company be retained to provide consultancy and/or inspections during the earthwork stages.

TABLE OF CONTENTS

1	Introduction.....	1
2	Objectives.....	1
3	Site Details	1
4	Geology and Environmental Studies	2
5	Fieldwork and Laboratory Testing	2
	5.1 Investigation Fieldwork.....	2
	5.2 Laboratory Testing	2
6	Results	2
	6.1 Geology and Groundwater	2
	6.1.1 Fill.....	2
	6.1.2 Topsoil	3
	6.1.3 Sand (SP)	3
	6.1.4 Sand (SP-SM-GP).....	3
	6.1.5 Silty Sand (SP-SM).....	3
	6.1.6 Clayey Sand (SC).....	3
	6.1.7 Sandy Clay (CI)	3
	6.1.8 Coffee Rock	3
	6.1.9 Groundwater	4
	6.2 Geotechnical Laboratory Test Results	5
7	Analysis and Conclusions	5
	7.1 Subsurface Conditions.....	5
	7.2 Groundwater.....	6
	7.3 Site Classification.....	6
	7.4 Site Remediation Measures	6
	7.5 Site Drainage Recommendations	6
	7.6 Earthwork Inspections.....	7
	REFERENCES	8

LIST OF TABLES

Table 1	Groundwater Depths
Table 2	Laboratory Test Results

LIST OF FIGURES

Figure 1	Site Location Plan
Figure 2	Test Location Plan

LIST OF APPENDICES

Appendix A	Test Pit Log
Appendix B	Perth Sand Penetrometer Plots
Appendix C	Laboratory Test Certificates

1 Introduction

It is proposed to develop Lots 1, 2, 3, 4 and 1600 Balfour Street, Southern River for residential use. This report presents the results of the geotechnical investigation for the development. Brown Geotechnical & Environmental were retained to undertake the investigation.

The terms of reference for the investigation were outlined in Brown Geotechnical and Environmental's proposal dated 12 December 2007. Instructions to proceed with the investigation were received from the Client – Mammoth Nominees on 11 January 2008.

A Bush Forever area occupies the southern portions of Lots 2, 3 and 4, no investigation was carried out in this area (refer Figure 2).

2 Objectives

The objectives of this investigation were as follows:

- To determine the subsurface conditions.
- To determine the presence of fill.
- To determine the present site classification in accordance with AS 2870-1996 [1].
- To recommend earthwork requirements to obtain a site classification suitable for development of the site.
- To address site drainage issues.

3 Site Details

The site is located on the western corner of the intersection of Holmes and Balfour Street, Southern River (refer Figure 1). The general area can be characterised as old farmland paddocks being replaced by high density residential developments.

The area under investigation consisted of grass paddocks with sparse shrub vegetation. The south western half of Lot 1 was covered by dense bushland. Lots 2, 3, 4 and 1600 contained existing single story buildings adjacent to their respective streets.

The site area is approximately 13ha and survey data shows ground levels to vary from 21m to 22m AHD.

4 Geology and Environmental Studies

The Environmental Geology sheet for the area [2] indicates the site to be underlain by Swamp Deposits consisting of peaty sands and peat rich sand. Bassendean Sands are present towards the north, east and southern boundaries.

The WAPC Bulletin No.64 – *Acid Sulphate Soils Central Metro Region* [3] indicates the potential for acid sulphate generating soils at the site to be “high to moderate” risk where swamp deposits occur and “moderate to low” risk in other areas. No acid sulphate soil investigation was requested.

The Perth Groundwater Atlas [4] shows the maximum historical groundwater level to be approximately 21m AHD.

5 Fieldwork and Laboratory Testing

5.1 Investigation Fieldwork

The fieldwork was carried out on 22 and 23 January 2008. Thirty five test pits were excavated using a 5 tonne excavator and were extended to a maximum depth of 2.9m. Perth Sand Penetrometer (PSP) tests were carried out to determine the relative density of the soil. Soil samples were obtained from the test pits for field descriptions and laboratory tests.

Test pit and PSP locations are shown in Figure 2, with test pit logs enclosed in Appendix A and PSP plots in Appendix B.

5.2 Laboratory Testing

Soil samples were delivered to Western Geotechnics Group laboratories for the following tests; particle size distribution, standard compaction tests and percentage fines. The laboratory test certificates are presented in Appendix C.

6 Results

6.1 Geology and Groundwater

Subsurface conditions encountered in the test pits and inferred from PSP plots and laboratory test results are described as follows:

6.1.1 Fill

Fill was encountered in TP16 to a depth of 1.5m below ground level. The fill material consisted of gravel to 0.3m, underlain by 1.2m of building debris, concrete, steel pipe and rubbish in a matrix of brown sand.

6.1.2 Topsoil

Topsoil was encountered in test pits TP1 to TP12, TP15 and TP18 to TP35. The topsoil consisted of medium grained, light grey to dark grey sand with rootlets. Black topsoil was encountered in TP5. The thickness of the topsoil varied from 0.05m to 0.5m, with an average of 0.25m.

6.1.3 Sand (SP)

Medium grained, grey sand (SP) with trace amounts of silt was encountered in all test pits. Occasional tree roots were encountered to an average depth of 1m most test pits. TP11 encountered roots from 1.2m to 2.3m. The relative density of the sand was medium dense to dense. The sand locally became yellow and brown with depth.

6.1.4 Sand (SP-SM-GP)

Medium grained, light brown sand with gravel and silt (SP-SM-GP) was encountered in TP28 and TP34 at 1.4m and 0.9m respectively. The material continued to the base of the test pit (2.1m) in TP28 and 1.3m in TP34. The relative density of the material was very dense.

6.1.5 Silty Sand (SP-SM)

Medium grained, yellow-brown silty sand was encountered in TP6 from 0.2m to 1.8m. The relative density of the material was very dense.

6.1.6 Clayey Sand (SC)

Medium grained, blue-grey, clayey sand (SC) was encountered in TP6 and TP23 below 1.8m and 1.5m respectively. The clayey material continued to the base of the test pits. The relative density of the material was dense to very dense.

6.1.7 Sandy Clay (CI)

Stiff, medium plasticity, blue-grey sandy clay (CI) was encountered below 1.5m in TP33 and 1.3m in TP34. The material extended to the base of each test pit.

6.1.8 Coffee Rock

Coffee rock (weakly cemented iron rich silty sand) was encountered in TP13, TP23, TP26, TP28 and TP29 at depths ranging from 0.9m to 2.4m. The thickness of the material varied from 0.05m to 0.4m. The thicker layers often caused refusal of the excavator.

6.1.9 Groundwater

Groundwater was encountered in twenty two test pits. Groundwater depths and reduced levels are shown in Table 1. Ground levels have been estimated from governmental survey data in the absence of any current feature survey.

Table 1 - Groundwater Depth

Location	Groundwater Depth (m BGL)	Ground Level (m AHD)	Groundwater Level (m AHD)
TP01	1.8	21.2	19.4
TP02	1.4	21.0	19.6
TP03	1.2	21.0	19.8
TP04	1.2	21.0	19.8
TP05	0.8	21.0	20.2
TP06	1.6	21.0	19.4
TP07	1.5	21.0	19.5
TP09	2.1	21.8	19.7
TP19	2.4	21.5	19.1
TP22	1.3	20.9	19.6
TP23	1.3	20.9	19.6
TP24	1.3	20.9	19.6
TP25	1.2	20.8	19.6
TP26	1.8	20.8	19.0
TP27	1.7	20.8	19.1
TP28	1.4	20.9	19.5
TP29	1.3	21.0	19.7
TP30	2.4	21.0	18.6
TP31	1.3	20.9	19.6
TP32	1.1	20.9	19.8
TP33	1.3	21.0	19.7
TP34	1.2	21.0	19.8

The maximum groundwater level identified during the investigation was 20.2m AHD (0.8m below existing ground level).

6.2 Geotechnical Laboratory Test Results

Laboratory test results are summarised in Table 2.

Table 2 - Laboratory Test Results

Test Pit No.	Depth (m)	Particle Size Distribution						OMC (%)	MMD (t/m³)	USC
		Fines (%)	Sand			Gravel (%)	Cobbles (%)			
			Fine (%)	Medium (%)	Coarse (%)					
TP5	0.6 - 0.8	2	11	65	22	0	0	14.5	1.74	SP
TP11	1.0 - 1.2	2	13	60	24	1	0	14.5	1.69	SP
TP17	0.8 - 1.0	4	17	66	13	0	0	16.5	1.74	SP
TP28	0.6 - 0.8	3	10	67	19	1	0	16.0	1.70	SP
TP34	1.0 - 1.3	6	13	56	12	11	2	11.5	1.86	SP-GP
TP34	1.4 - 1.5	69	-	-	-	-	-	-	-	CI

7 Analysis and Conclusions

7.1 Subsurface Conditions

The site is generally underlain by a thin layer of topsoil consisting of medium grained, grey sand with rootlets and occasional tree roots. Building debris is present at the surface in the western corner of the site. Dwellings and associated fill are present locally in other areas of the site (refer Figure 2).

The topsoil is underlain by medium dense to dense, medium grained, grey sand with occasional tree roots to approximately 1m depth. Thin horizons of silty sand and gravel occur within the sand below about 1m depth.

Sand with gravel and/or silt overlies sandy clay/clayey sand below approximately 1.5m in the southern corner of the site and adjacent to the southern corner of the Bush Forever area.

Coffee rock was encountered intermittently across the site at depths from 1m to 2.4m and occasionally caused refusal of the 5 tonne excavator.

7.2 Groundwater

The maximum groundwater level identified during the investigation was 20.3m AHD (0.8m below existing ground level). However, the Perth Groundwater Atlas [4] indicates the maximum historical groundwater level to be at 21m AHD.

7.3 Site Classification

The site classification in accordance with AS 2870 – 1996 [1] is Class 'S' for the southern corner of the site and Class 'A' for the remainder of the site (refer Figure 2). The entire site can be classified Class 'A' if recommendations in Sections 7.4 and 7.5 are implemented.

7.4 Site Remediation Measures

All topsoil should be excavated and screened to remove root material before re-use. All existing buildings, foundations and associated fill should be completely removed from the site. A geotechnical inspection will be required at this stage to confirm the removal of all topsoil, root material, building debris and associated fill, and to confirm subsurface conditions identified in the test pits are consistent across the site, especially below old foundations.

The site surface should then be proof rolled to achieve at least 95% SMDD. This approximates to at least 8 blows per 300mm using a Perth sand penetrometer (PSP) to a depth of 750mm. Moisture conditioning (wetting) of the sand may be required to optimise compaction. The material should be prepared so that moisture content is within $\pm 2\%$ of optimum. Compaction parameters are shown in Table 2.

Additional sand fill imported to obtain site formation levels should be compacted in layers not more than 300mm thick to at least 95% SMDD. This approximates to at least 8 blows per 300mm using a PSP in the depth range 150mm to 450mm below the compacted layer surface. If the required blow counts can not be achieved, in-situ density tests should be carried out to calibrate the PSP to specific densities of the compacted material. Moisture conditioning (wetting) of the sand may be required to optimise compaction. Imported sand should contain less than 5% non-plastic fines.

Following excavation for foundations, the bases of strip footings should be compacted to achieve at least 95% SMDD.

7.5 Site Drainage Recommendations

The maximum groundwater level encountered during the investigation was 20.2m AHD. However, the maximum historic groundwater level according to the Perth Groundwater Atlas [4] is approximately 21m AHD.

In the absence of any long term monitoring details for the site to confirm the Annual Average Maximum Groundwater Level (AAMGL), it is recommended that the minimum site formation level should be 22.2m AHD, thus conforming to subdivisional guidelines [5] which recommend a minimum separation of 1.2m between the floor slab and the AAMGL, in the absence of subsoil drainage.

Shallow soak wells will be suitable for the disposal of storm water assuming a minimum site formation level of 22.2m AHD is obtained. A soil permeability of 1×10^{-4} m/s is suggested for soak well design.

7.6 Earthwork Inspections

It is recommended that a geotechnical engineer inspects the site after the removal of topsoil, root material, existing buildings, foundations and associated fill to confirm subsurface conditions identified in the test pits are consistent across the site. Inspections and auditing of the earthworks should be carried out by a geotechnical consultant to enable confirmation of the final site classification.

BROWN GEOTECHNICAL & ENVIRONMENTAL

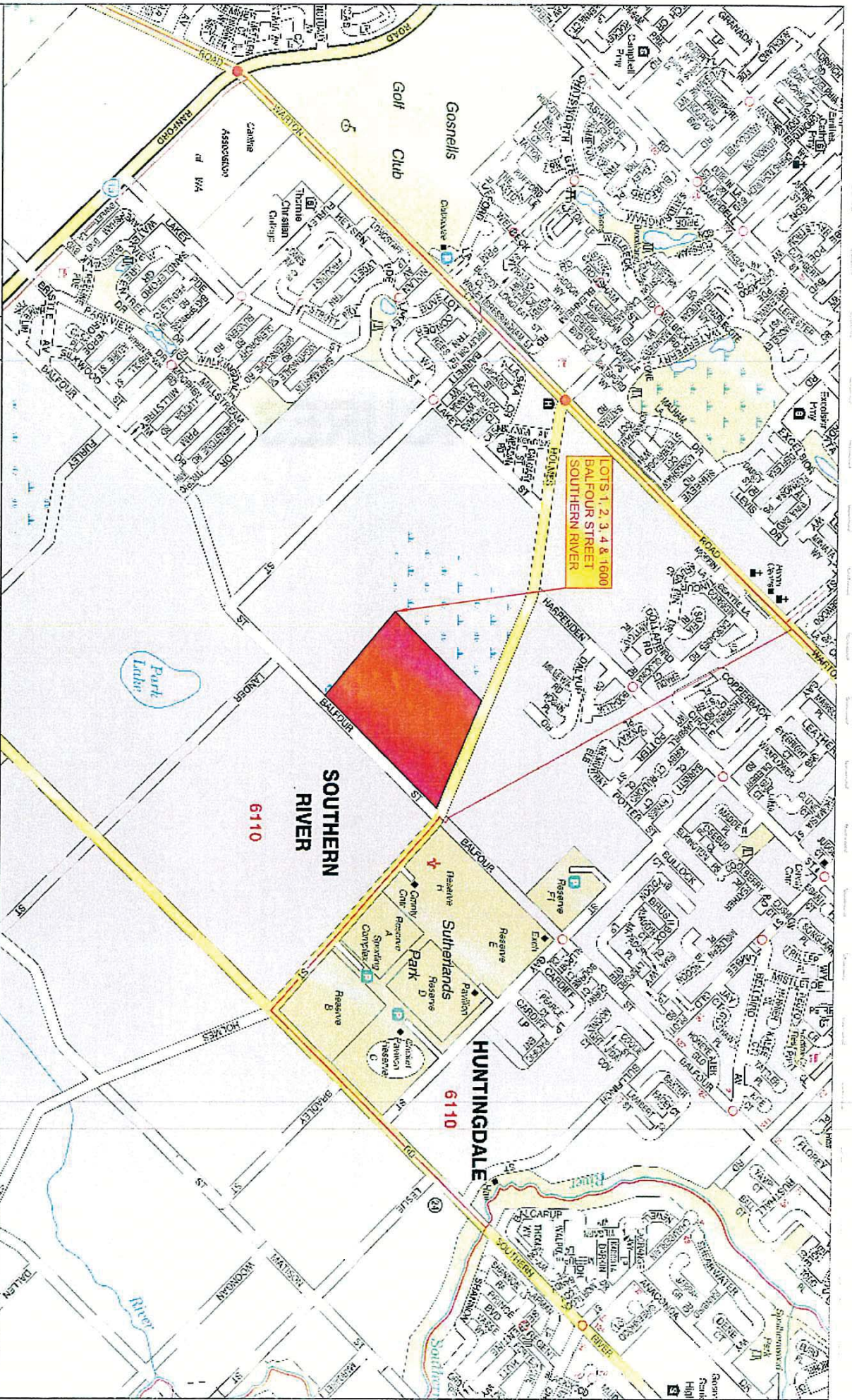
Ben Darby

**Reviewed By
Ken Brown**

REFERENCES

1. Residential Slabs and Footings – Construction. Standards Australia AS 2870 (1996)
2. 1:50,000 Environmental Geology Series, Perth. Geological Survey of Western Australia.
3. DEC and WAPC (up-date May 2007). Planning Bulletin No.64. Central Metropolitan Region Scheme Acid Sulphate Soils.
4. Department of Water: www.environment.wa.gov.au.
5. Institute of Municipal Engineering Australia, WA Division Inc. Guidelines for Subdivisional Development, October 1998.

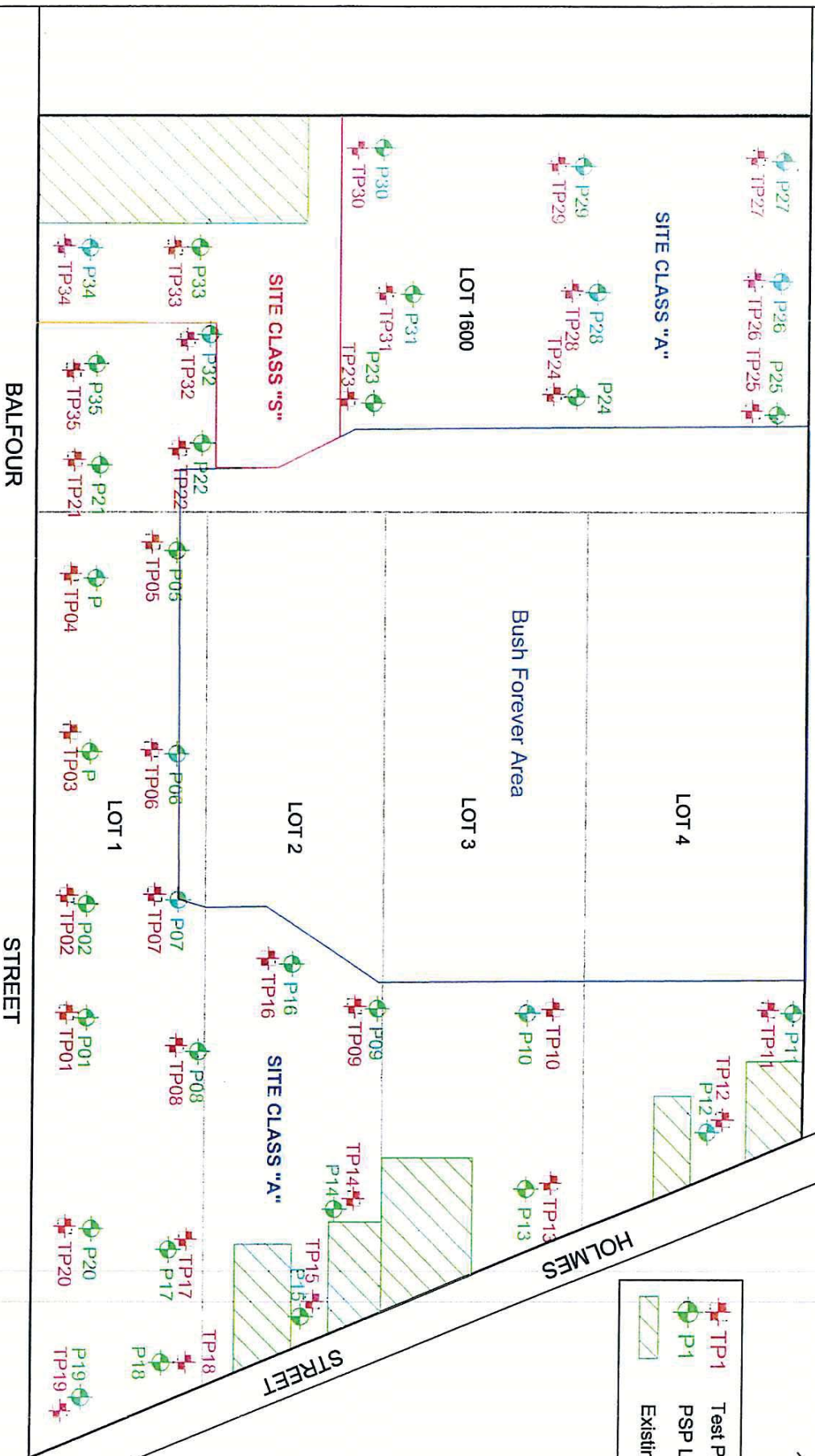
FIGURES



Brown Geotechnical & Environmental

Suite 4, 47 Monash Avenue
Como WA 6152
Tel: 08 9388 2615
Email: bge@bge.com.au

Date	Description	Drawn	Checked	Approved	TEST LOCATION PLAN	CLIENT	Drawing No. 08002 Fig1 Scale: NTS
24.01.08	Site Location Plan	MW	MS				
					LOTS 1, 2, 3, 4 & 1600 BALFOUR ST SOUTHERN RIVER	MAMMOTH NOMINEES	Sheet Size: A4
							Job No: J08002.01
							FIGURE 4



Brown Geotechnical & Environmental Suite 4, 47 Monash Avenue Como WA 6152 Tel: 08 9398 2615 Email: bge@adidss.com.au				Date	Description	Drawn	Checked	Approved	TEST LOCATION PLAN	CLIENT	Drawing No. 08002 Fig2
				25.01.08	Test Location Plan	MW	MS				Scale: NTS
											Sheet Size: A4
											Job No: J08002.01
									LOTS 1, 2, 3, 4 & 1600 BALFOUR STREET SOUTHERN RIVER	MAMMOTH NOMINEES	

significance. Proposals likely to have an impact on a wetland of high conservation significance are required to be referred to the EPA for formal assessment.

4. Wetlands that are to be conserved require a buffer between them and any proposed development, to protect them from potential adverse impacts and, maintain ecological processes and functions within the wetland. The width of the buffer should be determined based on the values of the wetland to be protected and the threats posed by the adjacent land use, 50m being the minimum buffer distance applied. The plan has insufficiently addressed the importance of wetland buffers and has not justified that the proposed 25m wetland buffer distance will maintain if not improve the values of the wetland. DEC does not support the proposed 25m wetland buffer distance.
5. A site specific wetland buffer study should be conducted for the wetland within the proposal in accordance with the information outlined in Chapter B4 of Guidance Statement No. 33 (EPA 2005). The draft *Guideline for the Determination of Wetland Buffer Requirements* (Essential Environment Services 2005) also provides guidance on determining wetland buffers however, its methodology has not been endorsed.
6. The plan includes a proposed subdivision plan. As the proposed subdivision layout has not been approved, it is not considered relevant to the plan.
7. The plan states that a portion of Resource Enhancement wetland UFI 13986 supports vegetation in Excellent condition and should be assessed for reclassification (sic) to a Conservation management category. Modifications to wetland management categories should be conducted in accordance with the *Protocol for proposing modification to the Geomorphic Wetlands Swan Coastal Plain dataset* (DEC 2007). Requests should be submitted to DEC Wetlands Program prior to any development or subdivision proposals.
8. Wetland UFI 13986 should be managed and protected in accordance with its described values, including the provision of an appropriate buffer.
9. The site contains two portions of wetlands not acknowledged in the plan. Conservation management category wetland UFI 14141 located on pt Lot 1601 and Multiple Use management category wetland UFI 13501 located on Lot 1600 and pt Lot 1601 should be acknowledged in the plan with adequate management strategies proposed.
10. The plan currently lacks fundamental information relevant to its management commitments including management objectives, specific timings and priorities for individual strategies and actions, a management authority responsible for implementation and performance criteria (see Attachment B4-5 of Guidance Statement No. 33 (EPA 2005)).
11. It is recommended that the overall management goal for the wetlands within the site be revised to 'retain and enhance the environmental values of the wetland and bushland areas during earthworks on site'.
12. The following comments refer to the proposed management actions:
 - MA1 - DEC supports this management action and suggests that government authorities involved in the maintenance of the management area and its surrounds should be provided a copy of the plan. It is also recommended that monitoring be undertaken to ensure the plan's strategies are implemented by land managers, contractors and volunteers.
 - MA2 - Refer to comment 13.
 - MA3 - Specific information on where and how the surface drainage water will be channelled and proposed techniques to minimise erosion should be outlined.

APPENDIX 5

Flora and Vegetation Study



LEGEND

- Subject Area
- Bush Forever

SPRING UPDATE - FLORA & VEGETATION SURVEY & WETLANDS ASSESSMENT LOTS 1-4 & 1600 & 1601 SOUTHERN RIVER FIGURE 2 : BUSH FOREVER SITES

PROJECT
DRAWING TITLE
PRINCIPAL
MAMMOTH NOMINEES Pty Ltd

This drawing has been prepared in accordance with the Carpio BSD Quality Management System. It remains the property of Carpio BSD Pty Ltd. and shall not be used without permission. This drawing shall be used in accordance with the conditions of use set out in the project agreement.

DATE	BY	ACTIVITY / REVISION DESCRIPTION	DATE	BY	ACTIVITY / REVISION DESCRIPTION

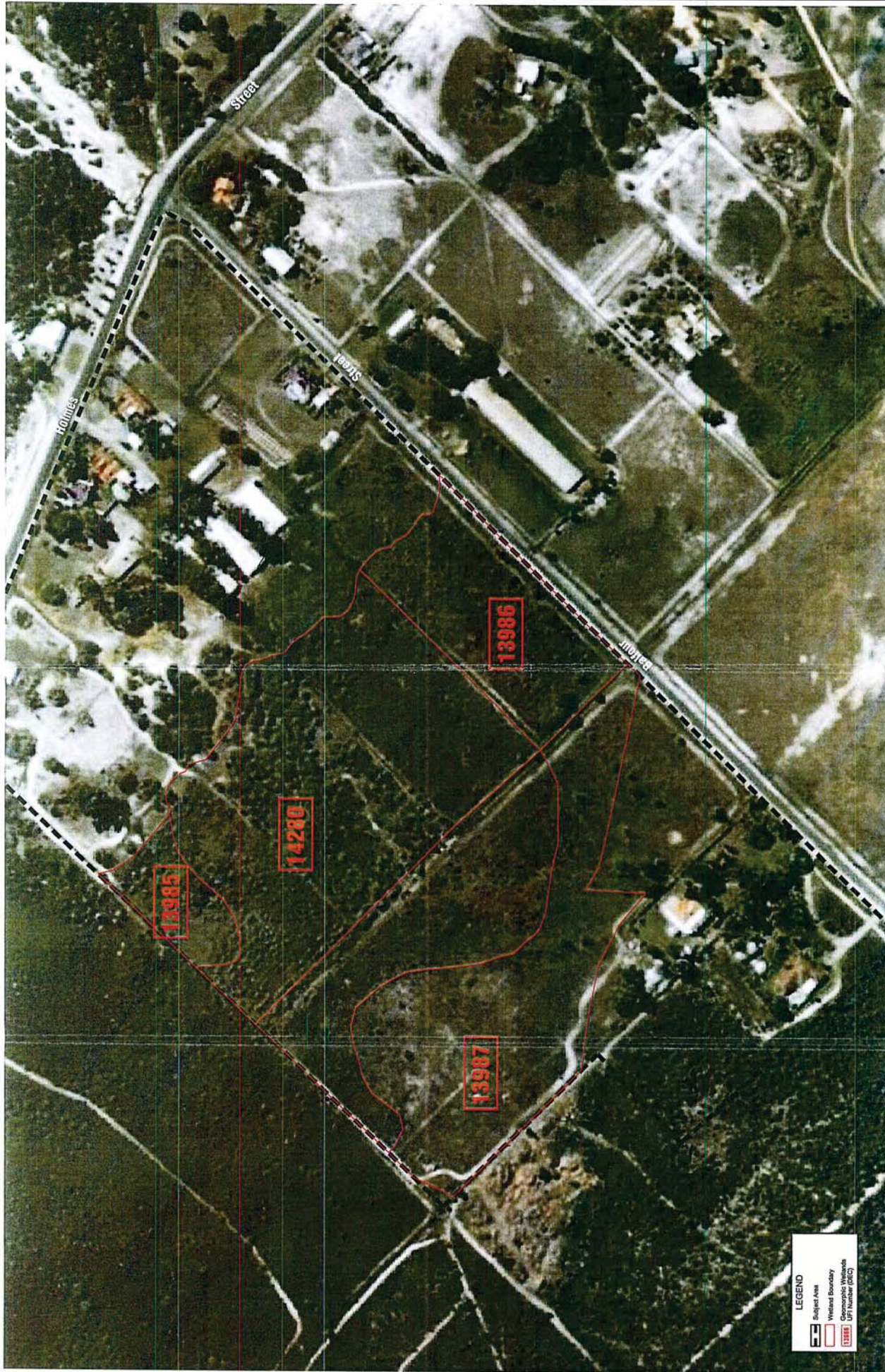


CONSULTING ENGINEERS
TOWN PLANNERS
PROJECT MANAGERS
ENVIRONMENTAL CONSULTANTS

Carpio BSD Corp 7 Belford Road
P.O. Box 155 Subiaco
Western Australia 6004
Telephone (08) 9273 3088
Facsimile (08) 9308 3031

Project Number
V7030
Designed
SC
Drawn
MGW
Local Authority
CITY OF GOSNELLS

Drawing Number
SK02
Checked
Approved
Date
20.08.07
Sheet
1 of 1



LEGEND

- Subject Area
- Wetland Boundary
- Geomorphic Wetlands (1:100000)

SCALE 1:2500		0 25m 50 75 100 125 150 175 200 225 250	
CONSULTING ENGINEERS		Project Number	Revision
TOMPLANDERS		V7030	A3
PROJECT MANAGERS		Designed	SC
ENVIRONMENTAL CONSULTANTS		Drawn	MGW
CITY OF GOSNELLS		Approved	1
Date		5/12/2017	Sheet
Telephone (08) 9273 3368		Facsimile (08) 9288 3831	Of

PROJECT SPRING UPDATE - FLORA & VEGETATION SURVEY & WETLANDS
ASSESSMENT Lots 1-4 & 1400 & 16001 Southern River
FIGURE 3: GEOMORPHIC WETLAND BOUNDARIES
PREPARED BY MAMMOTH NOMINEES Pty Ltd.
 This drawing has been prepared in accordance with the Geomatics (BOD) Quality Management System. It remains the property of Mammoth Pty Ltd and shall not be used without permission. This drawing shall be preliminary only and not for construction and/or approval.

DATE	NO.	ACTIVITY	REVISION/DESCRIPTION	DATE	BY	CHKD	APPD

PHOTOGRAPHIC PLATES



Plate 1: Area R1: – Areas developed for residential and semi-rural purposes, Lot 1, April 2007.



Plate 2: Area R1 – Areas developed for residential and semi-rural purposes, Lot 1600, November 2007



Plate 3: Area R2: – Areas developed for rural purposes. Part with densest overstorey shown, August 2007.



Plate 4: Area R2 – November 2007



Plate 5: Community S1 - Thicket to Shrubland of *Melaleuca raphiophylla* over *Melaleuca lateritia* and *Melaleuca teretifolia* over *Lepidosperma longitudinale* and *Juncus pallidus* on brown loamy sands, April 2007.



Plate 6: Community S1 - Thicket to Shrubland of *Melaleuca raphiophylla* over *Melaleuca lateritia* and *Melaleuca teretifolia* over *Lepidosperma longitudinale* and *Juncus pallidus* on brown loamy sands, November 2007



Plate 7: Community S2 - Thicket to Shrubland of *Kunzea glabrescens* with *Banksia attenuata* and *Banksia menziesii* over *Macrozamia riedlei*, *Xanthorrhoea preissii* and *Adenanthos cygnorum* over *Dasypogon bromeliifolius* and *Desmocladius flexuosus* on brown loamy sands, August 2007.



Plate 8: Surface water under *Melaleuca raphiophylla*, Lot 4, November 2007



Plate 9: Open water area on Lot 1, November, 2007. Looking northwest towards Lot 2 from Balfour St.

APPENDIX A

Vascular plant species recorded on Lots 1, 2, 3 & 4 Holmes St,
and Lot 1600 and Pt Lot 1601 Balfour St, Southern River, 2007

APPENDIX A

VASCULAR PLANT SPECIES RECORDED ON LOTS 1, 2, 3, 4 HOLMES ST AND LOTS 1600 AND 1601 BALFOUR ST, SOUTHERN RIVER, 2007

Note: * signifies introduced (weed) taxa

FAMILY	SPECIES
Zamiaceae	<i>Macrozamia riedlei</i>
Typhaceae	* <i>Typha orientalis</i>
Juncaginaceae	<i>Triglochin linearis</i>
Poaceae	* <i>Alopecurus myosuroides</i> * <i>Avena barbata</i> * <i>Briza maxima</i> * <i>Briza minor</i> * <i>Bromus diandrus</i> * <i>Cortaderia selloana</i> * <i>Cynodon dactylon</i> * <i>Ehrharta calycina</i> * <i>Eragrostis curvula</i> * <i>Phalaris paradoxa</i> * <i>Lolium perenne</i> * <i>Lolium rigidum</i> * <i>Myuros</i> sp. * <i>Paspalum distichum</i> * <i>Stenotaphrum secundatum</i>
Cyperaceae	<i>Baumea juncea</i> * <i>Isolepis marginata</i> <i>Isolepis producta</i> <i>Lepidosperma longitudinale</i> <i>Lepidosperma pubisquameum</i>
Lemnaceae	<i>Lemna disperma</i>
Restionaceae	<i>Desmocladius flexuosus</i> <i>Hypoleana exsulca</i> <i>Lyginia barbata</i> <i>Meeboldina roycei</i> ms
Juncaceae	* <i>Juncus bufonius</i> <i>Juncus pallidus</i>
Dasypogonaceae	<i>Dasypogon bromeliifolius</i> <i>Lomandra caespitosa</i>
Xanthorrhoeaceae	<i>Xanthorrhoea preissii</i>
Anthericaceae	<i>Thysanotus multiflorus</i>

APPENDIX A

VASCULAR PLANT SPECIES RECORDED ON LOTS 1, 2, 3, 4 HOLMES ST AND LOTS 1600 AND 1601 BALFOUR ST, SOUTHERN RIVER, 2007

Note: * signifies introduced (weed) taxa

FAMILY	SPECIES
Colchicaceae	<i>Burchardia congesta</i>
Haemodoraceae	<i>Anigozanthus manglesii</i> <i>Conostylis aculeata</i> subsp. <i>aculeata</i> <i>Conostylis juncea</i> <i>Phlebocarya ciliata</i>
Iridaceae	* <i>Gladiolus caryophyllaceus</i> <i>Patersonia occidentalis</i> * <i>Romulea rosea</i> * <i>Watsonia meriana</i> var. <i>bulbelifera</i>
Orchidaceae	* <i>Disa bracteata</i> <i>Microtis media</i>
Casuarinaceae	<i>Allocasuarina fraseriana</i>
Proteaceae	<i>Adenanthos cygnorum</i> subsp. <i>cygnorum</i> <i>Banksia attenuata</i> <i>Banksia menziesii</i> <i>Petrophile linearis</i>
Polygonaceae	* <i>Acetosella vulgaris</i> * <i>Rumex crispus</i>
Chenopodiaceae	* <i>Chenopodium glaucum</i>
Aizoaceae	* <i>Carpobrotus edulis</i>
Molluginaceae	<i>Macarthuria australis</i>
Lauraceae	<i>Cassytha glabella</i> forma <i>glabella</i>
Mimosaceae	<i>Acacia pulchella</i>
Papilionaceae	<i>Bossiaea eriocarpa</i> <i>Gompholobium tomentosum</i> <i>Hovea trisperma</i> <i>Jacksonia furcellata</i> <i>Jacksonia sericea</i> (P4) * <i>Lotus subbiflorus</i> * <i>Ornithopus compressus</i> * <i>Trifolium arvense</i> * <i>Trifolium subteranneum</i>

APPENDIX A

VASCULAR PLANT SPECIES RECORDED ON LOTS 1, 2, 3, 4 HOLMES ST AND LOTS 1600 AND 1601 BALFOUR ST, SOUTHERN RIVER, 2007

Note: * signifies introduced (weed) taxa

FAMILY	SPECIES
Myrtaceae	<i>Agonis flexuosa</i> <i>Calytrix fraseri</i> * <i>Eucalyptus grandis</i> <i>Eucalyptus tottiana</i> <i>Kunzea glabrescens</i> <i>Melaleuca lateritia</i> <i>Melaleuca preissiana</i> <i>Melaleuca raphiophylla</i> <i>Melaleuca serata</i> <i>Melaleuca teretifolia</i> <i>Melaleuca thymoides</i> <i>Scholtzia involucreta</i>
Apiaceae	<i>Centella asiatica</i>
Boraginaceae	* <i>Echium plantagineum</i>
Lamiaceae	<i>Hemiandra pungens</i>
Solanaceae	* <i>Solanum nigrum</i>
Campanulaceae	* <i>Wahlenbergia capensis</i>
Goodeniaceae	<i>Dampiera linearis</i>
Asteraceae	* <i>Conyza albida</i> * <i>Cotula coronopifolia</i> * <i>Hypochaeris glabra</i> * <i>Sonchus asper</i> * <i>Sonchus oleraceus</i> * <i>Symphotrichum squamatum</i> * <i>Ursinia anthemoides</i>

APPENDIX B:

Species occurrence in each community recorded on Lots 1, 2, 3 &
4 Holmes St, and Lot 1600 and Pt Lot 1601 Balfour St, Southern
River, 2007

APPENDIX B

SPECIES OCCURRENCE IN EACH COMMUNITY RECORDED AT HOLMES AND BALFOUR STREETS, SOUTHERN RIVER, 2007

Species (* denotes introduced)	Community			
	R1	R2	S1	S2
<i>Acacia pulchella</i>				X
* <i>Acetosella vulgaris</i>			X	
<i>Adenanthos cygnorum</i> subsp. <i>cygnorum</i>				X
<i>Agonis flexuosa</i>	X		X	
<i>Allocasuarina fraseriana</i>				X
* <i>Alopecurus myosuroides</i>			X	
<i>Anigozanthus manglesii</i>				X
* <i>Avena barbata</i>	X		X	
<i>Banksia attenuata</i>				X
<i>Banksia menziesii</i>				X
<i>Baumea juncea</i>			X	
<i>Bossiaea eriocarpa</i>				X
* <i>Briza maxima</i>			X	X
* <i>Briza minor</i>	X		X	
* <i>Bromus diandrus</i>	X		X	
<i>Burchardia congesta</i>				X
<i>Calytrix fraseri</i>				X
* <i>Carpobrotus edulis</i>		X	X	
<i>Cassytha glabella</i> forma <i>glabella</i>	X		X	
<i>Centella asiatica</i>			X	
* <i>Chenopodium glaucum</i>			X	
<i>Conostylis aculeata</i> subsp. <i>aculeata</i>		X		
<i>Conostylis juncea</i>				X
* <i>Conyza albida</i>			X	
* <i>Cortaderia selloana</i>			X	
* <i>Cotula coronopifolia</i>			X	
* <i>Cynodon dactylon</i>			X	
<i>Dampiera linearis</i>				X
<i>Dasypogon bromeliifolius</i>				X
<i>Desmodium flexuosus</i>				X
* <i>Disa bracteata</i>		X		X
* <i>Echium plantagineum</i>	X			
* <i>Ehrharta calycina</i>	X	X		X
* <i>Eragrostis curvula</i>	X	X		X
* <i>Eucalyptus grandis</i>			X	
<i>Eucalyptus tottiana</i>	X			X
* <i>Gladiolus</i> sp.				X
<i>Gompholobium tomentosum</i>				X
<i>Hemiandra pungens</i>				X
<i>Hovea trisperma</i>				X
* <i>Hypochaeris glabra</i>	X	X		X
<i>Hypoleana exsulca</i>		X		
* <i>Isolepis marginata</i>			X	
<i>Isolepis producta</i>			X	
<i>Jacksonia furcellata</i>				X
<i>Jacksonia sericea</i> (P4)				X

APPENDIX 6

Bushfire Management Plan



BUSHFIRE MANAGEMENT PLAN

Strategic Planning Proposal (Structure Plan Amendment)

Lots 2, 23 & 24 Holmes Road and Lots 1, 1600 & 1601 Balfour Street, Southern River

Version: 2.1 Reference: 3029 October 2016



Project Number: 3029

Project Name: Lots 2, 23 & 24 Holmes Road and Lots 1, 1600 & 1601 Balfour Street, Southern River

Author: Darrel Krammer, Grad Cert Bushfire Protection, BPAD33412 Level 1

Version: 2.1 FINAL RELEASE

Date of issue: 05th October 2016

A handwritten signature in black ink, appearing to read "D. Krammer", written over a horizontal line.

Author:
Date: 05/10/2016

In the signing the above, the author declares that this Bushfire Management Plan meets the requirements of State Planning Policy 3.7. This report supersedes all previous Bushfire Management Plans for the site.

DISCLAIMER AND LIMITATION

This report is prepared solely for **GHT Pty Ltd ATF The Guce Holding Trust** (the 'proponent') and any future landowners of the subject lot(s) and is not for the benefit of any other person and may not be relied upon by any other person.

The mitigation strategies contained in this Bushfire Management Plan are considered to be prudent minimum standards only, based on the writer's experience as well as standards prescribed by relevant authorities. It is expressly stated that RUIC Fire and the writer do not guarantee that if such standards are complied with or if a property owner exercises prudence, that a building or property will not be damaged or that lives will not be lost in a bush fire.

Fire is an extremely unpredictable force of nature. Changing climatic factors (whether predictable or otherwise) either before or at the time of a fire can also significantly affect the nature of a fire and in a bushfire prone area it is not possible to completely guard against bushfire.

Further, the growth, planting or removal of vegetation; poor maintenance of any fire prevention measures; addition of structures not included in this report; or other activity can and will change the bushfire threat to all properties detailed in the report. Further, the achievement of the level of implementation of fire precautions will depend on the actions of the landowner or occupiers of the land, over which RUIC Fire has no control. If the proponent becomes concerned about changing factors then a new Fire Risk Management Plan should be requested.

To the maximum extent permitted by the law, RUIC Fire, its employees, officers, agents and the writer ("RUIC Fire") excludes all liability whatsoever for:

1. claim, damage, loss or injury to any property and any person caused by fire or as a result of fire or indeed howsoever caused;
2. errors or omissions in this report except where grossly negligent; and

the proponent expressly acknowledges that they have been made aware of this exclusion and that such exclusion of liability is reasonable in all the circumstances.

If despite the provisions of the above disclaimer RUIC Fire is found liable then RUIC Fire limits its liability to the lesser of the maximum extent permitted by the law and the proceeds paid out by RUIC Fire's professional or public liability insurance following the making of a successful claim against such insurer.

RUIC Fire accepts no liability or responsibility whatsoever for or in respect of any use or reliance upon this report and its supporting material by any third party.

This report is valid for a period of three years only from the date of its issue. All BAL ratings identified in this report are indicative and are required to be verified at the time of construction of individual buildings to ensure appropriate setbacks identified in the proposed development have been achieved.

RUIC Fire is a trading name of

Rural Fire Risk Consultancy Pty Ltd

ABN: 48 151 451 713

Contents Page

1.0	Introduction	5
1.1	Subject Site	5
1.2	Development Description	5
1.3	Previous Bushfire Assessments	5
2.0	Spatial consideration of bushfire threat	9
2.1	Bushfire Fuels and Potential Bushfire Impact	9
2.2	Bushfire Hazard Issues	16
3.0	Proposal compliance and justification	18
3.1	State Planning Policy 3.7 – Planning in Bushfire Prone Areas (SPP 3.7)	18
3.1.1	Objectives	18
3.1.2	Policy Measures	18
3.2	Guidelines for Planning in Bushfire Prone Areas (the Guidelines)	20
4.0	Bushfire Risk Management Measures	21
4.1	Element 1 - Location	21
4.2	Element 2 - Siting and design of Development	21
4.3	Element 3 - Vehicular Access	23
4.4	Element 4 – Water	27
5.0	Implementation and Enforcement	30
6.0	Conclusion	31
7.0	References	32
8.0	Appendix 1 – Landscaping Plan	33

1.0 Introduction

1.1 Subject Site

The site the subject of this Bushfire Management Plan (BMP) is Lots 2, 23 & 24 Holmes Road and Lots 1, 1600 & 1601 Balfour Street Southern River. The site is bound to the east by Balfour Road and to the north by Holmes Road.

The site is located within the municipality of the City of Gosnells. Figure 1A illustrates the subject site and its immediate surrounds. Figure 1B illustrates the concept subdivision plan within the site boundaries.

The site is identified as being Bushfire Prone on the State Bushfire Prone Maps.

An independent Wetland Management Plan was developed that identifies Bush Forever Site 125, and a Conservation Category Wetland (within and bordering the development site) as areas of conservation value that should be preserved. Approximately 4.14 ha of the area is occupied by Bush Forever site 125. This area is reserved for parks and recreation under the metropolitan regional scheme (Endemic, 2016). Figure 1C details the extent of the Bush Forever areas within and surrounding the site (WALGA, 2016).

Much of the central portion of the lots is identified as wetlands. This BMP has been developed with due regard to the Wetland Management Plan prepared by Endemic & Associates Pty Ltd (2016) and the Landscaping Plan (Calibre, 2016). As such, bushfire risk management strategies detailed within the BMP will not impact on the conservation areas.

The proponent has not identified any other relevant environmental considerations within the site or being affected by the development.

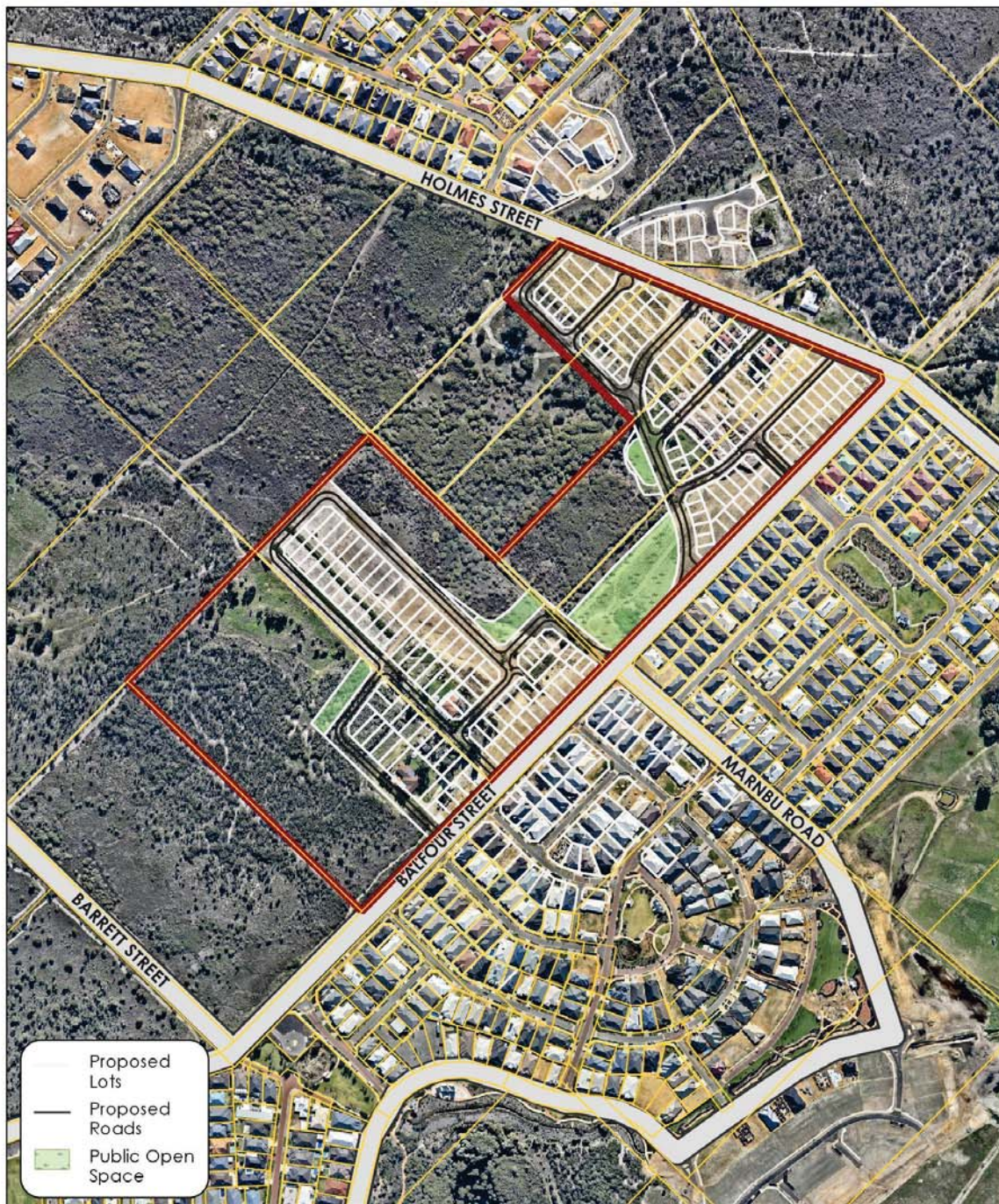
1.2 Development Description

It is proposed to develop the site as residential living, with managed Public Open Space (POS), Parks and Recreation areas and Conservation Management Wetlands (Figure 1B).

The land is currently subject to an amendment to the Structure Plan to facilitate the development. This BMP is required to satisfy Condition 17 (WAPC GOSN/2015/3).

1.3 Previous Bushfire Assessments

A previous Bushfire Management Plan was prepared for the site by RUIC Fire in 2015 (RUIC Fire, V1.0, March 2015). It was completed in accordance with the now superseded Planning for Bushfire Protection Guidelines, 2nd Edition 2010. This BMP supersedes the former BMP.



1300 797 607
ruicfire.com.au

BUSHFIRE MANAGEMENT PLAN MAP
Lot 1 & 4 Holmes Street, Southern River

Site Overview

-  Site Boundary
-  Cadastre
-  Main Road



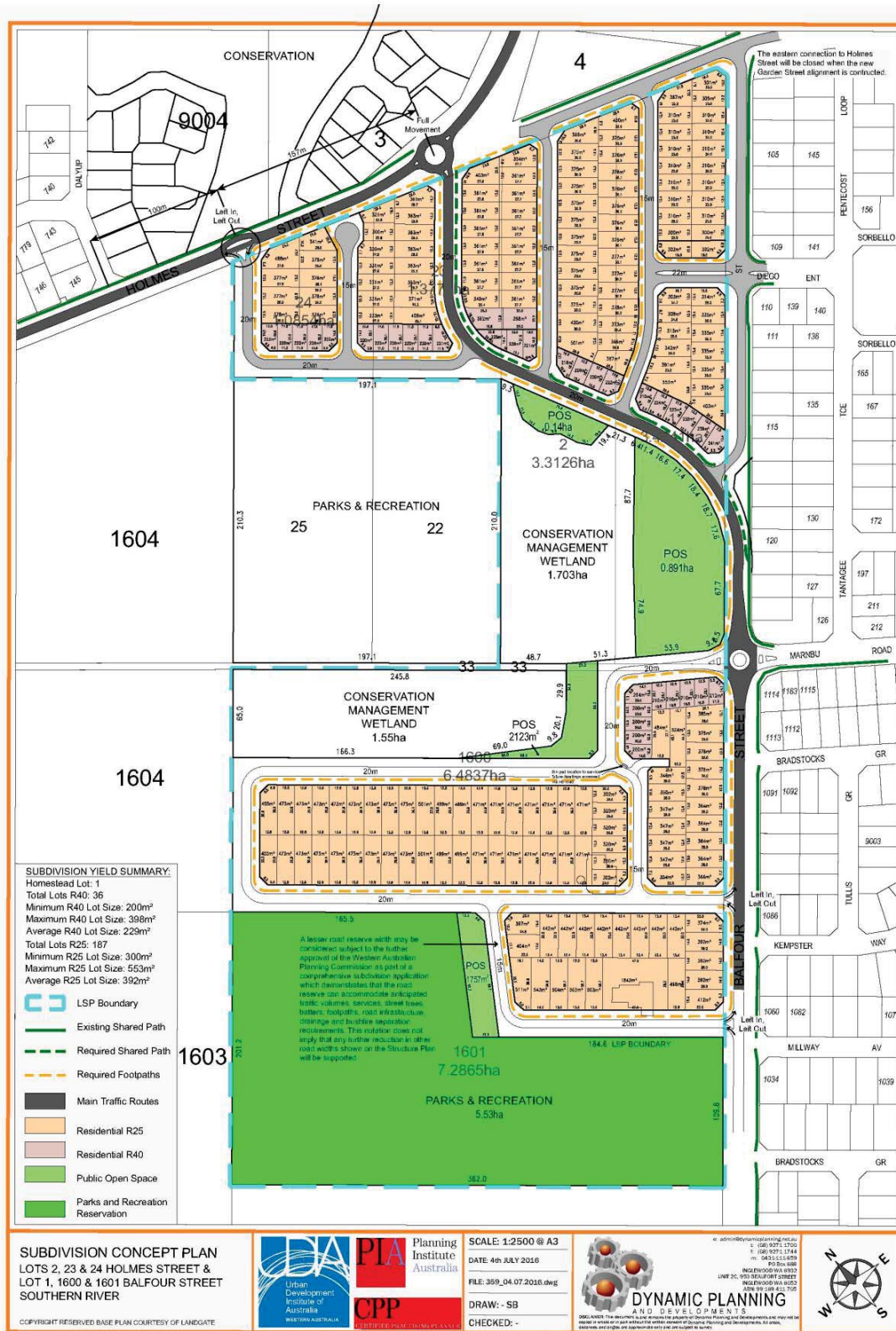
Size: A4
Scale: 1:5,500

0 50 100 150 200 250 m

Ref: 3029_001_01_BaseMap_20160809
Projection: GDA94 MGA50
Author: MWA - RUIC | Date: 2016-10-04
Data Source: Cadastre - Landgate; Imagery -
Nearmap; Roads, Site Boundary, Veg, BAL, Buffers,
BVS - RUIC.

Disclaimer: Although the data within this map is considered accurate at the time of creation, RUIC Fire does not guarantee, and accept no legal liability whatsoever arising from or connected to, the accuracy, reliability, currency or completeness of any data used within this map.

Figure 1A: Site Overview



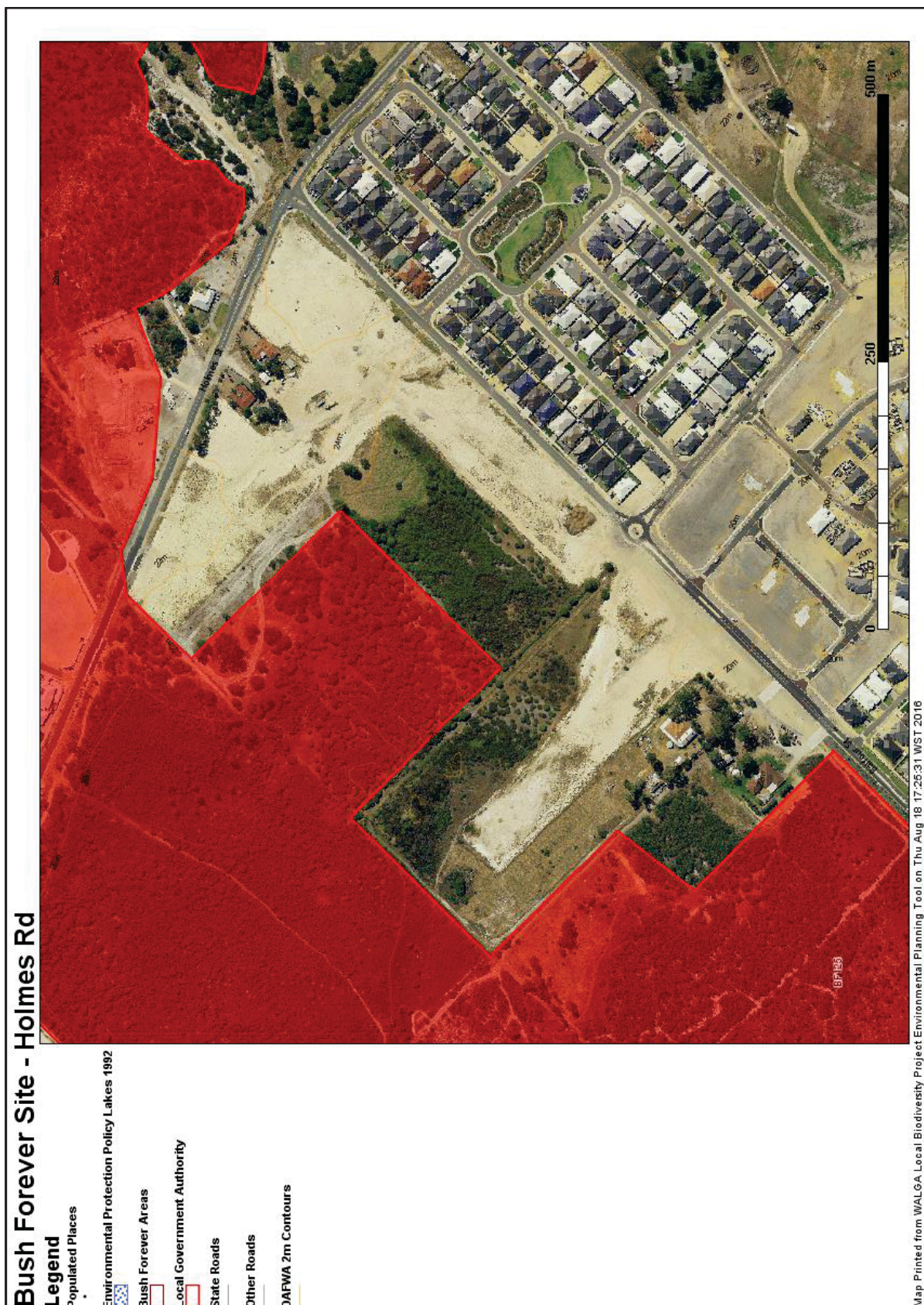


Figure 1C: Bush Forever Overlay (WALGA Environmental Planning Tool, 2016)

2.0 Spatial consideration of bushfire threat

2.1 Bushfire Fuels and Potential Bushfire Impact

The location and extent of AS 3959 vegetation structures, including Clause 2.2.3.2 exclusions, within 100 metres of the site are mapped in Figure 2A and illustrated in the photos below. Bushfire fuel loads are identified as consistent with AS 3959 Table B2 for radiant heat flux modelling purposes. All bushfire structures and fuel loads are assessed in their mature states (including revegetation and rehabilitation areas) unless otherwise identified.

All vegetation on site will be removed as part of the development, with the exception of the Conservation Management Wetlands and Parks & Recreation areas. If the development is to be staged, all vegetation excluding the Conservation Management Wetland and Parks and Recreation areas, within 100 metres of residential lots will be reduced to low threat vegetation. Public Open Space (POS) lots will be managed as low threat vegetation in accordance with AS 3959 Clause 2.2.3.2(f) as detailed in the Landscaping Plan at Appendix 1 (Calibre, 2016). This will be specifically addressed at the subdivision stage of planning when staging and detailed landscape management plans are available (if applicable).

Plot 1



Pre Development

Exclusion 2.2.3.2 (e) non vegetated area & (f) maintained lawns

Post Development

Exclusion 2.2.3.2 (e) non vegetated area & (f) maintained lawns

Plot 2



Pre Development

Class B Woodland

Post Development

Class B Woodland

Plot 3



Pre Development

Exclusion 2.2.3.2 (e) non vegetated area & (f) maintained lawns

Post Development

Exclusion 2.2.3.2 (e) non vegetated area & (f) maintained lawns

Plot 4



Pre Development

Class B Woodland

Post Development

Class B Woodland

Plot 5



Pre Development

Exclusion 2.2.3.2 (e) non vegetated area & (f) maintained lawns

Post Development

Exclusion 2.2.3.2 (e) non vegetated area & (f) maintained lawns

Plot 6

DIRECTION 245 deg(T)	32.09236°S 115.95457°E	ACCURACY 5 m DATUM WGS84
-------------------------	---------------------------	-----------------------------



Pre Development

Class D Scrub

Post Development

Class D Scrub

Plot 7

DIRECTION 140 deg(T)	32.09298°S 115.95421°E	ACCURACY 5 m DATUM WGS84
-------------------------	---------------------------	-----------------------------



Pre Development

Class G Grassland

Post Development

Class G Grassland

Plot 8

DIRECTION 258 deg(T)	32.09481°S 115.95570°E	ACCURACY 5 m DATUM WGS84
-------------------------	---------------------------	-----------------------------



Pre Development

Class D Scrub

Post Development

Class D Scrub

Plot 9



Pre Development

Class D Scrub

Post Development

Class D Scrub - contained within Conservation Management Wetland area

Plot 10



Pre Development

Class C Shrub

Post Development

Class C Shrub

Plot 11



Pre Development

Class G Grassland

Post Development

Class G Grassland – contained within Parks and Recreation area

Plot 12



Pre Development

Class D Scrub

Post Development

Class D Scrub – contained within Parks and Recreation area

Plot 13



Pre Development

Class G Grassland

Post Development

Planted basin being revegetated to Class D Scrub

Plot 14



Pre Development

Low Threat exclusion 2.2.3.2 (e) non vegetated areas.

Post Development

Replaced with Exclusion 2.2.3.2 (f) maintained lawns/public reserves.

Plot 15



Pre Development

Class D Scrub

Post Development

Replaced with Exclusion 2.2.3.2 (f) maintained lawns/public reserves.

Plot 16



Pre Development

Class G Grassland

Post Development

Replaced with Exclusion 2.2.3.2 (f) maintained lawns/public reserves.

Nearmap image due to restricted access

Potential bushfire impact analysis was undertaken in accordance with AS 3959 Methodology 1 to determine the potential worst case scenario radiant heat impact on the lots within the proposed subdivision. In accordance with SPP 3.7, a BAL Contour Map has been prepared to illustrate the potential radiant heat impacts and associated BAL ratings for the assessment area after the development is completed (see Figure 2A).

The following table, Table 2A, outlines the worst case BAL from each of the vegetation plots based on the vegetation class, effective slope and separation distance to the development site post development. The slope of land throughout the site is constant and can be considered to be flat/ upslope.

The worst case scenario is determined by measuring the distance between each vegetation Plot and the nearest residential lot boundary. This BMP is to be updated to include final BAL ratings per lot, during the subdivision planning stage.

Table 2A: Worst case BAL that applies to the external boundaries of the residential lots (the habitable development area) Post Development

Plot	Vegetation Classification	Effective Slope	Separation (m)	BAL
1	Exclusion 2.2.3.2 (e) non vegetated areas & (f) maintained lawns	N/A	N/A	N/A
2	Class B Woodland	Flat/Upslope	19	BAL-29
3	Exclusion 2.2.3.2 (e) non vegetated areas & (f) maintained lawns	N/A	N/A	N/A
4	Class B Woodland	Flat/Upslope	41	BAL-12.5
5	Exclusion 2.2.3.2 (e) non vegetated areas & (f) maintained lawns	N/A	N/A	N/A
6	Class D Scrub	Flat/Upslope	20	BAL-19
7	Class G Grassland	Flat/Upslope	20	BAL-12.5
8	Class D Scrub	Flat/Upslope	20	BAL-19
9	Class D Scrub	Flat/Upslope	20	BAL-19
10	Class C Shrubland	Flat/Upslope	19.5	BAL-12.5
11	Class G Grassland	Flat/Upslope	20	BAL-12.5
12	Class D Scrub	Flat/Upslope	23	BAL-19
13	Class D Scrub	Flat/Upslope	20	BAL-19
14	Exclusion 2.2.3.2 (e) non vegetated areas & (f) maintained lawns/public reserves	N/A	N/A	N/A
15	Exclusion 2.2.3.2 (e) non vegetated areas & (f) maintained lawns/public reserves	N/A	N/A	N/A
16	Exclusion 2.2.3.2 (e) non vegetated areas & (f) maintained lawns/public reserves	N/A	N/A	N/A

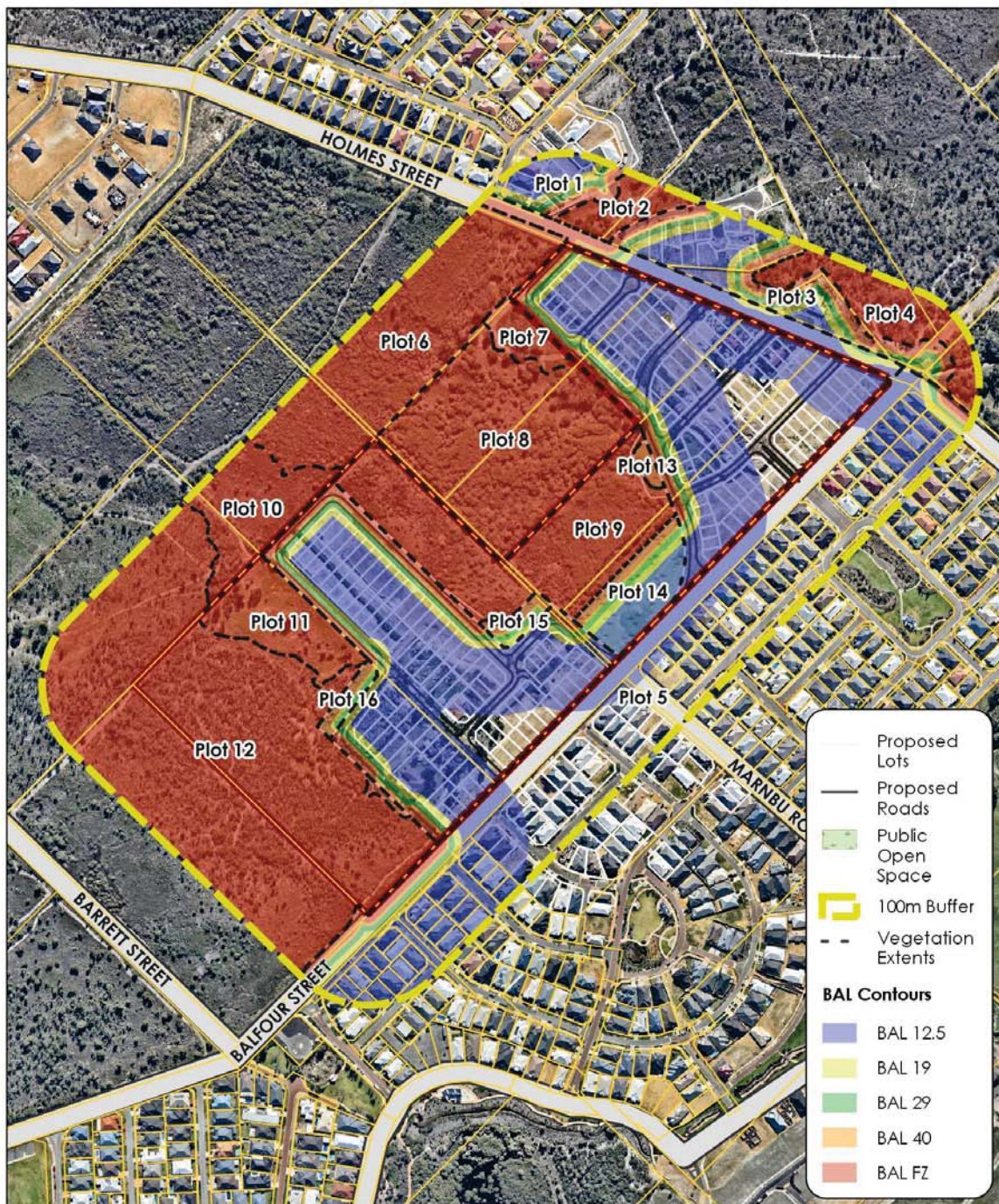
From Table 2A and Figure 2A it can be seen that the highest BAL applicable to any of the residential lots within the proposed concept subdivision plan is BAL-29. This complies with Acceptable Solution A1.1.

2.2 Bushfire Hazard Issues

From the BAL Contour Map, the following bushfire hazard issues have been identified.

- There are lots in the proposed development with a BAL of BAL-12.5 or higher. Future residential BCA Class 1, 2, 3 or 10a buildings are to be constructed to the applicable construction standard of AS 3959. Identification of individual BAL ratings per lot will be shown for the subdivision stage of planning.
- During construction (staging of development), a separation of at least 100 metres is required to be provided to any classifiable vegetation on site (where practicable).
- The BAL Contour map prepared as part of this BMP is to be considered indicative. A site wide confirmatory BAL Contour map or individual lot BAL assessments is required to be completed post subdivision completion to confirm actual BAL ratings.

Section 4 of this BMP addresses bushfire protection criteria.



1300 797 607
ruicfire.com.au

BUSHFIRE MANAGEMENT PLAN MAP
Lot 1 & 4 Holmes Street, Southern River

BAL Contours



Size: A4
Scale: 1:5,500

0 50 100 150 200 250 m

Ref: 3029_002_01_BAL_20160809
Projection: GDA94 MGA50
Author: MM - RUIC | Date: 2016-10-04
Data Source: Cadastre - Landgate; Imagery -
Nearmap; Roads, Site Boundary, Veg, BAL, Buffers,
BMS - RUIC.

Disclaimer: Although the data within this map is considered accurate at the time of creation, RUIC Fire does not guarantee, and accepts no legal liability whatsoever arising from or connected to, the accuracy, reliability, currency or completeness of any data used within this map.

- Site Boundary
- Cadastre
- Main Road

Figure 2A: BAL Contour Map

3.0 Proposal compliance and justification

3.1 State Planning Policy 3.7 – Planning in Bushfire Prone Areas (SPP 3.7)

SPP3.7 applies to all development applications in designated bushfire prone areas.

3.1.1 Objectives

Policy Measure 5 contains the objectives of SPP3.7. The following demonstrates how the proposed development meets each of the objectives.

Objective 1: *Avoid any increase in the threat of bushfire to people, property and infrastructure. The preservation of life and the management of bushfire impact are paramount.*

Development Response

Objective 1 is satisfied through the compliance of the proposed development with all required Policy Principles as detailed below and all Performance Principles of the Guidelines as detailed in Section 4 of this report.

Objective 2: *Reduce vulnerability to bushfire through the identification and consideration of bushfire risks in decision-making at all stages of the planning and development process.*

Development Response

Objective 2 is satisfied through the appropriate identification and assessment of all relevant bushfire hazards as detailed in Section 2 of this report, specifically the BAL Contour Mapping.

Objective 3: *Ensure that higher order strategic planning documents, strategic planning proposals, subdivision and development applications take into account bushfire protection requirements and include specified bushfire protection measures.*

Development Response

Objective 3 is satisfied through the compliance of the proposed development with all required Policy Principles as detailed below and all Performance Principles of the Guidelines as detailed in Section 4 of this report.

Objective 4: *Achieve an appropriate balance between bushfire risk management measures and, biodiversity conservation values, environmental protection and biodiversity management and landscape amenity, with consideration of the potential impacts of climate change.*

Development Response

Objective 4 is satisfied through the appropriate consideration of all biodiversity and environmental assets as detailed in Section 1 of this report in the development of bushfire related risk mitigation strategies detailed in Section 4 of this report.

3.1.2 Policy Measures

3.1.2.1 Strategic Planning Proposals

Policy Measure 6.2 requires that strategic planning proposals within designated bushfire prone areas and that have a BAL above BAL-LOW are to comply with Policy Measure 6.3.

3.1.2.2 Information to Accompany Strategic Planning Proposals

Policy Measure 6.3 applies to Strategic Planning Proposals. It requires certain information to be provided with such applications. The following outlines where the required information has been provided.

Table 3A: Compliance of the proposed development with the Policy Measures of SPP 3.7.

Policy Measure	Description	Development Response
a	(i) the results of a BHL assessment determining the applicable hazard level(s) across the subject land, in accordance with the methodology set out in the Guidelines. BHL assessments should be prepared by an accredited Bushfire Planning Practitioner; or (ii) where the lot layout of the proposal is known, a BAL Contour Map to determine the indicative acceptable BAL ratings across the subject site, in accordance with the Guidelines. The BAL Contour Map should be prepared by an accredited Bushfire Planning Practitioner; and	Figure 2A provides the BAL Contour Map.
b	The identification of any bushfire hazard issues arising from the relevant assessment; and	Section 2.2 addresses the bushfire hazard issues.
c	Clear demonstration that compliance with the bushfire protection criteria in the Guidelines can be achieved in subsequent planning stages.	Section 4 provides an assessment of the development against the bushfire protection criteria.

3.1.2.3 Vulnerable or High Risk Land Uses

The proposed development, at this stage, is not known to contain any vulnerable or high risk land uses.

3.1.2.4 Applications in BAL-40/BAL-FZ Areas

On completion of development, the developable land would not be subject to BAL-40 or BAL-FZ as outlined in Section 2.1.

3.1.2.5 Advice of State/Relevant Authority/s for Emergency Services to be Sought

The proposed subdivision:

- Complies with the SPP3.7 Policy measures;
- Does not propose any additional/alternative measures; and
- Does not contain unavoidable development, vulnerable or high risk land uses.

Therefore, the advice of State/Relevant Authorities for Emergency Services is not required to be sought for this application.

3.1.2.6 Advice of State/Relevant Agencies/Authorities for Environmental Protection to be Sought

The proposed subdivision:

- Is not known to propose clearing of vegetation within environmentally sensitive areas protected under State or Federal legislation;
- Is not known to propose clearing of locally significant native vegetation; and
- Does abut vegetated land managed by that authority.

The State/Relevant Agencies/Authorities for Environmental Protection has been consulted in the preparation of the Wetland Management Plan and may require further consultation for the application.

3.2 Guidelines for Planning in Bushfire Prone Areas (the Guidelines)

The Guidelines apply to development applications located within designated bushfire prone areas. The Guidelines provide supporting information for implementation of SPP3.7. Specifically, they provide the Bushfire Protection Criteria to be address for all applications.

This report has also been developed in order to comply with the requirements of all referenced and applicable documents. No non-compliances have been identified.

4.0 Bushfire Risk Management Measures

The bush fire risk mitigation strategies detailed in this report are designed to comply with the Bushfire Protection Criteria detailed in Guidelines for Planning in Bushfire Prone Areas (the Guidelines) Appendix 4 (2015).

- i. The notation (P3) refers to Performance Principle 3 of the Guidelines Appendix 4.
- ii. The notation (A3.1) refers to Acceptable Solution 3.1 of the Guidelines Appendix 4.
- iii. The notation (E3.1) refers to Explanatory Note 3.1 of the Guidelines Appendix 4.
- iv. Where discrepancy occurs between State and Local bushfire planning provisions the higher standard of mitigation has been selected.

4.1 Element 1 - Location

Intent: To ensure that strategic planning proposals, subdivision and development applications are located in areas with the least possible risk of bushfire to facilitate the protection of people, property and infrastructure.

Performance Principle (P1): The strategic planning proposal, subdivision and development application is located in an area where the bushfire hazard assessment is or will, on completion, be moderate or low, or a BAL-29 or below, and the risk can be managed. For minor or unavoidable development in areas where BAL-40 or BAL-FZ applies, demonstrating that the risk can be managed to the satisfaction of the Department of Fire and Emergency Services and the decision-maker.

Acceptable Solution A1.1 Development location

The strategic planning proposal, subdivision and development application is located in an area that on completion will be subject to a BAL-29 or below for all habitable buildings.

Development Response/Recommendations

As outlined in Figure 2A and Table 2A, the development would ensure that all future habitable development areas are, upon completion of development, located in an area subject to BAL-29 or lower.

The BAL Contour map prepared as part of this BMP is to be considered indicative. A site wide confirmatory BAL Contour map or individual lot BAL assessments is required to be completed post subdivision completion to confirm actual BAL ratings.

4.2 Element 2 - Siting and design of Development

Intent: To ensure that the siting of development minimises the level of bushfire impact.

Performance Principle (P2): The siting and design of the strategic planning proposal, subdivision or development application, including roads, paths and landscaping, is appropriate to the level of bushfire threat that applies to the site. That it minimises the bushfire risk to people, property and infrastructure, including compliance with AS 3959 if appropriate.

Acceptable Solution A2.1 Asset Protection Zone (APZ)

Every building is surrounded by an Asset Protection Zone (APZ), depicted on submitted plans, which meets the following requirements:

- a. Width: 20 metres measured from any external wall of future buildings. Where the slope increases above 10 degrees, the APZ should be increased to ensure the potential radiant heat impact of a fire does not exceed 29kW/m²;
- b. Location: within the boundaries of the lot on which the building is situated;
- c. Fine fuel load: reduced to and maintained at 2 tonnes per hectare;
- d. Trees (crowns) are a minimum distance of ten metres apart. A small group of trees within close proximity to one another may be treated as one crown provided the combined crowns do not exceed the area of a large or mature crown size for that species;
- e. No tall shrubs or trees located within 2 metres of a building;
- f. No tree crowns overhanging the building;
- g. Fences and sheds within APZ are constructed using non-combustible materials (eg. iron, brick, limestone, metal post and wire); and
- h. Sheds within the APZ should not contain flammable materials.

Development Response/Recommendations

Asset Protection Zones are to be established across all lots as illustrated in Figure 4A and may include adjacent roadways and POS. Additional roadways and urban development external to the site boundaries provide further separation from classified vegetation.

Implementation

- i. APZs to be implemented prior to the clearance of subdivision for affected lots in accordance with Figure 4A and provisions b-h above.
- ii. It is the responsibility of the developer to ensure the APZ standard is established.
- iii. It is the responsibility of the individual property owner (private land)/local government (in road reserves/reserves) to ensure the APZ standard continues to be achieved post completion of the construction.

Acceptable Solution A2.2 Hazard Separation Zone (HSZ)

Every building and its contiguous APZ is surrounded by a Hazard Separation Zone (HSZ), depicted on submitted plans, that meets the following requirements:

- a. Minimum width: 80 metres, measured from the outer edge of the APZ, for any vegetation classified in AS 3959 as forests, woodlands, closed shrub, open shrub, mallee/mulga and rainforest; OR 30 metres, measured from the outer edge of the APZ, for unmanaged grassland;
- b. Location: within the boundaries of the lot on which the building is situated or, where this is not possible or desirable, within the boundaries of the development precinct in which the building is proposed to be located; and
- c. Fine Fuel load (Dead Material <6mm diameter and <3mm for live material): reduced to and maintained at between five and eight tonnes per hectare for jarrah/marri dominated forest and woodlands, below 12-15 tonnes per hectare in mallee heath and below 15 tonnes per hectare in karri forest.

Note: A HSZ may not be required if the proposed construction meets the standard appropriate to the BAL for that location, and does not exceed BAL-29.

Development Response/Recommendations

No BAL on site will exceed BAL-29. Construction standards will be applied to relevant buildings in accordance with AS 3959 as part of the future Building Permits. In this regard a HSZ is not required for this development. The development can achieve the requirement of A2.2.

4.3 Element 3 - Vehicular Access

Intent: To ensure that the vehicular access serving a subdivision/ development is safe in the event of a bush fire occurring.

Performance Principle (P3): The internal layout, design and construction of public and private vehicular access in the subdivision/development allows emergency and other vehicles to move through it easily and safely at all times.

Solution	AS	PS	N/A	Comment
A4.1 Two Access Routes	☒	☐	☐	
A4.2 Public Road	☒	☐	☐	
A4.3 Cul-de-sac	☒	☐	☐	
A4.4 Battle-axe	☐	☐	☒	
A4.5 Private Driveway longer than 50 metres	☐	☐	☒	
A4.6 Emergency Access Way	☒	☐	☐	One emergency access way
A4.7 Fire Service Access Routes	☐	☐	☒	
A4.8 Firebreak width	☒	☐	☐	Applicable during construction

Acceptable Solution A3.1 Two access routes

Two different vehicular access routes are provided, both of which connect to the public road network, provide safe access and egress to two different destinations and are available to all residents/the public at all times and under all weather conditions.

Development Response/Recommendations

The development achieves at least two different vehicular access routes from all lots, both connecting to the public road network to provide egress to two different destinations at all times. Construction staging is to ensure at least two access routes are provided at all times. Therefore, the development will comply with A4.1.

Acceptable Solution A3.2 Public roads

A public road is to meet the requirements in Table 4A, Column 1.

Table 4A: Vehicular access technical requirements

Technical Requirement	Public road	Cul-de-sac	Private driveway	Emergency access way	Fire service access routes
Minimum trafficable surface (m)	6	6	4	6	6
Horizontal clearance (m)	6	6	6	6	6
Vertical clearance (m)	4	N/A	4.5	4.5	4.5
Maximum grade over <50m	1 in 10	1 in 10	1 in 10	1 in 10	1 in 10
Minimum weight capacity (t)	15	15	15	15	15
Maximum crossfall	1 in 33	1 in 33	1 in 33	1 in 33	1 in 33
Curves minimum inner radius (m)	8.5	8.5	8.5	8.5	8.5

Development Response/Recommendations

All public roads shall be designed to meet the requirements of Table 4A.

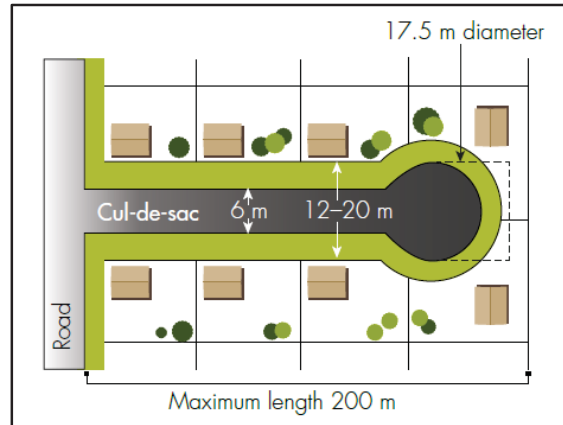
Implementation

- Public roads are to be constructed prior to the clearance of subdivision for affected lots serviced by the public road.
- It is the responsibility of the developer to ensure the public road standard is established in accordance with Table 4A.
- It is the responsibility of Local Government to ensure the maintenance of public roads vested within their jurisdiction.

Acceptable Solution A3.3 Cul-de-sac (including a dead-end road)

A cul-de-sac and/or a dead end road should be avoided in bushfire prone areas. Where no alternative exists (i.e. the lot layout already exists and/or will need to be demonstrated by the proponent), the following requirements are to be achieved:

- Requirements in Table 4A, Column 2;
- Maximum length: 200 metres (if public emergency access is provided between cul-de-sac heads maximum length can be increased to 600 metres provided no more than eight lots are serviced and the emergency access way is no more than 600 metres); and
- Turn-around area requirements, including a minimum 17.5 metre diameter head.



Source: Guidelines for Planning in Bushfire Prone Areas, Appendix 4, Fig. 18

Development Response/Recommendations

To limit traffic intersects with Holmes Rd, one cul-de-sac is proposed for the development in the northern portion of the site. The cul-de-sac is approximately 85m in length. Cul-de-sac construction is to comply with Table 4A, Column 2. An emergency access way will be required to connect the cul-de-sac head to Holmes Rd.

Implementation

- i. To be implemented prior to the clearance of subdivision for affected lots that the cul-de-sac services.
- ii. It is the responsibility of the developer to ensure the cul-de-sac meets the required standard in accordance with Table 4A.
- iii. It is the responsibility of the Local Government to ensure the cul-de-sac continues to meet the required standard for any permanent cul-de-sacs.

Acceptable Solution A3.4 Battle-axe

Battle-axe access leg should be avoided in bushfire prone areas. Where no alternative exists, (this will need to be demonstrated by the proponent) all of the following requirements are to be achieved:

- a. Requirements in Table 4A, Column 3;
- b. Maximum length: 600 metres; and
- c. Minimum width: six metres.

Development Response/Recommendations

No battle-axe lots are proposed as part of the development. Therefore, A3.4 is not applicable to this development.

Acceptable Solution 3.5 Private Driveway longer than 50 metres

A private driveway is to meet all of the following requirements:

- a. Requirements in Table 4A, Column 3;
- b. Required where a house site is more than 50 metres from a public road;

- c. Passing bays: every 200 metres with a minimum length of 20 metres and a minimum width of two metres (i.e. the combined width of the passing bay and constructed private driveway to be a minimum six metres);
- d. Turn-around areas designed to accommodate type 3.4 fire appliances and to enable them to turn around safely every 500 metres (i.e. kerb to kerb 17.5 metres) and within 50 metres of a house; and
- e. Any bridges or culverts are able to support a minimum weight capacity of 15 tonnes.
- f. All-weather surface (i.e. compacted gravel, limestone or sealed).

Development Response/Recommendations

No private driveways longer than 50 metres are proposed as part of the development. Therefore, A3.5 is not applicable to the development.

Acceptable Solution 3.6 Emergency Access Way

An access way that does not provide through access to a public road is to be avoided in bushfire prone areas. Where no alternative exists (this will need to be demonstrated by the proponent), an emergency access way is to be provided as an alternative link to a public road during emergencies. An emergency access way is to meet all of the following requirements:

- a. Requirements in Table 4, Column 4;
- b. No further than 600 metres from a public road;
- c. Provided as right of way or public access easement in gross to ensure accessibility to the public and fire services during an emergency; and
- d. Must be signposted.

Development Response/Recommendations

One Emergency Access Way (EAW) is required from the proposed cul-de-sac to Holmes Rd. The EAW is required to be constructed to the standards of Table 4A, Column 4.

Acceptable Solution 3.7 Fire Service Access Routes (Perimeter Roads)

Fire service access routes are to be established to provide access within and around the edge of the subdivision and related development to provide direct access to bushfire prone areas for fire fighters and link between public road networks for firefighting purposes. Fire service access routes are to meet the following requirements:

- a. Requirements Table 4, Column 5;
- b. Provided as right of ways or public access easements in gross to ensure accessibility to the public and fire services during an emergency;
- c. Surface: all-weather (i.e. compacted gravel, limestone or sealed)
- d. Dead end roads are not permitted;
- e. Turn-around areas designed to accommodate type 3.4 appliances and to enable them to turn around safely every 500 metres (i.e. kerb to kerb 17.5 metres);
- f. No further than 600 metres from a public road;
- g. Allow for two-way traffic and;
- h. Must be signposted.

Development Response/Recommendations

No Fire Service Access Routes are proposed as part of the development. Therefore, A3.7 is not applicable to the development.

Acceptable Solution A3.8 Firebreak width

Lots greater than 0.5 hectares must have an internal perimeter firebreak of a minimum width of three metres or to the level as prescribed in the local firebreak notice issued by the local government.

Development Response/Recommendations

Any balance title lots are required to have a three metre wide firebreak installed in accordance with the requirements of the City of Gosnells annual Firebreak Notice. Public roads and low threat vegetation within POS area, forming part of the development will serve as a firebreak, in lieu of further vegetation removal.

4.4 Element 4 – Water

Intent: To ensure that water is available to the subdivision, development or land use to enable people, property and infrastructure to be defended from bushfire.

Performance Principle (P4): The subdivision, development or land use is provided with a permanent and secure water supply that is sufficient for firefighting purposes.

Solution	AS	PBS	N/A	Comment
A4.1 Reticulated Areas	☒	☐	☐	
A3.2 Non-reticulated Areas	☐	☐	☒	
A3.3 Individual lots within non-reticulated areas	☐	☐	☒	

Acceptable Solution A4.1 Reticulated areas

The subdivision, development or land use is provided with a reticulated water supply in accordance with the specifications of the relevant water supply authority and Department of Fire and Emergency Services.

Development Response/Recommendations

The site will be serviced by reticulated scheme water and firefighting hydrants in accordance with the Water Corporations Design Standard No.63, satisfying Acceptable Solution A4.1. The locations of existing and future indicative hydrants are shown in Figure 4A.

Acceptable Solution A4.2 Non-reticulated areas

Water tanks for fire fighting purposes with a hydrant or standpipe are provided and meet the following requirements:

- a. Volume: minimum 50,000 litres per tank;
- b. Ratio of tanks to lots: minimum one tank per 25 lots (or part thereof);

- c. Tank location: no more than two kilometres to the further most house site within the residential development to allow a 2.4 fire appliance to achieve a 20 minute turnaround time at legal road speeds;
- d. Hardstand and turn-around areas suitable for a type 3.4 fire appliance (i.e. kerb to kerb 17.5 metres) are provided within three metres of each water tank; and
- e. Water tanks and associated facilities are vested in the relevant local government.

Development Response/Recommendations

The development will be connected to reticulated water supply. Therefore, A4.2 is not applicable to this development.

Acceptable Solution A4.3 Individual lots within non-reticulated areas

Single lots above 500 square metres need a dedicated static water supply on the lot that has the effective capacity of 10,000 litres.

Note - Only for use if creating one additional lot and cannot be applied cumulatively.

Development Response/Recommendations

The development will be connected to reticulated water supply. Therefore, A4.3 is not applicable to this development.



1300 797 607
ruicfire.com.au

BUSHFIRE MANAGEMENT PLAN MAP
Lot 1 & 4 Holmes Street, Southern River

Bushfire Management Strategies



Size: A4
Scale: 1:5,500

0 50 100 150 200 250 m

Ref: 3029_003_01_BMS_20160819
Projection: GDA94 MGA50
Author: MM - RUIC | Date: 2016-10-04
Data Sources: Cadastre - Landgate; Imagery -
Nearmap; Roads, Site Boundary, Veg, BAL, Buffers,
BMS - RUIC.

Disclaimer: Although the data within this map is
considered accurate at the time of creation, RUIC
Fire does not guarantee, and accepts no legal
liability whatsoever arising from or connected to,
the accuracy, reliability, currency or completeness
of any data used within this map.

Figure 4A: Bushfire Management Strategies Map

5.0 Implementation and Enforcement

Table 5A summarises the responsible party for each mitigation strategy and the time frame in which it must be completed.

Table 5A: Developer Schedule of Works

Strategy	Implementation		Maintenance	
	Responsible	Time Frame	Responsible	Time Frame
Amendments to BMP	Any amendments to this BMP shall be approved by the relevant Jurisdiction Having Authority.			
Asset Protection Zone	Developer	Prior to subdivision clearance	Individual Land Owners (private land) /local government (public land)	Ongoing
Hazard Separation Zone	N/A	N/A	N/A	N/A
Construction to AS 3959	Individual Land Owners & Local Government	On construction of all habitable buildings	Individual Land Owners	Ongoing
Public Roads	Developer	Prior to subdivision clearance	Local Government	Ongoing
Cul-de-sacs	Developer (where required)	Prior to subdivision clearance	Local Government	Ongoing
Battle Axes	N/A	N/A	N/A	N/A
Private Driveways & Turnaround Area	N/A	N/A	N/A	N/A
Emergency Access Ways	Developer	Prior to subdivision clearance	Local government	Ongoing
Fire Service Access Routes	N/A	N/A	N/A	N/A
Firebreaks	Developer	Prior to subdivision clearance	Developer (during staging progress)	Not required upon completion of development
Firefighting Water (hydrants)	Development	Prior to subdivision clearance	Water Corporation	Ongoing
Firefighting Water (private tanks)	N/A	N/A	N/A	N/A
Firefighting Services & Response	DFES and Local Government	Ongoing	DFES and Local Government	Ongoing
Fuel Load Reduction and Fire Break Notice	Local Government	In accordance with firebreak notice	Local Government	In accordance with firebreak notice

Strategy	Implementation		Maintenance	
	Responsible	Time Frame	Responsible	Time Frame
Inspection and Issue of Works Orders or Fines.	Local Government	Ongoing	Local Government	Ongoing

6.0 Conclusion

On completion of the proposed development, all habitable development will be located in an area that has a low to moderate bushfire hazard level (i.e. BAL-29 or below). With the implementation of the Bushfire Management Strategies outlined in Section 4 and shown in Figure 4A, the proposed development is considered to be appropriately protected from bushfire and complies with the requirements of SPP 3.7 and the Guidelines.

7.0 References

Calibre Consulting. (2016). Landscaping Plan.

Endemic and Associates. (2016). Wetland Management Plan.

RUIC Fire. (2015). Bushfire Management Plan.

Standards Australia. (2009). AS 3959:2009 Construction of buildings in bushfire prone areas: SAI Global.

WALGA (2015). Environmental Planning Tool. Western Australian Local Government Association, WA.

WAPC. (2006). State Planning Policy 3.4 Natural Hazards and Disasters. State Law Publisher.

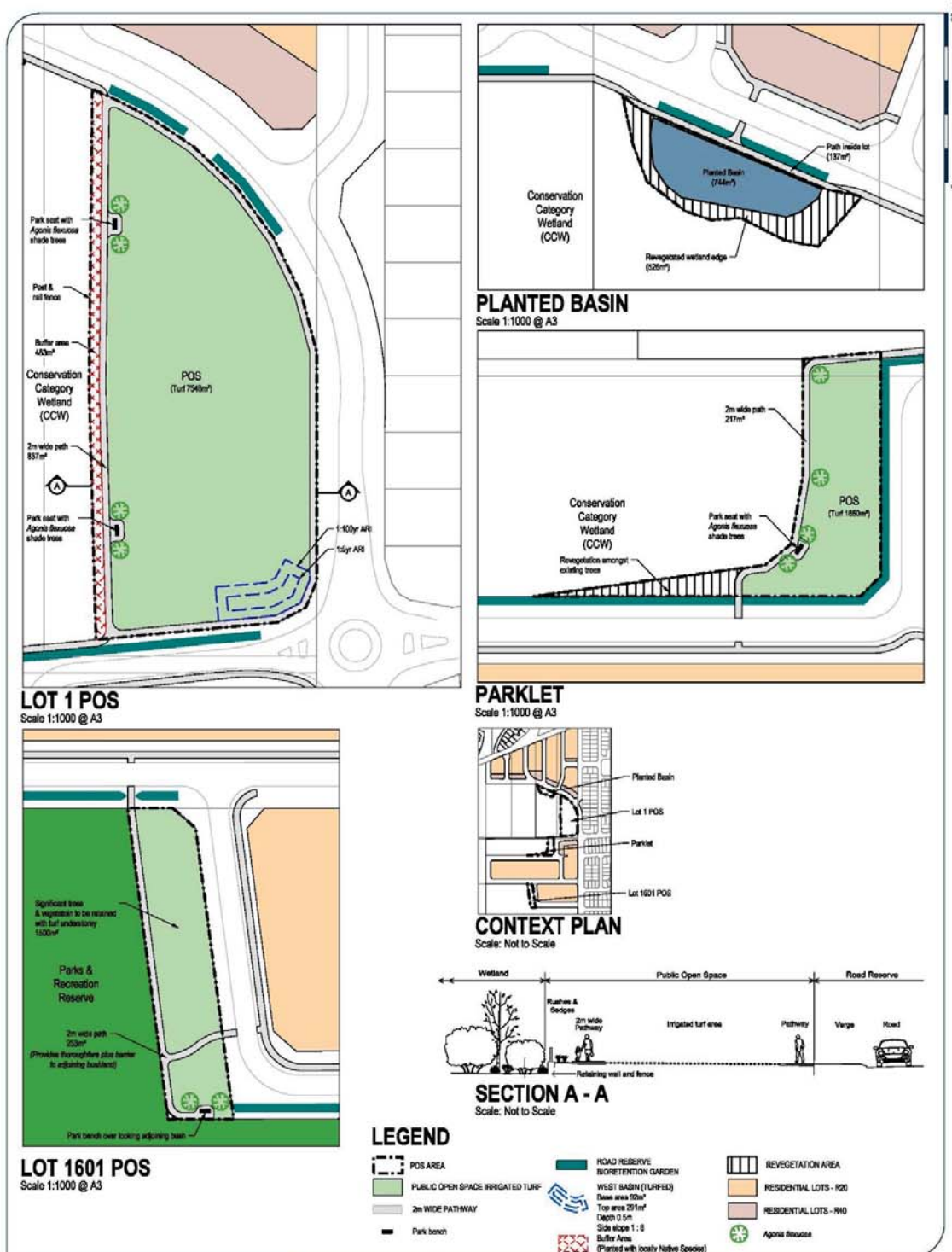
WAPC. (2015a). State Planning Policy 3.7 Planning in Bushfire Prone Areas. Western Australian Planning Commission & Department of Planning.

WAPC. (2015b). Guidelines for Planning in Bushfire Prone Areas. Western Australian Planning Commission, Department of Planning & Department of Fire and Emergency Services.

WAPC. (2015c). Guidelines for Planning in Bushfire Prone Areas Appendices. Western Australian Planning Commission, Department of Planning & Department of Fire and Emergency Services.

WAPC. (2015d). Planning Bulletin 111/2015 Planning in Bushfire Prone Areas. Western Australian Planning Commission.

8.0 Appendix 1 – Landscaping Plan



Calibre Consulting (Aust) Pty Ltd
Unit 5, 53 Victoria Street
Bunbury WA 6230
Ph 08 9701 4411
www.calibreconsulting.co

Copyright: This document is and shall remain the property of Calibre Consulting (Aust) Pty Ltd.

LANDSCAPING PLAN
Lots 2 and 1601 Holmes and Balfour Roads

Plan No: 16018P-MP-02

Date: 01.08.2016
Rev: ORIGINAL
Scale: A1 @ 1:500, A3 @ 1:1000
Co-ords: MCA
Aerial: N/A



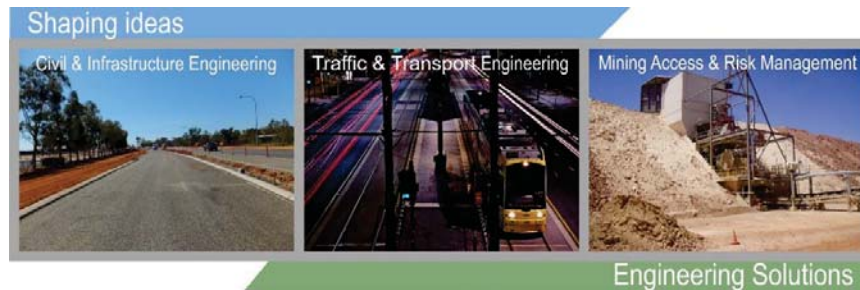
This plan has been prepared for planning purposes. Areas, contours and dimensions shown are subject to survey.

APPENDIX 7

Shawmac Movement Network Assessment



CONSULTING CIVIL & TRAFFIC ENGINEERS, RISK MANAGERS.



Project: Southern River - Precinct 2 Phase 3
Transport Assessment

Client: Dynamic Planning

Author: Angela Wetton

Signature: 

Date: 22/07/16

1 ST. FLOOR, 908 ALBANY HIGHWAY, EAST VICTORIA PARK WA 6101.
PHONE +61 8 9355 1300
FACSIMILE +61 8 9355 1922
EMAIL admin@shawmac.com.au



Document Status

Version No.	Author	Reviewed by	Date	Document status	Signature	Date
0	A Wetton	E Wilks	22/07/16	Draft		22/07/16

SHAWMAC PTY LTD

ABN 51 828 614 001

PO BOX 937

SOUTH PERTH WA 6951

T: + 61 8 9355 1300

F: + 61 8 9355 1922

E: admin@shawmac.com.au

© Shawmac Pty. Ltd. 2015



CONTENTS

1. Introduction and Background	1
1.1. General	1
1.2. Transport Statement Objective	1
1.3. Background Information	1
1.4. Site Location	1
1.5. Surrounding Major Attractors and Generators	3
2. Existing Situation	4
2.1. Land Use	4
2.2. Zoning	4
2.3. Existing Road Network	4
2.4. Road Hierarchy vs Actual Flows	5
2.5. Public Transport Facilities	6
2.6. Existing Pedestrian and Cycling Network	7
2.7. Subdivision Proposal	7
2.8. Proposed Land Use	9
2.9. Changes to External Transport Networks	9
3. Transport Assessment	10
3.1. Assessment Period	10
3.2. Traffic Generation	10
3.3. Traffic Distribution	10
3.4. Design Traffic Flows	10
3.5. External Traffic Flows	12
4. Roads and Intersections	13
4.1. Road Hierarchy and Reserves	13
4.1.1. Intersection Analysis	15
4.2. Pedestrian/ Cyclist Access	15
4.3. Public Transport Access	16



4.4. Safety issues	16
4.5. Noise	17
5. Conclusions	18
Appendix A – Site Plans.....	19
Appendix B - Traffic Counts	22
Appendix C - SIDRA Movement Summaries.....	24
Appendix D - Road Hierarchy Criteria	26

FIGURES

Figure 1 - Regional Context	2
Figure 2 - Local Context.....	3
Figure 3 - Extract of City of Gosnells <i>Intramaps</i> TPS 6 Zoning.....	4
Figure 4 - Road Hierarchy.....	5
Figure 5 - Existing Public Transport Services	6
Figure 6 - Cycling Network Development Proposal.....	7
Figure 7 - Proposed Subdivision Concept Plan.....	8
Figure 8 - Extract of the Metropolitan Region Scheme (Planning, 2016)	9
Figure 9 - Future Daily Traffic Volumes	11
Figure 10 - Access Street D indicative cross section.	14
Figure 11 - Neighbourhood Connector B indicative cross section.....	14
Figure 12 - Suggested Bus Routes (Extract from Southern River / Forrestdale / Brookdale <i>District Structure Plan</i>)	16

TABLES

Table 1 - Road Classification and Current Traffic Volumes	6
Table 2 - Proposed Land Use	9
Table 3 - Internal Roads - Future Daily Traffic Volumes	12
Table 4 - Existing Road Network - Predicted Flows	12
Table 5 - Proposed Road Hierarchy and Road Reservations	13
Table 6 - Intersection Analysis Warrants	15



1. Introduction and Background

1.1. General

This Transport Assessment has been prepared by Shawmac Pty Ltd, on behalf of Dynamic Planning to support a proposed Structure Plan and Subdivision Concept Plan for Southern River Precinct 2 Phase 3, consisting of Lots 2, 23 and 24 Holmes Street and Lots 1, 1600 and 1601 Balfour Street, Southern River, in the City of Gosnells.

1.2. Transport Statement Objective

This Transport Assessment outlines the likely impact of the proposed subdivision on network traffic flows, safe access, pedestrian and cycle facilities and local amenity. As part of the assessment, Shawmac considered the likely traffic demand that would be generated through the proposed development.

The assessment considers aspects associated with:

- Generation of traffic including impacts on roads;
- Integration with the surrounding land uses;
- Use of public and other transport modes such as walking and cycling; and
- Safety and access issues.

1.3. Background Information

The subject site is within the *Southern River / Forrestdale / Brookdale / Wungong District Structure Plan Area*, endorsed by the Western Australian Planning Commission (WAPC) in January 2001.

A Structure Plan for Southern River, Precinct 2 was endorsed by the City of Gosnells in 2006 and included a Transport Assessment for Precinct 2, prepared by Transcore Consultants in October 2005.

A Technical Note was prepared by Shawmac on the 2nd November 2015 which assessed the traffic generation and assignment of the proposed subdivision which was used to determine the required cross-section of the internal roads.

1.4. Site Location

The subject site is located within the suburb of Southern River, approximately 20 kilometres south-east of the Perth CBD. **Figure 1** below shows the broad the location of the site.

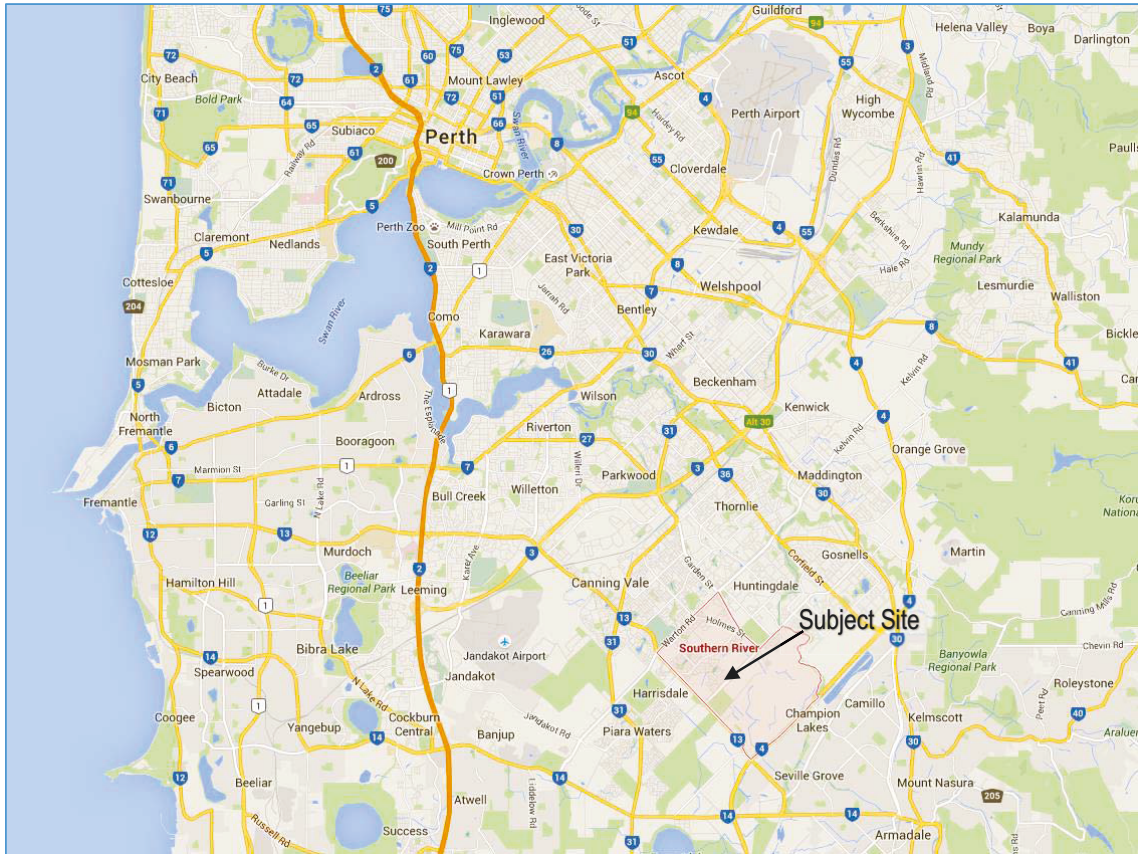


Figure 1 - Regional Context

The subject site is located on the south west corner of Holmes Street and Balfour Street.

There is undeveloped bush land to the north and west, with existing and future urban development to the south and east.

Figure 2 shows the location of the site in the context of the local area.



Figure 2 - Local Context

1.5. Surrounding Major Attractors and Generators

The subject site is bound by residential development and bushland. There are commercial and retail developments including a local shopping centre located along Warton Road and near the intersection of Warton Road, Amherst Road and Holmes Street, approximately 1.5km from the site.

The local primary schools include Bletchley Park Primary School, Campbell Primary School, Forest Crescent Primary School and Ashburton Drive Primary School. The local secondary schools include Southern River College and John Wollaston Anglican Community School.

2. Existing Situation

2.1. Land Use

The subject site is a mix of undeveloped bush land and cleared undeveloped land, with one existing residential dwelling located on each of Lots 1600 and 1601 Balfour Road and two residential dwellings located on Lot 2 Holmes Street. There is undeveloped land to the north and west of the subject site and residential development to the east and south of the site.

2.2. Zoning

The subject site is currently zoned “Residential Development” under the City of Gosnells *Town Planning Scheme No 6 (TPS 6)*. An extract from the planning scheme zones from the City of Gosnells *Intramaps* is shown below in **Figure 3**.

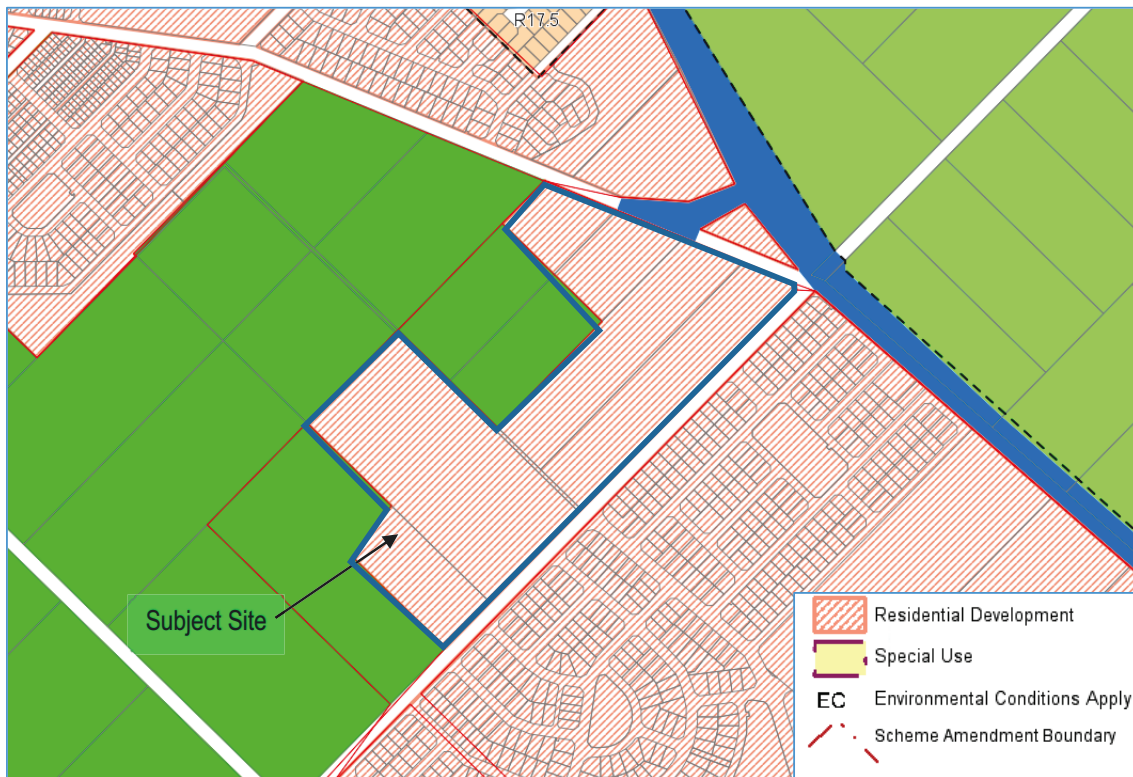


Figure 3 - Extract of City of Gosnells *Intramaps* TPS 6 Zoning

2.3. Existing Road Network

Balfour Street forms the south-east boundary to the site and provides a connection between Ranford Road and Holmes Street. Adjacent to the site, Balfour Street is classified as an *Access Road* under the MRWA Functional Road Hierarchy and operated under a 50km/h speed limit. Balfour Road has been constructed as a single

undivided carriageway with 7.5m wide seal within a 20m wide road reservation. There is a 2m wide concrete path on the southern side of the road.

Holmes Street forms the north-east boundary of the site and provides a connection between Warton Road to Passmore Street. Holmes Street is classified as a District Distributor B Road under the MRWA Functional Road Hierarchy and operates under a 70km/h posted speed limit. Holmes Street has been constructed as a single undivided carriageway with a 7.2m wide seal, with an 80m long right turning lane for southbound traffic turning into Balfour Street.

The road classification for each road surrounding the proposed development site is shown on **Figure 4** as an extract from Main Roads Western Australia (MRWA) *Road Information Mapping System*.

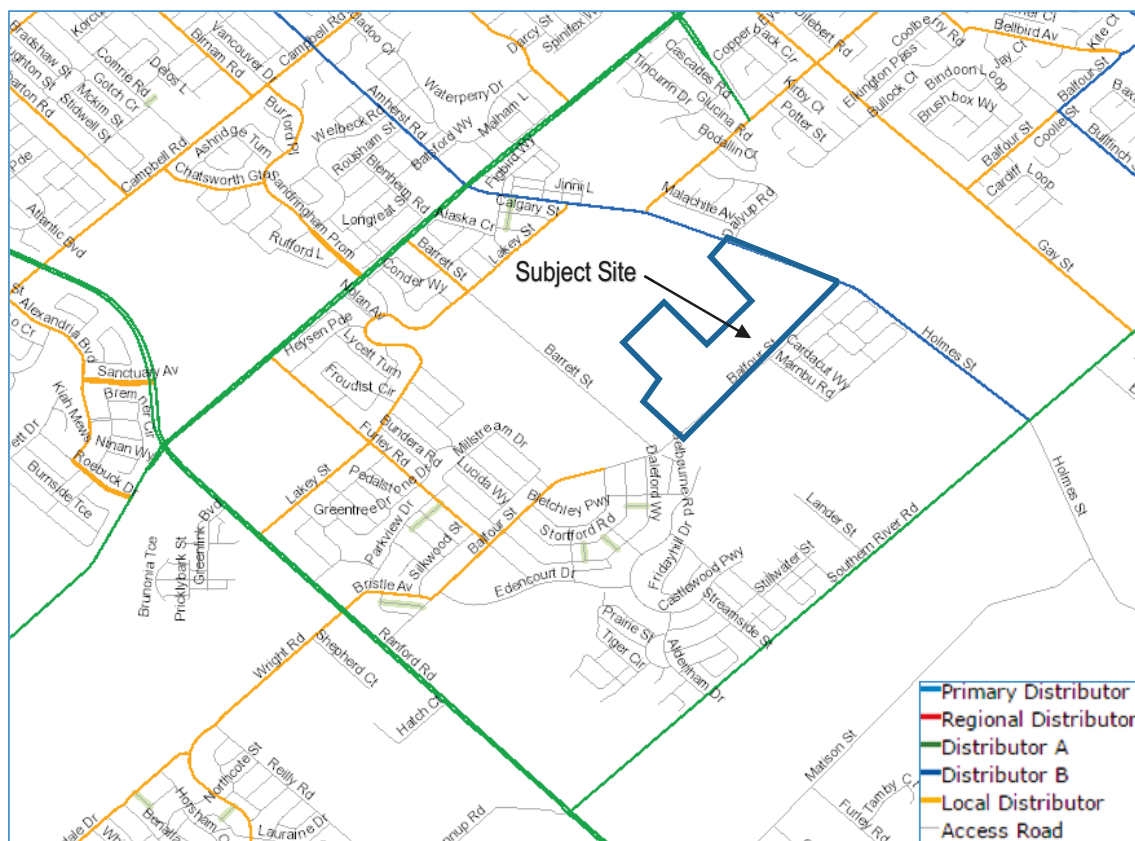


Figure 4 - Road Hierarchy

2.4. Road Hierarchy vs Actual Flows

Traffic counts provided by the City of Gosnells for Holmes Street west of Balfour Street from February 2014 indicated an average weekday traffic volume of 5,234 vehicles per day (vpd). Traffic counts for Balfour Street South of Diego Entrance from May 2013 indicated an average weekday traffic volume of 416vpd. The traffic data is attached in **Appendix B**.

Table 1 details the comparison of actual flows against the recommended maximum flows under the *Liveable Neighbourhood* guidelines. The table indicates that all roads in the vicinity of the subject site are currently operating within their classification.

Table 1 - Road Classification and Current Traffic Volumes

MRWA Road Classification	Road Category	Road Name	Desirable Max. Traffic Volume. (vpd)	Current Traffic Volumes (vpd)	Date
Access Road	Access Road	Balfour Street	3,000	416	21/5/13
District Distributor B	Integrator B Road	Holmes Street	15,000	5,234	10/2/14

2.5. Public Transport Facilities

Figure 5 shows the public transport services in the surrounding area. There are currently no public transport facilities within a 400m walkable catchment of the subject site. The nearest bus stops are located on Holmes Street before Lakely Street (700m) and on Gay Street, after Balfour Street (1km).

As the suburb of Southern River becomes increasingly urbanised, there will be a need for more public transport services.

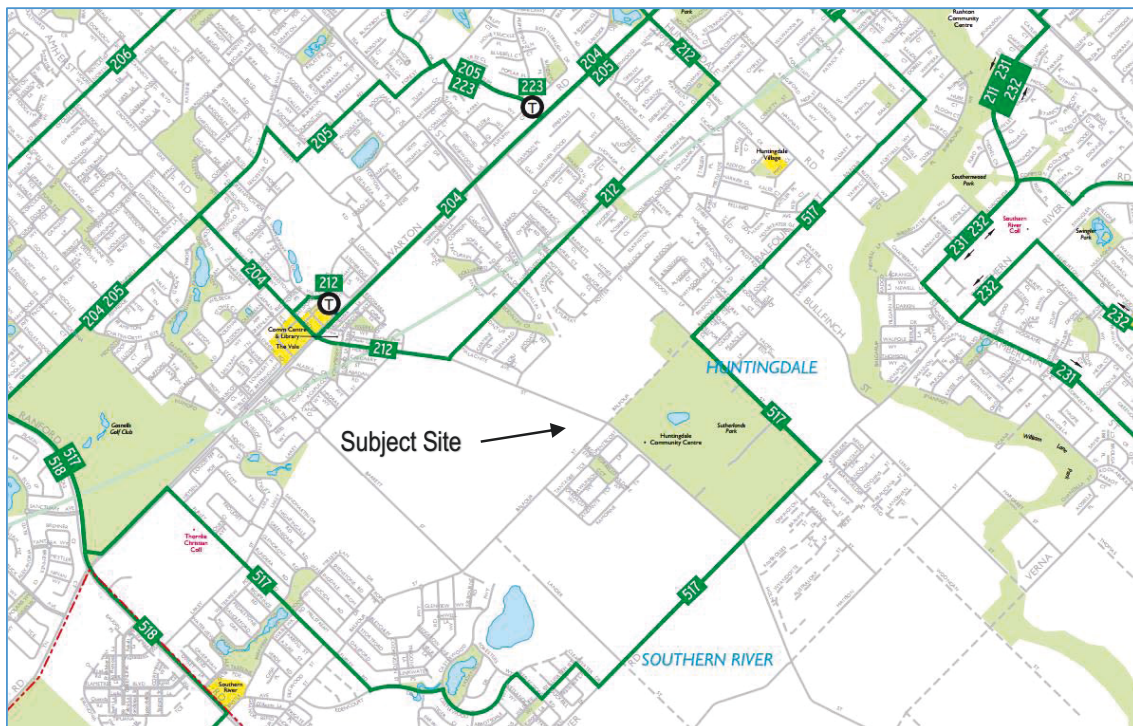


Figure 5 - Existing Public Transport Services

2.6. Existing Pedestrian and Cycling Network

Figure 6 illustrates the cycling network in the vicinity of the subject site. Holmes Street is described as a “good road riding environment”. Balfour Street has a concrete path on the southern side of the road which cyclists may use while giving way to pedestrians.



Figure 6 - Cycling Network Development Proposal

2.7. Subdivision Proposal

The proposed subdivision concept plan is attached in **Appendix A** and shown in **Figure 7**.



The proposed subdivision land use is residential lots zoned R25 and R40 and Public Open Space (POS).

2.8. Proposed Land Use

The proposed subdivision as shown in **Figure 7** consists of 223 residential lots and public open spaces. The proposed land use is shown in **Table 2** below

Table 2 - Proposed Land Use

Land Use	Quantum
Residential R40	36 lots
Residential R25	187 lots
Public Open Space (POS)	1.419 hectares

2.9. Changes to External Transport Networks

A realignment of Balfour Street is proposed, north of Marnbu Road, which will provide a connection through the subdivision to a new roundabout intersection with Holmes Street and the future Garden Street extension. The eastern connection to Holmes Street will be closed when the Garden Street extension is constructed. The Metropolitan Region Scheme (MRS) indicates a Distributor Road between Nicholson Road / Garden Street to Tonkin Highway / Champion Drive as shown in **Figure 8**.

A four-way intersection is proposed at the existing Balfour Street / Diego Entrance intersection, a roundabout intersection at Marnbu Road / Balfour Street, and two left-in, left-out intersections are proposed on Balfour Street.

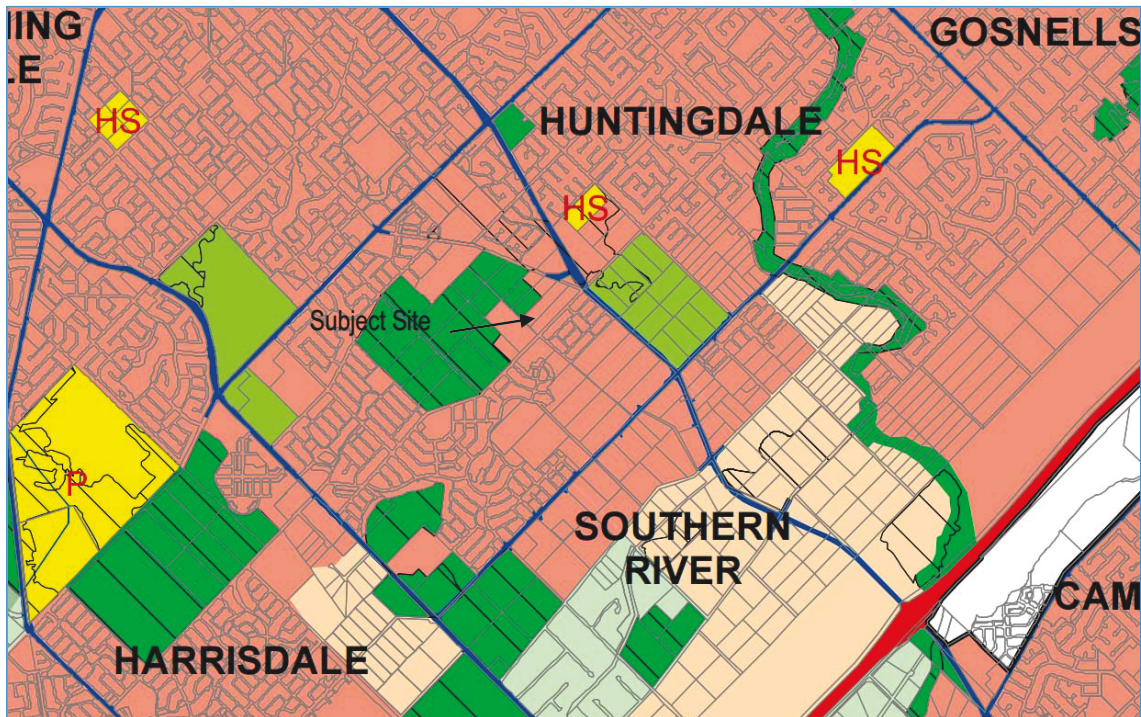


Figure 8 - Extract of the Metropolitan Region Scheme (Planning, 2016)

3. Transport Assessment

3.1. Assessment Period

The time periods for assessment were chosen based on the full development of the proposed subdivision.

3.2. Traffic Generation

Traffic generation is based on approximately 10 trips per lot with the subdivision generating approximately 2,230 trips per day. The Shawmac Technical Note from November 2015 assumed the main desire lines to the north to and from Holmes Street with an attraction of up to 80% of traffic generated.

3.3. Traffic Distribution

Based on the location and connectivity of the surrounding network and the major attractors / generators discussed in Section 2.4, the following assumptions have been made for the distribution of the site-generated traffic:

- 80% will enter and exit from the roundabout intersection at Holmes Street and Garden Street.
 - 50% to and from the west via Holmes Street
 - 30% to and from the north via the Garden Street extension
- 20% will enter and exit from the south via Balfour Street

3.4. Design Traffic Flows

The traffic flows of the network were adopted from the Shawmac Technical Note as shown in **Figure 9. Table 3** lists the predicted traffic flows for the internal road network.

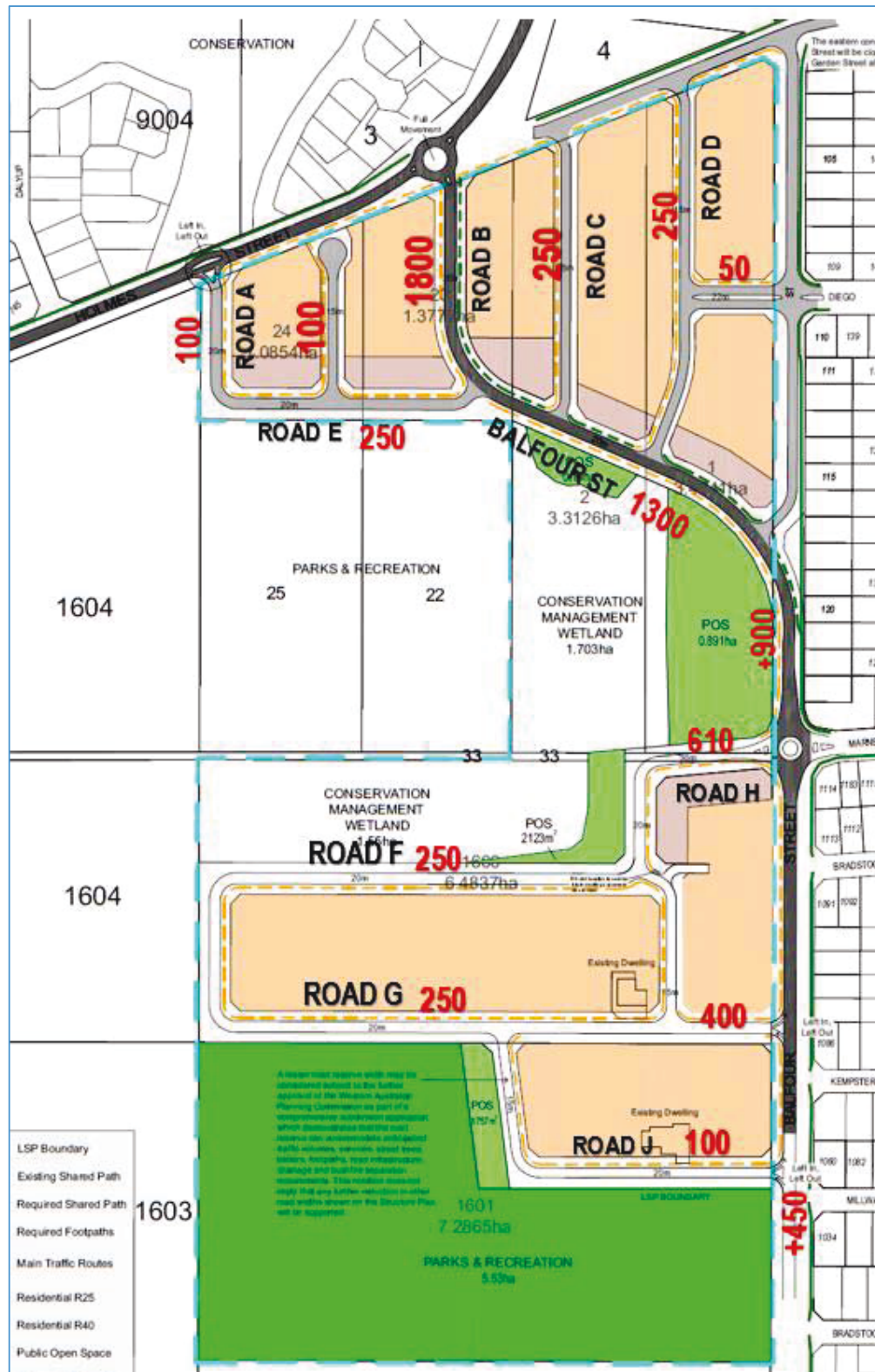


Figure 9 - Future Daily Traffic Volumes



Table 3 - Internal Roads - Future Daily Traffic Volumes

Road Name.	Predicted Traffic Volumes (vpd)
Road A	100 vpd
Road B	100 vpd
Road C	250 vpd
Road D	250 vpd
Road E	200 vpd
Road F	250 vpd
Road G	250 - 400 vpd
Road H	610 vpd
Road J	100 vpd

3.5. External Traffic Flows

The predicted flows were added to the existing volumes of traffic as shown in **Table 4** below. The traffic increases on Holmes Street and Balfour Street are not expected to impact the operation of the roads.

Table 4 - Existing Road Network - Predicted Flows

Road Name.	Desirable Max. Traffic Volume. (vpd)	Current Traffic Volumes (vpd)	Predicted Traffic Volumes (vpd)	Change in Traffic
Holmes Street	15,000	5,234	7,034	+1,800
Balfour Street	3,000	417	2,217	+1,800

4. Roads and Intersections

4.1. Road Hierarchy and Reserves

The road cross section requirements have been based on recommendations contained within Liveable Neighborhoods and the Austroads Guide to Traffic Engineering Practice which is attached in **Appendix C**.

Figures 10 and 11 show the typical cross sections for the recommended road classifications.

Table 5 - Proposed Road Hierarchy and Road Reservations

Road	Predicted daily traffic (combined direction)	Classification	Recommended Road Pavement Width	Recommended Reserve Width	Recommended Intersection treatment
Road A	100 vpd	Access Road D	6 metres	20 metres	Standard non channelised intersection at Holmes Street
Road B	100 vpd	Access Road D	6 metres	15 metres	Channelised left in left out intersection at Holmes Street Standard non channelised intersection at Road E
Road C	250 vpd	Access Road D	6 metres	15 metres	Standard non channelised intersection at Holmes Street. Standard non channelised intersection at Balfour Street.
Road D	250 vpd	Access Road D	6 metres	15 metres	Standard non channelised intersection at Holmes Street. Channelised intersection at Diego Entrance. Standard non channelised intersection at Balfour Street.
Road E	200 vpd	Access Road D	6 metres	20 metres	Channelised intersection at Balfour Street. Widening and central median on 90 degree bend with Road A.
Road F	250 vpd	Neighbourhood Connector B	11.2 metres including parking on POS side of road.	20 metres	Channelised intersection with Road K. Widening and central median on 90 degree bends with Roads G and H.
Road G	250 - 400 vpd	Neighbourhood Connector B	11.2 metres including parking on POS side of road.	20 metres	Standard non channelised intersection with Road J. Standard non channelised intersection with Road K. Channelised intersection with Balfour Street.
Road H	610 vpd	Neighbourhood Connector B	11.2 metres including parking on POS side of road.	20 metres	Channelised intersection with Balfour Street (Roundabout).
Road J	100 vpd	Access Road D	6 metres	12 - 20 metres	Standard non channelised intersection at Balfour Street.

Road	Predicted daily traffic (combined direction)	Classification	Recommended Road Pavement Width	Recommended Reserve Width	Recommended Intersection treatment
Balfour Street South of Road J	Plus 200 vpd.	Neighbourhood Connector B	11.2 metres including parking.	20 metres	As above.
Balfour Street South of Road H	Plus 400 vpd.	Neighbourhood Connector B	11.2 metres including parking.	20 metres	As above.
Balfour Street South of Road D	Plus 1,000 vpd.	Neighbourhood Connector B	11.2 metres including parking.	20 metres	As above.
Balfour Street South of Holmes Street.	Plus 1,800 vpd.	Neighbourhood Connector B	11.2 metres including parking.	20 metres	As above.

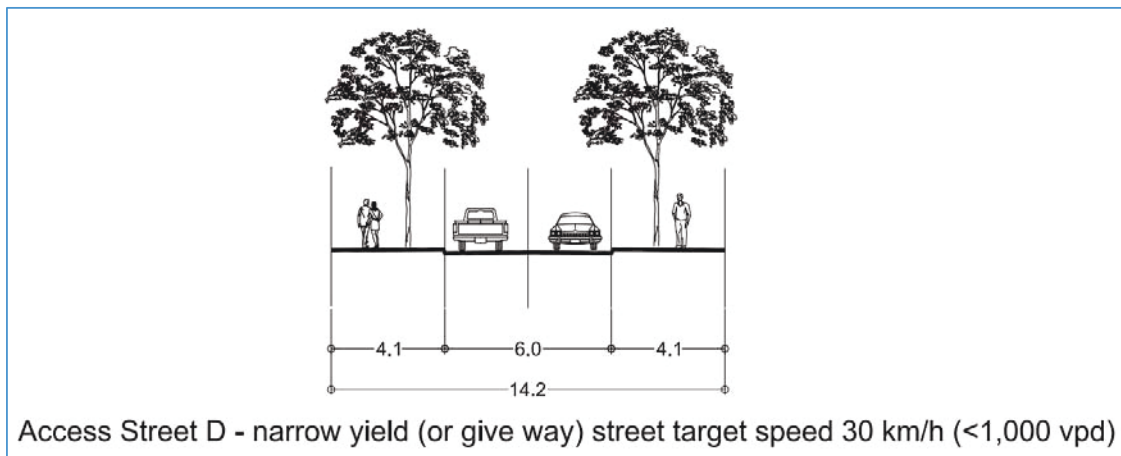


Figure 10 - Access Street D indicative cross section.

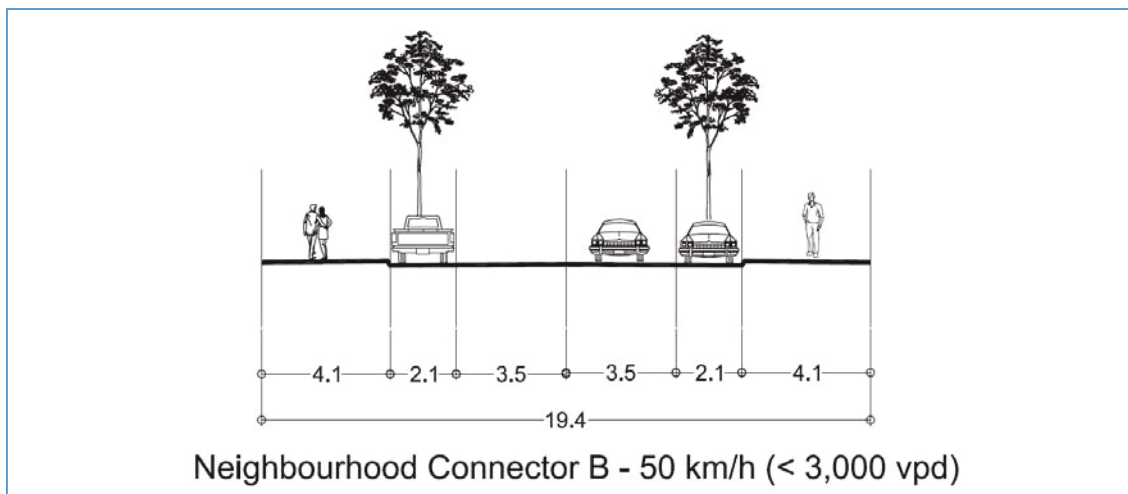


Figure 11 - Neighbourhood Connector B indicative cross section

4.1.1. Intersection Analysis

Internal peak hour traffic volumes within the development are generally small and as such negligible impacts are predicted. Warrants for analysis for each intersection as shown in Table 6.1 of Austroads Guide to Traffic Management Part 3, Traffic Studies and Analysis, shown below as **Table 6**, were applied and determined that the intersection of Holmes Street, Balfour Street and Garden Street required capacity analysis. Peak hour traffic volumes were assumed to be approximately 10% of predicted daily traffic.

Table 6 - Intersection Analysis Warrants

Intersection	Hourly volume major road	Hourly volume minor road	Comment.
Warrants as per Table 6.1 of Austroads Guide to Traffic Management Part 3, Traffic Studies and Analysis - Two Lane Major Road Cross Road	400 vph 500 vph 650 vph	250 vph 200 vph 100 vph	Table details flows that initiate intersection analysis. As major flows increase, there is reduced capacity to accept minor flows.
Holmes Street / Garden Street / Precinct 2 Phase 3 Roundabout	900	180	3 way roundabout intersection – Analysis required.
Balfour Street - Road H - Mambu Road	200	61	4 way roundabout intersection – Analysis not required.
All others intersections	<100	<100	Analysis not required.

The main subdivision intersection, between Holmes Street, Balfour Street and Garden Street meets the warrants for analysis. Main Road WA 2031 ROM data as quoted in the *Southern River Precinct 3A (South) ODP Transport Assessment* (Transcore, 2014) was used to determine the predicted traffic volumes on Garden Street, Holmes Street and Balfour Street for the ultimate build out of the Southern River Area. The report assumes the continuation Holmes Street to Southern River Road, whereas the latest LSP indicates the eastern connection to Holmes Street will be closed with the Garden Street Extension with the majority of through-traffic from Garden Street to Holmes Street East bypassing the subdivision.

The roundabout intersection was assessed using SIDRA 6.1 Intersection software. The results of the analysis indicate that the intersection will operate at a satisfactory level of service using 2031 estimated traffic volumes. The movement summaries are attached in Appendix C.

4.2. Pedestrian/ Cyclist Access

The Subdivision Concept Plan and Local Structure Plan documents attached in Appendix A outline the proposed pedestrian and cyclist network. A shared path is proposed for the main internal route, connecting to the existing shared paths on Holmes Street and Balfour Street. Footpaths are proposed one side of each of the internal local roads and on the main internal road, on the opposite side to the shared path, including along the north side of the existing Balfour Street. The proposed network provides connections to the established pedestrian and cycling network external to the area. It is recommended that all footpaths are constructed with a minimum width of 1.5 metres and shared paths to a minimum of 2.4m.

Due to the low volumes of traffic and the low speed environment on the internal access roads, on-road cycle lanes are not required and cyclists are able to safely share the roadway with motorised vehicles.

4.3. Public Transport Access

As discussed in Section 3.5, there are limited public transport services in the area. As shown in **Figure 12** below, no bus routes were identified adjacent to the site as a bus route in the Southern River / Forrestdale / Brookdale District Structure Plan, however as the area has been developed the Public Transport Authority (PTA) had provided services and it is anticipated that the PTA will review the requirements for this area as urban development progresses.

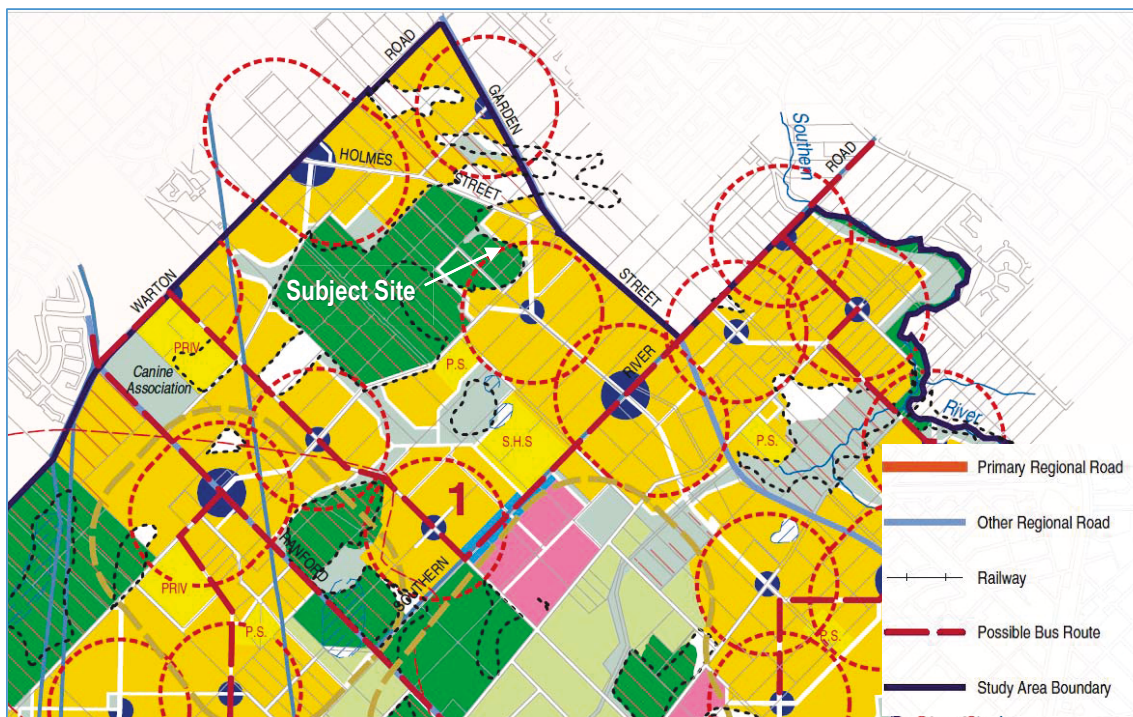


Figure 12 - Suggested Bus Routes (Extract from Southern River / Forrestdale / Brookdale District Structure Plan)

4.4. Safety issues

A review of the overall transport proposal for the site did not identify any specific issues that present unacceptable risks to the road user or that cannot be managed through appropriate design protocols.

Road hazards are typically present at intersections and may occur due inadequate sight distance, inappropriate geometry or substandard capacity that promotes undesirable and potentially hazardous movements.

For the new roads, the allocation of adequate road reservation width and truncation of corners will generally allow sight distance requirements to be accommodated in the detailed design phase of the project. Geometric standards prescribed by Austroads and Main Roads WA guidelines will ensure that no unacceptable risk is introduced into

the road environment. Assessment of the operational performance of intersections undertaken in this study prescribes appropriate geometry and lane allocation to minimise delay and optimise performance.

Detailed design undertaken as part of the Development Application process would need to define at least the following elements:

- Road cross sections including lane widths, on-road cycle lanes, path widths and provisions for people with disabilities;
- Intersection geometries; and
- Pedestrian and cycle facilities (cross sections, crossing requirements and ramps).

4.5. Noise

The proposed development is not likely to generate any traffic noise or result in any vibration issues.

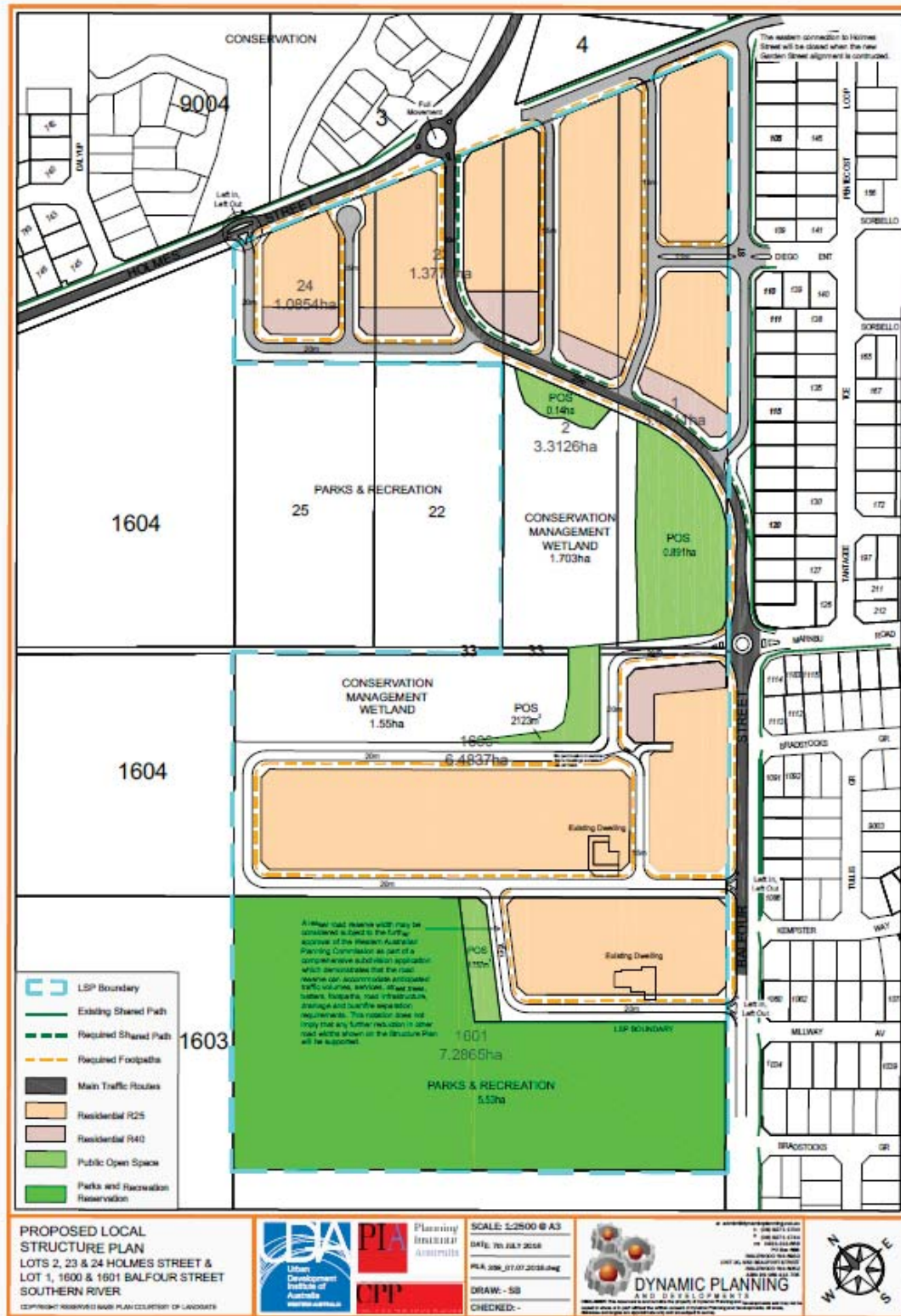
5. Conclusions

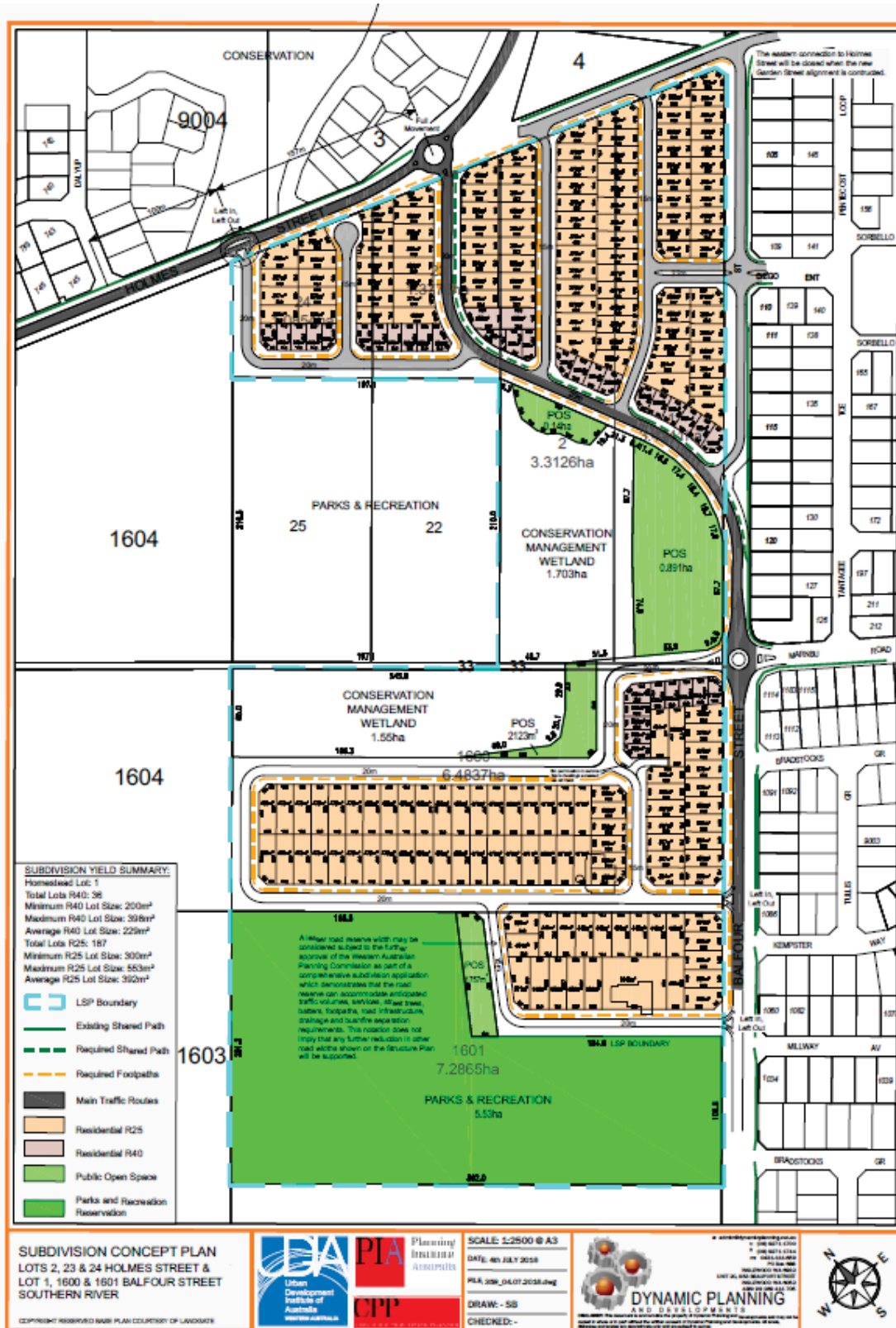
With respect to the proposed Subdivision Concept Plan area, the following is concluded;

- Under the ultimate development of the subdivision, the subdivision will yield approximately 223 dwellings.
- The predicted traffic flows are approximately 2,230 vehicles per day.
- All intersections within the subdivision are expected to operate satisfactorily.
- The roads within the subdivision area will be constructed as *Access Roads* or *Neighbourhood Connector B* roads with cross section details, line marking, intersection control and local area traffic management measures to be addressed during the detailed subdivision design stages.
- The proposed pedestrian and cyclist facilities provide good internal and external connectivity.
- Public Transport services should be considered for the area as it becomes increasingly urbanised.



Appendix A – Site Plans







Appendix B - Traffic Counts

Balfour Street (North and South bound data combined) 60m South of Diego Entrance

21/5/2013 => 24/6/2013

	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Averages	
								1 - 5	1 - 7
Hour									
0000-0100	0.6	0.3	1.2	0.8	2.0	2.2	2.4	1.0	1.4
0100-0200	1.2	2.0	1.2	1.2	0.4	1.6	2.4	1.2	1.4
0200-0300	1.0	1.3	1.0	0.4	0.8	1.2	1.8	0.9	1.1
0300-0400	0.4	0.3	0.2	0.4	0.2	1.4	0.6	0.3	0.5
0400-0500	0.6	0.5	2.0	1.6	2.4	0.8	0.4	1.5	1.2
0500-0600	4.0	4.8	3.8	5.0	5.0	2.0	1.2	4.5	3.6
0600-0700	9.6	11.8	19.8	15.6	16.8	4.0	2.8	14.8	11.5
0700-0800	25.8	33.0	36.2	35.0	27.4	12.2	5.2	31.4	24.7
0800-0900	28.0	39.8	42.2	38.6	32.0	15.8	6.8	36.0	28.7
0900-1000	25.4	30.5	31.4	35.2	31.0	22.8	10.6	30.7	26.6
1000-1100	23.6	34.0	32.8	33.2	35.2	21.8	14.2	31.7	27.6
1100-1200	27.5	32.8	39.0	32.6	27.8	21.6	14.6	32.1	28.0
1200-1300	27.3	33.6	34.8	31.6	32.6	16.4	17.8	32.2	27.7
1300-1400	31.5	33.0	31.4	34.8	30.2	13.6	14.2	32.2	26.8
1400-1500	31.0	42.4	34.6	34.8	37.4	16.4	14.6	36.3	30.1
1500-1600	31.5	34.4	40.8	29.4	34.2	23.8	15.6	34.2	29.9
1600-1700	24.8	34.8	30.0	39.4	34.4	26.8	23.0	33.0	30.6
1700-1800	23.8	22.4	24.2	28.0	26.6	18.6	9.8	25.0	21.9
1800-1900	10.8	11.2	13.4	13.6	18.0	21.2	10.4	13.5	14.2
1900-2000	6.3	8.2	7.0	7.4	9.6	11.8	6.0	7.8	8.1
2000-2100	2.8	5.0	7.6	7.2	6.8	8.4	5.8	6.0	6.3
2100-2200	2.3	2.4	3.6	4.4	6.8	5.4	3.6	4.0	4.1
2200-2300	1.3	3.0	3.2	3.2	10.6	6.2	7.2	4.4	5.1
2300-2400	1.0	1.6	1.0	0.8	4.0	4.6	4.0	1.7	2.5
Totals									
0700-1900	310.8	381.8	390.8	386.2	366.8	231.0	156.8	368.2	316.9
0600-2200	331.6	409.2	428.8	420.8	406.8	260.6	175.0	400.8	346.9
0600-0000	333.9	413.8	433.0	424.8	421.4	271.4	186.2	406.8	354.5
0000-0000	341.7	422.8	442.4	434.2	432.2	280.6	195.0	416.1	363.7
AM Peak	0800	0800	0800	0800	1000	0900	1100		
	28.0	39.8	42.2	38.6	35.2	22.8	14.6		
PM Peak	1500	1400	1500	1600	1400	1600	1600		
	31.5	42.4	40.8	39.4	37.4	26.8	23.0		



Holmes Street (East and West bound data combined)
130m West of Balfour Street

10/2/2014 => 25/2/2014

	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Averages	
								1 - 5	1 - 7
Hour									
0000-0100	9.5	11.3	13.0	15.5	16.0	49.0	60.0	12.9	24.0
0100-0200	2.5	4.0	6.0	8.0	15.5	17.0	30.0	6.9	11.3
0200-0300	5.0	5.3	6.5	6.0	7.5	20.0	15.5	6.0	9.1
0300-0400	7.0	9.7	7.5	8.5	12.5	15.0	12.5	9.1	10.3
0400-0500	26.5	31.3	33.5	33.0	22.0	18.0	19.5	29.5	26.6
0500-0600	109.0	123.0	123.0	118.5	118.5	42.0	21.5	118.8	95.6
0600-0700	220.0	210.7	222.0	220.5	218.0	77.0	45.5	217.5	175.9
0700-0800	343.0	346.7	325.5	356.0	324.5	147.5	93.0	339.8	281.3
0800-0900	470.0	447.7	466.0	485.0	487.5	258.0	163.5	469.1	400.2
0900-1000	248.5	248.3	258.0	263.5	260.0	316.5	221.0	255.0	258.7
1000-1100	252.0	235.3	237.0	266.0	258.5	351.0	271.0	248.5	265.1
1100-1200	238.5	238.3	234.5	270.0	260.0	358.0	320.5	247.4	271.9
1200-1300	228.5	232.7	228.5	251.0	251.5	363.5	314.0	237.9	264.8
1300-1400	231.5	229.3	240.0	231.0	273.5	329.0	325.5	240.0	263.3
1400-1500	381.0	396.0	390.0	365.5	414.5	319.0	288.5	390.0	367.0
1500-1600	439.5	449.3	453.0	489.0	490.5	310.0	282.5	462.9	418.5
1600-1700	451.0	463.7	472.5	495.0	504.5	330.5	308.0	476.1	434.3
1700-1800	460.5	466.7	496.5	496.5	516.5	347.0	313.0	485.5	444.0
1800-1900	258.7	369.0	368.5	385.0	400.5	304.5	259.0	349.3	332.4
1900-2000	223.7	189.0	251.0	274.0	298.5	255.0	206.0	240.4	237.9
2000-2100	137.0	163.0	167.0	190.0	168.0	166.0	146.0	162.5	160.7
2100-2200	92.3	105.5	124.5	137.0	159.0	130.0	78.5	120.8	116.4
2200-2300	48.7	65.5	60.5	82.5	99.5	113.5	44.0	69.3	71.8
2300-2400	24.7	26.0	31.0	34.5	84.0	85.0	25.0	38.6	43.0
Totals									
0700-1900	4002.7	4123.0	4170.0	4353.5	4442.0	3734.5	3159.5	4201.3	4001.3
0600-2200	4675.7	4791.2	4934.5	5175.0	5285.5	4362.5	3635.5	4942.6	4692.2
0600-0000	4749.0	4882.7	5026.0	5292.0	5469.0	4561.0	3704.5	5050.5	4807.0
0000-0000	4908.5	5067.3	5215.5	5481.5	5661.0	4722.0	3863.5	5233.7	4984.0
AM Peak	0800	0800	0800	0800	0800	1100	1100		
	470.0	447.7	466.0	485.0	487.5	358.0	320.5		
PM Peak	1700	1700	1700	1700	1700	1200	1300		
	460.5	466.7	496.5	496.5	516.5	363.5	325.5		

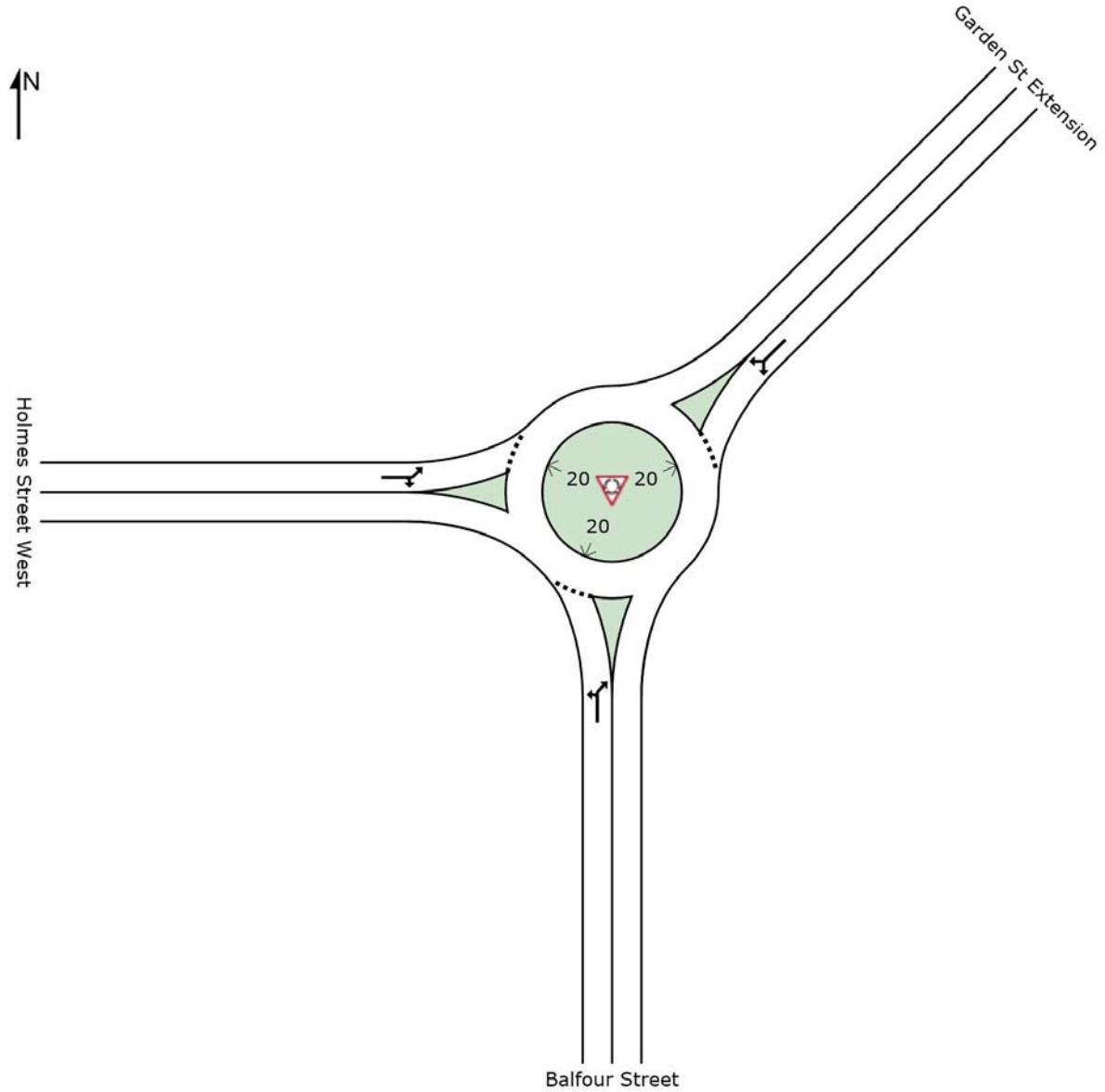
Appendix C - SIDRA Movement Summaries

SITE LAYOUT



Site: Holmes St Garden St Subdivision 2031 AM / PM Peak

Holmes St / Garden St / Balfour Street
Roundabout



**MOVEMENT SUMMARY****Site: Holmes St Garden St Subdivision 2031 AM Peak**

Holmes St / Garden St / Balfour Street
Roundabout

Movement Performance - Vehicles

Mov ID	ODMo v	Demand Total veh/h	Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Balfour Street											
1	L2	80	0.0	0.197	9.5	LOS A	1.3	8.9	0.79	0.82	50.3
3a	R1	54	0.0	0.197	13.3	LOS B	1.3	8.9	0.79	0.82	50.9
Approach		134	0.0	0.197	11.1	LOS B	1.3	8.9	0.79	0.82	50.5
NorthEast: Garden St Extension											
24a	L1	43	0.0	0.587	4.2	LOS A	5.7	39.8	0.35	0.56	52.6
26a	R1	836	0.0	0.587	8.2	LOS A	5.7	39.8	0.35	0.56	52.5
Approach		879	0.0	0.587	8.0	LOS A	5.7	39.8	0.35	0.56	52.5
West: Holmes Street West											
10a	L1	674	0.0	0.492	4.1	LOS A	4.7	33.2	0.31	0.43	55.1
12	R2	65	0.0	0.492	9.1	LOS A	4.7	33.2	0.31	0.43	55.5
Approach		739	0.0	0.492	4.5	LOS A	4.7	33.2	0.31	0.43	55.2
All Vehicles		1752	0.0	0.587	6.8	LOS A	5.7	39.8	0.37	0.53	53.4

Level of Service (LOS) Method: Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections.

Vehicle movement LOS values are based on average delay per movement

Intersection and Approach LOS values are based on average delay for all vehicle movements.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

MOVEMENT SUMMARY**Site: Holmes St Garden St Subdivision 2031 PM Peak**

Holmes St / Garden St / Balfour Street
Roundabout

Movement Performance - Vehicles

Mov ID	ODMo v	Demand Total veh/h	Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance m	Prop. Queued	Effective Stop Rate per veh	Average Speed km/h
South: Balfour Street											
1	L2	80	0.0	0.200	9.7	LOS A	1.3	9.1	0.80	0.83	50.1
3a	R1	54	0.0	0.200	13.5	LOS B	1.3	9.1	0.80	0.83	50.8
Approach		134	0.0	0.200	11.2	LOS B	1.3	9.1	0.80	0.83	50.4
NorthEast: Garden St Extension											
24a	L1	43	0.0	0.596	4.2	LOS A	5.9	41.1	0.35	0.56	52.6
26a	R1	851	0.0	0.596	8.2	LOS A	5.9	41.1	0.35	0.56	52.5
Approach		894	0.0	0.596	8.0	LOS A	5.9	41.1	0.35	0.56	52.5
West: Holmes Street West											
10a	L1	674	0.0	0.492	4.1	LOS A	4.7	33.2	0.31	0.43	55.1
12	R2	65	0.0	0.492	9.1	LOS A	4.7	33.2	0.31	0.43	55.5
Approach		739	0.0	0.492	4.5	LOS A	4.7	33.2	0.31	0.43	55.2
All Vehicles		1766	0.0	0.596	6.8	LOS A	5.9	41.1	0.37	0.53	53.4

Level of Service (LOS) Method: Delay (HCM 2000).

Roundabout LOS Method: Same as Signalised Intersections.

Vehicle movement LOS values are based on average delay per movement

Intersection and Approach LOS values are based on average delay for all vehicle movements.

Roundabout Capacity Model: SIDRA Standard.

SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).

HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Appendix D - Road Hierarchy Criteria

Indicative volume.	Liveable Neighbourhoods Classification	MRWA equivalent classification	Indicative Reserve Width.	Indicative Carriageway Width.
50,000.	Primary Distributor.	Primary Distributor		Determined by Main Roads WA
35,000.	Primary Distributor.	Primary Distributor		Determined by Main Roads WA
15,000 to 35,000.	Integrator Arterial A (District Distributor A).	Primary Distributor/ District Distributor A	50.6 – 52.6 metres.	2 x 8.2 metre carriageways including bike lane and 2 x 5.5 metre service roads containing parking.
<25,000	Integrator Arterial A (District Distributor A).	District Distributor A	35.6 metres.	2 x 10.7 metre carriageways including combined on street parking and bike lane.
7,000 to 15,000.	Integrator Arterial B (District Distributor B).	District Distributor A/ District Distributor B	29.2 metres.	2 x 7.5 metre carriageways with on street parking and bike lane.
15,000.	Integrator Arterial B (District Distributor B).	District Distributor B	25.2 metres.	2 x 7.5 metre carriageways with on street parking.
7,000.	Neighborhood Connector A.	Local Distributor	24.4 metres	2 x 7.1 metres including parking, on street bike lane, median plus shared path on one verge.
3,000.	Neighborhood Connector B.	Local Distributor	19.4 metres	11.2 metres including parking plus shared path on one verge.
3,000.	Access Street A (Avenue).	Local Distributor/ Access Road	20 - 24 metres.	2 x 3.5 metre lanes plus indented parking.
3,000.	Access Street B (Wider street).	Local Distributor/ Access Road	16.5 - 18 metres.	9.7 metre lane.
3,000.	Access Street C (Yield or give way street).	Access Road	15.4 - 16 metres.	7.2 (7.0 – 7.5) metre lane.
1,000.	Access Street D (Narrow yield or give way street).	Access Road	14.2 metres.	5.5 – 6.0 metre lane.
150	Access Street D (Narrow yield or give way street).	Access Road	14.2 metres.	3.5 metre lane plus parking indents.
3,000.	Access Street D (Wider street).	Access Road	16.5 - 18 metres.	9.7 metre lane.